CERTIFICACIÓN NÚMERO 23-50 E

La que suscribe, Secretaria del Senado Académico del Recinto Universitario de Mayagüez de la Universidad de Puerto Rico, **CERTIFICA** que, en la reunión ordinaria celebrada el martes, 19 de septiembre de 2023, este organismo **APROBÓ** la **PROPUESTA DE CREACIÓN DEL PROGRAMA GRADUADO EN INGENIERÍA DE SOFTWARE**.

El programa consta de los siguientes grados académicos:

1. Maestría de Ciencias en Ingeniería de Software (MS) (Plan I)
   a. Total de créditos: 30
   b. Duración: 4 semestres (2 años)

2. Maestría de Ingeniería en Ingeniería de Software (ME) (Plan II y Plan III)
   a. Total de créditos: 30
   b. Duración: 4 semestres (2 años)

3. Doctorado en Filosofía en Ingeniería de Software (PhD)
   a. Total de créditos: 54
   b. Duración: 8 semestres (4 años)

La propuesta se hace formar parte de esta certificación.

Y para que así conste expido y remito la presente certificación a las autoridades universitarias correspondientes, bajo el Sello de la Universidad de Puerto Rico a los treinta días del mes de noviembre del año dos mil veintitrés, en Mayagüez, Puerto Rico.

Carmen A. Negrón Moure
Carmen A. Negrón Moure
Secretaria

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Anejo

Se enmienda para sustituir Ingeniería en Software por Ingeniería de Software.

24 de mayo de 2023

Miembros del Senado Académico Recinto Universitario de Mayagüez

PROPUESTA DE CREACIÓN DE UN PROGRAMA GRADUADO EN INGENIERÍA DE SOFTWARE

El Comité de Asuntos Curriculares recibió ante su consideración la propuesta de el Departamento de Ciencia e Ingeniería de Computación del Colegio de Ingeniería del Recinto Universitario de Mayagüez para crear un programa graduado en Ingeniería de Software. La propuesta incluye dos grados de maestría (MS y ME) y un grado de Doctorado (PhD).

El programa aquí propuesto consta de los siguientes grados académicos:

1. Maestría de Ciencias en Ingeniería de Software (MS) (Plan I)
    a. Total de créditos: 30
    b. Duración: 4 semestres (2 años)
2. Maestría de Ingeniería en Ingeniería de Software (ME) (Plan II y Plan III)
    a. Total de créditos: 30
    b. Duración: 4 semestres (2 años)
3. Doctorado en Filosofía en Ingeniería de Software (PhD)
    a. Total de créditos: 54
    b. Duración: 8 semestres (4 años)

La propuesta fue revisada y aprobada por el Comité de Estudios Graduados e Investigación en reunión celebrada el 10 de noviembre de 2022 y por la facultad de ingeniería el 29 de noviembre de 2022.

Características principales de la maestría propuesta:

La maestría en Ingeniería de Software (SWE) está dirigido a estudiantes que hayan obtenido un bachillerato en Ingeniería de Software, Ciencias de la Computación e Ingeniería, Ciencias de la Computación, Ingeniería Informática, o campos estrechamente relacionados. Su objetivo es proporcionar a los estudiantes conocimientos avanzados en Ingeniería de Software en áreas de diseño de programas, pruebas, mantenimiento despliegue de producción, supervisión, ingeniería de software seguro, protección de software e ingeniería de datos. Los estudiantes adquirirán habilidades de alto nivel para el análisis de software, y la capacidad de contribuir eficazmente a la solución de problemas complejos a través del desarrollo de artefactos de software para su uso en producción. El programa tiene un total de treinta (30) créditos, y debe completarse en un plazo de dos (2) años tras la obtención del de grado bachillerato.

Para alcanzar los objetivos del Programa, todos los estudiantes matriculados en la maestría en SWE deben aprobar tres (3) cursos graduados básicos (9 créditos):

1) Principios de Ingeniería del Software
2) Ingeniería de sistemas de bases de datos
3) Sistemas de software seguros

Además, los estudiantes matriculados en la maestría deben especializarse completando lo siguiente:

- Nueve (9) créditos en cursos graduados electivos dentro del Programa de Graduado SWE.
- Seis (6) créditos en cursos electivos graduados fuera del Programa de Graduado SWE.
- Planes de estudio:
    - o Plan I: seis (6) créditos en una Tesis de Maestría.
    - o Plan II: seis (6) créditos en un Proyecto de Maestría.
    - o Plan III: un bloque adicional de seis (6) créditos en cursos optativos dentro del programa de Graduado de SWE.

El Doctorado en Ingeniería del Software (SWE) es un título de formación en investigación concebido como una experiencia graduada orientada a la investigación en comparación con la maestría en SWE. El doctorado en SWE énfasis en la realización de trabajos de investigación de vanguardia. Similar al Máster en SWE, tiene como objetivo proporcionar a los estudiantes conocimientos avanzados en Ingeniería de Software en áreas de diseño de programas, pruebas, mantenimiento, despliegue en producción, monitorización, ingeniería de software seguro, protección de software e ingeniería de datos. Pero al ser un título de formación en investigación, las actividades educativas adicionales del doctorado en SWE se centran en el desarrollo de las habilidades necesarias para llevar a cabo la investigación y en la producción de un trabajo académico de alta calidad en la frontera del conocimiento y la tecnología en Ingeniería de Software. El programa tiene un total de cincuenta y cuatro (54) créditos, y debe ser completado en cuatro (4) años por aquellos estudiantes que son aceptados con una licenciatura en Ingeniería de Software, Ciencias de la Computación e Ingeniería, Ingeniería Informática, o campo estrechamente relacionado. Los estudiantes que sean aceptados con una maestría en SWE deberán completar el grado en dos (2) años.

La secuencia de cursos de doctorado comparte los mismos tres (3) cursos básicos de postgrado (9 créditos) que la maestría en SWE:

1) Principios de Ingeniería del Software
2) Ingeniería de sistemas de bases de datos
3) Sistemas de software seguros

Además, los estudiantes matriculados en el Doctorado en SWE deben especializarse completando lo siguiente:

- Quince (15) créditos en cursos electivos de posgrado dentro del Programa de Graduado en SWE.
- Seis (6) créditos en cursos electivos de posgrado fuera del Programa de Graduado SWE.
- Tres (3) créditos en un curso de Temas Avanzados en SWE.
- Tres (3) créditos en un Seminario de Doctorado.
- Dieciocho (18) créditos en Investigación de Tesis Doctoral.
- Examen de cualificación para el doctorado.
- Examen de candidatura al doctorado.
- Publicación de un artículo científico revisado por pares.
- Examen de Defensa de la Tesis Doctoral.

El doctorado en SWE se concede a los candidatos cuya tesis se basa en una investigación amplia y original en el campo elegido dentro de SWE. El Comité de Graduado del estudiante aprobará la publicación revisada por pares, basándose en las características particulares del tema de investigación dentro de SWE. El estudiante debe ser el primer autor de la publicación revisada por pares y debe estar directamente relacionada con la tesis del estudiante.

Los cursos que acompañan esta propuesta fueron aprobados por el Senado Académico del Recinto Universitario de Mayagüez el 23 de mayo de 2023. Ver Certificación 23-36

De la revisión de la documentación sometida se desprende que los proponentes hicieron un análisis ponderado y completo del programa graduado propuesto con dos grados de maestría y un grado de doctorado en filosofía en ingeniería de software. Además, este programa cubre unas necesidades muy importantes para el desarrollo del país en el área de creación de software. Por estas razones el Comité de Asuntos Curriculares recomienda al Senado Académico aprobar estos tres grados académicos.

Cordialmente,

Prof. Jaime Sepúlveda Rivera
Co-Presidente Comité Asuntos Curriculares

Dr. Omell Pagán Parés
Co-Presidente del Comité de Asuntos Curriculares

CERTIFICACIÓN NÚMERO 23-36

La que suscribe, Secretaria del Senado Académico del Recinto Universitario de Mayagüez de la Universidad de Puerto Rico, **CERTIFICA** que, en la reunión ordinaria celebrada el martes, 23 de mayo de 2023, este organismo **APROBÓ** el **INFORME DE CURSOS 22-23-014** del Comité de Cursos, el cual contiene las recomendaciones para la creación y modificación de los siguientes cursos que pertenecen a la Propuesta de Creación del Programa Graduado en Ingeniería de Software del Departamento de Ciencia e Ingeniería de la Computación. Se aprobaron los siguientes cursos: **INSO 6005. PRINCIPIOS DE LA INGENIERÍA DE SOFTWARE, INSO 6006. INGENIERÍA DE SISTEMAS DE BASES DE DATOS, INSO 6007. SISTEMAS DE SOFTWARE SEGUROS, INSO 6010. DESARROLLO Y OPERACIONES, INSO 6015. APRENDIZAJE AUTOMATIZADO Y OPERACIONES, INSO 6030. INGENIERÍA DE APLICACIONES PARA LA WEB Y DISPOSITIVOS MÓVILES, INSO 6040. INGENIERÍA DE APLICACIONES RELACIONADAS CON LA SALUD, INSO 6050. INGENIERÍA DE SISTEMAS EN LA FRONTERA DE LA NUBE, INSO 6070. INGENIERÍA DE REDES DEFINIDAS EN SOFTWARE, INSO 6080. INGENIERÍA DEL APRENDIZAJE PROFUNDO, INSO 6998. PROYECTO DE MAESTRÍA, INSO 6999. TESIS DE MAESTRÍA, INSO 8995. TEMAS AVANZADOS, INSO 8996. SEMINARIO DOCTORAL E INSO 8999. DISERTACIÓN DOCTORAL.**

El informe de cursos se hace formar parte de la certificación.

Y para que así conste expido y remito la presente certificación a las autoridades universitarias correspondientes, bajo el Sello de la Universidad de Puerto Rico a los veinticuatro días del mes de mayo del año dos mil veintitrés, en Mayagüez, Puerto Rico.

Carmen A. Negrón Moure
Carmen A. Negrón Moure
Secretaria

bvm

Anejo

Universidad de Puerto Rico
Recinto Universitario de Mayagüez
Senado Académico, Junta Administrativa y Claustro

A : **Miembros del Senado Académico**

DE : **Dra. Betsy Morales Caro**
Comité de Cursos
Decana de Asuntos Académicos

FECHA : 15 de mayo de 2023

ASUNTO : **Informe de Cursos 22-23-14**

De acuerdo con lo dispuesto por el Reglamento Interno del Senado Académico del Recinto Universitario de Mayagüez, el Comité de Cursos del Senado consideró las recomendaciones de los siguientes cursos que pertenecen a la Propuesta de Creación del Programa Graduado en Ingeniería de Software del Departamento de Ciencia e Ingeniería de la Computación del Colegio de Ingeniería y le recomienda al Senado Académico que apruebe los mismos según se indica a continuación:

CURSO	TIPO DE ACCIÓN	ORIGINAL	APROBACIÓN COMITÉ DE CURSOS	JUSTIFICACIÓN DE LA ACCIÓN SOLICITADA
INSO 6005. PRINCIPIOS DE LA INGENIERÍA DE SOFTWARE **SOFTWARE ENGINEERING PRINCIPLES**	**Creación permanente**		Tres horas crédito. Tres horas de conferencia semanal. Estudio integral de los principios y técnicas modernas de ingeniería de software para la entrega eficiente de sistemas de software escalables y seguros para uso en producción. Especificación, diseño e implementación de sistemas de software utilizando tecnologías en la nube, métodos ágiles, SCRUM, patrones de diseño, refactorización, integración continua, entrega continua, sistemas de registro y control de calidad del software. Three credit hours. Three hours of lecture per week. Comprehensive study of modern software engineering principles and techniques for the efficient delivery and maintenance of correct, scalable, and secure software systems for production use. Specification, design, and implementation of software systems using cloud technologies, agile methods, SCRUM, design patterns, refactoring, continuous integration, continuous delivery, logging systems, and software quality assurance.	Provide graduate students in Software Engineering with in-depth knowledge of the principles and techniques necessary to carry out modern software development projects.

CURSO	TIPO DE ACCIÓN	ORIGINAL	APROBACIÓN COMITÉ DE CURSOS	JUSTIFICACIÓN DE LA ACCIÓN SOLICITADA
INSO 6006. INGENIERÍA DE SISTEMAS DE BASES DE DATOS **DATABASE SYSTEMS ENGINEERING**	**Creación permanente**		Tres horas crédito. Tres horas de conferencia semanal. Estudio integral de los principios de ingeniería para construir los componentes internos de los sistemas modernos de administración de bases de datos. Diseño e implementación de sistemas orientados a filas, sistemas orientados a columnas, motores en memoria, motores de datos de múltiples núcleos, ejecución vectorizada y sistemas RDMA. Three credit hours. Three hours of lecture per week. Comprehensive study of engineering principles to build the internals of modern database management systems. Design and implementation of row-oriented systems, column-oriented systems, in-memory engines, multi-core data engines, vectorized query executors, and RDMA systems.	Provide graduate students in Software Engineering with in-depth knowledge of the principles and techniques necessary to design and implement modern data management systems and applications.
INSO 6007. SISTEMAS DE SOFTWARE SEGUROS **SECURE SOFTWARE SYSTEMS**	**Creación permanente**		Tres horas crédito. Tres horas de conferencia semanal. Conceptos de desarrollo de software seguro en el contexto de principios de diseño de sistemas operativos seguros, mecanismos de protección, control de acceso, autenticación, análisis de vulnerabilidades y su aplicación en casos de estudio. Los casos de estudio se enfocarán en avances en el área de sistemas de software seguro para aplicaciones como protección de datos en reposo, dispositivos inteligentes y sistemas autónomos. Three credit hours. Three hours of lecture per week. Concepts of secure software development in the context of secure operating system design principles, protection methods, access control, authentication, vulnerability analysis and case studies. Case studies will focus on secure software systems for applications such as securing data at rest, smart devices and autonomous systems.	Provide graduate students in Software Engineering with in-depth knowledge of the principles and techniques necessary to design and implement secure, privacy-preserving, and protected software systems and applications.

CURSO	TIPO DE ACCIÓN	ORIGINAL	APROBACIÓN COMITÉ DE CURSOS	JUSTIFICACIÓN DE LA ACCIÓN SOLICITADA
INSO 6010. DESARROLLO Y OPERACIONES **DEVELOPMENT AND OPERATIONS**	**Creación permanente**		Tres horas crédito. Tres horas de conferencia semanal. Estudio integral de los principios y técnicas de ingeniería de software DevOps para el desarrollo, la integración y la entrega rápida y continua de sistemas de software para uso en producción. Diseño e implementación de la infraestructura DevOps utilizando contenedores de software, microservicios, integración continua, entrega continua, sistemas de registro y herramientas de colaboración. Three credit hours. Three hours of lecture per week. Comprehensive study of DevOps software engineering principles and techniques for the rapid and continuous development, integration, and delivery of software systems for production use. Design and implementation of DevOps infrastructure using software containers, microservices, continuous integration, continuous delivery, logging systems, and collaborations tools.	Provide graduate students in Software Engineering with in-depth knowledge of the principles and techniques for the rapid and continuous development, integration, and delivery of software systems for production use.
INSO 6015. APRENDIZAJE AUTOMATIZADO Y OPERACIONES	**Creación permanente**		Tres horas crédito. Tres horas de conferencia semanal. Estudio integral de los principios y técnicas de ingeniería de software de MLOps para el desarrollo, la integración y la entrega rápida y continua de sistemas de producción de aprendizaje automático. Diseño e implementación de canales de procesamiento de datos, etiquetado y validación efectiva de datos, aumento de muestras de datos, búsqueda de modelos, análisis de modelos, administración de recursos computacionales, servicio de modelos, administración y entrega de modelos, monitoreo y registro de eventos.	Provide graduate students in Software Engineering with in-depth knowledge of the principles and techniques for the rapid and continuous development, integration, and delivery of Machine Learning production systems.

CURSO	TIPO DE ACCIÓN	ORIGINAL	APROBACIÓN COMITÉ DE CURSOS	JUSTIFICACIÓN DE LA ACCIÓN SOLICITADA
INSO 6015. MACHINE LEARNING AND OPERATIONS	**Creación permanente**		Three credit hours. Three hours of lecture per week. Comprehensive study of MLOps software engineering principles and techniques for the rapid and continuous development, integration, and delivery of Machine Learning production systems. Design and implementation of data processing pipelines, effective data labeling and validation, data augmentation, model search, model analysis, resource management, model serving, model management and delivery, and monitoring and logging.	
INSO 6030. INGENIERÍA DE APLICACIONES PARA LA WEB Y DISPOSITIVOS MÓVILES **WEB AND MOBILE APPLICATION ENGINEERING**	**Creación permanente**		Tres horas crédito. Tres horas de conferencia semanal. Estudio integral de los principios y técnicas de ingeniería de software para el desarrollo de aplicaciones móviles y web en sistemas de producción. Diseño e implementación de aplicaciones de varios niveles, REST APIs, capas de persistencia de datos distribuidos, APIs de sockets web seguros, interfaces de usuario basadas en la web, aplicaciones móviles híbridas y nativas, APIs para administrar el hardware del teléfono, la instrumentación y los sistemas de monitoreo. Three credit hours. Three hours of lecture per week. Comprehensive study of software engineering principles and techniques for the development of mobile and web applications in production systems. Design and implementation of multi-tier applications, REST APIs, distributed data persistence layers, secure web sockets APIs, web-based user interfaces, hybrid and native mobile apps, APIs to manage phone hardware, instrumentation, and monitoring systems.	Provide graduate students in Software Engineering with in-depth knowledge of the principles and techniques for the development of mobile and web applications in production systems.

CURSO	TIPO DE ACCIÓN	ORIGINAL	APROBACIÓN COMITÉ DE CURSOS	JUSTIFICACIÓN DE LA ACCIÓN SOLICITADA
INSO 6040. INGENIERÍA DE APLICACIONES RELACIONADAS CON LA SALUD **HEALTH-RELATED APPLICATION ENGINEERING**	**Creación permanente**		Tres horas crédito. Tres horas de conferencia semanal. Análisis de datos de relacionados con la salud en diferentes dominios, tales como imágenes, análisis de series temporales de información fisiológica, texto en documentos médicos, y registros electrónicos de la salud. Se discutirán los retos y ventajas del uso de la inteligencia artificial (IA) para resolver problemas en el área de la medicina. Discusión sobre conceptos fundamentales de los sistemas aprendizaje profundo, aprendizaje automático, aprendizaje supervisado, aprendizaje distribuido, análisis de imágenes, representación de datos de texto, estrategias para resolver problemas que involucran datos multimodales, y proyectos interdisciplinarios utilizando IA. Three credit hours. Three hours of lecture per week. Analysis of health-related data in different domains, such as images, time series analysis of physiological data, text in medical documents, and electronic health records. The challenges and advantages of using artificial intelligence (AI) to solve problems in the area of medicine will be discussed. Discussion of fundamental concepts in deep learning systems, machine learning, supervised learning, distributed learning, image analysis, text data representation, problem solving strategies involving multimodal data, and interdisciplinary projects using AI.	Provide graduate students in Software Engineering with in-depth knowledge of the principles and techniques for building health applications in terms of the data context such as images, time series analysis of physiological data, text and electronic health records.
INSO 6050. INGENIERÍA DE SISTEMAS EN LA FRONTERA DE LA NUBE	**Creación permanente**		Tres horas crédito. Tres horas de conferencia semanal. Estudio integral de los principios de ingeniería de software para computación en la frontera de la nube, con énfasis en análisis de datos masivos y computación distribuida. Diseño e implementación de sistemas orientados a dispositivos de computación en la frontera incluyendo aspectos de computación en la nube, sincronización, manejo de recursos, resistencia a fallas, servicios, análisis de datos de múltiples sensores y sus aplicaciones.	Provide graduate students in Software Engineering with in-depth knowledge of the principles and techniques for building applications in Edge Computing, with a focus on big data analytics and distributed computing.

CURSO	TIPO DE ACCIÓN	ORIGINAL	APROBACIÓN COMITÉ DE CURSOS	JUSTIFICACIÓN DE LA ACCIÓN SOLICITADA
INSO 6050. SOFTWARE ENGINEERING FOR EDGE SYSTEMS	**Creación permanente**		Three credit hours. Three hours of lecture per week. Comprehensive study of existing frameworks and applications in Edge Computing, with a focus on big data analytics and distributed computing. Design and implementation of computing systems over edge devices and the cloud including synchronization, resource management, fault tolerance, services, multi-sensor data analytics, and their applications.	
INSO 6070. INGENIERÍA DE REDES DEFINIDAS EN SOFTWARE **SOFTWARE-DEFINED NETWORKS ENGINEERING**	**Creación permanente**		Tres horas crédito. Tres horas de conferencia semanal. Estudio comprensivo de los principios de ingeniería para desarrollar sistemas modernos de redes definidas por software (SDN). Análisis, diseño e implementación de funciones que se ejecutan en controladores SDN, conmutadores SDN y aplicaciones SDN. Three credit hours. Three hours of lecture per week. Comprehensive study of engineering principles to develop modern software-defined networking (SDN) systems. Analysis, design and implementation of functions running on SDN controllers, SDN switches, and SDN applications.	Provide graduate students in Software Engineering with in-depth knowledge of the principles and techniques for building modern software-defined networking (SDN) systems.
INSO 6080. INGENIERÍA DEL APRENDIZAJE PROFUNDO	**Creación permanente**		Tres horas crédito. Tres horas de conferencia semanal. Principios de la ingeniería del aprendizaje profundo con arquitecturas de redes neuronales profundas. Estudio de algoritmos y técnicas de implementación para redes neuronales completamente conectadas, redes convolucionales, redes recurrentes, métodos de vectorización de palabras, métodos de atención, redes adversarias generativas y transformadores. Análisis de optimización de descenso de gradiente, selección de hiper-parámetros, sobreajuste y modelado probabilístico. Uso de bibliotecas en un lenguaje de programación de alto-nivel utilizando un modelo computacional de grafos dirigidos en Sistema de Computación Distribuida y de unidades de procesamiento gráfico (“GPU”).	Provide graduate students in Software Engineering with in-depth knowledge of the principles and techniques for building modern deep learning systems and applications.

CURSO	TIPO DE ACCIÓN	ORIGINAL	APROBACIÓN COMITÉ DE CURSOS	JUSTIFICACIÓN DE LA ACCIÓN SOLICITADA
INSO 6080. DEEP LEARNING ENGINEERING	**Creación permanente**		Three credit hours. Three hours of lecture per week. Engineering Principles of deep learning with deep neural network architectures. Study of algorithms and implementation techniques for fully connected neural networks, convolutional networks, recurrent networks, word embeddings, attention methods, generative adversarial networks, and transformers. Analysis of gradient descent optimization, hyperparameters selection, overfitting, and probabilistic modeling. Use of software libraries and frameworks using computational models of directed graphs in distributed systems and graphical processing units ("GPU").	
INSO 6998. PROYECTO DE MAESTRÍA **MASTER'S PROJECT**	**Creación permanente**		Cero a seis horas crédito. Una a seis horas de tesis o disertación semanal. Prerrequisito: autorización del Director de Departamento. Producción supervisada de un trabajo académico que aporte una contribución original a un problema de aplicación y desarrollo de Ingeniería de Software. Zero to six credit hours. One to six hours of thesis or dissertation per week. Prerequisite: authorization of the Director of the Department. Supervised production of scholarly work that makes an original contribution to an application and development problem in Software Engineering.	Provide graduate students in Software Engineering with experience in the design and implementation of a complex software artifact.
INSO 6999. TESIS DE MAESTRÍA	**Creación permanente**		Cero a seis horas crédito. Una a seis horas de tesis o disertación semanal. Prerrequisito: autorización del Director de Departamento. Producción supervisada de un trabajo académico que aporte una contribución original a un problema de investigación en Ingeniería de Software.	Provide graduate students in Software Engineering with experience in the research of a complex software engineering problem.

CURSO	TIPO DE ACCIÓN	ORIGINAL	APROBACIÓN COMITÉ DE CURSOS	JUSTIFICACIÓN DE LA ACCIÓN SOLICITADA
INSO 6999. MASTER'S THESIS	**Creación permanente**		Zero to six credit hours. One to six hours of thesis or dissertation per week. Prerequisite: authorization of the Director of the Department. Supervised production of scholarly work that makes an original contribution to a research problem in Software Engineering.	
INSO 8995. TEMAS AVANZADOS **ADVANCED TOPICS**	**Creación permanente**		Tres horas crédito. Tres horas de conferencia semanal. Discusión de temas avanzados en un área activa de investigación en Ingeniería de Software. Three credit hours. Three hours of lecture per week. Discussion of advanced topics in an active research field within Software Engineering.	Provide doctoral students in Software Engineering with cutting-edge knowledge of a new, emerging research area in software engineering. This course is intended for second year student in the PhD Program in Software Engineering. Permission of the Director is needed in orders to ensure that students have the background to successfully complete the research activities in the course.
INSO 8996. SEMINARIO DOCTORAL **DOCTORAL SEMINAR**	**Creación permanente**		Tres horas crédito. Tres horas de seminario semanal. Prerrequisito: autorización del Director de Departamento. Discusión y ejercicio de habilidades para la redacción técnica o científica. Evaluación de trabajos y propuestas de investigación, escribir críticas científicas y artículos de revisión de literatura y participar en paneles de revisión de investigaciones. Three credit hours. Three hours of seminar per week. Prerequisite: authorization of the Director of the Department. Discussion and exercise of skills for technical or scientific writing. Assessment of research papers and proposals, write scientific critiques and survey papers, and participate in research review panels.	Provide doctoral students in Software Engineering with the knowledge and skills to review, critique, and write papers, proposals, and other scientific writings.

CURSO	TIPO DE ACCIÓN	ORIGINAL	APROBACIÓN COMITÉ DE CURSOS	JUSTIFICACIÓN DE LA ACCIÓN SOLICITADA
INSO 8999. DISERTACIÓN DOCTORAL **DOCTORAL DISSERTATION**	**Creación permanente**		Cero a dieciocho horas crédito. De una a dieciocho horas de tesis o disertación semanal. Prerrequisito: autorización del Director de Departamento. Producción supervisada de una disertación académica que aporte una contribución original a un problema de investigación en Ingeniería de Software. Zero to eighteen credit hours. One to eighteen hours of thesis or dissertation per week. Prerequisite: authorization of the Director of the Department. Supervised production of an academic dissertation that makes an original contribution to a research problem in Software Engineering.	Provide graduate students in Software Engineering with experience in the research of a complex, state-of-the-art software engineering research problem.

Proposal to Establish a

Graduate Program in Software Engineering at the University of Puerto Rico, Mayagüez

By

Ad-hoc Committee of the Department of Computer Science and Engineering

Dr. Manuel Rodríguez-Martínez
Dr. Heidy Sierra-Gil
Dr. Emmanuel Arzuaga

Department of Computer Science and Engineering
College of Engineering
University of Puerto Rico at Mayagüez

1 Introduction

1.1 Name of the program and degrees conferred

1.1.1 *Name of the program*

The name of the program is **Graduate Program in Software Engineering**.

1.1.2 *Degrees Conferred*

The program shall confer the following degrees:

- **Master of Science (MS) in Software Engineering**
- **Master of Engineering (ME) in Software Engineering**
- **Doctor of Philosophy (PhD) in Software Engineering**

The degree options are provided in Certification 09-09 of the Academic Senate of the University of Puerto Rico, Mayaguez (UPRM), as amended by Certification 15-21 of the same decisional body. **These are the certifications upon which this proposal is based**.

1.1.2.1 Master's Degree

Students pursuing the Master's degree program will obtain their degree by choosing a **study plan** as follows:

- *Plan I with a Master's Thesis* – Degree conferred: Master of Science in Software Engineering
- *Plan II with a Master's Project* - Degree conferred: Master of Engineering in Software Engineering
- *Plan III without Thesis or Project* - Degree conferred: Master of Engineering in Software Engineering

1.1.2.2 Doctoral Degree

The Doctor of Philosophy (PhD) in Software Engineering is a **research training** experience designed on top of the course work of the Master's in Software Engineering. It is aimed at students pursuing a research career in industry or academia.

1.2 Brief description of the Program

1.2.1 Master in Software Engineering

The Master in Software Engineering (SWE) degree is intended for students who have earned a bachelor degree in Software Engineering, Computer Science and Engineering, Computer Science, Computer Engineering, or closely related fields. It aims at providing students with advanced knowledge in Software Engineering in areas of **program design, testing, maintenance, production deployment, monitoring, secure software engineering, software protection, and data engineering**. Students shall acquire high order skills for software analysis, and an ability to contribute effectively to the solution of complex problems through the development of software artifacts for production use. The program has a total of thirty (30) credits, and should be completed within two (2) years upon obtaining the bachelor degree.

To achieve the Program aims, **all students** enrolled in the Master in SWE must pass three (3) core graduate courses (9 credits):

1) Software Engineering Principles
2) Database Systems Engineering
3) Secure Software Systems

In addition, students enrolled in the MS degree must specialize by completing the following:

- Nine (9) credits in elective graduate courses within the SWE Graduate Program.
- Six (6) credits in elective graduate courses outside of the SWE Graduate Program.
- Plans of Study:
    - Plan I: six (6) credits in a Master Thesis.
    - Plan II: six (6) credits in a Master Project.
    - Plan III: an additional block of six (6) credits in elective courses within the SWE Graduate program.

The curricular sequence for the Master in SWE can be found in Section 6 of this proposal.

1.2.2 Doctor of Philosophy in Software Engineering

The PhD in Software Engineering (SWE) is a **research training** degree conceived as a research-oriented graduate experience when compared to the Master in SWE. The PhD in SWE has an emphasis on conducting *state-of-the-art research endeavors,* as opposed to completing extensive course sequences. Similar to the Master in SWE, it aims at providing students with advanced knowledge in Software Engineering in areas of **program design, testing, maintenance, production deployment, monitoring, secure software engineering, software protection, and data engineering**. But being a research training degree, the additional educational activities of the PhD in SWE emphasize on the development of skills that are necessary to **conduct research**, and on the actual production of a high-quality scholarly work on the frontier of knowledge and technology in Software Engineering. The program has a total of fifty-four (54) credits, and should be completed in four (4) years by those students that are accepted with a bachelor degree in Software Engineering, Computer Science and Engineering, Computer Engineering, or closely related field. Students that are accepted with a Master in SWE should complete the degree in two (2) years.

The PhD coursework sequence shares the same three (3) core graduate courses (9 credits) as the Master in SWE:

1) Software Engineering Principles
2) Database Systems Engineering
3) Secure Software Systems

In addition, students enrolled in the PhD in SWE must specialize by completing the following:

- Fifteen (15) credits in elective graduate courses within the SWE Graduate Program.
- Six (6) credits in elective graduate courses outside the SWE Graduate Program.
- Three (3) credits on an Advanced Topics in SWE course.
- Three (3) credits on a Doctoral Seminar.
- Eighteen (18) credits in Doctoral Dissertation Research.
- PhD Qualifying Examination.
- PhD Candidacy Examination.
- Publication of a peer-reviewed scientific article.
- PhD Dissertation Defense Examination.

Thus, the PhD in SWE is awarded to candidates whose dissertation is based on extensive and original research in their chosen field within SWE. The Student's Graduate Committee will approve the peer-reviewed publication, based on the particular characteristics of the research topic within SWE. The student **must** be the first author of the peer-reviewed publication and the later must be directly related with the student's dissertation.

Students **holding** a Master in SWE from UPRM, should enter directly into the research components of the PhD coursework, and have their completed master coursework validated as appropriate. These students should complete the PhD program in two (2) years of studies. Students holding a bachelor's in Software Engineering, Computer Science and Engineering, Computer Science, Computer Engineering, or closely related field start out the PhD in SWE by taking a similar set of courses as those in the Master in SWE. These students should complete the program in four (4) years of studies.

The curricular sequence for the PhD in SWE can be found in Section 6.

1.2.3 CIP Code

The program shall be classified under CIP Code 14.0903

1.3 Modalities

The program will be offered in day mode. For most SWE courses, there shall be both on-campus (face-to-face) and hybrid sections for the course, and shall simultaneously transmit the class over the Internet using a video-conferencing system (e.g., Microsoft Teams). On-campus students will take their lectures by attending to the classroom. Off-campus students will connect to the video-conferencing platform to attend the lecture. These courses will be scheduled to accommodate the

needs of working professionals. In most cases, courses will be scheduled late in the afternoon, or early in the morning, taking into consideration student input. Some SWE courses might be offered as distance courses, depending on both students and Program needs. For all courses being offered, all lectures will be recorded, and will be accessible through the official distance learning platform. Currently, this is the *UPR Distance Learning Platform* **online.upr.edu**. In addition, all lecture materials, exams, quizzes, projects, and any other class activity will be submitted by all students using the **online.upr.edu** platform. Software programming assignments will be submitted using software version control platforms such as GitHub or GitLab. Alternative distance learning platforms or software version control platforms could be used with prior approval by the faculty of the Computer Science and Engineering Department in a duly assembled meeting.

Any students in the SWE Program might fulfill the requirement of six (6) credits in elective graduate courses **outside** the SWE Graduate Program by taking face-to-face, hybrid, or distance courses outside the program. The Computer Science and Engineering (CSE) Department will help students identify such courses, and will also coordinate with other departments to seek the inclusion of hybrid or distance graduate courses in the regular offerings.

1.4 Starting date

The program shall start on the Fall of 2023.

1.5 Duration for full-time students and maximum time to complete

1.5.1 Master in SWE

The Master in SWE requires thirty (30) credits for completion. The Master in SWE is intended for students with a bachelor in Software Engineering, Computer Science and Engineering, Computer Science, Computer Engineering, or closely related fields. The Master in SWE is designed to be completed in four (4) academic semesters (i.e., two (2) years) by students that are admitted without deficiencies. Students enrolled in the UPRM bachelor in Software Engineering (INSO), or in Computer Science and Engineering (CIIC), might bring up to 15 credits of SWE courses from their bachelor degree. These students might graduate from the Master in SWE in just one (1) year.

Based on Certification 09-09 of the UPRM Academic Senate, the maximum time to complete the Master in SWE is **six** (6) years from the moment in which the student enrolled in a graduate program for the first time.

1.5.2 PhD in SWE

The PhD in SWE requires fifty-four (54) credits for completion. The PhD in SWE is designed to be completed in eight (8) academic semesters (i.e., four (4) years) by students that are admitted without deficiencies. However, this time might vary depending on the complexity on the research project undertaken for the doctoral dissertation. Students holding a MS in SWE can transfer credits to the PhD in SWE as provided in Certification 09-09 of the UPRM Senate, amended by Certification 15-21. These students might graduate from the PhD in SWE in just two (2) years.

Based on Certification 09-09 of the UPRM Academic Senate, the maximum time to complete the PhD in SWE is:

- eight (8) years from the moment in which the student enrolled in a program for the first time, if the student already had a Master degree.
- ten (10) years from the moment in which the student enrolled in a program for the first time, if the student did not have a Master degree.

1.6 Administration of the SWE Graduate Program

The SWE Graduate Program shall be administered by the Department of Computer Science and Engineering (CSE) at UPRM. For this purpose, the faculty members of the CSE Department shall elect a Graduate Committee, as specified in Certification 09-09. This committee shall be named the **Software Engineering Graduate Committee** (SWE Graduate Committee). The SWE Graduate Committee will handle all academic and administrative matters of the program, with clerical support provided by the staff of the CSE Department. The SWE Graduate Committee shall consist of three (3) members, all of which must be faculty members of the CSE Department.

More details about the SWE Graduate Committee can be found in section 11 of this proposal.

2 Accreditations and Requirements for Professional Practice

2.1 Professional accreditation

The program does not require a professional accreditation.

2.2 Permit by the Council of Education of Puerto Rico (CEPR)

To be requested by the UPR Central Administration after the approval of this proposal by all the corresponding instances within the University of Puerto Rico.

2.3 Professional practice requirements

Does not apply.

3 Justification and Need for the New Academic Program

3.1 Background on the Computing Disciplines

In this section we provide summarized definitions of various Computing disciplines as defined by the ACM-IEEE Computing Curricula Task Force[1]. These definitions provide background to better understand the justification for the new academic program. It is virtually universally recognized that the Computing field has expanded so dramatically that academic programs in related disciplines such as Computer Science, Computer Engineering, and Software Engineering should have their own distinct curricular guidelines as well as accreditation criteria. In fact, ABET accredits Computer Science programs under its Computing Accreditation Commission (CAC)[2], whereas its Engineering Accreditation Commission (EAC)[3] accredits Computer Engineering and Software Engineering Programs. Programs named Computer Science and Engineering are jointly accredited by the CAC and EAC of ABET.

3.1.1 Computer Science

Computer science spans a wide range of subdisciplines, from its theoretical and algorithmic foundations to cutting-edge developments in robotics, computer vision, intelligent systems, bioinformatics, and other exciting areas. We can think of the work of computer scientists as falling into three categories:

- They design and implement software. Computer scientists take on challenging programming jobs. They also supervise other programmers, keeping them aware of new approaches.
- They devise new ways to use computers. Progress in the CS areas of networking, database, and human-computer-interface enabled the development of the World Wide Web. CS researchers are working with scientists from other fields to make robots become practical and intelligent aides, to use databases to create new knowledge, and to use computers to help decipher the secrets of our DNA and protein functions.
- They develop effective ways to solve computing problems. For example, computer scientists develop the best possible ways to store information in databases, send data over networks, and display complex images. Their theoretical background allows them to determine the best performance possible, and their study of algorithms helps them to develop new approaches that provide better performance.

Computer science spans the range from theory through programming on system infrastructures, software development methodologies, applications, and computing architectures, as shown in Figure 1. Curricula that reflect this breadth are sometimes criticized for failing to prepare graduates for specific jobs. While other disciplines may produce graduates with more immediately relevant

[1] ACM-IEEE Computing Task Force: https://www.acm.org/articles/bulletins/2021/march/computing-curricula-2020-bulletin-educators
[2] CAC of ABET: https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-computing-programs-2022-2023/
[3] EAC of ABET: https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2022-2023/

job-related skills, computer science offers a comprehensive foundation that permits graduates to adapt to new technologies and new ideas over the long-range.

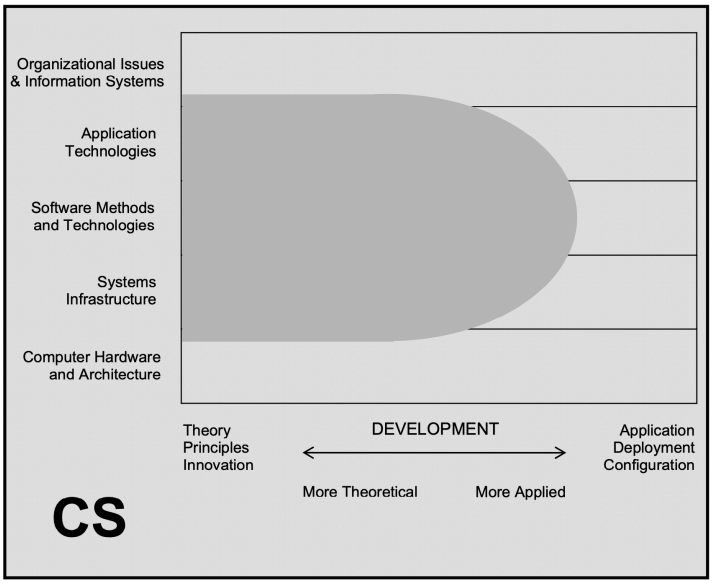


Figure 1: Computer Science Scope

3.1.2 Computer Engineering

Computer engineering (CE) brings together computing and electrical engineering in a way that embodies the science and technology of design, construction, implementation, and maintenance of software and hardware components of modern computing systems, computer-controlled equipment, and networks of intelligent devices. CE is the computing discipline that explicitly focuses on the development of hardware and software interface as a hardware embedded element of a computing system. CE graduates should have the ability to design computers, design computer-based systems, and design networks with additional specifications that design needs to exceed simple configuration and assembly. CE is specifically an engineering discipline where graduates must have a breadth of knowledge in mathematics and engineering sciences with a preparation for professional practice or graduate work in engineering. Many countries provide CE graduates the opportunity to become licensed professional engineers according to local governmental rules.

Computer engineering covers the range from theory and principles to the practical application of designing and implementing products using hardware and software, as shown in Figure 2. Among all other Computing disciplines, computer engineers must incorporate the most in-depth knowledge and understanding of aspects of the computing system closer to its hardware devices and their interoperation and management.

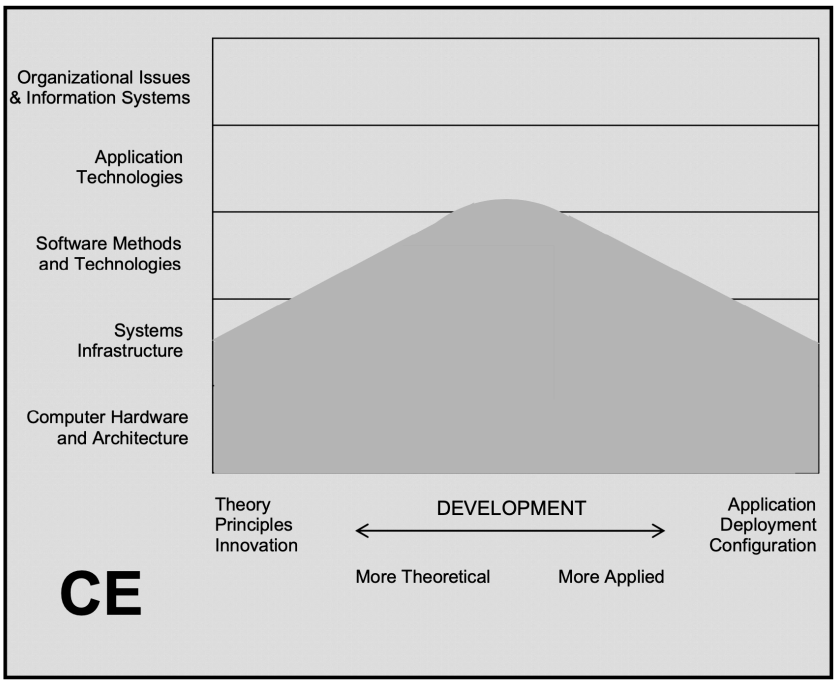


Figure 2: Computer Engineering Scope

3.1.3 Software Engineering

Software engineering (SE or SWE)[4] is an engineering discipline that focuses on the development and use of rigorous methods for designing and constructing software artifacts that will reliably perform specified tasks. The term "software engineer"—used to denote a profession—is much more broadly employed than "software engineering" as an academic discipline or a degree program. There are many more individuals with a job title or professional identity of a "software engineer" than those who have graduated from software engineering programs. Adding to the confusion, software engineering courses or software development courses are often a part of computer engineering and computer science academic programs.

Software engineering covers a wide rang of topics pertaining to the systematic development of software, as shown in Figure 3. This is because SE people fill a wide range of needs in large-project software expertise. SE's main goal is to develop systematic models and reliable techniques for producing high-quality software on time and within budget, and these concerns extend all the way from theory and principles to daily practice. The domain of SE also extends downward through systems infrastructure since SE people develop software infrastructure that is robust in operation. Its domain also extends upward into organizational issues because SE people are interested in designing and developing information systems that are appropriate to the client organization.

In summary, software engineering programs (SE) differ from computer science (CS) and computer engineering (CE) programs because they provide an in-depth focus on topics of software design

[4] The Software Engineering name is often abbreviated as either SE or SWE. There is no consensus on this. We will mostly use SWE in this document.

patterns, requirements analysis, software testing, software deployment, continuous integration, secure software development, and data engineering. These skills **are necessary to build complex mission-critical software systems**. As a result, **SE programs do not emphasize algorithm analysis, advanced data structures, operating systems, high-performance computing, bioinformatics, or foundational artificial intelligence as CS programs do**. Likewise, **SE programs do not emphasize digital design, computer architectures, computer networks, embedded systems, cyber-physical systems, and digital signal processing as CE programs do**.

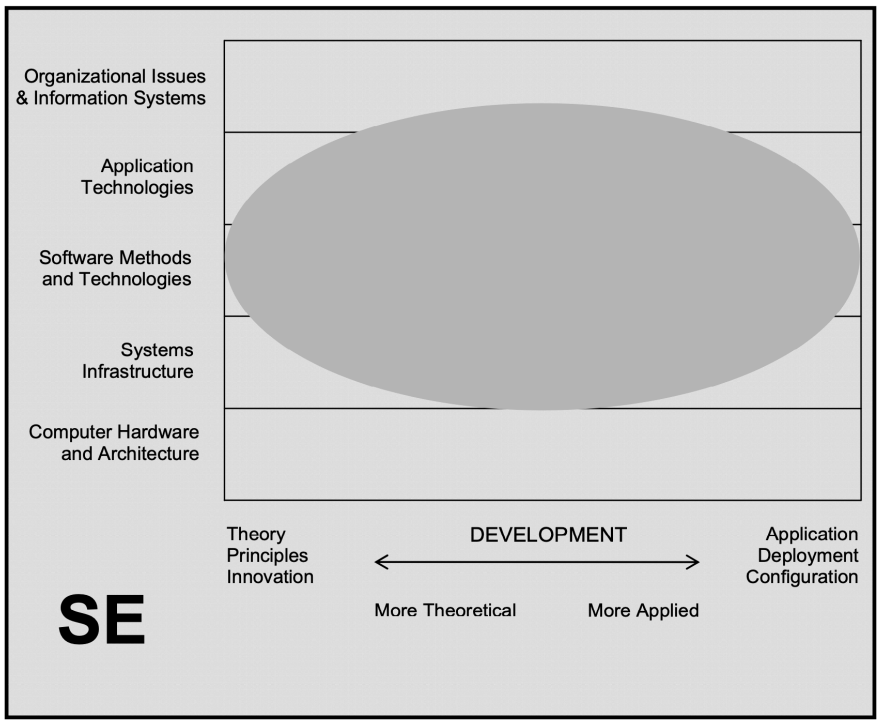


Figure 3: Software Engineering Scope

3.2 Academic Reasons for the Program

Currently, the University of Puerto Rico System **does not** offer any graduate program (MS o PhD) in Software Engineering. The Bachelor's Degree in Software Engineering (program code 0509) at UPRM is the **only** undergraduate Software Engineering degree at UPR and within the entire Puerto Rico Higher Education Jurisdiction. This degree is currently accredited by the Engineering Accreditation Commission (EAC) of ABET. But there are no graduate programs in Software Engineering in Puerto Rico. Hence the portfolio of academic programs in Software Engineering is **limited** and **incomplete**, hindering the **growth** and **impact** of this discipline in Puerto Rico's educational system.

An undergraduate degree in Software Engineering, Computer Science, or Computer Engineering provides a basis for software development, computing reasoning, and problem solving. However, the fast pace of development in the software industry and the continuous emergence of new technology and research results brings about a need to deepen and expand the knowledge and skills

of Software Engineering professionals beyond their baccalaureates. The number of undergraduate advanced technical elective courses is seldom enough to cope with the pace of software development advances, as evidenced by an increasing demand for professionals with post baccalaureate training in the job market. In fact, new areas of specialization keep emerging on the horizon, as do new training and certification programs. For example, DevOps (*acronym for Development and Operations*) is a relatively recent area that focuses on integrating software design, development, testing, deployment, and infrastructure management as a continuous integration process. This new area blurs the lines between production and testing environments, forcing companies to bring in more diverse developers and re-think how their teams build software systems that must always pass a set of test suites and immediately enter into production without breaking existing systems. DevOps is a direct result of the combination of technologies such as Cloud Computing, container technologies (e.g., Docker), distributed source control, and agile software development technologies. In turn, the application of DevOps ideas to Machine Learning (ML) systems directly led to the new, state-of-the-art field of MLOps, a new area focused on managing the software development, training, and deployment cycle for ML applications. Google defines MLOps[5] as "an ML *engineering culture and practice that aims at unifying ML system development (Dev) and ML system operation (Ops). Practicing MLOps means that you advocate for automation and monitoring at all steps of ML system construction, including integration, testing, releasing, deployment and infrastructure management*".

The demand to recruit engineers in these high-impact areas, such as Deep Learning, Edge Computing, DevOps, and MLOps has grown so quickly that it is very difficult to find formal courses on these topics in undergraduate Software Engineering programs. Industry and research organizations in the U.S. and abroad often rely on professional certifications and graduate programs to recruit professionals with these highly specialized skills.

This state of affairs represents an outstanding and unprecedented opportunity for the UPR system, and the UPRM College of Engineering in particular, to establish a state-of-the art graduate program in Software Engineering, especially since the undergraduate program has just received full ABET EAC accreditation to 2026, and has demonstrated a rapid and continuous growth since its establishment in 2015.

This proposal aims at fulfilling the needs in both fundamental and advanced Software Engineering education that our industrial and research constituents have constantly expressed, especially during the last few years. Even companies that traditionally hired students in areas directly related with their main non-software products - fuels (Chevron), cars (GM), air/space (L3Harris) - have shifted their focus to hiring software engineers in huge numbers. They consistently report to us that there are **just not enough** software engineers to fulfill the demand for years to come.

The Department of Computer Science and Engineering currently offers a variety of 5000-level courses in Software Engineering and in Computer Science and Engineering. Although these courses provide a solid base for further specialization, students can only fit a few of them in their undergraduate programs, and thus, they are seldom enough to achieve a well-rounded specialized professional profile. The Graduate Program in SWE is designed to fill this gap in our academic

[5] *MLOps: Continuous delivery and automation pipelines in machine learning* – URL: https://cloud.google.com/architecture/mlops-continuous-delivery-and-automation-pipelines-in-machine-learning

offerings in Software Engineering at UPRM, providing students the opportunity to deepen their knowledge and skills in the field and obtain an advanced degree that will warrant them higher salaries and significantly better avenues for long term career growth. The Master in SWE offers a compact curriculum constructed around advanced courses, which is targeted to provide a specialized professional profile in Software Engineering. In short, the Master in SWE aims at providing students with advanced knowledge in Software Engineering in areas of **program design, testing, maintenance, production deployment, monitoring, secure software engineering, software protection, and data engineering**.

The PhD in SWE in turn, builds on prior knowledge, education, and experience obtained in the baccalaureate degree and/or master in SWE degree. Consequently, the program initially **builds** upon coursework and then concentrates on seminars, independent study, and research in a focused area of interest aimed at developing an original contribution to the field. The work towards the PhD in SWE will train the student to read, understand, and criticize scientific publications. In addition, the student will learn how to formulate a research agenda that involves modeling, analysis, and experimentation with the goal of producing high-quality publications, software systems, prototypes, and other forms of intellectual property (e.g., patents, copyrighted software). The PhD in SWE aims at providing students with advanced knowledge in Software Engineering in areas of **program design, testing, maintenance, production deployment, monitoring, secure software engineering, software protection, and data engineering**. But it adds to these **the aims of producing a highly skilled professional with deep knowledge of state-of-the-art research directions in Software Engineering, an ability to effectively communicate research results with the scientific community, and a vision to conceptualize and propose innovative future research directions.**

3.3 R&D Reasons for the Program

Several federal agencies such as NSF, NIH, DoD, DOE, NASA, and NOAA have made Cloud Computing, Artificial Intelligence (AI), Software Security, and Big Data Analytics **major strategic priorities** for funding. Moreover, these agencies are looking at software solutions that are based on these priority areas and that can be quickly translated to production settings. These initiatives provide a unique opportunity for the Department of Computer Science and Engineering (CSE) at UPRM to secure external funding resources that can be used to help cover its operational expenses. Currently, the faculty of the CSE Department has been able to secure over $2.6M in external funding over the past five-to-six years. Notice, however, that these federal agencies evaluate each proposal in terms of the specific research environment at the proposing institution, and this aspect includes the **presence** of advanced graduate degrees in the discipline. The **lack** of a graduate degree in **Software Engineering hinders** our ability to compete for funding with other universities. Moreover, the lack of a graduate offering in Software Engineering limits the pool of properly **trained** graduate students, which are essential to execute R&D projects in these priority areas for these federal agencies. This situation poses the risk of limiting the ability of our CSE faculty members to grow and expand their research agendas to the benefit of our students, UPRM, and the People of Puerto Rico.

3.4 Discipline-specific Reasons for the Program

The driving force behind the explosive expansion of Software Engineering is an ever-increasing range of scientific, industrial, business, and service problems that demand new or better software solutions. Such solutions emerge from deep interplay between fundamental domain knowledge and insights that result in scientific and engineering breakthroughs. Engineering solutions that obey realistic technical, societal, and ethical constrains are a key requirement to bring these new software solutions to practice. As a consequence, finding new software-based solutions requires: a) a solid and well-balanced combination of engineering principles, b) technical, hands-on experiences in the discipline of Software Engineering, and c) an *in-depth knowledge* of domain-specific topics. However, such specialization is not easy to achieve within a baccalaureate program in Software Engineering, whose main goal is to provide **breadth of knowledge** to the students. Likewise, interdisciplinary and multidisciplinary programs (both graduate and undergraduate) are not an adequate vehicle for this specialization since the nature of these programs caters to **overlapping** issues between two or more disciplines. Hence, these interdisciplinary and multidisciplinary programs often provide only **basic working knowledge** of the underlying disciplines in order to understand and expand on the overlapping issues. In contrast, the Master's and Doctoral degrees being proposed here are focused on **in-depth treatment** of core and highly specialized areas within Software Engineering, without any compromise due to interdisciplinary/multidisciplinary constrains. These programs cater to students with solid backgrounds in Software Engineering, Computer Science and Engineering, and closely related fields.

3.5 Growth Opportunity for UPRM

Figure 4 (taken from the OPIMI Enrollment Dashboard[6]) shows the growth of the undergraduate Software Engineering Program at UPRM. As we can see from the figure, the program has made significant advances, and is in route to become a very popular undergraduate program at UPRM.

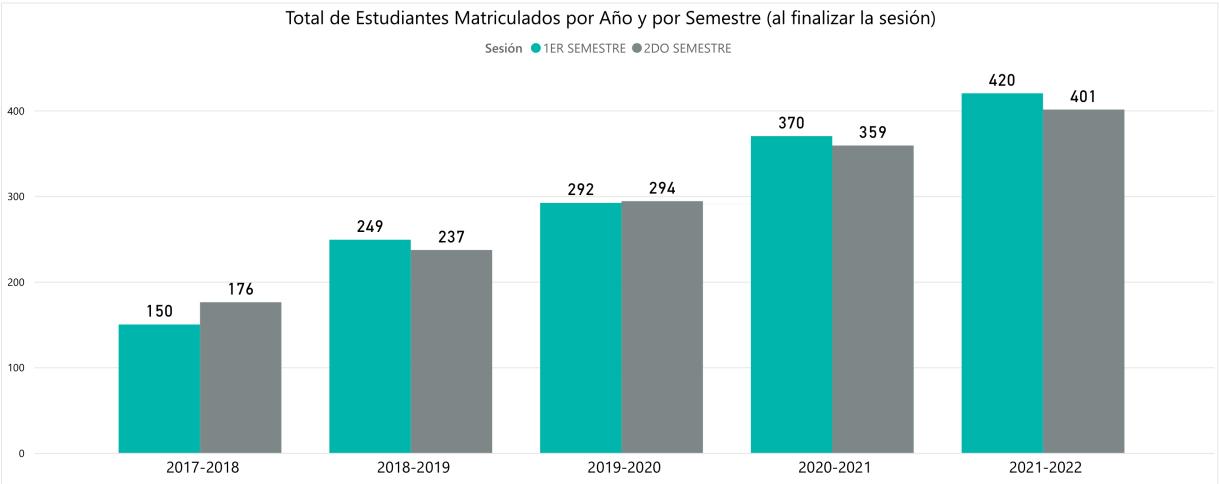


Figure 4: Software Engineering Student Enrollment

[6] UPRM OPIMI Enrollment Dashboard: https://oiip.uprm.edu/dashboards/

However, based on current demographical changes in Puerto Rico, there is a projection that fewer and fewer undergraduate students will be available for enrollment in the future. This situation is expected to cap further growth for UPRM at the undergraduate level. In contrast, an older, more mature population will dominate the workforce, and this untapped population represents an excellent opportunity for growth at the graduate level for UPRM.

The proposed MS/PhD Program in Software Engineering provides a unique opportunity for UPRM to augment its graduate student base by appealing to working professionals with undergraduate degrees in Software Engineering, Computer Science and Engineering, Computer Science, Computer Engineering and related fields. There is a great pool of these professionals in the San Juan Metropolitan Area, the Aguadilla Metropolitan Area, and the US Mainland. These professionals can (and should) be recruited for our Software Engineering Graduate Program. The fact that we can have hybrid and distance courses as part of the program, increases the likelihood that these working professionals will enroll in our program. We have conducted student surveys among our own undergraduate students and alumni (see section 3.6), showing a **strong interest** among respondents to pursue a graduate degree focused on Software Engineering.

3.6 Program Demand Survey

We conducted a survey on the interests of undergraduate students and alumni to pursue a graduate degree focused on Software Engineering. The survey ran from March 24, 2022 through April 7, 2022. A total of 96 responses were received from the survey, with students almost evenly divided by their year of study, as shown in Figure 5.

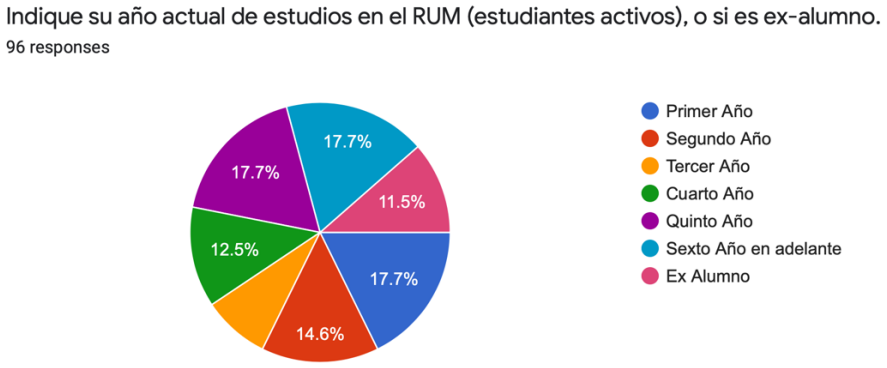


Figure 5: Survey Student Distribution

When we look at the details in Figure 6, we see that the vast majority of interest comes from students and alumni from the undergraduate Software Engineering program.

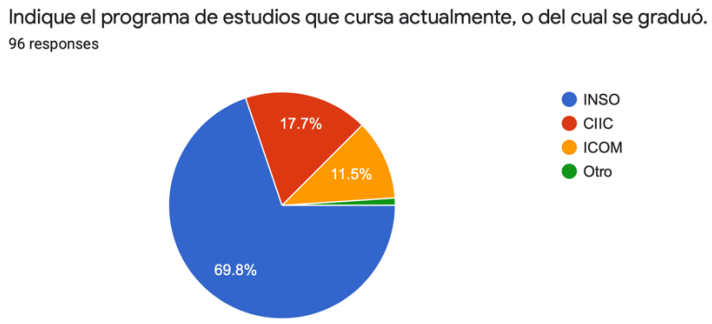


Figure 6: Survey Distribution by Program

Figure 7 shows the results for the first survey question: *Would you be interested in completing a master's degree in Software Engineering (INSO) at UPRM, with a duration of 2 years from your baccalaureate?* In this case, 49% of the responses were Yes, 44.8% were Maybe, and only 6.2% were No. This gives a universe of 93.8% of respondents that either a) want to enter the program at some point once it is established, or b) have some interest on it but are still undecided. Thus, there is overwhelming interest from the respondents on the MS SWE degree. Clearly, a proper promotional and recruitment plan is needed to capture as many individuals this student population.

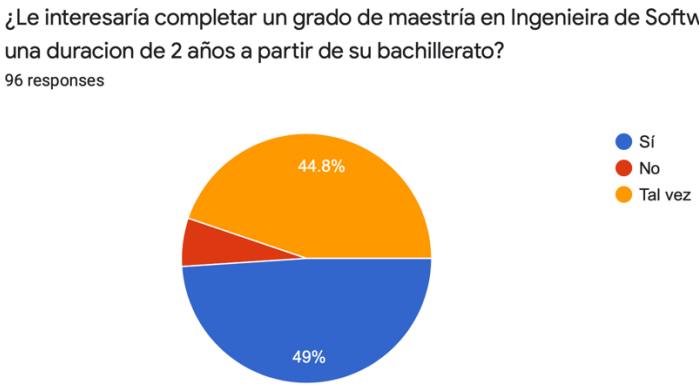


Figure 7: Interest in the MS in SWE Degree

The second survey question was: *How much can the fact that the proposed master's degree can be completed in only one (1) year influence your decision, if up to 9 credits of courses in Computing (CIIC or INSO) at level 5000 are validated from the baccalaureate*? Figure 8 show the results. We see that for 40.6 % of the respondents, this opportunity alone would make them apply to the program right away. Next, 56.3% of the respondents indicated that this opportunity would motivate them more to apply to the program. This population would need additional information before making their decision. Finally, a total of 3.1% of the respondents indicated that this opportunity has no influence in their decision: they will either come to the program, or do not regardless of

prior course work. From these results, we can see that bringing courses from their undergraduate program can be used as a tool to recruit these students.

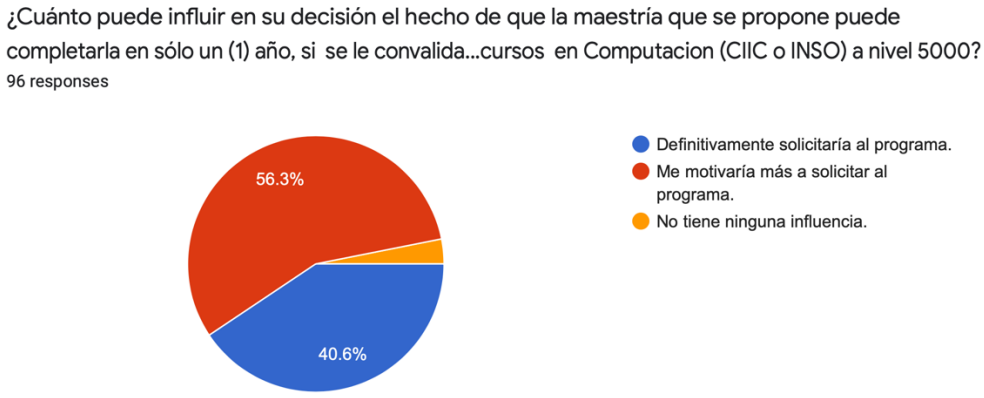


Figure 8: Influence of validating 9-credits from BS degree for MS

The third question of the survey was: *How much can the fact that the proposed master's degree can be completed by taking courses remotely influence your decision*? The results are shown in Figure 9 . We see that for 52.1 % of the respondents, this opportunity alone would make them apply to the program right away. Next, 34.4% of the respondents indicated that this opportunity would motivate them more to apply to the program. Finally, 13.5% of the respondents indicated that this opportunity had no influence in their decision: they will either come to the program, or do not regardless of course modality. Thus, having distance and hybrid courses can be used as a key enabler to recruit these students to the SWE MS Program. In fact, this option seems to be more powerful that the option of bringing courses from the undergraduate degree, since 52.1% see it as motivating factor.

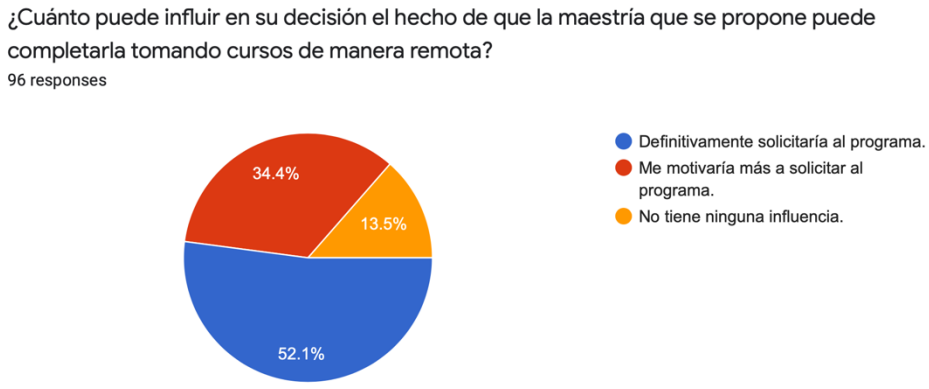


Figure 9: Influence of having remote courses for the MS degree

We now move to the questions related to the PhD in SWE. The questions are essentially the same, but this time the target degree was the PhD in SWE. The fourth question in the survey was: *Would*

you be interested in doing doctoral studies (Ph.D.) in Software Engineering at UPRM, with the possibility of completing the degree in only 4 years from your baccalaureate? The results are presented in ***Figure 10***. In this case, 30.2% of the responses said Yes, 40.6% were Maybe, and 29.2% were No. This gives a universe of 70.8% of respondents that either a) want to enter the program or b) have some interest on it but need additional information before making a decision. Thus, there is a majority of respondents showing interest in the PhD SWE degree. Notice that this is a long-term degree, and we can expect that interest in the program would not be as high as for the MS in SWE degree, the latter being a shorter degree. Nonetheless, there is a clear majority of students that have some interest in the program.

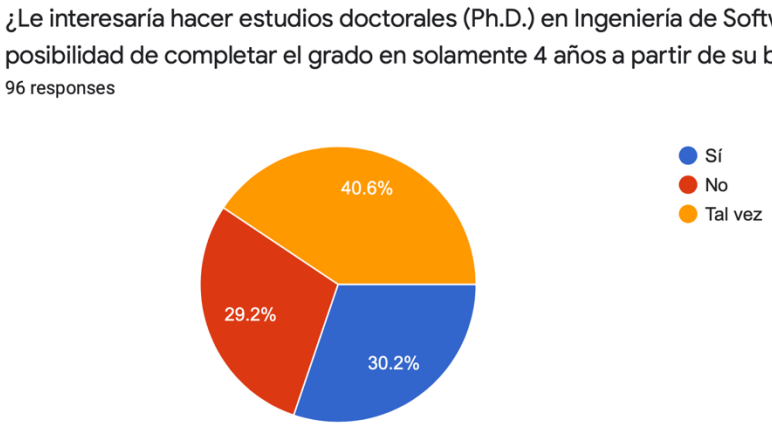


Figure 10: Interest in PhD in SWE Degree

The firth survey question was: *How much can the fact that the proposed doctorate can be completed in 3 years influence your decision, if up to 9 credits of courses in Computing (CIIC or INSO) at level 5000 are validated from the baccalaureate?* Figure 11 show the results. We see that for 20.8 % of the respondents, this opportunity alone would make them apply to the program right away. Next, 58.3% of the respondents indicated that this opportunity would motivate them more to apply to the program. Finally, 20.8% of the respondents indicated that this opportunity had no influence in their decision: they will either come to the program, or do not regardless of prior course work. Thus, bringing course from their undergraduate program can be used as tool to recruit these students. Also, notice that there appear to be a 20-29% of students who simply are not interested in a PhD degree. Again, this is to be expected given the long-term nature of the program.

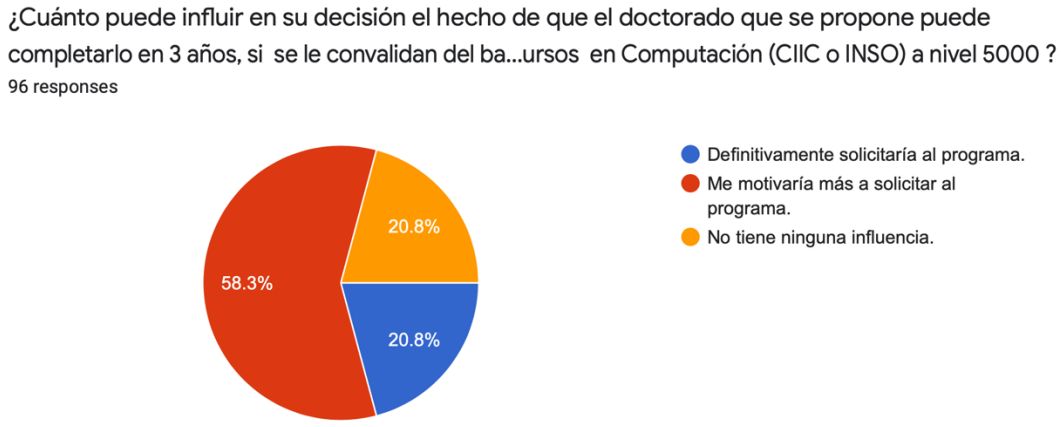


Figure 11: Influence of validating 9-credits from BS degree for PhD

The sixth and final question of the survey was: *How much can your decision be influenced by the fact that the proposed doctorate can be completed by taking courses remotely?* The results are shown in Figure 12. We see that for 43.7.1 % of the respondents, this opportunity alone would make them apply to the program right away. Next, 30.2% of the respondents indicated that this opportunity would motivate them more to apply to the program. Finally, 26% of the respondents indicated that this opportunity had no influence in their decision: they will either come to the program, or do not regardless of course modality. Thus, having distance and hybrid courses can be used as a tool to recruit these students.

In summary the survey shows the following:

1. A clear majority of students are interested in the Graduate Program in SWE.
2. As expected, the MS in SWE has more appeal to students. A total of 93.8% of respondents have interest in the MS in SWE, and 70.8% of respondents have interest in the PhD in SWE. Again, this is to be expected given the long-term nature of the PhD program.
3. Validating undergraduate courses, and having remote graduate courses provide a strong influence to recruit students into the program. Of these two elements, remote graduate courses appear to have stronger influence.

Thus, the proposed graduate program in SWE should have sufficient interest to attract students into the program, particularly those that wish to take as many courses as possible in the hybrid or distance modalities.

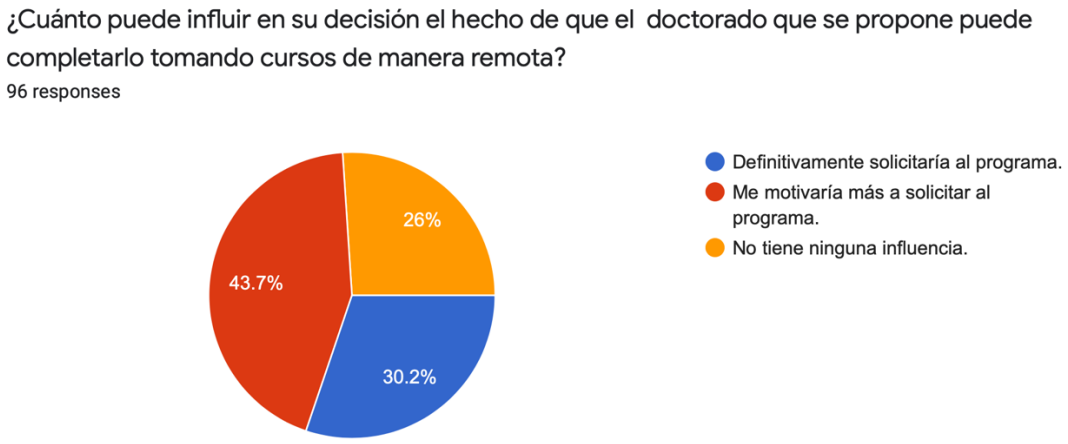


Figure 12: Influence of having remote course in the PhD

3.7 Employment Opportunities for the Graduates of the Program

The salaries for software engineers, computer engineers, and computer scientists are amongst the highest in the U.S. job market. This is shown Table 1 below. These technology professionals come from what are often called *Computing fields*. The infusion of Computing technology in just about every aspect of modern society has brought about unprecedented demands for qualified *computer and information science scientists* (CISS). CISS is a term coined by the USA Bureau of Labor Statistics (BLS) to refer to "…*research scientists that invent and design new approaches to computing technology and find innovative uses for existing technology. They study and solve complex problems in computing for business, medicine, science, and other fields*." Thus, CISS is an **umbrella** term used to classify workers that fall within the realm of Software Engineering, Computer Engineering, or Computer Science. The 2019 BLS report[7] provides the next indicators on the status of employment demand for several CISS professionals:

Table 1: Average wages of computing professionals holding a bachelor's degree

Specialty	Wage ($)
Computer Network Architects	109,020
Computer Programmers	84,280
Computer Systems Analysts	88,740
Information Security Analysts	95,510
Network and Computer Systems Administrators	82,050
Software Developers	105,590

Highlights of the report:

[7] Url: https://www.bls.gov/ooh/computer-and-information-technology/home.htm

- Software Engineering professionals typically occupy Software Developers and Computer Programmers specialties. The salaries range from $84,280 to $105, 590 for professionals with an undergraduate degree.
- Demand for these workers will grow from greater emphasis on cloud computing, the collection and storage of big data, and information security.
- The projected percent change in employment from 2018 to 2028 is 12%. The average growth rate for all occupations is 7 % .
- The projected numeric change in employment from 2018 to 2028 is 546,200.
- Overall, the median wage of the workers in the occupation is $**86,320**.
- According to Table 1, the average salary of the workers in the occupation that hold a bachelor's degree without a master is $**94,198 .**
- The median annual wage for all USA workers in 2018 was $**38,640.**

The same publication reports that a CISS professionals holding a **Master's degree** have an average wage of $**118,370**, which is about 21% higher income for these professionals.

The MS in SWE is aligned with the CISS profile description for Software Developers and Computer Programmers, adding more **advanced skills** to prepare them to *invent and design new approaches to computing technology*. As a continuation degree, the PhD in SWE adds to this profile an ability to *conduct scientific research and highly innovative projects at the frontier of software engineering and technology*. This increases the possibilities of doctorates in SWE to start a research-based company or pursue a career in academia. Several large-scale software industries, and a significant number of industry research laboratories, especially those in which advanced levels of knowledge are required to oversee innovative team projects, require workers holding a doctoral degree. For example, according to web site payscale.com[8], the average salary of a professional with a PhD in a Computing-related field is **$121,000** per year. Some companies, such as Google, often pay up to $273,000 to these professionals. Another important impact of the proposed graduate program is entrepreneurship. The Graduate Program in SWE capacitates professionals to start entrepreneurial ventures through SBIR's or similar federal grants, or partnership ventures with the Puerto Rican Science and Technology Trust. This can have a profound positive effect on the Puerto Rican labor market and economy by creating local technology companies in Puerto Rico that export their products and services worldwide.

[8] Url: https://www.payscale.com/research/US/Degree=Doctorate_(PhD)%2C_Computer_Science_(CS)/Salary

4 Relation with the Strategic Plan of the University of Puerto Rico and with Other Programs in Puerto Rico

4.1 Relation with the Strategic Plan of the University of Puerto Rico

The proposed Graduate Program in SWE is aligned with at least three *Strategic Matters* in the Strategic Plan 2017-2022 of the University of Puerto Rico as approved by the UPR Governing Board. These are discussed below.

4.1.1 Educational Environment: Aims 1, 2, and 3

The program will contribute to "*Enrich the academic offer with differentiated and competitive relevant programs through different modalities that respond to the evolution and requirement of the disciplines, the professions and the labor market* […]," as expressed in the first aim of this strategic matter. Also, the program is expected to "*Attract a diverse student population and retain it through an innovative university experience that facilitates its transition to graduate studies, insertion in the labor market and entrepreneurship,*" as stated in the second aim of this strategic matter. Finally, the program will also contribute to "*Promote the UPR as a competitive option for learning and global projection for students, faculty, researchers, the Puerto Rican diaspora and the international context;*" which is the third aim in this strategic matter.

4.1.2 Research and Creation: Aims 1 and 2

As a graduate program in Software Engineering, the program will "*Develop new knowledge through research and creation* […]" to a MS or PhD level, while "[…] *making the best use of human and fiscal resources, and technologies of the UPR system*;" as envisioned in aim 1 of this strategic matter. Also, as a graduate program focused on engineering research, the Graduate Program in SWE will serve as a means to "*Increase the search and obtain external funds for research and creation*," as stated in aim 2 of this strategic matter.

4.1.3 Technology Culture: Aim 1

Aim 1 of this strategic matter says, "*Develop and offer undergraduate, graduate and professional distance academic programs that meet the educational needs and opportunities in Puerto Rico and internationally.*" The Graduate Program in SWE is designed to use state-of-the-art software development infrastructures for production settings, with some courses being delivered as hybrid or distance courses. This makes the program tailored to a diverse student population, including **working professionals** seeking to accommodate graduate courses within their work schedule.

4.2 Relation with the Strategic Plan of the University of Puerto Rico at Mayagüez

The proposed Graduate Program in SWE is aligned with at least four *Strategic Aims* in the Strategic Plan 2012-2022 of the University of Puerto Rico at Mayagüez. These are discussed below.

4.2.1 *Aim 2:* Be at the forefront of higher education in Puerto Rico ensuring that our students receive the best education

As discussed in Section 3.1 of this document, the University of Puerto Rico does not offer any graduate program (MS or PhD) in Software Engineering. Additionally, as stated in the same section, the fast pace of innovation in the field brings about a need to educate software engineering professionals beyond baccalaureates. Thus, the proposed program is aligned with the statement of "[*Having*] *curricula and programs that integrate the most recent advancements in the different areas of knowledge*;" which is one of the elements of this Aim in the UPRM Strategic Plan.

4.2.2 *Aim 3*: Increase and diversify the sources of income of the Institution

The SWE Graduate Program provides the opportunity for UPRM to expand its graduate student population and bring additional income via tuition fees. Any expansion in the offer of graduate programs widens and strengthens the possibilities of the Institution for obtaining external funds for research. As with other graduate programs, the institution will receive the indirect costs, the equipment, and a fraction of the time purchases resulting from research proposals associated with this program. In particular, the program will proactively "*disseminate among undergraduate and graduate students, opportunities for scholarships and assistantships funding from external sources*," which is one of the strategies identified to achieve this aim, in the UPRM Strategic Plan.

4.2.3 *Aim 5*: Strengthen research and competitive creative work;

The Graduate Program in SWE, by its nature, will "*provide the support and resources necessary for the creative and research work to be carried out efficiently,*" which is identified in the UPRM Strategic Plan as the first strategy towards this Aim. Also, as already mentioned in subsection 4.2.2. being a graduate program, it is expected to "*increase external funds for research and creative work that provide income to the Campus, stimulating in turn the obtaining of income for researchers*;" which is the second strategy towards this Aim, in UPRM Strategic Plan.

4.2.4 *Aim 6*: Impact our Puerto Rican society

The Department of Computer Science and Engineering regards the Graduate Program in SWE as an important addition to its efforts to

1. "*Promote the use of the expertise of our university community to meet the needs of the Campus and the country;"*

2. *"Promote, develop and facilitate research focused on the application and marketing of results to meet the needs of the country;" and*

5. *"Promote a business and leadership mentality among our students in all areas of knowledge;"*

which are identified as Strategies 1, 2 and 5 for the achievement of Aim 6 in the UPRM Strategic Plan.

4.3 Relation with Established Programs in Puerto Rico

4.3.1 Graduate Programs within the University of Puerto Rico at Mayagüez (UPRM)

Currently there are **no** graduate programs in Software Engineering, neither at UPRM nor at any other UPR Campus.

4.3.1.1 Master's Programs

The Department of Electrical and Computer Engineering has been offering a Master in Computer Engineering (MS CpE) since the mid-nineties. The program was developed mainly to offer students with diverse undergraduate degrees in Computing-related fields the opportunity to obtain an advanced degree in Computer Engineering. The program has and continues to serve our students well and it has contributed to the expansion of course offerings in particular in Computer Science and software-related fields. This expansion resulted in the establishment of new undergraduate programs in Computer Science and Engineering, and Software Engineering in 2015 and the creation of a new Department of Computer Science and Engineering in 2016 to administer the new programs and offer all software-related courses. Today these two new programs have received full ABET accreditation, serve over 600 undergraduate students and continue to grow steadily. The natural consequence of these new developments is the opportunity to offer our students a graduate program specifically focused on Software Engineering that will complement the Master in Computer Engineering. We have conducted student surveys among our own undergraduate students and alumni (see section 3.6) showing a strong interest among respondents to pursue a graduate degree focused on Software Engineering. Both departments shall collaborate to make all relevant courses available to each other's students and to make the most efficient use of their resources.

The Master program in Scientific Computing offered by the Department of Mathematics of the University of Puerto Rico in Mayaguez concentrates on mathematical and statistical methods for the computer solution of scientific problems, an aspect that is not emphasized in the Master in SWE program. Students enrolled in the Master of SWE may take courses in the Master in Scientific Computing as courses outside the specialty.

4.3.1.2 PhD Programs

UPRM began offering a multidisciplinary PhD in Computer and Information Sciences and Engineering (CISE) in 2001 with two specialty areas: Computer Science and Engineering, and Scientific Computing. The CISE program is jointly administered by a joint CISE Graduate Committee with members from the Departments of Mathematical Sciences (College of Arts and Sciences) and Computer Science and Engineering (College of Engineering). It was originally designed to serve students with diverse backgrounds such as Computer Science, Scientific Computing, Mathematics, Statistics, Computational Mathematics, Information Systems, among

others. As a consequence, the three core course requirements are intended to level all incoming students with fundamental knowledge in Computer Architecture, Algorithms, and Computability. Such knowledge is often obtained in undergraduate programs such as the recently (2015) created BS programs in 1) Computer Science and Engineering, and 2) Software Engineering at the UPRM College of Engineering. As the demand for these new programs continues to grow, the need for a focused graduate (MS/PhD) program in Software Engineering has become evident as clearly demonstrated by surveys conducted among our undergraduate students (see section 3.6).

The newly proposed graduate program in Software Engineering includes core courses which are truly graduate in nature and thus require mastery of the corresponding topics at the level of an undergraduate program in Software Engineering, or in Computer Science and Engineering. Students of the proposed graduate program in SWE will have the opportunity to quickly dive into graduate-level studies and research which will enable them to make more significant contributions and achieve a more profound mastery of the discipline. The UPRM will enhance its mission by supplying industry and academia with much needed graduates ready to take on leading roles in Software Engineering research and development. All new and existing courses in Software Engineering will become available and further nurture the development of the CISE program which will remain an option for students with more diverse backgrounds. The Graduate Committee of the proposed Graduate Software Engineering Program will be formed by faculty appointed to the Department of Computer Science and Engineering and will operate independently from the Graduate Committee for the CISE program, as specified in Certification 09-09. The CSE Department assumed the administration of the CISE PhD Program, and will continue to collaborate with the Department of Mathematical Sciences to support the program.

4.3.2 Graduate programs in other units of the University of Puerto Rico

Currently, there is **no** graduate program in Software Engineering within the UPR system.

The University of Puerto Rico, Río Piedras campus (UPRRP) has recently been approved to offer a graduate program (MS/PhD) in Computer Science and began recruiting students for the MS degree in 2022. The program follows up on their undergraduate BS program in Computer Science, which was established in early 2000's and has been fully accredited by the Computing Accreditation Commission (CAC) of ABET. This 4-year undergraduate CS program is not considered an engineering program, and therefore does not have the general engineering requirements that UPRM programs have and offers an alternative for students who do not wish to pursue an engineering degree.

The UPRRP graduate CS program includes core courses in four traditional CS areas: Algorithms, Programming Languages, Computing Systems, and Computing Applications. The newly proposed graduate program in SWE will be focused on and will include graduate-level core courses and advanced electives in Software Engineering which do not exist at the UPR Río Piedras CS Program. All UPRM SWE graduate courses will be available remotely which will offer an opportunity for stronger collaboration and resource sharing with the graduate CS program at UPR Río Piedras. The UPRM CSE Department looks forward and will encourage all such collaborations.

4.3.3 Graduate programs in other universities in Puerto Rico

The Polytechnic University of Puerto Rico offers a Master of Computer Engineering. This program concentrates in Communication Systems and Digital Signal Processing. Thus, there is no relation between this program and the proposed Master in SWE.

The Inter American University of Puerto Rico offers a Masters of Open Information Systems. This program concentrates on the application of information technology products for business administration. This is mostly a professional Master's degree and has no relation with the proposed Master in SWE program.

Ana G. Méndez University offers a Master of Networking. This is a professional master's that concentrates on maintenance aspects of computer networks. Thus, there is no relation between this program and the proposed Master in SWE.

4.3.4 Undergraduate programs in computing and information technologies

The proposed graduate program in SWE will serve alumni from several related undergraduate programs available both within the UPR system and at other higher education institutions in Puerto Rico. This section summarizes these potential source programs.

The Department of Computer Science and Engineering of the University of Puerto Rico at Mayaguez offers a Baccalaureate in Computer Science and Engineering (CIIC), and a Baccalaureate in Software Engineering (INSO). Students from these programs can enter the SWE Graduate Program with no deficiencies. Moreover, with the possibility of using 9 credits of 5000-level courses and 6 credits of 6000-level courses, all taken during their bachelor's program, t**hese students could complete the MS in SWE in one year**.

The Department of Electrical and Computer Engineering offers a baccalaureate in Computer Engineering. Graduates from this program can enter the SWE Graduate Program with some deficiencies.

The Department of Computer Science of the UPR at Rio Piedras offers a baccalaureate in Computer Science. Graduates from this program can enter the SWE Graduate Program with some deficiencies.

The Department of Mathematics of the UPR at Mayaguez offers a Baccalaureate in Computer Science. Graduates from this program can enter the SWE Graduate Program with some deficiencies.

The Department of Computer Science of the University of Puerto Rico at Arecibo offers a baccalaureate in Computer Science. Graduates from this program can enter the SWE Graduate Program with some deficiencies.

The Department of Computer Science of the University of Puerto Rico at Bayamón offers a baccalaureate in Computer Science. Graduates from this program can enter the SWE Graduate Program with some deficiencies.

The Department of Mathematics of the University of Puerto Rico at Humacao offers a baccalaureate in Computational Mathematics. Graduates from this program can enter the SWE Graduate Program with some deficiencies.

The College of Business Administration of the UPR at Mayaguez offers an option in Computerized Information Systems within its baccalaureate in Business Administration. Graduates from this program can enter the SWE Graduate Program with some deficiencies.

5 Conceptual Description of the Program

5.1 Mission

The mission of the **Graduate Program in Software Engineering** is to prepare highly skilled software engineering professionals that are capable of building complex mission-critical software systems and/or conducting research to create new, state-of-the-art software technologies that solve science, business, engineering, and technology challenges faced by our society, while observing the highest ethical standards and appropriate engineering practices.

5.2 Aims of the Graduate Program in SWE

At the end of the first five-year cycle, the program should have completed the following aims**:**

5.2.1 **Aim 1:** Have a sustained average enrollment of at least forty-five (45) students per year, distributed as follows: a) 20 PhD students, and b) 25 MS/ME students;

5.2.2 **Aim 2:** Maintain a retention and graduation rate consistent with the length of the program: 1) 50% students finish the MS degree within two (2) years, and 50% of PhD students finish the PhD withing four (4) years;

5.2.3 **Aim 3:** Sustain a network of external collaborators from the software engineering industry, academia, and government with at least ten (10) collaborators per year;

5.2.4 **Aim 4:** Exhibit at least four (4) thesis or projects of recognized impact on scientific or industrial environments by having a related peer-reviewed publication;

5.2.5 **Aim 5**: Sustain a portfolio of externally funded research projects that directly support the students with at least 50% of faculty members participating in external projects;

5.2.6 **Aim 6:** Have in place an effective assessment and communication system with at least 75% faculty participation in the system;

5.3 Objectives of the Graduate Program in SWE

The SWE seeks to produce professionals with advanced knowledge in Software Engineering in areas of program design, testing, maintenance, production deployment, monitoring, secure software engineering, software protection, and data engineering. Graduates from the program shall be able to:

1. Excel in the execution of research projects, making original contributions to the field and securing external funding or investments for their institution.
2. Lead the development of complex mission-critical software systems.
3. Contribute to the advancement of society through the ethical applications of their knowledge and skills.
4. Demonstrate professional competence, leadership, and entrepreneurial spirit to excel in the practice of their profession.
5. Effectively participate and contribute in global markets.

6. Pursue advanced studies, continued education, and be involved in professional societies to succeed in a constantly evolving field.

5.4 Graduated Profile of SWE Students

The educational objectives are contained in the Graduate Profiles for each degree type.

5.4.1 Masters in SWE Graduate Profile

The graduates of the Master in Software Engineering shall have:

1) an ability to apply advanced software engineering techniques to design, implement, test, deploy, and monitor complex mission-critical software systems comprised of multiple software components that are possibly operating from different computer nodes in a networked environment;
2) an ability to apply secure software engineering techniques to create software tools to detect vulnerabilities and threats in software deployment systems, and to apply techniques for secure software development in various complex applications domains;
3) an ability to apply advanced data engineering techniques to build scalable, highly-available, fault-tolerant, secure, and extensible data management solutions in support of complex software solutions;
4) an ability to acquire and apply advanced, domain-specific knowledge in computing and software engineering to develop novel software systems and applications;
5) an ability to work in groups to develop a complete and functional software solutions to business, science, engineering, or technological problems, including state-of-there-art research problems;
6) an ability to recognize ethical and social responsibilities related with the software engineering field, and used them to make appropriate, and informed decisions;
7) an ability to communicate fluently and effectively with a wide range of audiences;

To simplify cross referencing these outcomes, particularly in Section 6 – Curricular Design, we provide a mapping between the outcome and a short name in Table 2 below.

Table 2: Mapping Master's Outcomes to Short, Descriptive Names

Outcome Number	Outcome short name
1)	Software Engineering skills
2)	Secure Software Engineering skills
3)	Data Engineering skills
4)	Domain-specific application skills
5)	Teamwork skills
6)	Ethical and Societal skills
7)	Communication skills

5.4.2 Doctor of Philosophy in SWE Graduate Profile

The graduates of the Doctor of Philosophy in Software Engineering shall have:

1) an ability to apply advanced software engineering techniques to design, implement, test, deploy, and monitor complex mission-critical software systems comprised of multiple software components that are possibly operating from different computer nodes in a networked environment;
2) an ability to apply secure software engineering techniques to create software tools to detect vulnerabilities and threats in software deployment systems, and to apply techniques for secure software development in various applications domains;
3) an ability to apply advanced data engineering techniques to build scalable, highly-available, fault-tolerant, secure, and extensible data management solutions in support of complex software solutions;
4) an ability to acquire and apply advanced, domain-specific knowledge in computing and software engineering to develop novel software systems and applications;
5) an ability to work in groups to develop a complete and functional software solutions to business, science, engineering, or technological problems, including state-of-there-art research problems;
6) an ability to recognize ethical and social responsibilities related with the software engineering field, and used them to make appropriate, and informed decisions;
7) an ability to conduct a discrete, specified, circumscribed research project within the software engineering field;
8) an ability to conceptualize and propose innovative future research directions to the scientific community and to funding agencies;
9) an ability to review, and prepare scientific publications, and research proposals, identifying their contributions, strengths, limitations, and applicability to specific software engineering problems;
10) an ability to effectively communicate research results to a wide range of audiences by means of peer-reviewed scientific articles, technical presentations, or technology forums;

To simplify cross referencing these outcomes, particularly in Section 6 – Curricular Design, we provide a mapping between the outcome and a short name in **Table 3**.

Table 3: Mapping Doctoral Outcomes to Short, Descriptive Names

Outcome Number	Outcome short name
1)	Software Engineering skills
2)	Secure Software Engineering skills
3)	Data Engineering skills
4)	Domain-specific skills
5)	Teamwork skills
6)	Ethical and Societal skills
7)	Research skills
8)	Research Vision skills
9)	Peer Review skills
10)	Communication skills

5.5 Philosophy

It is the philosophy of the Graduate Program in Software Engineering that the discipline of software engineering is a key enabler for economic growth, improved quality of life, and social mobility for the People of Puerto Rico. Thus, the Graduate Program in Software Engineering aims at serving as an effective vehicle for technical skills development, lifelong learning and continual growth, and as such, it pursues to create and maintain an atmosphere of creative discussion and openness to new ideas and points of view. Through lectures, seminars, class projects, and research experiences the program seeks to help students develop their full potential as agents of innovation in Software Engineering endeavors. Thus, along with technical graduate coursework, the program also seeks to provide an environment for supporting critical thinking, innovation, entrepreneurship, diversity, ethical conduct, best-in class engineering practices, and effective communication skills.

5.6 Coherence and Sufficiency

5.6.1 Masters in SWE Graduate Profile Coherence and Sufficiency

Master's Graduate Profile Outcomes 1-3 are achieved with the breadth and depth of knowledge derived from SWE core courses. Outcome 4 is achieved with the SWE technical electives, thesis/project work, and the courses outside the SWE Program. Outcome 5 is naturally obtained through the class projects done as part of the SWE core courses and electives. Outcomes 6 and 7 come from the work on the Master's thesis, Master's project, and class projects conducted by the student. This matter is further discussed in section 6.3.1.

5.6.2 Doctor of Philosophy in SWE Graduate Profile Coherence and Sufficiency

Doctoral Outcomes 1-3 are achieved with the breadth and depth of knowledge derived from SWE core courses. Outcome 4 is achieved with the SWE technical electives, thesis/project work, and the courses outside the SWE Program. Outcome 5 is naturally obtained through the class projects done as part of the SWE core courses and electives. Outcome 6 comes from the work on the Doctoral dissertation, seminars, and class projects conducted by the student. Outcome 7 is the direct result from the Doctoral dissertation work. Outcome 8 is achieved through the advanced topics course, the research seminar, the doctoral dissertation work, the Qualifier Exam, the Candidacy Exam, and the Dissertation Defense. Outcome 9 results from the doctoral dissertation work, research seminar, the Candidacy Exam, and the requirement for a peer-reviewed publication. Outcome 10 results from the doctoral dissertation work, research seminar, the Qualifier Exam, the Candidacy Exam, the Dissertation Defense, and the requirement for a peer-reviewed publication. This matter is further discussed in section 6.3.2.

6 Curricular Design

6.1 Components and Balance of the Graduate SWE Program

The Graduate Program in Software Engineering consists of core SWE courses, elective SWE courses, courses outside the Program, Master's Thesis or Master's Project for students enrolled in MS Plan I or II, seminars, and Doctoral Dissertation courses for PhD students. These components are designed to fulfil the graduate profile, provide breadth and depth, and balance practical experience with technical content. In the next sections, we present descriptions of these components.

6.1.1 Master in Software Engineering Degree Components

The Master's degree options (Plan I, Plan II, and Plan III) consist of a total of **thirty** (30) credits, and their duration is two (2) years from having obtained a baccalaureate degree. The following table shows the breakdown of courses and credits.

Table 4: Master's Degree Components

Component	Credits
SWE Core Courses	9
SWE Elective Courses	9
Courses outside the SWE Program	6
Master's Thesis (Plan I), Master's Project (Plan II), or additional SWE Elective Courses (Plan III)	6
Total Credits	**30**

6.1.2 Doctor of Philosophy Engineering Degree Components

The Doctor in Philosophy degree consists of a total of **fifty-four** (54) credits, and its duration is four (4) years from having obtained a baccalaureate, or two (2) from having obtained a Master in Software Engineering at UPRM. The following table shows the breakdown of courses and credits.

Table 5: Doctor of Philosophy Degree Components

Component	Credits
SWE Core Courses	9
SWE Elective Courses	15
Courses outside the SWE Program	6
SWE Advanced Topics	3
Doctoral Seminar	3
Doctoral Dissertation Research	18
Total Credits	**54**

In addition to these courses, students in the PhD in SWE **must complete** the following:

1) **Qualifier exam** – a special exam used to judge the ability and readiness of the student to conduct research.
2) **Candidacy exam** – a special exam used to evaluate the progress of the research effort being conducted by the student.
3) **Peer-reviewed publication** – an original scientific peer-reviewed publication written by the student and directly related with his/her research.
4) **Dissertation exam** – the final special exam used to evaluate the student's final research effort.

6.1.3 Software Engineering Core courses

All students in the Graduate Program in SWE must take t**hree** (3) core courses. The initial set of core courses is shown in Table 6.

Table 6: Core courses of the SWE Program

Course	Course Title
INSO 6005	Software Engineering Principles
INSO 6006	Database Systems Engineering
INSO 6007	Secure Software Systems

These courses are:

1) **INSO 6005 – Software Engineering Principles**: This course prepares students to use modern techniques to design, implement, test, deploy, and monitor complex, multi-layer software systems for production use in networked environments.

2) **INSO 6006 – Database Systems Engineering**: This course prepares students to apply advanced data engineering techniques to build scalable, highly-available, fault-tolerant, secure, and extensible data management solutions.
3) **INSO 6007 – Secure Software Systems**: This course prepares students to apply secure software engineering techniques to build secure software applications, secure Application Programming Interfaces (APIs), and software tools to detect vulnerabilities and threats in deployed software systems.

The CSE Department will **maintain, update,** and **publish** a list of all graduate SWE core and elective courses as needed. Changes will be done with the **approval** of the CSE Departmental faculty in a duly convened meeting. Any changes will apply prospectively to students in the program. Changes will be informed to the Dean of Engineering, the UPRM Director of Graduate Studies, the UPRM Dean of Academic Affairs, and published on the Department's web page.

6.1.4 Software Engineering Elective Courses

The elective courses provide advanced, domain-specific knowledge in various software engineering and related computing topics. They complement the core courses by exposing students to novel technologies such as DevOps, MLOps, Medical Applications, Cloud Computing, Machine Learning, and Big Data Analytics, to name a few. Table 7 shows the **initial** list of graduate SWE elective courses.

Table 7: Graduate Level SWE Technical Electives

Course Level	Course Title
INSO 6010	Development and Operations (DevOps)
INSO 6015	Machine Learning and Operations (MLOps)
INSO 6030	Web and Mobile Applications Engineering
INSO 6040	Health-related Applications Engineering
INSO 6050	Software Engineering for Edge Systems
INSO 6070	Software-Defined Networks Engineering
INSO 6080	Deep Learning Engineering

In addition, the following existing 5000-level courses (see Table 8) shall be **initially** accepted as 5000-level technical electives, up to **nine** (9) credits, as specified by Certification 09-09 of the UPRM Academic Senate:

Table 8: Undergraduate, 5000-level Acceptable Technical Electives

Course Level	Course Title
INSO 5111	Introduction to Human Computer Interaction
INSO 5118	Software Engineering Project Management
CIIC 5015	Artificial Intelligence
CIIC 5019	High Performance Computing
CIIC 5029	Compilers Development
CIIC 5120	Virtual Machines
CIIC 5130	Cloud Computing Infrastructures
CIIC 5140	Big Data Analytics
CIIC 5150	Machine Learning Algorithms

The CSE Department will **maintain, update,** and **publish** the complete list of all graduate SWE elective courses (including any 5000-level courses) as needed. Changes will be done with the **approval** of the CSE Departmental faculty in a duly convened meeting. Any changes will apply prospectively to students in the program. Changes will be informed to the Dean of Engineering, the UPRM Director of Graduate Studies, the UPRM Dean of Academic Affairs, and published on the Department's web page.

NOTE: Individual technical elective courses will be scheduled for offer once per year, on a rotation basis of two to three years. This is done to ensure diversity in the academic offer and match the faculty resources available to teach them.

6.1.5 Software Engineering Advanced Topics Course

The Advanced Topics in Software Engineering course (see Table 9) is focused on advanced, state-of-the-art research topics in software engineering, based on research priorities of the faculty of the program. The course contents will be mostly based on recent research publications, which the students read and discuss under the guidance of a faculty member. A term-project and publishable technical report is expected at the end of each Advanced Topics course.

Table 9:Advanced Topics Course

Course	Course Title
INSO 8995	Advanced Topics

6.1.6 Doctoral Seminar Course

The seminar course, shown in Table 10, seeks to enhance the student scientific reading, writing and verbal communication skills, as well as the ethics dimension. Each student in the seminar will be an active and engaged participant analyzing, constructing, creating, and evaluating information presented in technical or scientific publications or proposals for external funding. Through the seminar, students will discuss ethical issues and produce quality scientific writings, reviews, and presentations.

Table 10: Doctoral Seminar

Course	Course Title
INSO 8996	Doctoral Seminar

6.1.7 Master's Thesis, Master's Project, and Doctoral Dissertation Courses

Table 11 shows the Master's Thesis, Master's Project, and Doctoral Dissertation Courses.

Table 11: Master's Thesis, Master's Project and Doctoral Dissertation Courses

Course	Course Title
INSO 6998	Master's Project
INSO 6999	Master's Thesis
INSO 8999	Doctoral Dissertation Research

Both, *Master's Thesis* and *Master's Project*, are pieces of scholarly work that contain original contributions of the student to a discrete, specified, and circumscribed problem in Software Engineering. Although similar in spirit to a doctoral dissertation, the Master's thesis and project are much more limited in scope and hence, significantly shorter in length. In addition, the Master's project tends to be more focused on producing a software application, rather than creating new techniques, algorithms, or software infrastructure paradigms.

The *Doctoral Dissertation* is a significant piece of scholarly work that contains an original contribution to the knowledge in a specific subject in Software Engineering. The doctoral dissertation is the result of the student's original, extensive research, which has been conducted under the advice of a faculty member. The PhD in SWE requires the publication of some of the results of the doctoral dissertation in the refereed scientific literature as a **condition** for graduation.

6.2 Curricular design

6.2.1 Master's Degree in SWE - Plan I

Students enrolled on the Master's degree with Plan I must complete thirty (30) credits, including 6 credits in Master's Thesis. These students will be awarded a **Master of Science in Software Engineering**. The specific breakdown is as follows:

- **SWE Core Courses (9 credits)** – these are the courses defined in section 6.1.3 of this proposal.
- **SWE Elective Courses (9 credits)** – these are the software engineering elective courses, chosen from the list of approved courses by the Department (see section 6.1.4 for initial group of courses).
- **Elective Courses Outside of the SWE Program (6 credits)** – these are two courses outside the SWE Program.
- **Master's Thesis (6 credits)** – these are Master's Thesis courses (see section 6.1.7).

6.2.1.1 Master's Degree Plan I - Curricular Diagram

The following is the curricular sequence diagram for the Master's Degree in SWE - Plan I:

First Semester		
Code	**Title**	**Credits**
INSO 6005	Software Engineering Principles	3
INSO 6006	Database Systems Engineering	3
INSO ----	Elective in SWE	3
	Total	**9**

Second Semester		
Code	**Title**	**Credits**
INSO 6007	Secure Software Systems	3
INSO ----	Elective in SWE	3
INSO ----	Elective in SWE	3
	Total	**9**

Third Semester		
Code	**Title**	**Credits**
----	Elective course outside of SWE Program	3
INSO 6999	Master's Thesis	3
	Total	**6**

Fourth Semester		
Code	**Title**	**Credits**
----	Elective course outside of SWE Program	3
INSO 6999	Master's Thesis	3
	Total	**6**

Total: 30 credits

6.2.2 Master's Degree in SWE - Plan II

Students enrolled on the Master's degree with Plan II must complete thirty (30) credits, including 6 credits in Master's Project. These students will be awarded a **Master of Engineering in Software Engineering** The specific breakdown is as follows:

- **SWE Core Courses (9 credits)** – these are the courses defined in section 6.1.3 of this proposal.
- **SWE Elective Courses (9 credits)** – these are three software engineering courses, chosen from the list of approved courses by the Department (see section 6.1.4 for initial list of courses).

- **Elective Courses Outside of the SWE Program (6 credits)** – these are two courses outside the SWE Program.

- **Master's Projects (6 credits)** – these are Master's Projects courses (see section 6.1.7).

6.2.2.1 Master's Degree Plan II - Curricular Diagram

The following is the curricular sequence diagram for the Master's Degree in SWE - Plan II:

First Semester		
Code	**Title**	**Credits**
INSO 6005	Software Engineering Principles	3
INSO 6006	Database Systems Engineering	3
INSO ----	Elective in SWE	3
	Total	**9**

Second Semester		
Code	**Title**	**Credits**
INSO 6007	Secure Software Systems	3
INSO ----	Elective in SWE	3
INSO ----	Elective in SWE	3
	Total	**9**

Third Semester		
Code	**Title**	**Credits**
----	Elective course outside of SWE Program	3
INSO 6998	Master's Project	3
	Total	**6**

Fourth Semester		
Code	**Title**	**Credits**
----	Elective course outside of SWE Program	3
INSO 6998	Master's Project	3
	Total	**6**

Total: 30 credits

6.2.3 Master's Degree - Plan III

Students enrolled on the Master's degree with Plan III must complete thirty (30) credits, including 6 credits in **additional** SWE courses. These students will be awarded a **Master of Engineering in Software Engineering**. The specific breakdown is as follows:

- **SWE Core Courses (9 credits)** – these are the courses defined in section 6.1.3 of this proposal.
- **SWE Elective Courses (9 credits)** – these are three software engineering courses, chosen from the list of approved courses by the Department (see section 6.1.4 for initial list of courses).
- **Elective Courses Outside of the SWE Program (6 credits)** – these are two courses outside the SWE Program.
- **Additional SWE Elective Courses (6 credits)** – these are two additional software engineering courses, chosen from the list of approved courses by the Department (see section 6.1.4 for initial list of courses).

6.2.3.1 Master's Degree Plan III- Curricular Diagram

The following is the curricular sequence diagram for the Master's Degree in SWE - Plan III:

First Semester		
Code	**Title**	**Credits**
INSO 6005	Software Engineering Principles	3
INSO 6006	Database Systems Engineering	3
INSO ----	Elective in SWE	3
	Total	**9**

Second Semester		
Code	**Title**	**Credits**
INSO 6007	Secure Software Engineering	3
INSO ----	Elective in SWE	3
INSO ----	Elective in SWE	3
	Total	**9**

Third Semester		
Code	**Title**	**Credits**
----	Elective course outside of SWE Program	3
INSO ----	Elective in SWE	3

Total	**6**

Fourth Semester		
Code	**Title**	**Credits**
----	Elective course outside of SWE Program	3
INSO ----	Elective in SWE	3
	Total	**6**

Total: 30 credits

6.2.4 Doctoral Degree in SWE

Students enrolled in the doctoral program must complete fifty-four (54) credits, take several special examinations, and publish at least one article in a peer-reviewed forum. These students will be awarded a **Doctor of Philosophy in Software Engineering**. The specific breakdown is as follows:

- **SWE Core Courses (9 credits)** – these are the courses defined in section 6.1.3 of this proposal.

- **SWE Elective Courses (15 credits)** – these are five software engineering courses, chosen from the list of approved courses by the Department (see section 6.1.4 for initial list of courses).

- **Advanced Topics in SWE Course (3 credits)** – this a course on advanced, state-of-the-art research topics in software engineering (see section 6.1.5), based on research priorities of the faculty of the program. The course contents will be mostly based on recent publications which the students read and discuss under the guidance of a faculty member. A term-project publishable technical report is expected at the end of each Advanced Topics course.

- **Elective Courses Outside of the SWE Program (6 credits)** – these are two courses outside the SWE Program.

- **Doctoral Seminar in SWE (3 credits)** – Workshops on topics of scientific interest, including scientific methods, emerging approaches in software engineering, and ethics (see section 6.1.6). Each student will participate in discussions, make a brief presentation, and write an article or essay on the topic of the seminar. Each student will also serve as peer-reviewer of the other students' articles or essays, following guidelines provided by the instructor.

- **Qualifier exam** –In this **oral special exam**, the student's aptitude to do research will be evaluated. The student will prepare and submit a **review** article of the recent research literature ("survey paper") on his/her area of interest in Software Engineering, and the possible research topics that can be explored. This article and the SWE core courses will be used as the **basis** for asking the questions in the exam. The evaluation committee will

be the student's graduate committee, plus an external evaluator, holding a PhD degree in a Computing related field, appointed by the Director of the CSE Department. The student will make an oral presentation on the survey paper to the evaluation committee. The survey paper will be at least 15 pages long, using the ACM or IEEE double column format. This exam can be repeated only once, and must be approved before taking the Candidacy Exam. Each semester, the SWE Graduate Committee shall announce, with consent from the Director of the CSE Department, the last date on the semester when Qualifier exams can be taken.

- **Candidacy Exam** – An special exam for assessing the progress of the student in his/her doctoral research, and the quality of his/her research is required to continue working on the doctoral dissertation. The Candidacy Exam will consist of 1) a **progress report**, 30 to 50 pages long, describing the research already done and the research still to be undertaken, 2) a **public, oral presentation** immediately followed by **a closed oral examination** before the student's graduate committee. The report must follow the UPRM Graduate School dissertation format. The exam can be repeated only once, and must be **approved** before enrolling for a **fourth** time in the Doctoral Dissertation course, and before taking the Dissertation Defense exam. Each semester, the SWE Graduate Committee shall announce, with consent from the Director of the CSE Department, the last date on the semester when Candidacy exams can be taken.

- **Doctoral Dissertation Research (18 credits)** – Development of new knowledge, theories or practices in the field of Software Engineering, under the council and supervision of a faculty member that is an active researcher in the field, and a graduate committee.

- **Peer-reviewed Publications** – At least **one** article accepted for publication or already published in a peer-reviewed forum is required **prior** to the presentation of the dissertation defense exam. This publication **must** be based on the work performed to complete the dissertation. The student **must** be the first author of the paper, and **must** be published or accepted for publication while the student is **enrolled** in the SWE Graduate Program.

- **Dissertation Defense** – All doctoral programs require a final dissertation defense examination. The UPRM Office of Graduate Studies administers the final dissertation defense exam, according to the rules established under the Certification 09-09 of the Academic Senate of the University of Puerto Rico at Mayaguez.

6.2.4.1 Doctoral Degree Curricular Diagram

The following is the curricular sequence diagram for the Doctoral Degree in SWE:

First Semester		
Code	**Title**	**Credits**
INSO 6005	Software Engineering Principles	3
INSO 6006	Database Systems Engineering	3
INSO ----	Elective in SWE	3

Total	**9**

Second Semester		
Code	**Title**	**Credits**
INSO 6007	Secure Software Systems	3
INSO ----	Elective in SWE	3
INSO ----	Elective in SWE	3
	Total	**9**

Third Semester		
Code	**Title**	**Credits**
INSO 8996	Doctoral Seminar	3
INSO ----	Elective in SWE	3
-----	Elective course outside of SWE Program	3
	Total	**9**

Fourth Semester		
Code	**Title**	**Credits**
INSO 8995	Advanced Topics	3
INSO ----	Elective in SWE	3
-----	Elective course outside of SWE Program	3
	Total	**9**

Fifth Semester		
Code	**Title**	**Credits**
INSO 8999	Doctoral Dissertation Research	6
	Total	**6**

Sixth Semester		
Code	**Title**	**Credits**
INSO 8999	Doctoral Dissertation Research	6
	Total	**6**

Seventh Semester		
Code	**Title**	**Credits**
INSO 8999	Doctoral Dissertation Research	3
	Total	**3**

Eighth Semester		
Code	**Title**	**Credits**
INSO 8999	Doctoral Dissertation Research	3
	Total	**3**

Total: 54 credits

6.2.4.2 Doctoral Degree Exams Time Table

The following time table proposes the semester upon admission by which a SWE PhD student, **without** a Master's degree, should take the **first** attempt of the various examinations:

Exam	Recommended Date	Latest Date
Qualifier Exam	Fourth Semester	Fifth Semester
Candidacy Exam	Sixth Semester	Seventh Semester
Dissertation Defense	Eight Semester	Before time the limit to complete PhD degree

The following time table proposes the dates by which SWE PhD students, holding a Master in SWE from UPRM, should take the **first** attempt of the various examinations:

Exam	Recommended Date	Latest Date
Qualifier Exam	First Semester	Second Semester
Candidacy Exam	Second Semester	Third Semester
Dissertation Defense	Fourth Semester	Before time the limit to complete PhD degree

6.3 Coherence and Sufficiency

In this section, we present how the courses and other educational activities serve to fulfill the graduate profile for each degree in the program.

6.3.1 Master's Degree Coherence and Sufficiency

Table 12 shows how each student graduate profile outcome in the Master's Degree is **fulfilled** by a combination of courses and other activities within the curriculum.

Table 12: Mapping Master's Graduate Outcomes to Courses and Other Activities

Graduate Profile Outcome	Courses	Other Activities
1) Software Engineering skills	INSO 6005	
2) Secure Software Engineering skills	INSO 6007	
3) Data Engineering skills	INSO 6006	
4) Domain-specific skills	INSO 6998, INSO 6999, Electives in SWE, electives outside the SWE Program	Thesis, or Project Report

Graduate Profile Outcome	Courses	Other Activities
5) Teamwork skills	INSO 6005, INSO 6006, INSO 6007, Electives in SWE	
6) Ethical and Societal skills	INSO 6005, INSO 6006, INSO 6007, Electives in SWE, INSO 6998, INSO 6999	Thesis, or Project Report
7) Communication skills	INSO 6005, INSO 6006, INSO 6007, INSO 6998, INSO 6999, Electives in SWE	Thesis, or Project Report

6.3.2 Doctoral Degree Coherence and Sufficiency

Table 13 shows how each student graduate profile outcome in the Doctoral Degree is **fulfilled** by a combination of courses and other activities within the curriculum.

Table 13: Mapping Doctoral Graduate Outcomes to Courses and Other Activities

Graduate Profile Outcome	Courses	Other Activities
1) Software Engineering skills	INSO 6005	
2) Secure Software Engineering skills	INSO 6007	
3) Data Engineering skills	INSO 6006	
4) Domain-specific skills	Electives in SWE, electives outside the SWE Program, INSO 8995, INSO 8999	Dissertation
5) Teamwork skills	INSO 6005, INSO 6006, INSO 6007, Electives in SWE	
6) Ethical and Societal skills	INSO 6005, INSO 6006, INSO 6007, Electives in SWE, INSO 8996, INSO 8999	Dissertation
7) Research skills	INSO 8995, INSO 8996, INSO 8999	Peer-reviewed publication, Dissertation
8) Research Vision skills	INSO 8995, INSO 8996, INSO 8999	Qualifier Exam, Candidacy Exam, Dissertation
9) Peer Review skills	INSO 8996, INSO 8999	Qualifier Exam, Candidacy Exam, Peer-reviewed publication, Dissertation
10) Communication skills	INSO 8996, INSO 8999	Qualifier Exam, Candidacy Exam, Peer-reviewed publication, Dissertation

6.4 Description of New Courses

INSO 6005 - Software Engineering Principles (3 credits): Comprehensive study of modern software engineering principles and techniques for the efficient delivery of scalable and secure software systems for production use. This course prepares students to specify, design and implement software systems using cloud technologies, agile methods, SCRUM, design patterns, refactoring, continuous integration, continuous delivery, logging systems, and software quality assurance. This course may be offered in any of the following modalities: face-to-face, hybrid or online.

INSO 6006 - Database Systems Engineering (3 credits): Comprehensive study of engineering principles to build the internals of modern database management systems. This course prepares students to design and implement row-oriented systems, column-oriented systems, in-memory engines, multi-core data engines, vectorized query executors, and RDMA systems. This course may be offered in any of the following modalities: face-to-face, hybrid or online.

INSO 6007 – Secure Software Engineering (3 credits): Concepts of secure software development in the context of secure operating system design principles, protection methods, access control, authentication, vulnerability analysis and case studies. Case studies will focus on secure software systems for applications such as securing data at rest, smart devices and autonomous systems.This course may be offered in any of the following modalities: face-to-face, hybrid or online.

INSO 6010 – DevOps (3 credits): Comprehensive study of DevOps software engineering principles and techniques for the rapid and continuous development, integration, and delivery of software systems for production use. This course prepares students to design and implement DevOps infrastructure using software containers, microservices, continuous integration, continuous delivery, logging systems, and collaborations tools. This course may be offered in any of the following modalities: face-to-face, hybrid or online.

INSO 6015 – MLOps (3 credits): Comprehensive study of MLOps software engineering principles and techniques for the rapid and continuous development, integration, and delivery of Machine Learning production systems. This course prepares students to design and implement data processing pipelines, effective data labeling and validation, data augmentation, model search, model analysis, resource management, model serving, model management and delivery, and monitoring and logging. This course may be offered in any of the following modalities: face-to-face, hybrid or online.

INSO 6030 - Web and Mobile Applications Engineering (3 credits): Comprehensive study of software engineering principles and techniques for the development of mobile and web applications in production systems. This course prepares students to design and implement multi-tier applications, REST APIs, distributed data persistence layers, secure web sockets APIs, web-based user interfaces, hybrid and native mobile apps, APIs to manage phone hardware, instrumentation, and monitoring systems. This course may be offered in any of the following modalities: face-to-face, hybrid or online.

INSO 6040 - Health-related Applications Engineering (3 credits): Advances in medicine demands highly regulated and complex systems to handle, analyze, represent and interpret healthcare data. In this course students will be introduced to the challenges in health applications in terms of the data context such as images, time series analysis of physiological data, text and electronic health records. AI approaches to solve healthcare problems will be discussed. The topics will include fundamental concepts of machine learning, deep learning, supervised learning, distributed learning, image analysis, text data representation, strategies to solve problems that involve multimodal data and interdisciplinary projects using AI. This course may be offered in any of the following modalities: face-to-face, hybrid or online.

INSO 6050 - Software Engineering for Edge Systems (3 credits): Comprehensive study of existing frameworks and applications in Edge Computing, with a focus on big data analytics, containers, and clouds. This course prepares students to design and implement computing systems over edge devices and the cloud including synchronization, resource management, fault tolerance, services, multi-sensor data analytics and their applications. This course may be offered in any of the following modalities: face-to-face, hybrid or online.

INSO 6070 - Software-Defined Networks Engineering (3 credits): Comprehensive study of engineering principles to develop modern software-defined networking (SDN) systems. This course prepares students to analyze, design and implement functions running on SDN controllers, SDN switches, and SDN applications. This course may be offered in any of the following modalities: face-to-face, hybrid or online.

INSO 6080 – Deep Learning Engineering (3 credits): Engineering Principles of deep learning with deep neural network architectures. Study of algorithms and implementation techniques for fully connected neural networks, convolutional networks, recurrent networks, word embeddings, attention methods, generative adversarial networks, and transformers. Analysis of gradient descent optimization, hyperparameters selection, overfitting, and probabilistic modeling. Use of software libraries and frameworks using computational models of directed graphs in distributed systems and graphical processing units ("GPU"). Discussion of recent research publications in machine learning and their application in industry and academia.

INSO 6998 - Master Project (0-6 credits): Supervised production of a piece of scholarly work that contains original contributions to an application and development problem in Software Engineering. This course may be offered in any of the following modalities: face-to-face, hybrid or online.

INSO 6999 - Master Thesis (0-6 credits): Supervised production of a piece of scholarly work that contains original contributions to a research problem in Software Engineering. This course may be offered in any of the following modalities: face-to-face, hybrid or online.

INSO 8995 - Advanced Topics (3 credits): Discussion of an advanced topics in an active research field within Software Engineering. This course may be offered in any of the following modalities: face-to-face, hybrid or online.

INSO 8996 - Doctoral Seminar (3 credits): Workshops for the discussion and exercise of skills for technical or scientific writing. This course prepares students to read research papers and proposals, write scientific critiques, write survey papers, and participate in research review panels. This course may be offered in any of the following modalities: face-to-face, hybrid or online.

INSO 8999 - Doctoral Dissertation Research (3 credits): Supervised production of a piece of scholarly work that contains original contributions to a cutting-edge research problem in Software Engineering. This course may be offered in any of the following modalities: face-to-face, hybrid or online.

6.5 Course Syllabi

The syllabi of all the new courses can be found in Appendix D of this document.

6.6 Educational Methods

The program will be offered in day mode. For most SWE courses, there shall be both on-campus (face-to-face) and hybrid sections for the course, and shall simultaneously transmit the class over the Internet using a video-conferencing system (e.g., Microsoft Teams). On-campus students will take their lectures by attending to the classroom. Off-campus students will connect to the video-conferencing platform to attend the lecture. These courses will be scheduled to accommodate the needs of working professionals. In most cases, courses will be scheduled late in the afternoon, or early in the morning, taking into consideration student input. Some SWE courses might be offered as distance courses, depending on both students and Program needs. For all courses being offered, all lectures will be recorded, and will be accessible through the official distance learning platform. Currently, this is the *UPR Distance Learning Platform* **online.upr.edu**. In addition, all lecture materials, exams, quizzes, projects, and any other class activity will be submitted by all students using the **online.upr.edu** platform. Software programming assignments will be submitted using software version control platforms such as GitHub or GitLab. Alternative distance learning platforms or software version control platforms could be used with prior approval by the faculty of the Computer Science and Engineering Department in a duly assembled meeting.

7 Admission, Enrollment, Transfers, and Residence

7.1 Admission requirements

The general admission requirements of the SWE Graduate Program are those specified in Section G.1 of Certification 09-09 of the Academic Senate of the University of Puerto Rico at Mayaguez, as amended on March 17, 2015 by Certification 15-21.

7.1.1 Program Specific requirements for admission

Applicants must possess a bachelor's degree in Software Engineering, Computer Science and Engineering, Computer Science, Computer Engineering, or closely related field. UPRM students that have completed the UPRM Minor in Computer Science and Engineering might also apply. For admission consideration, the body of knowledge in the applicant's transcript shall at least include the following:

1. One semester college-level Calculus
2. Two semesters of college-level Physics
3. Two semesters of Computer Programming courses
4. One semester of Data Structures

The SWE Graduate Committee reviews all applications that the UPRM Office of Graduate Studies has judged complete and consistent with the general criteria established for graduate studies at UPRM. The SWE Graduate Committee evaluates:

- The applicant's coursework, academic history, and the appropriateness of her/his academic background;
- The degree of alignment of the applicant's interests and the program's graduate profile outcomes;
- The quality of the applicant's essay;
- The contents of the letters of recommendation in support of the applicant;
- The potential of the applicant for succeeding in the program within a reasonable period of time.

The SWE Graduate Committee submits its recommendations for all reviewed applications to the UPRM Office of Graduate Studies for final admission decisions.

7.2 Admission with Deficiencies

Good applicants whose academic record lacks one or more of the following courses are considered to have deficiencies:

1. **Introduction to Software Engineering**
2. **Introduction to Databases Systems**
3. **Introduction to Operating Systems**
4. **Introduction to Probability and Statistics**

These applicants might be accepted into the program based on the strength their academic record, and might be required to take up to four of these undergraduate remedial courses upon acceptance into the program, as specified in section G.2.d. of Certification 09-09 of the Academic Senate at UPRM. All remedial courses must be approved during the first **two** years in the program.

The SWE Graduate Committee will maintain and update the list of courses that are considered as deficiencies. This is to accommodate changes in the body of knowledge in the discipline. Any changes to the list will be approved by the SWE Graduate Committee in a duly convened meeting. Changes will be informed to the CSE Associate Director. In turn, the CSE Associate Director will inform of these changes to the Dean of Engineering, UPRM Director of Graduate Studies, and the UPRM Dean of Academic Affairs.

7.3 Course Validations

The rules for course validations are specified in Section G.3 of Certification 09-09 of the Academic Senate of the University of Puerto Rico at Mayaguez, as amended on March 17, 2015 by Certification 15-21.

7.4 Graduation requirements

The graduation requirements are specified in Section G.7 of Certification 09-09 of the Academic Senate of the University of Puerto Rico at Mayaguez, as amended on March 17, 2015 by Certification 15-21. Students in the Master in SWE must satisfactorily complete all the course work and special exams presented in section 6.1.1, and either section 6.2.1, 6.2.2 or 6.2.3, depending on their programs of studies. PhD students must satisfy all the course work, examinations, and the peer-reviewed publication requirement presented in sections 6.1.2 and 6.2.4.

7.5 Expected enrollment

The Master in SWE degree is expected to have an enrollment of twenty-five (25) students per year in steady state. The Doctor of Philosophy in SWE is expected to have an enrollment of twenty (20) students per year in steady state, although this number may vary depending on the number of active doctoral student research projects available.

7.6 Minimal academic indices

The minimal academic indices are specified in Section G.9 of Certification 09-09 of the Academic Senate of the University of Puerto Rico at Mayaguez, as amended on March 17, 2015 by Certification 15-21.

7.7 Transfers

The rules and criteria for internal transfers are set in Section G.8 of Certification 09-09 of the Academic Senate of the University of Puerto Rico at Mayaguez, as amended on March 17, 2015 by Certification 15-21.

7.8 Residence

The residence requirement is determined in Section G.6 of Certification 09-09 of the Academic Senate of the University of Puerto Rico at Mayaguez, as amended on March 17, 2015 by Certification 15-21.

7.9 Maximum number of years for completing the degree

The maximum number of years is established in Section G.9.f. of Certification 09-09 of the Academic Senate of the University of Puerto Rico at Mayaguez, as amended on March 17, 2015.

Based on Certification 09-09 of the UPRM Academic Sente, the maximum time to complete the Master in SWE is **six** (6) years from the moment in which the student enrolled in a graduate program for the first time.

Based on Certification 09-09 of the UPRM Academic Senate, the maximum time to complete the PhD in SWE is:

- eight (8) years from the moment in which the student enrolled in a program for the first time, if the student already had a Master degree.
- ten (10) years from the moment in which the student enrolled in a program for the first time, if the student did not have a Master degree.

8 Faculty

8.1 Profile of Graduate Faculty

The following table lists the current graduate faculty, their fields of research and the courses they may teach in the proposed SWE Graduate Program.

Table 14: Graduate Faculty for the SWE Program

Name	Highest Degree	Fields of Specialty	Courses
Emmanuel Arzuaga	PhD	Virtualization, Cloud Computing, Machine Learning	INSO 6007, INSO 6015, INSO 6050, INSO 6998, INSO 6997, INSO 8995, INSO 8996, INSO 8997, INSO 8999
Kejie Lu	PhD	Networking	INSO 6007, INSO 6070, INSO 6998, INSO 6997, INSO 8995, INSO 8996, INSO 8997, INSO 8999
Wilson Rivera	PhD	High Performance Computing, Big Data Analytics	INSO 6007, INSO 6010, INSO 6015, INSO 6998, INSO 6997, INSO 8995, INSO 8996, INSO 8997, INSO 8999
Pedro Rivera	PhD	Algorithms	INSO 6030, INSO 6998, INSO 6997, INSO 8995, INSO 8997, INSO 8999
Manuel Rodríguez	PhD	Database Systems, Big Data Analytics, Data Engineering	INSO 6006, INSO 6030, INSO 6040, INSO 6998, INSO 6997, INSO 8995, INSO 8996, INSO 8997, INSO 8999
Marko Schutz	PhD	Software Engineering, Algorithms	INSO 6005, INSO 6010, INSO 6998, INSO 6997, INSO 8995, INSO 8997, INSO 8999
Heidy Sierra	PhD	Computational Optics, Deep Learning	INSO 6015, INSO 6998, INSO 6997, INSO 8995, INSO 8996, INSO 8997, INSO 8999

Bienvenido Vélez	PhD	Software Quality, Software Engineering, Programming Language and Compilers	INSO 6005, INSO 6006, INSO 6030, INSO 6998, INSO 6997, INSO 8999
New Faculty Hire #1 [9] for 2022-2023	PhD	Machine Learning, Software Engineering	INSO 6005, INSO 6015, INSO 6040, INSO 6998, INSO 6997, INSO 8995, INSO 8996, INSO 8997, INSO 8999
New Faculty Hire #2 for 2022-2023	PhD	Data Streaming, Sensor Networks	INSO 6006, INSO 6040, INSO 6070, INSO 6998, INSO 6997, INSO 8996, INSO 8997, INSO 8999
New Faculty Hire #3 for 2022-2023	PhD	Data Science & Analytics, Software Engineering	INSO 6007, INSO 6006, INSO 6040, INSO 6998, INSO 6997, INSO 8995, INSO 8996, INSO 8997, INSO 8999

8.2 Recruitment plan

The CSE Department is a key stakeholder in the NSF Center for the Advancement of Wearable Technology (CAWT). The following faculty members play important roles in the project:

1. Manuel Rodriguez Martinez – Co-lead of the Independent Research Group 3
2. Emmanuel Arzuaga – Member of Independent Research Group 3
3. Heidy Sierra - Member of Independent Research Groups1 and 3

As part of the UPR commitments with NSF CAWT, three new faculty positions will be filled in the next two years, for the duration of the project. These new faculty members will directly support the SWE Graduate Program. Table 15 show the schedule to hire these faculty members, their target field, and the specific expertise that is being sought. These new hires will raise to eleven the total of faculty member available for the program.

[9] Replacement of Dr. Ahmed ElSaid

Table 15: New Faculty Hires to support the SWE Graduate Program in the short term

Recruitment Year	Name	Field	Area of Expertise
2022-2023	TBD[10]	Machine Learning	Expertise in data mining and machine learning applied to health or medical applications
2022-2023	TBD	Sensor and Data Streaming Systems	Expertise in biosensor information and implementation of data processing functions
2022-2023	TBD	Data Science and Analytics	Expertise in algorithms to extract information and insights from data collected in different forms.

Beyond these faculty hires, the CSE Department has submitted to the College of Engineering the following long term faculty recruitment plan:

Table 16: Long term, research-based CSE Faculty Recruitment Plan

Field	Area of Expertise
Software Engineering	Expertise in software verification, debugging, and programmer support using AI and ML techniques.
Software Engineering	Expertise in Software Deployment and Continuous Integration.
Secure Software Engineering	Expertise in secure software design and testing.
Cloud Computing	Expertise in cloud computing, edge systems, and distributed computing.
Data Analytics	Expertise in data analytics, data science, and database systems.

The faculty hires in Table 16 shall help strengthen the SWE Graduate Program in the long run.

8.3 Faculty Professional Development

New faculty members in our institution must take a minimum of 30 contact hours of professional enhancement seminars during the first years in tenure-track. Those training activities are coordinated by the Center of Professional Enhancement at UPRM (http://www.uprm.edu/cep).

[10] Replacement for Dr. Ahmed ElSaid.

That center also coordinates other periodic activities that are open to all faculty members in UPRM to support their professional development. Those are mainly focused in pedagogical strategies to promote excellence in education, as well as in the proper use of modern tools to facilitate course management and dissemination. Such activities include workshops, seminars and courses.

In addition, by state law, every two years, all government employees in Puerto Rico are required to take 20 hours of training (which could be specialized lectures, discussion activities, or formal conferences) in ethics applied to different fields. We can assert that our faculty has complied with those training hours for the last two years.

All of our faculty members have recently completed in-campus workshops focused on the use of online educational systems; in particular, on how to effectively integrate the Moodle learning management system into our courses. That has included training for the proper use and integration of other specific tools for video streaming and conference video recording for synchronous and asynchronous teaching. And, in the case of courses in which software development is required as part of the activities in the course, the faculty involved have been trained into how to integrate the Moodle platform with automatic grading tools for computer programs.

In June 2020, the UPRM's chancellor assigned funds to cover the registration fees of the official UPRM's course for professors to get certified to teach online or remote courses. That course is being offered by the Center of Professional Enhancement at UPRM. Some members in our department have already completed it, while others are currently in the process.
Table **17** is a compilation of other specific professional development activities for specific faculty members.

Table 17: Faculty Development Activities

Faculty	Professional Development Activities
Bienvenido Vélez	• Completed UPRM's certification to teach online or remote courses in July 2020. • Completed (Spring 2019) the training required to become an ABET PEV for CS programs. • He is also a successful entrepreneur as founder and CEO of a local software development companies (Phidelix and Axiomatica).
Emmanuel Arzuaga	• Has participated in several activities within the scope of his professional development since he joined UPRM. • In 2017, he participated in the Facebook Infrastructure Faculty Symposium. There, he was exposed to the high-performance infrastructure of that company, their needs for such infrastructure, and roles that the academic world can play in providing the needed skills for students to become proficient in that area. That in particular has been useful in several of his courses, including the computer architecture courses, the operating systems course, as well as the

Faculty	Professional Development Activities
	technical elective courses in virtual computing and cloud computing. • In August 2017, he participated in another symposium, also in Facebook, where participants were exposed to different strategies for educational improvements in the areas of data structures and algorithms from the perspective of that company. • Has acted as referee for conferences and journals, as well as in different proposal review panels at NSF. • Participated in faculty internships in ONR and Harris during Summer 2019.
Heidy H. Sierra	• Participated in the Facebook symposium for education in CS that took place in July 2017 and which was described earlier. • She has also been active as a panel reviewer at NSF.
Kejie Lu	• Is an editor of the IEEE Communications Surveys & Tutorials from 2009, which has the highest impact factor (22.97) on all IEEE journals[11]. • From 2016 to 2017 he also served as an editor of the journal IEEE Internet of Things. • Has been an active participant as referee, as well as an author, in respectable journals and conferences in the area.
Manuel Rodríguez	• Completed UPRM's certification to teach online or remote courses in July 2020. • Completed several courses in Coursera, in the areas of Machine Learning and Big Data. That has been useful for his research projects and improve upon his teaching capabilities of the recently created courses in the area of big data. • Was a co-Chair of the Workshop on Big Data in Smart Grids at the EII Big Data Conference in Washington, D.C. in 2016.
Marko Schutz	• Attended seven different ethics/professional development workshops • Attended several different workshops on online education and the Moodle system
Pedro I. Rivera-Vega	• Completed UPRM's certification to teach online or remote courses in July 2020. • Attended the Facebook workshop in August 2017 previously described. • In August 2019, he participated in another symposium, also sponsored by Facebook, where he was exposed to different strategies for the improvement on how to teach the data structures and algorithms topics.

[11] https://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=9739

Faculty	Professional Development Activities
	• During 2017, he took several courses in data science with R using from Coursera and offered by John-Hopkin university.
Wilson Rivera-Gallego	• Has participated as Visiting Faculty & Affiliate in the Lawrence Berkeley National Laboratory. • Has been working on applications of deep learning in protein structure classification and prediction. • Active participant in the program committee of several international conferences in different areas of computing. • In December 2016, he participated as Co-Chair of the Workshop on Big Data in Smart Grids at the IEEE Big Data Conference in Washington, D.C.
Abdelrahman A. Elsaid	• Attended seven different ethics/professional development workshops • Attended several different workshops on online education and the Moodle system

8.4 Faculty CVs

The following pages contain the CVs of the faculty for the SWE Graduate Program.

1. **Name: Emmanuel Arzuaga**

2. Education – degree, discipline, institution, year

Degree	Institution
PhD in Computer Engineering	Northeastern University, 2012
MS in Computer Engineering	University of Puerto Rico Mayaguez, 2002
BS in Computer Engineering	University of Puerto Rico Mayaguez, 2000

3. Academic experience – institution, rank, title (chair, coordinator, etc. if appropriate), when (ex. 1990-1995), full time or part time

Institution	Title	Period	F/P Time
University of Puerto Rico at Mayagüez	Associate Professor	2018-present	Full Time
University of Puerto Rico at Mayagüez	Assistant Professor	2012-2018	Full Time

4. Non-academic experience – company or entity, title, brief description of position, when (ex. 1993-1999), full time or part time

Entity	Title	Brief Description	When	Type
VMware Inc	MTS Intern	R&D kernel development in the ESX I/O subsystem. Study I/O subsystem to identify performance enhancements for virtual machine execution.	2009-2010	Full Time
Intel Corp	Graduate Technical Intern	Synthetic enterprise workload development to model, simulate, and evaluate performance enhancements to Itanium processor designs.	2008	Full Time
ExaGrid	Research Intern	Performance evaluation and testing; contrast and compare the effectiveness of delta compression techniques and other data de-duplication techniques.	2006-2007	Full Time
UPRM LARSIP	Software Developer	Development of software tools for image analysis.	2002-2004	Full Time

5. Certifications or professional registrations
   None

6. Current membership in professional organizations

ACM, IEEE, IEEE-CS, SPIE

7. Honors and awards

- ONR Summer Senior Faculty Fellow Award, 2019.
- DoD-NSWC Award #N001741910013: Improving Virtualized Data Center Resource Efficiency Using Dynamic Container Placement Strategies, (PI, 2019).
- NSF Award #1828443: MRI: Development of a Real-world Microgrid Simulation/Testing Instrument, (Co-PI, 2018).
- NSF Award #1818675: RAPID: Resilience Assessment for Communications right after Emergencies/Disasters (RACE), (PI, 2018).
- Google Award #287913 ARA Characterization of Workload Execution and Resource Usage, (PI, 2015).

8. Service activities (within and outside of the institution) \

- Director, Laboratory for Applied Remote Sensing, Imaging and Photonics (LARSIP) UPRM.
- Associate Director, Center for Aerospace and Unmanned Systems Engineering (CAUSE) UPRM.
- NSF CISE Proposal Review Panelist.
- Technical Program Committee Member, Workshop in Computer Architecture Education 2015 and 2019.

9. Briefly list the most important publications and presentations from the past five years – title, co-authors if any, where published and/or presented, date of publication or presentation

- Improving Execution Time for Supervised Sparse-Representation Classification of Hyperspectral Images using the Moore-Penrose Pseudoinverse, F. Arias, H. Sierra, E. Arzuaga, SPIE Journal of Applied Remote Sensing, 2019.
- *Gorilla: An Open Interface for Smart Agents and Real-Time Power Microgrid System Simulations*, C. Velez-Rivera, F. Andrade, E. Arzuaga-Cruz, A. Irizarry-Rivera, Inventions 3 (3), 58, 2018.
- *GDedup: Distributed File System Level Deduplication for Genomic Big Data*, P. Bartus, E. Arzuaga, 2018 IEEE International Congress on Big Data (BigData Congress), 120-127, 2018.
- *Using file-aware deduplication to improve capacity in storage systems,* P. Bartus, E. Arzuaga, 2017 IEEE Colombian Conference on Communications and Computing (COLCOM), 1-6, 2017.
- *American sign language translation using edge detection and cross correlation*, A. Joshi, H. Sierra, E. Arzuaga, 2017 IEEE Colombian Conference on Communications and Computing (COLCOM), 1-6, 2017.
- Subsurface classification of objects under turbid waters by means of regularization techniques applied to real hyperspectral data, E. Carpena, L.O. Jiménez, E. Arzuaga, S. Fonseca, E. Reyes, J. Figueroa, Algorithms and Technologies for Multispectral, Hyperspectral, and Ultraspectral, SPIE, 2017.

- Supervised Sparse-Representation Classification on Hyperspectral Images Using the City-Block Distance to Improve Performance, F.X. Arias, H. Sierra, L.O. Jimenez-Rodriguez, E. Arzuaga, IET Digital Library, 2017.
- *Linear unmixing for subsurface estimation on coastal shallow waters,* E. Carpena-Colón, L.O. Jiménez-Rodríguez, E. Arzuaga-Cruz, IET Digital Library, 2017.

10. Briefly list the most recent professional development activities
NONE

1. **Name: Kejie Lu**

2. Education – degree, discipline, institution, year

Degree	Institution
Ph.D. in Electrical Engineering	University of Texas at Dallas, 2003
MS in Communications and Electronic Systems	Beijing University of Posts and Telecom, 1997
BS in Telecommunications Engineering	Beijing University of Posts and Telecom, 1994

3. Academic experience – institution, rank, title (chair, coordinator, etc. if appropriate), when (ex. 1990-1995), full time or part time

Institution	Title	Period	F/P Time
University of Puerto Rico at Mayagüez	Professor	2016-present	Full Time
University of Puerto Rico at Mayagüez	Associate Professor	2012-2016	Full Time
University of Puerto Rico at Mayagüez	Assistant Professor	2005-2012	Full Time
University of Florida	Post-Doctoral	2004-2005	Full Time
University of Texas at Dallas	Research Assistant	2001-2003	Part Time

4. Non-academic experience – company or entity, title, brief description of position, when (ex. 1993-1999), full time or part time

Entity	Title	Brief Description	When	Type
Huawei Technologies	Senior Software Engineer	Developing System Software for ATM Switch	1998-2000	Full Time
Gaohong Telecom	Software Engineer	Developing System Software for ATM Switch	1997-1998	Full Time

5. Certifications or professional registrations
   NONE

6. Current membership in professional organizations
   NONE

7. Honors and awards

Outstanding Professor of UPRM (2016~2017)
Outstanding Researcher of UPRM (2014)
Outstanding Researcher of UPRM (2013)
Outstanding Professor of UPRM (2008~2009)

8. Service activities (within and outside of the institution)
Editor of IEEE Communications Society Survey & Tutorial, 2009~
Editor of IEEE Internet of Things Journal, 2016~2017

9. Briefly list the most important publications and presentations from the past five years – title, co-authors if any, where published and/or presented, date of publication or presentation

Chunming Cao, Jin Wang, Jianping Wang, Kejie Lu, Jingya Zhou, Admela Jukan, and Wei Zhao, "Optimal Task Allocation and Coding Design for Secure Coded Edge Computing," to appear, Proc. IEEE ICDCS 2019, Dallas, Texas, Jul 2019.

Songwei Li, Chenyuan He, Mushuang Liu, Yan Wan, Yixin Gu, Junfei Xie, Shengli Fu, Kejie Lu, "The Design and Implementation of Aerial Communication Using Directional Antennas: Learning Control in Unknown Communication Environments," Published online, IET Control Theory and Applications, Apr. 2019.

Jin Wang, Kejie Lu, Jianping Wang, Chuan Wu, and Naijie Gu, "Enhancing the Anonymity in Information Diffusion Based on Obfuscated Coded Data," Published online, IEEE Transactions on Network Science and Engineering, Dec. 2018.

Ruimin Zhao, Jin Wang, Kejie Lu, Xiangmao Chang, Juncheng Jia, and Shukui Zhang, "Optimal Transmission Topology Construction and Secure Linear Network Coding Design for Virtual-source Multicast with Integral Link Rates," IEEE Transactions on Multimedia, Vol. 20, No. 11, pp. 3069-3083, Nov. 2018.

Bin He, Jin Wang, Jingya Zhou, Kejie Lu, Lingzhi Li and Shukui Zhang, "The Design and Implementation of Random Linear Network Coding based Distributed Storage System in Dynamic Networks," in Proc. the 18th International Conference on Algorithms and Architectures for Parallel Processing (ICA3PP), Nov. 2018.

Jinguo Li, Mi Wen, Kui Wu, Kejie Lu, Fengyong Li, Hongjiao Li, "Secure, flexible and high-efficient similarity search over encrypted data in multiple clouds," Published online, Springer Peer-to-Peer Networking and Applications, Oct. 2018.

Ruimin Zhao, Jin Wang, Kejie Lu, Jianping Wang, Xiumin Wang, Jingya Zhou, and Chunming Cao, "Weakly Secure Coded Distributed Computing," in Proc. of the 15th IEEE International Conference on Ubiquitous Intelligence and Computing (UIC), Oct. 2018.

Baoqian Wang, Junfei Xie, Songwei Li, Yan Wan, Shengli Fu, and Kejie Lu, "Enabling High-Performance Onboard Computing with Virtualization for Unmanned Aerial Systems,"

in Proc. 2018 International Conference on Unmanned Aircraft Systems (ICUAS), pp. 202-211, Jun. 2018.

10. Briefly list the most recent professional development activities
NONE

1. **Name: Wilson Rivera-Gallegos**

2. Education – degree, discipline, institution, year

Degree	Institution
Ph.D. in Computational Engineering	Mississippi State University, 2000
MS in Mathematics	University of Puerto Rico, 1994
BS in Mathematics	Universidad del Valle, 1989

3. Academic experience – institution, rank, title (chair, coordinator, etc. if appropriate), when (ex. 1990-1995), full time or part time

Institution	Title	Period	F/P Time
University of Puerto Rico at Mayagüez	Professor	2012-present	Full Time
University of Puerto Rico at Mayagüez	Associate Professor	2005-2012	Full Time
University of Puerto Rico at Mayagüez	Assistant Professor	2000-2005	Full Time

4. Non-academic experience – company or entity, title, brief description of position, when (ex. 1993-1999), full time or part time

Entity	Title	Brief Description	When	Type
Lawrence Berkeley National Laboratory	Visiting Faculty & Affiliate	Applied deep learning to protein structure classification and prediction.	2018-Present	Part Time
Hewlett-Packard Labs	Visiting Researcher	Developed algorithms for data center energy management.	2008-2009	Full Time

5. Certifications or professional registrations
   NONE

6. Current membership in professional organizations
   Association for Computing Machinery – ACM

7. Honors and awards
   Distinguished Professor 2004-2005; Electrical and Computer Engineering Department

8. Service activities (within and outside of the institution)

President CSE Academic Affairs Committee 2016-2017
Member INEL/ICOM Planning Committee 2012-2017
Instructor International Engineering Educator Certification Program (IGIP Certification)
Program Committee International Conference on Pattern Recognition Systems (ICPRS)
Program Committee International Workshop on Security, Privacy, Trust, and Machine Learning for Internet of Things (IoTSPT-ML 2019)
Program Committee International Conference on Data Analytics (Data 2018-2019)
Program Committee International Workshop on Internet on Things: Privacy, Security, and Trust (IoPDST 2018)
Program Committee Latin American Conference on Networked Electronic Media (LACNEM 2017)

9. Briefly list the most important publications and presentations from the past five years – title, co-authors if any, where published and/or presented, date of publication or presentation

D. Rosa de Jesus, J. Cuevas, W. Rivera and S. Crivelli (2018). Capsule Networks for Protein Structure Classification. IEEE/ACM Supercomputing 2018.

D. Rosa de Jesus and W. Rivera (2018). Application of Evolutionary Algorithms for Load Forecasting in Smart Grids. 14th International Conference on Foundations of Computer Science, Las Vegas, USA

W. Rivera and F. Andrade (2018). A Security Framework for Smart Grids. 17th International Conference on e-Learning, e-Business, Enterprise Information Systems, and e-Government, Las Vegas, USA

D. Rosa de Jesus and W. Rivera (2018). Multi-Objective Optimization in Smart Grids. IEEE Clemson University Power Systems Conference.

W. Rivera and M. Rodriguez-Martinez. “Towards Cloud Services in Smart Power Grids.” IEEE PES Innovative Smart Grid Technologies Conference. 2016.

M. Rodriguez-Martinez, E. O'Neil-Carrillo, M. Perez, F. Andrade, W. Rivera, A. Irizarry-Rivera, R. Rodriguez, C. Ortiz, and E. Lugo, "A Case for Open Access Smart Grids (OASIS)", IEEE SusTech 2016. 2016 IEEE Conference on Technologies for Sustainability (SusTech), Phoenix, AZ, 2016, pp. 174-179.

10. Briefly list the most recent professional development activities

a. Co-Chair: Workshop on Big Data in Smart Grids, 2016 IEEE Big Data Conference, December 4-6, 2016, Washington, DC.
b. Visiting Faculty Program. Lawrence Berkeley National Lab. (Summer 2018, Summer 2019).

1. Name: Pedro I. Rivera-Vega

2. Education – degree, discipline, institution, year

Degree	Institution
Ph.D. in Computer Science	University of Florida, 1990
MS in Applied Mathematics	University of Puerto Rico, 1980
BS in Mathematics	University of Puerto Rico, 1977

3. Academic experience – institution, rank, title (chair, coordinator, etc. if appropriate), when (ex. 1990-1995), full time or part time

Institution	Title	Period	F/P Time
University of Puerto Rico at Mayagüez	Professor	2001-present	Full Time
University of Puerto Rico at Mayagüez	Chairman ECE Department	2011-2015	Full Time
University of Puerto Rico at Río Piedras	Associate Professor	1990-2001	Full Time
University of Puerto Rico at Cayey	Instructor	1983-1990	Full Time

4. Non-academic experience – company or entity, title, brief description of position, when (ex. 1993-1999), full time or part time

Entity	Title	Brief Description	When	Type
Puerto Rico Electoral Commission	Technical Advisor	Advising the commission in information systems.	1996-1999	Part Time
Department of Natural Resources	EDP Manager	Director of Computer Center	1983 (February-July)	Permanent
University of Puerto Rico at Humacao	Programmer Analyst	In charge of automating university (academic and administrative).	1980-1983	Permanent

5. Certifications or professional registrations
NONE

6. Current membership in professional organizations:
   a. Member of ACM

7. Honors and awards:
NONE

8. Service activities (within and outside of the institution):
   a. Faculty advisor of the Local Engineering and Sciences ACM Student Chapter in UPR-Mayaguez, 2005-2009
   b. CIO & IT Leadership Conference, Panelist in panel "How Can the Academy Improve the Human Capital Supply for IT", Feb 7, 2014, San Juan PR.
   c. Reviewer for various technical journals and conferences, including: IEEE Transactions on Computers, International Conference on System Sciences, Parallel Processing Letters, CRC at UPR-RUM, and The IASTED International Conference in Information and Knowledge Sharing
   d. Member of the IASTED Technical Committee on Information and Knowledge Sharing on 2001 and 2004
   e. Reviewer in different grant programs:
      i. FIPI Program: University of Puerto Rico at Río Piedras (1997, 1998, 2009)
      ii. NSF-CISE and NSF-SBIR: Grants reviewer on three occasions during 1997, 1998, 2002, and 2005. Also served as panel member for all these review activities at NSF headquarters in Washington D.C.
   f. One of the developers of the web application www.practicatuvoto.com.
   g. Evaluator appointed by the Board of Higher Education in Puerto Rico to evaluate a graduate program in e-commerce at the Interamerican University of Puerto Rico, Bayamon, during 2002-2003

9. Briefly list the most important publications and presentations from the past five years – title, co-authors if any, where published and/or presented, date of publication or presentation
NONE

10. Briefly list the most recent professional development activities
   a. Participated in Facebook Faculty Meeting for improvement of programming courses. July 2017.
   b. Participated in Facebook Faculty Summit for improvements on CS courses in Data Structures and Algorithms. August 2019.

1. **Name: Manuel Rodriguez-Martinez**

2. Education – degree, discipline, institution, year

Degree	Institution
Ph.D. in Computer Science	University of Maryland, College Park, 2001
MS in Computer Science	University of Maryland, College Park, 1996
BS in Mathematics	University of Puerto Rico, Rio Piedras, 1994

3. Academic experience – institution, rank, title (chair, coordinator, etc. if appropriate), when (ex. 1990-1995), full time or part time

Institution	Title	Period	Type
University of Puerto Rico at Mayagüez	Associate Director, CSE Department	2019-2020	Full Time
University of Puerto Rico at Mayagüez	Associate Director, ECE Department	2015-2016	Full Time
University of Puerto Rico at Mayagüez	Professor	2012-Present	Full Time
University of Puerto Rico at Mayagüez	Associate Professor	2005-2012	Full Time
University of Puerto Rico at Mayagüez	Assistant Professor	2001-2015	Full Time

4. Non-academic experience – company or entity, title, brief description of position, when (ex. 1993-1999), full time or part time

Entity	Title	Brief Description	When	Type
Mobile Plus Cloud, LLC	CEO	CEO and consultant for small business IT firm	2013 –2016	Part-time

5. Certifications or professional registrations
   - Sequence Models Certification, Coursera, 2018
   - Improving Deep Neural Networks: Hyperparameter tuning, Regularization, and Optimization Certification, Coursera, 2017
   - Neural Networks and Deep Learning Certification, Coursera, 2017
   - Machine Learning Certification, Coursera, 2017

6. Current membership in professional organizations
   - Member of ACM from 1996 - present

7. Honors and awards

- 2005 NSF CAREER Award
- 2006-2007 Distinguished Professor of the UPRM Electrical and Computer Engineering
- 2015-2016 Distinguished Professor of the UPRM Electrical and Computer Engineering

8. Service activities (within and outside of the institution)

- Seminar *Beyond Academia: Maximizing Research Impact* **-** 02/12/2016, University of Puerto Rico, Mayaguez,
- Seminar *Big Data: A Bridge to Eliminate Health Disparities* – 04/01/2016, organized by the Puerto Rico Clinical and Translational Research Consortium, Marriot Courtyard Hotel, Isla Verde, PR
- Seminar *Accuracy and Time Efficient Mobile Application for Vehicle Crash Records: Preliminary Analysis*, Second Annual Symposium on Transportation Informatics, August 5-6, 2016, Arlington, VA
- NSF Panelist, Directorate of Engineering PFI:BIC Program
- NSF Panelist, Directorate of Engineering SBIR/STTR Program
- NSF Panelist, Directorate of Computer and Information Science and Engineering, MRI Program
- NSF Panelist, Office for Advanced Cyberinfrastructure, Campus Cyberinfrastructure Program
- External Referee ACM SIGMOD

9. Briefly list the most important publications and presentations from the past five years – title, co-authors if any, where published and/or presented, date of publication or presentation

NONE

- Manuel Rodriguez-Martinez, and Cristian Garzon, "Twitter Health Surveillance (THS) System", in Proc. Of 2018 IEEE Big Data Conference, Seattle, WA.
- M. Rodriguez-Martinez, "Experiences with the Twitter Health Surveillance System", 2017 IEEE Big Data Congress, Honolulu, HI.
- H. Martinez and M. Rodriguez-Martinez, "Cloud-based and Big data-enabled Brokerage System for Smart Grids", 2017 IEEE Big Data Congress, Honolulu, HI.
- M. Rodriguez-Martinez, E. O'Neil-Carrillo, M. Perez, F. Andrade, W. Rivera, A. Irizarry-Rivera, R. Rodriguez, C. Ortiz, and E. Lugo, "A Case for Open Access Smart Grids (OASIS)", IEEE SusTech 2016, Phoenix, AZ.
- W. Rivera and M. Rodriguez-Martinez. "Towards Cloud Services in Smart Power Grids." 2916 IEEE PES Innovative Smart Grid Technologies Conference, Melbourne, Australia.

10. Briefly list the most recent professional development activities

- Attended seminar "NIH Funding Strategies" by Dr. Susan Newcomer, retired NIH Program Director, held at University of Puerto Rico, Mayagüez, December 2018
- Taking online course "Convolutional Neural Networks", Coursera.

1. **Name: Marko Schütz-Schmuck**

2. Education – degree, discipline, institution, year

Degree	Institution
Ph.D. in Computer Science	Goethe University, Germany, 2001
MS in Computer Science	Goethe University, Germany, 1994

3. Academic experience – institution, rank, title (chair, coordinator, etc. if appropriate), when (ex. 1990-1995), full time or part time

Institution	Title	Period	F/P Time
University of Puerto Rico at Mayagüez	Professor	2007-present	Full Time
The University of the South Pacific	Senior Lecturer	2004-2007	Full Time
FH Darmstadt (now (H-DA)	Professor	2002-2004	Full Time
Goethe University, Frankfurt, Germany	Scientific Associate	1995-2001	Full Time
Freie University, Berlin, Germany	Scientific Associate	1995	Full Time

4. Non-academic experience – company or entity, title, brief description of position, when (ex. 1993-1999), full time or part time

Entity	Title	Brief Description	When	Type
CREATRON/FFP	Software Developer	Developed in C scripting language for multimedia production for CD-I	1992-1994	Full Time in 1992 Part Time in 1993-94
Agrar Data	Software Developer	Developed in C framework for acconting software	1988-1989	Full Time
EDV Bertung Dodt	Software Developer	Developed in C various components of the word processor TOPTEX	1986-1987	Part Time during semester, Full Time outside semesters
Data Processing Translations	Translator	Translated German industrial standards (DIN) form German to English	1985	Full Time

5. Certifications or professional registrations

NONE

6. Current membership in professional organizations
ACM since 1997

7. Honors and awards
NONE

8. Service activities (within and outside of the institution)

- Member of the Committee for the Quintennial Evaluation of the Master in Scientific Computation Program
- Member of the CISE PhD program committee
- Member of the Scientific Computation committee
- Member of the Computer Science committee
- Faculty sponsor of the student programming competition team
- Faculty sponsor of the ACM student chapter ACM-CS at UPRM
- Member of the ABET accreditation committee for the Bachelor in CS program
- Member of the Personnel Committee of the Department of Mathematics
- Member of the Personnel Committee of the Faculty of Arts and Sciences
- Member of the Curriculum Committee of the Department of Mathematics
- Member of the MSc qualifying exam committee
- Since 2013, I am the Executive Director of the ICPC UPRM Finals programming competition and in 2018 I was also the executive director of the ICPC Puerto Rico nationals
- Since 2013, I have been a judge for each of edition of the Interuniversity Programming Competition at the University of Puerto Rico at Bayamón

9. Briefly list the most important publications and presentations from the past five years – title, co-authors if any, where published and/or presented, date of publication or presentation

Marko Schütz-Schmuck. Modernizing the Introduction to Software Engineering Course. In Proc. of SACLA 2019. School of Computing, University of South Africa, July 2019. accepted for publication, presented at the 2019 SACLA conference.

10. Briefly list the most recent professional development activities
Attended six different ethics workshops.

1. **Name: Heidy Sierra-Gil**

2. Education – degree, discipline, institution, year

Degree	Institution
PhD in Electrical Engineering	Northeastern University, 2010
MS in Computer Engineering	University of Puerto Rico at Mayagüez, 2003
BS in Mathematics	Industrial University of Santander, 1998

3. Academic experience – institution, rank, title (chair, coordinator, etc. if appropriate), when (ex. 1990-1995), full time or part time

Institution	Title	Period	F/P Time
Rutgers University, New Jersey, USA	Postdoctoral Fellow	2010-2012	Full Time
Northeastern University	Teaching Assistant	2003-2008	Full Time

4. Non-academic experience – company or entity, title, brief description of position, when (ex. 1993-1999), full time or part time

Entity	Title	Brief Description	When	Type
MSKCC	Research Fellow	Development of imaging technology for health care.	2012-2014	Full Time
MSKCC	Research Scientist	Development of imaging technology for health care.	2015-2016	Full Time

5. Certifications or professional registrations
   NONE

6. Current membership in professional organizations
   Eta Kappa Nu ECE Honor Society, International Confocal Group (ICG), Optical Society of America (OSA), IEEE, International Society for Optics and Photonics (SPIE).

7. Honors and awards
   - Distinguished Professor of 2018 Award from the College of Engineering
   - NSF CAREER Award 2018
   - Invited speaker to the Symposium: Photonics, Medicine and the Environment, 2015 by the Puerto Rico Institute of Photonics (PRPI).
   - Selected speaker for the 7th NCIGT and NIH Image Guided Therapy Workshop, 2014, Boston, MA.

- Travel Grant Gordon Research Conferences Lasers in Medicine & Biology from Basic Science Discovery to Translational Applications, 2014 VT.
- Outstanding Teaching Award from the College of Engineering, Northeastern University, 2006

8. Service activities (within and outside of the institution)
- NSF Panelist during 2018 and 2019
- Reviewer of OSA- Optics Letters and Applied Optics
- Member of graduate committee of PhD. program of departments of ECE, BIOENGINEERING and CSE

9. Briefly list the most important publications and presentations from the past five years – title, co-authors if any, where published and/or presented, date of publication or presentation
- Fernando X. Arias, Heidy Sierra, Luis O. Jimenez-Rodriguez, Emmanuel Arzuaga, Supervised Sparse-Representation Classification of Hyperspectral Images with Linear Time Complexity, Journal of Applied Remote Sensing (JARS), 2019.
- Fernando X. Arias, Heidy Sierra, Emmanuel Arzuaga, A Framework for An Artificial Neural Network Enabled Single Pixel Hyperspectral Imager, Submitted to WHISPERS, 2019
- Navarrete-Dechent, Cristian et al. Reflectance confocal microscopy-guided carbon dioxide laser ablation of low-risk basal cell carcinomas: A prospective study, Journal of the American Academy of Dermatology, Volume 0, Issue 0, 2019.
- Fernando X. Arias, Heidy Sierra, Luis O. Jimenez-Rodriguez, Emmanuel Arzuaga, Supervised Sparse-Representation Classification on Hyperspectral Images Using the City-Block Distance to Improve Performance, IET International Conference on Pattern Recognition Systems (ICPRS17), Madrid, Spain, 2017.
- Heidy Sierra, Oriol Yélamos, Miguel A. Cordova, Chih-Shan Jason Chen, and Milind Rajadhyaksha "Reflectance confocal microscopy-guided laser ablation of basal cell carcinomas: initial clinical experience," Journal of Biomedical Optics 22(8), 085005 (23 August 2017).
- BP Hibler, O Yélamos, M Cordova, H Sierra, et. al., Handheld reflectance confocal microscopy to aid in the management of complex facial lentigo maligna, Cutis, 2017
- Fernando X. Arias, Fernando X. Arias, Heidy Sierra, Heidy Sierra, Emmanuel Arzuaga, Emmanuel Arzuaga, Classification performance of a block-compressive sensing algorithm for hyperspectral data processing, Proc. SPIE 9840, Algorithms and Technologies for Multispectral, Hyperspectral, and Ultraspectral Imagery XXII, 984005 (2016).
- A Joshi, H Sierra, E Arzuaga, American sign language translation using edge detection and cross correlation, in 2017 IEEE Colombian Conference on Communications and Computing (COLCOM), 2017.
- BP Hibler, H Sierra, M Cordova, W Phillips, et. al., Carbon dioxide laser ablation of basal cell carcinoma with visual guidance by reflectance confocal microscopy: a proof-of-principle pilot study, British Journal of Dermatology, 2016
- H. Sierra, K. Nehal, B. Hitbler, R. Rossi and M. Rajadhyaksha, “Confocal Imaging of Carbon Dioxide Laser-Ablated Basal Cell Carcinomas: An Ex-vivo Study on the Uptake

of Contrast Agent and Ablation Parameters", Journal of Lasers in Surgery and Medicine (2015).

10. Briefly list the most recent professional development activities
    - Assisted to the Facebook faculty summit July 2017
    - Assisted to CEP seminars
    - Assisted to Moodle seminars

1. **Name: Bienvenido Velez-Rivera**

2. Education – degree, discipline, institution, year

Degree	Institution
Ph.D. in Computer Science	Massachusetts Institute of Technology, 2000
MS in Computer Science	University of California, Berkeley, 1988
BS in Computer Science	Cornell University, New York, 1986

3. Academic experience – institution, rank, title (chair, coordinator, etc. if appropriate), when (ex. 1990-1995), full time or part time

Institution	Title	Period	F/P Time
University of Puerto Rico at Mayaguez, College of Engineering	Interim Dean	2019-Present	Full Time
University of Puerto Rico at Mayaguez, Dept. Computer Science and Engineering	Director/Associate Professor	2016-2019	Full Time
University of Puerto Rico at Mayagüez, Dept. Electrical and Computer Engineering	Associate Professor	2005-2015	Full Time
University of Puerto Rico at Mayagüez Dept. Electrical and Computer Engineering	Assistant Professor	2000-2005	Full Time

4. Non-academic experience – company or entity, title, brief description of position, when (ex. 1993-1999), full time or part time

Entity	Title	Brief Description	When	Type
Axiomatica, Inc., Mayagüez	Founder and CEO	Axiomatica, Inc. created 4 new Puerto Rican startups with a high development potential. A patent application for a technology and its business model was submitted.	2011-Present	Part Time
Phidelix Technologies, Inc., Mayagüez, PR	Founder/ President	A high-tech company which gave the opportunity in creating specialized and full-time jobs for engineers. In 2011 Phidelix became Axiomatica, Inc.	2005-2011	Part Time

5. Certifications or professional registrations: ABET Evaluator for Computer Science and Engineering Programs

6. Current membership in professional organizations: IEEE Computer Society, ACM

7. Honors and awards: NONE

8. Service activities (within and outside of the institution)

- Graduate and Undergraduate Student Training (2000 - present): Dr. Vélez-Rivera has mentored approximately 30 undergraduate researchers, 11 MS students, and 1 PhD student all from underrepresented minorities.
- Research mentor to approximately 10 graduate summer interns from HBCU's attending the MARC summer internship in Bioinformatics at the Pittsburgh Super Computing Center and Carnegie Mellon University
- For over 10 years lectured in Computer Science and Bioinformatics to faculty in sciences and engineering from approximately 10 HBCU's attending the MARC Summer workshop in Bioinformatics at the Pittsburgh Super Computing Center and Carnegie Mellon University.
- Founder and CEO of two software development startups in Mayagüez, Puerto Rico. The latest startup, Axiomatica Inc., is still operating and currently hires 5 full-time engineers, all UPR Mayagüez alumni, including 2 MS and 1 PhD. Axiomatica currently serves as the IT arm in four non-IT startups in diverse areas such as online learning, interactive online video services.
- Outreach programs and public service: Developed web-based software to support two university centers providing help to disadvantaged communities and students. The Community Development Center offers technical and social assistance to over 50 disadvantaged communities throughout Puerto Rico. The Center for Access helps high school students from poor communities gain access to a college education by offering them advice and motivation.

9. Briefly list the most important publications and presentations from the past five years – title, co-authors if any, where published and/or presented, date of publication or presentation

- Bengoa, David & Vélez, Bienvenido & others. "Development of an Educational Video Game for Industrial Engineering Freshman Students". Industrial and Systems Engineering research Conference. San Juan, PR. May 2013.
- León, Luis & Vélez, Bienvenido. "TouchMouse: A touch sensitive cursor to facilitate adaptation of mouse-based GUIs to touch screen technology". International Conference on Software Engineering Research and Practice SERP 2009. Las Vegas, Nevada. July 2009.
- Vélez, Ivan & Vélez, Bienvenido. "Lynx: An Open Architecture for Catalyzing the Deployment of Interactive Digital Government Workflow-Based Systems". 7th Annual International Conference on Digital Government Research (DG.O 2006). San Diego, California, USA. May 21-24, 2006.
- Velez, Ivan & Velez, Bienvenido. Lynx: An Open Email Extension for Workflow Systems Based on Web Services and its Application to Digital Government. IEEE International Conference on Internet and Web Applications and Services (ICIW'06). Guadeloupe, French Caribbean. February 23-25, 2006.
- Lizvette Malavé y Bienvenido Vélez. "TerraScope Image Clustering: Applying Clustering Techniques to Image Agglomeration in Image Retrieval Systems".

International Conference on Communications, Internet and Information Technology. Saint Thomas VI. November 2004.

10. Briefly list the most recent professional development activities

9 Learning Resources

9.1 Existing resources

The **General Library Collections** (http://www.upr.edu/biblioteca-rum/) holdings include: 736,088 volumes; 278,235 book volumes; 177,910 journals; 221,800 electronics journals; 8,896 electronic books; 69,705 microfiches; 386 microcards; 2,490 microfilms; 171,848 government documents; 3,545 films; 4,563 maps; 10,300 sound recordings; 442 musical scores; 508 sound magnetic tapes; 2,852 videocassettes; 3,467 CD/DVD; 4,881 theses; and access to millions of U.S. patents and trademarks.

Most of the library's electronic resources are available to registered students, faculty, and staff both on campus and remotely via the library website. General databases such as EBSCO Academic Search Complete and ProQuest Central provide access to a wide range of multidisciplinary full-text articles from scholarly journals, magazines and newspapers.

9.2 Core engineering collection

Although the available electronic collections have been seriously affected by the economic crisis that the University of Puerto Rico has been facing, there is still a minimal critical collection of current e-resources subscriptions relevant to SWE including:

- **ACM Digital Library** (journals, conference proceedings, magazines, and newsletters of the Association for Computing Machinery)
- **IEEE Xplore** (complete collection of journals, magazines, conference proceedings and limited collection of standards
- **IHS Intra/Spex** (includes access to a collection of standards from ASTM, ANSI-Construction, ANSI-Mechanical, ANSI-Information Systems, and ASCE)
- **Morgan and Claypool eBooks** (entire Synthesis Collections)
- **ScienceDirect** (Elsevier Freedom Collection)
- **SpringerLink** eBooks (General Engineering Collection)

In addition, the Library subscribes to e-journal collections published by the American Chemical Society (ACS), American Institute of Physics, American Mathematical Society (AMS), and Royal Society of Chemistry just to mention a few. Finally, two discovery platforms (index/abstract subscription databases) complete the core collection; these are Engineering Village (Elsevier IE) and SciFinder (CAS/American Chemical Society).

9.3 Staff

The Library staff includes 16 full-time librarians (faculty), 20 full- time classified employees, and 10 information technologies or other administrative support, all committed to assist the users in their information and research needs. Specifically, since 2007, Prof. Jaquelina Alvarez has been the Library Liaison to the College of Engineering, thus library representative to the Engineering Library Committee. Additionally, since 2016, Dr. Anidza Valentín began sharing the engineering liaison responsibilities. They have worked with engineering faculty in fostering the development of information literacy skills, attitudes and behaviors necessary to become independent lifelong learners. The partnership between library and faculty has been successful by creating specific assignment, offering customized tailor-made instruction sessions and workshops on a wide variety of topics such as: finding scholarly information, evaluating Internet resources, writing literature reviews, citing references and ethical issues related to academic integrity and plagiarism.

9.4 Facilities

The main library building has an area of 124,335 square feet, with a seating capacity of approximately 1,000. Its facilities includes: ten (10) individual study rooms for graduate students and faculty; eight (8) study rooms for group discussions and collaborative work; one (1) room for thesis defense or presentations; two (2) library instruction rooms (56 seats, 54 computers); one (1) Center to access Electronic Resources (75 seats, 75 computers); one (1) conference room (96 seats), and two (2) smaller meeting rooms (24, 11 seats). There are two (2) outdoors patios (Bibliopatios. 22 seats).

9.5 Graduate Services

The Graduate Research and Innovation Center (GRIC) is an initiative coordinated by Prof. Jaquelina Alvarez. The GRIC, located in the General Library, is a creative and flexible space to foster collaboration and innovation, where graduate students and faculty can meet to develop projects and receive specialized assistance. It is a centralized space where all campus graduate students and faculty can gather research resources needed to carry out their projects and receive guidance from librarians and writing tutors. The GRIC mission is to facilitate research services and support graduate education at the UPRM. To accomplish this goal, the GRIC (a) supports the research and innovation ecosystem across the entire scholarly lifecycle; (b) provides a holistic suite of services in which students can be referred to specialists with the proper subject, technology, or content development expertise; (c) delivers a robust technological infrastructure to support interdisciplinary and interactive collaborations; and (d) supports graduate students' and faculty needs as creators of new knowledge. The newly (opened on September 1, 2016) created GRIC facilities include:

1. A multi-purpose commons designed as open space to promote the exchange of ideas, interactions between peers and the development of innovative initiatives. It can function as an extension of the conference room.

2. Three small rooms (hubs) with moveable ergonomic furniture and cutting-edge technology for Apple or Windows PC's that can be transformed to support the needs of each team.

3. A conference/multiuse room tailored to offer seminars, workshops and other educational activities. This area is also open to graduate students, professors and researchers who may adapt the facilities and technologies to meet their needs.

The research lifecycle has been defined as the core competences of GRIC. Its recently created services include three Graduate Writing Facilitators that offer personalized support in oral and written academic communication. Consultation on data management plans, preservation of paper or electronic research documents, deposit in the institutional digital repository, among others, are some of the services offered by five librarians. Faculty, researchers and graduate students have access to two online platforms to promote academic integrity: Turnitin and Ithenticate.

In addition to space, GRIC offers a variety of technologies such as dedicated Wi-Fi, data ports, scanners, tablets, monitors of different sizes to visualize data or work collaboratively, video conference systems and access to UPRM Virtual Lab (Visual Studio, MATLAB, ArcGIS, SAS & Minitab).
Finally, visitors have access to databases such as JSTOR and can print writing style manuals such as MLA, APA (Spanish & English), ACS, Chicago & CSE.

The GRIC services include Graduate Writing Facilitators (GWF). The GWFs are graduate students from different disciplines (currently from the English, civil engineering and biology departments) to support other campus graduate students' scholarly English communication needs (oral and written). The services include:

a) Support in the development of ideas and outlines for writing drafts (pre-writing).
b) Assistance in the revision and editing of academic work in English, such as: articles, proposals, abstracts, posters, personal essays, theses, dissertations, resumes and curriculum vitae.
c) Mentoring and support in oral communication in English through practice sessions, in preparation for professional interviews, academic presentations, talks, workshops, seminars, speeches, thesis and dissertations oral exams.
d) Individual peer tutoring sessions to review graduate students' scholarly/professional work in English with attention to grammar, style, tone, audience, reference style, organization, structure, lexicon, etc.
e) Writing Clinics and workshops scheduled to be offered during the academic year covering a wide array of topics, such as: the academic writing process, preparing academic abstracts, literature review, references and citations in academic writing, preparation of posters, tone and audience in scientific writing.

The available GRIC technology includes the necessary multi-purpose equipment and other technologies for educational, instructional, consulting, assessment, and collaborative work, including: both PC and Mac public workstations, media:scape by Steelcase, two 55" monitors, an 80" interactive board, 80" monitor, wePresent System, sound systems, two FUJITSU Image Scanner ScanSnap SV600, two Lenovo Yoga Home 900 All In One (large tablets), two Logitech

ConferenceCam Connect, and a monitor LG 35". Soon to arrive: 25 laptops and 4 Macintosh computers.

10 Physical Facilities and Equipment for Research and Education

10.1 Office Space

The CSE Department headquarters occupies 1,500 square feet for various administrative and support functions. This space is located in room S-220 in the Luis Stefani Building. Additionally, approximately 1,200 square feet are dedicated to 10 faculty offices. Most faculty offices are located in the Luis Stefani Building and a small number in the Faculty Offices Building.

Faculty offices vary in size, but the smallest has 120 square feet. All offices have telephones, internet connections, a computer or laptop, at least one desk, and a couple of chairs for the professors and the students during office hours. Some faculty offices also include a whiteboard, an individual printer, and extra tables depending on the available space. The faculty has a lounge and a meeting area in both buildings holding the faculty offices.

10.2 Classrooms

Classroom space is shared with the Electrical and Computer Engineering Department. Most lecture courses are offered in rooms S-203 to 207, and S-227 to S-229. Classrooms in the first group occupy an area of 473 square feet each and can accommodate up to 23 students while those in the second group occupy an area of 888 square feet each and can serve up to 45 students in the first two classrooms, and 38 in the third. S-227 is a classroom fully equipped for teleconference. The consolidated classroom area is 5,029 square feet in 8 classrooms. All classrooms have whiteboards, overhead projectors, and ceiling-mounted data display projectors. The department also owns four spare data display projectors that can be used by professors for their lectures, conferences, or educational activities outside the campus. All classrooms are air-conditioned.

For large groups, the Luis Stefani building auditorium with capacity of 150 students (S-113) is used when needed. It includes an amplified audio system and a ceiling-mounted data display projector. This room is mainly used for departmental tests in the evenings, and in occasions to accommodate mega-section courses, i.e. course sections with more than 45 students. This auditorium is also used for some of the shared workshops and student presentations for the capstone courses in Computer Engineering and Electrical Engineering programs. In all these areas wireless Internet connection is available for all the students. For courses with intermediate size (between 50 and 80 students), we can use the second auditorium located in room S-230. It includes a ceiling-mounted data display projector, and two white boards. This room is mainly used for industrial information sessions, and to teach large sections.

10.3 Instructional Computer Labs

The CSE Department has access to the Amadeus Laboratory (shared with the ECE Department), which is used for teaching courses and laboratory sessions for the courses CIIC 3011, CIIC 4010, CIIC 4020, and CIIC 4050. This laboratory is also available to support laboratory work for any other course that requires it. It consists of:

- 30 Dell OptiPlex 7070 minitowers with Intel Core i7 CPU, 32 GB of RAM, 512 GB SD, 1 Gbps Ethernet Card, and Dell 24 in monitor.
- 1 Short Range projector

Two additional computer labs with similar capacities to those the Amadeus Laboratory - INCADEL and CRAI - are used by our students and faculty for laboratory sessions as the need arises. These are also shared with the ECE department.

All these lab facilities are open 24 hours. When not in use on a laboratory session, students from our department, as well as those from the ECE department, have access to those facilities to work in course related activities. Students have access through personal electronic keys that they can acquired once they become students in one of the two departments. These lab facilities are also protected by security cameras.

In the Fall of 2021, we finished the process of adding an additional computer laboratory with similar capacities as the Amadeus Lab. This facility is located at room S-114A and has been substantially supported by a recent donation from Chevron Corporation, and with other institutional funds.

10.4 Distance Learning Platform

UPRM relies on the UPR **online.upr.edu** platform for the delivery of distance learning courses, and to complement face-to-face courses. This platform is based on Moodle, an open-source, on-line learning platform. According to the Moodle web site[12] it is a "*learning platform designed to provide educators, administrators and learners with a* ***single robust, secure and integrated system*** *to create personalised learning environments*." The online.upr.edu platform is managed by the UPR Central Administration. Currently, most courses in the CSE Department rely on online.upr.edu to provide access to students for lectures slides, lecture videos, homework, quizzes, exams, and other educational activities. This includes face-to-face courses, hybrid courses, and distance courses for the undergraduate Software Engineering Program, undergraduate Computer Science and Engineering Program, and the Doctoral Program in Computer and Information Science and Engineering (CISE). The Faculty of the CSE Department have been trained as on-line educators, mostly through the CREAD Division at UPRM. The CSE Department has several courses that are offered in the hybrid (H) or distance (D) modality. Moreover, most programming courses (even those face-to-face) rely on online.upr.edu for:

1. Delivery of laboratory session where programming exercises are performed.
2. Delivery of homework where programming exercises are performed.
3. Delivery of mid-term exams where programming exercises are performed.

Moodle plug-ins such as JavaUnitTest and CodeRunner are used to help grading the all these programming exercises.

[12] https://docs.moodle.org/311/en/About_Moodle

More complicated term-projects or multi-stage programming projects are submitted, revised and graded using online source control tools, specifically GitHub Classroom[13] and GitLab[14]. Both of these platforms are free to use for educational purposes.

Synchronous lectures and virtual office hours for these courses are managed with one of the following collaboration tools:

1. Microsoft Teams
2. Google Meet
3. Zoom

The online.upr.edu has several tools to manage submission of works and to verify for student academic dishonesty. These include Turnitin and Respondus.

These aforementioned technologies are sufficient for the faculty of the SWE Graduate Program to deliver course in face-to-face, hybrid, and distance modalities. Hence, the SWE Graduate Program can be delivered to student in two modalities:

1. **On-campus**: Students take their courses offered in the traditional face-to-face style in a classroom.

2. **On-line**: Students take their courses offered in the hybrid mode (H) or distance mode (D), as defined by certification 19-85 of the UPRM Academic Senate.

10.5 Other Campus-wide Educational Resources

The UPRM has several computing resources available for students and faculty, including a new 10gb connection to the main UPR-AC and to Internet2, a Wireless Network for the use of the students named RUMNET, this can be divided in various Wireless Networks around the Campus, (i.e. RUMNETCE, RUMNETFISH, RUMNETBIB, etc.). Students can use the WIFI access with a password. It is expected to implement in the near future, access to the WIFI networks using the campus email id. Also, the Science Network (Scinet 10gb network) is available for graduate and undergraduate researchers for high performance data. Finally, the Virtual Computing Lab (VCL) is a cloud technology service for students and professors. In VCL, users login with their UPR credentials to access available computational resources. More information about VCL can be provided upon request by the program evaluators.

Other UPRM campus tools and software available for students include, Moodle, Microsoft Office 365, Arc GIS and Minitab:

1. Moodle is an open source and free Learning Management System provides faculty an online environment to upload class material for their courses. Faculty can upload course

[13] GitHub Classroom - https://classroom.github.com
[14] GitLab - https://gitlab.com/

syllabus, presentations, exams, assignments or any link o material to complement the course goals. Moodle is also use for online or hybrid courses.

2. Microsoft Office 365 is a subscription service that includes access to MS Office applications and online productivity services. UPR students have access to download and install to Office 365 software suite in their personal computers, and the use the available online services.
3. ArcGIS, Esri ArgGIS Unlimited Educational Site License, allows UPRM students and faculty to use the geographic information system ArcGIS or ArcMAP in their research. The service can be used in laboratory and faculty offices with a license server validation, and for student personal computers using an EVA key. ESRI also provides online services.
4. Minitab unlimited license allows UPRM Campus community to use, for academic purposes, the tools included in this software at the Mayagüez campus computers using a license server validation, as well as through students and faculty personal computers.
5. Microsoft Imagine Premium subscription provides students with software design and development tools free of charge. Using UPR credentials students and professors can access, the Microsoft Azure Dev Tools for Teaching.

10.6 Research Facilities

The following facilities are available to support the research efforts associated with the program:

Advanced Data Management Laboratory (CID Building) – The Advanced Data Management Lab (ADMLab) is a laboratory that we have organized to provide support for all data management projects. The ADMLab has approximately 800 sq.ft. of space to host student desks, demonstration areas, machine room, and a meeting area.

Parallel and Distributed Computing Laboratory (CID Building) – The Parallel and Distributed Computing Laboratory (PDCLab) is a laboratory that we have organized to provide support for all parallel, distributed, and grid computing projects. The PDCLab has approximately 500 sq.ft. of space to host student desks, teleconference area, and a meeting area.

Laboratory for Applied Remote Sensing and Imaging and Photonics (LARSIP) (***CID Building***)- is a multidisciplinary laboratory dedicated to the research and implementation of Remote Sensing, Hyperspectral Image Processing, Signal and Image Processing, Geographical Information Systems (GIS), Emergency Response Systems, Global Positioning Systems (GPS) technologies, Applied Electromagnetics and Bio-Optics.

Computational Optics and Photonics Laboratory (COPLa) (***CID Building***) – This research laboratory focuses on interdisciplinary research that integrates fundamental knowledge in optical, signal processing, and computer science with targeted application to biomedical imaging and remote sensing. Research activities include to work with optical microscopes, spectral and commercial imaging instrumentation, compressed sensing and machine learning algorithms. The laboratory provides a testbed to train the workforce in imaging systems design and algorithm development for data acquisition, analysis and visualization.

10.7 Currently Available Research Equipment

UPRM SciNet (Campus Wide): The UPRM 10Gbps Science DMZ, known as UPRM SciNet, became operational in the summer of 2015 and interconnect five (5) buildings across campus, to expose our Cyberinfrastructure capabilities to the outside world via Internet 2. These buildings are home to our research groups in Gene Sequencing, High Energy Physics, Computational Chemistry, Oceanography, Fluid Mechanics, Networking, and Big Data Analytics. SciNet will enable these groups to share their data sets, equipment, and clusters, thus enhancing our ability to insert ourselves into national research initiatives. The Science DMZ (http://fasterdata.es.net/science-dmz/) is a firewall-less network that can sustain high-speed data transfers (e.g., 10 Gbps) between nodes within the DMZ. It provides a highly scalable medium for the secure exchange of scientific data, and the interconnection of cluster and/or cloud computing platforms. All security gets enforced at the communication end-points (e.g., data servers) of the network. Our faculty acquired this equipment through a competitive grant from the National Science Foundation (NSF) – Award #: ACI-1440552.

UPRM Voyager Cluster (L. Stefani Blgd): This new computational facility enables our research teams to conduct state-of-the-art work in Artificial Intelligence (AI), Big Data Analytics, Computational Chemistry, Bioinformatics, Statistical Analysis, Computational Physics, and other related fields.

The cluster is organized along three service types:

- **Compute Nodes** – 32 compute nodes, each having: 2 CPUs and 24 cores, 192GB of RAM, 2 TB of local store, 2x10Gbps NiC, and InfiniBand interconnection.
- **GPU Nodes** - 12 GPU nodes with 2 CPUs and 24 cores, 192 GB of RAM, 2 x NVIDIA Tesla V100 GPU – 32 GB RAM, 4 TB of storage, and 2x10Gbps NiC.
- **Big Data Nodes** - 10 high-memory nodes 2 CPUs and 24 cores, 384GB of RAM, 2 TB of local store, and 2x10Gbps NiC.

The cluster runs Ubuntu Linux and is managed with the OpenStack platform.

UPRM Private Cloud, known as Virtual Computing Laboratory (CTI Bldg)*:* This cloud is built atop : 1) an IBM Blade Center HX5, with 40 computing cores, each capable of two parallel execution threads, and 512 Gigabytes of RAM memory, 2) 15 IBM Blade Center HS23 with 16 computing cores and 120 GB of ram, and 3) one IBM StorWise 7000 with 10 TB of storage capacity.

UPRM Lockheed Martin private cloud facility (L. Stefani Bldg.) : This cloud runs Ubuntu Linux 12.04 LTS and Open Stack private cloud software. It has the following hardware:

- 12 (twelve) Dell Power Edge R420 with Intel Xeon Quad Core CPU, 8 GB RAM, 1TB disk, and 1Gbps NiC.

EECS Experimental Cloud (CID Bldg.): The experimental cloud facility consists of ten (10) machines forming a cloud with the ability to build 40 VMs. The machines run Ubuntu 12.04 LTS and both Eucalyptus and OpenStack private cloud software. Each machine was custom assembled featuring:

- AMD Phenom II Quad Core CPU, 8 GB RAM, 1Gbps NiC, and 2x500 GB disk.

10.8 Plans for expansion and improvement

The CSE Department is constantly monitoring its laboratory infrastructure to guarantee the proper maintenance, and the needs for upgrade or enhancement to support the SWE Graduate Program. A full-time staff of three computer and communications technicians are in charge of all the computing labs that are used by our students, the computer network infrastructure, and the centralized facilities that hosts computer servers and storage. They are responsible to constantly monitor the computer and network equipment, as well as the software systems. They are the first line of support whenever some malfunction is identified by users of these systems. Among their main duties and responsibilities, we can list the following:

- Give support to students and faculty in solving problems with the equipment in lab facilities or with the use/configuration of specialized software.
- They keep our systems up to date in the different software components that are installed.
- Contact vendors or service providers should the need arise to repair equipment that is still under some warranty.
- Inform the department of any need that requires actions from the department to make available funds to work on it; which may include to purchase new additional equipment or to replace existing one, to acquire new software, to renew software licenses or maintenance contracts, etc.
- Work with the department on strategies to enhance and upgrade our computer labs.
- Contact different vendors for quotations when new purchases are in progress.

When the need arises for a purchase, the department works on the identification of funds to support that. Different sources of funds are available for us to cover the cost that such purchases may imply. These are described under the section for Criterion 8 – Institutional Support.

Faculty members also contribute with money from their grants to support some laboratory miscellaneous supplies. Whenever the budget is not enough for supporting the enhancement or maintenance petitions, the budget to cover the need is added to the following cycle. Every three to five years the university administration assigns money in the budget to replace computers, and other obsolete equipment. Petitions for equipment for new research laboratories are submitted separately and are usually initiated by a donation or NSF Major Research Instrumentation (MRI) proposal. Donations from external sources are also used to improve our lab facilities and capacities. This is the case of the new academic computer lab that is in the process of being established in room Luis Stefani S-114A, which was furnished thanks to a donation from the Chevron Corporation.

10.9 Practice Centers

Does not apply.

11 Administration

The Department of Computer Science and Engineering at UPRM will administer the Graduate Program in Software Engineering (SWE). The administrative structure, regulations, and decision-making instances for the SWE Program are those specified in sections C, D and E of Certification 09-09 of the Academic Senate of the University of Puerto Rico at Mayaguez, as amended in March 17th, 2015 by Certification 15-21.

11.1 Departmental Leadership

The CSE Department is led by a Departmental Director which serves as its executive official, and supervisor of all faculty and staff members. The Director is assisted by an Associate Director, which serves the role of deputy director and second in command. Currently, the position of Departmental Director is held by Dr. Pedro I. Rivera Vega, and the Associated Director is Dr. Emmanuel Arzuaga Cruz.

11.2 Graduate Committee

The implementation of Section C of Certification 09-09 of the UPRM Academic Senate will be done with the **Software Engineering Graduate Committee**. The SWE Graduate Committee will handle all academic and administrative matters of the program, with clerical support provided by the staff of the CSE Department. The SWE Graduate Committee shall consist of at least three (3) members, all of which must be faculty members of the CSE Department. Each member will serve a three (3) year term, and can be re-elected once. Election of members shall happen in a duly convened CSE Departmental meeting. In order to guarantee stability and experience within the SWE Graduate Committee, the first time the SWE Committee is elected, two of its members will serve a two-year term, while the third one will serve a three-year term. This choice of terms will be done at random by the Chairman of the CSE Department. This arrangement will help ensure that not all committee members are replaced at the same time, and there will always be an experienced member in the committee. The CSE Department might change the number of members in the SWE Graduate Committee. This can be done by direct vote of the faculty members in a duly convened Departmental Meeting. Changes will be informed to the Dean of Engineering, the Director of Graduate Studies, and the UPRM Dean of Academic Affairs.

The members of the SWE Graduate Committee will choose one of its members as the President of the Committee. The SWE Graduate Committee shall establish a set of regular meetings throughout the semester to attend all businesses related with the SWE Graduate Program. All matters related with admissions, special exams, courses, or any other the issue related with the program shall be communicated by the President of the SWE Graduate Committee to the CSE Associate Director.

11.3 Staff Support

Direct clerical support for the program will be delivered by means of our existing Administrative Assistant position, currently held by Mrs. Lymari Arzola. This position also supports other programs of the CSE Department**.**

12 Student Services and Assistantships

The institution supports every program with teaching assistants and graders to support teaching. However, this is primarily done with the larger class sections (>35 students). Also, courses that have a laboratory as part of it (for example: CIIC 4010, CIIC 4020, and CIIC 4050) are assigned TAs, which take care of one or two sections of laboratories. Each of those laboratory sections groups at most 30 students.

Teaching is supported with workshops conducted every semester by the institution's Center for Professional Enrichment ("Centro de Enriquecimiento Profesional", CEP in Spanish). Their seminars and workshops cover all aspects of teaching and research for faculty and graduate students who are working as graders and teaching assistants. Faculty and graduate students that are involved in teaching (e.g., teaching assistants) must complete 30 hours of training within their first few years of hiring. Faculty evaluated for promotion often use additional training to improve their teaching skills and overall performance.

As a result of teaching demands posed by the baccalaureates in Computer Science and Engineering, and in Software Engineering, it is expected that 4 to 6 Teaching Assistantships will be available to support students enrolled in the program. Additional research assistantships will be available through externally funded research projects. Table 18 shows that the CSE Faculty has been able to obtain $2.7M in external funds. These funds will be used to pay for research assistantships for eligible graduate students.

Table 18: CSE Faculty funded projects over the past six years

PI/Co-PI	Title	Agency/ Company	Funds	Period
Bienvenido Vélez	Effective teaching of Computer Science (CS) in rural economically challenged communities in Puerto Rico	PR Science Trust	$70,000	9/1/19-8/31/20
Bienvenido Vélez	Google4HS: Creating a Networked Community for Improvement of Computer Science Teaching in Puerto Rico High Schools	Google	$25,000	1/5/18-4/30/9
Heidy Sierra (PI)	CAREER: Computational Optics and Photonics for Deep Imaging of Live Tissue	NSF	$498, 905	5/1/18-4/30/23
Emmanuel Arzuaga (PI)	DCP: Improving Virtualized Data Center Resource Efficiency Using Dynamic Container Placement Strategies,	DoD	$320, 634	5/8/19-5/7/22
Emmanuel Arzuaga (Co-PI)	MRI: Development of a Real-world Microgrid Simulation/Testing Instrument	NSF	$355,640	9/19/18-9/18/20
Emmanuel Arzuaga (PI)	RAPID: Resilience Assessment for Communications right after Emergencies/Disasters (RACE)	NSF	$128,936	2/1/18-1/31/19
Kejie Lu (PI)	CI-New: Collaborative Research: Developing an Open Networked Airborne Computing Platform	NSF	$242,451	9/1/17-8/31/20
Manuel Rodriguez (PI)	R15 THS: Using Twitter and Big Data Analytics to Track and Predict Health Conditions	NIH	$359,367	9/15/15-5/1/20
Manuel Rodriguez (PI)	CRISP Type 2: Interdependent Electric and Cloud Services for Sustainable, Reliable, and Open Smart Grids	NSF	$1,499,998	9/15/15-8/31/19
Manuel Rodriguez (PI)	CC*IIE Networking Infrastructure: SciNet: A ScienceDMZ for Science and Engineering Research at University of Puerto Rico Mayaguez	NSF	$499,995	9/1/14-8/31/16

Total Funds: $2,693,084

13 Catalog Information and Promotion strategies

13.1 Catalog Information

The Department of Computer Science and Engineering offers a Graduate Program in Software Engineering with the following degree options:

- Master of Science (MS) in Software Engineering
- Master of Engineering (ME) in Software Engineering
- Doctor of Philosophy (PhD) in Software Engineering

The general admission requirements are established by the Graduate Studies Office. In addition, students must have a Bachelor's degree in Software Engineering, Computer Science and Engineering, Computer Science, Computer Engineering, or closely related fields to be admitted to the program. Students must have undergraduate courses in: 1) Software Engineering, 2) Database Systems, 3) Operating Systems, and 4) Probability and Statistics. Students who do not meet these course requirements may be admitted on a provisional basis until deficiencies are met.

The **Master in Software Engineering (SWE**) degree is intended for students who have earned a bachelor degree in Software Engineering, Computer Science and Engineering, Computer Science, Computer Engineering, or closely related fields. It aims at providing students with advanced knowledge in Software Engineering in areas of program design, testing, maintenance, production deployment, monitoring, secure software engineering, software protection, and data engineering. Students shall acquire high order skills for software analysis, and an ability to contribute effectively to the solution of complex problems through the development of software artifacts for production use. The Master's degree has a total of thirty (30) credits, and should be completed within two (2) years upon obtaining the bachelor degree.

To achieve the Program aims, all students enrolled in the Master's in SWE must pass three (3) core graduate courses (9 credits):

1) Software Engineering Principles
2) Database Systems Engineering
3) Secure Software Engineering

In addition, students enrolled in the MS degree must specialize by completing the following:

- Nine (9) credits in elective graduate courses within the SWE Graduate Program.
- Six (6) credits in elective graduate courses outside of the SWE Graduate Program.
- One of the following:
    - Plan I – Master's of Science Degree: six (6) credits in Master's Thesis
    - Plan II – Master's of Engineering Degree: six (6) credits in Master's Project
    - Plan III – Master's of Engineering Degree: six (6) credits in additional elective courses within the SWE Graduate program.

The **PhD in Software Engineering (SWE)** is a research training degree conceived as a research-oriented graduate experience when compared to the Master in SWE, with an emphasis on conducting *state-of-the-art research endeavors* (as opposed to completing extensive course sequences). Similar to the Master in SWE, it aims at providing students with advanced knowledge in Software Engineering in areas of program design, testing, maintenance, production deployment, monitoring, secure software engineering, software protection, and data engineering. But being a research training degree, the additional educational activities of the PhD in SWE emphasize on the development of skills that are necessary to conduct research, and on the actual production of a high-quality scholarly work on the frontier of knowledge and technology in Software Engineering. Students admitted to the PhD in Software Engineering must have earned a Bachelor's or Master's degree in Software Engineering, Computer Science and Engineering, Computer Science, Computer Engineering, or closely related fields. The PhD degree has a total of fifty-four (54) credits, and should be completed in four (4) years by those students that are accepted with a bachelor degree, or in two (2) years by those students that are accepted with a Master in SWE.

The PhD coursework sequence shares the same three (3) core graduate courses (9 credits) as the Master in SWE:

1) Software Engineering Principles
2) Database Systems Engineering
3) Secure Software Engineering

In addition, students enrolled in the PhD in SWE must specialize by completing the following:

- Fifteen (15) credits in elective graduate courses within the SWE Graduate Program.
- Six (6) credits in elective graduate courses outside the SWE Graduate Program.
- Three (3) credits on an Advanced Topics in SWE course.
- Three (3) credits on a Doctoral Seminar.
- Eighteen (18) credits in Doctoral Dissertation Research.
- PhD Qualifying Examination.
- PhD Candidacy Examination.
- Publication of a peer-reviewed scientific article.
- PhD Dissertation Defense Examination.

Thus, the PhD in SWE is awarded to candidates whose dissertation is based on extensive and original research in their chosen field within SWE. The Student's Graduate Committee will approve the peer-reviewed publication, based on the particular characteristics of the research topic within SWE. The student must be the first author of the peer-reviewed publication and the later must be directly derived with the student's dissertation.

13.2 Promotion

The SWE Graduate Program will be announced in the website of the Department of Computer Science and Engineering, in the page of the Office of Graduate Studies of the University of Puerto Rico at Mayaguez, and in local Graduate Fairs. Informative sessions targeted to undergraduate

students of Computer Science and Engineering, Software Engineering, Computer Engineering, and Computer Science will be organized once a semester.

14 Budget Plan

14.1 Administration Costs

No extra funds are requested for administration; all administration costs of the program will be covered with the recurrent budget of the Department of Computer Science and Engineering (CSE). Direct clerical support for the program will be delivered by means of our existing staff, in particular our Administrative Assistant position, currently held by Mrs. Lymari Arzola. This position also supports the CISE PhD Program**.**

The implementation of Section C of Certification 09-09 of the UPRM Academic Senate will be done with the **Software Engineering Graduate Committee**. The SWE Graduate Committee will handle all academic and administrative matters of the program, with clerical support provided by the staff of the CSE Department. The SWE Graduate Committee shall consist of at least three (3) members, all of which must be faculty members of the CSE Department. Participation in this Committee will be counted as part of the regular committee duties of the faculty members.

14.2 Faculty Costs

The SWE Graduate Program requires the courses shown in Table 19 and Table 20 to be taught each year:

Table 19: Maximum Credits Required During Fall Terms

Course Code	Name	Credits
INSO 6005	Software Engineering Principles	3
INSO 6006	Database Systems Engineering	3
INSO 8996	Doctoral Research Seminar	3
INSO 6---	Elective Course in SWE	3
INSO 6---	Elective Course in SWE	3
	Total Credits Required	**15**

Table 20: Maximum Credits Required During Spring Terms

Course Code	Name	Credits
INSO 6007	Secure Software Engineering	3
INSO 8995	Advanced Topics	3
INSO 6---	Elective Course in SWE	3
INSO 6---	Elective Course in SWE	3
INSO 6---	Elective Course in SWE	3
	Total Credits Required	**15**

As we can see from Table 19 and Table 20, running the SWE Graduate Program requires **15 credits** in regular graduate courses per semester, whether it is the Fall semester, or the Spring semester. This number is a worst-case scenario, as it might be the case that some of the existing

5000-level courses currently being offered by the CSE Department are taken by the graduate students. Nonetheless, we shall continue using this 15-credit figure for the remainder of this presentation. In this analysis, we do not include the Master's thesis, Master's projects, or Doctoral dissertation courses because these courses are normally part of the research release time, or research buy-out time that CSE faculty members are assigned in order to execute their research projects and supervise the graduate students in those projects.

With the 15-credit per semester figure in hand, we can map this number to the Faculty Time Equivalent (**FTE**) figure that indicates the number of faculty members needed to run the program. The regular teaching load per faculty member at UPRM is 12 credits per semester, and this figure is equivalent to one (1) FTE. Hence, the SWE Graduate Program requires 1.25 FTE, in steady state, to cover all the courses in the program. There is a simple option to cover this FTE need:

- Hire three assistant professors that are 50% devoted to teaching and 50% devoted to research. These new hires represent 18 credits in teaching load and can cover all 15 credits in SWE Graduate courses. The remaining 3 credits in teaching load can be used to support other programs as needed.

The CSE Department can successfully accommodate and implement this option within its current faculty hiring plan and available faculty resources. During the Fall of 2021, the CSE Department hired Dr. Abdelrahman Ahmed ElSaid to a faculty position associated with the NSF Center for the Advancement of Wearable Technologies (CAWT). The CSE Department is a key partner in this research center, with the following participants:

1. Dr. Manuel Rodriguez-Martinez – Co-leader and researcher with the Interdisciplinary Research Group (IRG 3).
2. Dr. Emmanuel Arzuaga-Cruz – Researcher with the Interdisciplinary Research Group (IRG 3).
3. Dr. Heidy Sierra-Gil – Researcher with the Interdisciplinary Research Group (IRG 3), and liaison between IRG3 and IRG1.
4. Dr. Abdelrahman Ahmed ElSaid– Researcher with the Interdisciplinary Research Group (IRG 3).

In the Fall of 2022, Dr. ElSaid resigned his position at UPRM due to personal reasons. His faculty position is been re-hired in the 2022-2023 academic year and count towards the existing CSE Department Budget. In addition, and as part of the *Programmatic Terms and Conditions* between and NSF and UPR, the President of UPR has **committed** to **authorize two new** additional hires in the CSE Department to support the research efforts of the CAWT project. Thus, a total of three faculty members will be available to support the CAWT project. These faculty members could initially focus their faculty teaching efforts on teaching the SWE Graduate Efforts. Alternatively, the new hires can balance their load with graduate and undergraduate courses, while existing professors can also teach graduate and undergraduate courses. **The new FTE available with these hires provide the means to cover the teaching load required by the SWE Graduate Program**.

Table 21: CSE Faculty Hiring Plan for CAWT Project

Faculty Hire	Recruitment Year	Start Year	Rank	Salary	Salary + Benefits
Faculty #1	2022-2023	2023	Assistant Professor	$70,548.00	$ 95,980.15
Faculty #2	2022-2023	2023	Assistant Professor	$70,548.00	$ 95,980.15
				Total Faculty Costs	**$ 191,960.30**

Table 21 shows the hiring schedule and costs for the two new CAWT faculty hires that count towards the 2023-2024 fiscal year budget. As we can see from the table, the SWE Graduate Programs **costs** $191, 960.30 in new expenditures. This figure includes salary, health insurance, Christmas Bonus, and the other required fringe benefits (e.g., unemployment compensation). However, as we mentioned before, the President of UPR has committed to authorize these additional hires in the CSE Department to support the CAWT project. This is part of the 3% faculty hiring plan that the Puerto Rico Financial Oversight and Management Board (FOMB) (established under the PROMESA Federal Law) authorized for UPR. We launched the hiring search for the Faculty #1 during the month of February 2022, under faculty announcement number 22-01. The link for the announcement can be found at:

https://www.uprm.edu/empleos/2022/01/28/22-01-ciencia-e-ing-computacion-espan%cc%83ol/

Faculty #2 is also being hired and the link for the announcement 22-24 can be found at:

https://www.uprm.edu/empleos/2022/09/16/22-24es/

14.3 Program Incomes

The major source of income for the program is external. Funds for research in CSE are available on competitive basis from federal agencies. Table 18 showed the funded projects of the faculty of the CSE Department over the past five years. As we can see from the table, the total of amount of funding is roughly $2, 694, 000. These funds support researchers, equipment purchases, materials, travel expenses, and provide assistantships to graduate students. The SWE graduate program will also seek industry contributions.

15 Evaluation Plan

The evaluation of the Graduate Program in Software Engineering is an integral part of its administration. An annual evaluation plan (AEP), centered on assessing the expected yearly performance and results, is the base evaluation exercise of the program. This exercise in turn, is the basis for continuous improvement. The AEP articulates an explicit list of expected annual outcomes together with their quantitative and qualitative performance measures, the activities to be conducted towards their achievement and the human, physical and financial resources required for carrying them out. The AEP is guided by the strategic objectives and five-year aims described in Section 5.2 and are disseminated before the start of each academic year. The details of the plans are presented in Table 22, Table 23, and Table 24.

Table 22: SWE Annual Evaluation Plan: Aims and objectives

Output	Indicator	Baseline measurements	Target	Data collection frequency	Measurement tools
5.2.1 Applications / Acceptance	Number of Applicants And Accepted Applicants	None	MS/ME: 25-15 PhD: 20-10	Yearly	Applications submitted by Office of Graduate Studies, New enrollments
5.2.2 Retention	Retention and Graduation Rate	None	MS/ME: 10-7 PhD: 8-6	Yearly	Student counts
5.2.3 Network	Number of External Collaborators	5	10	Yearly	Committee members in Study Plans, co-authors and co-PI in proposals
5.2.4 Recognition	Number of Peer-reviewed publications related to dissertations, masters projects or master thesis	None	4	Yearly	Counts conducted by the SWE Graduate Committee
5.2.5 Assessment	Level of participation of the faculty in the program assessment	None	75% of faculty participation	Yearly	Counts taken from the lists of participation maintained by the SWE Graduate Committee

Table 23: SWE Master's Graduate Profile Annual Evaluation Plan

Output	Indicator	Baseline measurements	Target	Data collection frequency	Measurement tools
1) Software Engineering Skills	Rubrics to be established by the SWE Graduate Committee	None	3 in a scale of 1 to 5	Yearly	SWE Graduate Committee
2) Secure Software Engineering skills	Rubrics to be established by the SWE Graduate Committee	None	3 in a scale of 1 to 5	Yearly	SWE Graduate Committee
3) Data Engineering skills	Rubrics to be established by the SWE Graduate Committee	None	3 in a scale of 1 to 5	Yearly	SWE Graduate Committee
4) Domain-specific skills	Rubrics to be established by the SWE Graduate Committee	None	3 in a scale of 1 to 5	Yearly	SWE Graduate Committee
5) Teamwork skills	Rubrics to be established by the SWE Graduate Committee	None	3 in a scale of 1 to 5	Yearly	SWE Graduate Committee
6) Ethical and Societal skills	Rubrics to be established by the SWE Graduate Committee	None	3 in a scale of 1 to 5	Yearly	SWE Graduate Committee
7)Communication skills	Rubrics to be established by the SWE Graduate Committee	None	3 in a scale of 1 to 5	Yearly	SWE Graduate Committee

Table 24: SWE PhD Graduate Profile Annual Evaluation Plan

Output	Indicator	Baseline measurements	Target	Data collection frequency	Measurement tools
1) Software Engineering Skills	Rubrics to be established by the SWE Graduate Committee	None	3 in a scale of 1 to 5	Yearly	SWE Graduate Committee
2) Secure Software Engineering skills	Rubrics to be established by the SWE Graduate Committee	None	3 in a scale of 1 to 5	Yearly	SWE Graduate Committee
3) Data Engineering skills	Rubrics to be established by the SWE Graduate Committee	None	3 in a scale of 1 to 5	Yearly	SWE Graduate Committee
4) Domain-specific skills	Rubrics to be established by the SWE Graduate Committee	None	3 in a scale of 1 to 5	Yearly	SWE Graduate Committee
5) Teamwork skills	Rubrics to be established by the SWE Graduate Committee	None	3 in a scale of 1 to 5	Yearly	SWE Graduate Committee
6) Ethical and Societal skills	Rubrics to be established by the SWE Graduate Committee	None	3 in a scale of 1 to 5	Yearly	SWE Graduate Committee
7) Research skills	Rubrics to be established by the SWE Graduate Committee	None	3 in a scale of 1 to 5	Yearly	SWE Graduate Committee
8) Research Vision skills	Rubrics to be established by the SWE Graduate Committee	None	3 in a scale of 1 to 5	Yearly	SWE Graduate Committee
9) Peer Review skills	Rubrics to be established by the SWE Graduate Committee	None	3 in a scale of 1 to 5	Yearly	SWE Graduate Committee
10) Communication skills	Rubrics to be established by the SWE Graduate Committee	None	3 in a scale of 1 to 5	Yearly	SWE Graduate Committee

The annual evaluation is *formative* in nature, and thus, it is intended to assess the progress of the program in meeting the five-year outcomes, determine whether the program and its components are operating according to descriptions and implementation plans, and identify corrective actions.

The annual evaluation will be documented in the program's annual report, disseminated among stakeholders for their comments and feedback, and used as a basis for the next year planning exercise.

16 Development Plan

The five (5) year development plan is presented in this section.

16.1 Enrollment

The target enrollment figures for the SWE Graduate program are:

- Master's Degrees:
  - Master of Science: 10 to 15 student per year.
  - Master of Engineering: 6 to 10 student per year.
- Doctoral Degree:
  - 15-20 students per year.

Our target is to have approximately 45 students per year enrolled in the SWE Graduate Program.

16.2 Program Budget and Financial Support

16.2.1 Process to Establish the Program's Budget

The University of Puerto Rico's (UPR) budget comes primarily from state appropriations as calculated by the established formula on Law No. 2 (1966), as amended. That also includes revenues from gambling, as established by Law No. 36 (2005). These revenues are updated and reviewed according to the most recent projections of income from tourism and in alignment to the Fiscal Oversight Management Board (FOMB) plans. The UPR responsibly prepares an annual budget considering the adequate institutional operation, including the academic programs and services. The process begins at each campus. The engagement of the campuses' leadership assures that their academic programs and services are adequately taken into consideration. The UPRM is one of eleven campuses of the UPR system, and one of the three major campuses that receive the largest contributions from UPR's budget. UPRM distributes its assigned budget to the four academic colleges and to all of its supporting offices.

The preparation of the UPR system annual budget begins at the different departments or offices across its campuses. At UPRM campus, each department submits its budget plan to the Dean's Office by December of the previous year. The budget plan is based on the previous year's final operational budget, the short-term and long-term strategic activities, and the attention of ongoing projects. The budget is based on the UPRM strategic plan and responds to the particular program needs.

The Dean of Engineering harmonizes all programs' budgets and presents the College of Engineering's budget request to the Chancellor's office. The Administrative Board harmonizes the UPRM budget across all its units and presents it to the President, who prepares the university's budget and defends it before the University of Puerto Rico (UPR) Governing Board.

Certainly, the fiscal problems of the Government of Puerto Rico in recent years have caused a reduction of funds allocated to the UPR system, and in particular to UPRM. However, in spite of that, the final budget has always been sufficient to cover the base salaries and the fringe benefits of permanent personnel, as well as for the day-to-day operations in the department.

The following table (Table 25) contains a summary of the institutional funds that were assigned to the department to cover the base salaries and fringe benefits (FB) paid to permanent personnel (faculty and non-faculty), as well as the estimated initial amount of operational funds, for the past four academic years.

Table 25: CSE Department Operating Budgets

Fiscal Year	Salaries & FB	Operational
2016-2017	$ 1,119,986.47	$5,000.00
2017-2018	$ 1,168,425.55	$5,000.00
2018-2019	$ 1,116,671.36	$5,000.00
2019-2020	$ 1,108,132.69	$44,187.00

16.2.2 Sources of Financial Support

The program's main source of financial support is institutional funding coming from the state's annual allocation to the UPR system and under an annual budget as previously described. That covers at least the base salary and fringe benefits of all permanent personnel, as well as day-to-day operations in the department. Additional funding to support the CSE department and its programs is available from other sources as it is described next.

- *External Research Grants* – Our faculty is highly encouraged and supported for seeking external funding to support their research initiatives, or other special projects. Therefore, our department is continuously pursuing initiatives to increase external funding through research and institutional services projects. Most of those efforts have been successful in attracting funds from external sources, such as: NIH, NSF, DoD, ONR, PR Science and Technology Trust, as well as from private organizations.
- *Indirect Costs Recove*ry – The 3.5 percent of the indirect costs from external research grants are assigned to the department of the PI.
- *Research Time Buy-Out* – In those instances in which the grant allows the faculty involved to buy time-effort during the regular semesters, 35% of the total salary that is saved by the institution is assigned to the department.

- *Donations* – The department is actively seeking for donations from industries. In recent semesters, it has been successful in attracting important donations and it is committed to increase our effort to increase in this source of income.
- *Technology Fee Recovery* - As part of their tuition costs all undergraduate students are required to pay a fixed amount known a Technology Fee. Those funds are assigned by the Chancellor for university-wide projects (i.e. upgrading wireless network, Virtual Computing Lab) or to the departments (i.e. computer center, departmental wireless network, classroom audiovisual systems). For this, each department submits a proposal to the office of the dean at least once per year. The money is allotted based on the merits of each proposal and its expected impact on the students' education. For instance, for the year 2019-2020, the CSE department received $25k from these funds. They were assigned to buy 20 personal computers that will be part of a new instructional lab that the department is in the process to establish in conjunction with a recent donation from Chevron Corporation.
- *Permanent Infrastructure Improvement Fund* - Annual fund for the UPR-system managed by the UPR-Central Administration. Proposals for infrastructure development or improvement may be submitted annually and are evaluated by a system-wide panel.
- *Teaching Assistantships Fund* – The Dean of Engineering manages a fund that is used for teaching assistantships. That fund is distributed along the academic departments based on the needs that the department has on particular academic terms. Based on their particular needs, each department requests the necessary funds to the office of the dean. Those needs may vary from term to term.
- *Funds for Extra Compensations* – The Dean of Engineering also allocates funds to be used to pay for extra compensation to faculty should the need arise. That is the case when a faculty is assigned a workload equivalent to more than 12 credits on a semester. Those funds are aimed to cover for those additional expenses that the department may need to incur in a particular semester.
- *Funds for the maintenance of physical facilities* are directly provided by the College of Engineering since the building where our facilities are located is managed by the College and not by the CSE department. These include, physical maintenance of facilities, maintenance of AC units, remodeling of facilities, etc.

In addition to the previous sources, if the need arises, the department requests additional funds to the office of the dean to cover for additional expenses that the department may incur in.

16.2.3 Teaching Support by the Institution

The institution supports every program with teaching assistants and graders to support teaching. However, this is primarily done with the larger class sections (>35 students). Also, courses that have a laboratory as part of it (for example: CIIC 4010, CIIC 4020, and CIIC 4050) are assigned TAs, which take care of one or two sections of laboratories. Each of those laboratory sections groups at most 30 students.

Teaching is supported with workshops conducted every semester by the institution's Center for Professional Enrichment (Centro de Enriquecimiento Profesional, CEP in Spanish). Their

seminars and workshops cover all aspects of teaching and research for faculty and graduate students who are working as graders and teaching assistants. Faculty and graduate students that are involved in teaching (e.g., teaching assistants) must complete 30 hours of training within their first few years of hiring. Faculty evaluated for promotion often use additional training to improve their teaching skills and overall performance.

The UPR has available a centralized data center in which several utilities are available to support the administration of courses. In particular, some utilities allow for professors to have access to the lists of students in each one of their courses from day one, and to facilitate the communication with students, and the submission of final grades. In addition to those utilities, that centralized data center also includes the Moodle system to support the management of course work. The system includes the automatic creation of a Moodle course for each section of every course once the registration process is completed. Each professor has access to its courses by using his/her individual account in the upr.edu domain.

In our particular case, the administrators of the centralized Moodle system have supported us by installing different tools that are useful to our courses (most of them were requested by our own faculty); in particular, tools to support automatic grading (such as Java Unit Test plugin). That facilitates the configuration of practical exams with instantaneous grading and feedback to students and faculty, as well as allowing for better mechanisms to encourage student's practice of the programming skills in different computer languages. These tools have become popular in our introductory courses (CIIC 3011, CIIC 4010, and CIIC 4020), making it easier to our faculty to effectively manage the large number of students that usually register in these courses.

Also, the UPR has adopted the Google Apps for Education platform, which allows our faculty better control and management of all the material that they use in their respective courses and the sharing of that material with students in the courses. The ubiquitous availability and accessibility through an internet browser that such system provides have been very attractive to our faculty and students. It has certainly resulted in a very supportive system of the educational and administrative activities at UPRM.

16.2.4 Resources to Support the Program

With the support of the technical staff, the department is periodically evaluating the resources that it has to support its academic programs. Those resources are mostly based on computer servers and storage, communication networks, computers at the different computer labs, and software tools. The goal is to identify obsolete equipment that needs to be replaced or new equipment that needs to be added to enhance capabilities of existing one. That evaluation is usually done in periods of 4 to 5 years. If the department does not have enough funds to cover its current needs, a proposal is generated and submitted to the UPR's administration. The most recent proposal of that type was submitted during the last academic year. As a result, we have been able to acquire new servers, and a second part of that proposal (storage and communication switch) is now in the process of being funded.

Since its creation in 2016, the CSE Department has received substantial support from the office of the Dean. In particular, the new facilities of the administrative offices for the department were sponsored by that office, and it totaled an amount of approximately $40k. Also, the dean's office

sponsored the renovation of the main lab facility for courses (Room S-121) with a total cost of approximately $70k. That refurbish included new tables and chairs, new screen projector, new projection board, 30 new computers and new AC units. Part of those funds have come from economies that the college has experienced, donations from external sources, and from the funds that the UPR system collects from technology fee that students pay as part of the registration fees.

Other smaller donations (~$12.5k) from industry have provided funds to support workshops in CS for teachers, summer camps in CS for high school students, student competitions, workshops in CS for kids, etc.

Even when there is always room for improvement, we can unequivocally state that the resources available are adequate for the students in the program to be able to attain the student outcomes.

16.2.5 Adequacy of Resources

Even with the limitations in budget assigned to the department, we can unequivocally state that the resources available are adequate for the students in the program being able to attain the student outcomes.

16.3 Staffing

In addition to the two directors, the CSE department includes the following staff:

1. One official fully dedicated to academic advising of students in both SWE and CSE undergraduate programs.
2. Three administrative assistants to assist on the administrative tasks of the department and its programs, including support to the continuous assessment and improvement activities. The three official positions/ranks are: administrative official, administrative assistant, and administrative secretary.
3. Three technical (IT) personnel are shared with the ECE department. These personnel support the department in all activities related to network communications, computers in labs and in offices, main computer servers, student computing services, etc.
4. Other personnel are hired on temporary basis to support special needs that may arise in the department from time to time; in particular, to temporarily substitute a member of the staff that is in an extended leave of absence due to a health-related or personal situation.

The Department gets additional support from the College of Engineering by maintaining a centralized office to support in the management of the COOP program and interaction with industries.

In addition to the regular staff, the department has been consistently receiving the support of at least two undergraduate students, who work between 10 to 20 hours per week at the minimum salary rate. One of those students is fully dedicated to maintaining the department's web page. The others are assigned to support the administrative tasks in reception, document management, etc. For the past three terms, the department has also been assigned two undergraduate students to support the assessment process.

16.3.1 Adequacy of the Staff

In general, the support staff personnel are considered adequate. Additional standard support functions and services exist on an institution-wide basis to meet different needs. These services are assessed periodically in compliance with the Institutional Plan for the Assessment of Student Learning and the Administrative Assessment Plans. Outside of our department, all staff levels of the institution's administration are supportive of our goal to provide a quality program to the students.

16.3.2 Staff Retention and Training

Staff retention is very good. Most of the current staff employees have been with the department since its creation, and most were transferred to the CSE department from other offices in campus. In addition to the regular salary, all employees at the institution have the following incentives:

1. Health insurance plan that is paid by the institution.
2. Institutional contribution to the institutional retirement plan of employees.
3. Institutional contribution to the federal social security of employees.
4. Automatically accumulated days for health-related leave of absence. Every employee accumulates 1.5 days per month.
5. Female staff has also the additional benefit of maternity leave.

Staff and all personnel in administrative positions also accumulate 2.5 days per month for vacations. In addition, all employees at the institution have the right to apply for unpaid leave of absence for personal reasons.

Our staff is trained through internal seminars and workshops, including those from the Center for Professional Enrichment (CEP), which provides seminars continuously throughout the year. In the Spring 2020 semester, all our personnel have been participating in different workshops to train them in the proper use of technology for doing work remotely, on tools for verifiable electronic signatures, in new procedures for the better management of totally technology-based processes, etc. Although the need for this has recently increased because of the quarantine imposed by government orders due to the COVID-19 crisis, there are plenty of benefits that the operational activities in the department will gain for the future. In particular, this experience will allow us to better implement practices in which our staff can work from home from time to time, even after the crisis is over.

For instance, now as we write this report, we are going through the process of slowly coming back to campus. However, some of our staff have been allowed to work remotely. The main reason for this is to allow them to manage the reality that most schools and childcare centers are closed and therefore kids need to be at home. It would be hard for them to be required to come to campus and to leave their young children alone at home; so, without that opportunity for remote work, it is reasonable to deduce that some would opt for resignation. We consider this to be an attractive incentive to our personnel, especially during these tense moments. Moreover, it is now another option that the department has as an alternative of reasonable accommodation for our personnel, should the need for that arise.

16.4 Faculty Hiring and Retention

16.4.1 Process for Hiring New Faculty

The recent fiscal problems of the University of Puerto Rico have caused the institution to freeze the hiring of new faculty unless the need is clearly demonstrated. The CSE Department has established the immediate need to hire at least two new tenure track faculty to support our programs. Those needs have to be reported to the chancellor, who has the final decision as to where and how many resources to recruit. After authorization from the chancellor, the process to hire new faculty can be initiated by the department.

New faculty members are hired through the department's Personnel Committee, in coordination with the department's director. Faculty openings are advertised locally, as well as with national professional services. The department uses a variety of vehicles in the recruitment process, including ads in national journals, trade magazines, and local newspapers. Candidates prepare a presentation for the faculty and students as well as one class to evaluate his/her communication skills and mastery of subjects. Comments from faculty and students are analyzed by the Personnel Committee, who makes the final recommendation to the director of the department. This process is further scrutinized by the College of Engineering Personnel Committee to ensure an in-depth objective process. After this process is finished, if the decision is to make a final offer to the candidate, the Dean of Engineering and the Chancellor sign the final document with the formal offer. The Chancellor is the final authority in UPRM for hiring.

16.4.2 Faculty Hiring Plan

The faculty hiring plan was presented in section 8.2 of this proposal.

16.4.3 Faculty Retention Strategies

The UPRM has always been supportive of the faculty, based on the conviction that the faculty plays a fundamental role in the success of our programs and the fulfillment of its mission. Even under times of reduced budgets, the institution has been able to guarantee steady support for departments to be able to retain its qualified faculty.

Reduced workloads are provided to new hires during their first two years to give them time to develop research projects. The department gives them office space, computers, printers, and limited travel funds or seed money grants.

Faculty personnel also enjoy the same fringe benefits as all other personnel at the institution; in particular, the benefit of an institutional health insurance plan, contributions to the institutional retirement plan, contribution to the social security fees, and accumulation of days for health-related issues. Although it was in freeze during 4 to 5 years due to budget reductions, the UPRM recently restituted the sabbatical program for its faculty.

Among other important incentives, our faculty has the benefit of a transparent and fair process for tenure and promotion, departmental staff support, and teaching/grading assistance for course sections with large number of students.

Current qualified faculty are encouraged and supported to write competitive proposals while granting them time to be devoted to their projects in substitution of teaching load. The time allotted for each faculty member depends on performance and impact of their projects. This professional growth dimension for the faculty can lead to additional compensations and other incentives (e.g., Puerto Rico Law 101 - Tax Exemption of Competitive Research Grants, Research Incentives, and Salary Differentials) that can make their salaries more competitive.

16.4.4 Support of Faculty Professional Development

During the past 3 to 4 years, Government Budgets have decreased and the University of Puerto Rico (UPR) system has seen its state allocations heavily reduced. Nevertheless, the UPR outlined and implemented plans with current and projected measures towards sustained and ongoing excellence in its academic offering.

The director of the CSE Department has always worked hard to support the faculty development activities. Some of our faculty members have secured external funds to support research projects, which also allow them to fund trips to important conferences and meetings in which they have been able to be part of different professional development activities. Other members of our faculty have also been able to participate in workshops that are aimed to be aware of modern alternatives to teach fundamental courses in CS by invitation of important software-based industries (e.g., Google, Facebook, Bloomberg).

Although the department has limited institutional funds to support travel to conferences, workshops or external meetings outside of Puerto Rico, it certainly has the commitment to seek support whenever the need arises. Whenever there is the need to support a faculty member in being able to participate in some relevant professional development activity, we determine if department's funds are available for that. If so, and if the activity is in the best interest of our academic programs, the department will cover expenses as much as possible. In those instances in which the department does not have the funds, a request for support is elevated to the dean of the college of engineering.

The institution also supports the training of faculty through online courses available at DECEP. Some of those courses are available for free to our faculty. For other such courses that are not free, our faculty has a special rate that is lower than the usual rate. Also, in the 2020-2021 annual budget, the department has requested funds for a broader support of this type of training whenever it is estimated of benefit to our programs. That includes courses in the internal platform at DECEP or courses from external platforms such as, for example, Coursera. It is expected that some of our faculty are able to use these to get training in areas of interest such as, Data Science, Secure Software Systems, Edge Computing, or to catchup in modern new trends or applications in fundamental areas of the discipline.

16.5 Facilities and Equipment Maintenance

The CSE Department is constantly monitoring its laboratory infrastructure to guarantee the proper maintenance, and the needs for upgrade or enhancement to support the SWE Graduate Program. A full-time staff of three computer and communications technicians are in charge of all the computing labs that are used by our students, the computer network infrastructure, and the

centralized facilities that hosts computer servers and storage. They are responsible to constantly monitor the computer and network equipment, as well as the software systems. They are the first line of support whenever some malfunction is identified by users of these systems. Among their main duties and responsibilities, we can list the following:

- Give support to students and faculty in solving problems with the equipment in lab facilities or with the use/configuration of specialized software.
- They keep our systems up to date in the different software components that are installed.
- Contact vendors or service providers should the need arise to repair equipment that is still under some warranty.
- Inform the department of any need that requires actions from the department to make available funds to work on it; which may include to purchase new additional equipment or to replace existing one, to acquire new software, to renew software licenses or maintenance contracts, etc.
- Work with the department on strategies to enhance and upgrade our computer labs.
- Contact different vendors for quotations when new purchases are in progress.

When the need arises for a purchase, the department works on the identification of funds to support that. Different sources of funds are available for us to cover the cost that such purchases may imply. These are described under the section for Criterion 8 – Institutional Support.

Faculty members also contribute with money from their grants to support some laboratory miscellaneous supplies. Whenever the budget is not enough for supporting the enhancement or maintenance petitions, the budget to cover the need is added to the following cycle. Every three to five years the university administration assigns money in the budget to replace computers, and other obsolete equipment. Petitions for equipment for new research laboratories are submitted separately and are usually initiated by a donation or MRI proposal. Donations from external sources are also used to improve our lab facilities and capacities. This is the case of the new academic computer lab that is in the process of being established in room S-114A, an which was described at the beginning of this chapter.

The laboratories in general are adequate for instructional purposes.

Appendix A – Benchmarking with UPRM Graduate Programs

Table 26 shows the comparison in total credits between the SWE MS/ME Degree and other Engineering Master's programs at UPRM. As we can see from the table, the SWE MS/ME Degree, with its different study plans, has the same number of credits as other established programs such as Electrical Engineering, Computer Engineering, Industrial Engineering, and Civil Engineering. On average, the Engineering Master's programs at UPRM have 31 credits. Thus, the UPRM SWE MS/ME degree is close to the average.

Table 26: Credits Comparison with UPRM Engineering MS/ME Degree

Discipline	Degree	Plan	Credits
Electrical Engineering	MS	I	30
	ME	II	30
	ME	III	30
Computer Engineering	MS	I	30
	ME	II	30
	ME	III	30
Civil Engineering	MS	I	30
	ME	II	30
	ME	III	30
Mechanical Engineering	MS	I	31
	ME	II	34
	ME	III	36
Chemical Engineering	MS	I	31
	ME	II	31
	ME	III	31
Materials Engineering	MS	I	35
	ME	II	35
	ME	III	35
Industrial Engineering	MS	I	30
	ME	III	30
Bioengineering	MS	I	31
	ME	II	31
	ME	III	37
Software Engineering	MS	I	30
	ME	II	30
	ME	III	30

Table 27 shows the comparison in total credits between the SWE PhD Degree and other Engineering PhD programs at UPRM. As we can see from the table, the number of credits varies greatly between programs. Nonetheless, the SWE PhD Degree has a number of credits that sits right in the middle of the credit range when compared with other established programs such as Electrical Engineering, Mechanical Engineering, Bioengineering Engineering, and Civil Engineering. On average, the Engineering PhD programs at UPRM have 55 credits. Thus, the UPRM SWE PhD degree is close to the average.

Table 27: Credits Comparison for UPRM Engineering PhD Programs

Discipline	Degree	Credits
Electrical Engineering	PhD	49
Civil Engineering	PhD	60
Mechanical Engineering	PhD	61
Chemical Engineering	PhD	58
Computer and Information Science and Engineering	PhD	57
Bioengineering	PhD	49
Software Engineering	PhD	54

Appendix B – Benchmarking with Other SWE Graduate Programs

Table 28 shows the comparison in total credits between the UPRM SWE MS/ME Degree and other SWE Masters programs in the USA. As we can see from the table, the UPRM SWE MS/ME Degree, with its different study plans, has the same number of credits as other established programs in schools such as Auburn University, University of Maryland - College Park, Stevens Institute of Technology, and New Jersey Institute of Technology. On average, the SWE Masters programs in these schools have 31 credits. Thus, the UPRM SWE MS/ME degree is close to the average.

Table 28: Credits Comparison for Software Engineering MS/ME Degrees in the USA

Institution	Degree	Credits
Rochester Institute of Technology	MS	36
	ME	36
Stevens Institute of Technology	MS	30
	ME	30
New Jersey Institute of Technology	MS	30
	ME	30
University of Texas, Arlington	MS	30
	ME	36
University of Maryland, College Park	-	-
	ME	30
University of Texas, Dallas	-	-
	ME	33
Auburn Universitty	MS	30
	ME	30
Southern Methodist University	MS	30
	ME	30
UPRM	MS	30
	ME	30

Table 29 shows the comparison in total credits between the UPRM SWE PhD Degree and other SWE PhD programs in the USA and abroad. As we can see from the table, the number of credits varies greatly between programs, just like the case of Engineering PhD degrees within UPRM. Nonetheless, the UPRM SWE PhD Degree has a number of credits that sits right in the middle of the credit range when compared with other established programs in schools such as UC Irvine, Auburn University, and the University of Texas, Dallas. On average, the SWE PhD programs at these group of schools have 61 credits, although two of the schools have 12 credits in a minor or in free electives. If we subtract that component, and only focus on SWE course credits the average goes down to 58 credits. Thus, the UPRM SWE PhD degree is close to the average.

Table 29: Credits Comparison for USA and International Software Engineering PhD Programs

Institution	Degree	Credits	SWE Credits
UC Irvine	PhD	48	48
University of Texas, Dallas*	PhD	75	63
Carnegie Mellon University*	PhD	84	72
Auburn University	PhD	66	66
McMaster Univeristy (Canada)	PhD	51	51
Bahria University (Pakistan)	PhD	54	54
UPRM	PhD	54	54

* Includes 12-credits in minor or free electives

Appendix C – Five Year Schedule for INSO Courses

Course Code	Course Title	2023-2024			2024-2025			2025-2026			2026-2027			2026-2027		
		Fall	Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer
INSO 6005	Software Engineering Principles	X			X			X			X			X		
INSO 6006	Database Systems Engineering	X			X			X			X			X		
INSO 6007	Secure Software Systems		X			X			X			X			X	
INSO 6010	DevOps				X			X						X		
INSO 6015	MLOps		X			X									X	
INSO 6030	Web and Mobile Applications Engineering		X						X			X			X	
INSO 6040	Health-related Applications Engineering	X			X						X			X		
INSO 6050	Software Engineering for Edge Systems					X			X			X				
INSO 6070	Software-Defined Networks Engineering					X			X			X			X	
INSO 6080	Deep Learning Engineering							X			X					
INSO 8995	Advanced Topics					X			X			X			X	
INSO 8996	Doctoral Seminar				X			X			X			X		
INSO 6998	Master's Project			X	X	X	X	X	X	X	X	X	X	X	X	X
INSO 6999	Master's Thesis			X	X	X	X	X	X	X	X	X	X	X	X	X
INSO 8999	Doctoral Dissertation Research						X	X	X	X	X	X	X	X	X	X

Core Courses
Technical Electives
Topics, Seminars
Thesis and Projects

Appendix D – Course Syllabi

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
HOJA DE TRÁMITE PARA LA CREACIÓN DE CURSOS

CURSO: INSO 6005 - Software Engineering Principles

DEPARTAMENTO: Ciencia e Ingeniería de Computación

FACULTAD: Ingeniería

	COMENTARIOS
Fecha en que el proponente somete la propuesta de Creación de Curso: Fecha: 8/15/2022	
Firma del Director de Departamento: _____ Fecha: 11/15/2022	
Firma del Decano de Facultad: _____ Fecha:	
Fecha en que la solicitud es recibida en la Secretaría del Senado Académico: Fecha:	
Fecha en la que la solicitud es recibida por el Comité de Cursos del Senado Académico: Fecha:	
Firma del Presidente de Comité de Cursos del Senado Académico: _____ Fecha:	
Fecha en que la solicitud es recibida por el Decanato de Asuntos Académicos: Fecha:	

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
DECANATO DE ASUNTOS ACADÉMICOS

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

1 **Unidad: Recinto Universitario de Mayagüez**	1 **Colegio: Ingeniería**
1 **Departamento: Ciencia e Ingenieria de Computación** **Programa: MS/PhD en Ingeniería de Software**	1 **Profesor (es)** **Proponente(s): Manuel Rodriguez Martinez, Heidy Sierra, Ahmed ElSaid**
2 **Fecha de Solicitud: 8/15/2022**	3 **Fecha de Vigencia del Curso: 8/2023**
4 **Título Completo en Español: Principios de la Ingeniería de Software**	
5 **(Título Abreviado a 26 Espacios): Princ Ing Software**	
4 **Título Completo en Inglés: Software Engineering Principles**	
5 **(Título Abreviado a 26 Espacios): Soft Eng Principles**	
6 **Materia Principal del Curso (en clave alfa): INSO**	
7 **Justificación para la Creación del Curso:**	
Provide graduate students in Software Engineering with in-depth knowledge of the principles and techiques necessary to carry out modern software development projects.	
8 **Nivel del Curso (marque con una X):** __ 1 __ 2 __ 3 __ 4 __ 5 **Subgraduado** X 6 __ 7 __ 8 __ 9 **Graduado**	
9**Ubicación del curso, sea requisito, electivo o de continuación, en la secuencia curricular autorizada:** **(S=Semestres V=Verano) Período: _X___S1 ____S2 ____V**	
A partir del año de estudio de acuerdo con la secuencia: **_X__1ro ___2do ___3ro ___4to ___5to ___6to ___Otro ___ N/A**	
10 **Codificación Alfanumérica: INSO 6005**	11 **Cantidad de Créditos: 3**
12 **Tipo de Curso: __X____Requisito _____Electivo _____División de Educación Continua**	
13 **Tipo de créditos: __X__ Fijo ____Variable**	**Si es Variable, ¿puede repetirse con crédito? ___Si ___No**
	Si contesta si, indique la cantidad máxima que se puede repetir: _____
14 **Distribución de Horas Contacto Semanales dedicadas a la enseñanza:**	
__X___Conferencia	**_____Laboratorio** **_____Investigación**

_____Discusión	**_____Taller**	**_____Tesis o Disertación**
_____Seminario	**_____Internado**	**_____Estudio Independiente**
_____Práctica Supervisada		

15 Total de Horas Contacto: __45____

16 Equivalencia en Horas de Crédito para la carga académica del Profesor: ___3___

17 Descripción del Curso en Español (que no se exceda de 1,000 caracteres):
Estudio integral de los principios y técnicas modernos de ingeniería de software para la entrega eficiente de sistemas de software escalables y seguros para uso en producción. Este curso prepara a los estudiantes para especificar, diseñar e implementar sistemas de software utilizando tecnologías en la nube, métodos ágiles, SCRUM, patrones de diseño, refactorización, integración continua, entrega continua, sistemas de registro y control de calidad del software.

17 Descripción del Curso en Inglés (que no se exceda de 1,000 caracteres):

Comprehensive study of modern software engineering principles and techniques for the efficient delivery and maintenance of correct, scalable and secure software systems for production use. Methods to specify, design and implement software systems using cloud technologies, agile methods, SCRUM, design patterns, refactoring, continuous integration, continuous delivery, logging systems, and software quality assurance.

18 Prerrequisitos*	**18Correquisitos***
Ninguno	

***Especifique la Codificación Alfanumérica Correcta**

19 Requisitos especiales: _____
_____

20 Modalidad en la que el Curso se ofrecerá (Puede marcar más de una opción):

__X__Curso Presencial __X__Curso Híbrido _X___Curso a Distancia

21 Cargos por laboratorio: ____ Sí __X__No

22 Posibilidad de Equivalencia (en la unidad o en otras unidades del sistema):
___ Sí _X_No

Cursos:_____

Unidad(es) que lo(s) ofrece(n): _____

23 Equipo, materiales e instalaciones mínimas requeridas:

Facilidades computacionales existentes del Departamento de Ciencia e Ingeniería de Computación.

24 Cantidad de Estudiantes por sección: _ 3___ Cupo Mínimo __30__ Cupo Máximo

[25] **Sistema de Calificación:**

_X___Letra (A, B, C, D o F) **____ Aprobado (S), No Aprobado (NS)**

____ Aprobado (P), No Aprobado (NP) **____Aprobado (PS: Aprobado Sobresaliente; PN: Aprobado Bueno), No Aprobado (NP)**

____Aprobado (P), Fracasado (F) **____Otro (Especifique)_____**

[26] **Curso a Inactivar sujeto a la creación del nuevo curso:**

_X____No Aplica **_____Si; especifique el curso a inactivar: _____**

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

[27] **APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL DEPARTAMENTO**	**NOMBRE Y FIRMA** **Emmanuel Arzuaga, Ph.D**	**FECHA** **11/15/2022**
Director de Departamento		
[28]**APROBACIÓN Y CERTIFICACIÓN A NIVEL DE LA FACULTAD**	**NOMBRE Y FIRMA**	**FECHA**
Decano de la Facultad		
[29] **APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL SENADO ACADÉMICO**	**NOMBRE Y FIRMA**	**FECHA**
Presidente del Comité de Cursos		

PARA USO DEL DECANATO DE ASUNTOS ACADÉMICOS

[30] **Codificación: _____** **Fecha de Codificación_____**

Funcionario que procesó la solicitud: **Fecha de envío al Departamento y Facultad:**

_____ **_____**

University of Puerto Rico
Mayagüez Campus
College of Engineering
Department of Computer Science and Engineering
Software Engineering Graduate Program

COURSE SYLLABUS

COURSE TITLE:	Software Engineering Principles
ALPHA-NUMERIC CODIFICATION:	INSO 6005
NUMBER OF CREDITS-CONTACT HOURS:	Three credits / 45 hours
PREREQUISITES, COREQUISITES AND OTHER REQUIREMENTS:	None

COURSE DESCRIPTION:

Spanish: Estudio integral de los principios y técnicas modernos de ingeniería de software para la entrega eficiente de sistemas de software escalables y seguros para uso en producción. Este curso prepara a los estudiantes para especificar, diseñar e implementar sistemas de software utilizando tecnologías en la nube, métodos ágiles, SCRUM, patrones de diseño, refactorización, integración continua, entrega continua, sistemas de registro y control de calidad del software. Este curso podrá ofrecerse en cualquiera de las siguientes modalidades: presencial, híbrida, o a distancia.

English: Comprehensive study of modern software engineering principles and techniques for the efficient delivery and maintenance of correct, scalable and secure software systems for production use. Methods to specify, design and implement software systems using cloud technologies, agile methods, SCRUM, design patterns, refactoring, continuous integration, continuous delivery, logging systems, and software quality assurance. This course may be offered in any of the following modalities: face-to-face, hybrid or online.

COURSE OBJECTIVES:

Students will:

- Develop a domain description.
- Develop software requirements and formal specifications for target applications.
- Design a secure and robust application using Design Patterns and standard software architectures.
- Use Agile Techniques and SCRUM to run the development cycle of a target application.
- Apply continuous integration methods to merge code changes, automate builds, and run standardize unit test cases.
- Apply continuous delivery to build, test, and deploy updated software packages into cloud-resident production environments.
- Use logging and monitoring tools to analyze the performance behavior of software systems.

TEXT BOOK:

1. Ivar Jacobson, Harold Lawson, Pan-Wei Ng, *The Essentials of Modern Software Engineering: Free the Practices from the Method Prisons,* ACM Books, 2019

2. Neal Ford, Mark Richards, Pramod Sadalage, Zhamak Dehghani, *Software Architecture: The Hard Parts 1st ed*, O'Reilly, 2021.

Course time frame and thematic outline:

TIME DISTRIBUTION			
Theme	**Face-to-Face**	**Hybrid**	**Online**
I. Techniques for requirement analysis and formal software specifications	6 hours	6 hours (face-to-face)	6 hours
II. Software architectures	1.5 hours	1.5 hours (online)	1.5 hours
III. Software Design Patterns	3 hours	3 hours (online)	3 hours
IV. Software Refactoring	3 hours	3 hours (online)	3 hours
V. Unit Testing Frameworks	3 hours	3 hours (online)	3 hours
VI. Agile Techniques and SCRUM	6 hours	6 hours (face-to-face)	6 hours
VII. Introduction to Cloud and Container Platforms	3 hours	3 hours (online)	3 hours
VIII. Continuous Integration/Continuous Deployment Techniques	6 hours	6 hours (online)	6 hours
IX. Automation of Software Builds, Tests, and Deployment	3 hours	3 hours (face-to-face)	3 hours
X. Software Quality Assurance and Security	3 hours	3 hours (face-to-face)	3 hours
XI. Application Performance Profiling	1.5 hours	1.5 hours (online)	1.5 hours
XII. Benchmarks and Performance Evaluation	3 hours	3 hours (online)	3 hours
XIII. Midterm Exams	3 hours	3 hours (face-to-face)	3 hours
Total contact hours	**45 hours**	**45 hours** (21 face-to-face = 47% and 24 online hours= 53%)	**45 hours**

INSTRUCTIONAL STRATEGIES:

Face-to-Face	Hybrid	Online
• Conferences • Lectures • Team Programming Projects • Quizzes • Exams	• Live and recorded Conferences • Lectures • Team Programming Projects • Quizzes • Exams	• Recorded Conferences • Lectures • Team Programming Projects • Quizzes • Exams

MINIMUM OR REQUIRED RESOURCES AVAILABLE:

RESOURCE	FACE-TO-FACE	HYBRID	ONLINE
Institutional learning management platform account (Ex. Moodle)	Institution	Institution	Institution
Institutional email account	Institution	Institution	Institution
Computer with high-speed internet access or mobile device with data service	Student	Student	Student
Programs or applications: free open source InteliJ IDE, GitLab, Jenkins	Student	Student	Student
Webcam or mobile with camera and microphone	Not applicable	Student	Student
Institutional learning management platform account (Ex. Moodle)	Institution	Institution	Institution

EVALUATION STRATEGIES: (Examples of evaluation techniques)

FACE to FACE	HYBRID	ONLINE

All three modalities will be evaluated based on the following activities:

Activity	Quantity	Weight
Quizzes	5-10	10% - 20%
Homeworks	5-10	0% - 20%
Midterm Exams	2	10% - 20%
Final Exam	1	10% - 20%
Term Projects	1	40% - 60%

REASONABLE ACCOMMODATIONS:

The University of Puerto Rico at Mayagüez (RUM) recognizes that each student has an inherited right to request reasonable accommodation according to Law 51: Law for Integral Educational Services for People with Disabilities. Every student has the right to receive reasonable accommodation if he/she presents the necessary evidence to be evaluated by the Office of Services to Students with Disabilities (OSEI-RUM), and the related information can be found at the following link: https://www.uprm.edu/cms/index.php/page/85. If your case is approved by OSEI-RUM, you will receive reasonable accommodation in your courses and evaluation, and you must contact each professor for course registered. For additional information contact OSEI-RUM at Sánchez Hidalgo 410 or via telephone 787-832-4040 extension 3107.

ACADEMIC INTEGRITY:

The University of Puerto Rico promotes the highest standards of academic and scientific integrity. Article 6.2 of the UPR Student General Bylaws (Board of Trustees Certification 13, 2009-2010) states that academic dishonesty includes, but is not limited to: fraudulent actions; obtaining grades or academic degrees by false or fraudulent simulations; copying the whole or part of the academic work of another person; plagiarizing totally or partially the work of another person; copying all or part of another person's answers to the questions of an oral or written exam by taking or having someone else take the exam on his/her behalf; as well as enabling and facilitating another person to perform the aforementioned behavior. Any of these behaviors will be subject to disciplinary action in accordance with the disciplinary procedure established by the UPR Student General Bylaws.─.

To ensure the integrity and security of user data, all hybrid, distance and online courses must be offered through the institutional learning management platform, which uses secure connection and authentication protocols. The system authenticates the identity of the user (student and professor) using the username and password assigned by the institution. The users are responsible for keeping their password safe, protected, and not to share it with other people.

POLICY AGAINST DISCRIMINATION BASED ON SEX, SEXUAL ORIENTATION, AND GENDER IDENTITY:

«The University of Puerto Rico prohibits discrimination based on sex, sexual orientation, and gender identity in any of its forms, including that of sexual harassment. According to the Institutional Policy Against Sexual Harassment at the University of Puerto Rico, Certification 130 (2014-2015) from the Board of Governors, any student subjected to acts constituting sexual harassment, may turn to the Office of the Student Ombudsperson, the Office of the Dean of Students, or the Coordinator of the Office of Compliance with Title IX for an orientation or formal complaint».

GRADING SYSTEM

☒ Quantifiable (letters, A, B, C, D, F) ☐ Not Quantifiable

CONTINGENCY PLAN IN CASE OF AN EMERGENCY

In case of an emergency or class interruption, the professor can apply Bylaw 19-85 of the UPRM. This bylaw states that up to 25% of a class can be offered online.

BIBLIOGRAPHY

1. Ivar Jacobson, Harold Lawson, Pan-Wei Ng, *The Essentials of Modern Software Engineering: Free the Practices from the Method Prisons,* ACM Books, 2019

2. Neal Ford, Mark Richards, Pramod Sadalage, Zhamak Dehghani, *Software Architecture: The Hard Parts 1st ed*, O'Reilly, 2021.

3. Cornelia Davis, *Cloud Native Patterns: Designing change-tolerant software 1st Ed*, Manning, 2019.

4. Erich Gamma, Richard Helm, Ralph Johnson, John Vlissides, *Design Patterns: Elements of Reusable Object-Oriented Software 1st Ed,*Addison Wesley, 1994*.

5. Martin Fowler, *Refactoring: Improving the Design of Existing Code* 2nd Ed, Addison-Wesley Signature Series, 2018.

6. Electronic Portal to access technical research papers related to DevOps systems.
   i) ACM Digital Library: https://dl.acm.org/
   ii) IEEE Xplore Digital Library: https://ieeexplore.ieee.org

   Access to some papers might require valid subscription to ACM Digital Library, or IEEE Xplore. UPRM currently has access to these electronic digital libraries.

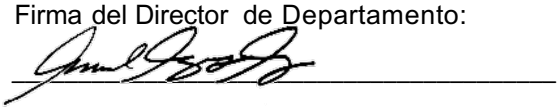
* Classic book.

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
HOJA DE TRÁMITE PARA LA CREACIÓN DE CURSOS

CURSO: INSO 6006 - Database Systems Engineering

DEPARTAMENTO: Ciencia e Ingeniería de Computación

FACULTAD: Ingeniería

	COMENTARIOS
Fecha en que el proponente somete la propuesta de Creación de Curso: Fecha: 8/15/2022	
Firma del Director de Departamento:  Fecha: 11/15/2022	
Firma del Decano de Facultad: _____ Fecha:	
Fecha en que la solicitud es recibida en la Secretaría del Senado Académico: Fecha:	
Fecha en la que la solicitud es recibida por el Comité de Cursos del Senado Académico: Fecha:	
Firma del Presidente de Comité de Cursos del Senado Académico: _____ Fecha:	
Fecha en que la solicitud es recibida por el Decanato de Asuntos Académicos: Fecha:	

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
DECANATO DE ASUNTOS ACADÉMICOS

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

1 **Unidad: Recinto Universitario de Mayagüez**	1 **Colegio: Ingeniería**
1 **Departamento: Ciencia e Ingenieria de Computación** **Programa: MS/PhD en Ingeniería de Software**	1 **Profesor (es)** **Proponente(s): Manuel Rodriguez Martinez, Heidy Sierra, Ahmed ElSaid**
2 **Fecha de Solicitud: 8/15/2022**	3 **Fecha de Vigencia del Curso: 8/2023**
4 **Título Completo en Español: Ingeniería de Sistemas de Bases de Datos**	
5 **(Título Abreviado a 26 Espacios): Ing Sis Bases de Datos**	
4 **Título Completo en Inglés: Database Systems Engineering**	
5 **(Título Abreviado a 26 Espacios): Database Systems Eng**	
6 **Materia Principal del Curso (en clave alfa): INSO**	
7 **Justificación para la Creación del Curso:**	
Provide graduate students in Software Engineering with in-depth knowledge of the principles and techiques necessary to desing and implemente modern data management systems and applications.	
8 **Nivel del Curso (marque con una X):** **__ 1 __ 2 __ 3 __ 4 __ 5 Subgraduado** **X 6 __ 7 __ 8 __ 9 Graduado**	
9**Ubicación del curso, sea requisito, electivo o de continuación, en la secuencia curricular autorizada:** **(S=Semestres V=Verano) Período: _X___S1 ____S2 ____V**	
A partir del año de estudio de acuerdo con la secuencia: **_X__1ro ___2do ___3ro ___4to ___5to ___6to ___Otro ___ N/A**	
10 **Codificación Alfanumérica: INSO 6006**	11 **Cantidad de Créditos: 3**
12 **Tipo de Curso: __X____Requisito _____Electivo _____División de Educación Continua**	
13 **Tipo de créditos: __X__ Fijo ____Variable**	**Si es Variable, ¿puede repetirse con crédito? ___Si ___No**
	Si contesta si, indique la cantidad máxima que se puede repetir: _____
14 **Distribución de Horas Contacto Semanales dedicadas a la enseñanza:**	

__X___Conferencia	**_____Laboratorio**	**_____Investigación**

_____Discusión	**_____Taller**	**_____Tesis o Disertación**
_____Seminario	**_____Internado**	**_____Estudio Independiente**
_____Práctica Supervisada		

15 Total de Horas Contacto: __45____

16 Equivalencia en Horas de Crédito para la carga académica del Profesor: ___3___

17 Descripción del Curso en Español (que no se exceda de 1,000 caracteres):
Estudio integral de los principios de ingeniería para construir los componentes internos de los sistemas modernos de administración de bases de datos. Este curso prepara a los estudiantes para diseñar e implementar sistemas orientados a filas, sistemas orientados a columnas, motores en memoria, motores de datos de múltiples núcleos, ejecución vectorizada, y sistemas RDMA. Este curso puede ofrecerse en cualquiera de las siguientes modalidades: presencial, híbrido u online.

17 Descripción del Curso en Inglés (que no se exceda de 1,000 caracteres):

Comprehensive study of engineering principles to build the internals of modern database management systems. This course prepares students to design and implement row-oriented systems, column-oriented systems, in-memory engines, multi-core data engines, vectorized query executors, and RDMA systems. This course may be offered in any of the following modalities: face-to-face, hybrid or online.

18 Prerrequisitos*	**18Correquisitos***
Ninguno	

***Especifique la Codificación Alfanumérica Correcta**

19 Requisitos especiales: _____
_____

20 Modalidad en la que el Curso se ofrecerá (Puede marcar más de una opción):

__X__Curso Presencial __X__Curso Híbrido _X___Curso a Distancia

21 Cargos por laboratorio: ____ Sí __X__No

22 Posibilidad de Equivalencia (en la unidad o en otras unidades del sistema):
___ Sí _X_No

Cursos:_____

Unidad(es) que lo(s) ofrece(n): _____

23 Equipo, materiales e instalaciones mínimas requeridas:

Facilidades computacionales existentes del Departamento de Ciencia e Ingeniería de Computación.

24 Cantidad de Estudiantes por sección: _ 3___ Cupo Mínimo __30__ Cupo Máximo

25 Sistema de Calificación:

_X___Letra (A, B, C, D o F) **____ Aprobado (S), No Aprobado (NS)**

____ Aprobado (P), No Aprobado (NP) **____Aprobado (PS: Aprobado Sobresaliente; PN: Aprobado Bueno), No Aprobado (NP)**

____Aprobado (P), Fracasado (F) **____Otro (Especifique)_____**

26 Curso a Inactivar sujeto a la creación del nuevo curso:

_X____No Aplica **_____Si; especifique el curso a inactivar: _____**

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

27 APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL DEPARTAMENTO	**NOMBRE Y FIRMA** **Emmanuel Arzuaga, Ph.D**	**FECHA** **11/15/2022**
Director de Departamento		
28APROBACIÓN Y CERTIFICACIÓN A NIVEL DE LA FACULTAD	**NOMBRE Y FIRMA**	**FECHA**
Decano de la Facultad		
29 APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL SENADO ACADÉMICO	**NOMBRE Y FIRMA**	**FECHA**
Presidente del Comité de Cursos		

PARA USO DEL DECANATO DE ASUNTOS ACADÉMICOS

30 Codificación: _____ **Fecha de Codificación_____**

Funcionario que procesó la solicitud: **Fecha de envío al Departamento y Facultad:**

_____ **_____**

University of Puerto Rico
Mayagüez Campus
College of Engineering
Department of Computer Science and Engineering
Software Engineering Graduate Program

COURSE SYLLABUS

COURSE TITLE:	Database Systems Engineering
ALPHA-NUMERIC CODIFICATION:	INSO 6006
NUMBER OF CREDITS-CONTACT HOURS:	Three credits / 45 hours
PREREQUISITES, COREQUISITES AND OTHER REQUIREMENTS:	None

COURSE DESCRIPTION:

Spanish: Estudio integral de los principios de ingeniería para construir los componentes internos de los sistemas modernos de administración de bases de datos. Este curso prepara a los estudiantes para diseñar e implementar sistemas orientados a filas, sistemas orientados a columnas, motores en memoria, motores de datos de múltiples núcleos, ejecución vectorizada, y sistemas RDMA. Este curso puede ofrecerse en cualquiera de las siguientes modalidades: presencial, híbrido u online.

English: Comprehensive study of engineering principles to build the internals of modern database management systems. This course prepares students to design and implement row-oriented systems, column-oriented systems, in-memory engines, multi-core data engines, vectorized query executors, and RDMA systems. This course may be offered in any of the following modalities: face-to-face, hybrid or online.

COURSE OBJECTIVES:

Students will:

- Identify use-cases for row-oriented vs columnar-oriented data engines in the context of OLTP vs OLAP.
- Explain the advantages of in-memory stores for OLTP workloads vs disk-based alternatives.
- Design and implement storage and indexing methods for row stores, columnar stores, and in-memory systems.
- Design and implement single-core and multi-core query operators, including parallel join operators.
- Design and implement pessimistic and optimistic concurrency control methods.
- Explain the tradeoffs in crash recovery methods based on write-ahead (ARIES) and write-behind logging.
- Explain the tradeoffs in query processing systems when using vectorized engines, NVEM, NVMA, RDMA, and GPUs.
- Perform database benchmarking activities.

TEXT BOOK: None. A list of technical research papers and lectures notes will be provided to the students.

Course time frame and thematic outline:			
TIME DISTRIBUTION			
Theme	**Face-to-Face**	**Hybrid**	**Online**
I. Review of relational algebra and SQL	3 hours	3 hours (face-to-face)	3 hours
II. Disk storage organization in row-oriented systems	3 hours	3 hours (online)	3 hours
III. Buffer Pool and Data Caching	3 hours	3 hours (face-to-face)	3 hours
IV. Query Processing: selections, projections, nested loops joins.	3 hours	3 hours (online)	3 hours
V. Indexing: ISAM, B+Tree, Hash, LSM-tree, BitMaps	4.5 hours	4.5 hours (face-to-face)	4.5 hours
VI. Advanced and Parallel Join Processing Methods	3 hours	3 hours (online)	3 hours
VII. TPC Benchmarks	1.5 hours	1.5 hours (face-to-face)	1.5 hours
VIII. Pessimistic Concurrency – 2PL	3 hours	3 hours (online)	3 hours
IX. Optimistic and Multi-version Concurrency	3 hours	3 hours (face-to-face)	3 hours
X. ARIES Crash Recovery	3 hours	3 hours (online)	3 hours
XI. Query Optimization – DP vs randomized	3 hours	3 hours (online)	3 hours
XII. Query Interpretation vs Compilation	1.5 hours	1.5 hours (online)	1.5 hours
XIII. Vectorized Engines	1.5 hours	1.5 hours (online)	1.5 hours
XIV. In-Memory Database Engines – Execution and Recovery	3 hours	3 hours (online)	3 hours
XV. Database Engines on new hardware: NVEM, NVMA, RDMA, and GPUs	3 hours	3 hours (online)	3 hours
XVI. Midterm Exams	3 hours	3 hours (face-to-face)	3 hours
Total contact hours	**45 hours**	**45 hours** (18 face-to-face = 40% and 27 online hours= 60%)	**45 hours**

INSTRUCTIONAL STRATEGIES:

Face-to-Face	Hybrid	Online
♦ Conferences ♦ Lectures ♦ Team Programming Projects ♦ Quizzes ♦ Exams	♦ Live and recorded Conferences ♦ Lectures ♦ Team Programming Projects ♦ Quizzes ♦ Exams	♦ Recorded Conferences ♦ Lectures ♦ Team Programming Projects ♦ Quizzes ♦ Exams

MINIMUM OR REQUIRED RESOURCES AVAILABLE:

RESOURCE	FACE-TO-FACE	HYBRID	ONLINE
Institutional learning management platform account (Ex. Moodle)	Institution	Institution	Institution
Institutional email account	Institution	Institution	Institution
Computer with high-speed internet access or mobile device with data service	Student	Student	Student
Programs or applications: free open source InteliJ IDE	Student	Student	Student
Webcam or mobile with camera and microphone	Not applicable	Student	Student

EVALUATION STRATEGIES:

FACE to FACE	HYBRID	ONLINE

All three modalities will be evaluated based on the following activities:

Activity	Quantity	Weight
Quizzes	10-12	10% - 20%
Midterm Exams	2	10% - 20%
Final Exam	1	10% - 20%
Programming Projects	4-6	40% - 60%

REASONABLE ACCOMMODATIONS:

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https://www.uprm.edu/cms/index.php/page/85. If your case is approved by OSEI-RUM, you will receive reasonable accommodation in your courses and evaluation, and you must contact each professor for course registered. For additional information contact OSEI-RUM at Sánchez Hidalgo 410 or via telephone 787-832-4040 extension 3107.

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GRADING SYSTEM

☒ Quantifiable (letters, A, B, C, D, F) ☐ Not Quantifiable

CONTINGENCY PLAN IN CASE OF AN EMERGENCY

In case of an emergency or class interruption, the professor can apply Bylaw 19-85 of the UPRM. This bylaw states that up to 25% of a class can be offered online.

BIBLIOGRAPHY

1. Abraham Silberschatz, Henry Korth, S. Sudarshan, *Database System Concepts*, 7th Edition, McGraw-Hill Ed., 2019.
2. A. Petrov, *Database Internals: A Deep Dive into How Distributed Data Systems Work*, 1st Edition, O'Reilly, 2019.
3. L. Campbell, C. Majors, *Database Reliability Engineering: Designing and Operating Resilient Database Systems*, 1st Edition, O'Reilly, 2017
4. ACM Special Interest Group in the Management of Data (SIGMOD) Digital Collection*, https://sigmod.org/
5. Very Large Databases (VLDB) Digital Collection*, https://www.vldb.org/
6. IEEE Data Engineering (TCDE) Digital Collection*, http://tab.computer.org/tcde/

* Electronic Portal to access technical research papers related to databases systems. Accesso to some papers might require valid subscription to ACM Digital Library, or IEEE Xplore. UPRM currently has access to these electronic digital libraries.

* Prepared by Manuel Rodriguez Martinez, on 11/12/21.

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
HOJA DE TRÁMITE PARA LA CREACIÓN DE CURSOS

CURSO: INSO 6007 - Secure Software Systems

DEPARTAMENTO: Ciencia e Ingeniería de Computación

FACULTAD: Ingeniería

	COMENTARIOS
Fecha en que el proponente somete la propuesta de Creación de Curso: Fecha: 8/15/2022	
Firma del Director de Departamento:  Fecha: 11/15/2022	
Firma del Decano de Facultad: _____ Fecha:	
Fecha en que la solicitud es recibida en la Secretaría del Senado Académico: Fecha:	
Fecha en la que la solicitud es recibida por el Comité de Cursos del Senado Académico: Fecha:	
Firma del Presidente de Comité de Cursos del Senado Académico: _____ Fecha:	
Fecha en que la solicitud es recibida por el Decanato de Asuntos Académicos: Fecha:	

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
DECANATO DE ASUNTOS ACADÉMICOS

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

[1] **Unidad: Recinto Universitario de Mayagüez**	[1] **Colegio: Ingeniería**
[1] **Departamento: Ciencia e Ingenieria de Computación** **Programa: MS/PhD en Ingeniería de Software**	[1] **Profesor (es)** **Proponente(s): Manuel Rodriguez Martinez, Heidy Sierra, Ahmed ElSaid**
[2] **Fecha de Solicitud: 8/15/2022**	[3] **Fecha de Vigencia del Curso: 8/2023**
[4] **Título Completo en Español: Sistemas de Software Seguros**	
[5] **(Título Abreviado a 26 Espacios): Sis Software Seguros**	
[4] **Título Completo en Inglés: Secure Software Systems**	
[5] **(Título Abreviado a 26 Espacios): Secure Software Sys**	
[6] **Materia Principal del Curso (en clave alfa): INSO**	
[7] **Justificación para la Creación del Curso:**	
Provide graduate students in Software Engineering with in-depth knowledge of the principles and techiques necessary to desing and implemente secure, privacy-perserving, and protected software systems and applications.	
[8] **Nivel del Curso (marque con una X): __ 1 __ 2 __ 3 __ 4 __ 5 Subgraduado** **X 6 __ 7 __ 8 __ 9 Graduado**	
[9] **Ubicación del curso, sea requisito, electivo o de continuación, en la secuencia curricular autorizada:** **(S=Semestres V=Verano) Período: ____S1 _X___S2 ____V**	
A partir del año de estudio de acuerdo con la secuencia: **_X__1ro ___2do ___3ro ___4to ___5to ___6to ___Otro ___ N/A**	
[10] **Codificación Alfanumérica: INSO 6007**	[11] **Cantidad de Créditos: 3**
[12] **Tipo de Curso: __X____Requisito _____Electivo _____División de Educación Continua**	
[13] **Tipo de créditos: __X__ Fijo ____Variable**	**Si es Variable, ¿puede repetirse con crédito? ___Si ___No**
	Si contesta si, indique la cantidad máxima que se puede repetir: _____
[14] **Distribución de Horas Contacto Semanales dedicadas a la enseñanza:**	
__X___Conferencia	**_____Laboratorio** **_____Investigación**

_____Discusión	**_____Taller**	**_____Tesis o Disertación**
_____Seminario	**_____Internado**	**_____Estudio Independiente**
_____Práctica Supervisada		

15 Total de Horas Contacto: __45____

16 Equivalencia en Horas de Crédito para la carga académica del Profesor: ___3___

17 Descripción del Curso en Español (que no se exceda de 1,000 caracteres):
Conceptos de desarrollo de software seguro en el contexto de principios de diseño de sistemas operativos seguros, mecanismos de protección, control de acceso, autenticación, análisis de vulnerabilidades y su aplicación en casos de estudio. Los casos de estudio se enfocarán en avances en el área de sistemas de software seguro para aplicaciones como proteger datos en reposo, dispositivos inteligentes y sistemas autónomos.

17 Descripción del Curso en Inglés (que no se exceda de 1,000 caracteres):

Concepts of secure software development in the context of secure operating system design principles, protection methods, access control, authentication, vulnerability analysis and case studies. Case studies will focus on secure software systems for applications such as securing data at rest, smart devices and autonomous systems.

18 Prerrequisitos*	**18Correquisitos***
Ninguno	

***Especifique la Codificación Alfanumérica Correcta**

19 Requisitos especiales: _____
_____

20 Modalidad en la que el Curso se ofrecerá (Puede marcar más de una opción):

__X__Curso Presencial __X__Curso Híbrido _X___Curso a Distancia

21 Cargos por laboratorio: ____ Sí __X__No

22 Posibilidad de Equivalencia (en la unidad o en otras unidades del sistema):
___ Sí _X_No

Cursos:_____

Unidad(es) que lo(s) ofrece(n): _____

23 Equipo, materiales e instalaciones mínimas requeridas:

Facilidades computacionales existentes del Departamento de Ciencia e Ingeniería de Computación.

24 Cantidad de Estudiantes por sección: _ 3___ Cupo Mínimo __30__ Cupo Máximo

[25] **Sistema de Calificación:**

_X___Letra (A, B, C, D o F) **____ Aprobado (S), No Aprobado (NS)**

____ Aprobado (P), No Aprobado (NP) **____Aprobado (PS: Aprobado Sobresaliente; PN: Aprobado Bueno), No Aprobado (NP)**

____Aprobado (P), Fracasado (F) **____Otro (Especifique)_____**

[26] **Curso a Inactivar sujeto a la creación del nuevo curso:**

_X____No Aplica **_____Si; especifique el curso a inactivar: _____**

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

[27] **APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL DEPARTAMENTO**	**NOMBRE Y FIRMA** **Emmanuel Arzuaga, Ph.D**	**FECHA** **11/15/2022**
Director de Departamento		
[28]**APROBACIÓN Y CERTIFICACIÓN A NIVEL DE LA FACULTAD**	**NOMBRE Y FIRMA**	**FECHA**
Decano de la Facultad		
[29] **APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL SENADO ACADÉMICO**	**NOMBRE Y FIRMA**	**FECHA**
Presidente del Comité de Cursos		

PARA USO DEL DECANATO DE ASUNTOS ACADÉMICOS

[30] **Codificación: _____** **Fecha de Codificación_____**

Funcionario que procesó la solicitud: **Fecha de envío al Departamento y Facultad:**

_____ **_____**

University of Puerto Rico
Mayagüez Campus
College of Engineering
Department of Computer Science and Engineering
Program in Software Engineering

COURSE SYLLABUS

COURSE TITLE:	Secure Software Systems
ALPHA-NUMERIC CODIFICATION:	INSO 6007
NUMBER OF CREDITS-CONTACT HOURS:	Three credits / 45 hours
PREREQUISITES, COREQUISITES AND OTHER REQUIREMENTS:	None

COURSE DESCRIPTION:

Spanish: Conceptos de desarrollo de software seguro en el contexto de principios de diseño de sistemas operativos seguros, mecanismos de protección, control de acceso, autenticación, análisis de vulnerabilidades y su aplicación en casos de estudio. Los casos de estudio se enfocarán en avances en el área de sistemas de software seguro para aplicaciones como proteger datos en reposo, dispositivos inteligentes y sistemas autónomos. El curso se puede ofrecer en una de las siguientes modalidades: presencial, hibrido o a distancia.

English: Concepts of secure software development in the context of secure operating system design principles, protection methods, access control, authentication, vulnerability analysis and case studies. Case studies will focus on secure software systems for applications such as securing data at rest, smart devices and autonomous systems.
(This course may be offered in any of the following modalities: face-to-face, hybrid or online.)

COURSE OBJECTIVES:

Students will :

1. Acquire knowledge of the fundamental principles of software development for secure systems and Application Programming Interfaces (API).
2. Design and implement security policies in high-level programming language frameworks using modern software engineering methods and tools.
3. Use and customize common security tools to detect vulnerabilities and threats in computer systems.
4. Learn modern techniques for secure coding in various applications such as web services, databases, cloud computing and big data infrastructures.

TEXT BOOK:

- William Stallings and Lawrie Brown, Computer Security Principles and Practice 4th Edition, Pearson Prentice Hall, 2017, ISBN: 9780134794105.
- Peter Kim, The Hacker Playbook 3: Practical Guide to Penetration Testing, CreateSpace Independent Publishing Platform, 2018, ISBN: 1980901759.

Course time frame and thematic outline:

	TIME DISTRIBUTION		
Theme	**Face-to-Face**	**Hybrid**	**Online**
I. Introduction to Secure Software Systems	1 hours	1 hours (face-to-face)	1 hours

II. Secure and trusted OS and API design principles	2 hours	2 hours (face-to-face)	2 hours
III. Virtualization as a security layer	3 hours	3 hours (online)	3 hours
IV. System environment reconnaissance and port scanning breakdown	4 hours	4 hours (3 online + 1 face-to-face)	4 hours
V. System services identification	4 hours	4 hours (3 online + 1 face-to-face)	4 hours
VI. Penetration testing and automated tools	4 hours	4 hours (3 online + 1 face-to-face)	4 hours
VII. Remote buffer overflows	4 hours	4 hours (3 online + 1 face-to-face)	4 hours
VIII. Denial of service attack models	3 hours	3 hours (online)	3 hours
IX. Exploiting trust and covering tracks	3 hours	3 hours (online)	3 hours
X. Backdoors and system startup manipulation	4 hours	4 hours (3 online + 1 face-to-face)	4 hours
XI. Remote control and keystroke loggers	3 hours	3 hours (online)	3 hours
XII. Secure coding and API principles	4 hours	4 hours (3 online + 1 face-to-face)	4 hours
XIII. Project Oral Presentations	3 hours	3 hours (face-to-face)	3
XIV. Exams	3 hours	3 hours (face-to-face)	3
Total contact hours	**45 hours**	**45 hours** (15 face-to-face = 33% and 30 online hours= 77%)	**45 hours**

INSTRUCTIONAL STRATEGIES:

Face-to-Face	Hybrid	Online
♦ Conferences ♦ Individual tasks ♦ Assessment activities ♦ Practice activities ♦ Oral presentations	♦ Online instructional modules ♦ Instructional Videos ♦ Individual tasks ♦ Practical activities ♦ Oral presentations ♦ Recorded and synchronous conferences	♦ Interactive instructional modules ♦ Instructional videos ♦ Individual tasks ♦ Practical activities ♦ Oral presentations ♦ Recorded conferences ♦ Synchronous conferences

MINIMUM OR REQUIRED RESOURCES AVAILABLE:

RESOURCE	FACE-TO-FACE	HYBRID	ONLINE
Institutional learning management platform account (Ex. Moodle)	Institution	Institution	Institution
Institutional email account	Institution	Institution	Institution

Computer with high-speed internet access or mobile device with data service	Institution/Student	Student	Student
Programs or applications: word processor, spreadsheets, presentation editor	Institution/Student	Student	Student
Built-in or external speakers	Not applicable	Student	Student
Webcam or mobile with camera and microphone	Not applicable	Student	Student

EVALUATION STRATEGIES: (Examples of evaluation techniques)

FACE to FACE

	Quantity	Percent
☒ Exams	2-3	25%-35%
☒ Final Exam	1	20%-25%
☐ Short Quizzes	0-6	0%-10%
☐ Oral Reports		
☐ Monographies		
☐ Portfolio		
☒ Projects	1	30%-40%
☐Journals		
☒Other, specify: Homework	0-10	0%-10%
TOTAL:		100%

HYBRID

	Quantity	Percent
☒ Exams	2-3	25%-35%
☒ Final Exam	1	20%-25%
☐ Short Quizzes	0-6	0%-10%
☐ Oral Reports		
☐ Monographies		
☐ Portfolio		
☒ Projects	1	30%-40%
☐Journals		
☒Other, specify: Homework	0-10	0%-10%
TOTAL:		100%

ONLINE

	Quantity	Percent
☒ Exams	2-3	25%-35%
☒ Final Exam	1	20%-25%
☐ Short Quizzes	0-6	0%-10%
☐ Oral Reports		
☐ Monographies		
☐ Portfolio		
☒ Projects	1	30%-40%
☐Journals		
☒Other, specify: Homework	0-10	0%-10%
TOTAL:		100%

REASONABLE ACCOMMODATIONS:

The University of Puerto Rico at Mayagüez (RUM) recognizes that each student has an inherited right to request reasonable accommodation according to Law 51: Law for Integral Educational Services for People with Disabilities. Every student has the right to receive reasonable accommodation if he/she presents the necessary evidence to be evaluated by the Office of Services to Students with Disabilities (OSEI-RUM), and the related information can be found at the following link: https://www.uprm.edu/cms/index.php/page/85. If your case is approved by OSEI-RUM, you will receive reasonable accommodation in your courses and evaluation, and you must contact each professor for course registered. For additional information contact OSEI-RUM at Sánchez Hidalgo 410 or via telephone 787-832-4040 extension 3107.

ACADEMIC INTEGRITY:

The University of Puerto Rico promotes the highest standards of academic and scientific integrity. Article 6.2 of the UPR Student General Bylaws (Board of Trustees Certification 13, 2009-2010) states that academic dishonesty includes, but is not limited to: fraudulent actions; obtaining grades or academic degrees by false or fraudulent simulations; copying the whole or part of the academic work of another person; plagiarizing totally or partially the work of another person; copying all or part of another person's answers to the questions of an oral or written exam by taking or having someone else take the exam on his/her behalf; as well as enabling and facilitating another person to perform the aforementioned behavior. Any of these behaviors will be subject to disciplinary action in accordance with the disciplinary procedure established by the UPR Student General Bylaws.─.

To ensure the integrity and security of user data, all hybrid, distance and online courses must be offered through the institutional learning management platform, which uses secure connection and authentication protocols. The system authenticates the identity of the user (student and professor) using the username and password assigned by the institution. The users are responsible for keeping their password safe, protected, and not to share it with other people.

POLICY AGAINST DISCRIMINATION BASED ON SEX, SEXUAL ORIENTATION, AND GENDER IDENTITY:

«The University of Puerto Rico prohibits discrimination based on sex, sexual orientation, and gender identity in any of its forms, including that of sexual harassment. According to the Institutional Policy Against Sexual Harassment at the University of Puerto Rico, Certification 130 (2014-2015) from the Board of Governors, any student subjected to acts constituting sexual harassment, may turn to the Office of the Student Ombudsperson, the Office of the Dean of Students, or the Coordinator of the Office of Compliance with Title IX for an orientation or formal complaint».

GRADING SYSTEM

☒ Quantifiable (letters, A, B, C, D, F) ☐ Not Quantifiable

CONTINGENCY PLAN IN CASE OF AN EMERGENCY

For example: In case of an emergency or class interruption, the professor will follow university rules to manage such cases. For example, Bylaw 19-85 of the UPRM states that up to 25% of a class can be offered online.

BIBLIOGRAPHY

1. William Stallings and Lawrie Brown, Computer Security Principles and Practice 4th Edition, Pearson Prentice Hall, 2017, ISBN: 9780134794105.*
2. Peter Kim, The Hacker Playbook 3: Practical Guide to Penetration Testing, CreateSpace Independent Publishing Platform, 2018, ISBN: 1980901759.
3. Loren Kohnfelder, Designing Secure Software: A Guide for Developers, No Starch Press, 2021, ISBN: 1718501927.
4. Mathew Hickey and Jennifer Arcuri, Hands on Hacking: Become an Expert at Next Gen Penetration Testing and Purple Teaming, 1st Edition, Wiley, 2020, ISBN: 1119561450
5. Ryan O'neill, Learning Linux Binary Analysis, Packt Publishing, 2016, ISBN: 9781782167105.
6. Daniel Deogun, Dan Bergh Johnsso, and Daniel Sawano, Secure By Design 1st Edition, Manning, 2019, ISBN: 1617294357
7. Neil Madden, API Security in Action 1st Edition, Manning, 2020, ISBN: 1617296023.
8. Electronic Portal to access technical research papers related to Database Systems.
   i) ACM Digital Library: https://dl.acm.org/
   ii) IEEE Xplore Digital Library: https://ieeexplore.ieee.org

Access to some papers might require valid subscription to ACM Digital Library, or IEEE Xplore. UPRM currently has access to these electronic digital libraries.

*Classic textbook.

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
HOJA DE TRÁMITE PARA LA CREACIÓN DE CURSOS

CURSO: INSO 8995 - Advanced Topics

DEPARTAMENTO: Ciencia e Ingeniería de Computación

FACULTAD: Ingeniería

	COMENTARIOS
Fecha en que el proponente somete la propuesta de Creación de Curso: Fecha: 8/15/2022	
Firma del Director de Departamento:  Fecha: 11/15/2022	
Firma del Decano de Facultad: _____ Fecha:	
Fecha en que la solicitud es recibida en la Secretaría del Senado Académico: Fecha:	
Fecha en la que la solicitud es recibida por el Comité de Cursos del Senado Académico: Fecha:	
Firma del Presidente de Comité de Cursos del Senado Académico: _____ Fecha:	
Fecha en que la solicitud es recibida por el Decanato de Asuntos Académicos: Fecha:	

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
DECANATO DE ASUNTOS ACADÉMICOS

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

[1] **Unidad: Recinto Universitario de Mayagüez**	[1] **Colegio: Ingeniería**
[1] **Departamento: Ciencia e Ingenieria de Computación** **Programa: MS/PhD en Ingeniería de Software**	[1] **Profesor (es)** **Proponente(s): Manuel Rodriguez Martinez, Heidy Sierra, Ahmed ElSaid**
[2] **Fecha de Solicitud: 8/15/2022**	[3] **Fecha de Vigencia del Curso: 8/2023**
[4] **Título Completo en Español: Temas Avanzados**	
[5] **(Título Abreviado a 26 Espacios): Temas Avanzados**	
[4] **Título Completo en Inglés: Advanced Topics**	
[5] **(Título Abreviado a 26 Espacios): Advanced Topics**	
[6] **Materia Principal del Curso (en clave alfa): INSO**	
[7] **Justificación para la Creación del Curso:**	
Provide doctoral students in Software Engineering with cutting-edge knowledge of a new, emergenging research area in software engineering. This course is intended for second year student in the PhD Program in Software Engineering. Permission of the Director is needed in orders to ensure that students have the background to successfully complete the research activities in the course.	
[8] **Nivel del Curso (marque con una X): 1 2 3 4 5 Subgraduado — 6 7 8 9 Graduado** (X en 8)	
[9] **Ubicación del curso, sea requisito, electivo o de continuación, en la secuencia curricular autorizada:** **(S=Semestres V=Verano) Período: ____S1 _X___S2 ____V**	
A partir del año de estudio de acuerdo con la secuencia: **___1ro _X__2do ___3ro ___4to ___5to ___6to ___Otro ___ N/A**	
[10] **Codificación Alfanumérica: INSO 8995**	[11] **Cantidad de Créditos: 3**
[12] **Tipo de Curso: __X____Requisito _____Electivo _____División de Educación Continua**	
[13] **Tipo de créditos: __X__ Fijo ____Variable**	**Si es Variable, ¿puede repetirse con crédito? ___Si ___No**
	Si contesta si, indique la cantidad máxima que se puede repetir: _____

14 Distribución de Horas Contacto Semanales dedicadas a la enseñanza:		
__X___Conferencia	**_____Laboratorio**	**_____Investigación**
_____Discusión	**_____Taller**	**_____Tesis o Disertación**
_____Seminario	**_____Internado**	**_____Estudio Independiente**
_____Práctica Supervisada		

15 Total de Horas Contacto: __45____

16 Equivalencia en Horas de Crédito para la carga académica del Profesor: ___3___

17 Descripción del Curso en Español (que no se exceda de 1,000 caracteres):

Discusión de temas avanzados en una área activa de investigación en Ingeniería de Software.

17 Descripción del Curso en Inglés (que no se exceda de 1,000 caracteres):

Discussion of an advanced topics in an active research field within Software Engineering.

18 Prerrequisitos*	**18Correquisitos***
Permiso del Director	

***Especifique la Codificación Alfanumérica Correcta**

19 Requisitos especiales: _____
_____

20 Modalidad en la que el Curso se ofrecerá (Puede marcar más de una opción):

__X__Curso Presencial __X__Curso Híbrido _X___Curso a Distancia

21 Cargos por laboratorio: ____ Sí __X__No

22 Posibilidad de Equivalencia (en la unidad o en otras unidades del sistema):
___ Sí _X_No

Cursos:_____

Unidad(es) que lo(s) ofrece(n): _____

23 Equipo, materiales e instalaciones mínimas requeridas:

Facilidades computacionales existentes del Departamento de Ciencia e Ingeniería de Computación.

24 Cantidad de Estudiantes por sección: _ 3___ Cupo Mínimo __30__ Cupo Máximo

[25] **Sistema de Calificación:**

_X___Letra (A, B, C, D o F) **____ Aprobado (S), No Aprobado (NS)**

____ Aprobado (P), No Aprobado (NP) **____Aprobado (PS: Aprobado Sobresaliente; PN: Aprobado Bueno), No Aprobado (NP)**

____Aprobado (P), Fracasado (F) **____Otro (Especifique)_____**

[26] **Curso a Inactivar sujeto a la creación del nuevo curso:**

_X____No Aplica **_____Si; especifique el curso a inactivar: _____**

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

[27] **APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL DEPARTAMENTO**	**NOMBRE Y FIRMA** **Emmanuel Arzuaga, Ph.D**	**FECHA** **11/15/2022**
Director de Departamento		
[28]**APROBACIÓN Y CERTIFICACIÓN A NIVEL DE LA FACULTAD**	**NOMBRE Y FIRMA**	**FECHA**
Decano de la Facultad		
[29] **APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL SENADO ACADÉMICO**	**NOMBRE Y FIRMA**	**FECHA**
Presidente del Comité de Cursos		

PARA USO DEL DECANATO DE ASUNTOS ACADÉMICOS

[30] **Codificación: _____** **Fecha de Codificación_____**

Funcionario que procesó la solicitud: **Fecha de envío al Departamento y Facultad:**

_____ **_____**

University of Puerto Rico
Mayagüez Campus
College of Engineering
Department of Computer Science and Engineering
Program in Software Engingeering

COURSE SYLLABUS

COURSE TITLE:	Advanced Topics
ALPHA-NUMERIC CODIFICATION:	INSO 8995
NUMBER OF CREDITS-CONTACT HOURS:	3 credits / 45 hours
PREREQUISITES, COREQUISITES AND OTHER REQUIREMENTS:	Permission of Department Chair

COURSE DESCRIPTION:

Spanish: Discusión de temas avanzados en una área activa de investigación en Ingeniería de Software. Este curso podrá ofrecerse en cualquiera de las siguientes modalidades: presencial, híbrida u online.

English: Discussion of an advanced topics in an active research field within Software Engineering, (This course may be offered in any of the following modalities: face-to-face, hybrid or online.)

COURSE OBJECTIVES:

Students will learn the state-of-the-art of field within Software Engineering and will be able to conduct exploratory research in said field.

TEXT BOOK:

None. A list of technical research papers and lectures notes will be provided to the students.

Course time frame and thematic outline:

	TIME DISTRIBUTION		
Theme	**Face-to-Face**	**Hybrid**	**Online**
Readings, lectures, and research activities in Software Engineering	45	25%-75% face-to-face 75%-25% online	45
Total contact hours	**45**	**45**	**45**

INSTRUCTIONAL STRATEGIES:

Face-to-Face	Hybrid	Online
• Conferences • Lectures • Team Programming Projects • Quizzes • Exams	• Live and recorded Conferences • Lectures • Team Programming Projects • Quizzes • Exams	• Recorded Conferences • Lectures • Team Programming Projects • Quizzes • Exams

MINIMUM OR REQUIRED RESOURCES AVAILABLE:

RESOURCE	FACE-TO-FACE	HYBRID	ONLINE

Institutional learning management platform account (Ex. Moodle)	Institution	Institution	Institution
Institutional email account	Institution	Institution	Institution
Computer with high-speed internet access or mobile device with data service	Institution/Student	Student	Student
Programs or applications: word processor, spreadsheets, presentation editor	Institution/Student	Student	Student
Built-in or external speakers	Not applicable	Student	Student
Webcam or mobile with camera and microphone	Not applicable	Student	Student

EVALUATION STRATEGIES:

FACE to FACE	HYBRID	ONLINE

All three modalities will be evaluated based on the following activities:

Activity	Quantity	Weight
Quizzes	5-10	0% - 20%
Homeworks	5-10	0% - 20%
Midterm Exams	1-2	10% - 20%
Final Exam	1	10% - 20%
Term Projects	1-4	40% - 60%

REASONABLE ACCOMMODATIONS:

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perform the aforementioned behavior. Any of these behaviors will be subject to disciplinary action in accordance with the disciplinary procedure established by the UPR Student General Bylaws.─.

To ensure the integrity and security of user data, all hybrid, distance and online courses must be offered through the institutional learning management platform, which uses secure connection and authentication protocols. The system authenticates the identity of the user (student and professor) using the username and password assigned by the institution. The users are responsible for keeping their password safe, protected, and not to share it with other people.

POLICY AGAINST DISCRIMINATION BASED ON SEX, SEXUAL ORIENTATION, AND GENDER IDENTITY:

«The University of Puerto Rico prohibits discrimination based on sex, sexual orientation, and gender identity in any of its forms, including that of sexual harassment. According to the Institutional Policy Against Sexual Harassment at the University of Puerto Rico, Certification 130 (2014-2015) from the Board of Governors, any student subjected to acts constituting sexual harassment, may turn to the Office of the Student Ombudsperson, the Office of the Dean of Students, or the Coordinator of the Office of Compliance with Title IX for an orientation or formal complaint».

GRADING SYSTEM

☒ Quantifiable (letters, A, B, C, D, F) ☐ Not Quantifiable

CONTINGENCY PLAN IN CASE OF AN EMERGENCY

For example: In case of an emergency or class interruption, the professor will follow university rules to manage such cases. For example, Bylaw 19-85 of the UPRM states that up to 25% of a class can be offered online.

BIBLIOGRAPHY

A list of technical research papers and lectures notes will be provided to the students based on topics from the following sources:

1. Electronic Portal to access technical research papers.
    a. ACM Digital Library: https://dl.acm.org/
    b. IEEE Xplore Digital Library: https://ieeexplore.ieee.org
2. ACM Special Interest Group in Software Engineering (SIGSOFT) Digital Collection, https://dl.acm.org/sig/sigsoft
3. IEEE Software Magazine, https://www.computer.org/csdl/magazine/so
4. IEEE Security and Privacy Magazine, https://www.computer.org/csdl/magazine/sp
5. ACM Special Interest Group in the Management of Data (SIGMOD) Digital Collection*, https://sigmod.org/

6. Very Large Databases (VLDB) Digital Collection*, https://www.vldb.org/
7. IEEE Data Engineering (TCDE) Digital Collection*, http://tab.computer.org/tcde/

* Access to some papers might require valid subscription to ACM Digital Library, or IEEE Xplore. UPRM currently has access to these electronic digital libraries.

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
HOJA DE TRÁMITE PARA LA CREACIÓN DE CURSOS

CURSO: INSO 8996 - Doctoral Seminar

DEPARTAMENTO: Ciencia e Ingeniería de Computación

FACULTAD: Ingeniería

	COMENTARIOS
Fecha en que el proponente somete la propuesta de Creación de Curso: Fecha: 8/15/2022	
Firma del Director de Departamento: _____ Fecha: 11/15/2022	
Firma del Decano de Facultad: _____ Fecha:	
Fecha en que la solicitud es recibida en la Secretaría del Senado Académico: Fecha:	
Fecha en la que la solicitud es recibida por el Comité de Cursos del Senado Académico: Fecha:	
Firma del Presidente de Comité de Cursos del Senado Académico: _____ Fecha:	
Fecha en que la solicitud es recibida por el Decanato de Asuntos Académicos: Fecha:	

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
DECANATO DE ASUNTOS ACADÉMICOS

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

1 **Unidad: Recinto Universitario de Mayagüez**	1 **Colegio: Ingeniería**
1 **Departamento: Ciencia e Ingenieria de Computación** **Programa: MS/PhD en Ingeniería de Software**	1 **Profesor (es)** **Proponente(s): Manuel Rodriguez Martinez, Heidy Sierra, Ahmed ElSaid**
2 **Fecha de Solicitud: 8/15/2022**	3 **Fecha de Vigencia del Curso: 8/2023**
4 **Título Completo en Español: Seminario Doctoral**	
5 **(Título Abreviado a 26 Espacios): Seminario Doctoral**	
4 **Título Completo en Inglés: Doctoral Seminar**	
5 **(Título Abreviado a 26 Espacios): Doctoral Seminar**	
6 **Materia Principal del Curso (en clave alfa): INSO**	
7 **Justificación para la Creación del Curso:**	
Provide doctoral students in Software Engineering with the knowledge and skills to review, critique, and write papers, proposals, and other scientific writings.	
8 **Nivel del Curso (marque con una X): 1 2 3 4 5 Subgraduado — 6 7 X 8 9 Graduado**	
9**Ubicación del curso, sea requisito, electivo o de continuación, en la secuencia curricular autorizada:** **(S=Semestres V=Verano) Período: _X___S1 ____S2 ____V**	
A partir del año de estudio de acuerdo con la secuencia: **___1ro _X__2do ___3ro ___4to ___5to ___6to ___Otro ___ N/A**	
10 **Codificación Alfanumérica: INSO 8996**	11 **Cantidad de Créditos: 3**
12 **Tipo de Curso: __X____Requisito _____Electivo _____División de Educación Continua**	
13 **Tipo de créditos: __X__ Fijo ____Variable**	**Si es Variable, ¿puede repetirse con crédito? ___Si ___No**
	Si contesta si, indique la cantidad máxima que se puede repetir: _____
14 **Distribución de Horas Contacto Semanales dedicadas a la enseñanza:**	
_____Conferencia	**_____Laboratorio** **_____Investigación**

_____Discusión	**_____Taller**	**_____Tesis o Disertación**
__X___Seminario	**_____Internado**	**_____Estudio Independiente**
_____Práctica Supervisada		

15 Total de Horas Contacto: __45____

16 Equivalencia en Horas de Crédito para la carga académica del Profesor: ___3___

17 Descripción del Curso en Español (que no se exceda de 1,000 caracteres):

Talleres para la discusión y ejercicio de habilidades para la redacción técnica o científica. Este curso prepara a los estudiantes para leer trabajos y propuestas de investigación, escribir críticas científicas, escribir artículos de repaso de literatura, y participar en paneles de revisión de investigaciones

17 Descripción del Curso en Inglés (que no se exceda de 1,000 caracteres):

Workshops for the discussion and exercise of skills for technical or scientific writing. This course prepares students to read research papers and proposals, write scientific critiques, write survey papers, and participate in research review panels.

18 Prerrequisitos*	**18Correquisitos***
Permiso del Director	

***Especifique la Codificación Alfanumérica Correcta**

19 Requisitos especiales: _____
_____

20 Modalidad en la que el Curso se ofrecerá (Puede marcar más de una opción):

__X__Curso Presencial __X__Curso Híbrido _X___Curso a Distancia

21 Cargos por laboratorio: ____ Sí __X__No

22 Posibilidad de Equivalencia (en la unidad o en otras unidades del sistema):
___ Sí _X_No

Cursos:_____

Unidad(es) que lo(s) ofrece(n): _____

23 Equipo, materiales e instalaciones mínimas requeridas:

Facilidades computacionales existentes del Departamento de Ciencia e Ingeniería de Computación.

24 Cantidad de Estudiantes por sección: _1___ Cupo Mínimo __30__ Cupo Máximo

25 Sistema de Calificación:

_X___Letra (A, B, C, D o F) **____ Aprobado (S), No Aprobado (NS)**

____ Aprobado (P), No Aprobado (NP) **____Aprobado (PS: Aprobado Sobresaliente; PN: Aprobado Bueno), No Aprobado (NP)**

____Aprobado (P), Fracasado (F) **____Otro (Especifique)_____**

26 Curso a Inactivar sujeto a la creación del nuevo curso:

_X____No Aplica **_____Si; especifique el curso a inactivar: _____**

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

27 APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL DEPARTAMENTO	**NOMBRE Y FIRMA** **Emmanuel Arzuaga, Ph.D**	**FECHA** **11/15/2022**
Director de Departamento		
28APROBACIÓN Y CERTIFICACIÓN A NIVEL DE LA FACULTAD	**NOMBRE Y FIRMA**	**FECHA**
Decano de la Facultad		
29 APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL SENADO ACADÉMICO	**NOMBRE Y FIRMA**	**FECHA**
Presidente del Comité de Cursos		

PARA USO DEL DECANATO DE ASUNTOS ACADÉMICOS

30 Codificación: _____ **Fecha de Codificación_____**

Funcionario que procesó la solicitud: **Fecha de envío al Departamento y Facultad:**

_____ **_____**

University of Puerto Rico
Mayagüez Campus
College of Engineering
Department of Computer Science and Engineering
Program in Software Engingeering

COURSE SYLLABUS

COURSE TITLE:	Doctoral Seminar
ALPHA-NUMERIC CODIFICATION:	INSO 8996
NUMBER OF CREDITS-CONTACT HOURS:	3 credits / 45 hours
PREREQUISITES, COREQUISITES AND OTHER REQUIREMENTS:	Permission of Department Chair

COURSE DESCRIPTION:

Spanish: Talleres para la discusión y ejercicio de habilidades para la redacción técnica o científica. Este curso prepara a los estudiantes para leer trabajos y propuestas de investigación, escribir críticas científicas, escribir artículos de repaso de literatura, y participar en paneles de revisión de investigaciones. Este curso podrá ofrecerse en cualquiera de las siguientes modalidades: presencial, híbrida o a distancia.

English: Workshops for the discussion and exercise of skills for technical or scientific writing. This course prepares students to read research papers and proposals, write scientific critiques, write survey papers, and participate in research review panels.
(This course may be offered in any of the following modalities: face-to-face, hybrid or online.)

COURSE OBJECTIVES:

Students will :

1. Learn how to read scientific papers and research proposals, identifying keys sections and understanding the contributions of each paper or research proposal.
2. Write a critique of a paper or proposal, identifying contributions, strengths, and weaknesses.
3. Write a survey research paper on a topic of his/her choice.
4. Participate in a mock panel to review papers produced by students in the course.

TEXT BOOK:

None. A list of technical research papers and lectures notes will be provided to the students.

Course time frame and thematic outline:

	TIME DISTRIBUTION		
Theme	**Face-to-Face**	**Hybrid**	**Online**
I. Introduction to scientific and technical writing and the peer reviewing process	2 hours	3 hours (face-to-face)	2 hours
II. Presentations and discussions on the contents, style and structure of the manuscripts	10 hours	10 hours (face-to-face)	10 hours
III. Submission and peer reviewing of	30 hours	30 hours (online)	30 hours

manuscripts. Responses of the authors to his/her article's peer reviews			
IV. Mock Panel	3 hours	3 hours (face-to-face)	3 hours
Total contact hours	**45**	**45** (15 hours face-to-face = 33%, and 30 hours online = 47%)	**45**

INSTRUCTIONAL STRATEGIES:

Face-to-Face	Hybrid	Online
• Conferences • Lectures • Team Programming Projects • Quizzes • Exams	• Live and recorded Conferences • Lectures • Team Programming Projects • Quizzes • Exams	• Recorded Conferences • Lectures • Team Programming Projects • Quizzes • Exams

MINIMUM OR REQUIRED RESOURCES AVAILABLE:

RESOURCE	FACE-TO-FACE	HYBRID	ONLINE
Institutional learning management platform account (Ex. Moodle)	Institution	Institution	Institution
Institutional email account	Institution	Institution	Institution
Computer with high-speed internet access or mobile device with data service	Institution/Student	Student	Student
Programs or applications: word processor, spreadsheets, presentation editor	Institution/Student	Student	Student
Built-in or external speakers	Not applicable	Student	Student
Webcam or mobile with camera and microphone	Not applicable	Student	Student

EVALUATION STRATEGIES:

FACE to FACE	HYBRID	ONLINE

All three modalities will be evaluated based on the following activities:

Activity	Quantity	Weight
Oral Report	1-2	20% - 40%
Research Paper	1	20% - 50%
Research Critiques	1-2	10% - 30%

REASONABLE ACCOMMODATIONS:

The University of Puerto Rico at Mayagüez (RUM) recognizes that each student has an inherited right to request reasonable accommodation according to Law 51: Law for Integral Educational Services for People with Disabilities. Every student has the right to receive reasonable accommodation if he/she presents the necessary evidence to be evaluated by the Office of Services to Students with Disabilities (OSEI-RUM), and the related information can be found at the following link: https://www.uprm.edu/cms/index.php/page/85. If your case is approved by OSEI-RUM, you will receive reasonable accommodation in your courses and evaluation, and you must contact each professor for course registered. For additional information contact OSEI-RUM at Sánchez Hidalgo 410 or via telephone 787-832-4040 extension 3107.

ACADEMIC INTEGRITY:

The University of Puerto Rico promotes the highest standards of academic and scientific integrity. Article 6.2 of the UPR Student General Bylaws (Board of Trustees Certification 13, 2009-2010) states that academic dishonesty includes, but is not limited to: fraudulent actions; obtaining grades or academic degrees by false or fraudulent simulations; copying the whole or part of the academic work of another person; plagiarizing totally or partially the work of another person; copying all or part of another person's answers to the questions of an oral or written exam by taking or having someone else take the exam on his/her behalf; as well as enabling and facilitating another person to perform the aforementioned behavior. Any of these behaviors will be subject to disciplinary action in accordance with the disciplinary procedure established by the UPR Student General Bylaws.─.

To ensure the integrity and security of user data, all hybrid, distance and online courses must be offered through the institutional learning management platform, which uses secure connection and authentication protocols. The system authenticates the identity of the user (student and professor) using the username and password assigned by the institution. The users are responsible for keeping their password safe, protected, and not to share it with other people.

POLICY AGAINST DISCRIMINATION BASED ON SEX, SEXUAL ORIENTATION, AND GENDER IDENTITY:

«The University of Puerto Rico prohibits discrimination based on sex, sexual orientation, and gender identity in any of its forms, including that of sexual harassment. According to the Institutional Policy Against Sexual Harassment at the University of Puerto Rico, Certification 130 (2014-2015) from the Board of Governors, any student subjected to acts constituting sexual harassment, may turn to the Office of the Student Ombudsperson, the Office of the Dean of Students, or the Coordinator of the Office of Compliance with Title IX for an orientation or formal complaint».

GRADING SYSTEM

☒ Quantifiable (letters, A, B, C, D, F) ☐ Not Quantifiable

CONTINGENCY PLAN IN CASE OF AN EMERGENCY

For example: In case of an emergency or class interruption, the professor will follow university rules to manage such cases. For example, Bylaw 19-85 of the UPRM states that up to 25% of a class can be offered online.

BIBLIOGRAPHY

A list of technical research papers and lectures notes will be provided to the students based on topics from the following sources:

1. Electronic Portal to access technical research papers.
    a. ACM Digital Library: https://dl.acm.org/
    b. IEEE Xplore Digital Library: https://ieeexplore.ieee.org
2. ACM Special Interest Group in Software Engineering (SIGSOFT) Digital Collection, https://dl.acm.org/sig/sigsoft
3. IEEE Software Magazine, https://www.computer.org/csdl/magazine/so
4. IEEE Security and Privacy Magazine, https://www.computer.org/csdl/magazine/sp
5. ACM Special Interest Group in the Management of Data (SIGMOD) Digital Collection*, https://sigmod.org/
6. Very Large Databases (VLDB) Digital Collection*, https://www.vldb.org/
7. IEEE Data Engineering (TCDE) Digital Collection*, http://tab.computer.org/tcde/

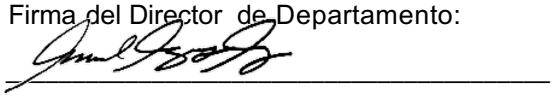
* Access to some papers might require valid subscription to ACM Digital Library, or IEEE Xplore. UPRM currently has access to these electronic digital libraries.

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
HOJA DE TRÁMITE PARA LA CREACIÓN DE CURSOS

CURSO: INSO 6998 - Master's Project

DEPARTAMENTO: Ciencia e Ingeniería de Computación

FACULTAD: Ingeniería

	COMENTARIOS
Fecha en que el proponente somete la propuesta de Creación de Curso: Fecha: 8/15/2022	
Firma del Director de Departamento:  Fecha: 11/15/2022	
Firma del Decano de Facultad: _____ Fecha:	
Fecha en que la solicitud es recibida en la Secretaría del Senado Académico: Fecha:	
Fecha en la que la solicitud es recibida por el Comité de Cursos del Senado Académico: Fecha:	
Firma del Presidente de Comité de Cursos del Senado Académico: _____ Fecha:	
Fecha en que la solicitud es recibida por el Decanato de Asuntos Académicos: Fecha:	

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
DECANATO DE ASUNTOS ACADÉMICOS

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

1 **Unidad: Recinto Universitario de Mayagüez**	1 **Colegio: Ingeniería**
1 **Departamento: Ciencia e Ingenieria de Computación** **Programa: MS/PhD en Ingeniería de Software**	1 **Profesor (es)** **Proponente(s): Manuel Rodriguez Martinez, Heidy Sierra, Ahmed ElSaid**
2 **Fecha de Solicitud: 8/15/2022**	3 **Fecha de Vigencia del Curso: 8/2023**
4 **Título Completo en Español: Proyecto de Maestría**	
5 **(Título Abreviado a 26 Espacios): Proyecto de Maestría**	
4 **Título Completo en Inglés: Master's Project**	
5 **(Título Abreviado a 26 Espacios): Master's Project**	
6 **Materia Principal del Curso (en clave alfa): INSO**	
7 **Justificación para la Creación del Curso:**	
Provide graduate students in Software Engineering with experience in the desing and implementation of a complex software artifact.	
8 **Nivel del Curso (marque con una X):** __ 1 __ 2 __ 3 __ 4 __ 5 **Subgraduado** X 6 __ 7 __ 8 __ 9 **Graduado**	
9**Ubicación del curso, sea requisito, electivo o de continuación, en la secuencia curricular autorizada:** **(S=Semestres V=Verano) Período: _X___S1 __X__S2 _X___V**	
A partir del año de estudio de acuerdo con la secuencia: **___1ro _X__2do _X__3ro ___4to ___5to ___6to ___Otro ___ N/A**	
10 **Codificación Alfanumérica: INSO 6998**	11 **Cantidad de Créditos: 0-6**
12 **Tipo de Curso: __X____Requisito _____Electivo _____División de Educación Continua**	
13 **Tipo de créditos: ____ Fijo _X___Variable**	**Si es Variable, ¿puede repetirse con crédito? _X__Si ___No**
	Si contesta si, indique la cantidad máxima que se puede repetir: ___0-6 creditos_____
14 **Distribución de Horas Contacto Semanales dedicadas a la enseñanza:**	
_____Conferencia	**_____Laboratorio** **_____Investigación**

_____Discusión	**_____Taller**	**__X___Tesis o Disertación**
_____Seminario	**_____Internado**	**_____Estudio Independiente**
_____Práctica Supervisada		

15 Total de Horas Contacto: __15-90____

16 Equivalencia en Horas de Crédito para la carga académica del Profesor: ___0-3___

17 Descripción del Curso en Español (que no se exceda de 1,000 caracteres):

Producción supervisada de una pieza de trabajo académico que contiene contribuciones originales a un problema de aplicación y desarrollo de Ingeniería de Software.

17 Descripción del Curso en Inglés (que no se exceda de 1,000 caracteres):

Supervised production of a piece of scholarly work that contains original contributions to an application and development problem in Software Engineering.

18 Prerrequisitos*	**18Correquisitos***
Permiso del Director	

***Especifique la Codificación Alfanumérica Correcta**

19 Requisitos especiales: _____
_____

20 Modalidad en la que el Curso se ofrecerá (Puede marcar más de una opción):

__X__Curso Presencial ____Curso Híbrido ____Curso a Distancia

21 Cargos por laboratorio: ____ Sí __X__No

22 Posibilidad de Equivalencia (en la unidad o en otras unidades del sistema):
___ Sí _X_No

Cursos:_____

Unidad(es) que lo(s) ofrece(n): _____

23 Equipo, materiales e instalaciones mínimas requeridas:

Facilidades computacionales existentes del Departamento de Ciencia e Ingeniería de Computación.

24 Cantidad de Estudiantes por sección: _ 1___ Cupo Mínimo __30__ Cupo Máximo

[25] **Sistema de Calificación:**

____Letra (A, B, C, D o F)

__X__ Aprobado (S), No Aprobado (NS)

____ Aprobado (P), No Aprobado (NP)

____Aprobado (PS: Aprobado Sobresaliente; PN: Aprobado Bueno), No Aprobado (NP)

____Aprobado (P), Fracasado (F)

__X__Otro (Especifique): al finallizar proyecto, asignar Letra (A, B, C, D, o F)

[26] **Curso a Inactivar sujeto a la creación del nuevo curso:**

_X____No Aplica **_____Si; especifique el curso a inactivar: _____**

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

[27] **APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL DEPARTAMENTO**	**NOMBRE Y FIRMA** **Emmanuel Arzuaga, Ph.D**	**FECHA** **11/15/2022**
Director de Departamento		
[28]**APROBACIÓN Y CERTIFICACIÓN A NIVEL DE LA FACULTAD**	**NOMBRE Y FIRMA**	**FECHA**
Decano de la Facultad		
[29] **APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL SENADO ACADÉMICO**	**NOMBRE Y FIRMA**	**FECHA**
Presidente del Comité de Cursos		

PARA USO DEL DECANATO DE ASUNTOS ACADÉMICOS

[30] **Codificación: _____** **Fecha de Codificación_____**

Funcionario que procesó la solicitud: **Fecha de envío al Departamento y Facultad:**

_____ **_____**

University of Puerto Rico
Mayagüez Campus
College of Engineering
Department of Computer Science and Engineering
Program in Software Engingeering

COURSE SYLLABUS

COURSE TITLE:	Master's Project
ALPHA-NUMERIC CODIFICATION:	INSO 6998
NUMBER OF CREDITS-CONTACT HOURS:	0-6 credits / 0-90 hours
PREREQUISITES, COREQUISITES AND OTHER REQUIREMENTS:	Permission of Department Chair

COURSE DESCRIPTION:

Spanish: Producción supervisada de una pieza de trabajo académico que contiene contribuciones originales a un problema de aplicación y desarrollo de Ingeniería de Software.

English: Supervised production of a piece of scholarly work that contains original contributions to an application and development problem in Software Engineering,

COURSE OBJECTIVES:

Students will conduct software development activities leading to original contributions in the knowledge of a given field within Software Engineering.

TEXT BOOK:

None. A list of technical research papers and lectures notes will be provided to the students.

Course time frame and thematic outline:

	TIME DISTRIBUTION		
Theme	**Face-to-Face**	**Hybrid**	**Online**
Development activities in Software Engineering	variable	variable	variable
Total contact hours	**variable**	**variable**	**variable**

INSTRUCTIONAL STRATEGIES:

Face-to-Face	Hybrid	Online
• Written Reports • Final Report • Oral presentations	• Written Reports • Final Report • Oral presentations	• Written Reports • Final Report • Oral presentations

MINIMUM OR REQUIRED RESOURCES AVAILABLE:

RESOURCE	FACE-TO-FACE	HYBRID	ONLINE

Institutional learning management platform account (Ex. Moodle)	Institution	Institution	Institution
Institutional email account	Institution	Institution	Institution
Computer with high-speed internet access or mobile device with data service	Institution/Student	Student	Student
Programs or applications: word processor, spreadsheets, presentation editor	Institution/Student	Student	Student
Built-in or external speakers	Not applicable	Student	Student
Webcam or mobile with camera and microphone	Not applicable	Student	Student

EVALUATION STRATEGIES:

FACE to FACE	HYBRID	ONLINE

Activity	Quantity	Weight
Master Project or Interim Report	1	100%

REASONABLE ACCOMMODATIONS:

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GRADING SYSTEM

☒ Quantifiable (letters, A, B, C, D, F) ☒ Not Quantifiable

CONTINGENCY PLAN IN CASE OF AN EMERGENCY

For example: In case of an emergency or class interruption, the professor will follow university rules to manage such cases. For example, Bylaw 19-85 of the UPRM states that up to 25% of a class can be offered online.

BIBLIOGRAPHY

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    a. ACM Digital Library: https://dl.acm.org/
    b. IEEE Xplore Digital Library: https://ieeexplore.ieee.org
2. ACM Special Interest Group in Software Engineering (SIGSOFT) Digital Collection, https://dl.acm.org/sig/sigsoft
3. IEEE Software Magazine, https://www.computer.org/csdl/magazine/so
4. IEEE Security and Privacy Magazine, https://www.computer.org/csdl/magazine/sp
5. ACM Special Interest Group in the Management of Data (SIGMOD) Digital Collection*, https://sigmod.org/
6. Very Large Databases (VLDB) Digital Collection*, https://www.vldb.org/
7. IEEE Data Engineering (TCDE) Digital Collection*, http://tab.computer.org/tcde/

* Access to some papers might require valid subscription to ACM Digital Library, or IEEE Xplore. UPRM currently has access to these electronic digital libraries.

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
HOJA DE TRÁMITE PARA LA CREACIÓN DE CURSOS

CURSO: INSO 6999 - Master's Thesis

DEPARTAMENTO: Ciencia e Ingeniería de Computación

FACULTAD: Ingeniería

	COMENTARIOS
Fecha en que el proponente somete la propuesta de Creación de Curso: Fecha: 8/15/2022	
Firma del Director de Departamento:  Fecha: 11/15/2022	
Firma del Decano de Facultad: _____ Fecha:	
Fecha en que la solicitud es recibida en la Secretaría del Senado Académico: Fecha:	
Fecha en la que la solicitud es recibida por el Comité de Cursos del Senado Académico: Fecha:	
Firma del Presidente de Comité de Cursos del Senado Académico: _____ Fecha:	
Fecha en que la solicitud es recibida por el Decanato de Asuntos Académicos: Fecha:	

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
DECANATO DE ASUNTOS ACADÉMICOS

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

1 **Unidad: Recinto Universitario de Mayagüez**	1 **Colegio: Ingeniería**
1 **Departamento: Ciencia e Ingenieria de Computación** **Programa: MS/PhD en Ingeniería de Software**	1 **Profesor (es)** **Proponente(s): Manuel Rodriguez Martinez, Heidy Sierra, Ahmed ElSaid**
2 **Fecha de Solicitud: 8/15/2022**	3 **Fecha de Vigencia del Curso: 8/2023**
4 **Título Completo en Español: Tesis de Maestría**	
5 **(Título Abreviado a 26 Espacios): Tesis de Maestría**	
4 **Título Completo en Inglés: Master's Thesis**	
5 **(Título Abreviado a 26 Espacios): Master's Thesis**	
6 **Materia Principal del Curso (en clave alfa): INSO**	
7 **Justificación para la Creación del Curso:**	
Provide graduate students in Software Engineering with experience in the research of a complex software engineering problem.	
8 **Nivel del Curso (marque con una X): __ 1 __ 2 __ 3 __ 4 __ 5 Subgraduado** **X 6 __ 7 __ 8 __ 9 Graduado**	
9**Ubicación del curso, sea requisito, electivo o de continuación, en la secuencia curricular autorizada:** **(S=Semestres V=Verano) Período: _X___S1 __X__S2 _X___V**	
A partir del año de estudio de acuerdo con la secuencia: **___1ro _X__2do _X__3ro ___4to ___5to ___6to ___Otro ___ N/A**	
10 **Codificación Alfanumérica: INSO 6999**	11 **Cantidad de Créditos: 0-6**
12 **Tipo de Curso: __X____Requisito _____Electivo _____División de Educación Continua**	
13 **Tipo de créditos: ____ Fijo _X___Variable**	**Si es Variable, ¿puede repetirse con crédito? _X__Si ___No**
	Si contesta si, indique la cantidad máxima que se puede repetir: ___0-6 creditos_____
14 **Distribución de Horas Contacto Semanales dedicadas a la enseñanza:**	
_____Conferencia	**_____Laboratorio** **_____Investigación**

_____Discusión	**_____Taller**	**__X___Tesis o Disertación**
_____Seminario	**_____Internado**	**_____Estudio Independiente**
_____Práctica Supervisada		

15 Total de Horas Contacto: __15-90____

16 Equivalencia en Horas de Crédito para la carga académica del Profesor: ___0-3___

17 Descripción del Curso en Español (que no se exceda de 1,000 caracteres):

Producción supervisada de una pieza de trabajo académico que contiene contribuciones originales a un problema de investigación en Ingeniería de Software.

17 Descripción del Curso en Inglés (que no se exceda de 1,000 caracteres):

Supervised production of a piece of scholarly work that contains original contributions to a research problem in Software Engineering.

18 Prerrequisitos*	**18Correquisitos***
Permiso del Director	

***Especifique la Codificación Alfanumérica Correcta**

19 Requisitos especiales: _____
_____

20 Modalidad en la que el Curso se ofrecerá (Puede marcar más de una opción):

__X__Curso Presencial ____Curso Híbrido ____Curso a Distancia

21 Cargos por laboratorio: ____ Sí __X__No

22 Posibilidad de Equivalencia (en la unidad o en otras unidades del sistema):
___ Sí _X_No

Cursos:_____

Unidad(es) que lo(s) ofrece(n): _____

23 Equipo, materiales e instalaciones mínimas requeridas:

Facilidades computacionales existentes del Departamento de Ciencia e Ingeniería de Computación.

24 Cantidad de Estudiantes por sección: _ 1___ Cupo Mínimo __30__ Cupo Máximo

[25] **Sistema de Calificación:**

____Letra (A, B, C, D o F)

__X__ Aprobado (S), No Aprobado (NS)

____ Aprobado (P), No Aprobado (NP)

____Aprobado (PS: Aprobado Sobresaliente; PN: Aprobado Bueno), No Aprobado (NP)

____Aprobado (P), Fracasado (F)

__X__Otro (Especifique)__ al finallizar proyecto, asignar Letra (A, B, C, D, o F)

[26] **Curso a Inactivar sujeto a la creación del nuevo curso:**

_X____No Aplica **_____Si; especifique el curso a inactivar: _____**

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

[27] **APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL DEPARTAMENTO**	**NOMBRE Y FIRMA** **Emmanuel Arzuaga, Ph.D**	**FECHA** **11/15/2022**
Director de Departamento		
[28]**APROBACIÓN Y CERTIFICACIÓN A NIVEL DE LA FACULTAD**	**NOMBRE Y FIRMA**	**FECHA**
Decano de la Facultad		
[29] **APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL SENADO ACADÉMICO**	**NOMBRE Y FIRMA**	**FECHA**
Presidente del Comité de Cursos		

PARA USO DEL DECANATO DE ASUNTOS ACADÉMICOS

[30] **Codificación: _____** **Fecha de Codificación_____**

Funcionario que procesó la solicitud: **Fecha de envío al Departamento y Facultad:**

_____ **_____**

University of Puerto Rico
Mayagüez Campus
College of Engineering
Department of Computer Science and Engineering
Program in Software Engingeering

COURSE SYLLABUS

COURSE TITLE:	Master's Thesis
ALPHA-NUMERIC CODIFICATION:	INSO 6999
NUMBER OF CREDITS-CONTACT HOURS:	0-6 credits / 0-90 hours
PREREQUISITES, COREQUISITES AND OTHER REQUIREMENTS:	Permission of Department Chair

COURSE DESCRIPTION:

Spanish: Producción supervisada de una pieza de trabajo académico que contiene contribuciones originales a un problema de investigación en Ingeniería de Software.

English: Supervised production of a piece of scholarly work that contains original contributions to a research problem in Software Engineering.

COURSE OBJECTIVES:

Students will research activities leading to original contributions in the knowledge of a given field within Software Engineering.

TEXT BOOK:

None. A list of technical research papers and lectures notes will be provided to the students.

Course time frame and thematic outline:

	TIME DISTRIBUTION		
Theme	**Face-to-Face**	**Hybrid**	**Online**
Research activities in Software Engineering	variable	variable	variable
Total contact hours	**variable**	**variable**	**variable**

INSTRUCTIONAL STRATEGIES:

Face-to-Face	Hybrid	Online
• Written Reports • Thesis • Oral presentations	• Written Reports • Thesis • Oral presentations	• Written Reports • Thesis • Oral presentations

MINIMUM OR REQUIRED RESOURCES AVAILABLE:

RESOURCE	FACE-TO-FACE	HYBRID	ONLINE

Institutional learning management platform account (Ex. Moodle)	Institution	Institution	Institution
Institutional email account	Institution	Institution	Institution
Computer with high-speed internet access or mobile device with data service	Institution/Student	Student	Student
Programs or applications: word processor, spreadsheets, presentation editor	Institution/Student	Student	Student
Built-in or external speakers	Not applicable	Student	Student
Webcam or mobile with camera and microphone	Not applicable	Student	Student

EVALUATION STRATEGIES:

FACE to FACE	HYBRID	ONLINE

Activity	Quantity	Weight
Master Thesis or Interim Report	1	100%

REASONABLE ACCOMMODATIONS:

The University of Puerto Rico at Mayagüez (RUM) recognizes that each student has an inherited right to request reasonable accommodation according to Law 51: Law for Integral Educational Services for People with Disabilities. Every student has the right to receive reasonable accommodation if he/she presents the necessary evidence to be evaluated by the Office of Services to Students with Disabilities (OSEI-RUM), and the related information can be found at the following link: https://www.uprm.edu/cms/index.php/page/85. If your case is approved by OSEI-RUM, you will receive reasonable accommodation in your courses and evaluation, and you must contact each professor for course registered. For additional information contact OSEI-RUM at Sánchez Hidalgo 410 or via telephone 787-832-4040 extension 3107.

ACADEMIC INTEGRITY:

The University of Puerto Rico promotes the highest standards of academic and scientific integrity. Article 6.2 of the UPR Student General Bylaws (Board of Trustees Certification 13, 2009-2010) states that academic dishonesty includes, but is not limited to: fraudulent actions; obtaining grades or academic degrees by false or fraudulent simulations; copying the whole or part of the academic work of another person; plagiarizing totally or partially the work of another person; copying all or part of another person's answers to the questions of an oral or written exam by taking or having someone else take the exam on his/her behalf; as well as enabling and facilitating another person to perform the aforementioned behavior. Any of these behaviors will be subject to disciplinary action in accordance with the disciplinary procedure established by the UPR Student General Bylaws.─.

To ensure the integrity and security of user data, all hybrid, distance and online courses must be offered through the institutional learning management platform, which uses secure connection and authentication protocols. The system authenticates the identity of the user (student and professor) using the username and password assigned by the institution. The users are responsible for keeping their password safe, protected, and not to share it with other people.

POLICY AGAINST DISCRIMINATION BASED ON SEX, SEXUAL ORIENTATION, AND GENDER IDENTITY:

«The University of Puerto Rico prohibits discrimination based on sex, sexual orientation, and gender identity in any of its forms, including that of sexual harassment. According to the Institutional Policy Against Sexual Harassment at the University of Puerto Rico, Certification 130 (2014-2015) from the Board of Governors, any student subjected to acts constituting sexual harassment, may turn to the Office of the Student Ombudsperson, the Office of the Dean of Students, or the Coordinator of the Office of Compliance with Title IX for an orientation or formal complaint».

GRADING SYSTEM

☒ Quantifiable (letters, A, B, C, D, F) ☒ Not Quantifiable

CONTINGENCY PLAN IN CASE OF AN EMERGENCY

For example: In case of an emergency or class interruption, the professor will follow university rules to manage such cases. For example, Bylaw 19-85 of the UPRM states that up to 25% of a class can be offered online.

BIBLIOGRAPHY

A list of technical research papers and lectures notes will be provided to the students based on topics from the following sources:

1. Electronic Portal to access technical research papers.
    a. ACM Digital Library: https://dl.acm.org/
    b. IEEE Xplore Digital Library: https://ieeexplore.ieee.org
2. ACM Special Interest Group in Software Engineering (SIGSOFT) Digital Collection, https://dl.acm.org/sig/sigsoft
3. IEEE Software Magazine, https://www.computer.org/csdl/magazine/so
4. IEEE Security and Privacy Magazine, https://www.computer.org/csdl/magazine/sp
5. ACM Special Interest Group in the Management of Data (SIGMOD) Digital Collection*, https://sigmod.org/
6. Very Large Databases (VLDB) Digital Collection*, https://www.vldb.org/
7. IEEE Data Engineering (TCDE) Digital Collection*, http://tab.computer.org/tcde/

* Access to some papers might require valid subscription to ACM Digital Library, or IEEE Xplore. UPRM currently has access to these electronic digital libraries.

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
HOJA DE TRÁMITE PARA LA CREACIÓN DE CURSOS

CURSO: INSO 8999 - Doctoral Dissertation Research

DEPARTAMENTO: Ciencia e Ingeniería de Computación

FACULTAD: Ingeniería

	COMENTARIOS
Fecha en que el proponente somete la propuesta de Creación de Curso: Fecha: 8/15/2022	
Firma del Director de Departamento:  Fecha: 11/15/2022	
Firma del Decano de Facultad: _____ Fecha:	
Fecha en que la solicitud es recibida en la Secretaría del Senado Académico: Fecha:	
Fecha en la que la solicitud es recibida por el Comité de Cursos del Senado Académico: Fecha:	
Firma del Presidente de Comité de Cursos del Senado Académico: _____ Fecha:	
Fecha en que la solicitud es recibida por el Decanato de Asuntos Académicos: Fecha:	

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
DECANATO DE ASUNTOS ACADÉMICOS

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

1 **Unidad: Recinto Universitario de Mayagüez**	1 **Colegio: Ingeniería**
1 **Departamento: Ciencia e Ingenieria de Computación** **Programa: MS/PhD en Ingeniería de Software**	1 **Profesor (es)** **Proponente(s): Manuel Rodriguez Martinez, Heidy Sierra, Ahmed ElSaid**
2 **Fecha de Solicitud: 8/15/2022**	3 **Fecha de Vigencia del Curso: 8/2023**
4 **Título Completo en Español: Disertación Doctoral**	
5 **(Título Abreviado a 26 Espacios): Disertación Doctoral**	
4 **Título Completo en Inglés: Doctoral Dissertation**	
5 **(Título Abreviado a 26 Espacios): Doctoral Dissertation**	
6 **Materia Principal del Curso (en clave alfa): INSO**	
7 **Justificación para la Creación del Curso:** **Provide graduate students in Software Engineering with experience in the research of a complex, state-of-the-art software engineering research problem.**	
8 **Nivel del Curso (marque con una X):** __ 1 __ 2 __ 3 __ 4 __ 5 **Subgraduado** __ 6 __ 7 **X** 8 __ 9 **Graduado**	
9**Ubicación del curso, sea requisito, electivo o de continuación, en la secuencia curricular autorizada:** **(S=Semestres V=Verano) Período: _X___S1 __X__S2 _X___V**	
A partir del año de estudio de acuerdo con la secuencia: **___1ro ___2do _X__3ro _X__4to _X__5to ___6to ___Otro ___ N/A**	
10 **Codificación Alfanumérica: INSO 8999**	11 **Cantidad de Créditos: 0-18**
12 **Tipo de Curso: __X____Requisito _____Electivo _____División de Educación Continua**	
13 **Tipo de créditos: ____ Fijo _X___Variable**	**Si es Variable, ¿puede repetirse con crédito? _X__Si ___No**
	Si contesta si, indique la cantidad máxima que se puede repetir: ___0-18 creditos_____
14 **Distribución de Horas Contacto Semanales dedicadas a la enseñanza:**	
_____Conferencia	**_____Laboratorio** **_____Investigación**

_____Discusión	**_____Taller**	**__X___Tesis o Disertación**
_____Seminario	**_____Internado**	**_____Estudio Independiente**
_____Práctica Supervisada		

15 Total de Horas Contacto: __15-270____

16 Equivalencia en Horas de Crédito para la carga académica del Profesor: ___0-3___

17 Descripción del Curso en Español (que no se exceda de 1,000 caracteres):

Producción supervisada de una pieza de trabajo académico que contiene contribuciones originales a un problema de investigación de punta de lanza en Ingeniería de Software.

17 Descripción del Curso en Inglés (que no se exceda de 1,000 caracteres):

Supervised production of a piece of scholarly work that contains original contributions to a cutting-edge research problem in Software Engineering.

18 Prerrequisitos*	**18Correquisitos***
Permiso del Director	

***Especifique la Codificación Alfanumérica Correcta**

19 Requisitos especiales: _____
_____

20 Modalidad en la que el Curso se ofrecerá (Puede marcar más de una opción):

__X__Curso Presencial ____Curso Híbrido ____Curso a Distancia

21 Cargos por laboratorio: ____ Sí __X__No

22 Posibilidad de Equivalencia (en la unidad o en otras unidades del sistema):
___ Sí _X_No

Cursos:_____

Unidad(es) que lo(s) ofrece(n): _____

23 Equipo, materiales e instalaciones mínimas requeridas:

Facilidades computacionales existentes del Departamento de Ciencia e Ingeniería de Computación.

24 Cantidad de Estudiantes por sección: _ 1___ Cupo Mínimo __30__ Cupo Máximo

[25] **Sistema de Calificación:**

____Letra (A, B, C, D o F)

__X__ Aprobado (S), No Aprobado (NS)

____ Aprobado (P), No Aprobado (NP)

____Aprobado (PS: Aprobado Sobresaliente; PN: Aprobado Bueno), No Aprobado (NP)

____Aprobado (P), Fracasado (F)

__X__Otro (Especifique)__ al finallizar proyecto, asignar Letra (A, B, C, D, o F)

[26] **Curso a Inactivar sujeto a la creación del nuevo curso:**

_X____No Aplica **_____Si; especifique el curso a inactivar: _____**

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

[27] **APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL DEPARTAMENTO**	**NOMBRE Y FIRMA** **Emmanuel Arzuaga, Ph.D**	**FECHA** **11/15/2022**
Director de Departamento		
[28]**APROBACIÓN Y CERTIFICACIÓN A NIVEL DE LA FACULTAD**	**NOMBRE Y FIRMA**	**FECHA**
Decano de la Facultad		
[29] **APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL SENADO ACADÉMICO**	**NOMBRE Y FIRMA**	**FECHA**
Presidente del Comité de Cursos		

PARA USO DEL DECANATO DE ASUNTOS ACADÉMICOS

[30] **Codificación: _____** **Fecha de Codificación_____**

Funcionario que procesó la solicitud: **Fecha de envío al Departamento y Facultad:**

_____ **_____**

University of Puerto Rico
Mayagüez Campus
College of Engineering
Department of Computer Science and Engineering
Program in Software Engingeering

COURSE SYLLABUS

COURSE TITLE:	Doctoral Dissertation
ALPHA-NUMERIC CODIFICATION:	INSO 8999
NUMBER OF CREDITS-CONTACT HOURS:	0-18 credits / 0-270 hours
PREREQUISITES, COREQUISITES AND OTHER REQUIREMENTS:	Permission of Department Chair

COURSE DESCRIPTION:

Spanish: Producción supervisada de una pieza de trabajo académico que contiene contribuciones originales a un problema de investigación de punta de lanza en Ingeniería de Software.

English: Supervised production of a piece of scholarly work that contains original contributions to a cutting-edge research problem in Software Engineering,

COURSE OBJECTIVES:

Students will research activities leading to original contributions in the state-of-the-art knowledge of a given field within Software Engineering.

TEXT BOOK:

None. A list of technical research papers and lectures notes will be provided to the students.

Course time frame and thematic outline:

	TIME DISTRIBUTION		
Theme	**Face-to-Face**	**Hybrid**	**Online**
Research activities in Software Engineering	variable	variable	variable
Total contact hours	**variable**	**variable**	**variable**

INSTRUCTIONAL STRATEGIES:

Face-to-Face	Hybrid	Online
• Written Reports • Dissertation • Oral presentations	• Written Reports • Dissertation • Oral presentations	• Written Reports • Dissertation • Oral presentations

MINIMUM OR REQUIRED RESOURCES AVAILABLE:

RESOURCE	FACE-TO-FACE	HYBRID	ONLINE

Institutional learning management platform account (Ex. Moodle)	Institution	Institution	Institution
Institutional email account	Institution	Institution	Institution
Computer with high-speed internet access or mobile device with data service	Institution/Student	Student	Student
Programs or applications: word processor, spreadsheets, presentation editor	Institution/Student	Student	Student
Built-in or external speakers	Not applicable	Student	Student
Webcam or mobile with camera and microphone	Not applicable	Student	Student

EVALUATION STRATEGIES:

FACE to FACE	HYBRID	ONLINE

Activity	Quantity	Weight
Doctoral Dissertation or Interim Report	1	100%

REASONABLE ACCOMMODATIONS:

The University of Puerto Rico at Mayagüez (RUM) recognizes that each student has an inherited right to request reasonable accommodation according to Law 51: Law for Integral Educational Services for People with Disabilities. Every student has the right to receive reasonable accommodation if he/she presents the necessary evidence to be evaluated by the Office of Services to Students with Disabilities (OSEI-RUM), and the related information can be found at the following link: https://www.uprm.edu/cms/index.php/page/85. If your case is approved by OSEI-RUM, you will receive reasonable accommodation in your courses and evaluation, and you must contact each professor for course registered. For additional information contact OSEI-RUM at Sánchez Hidalgo 410 or via telephone 787-832-4040 extension 3107.

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GRADING SYSTEM

☒ Quantifiable (letters, A, B, C, D, F) ☒ Not Quantifiable

CONTINGENCY PLAN IN CASE OF AN EMERGENCY

For example: In case of an emergency or class interruption, the professor will follow university rules to manage such cases. For example, Bylaw 19-85 of the UPRM states that up to 25% of a class can be offered online.

BIBLIOGRAPHY

A list of technical research papers and lectures notes will be provided to the students based on topics from the following sources:

1. Electronic Portal to access technical research papers.
    a. ACM Digital Library: https://dl.acm.org/
    b. IEEE Xplore Digital Library: https://ieeexplore.ieee.org
2. ACM Special Interest Group in Software Engineering (SIGSOFT) Digital Collection, https://dl.acm.org/sig/sigsoft
3. IEEE Software Magazine, https://www.computer.org/csdl/magazine/so
4. IEEE Security and Privacy Magazine, https://www.computer.org/csdl/magazine/sp
5. ACM Special Interest Group in the Management of Data (SIGMOD) Digital Collection*, https://sigmod.org/
6. Very Large Databases (VLDB) Digital Collection*, https://www.vldb.org/
7. IEEE Data Engineering (TCDE) Digital Collection*, http://tab.computer.org/tcde/

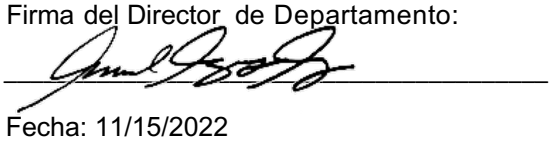
* Access to some papers might require valid subscription to ACM Digital Library, or IEEE Xplore. UPRM currently has access to these electronic digital libraries.

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
HOJA DE TRÁMITE PARA LA CREACIÓN DE CURSOS

CURSO: INSO 6010 - Development and Operations

DEPARTAMENTO: Ciencia e Ingeniería de Computación

FACULTAD: Ingeniería

	COMENTARIOS
Fecha en que el proponente somete la propuesta de Creación de Curso: Fecha: 8/15/2022	
Firma del Director de Departamento:  Fecha: 11/15/2022	
Firma del Decano de Facultad: _____ Fecha:	
Fecha en que la solicitud es recibida en la Secretaría del Senado Académico: Fecha:	
Fecha en la que la solicitud es recibida por el Comité de Cursos del Senado Académico: Fecha:	
Firma del Presidente de Comité de Cursos del Senado Académico: _____ Fecha:	
Fecha en que la solicitud es recibida por el Decanato de Asuntos Académicos: Fecha:	

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
DECANATO DE ASUNTOS ACADÉMICOS

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

1 **Unidad: Recinto Universitario de Mayagüez**	1 **Colegio: Ingeniería**
1 **Departamento: Ciencia e Ingenieria de Computación** **Programa: MS/PhD en Ingeniería de Software**	1 **Profesor (es)** **Proponente(s): Manuel Rodriguez Martinez, Heidy Sierra, Ahmed ElSaid**
2 **Fecha de Solicitud: 8/15/2022**	3 **Fecha de Vigencia del Curso: 8/2023**
4 **Título Completo en Español: Desarollo y Operaciones**	
5 **(Título Abreviado a 26 Espacios): DevOps**	
4 **Título Completo en Inglés: Development and Operations**	
5 **(Título Abreviado a 26 Espacios): DevOps**	
6 **Materia Principal del Curso (en clave alfa): INSO**	
7 **Justificación para la Creación del Curso:**	
Provide graduate students in Software Engineering with in-depth knowledge of the principles and techiques for the rapid and continuous development, integration, and delivery of software systems for production use.	
8 **Nivel del Curso (marque con una X): 1 2 3 4 5 Subgraduado** — **X 6 7 8 9 Graduado**	
9**Ubicación del curso, sea requisito, electivo o de continuación, en la secuencia curricular autorizada:** **(S=Semestres V=Verano) Período: __X__S1 ____S2 ____V**	
A partir del año de estudio de acuerdo con la secuencia: **_X__1ro _X__2do ___3ro ___4to ___5to ___6to ___Otro ___ N/A**	
10 **Codificación Alfanumérica: INSO 6010**	11 **Cantidad de Créditos: 3**
12 **Tipo de Curso: _____Requisito ___X___Electivo _____División de Educación Continua**	
13 **Tipo de créditos: __X__ Fijo ____Variable**	**Si es Variable, ¿puede repetirse con crédito? ___Si ___No**
	Si contesta si, indique la cantidad máxima que se puede repetir: _____
14 **Distribución de Horas Contacto Semanales dedicadas a la enseñanza:**	
__X___Conferencia	**_____Laboratorio** **_____Investigación**

_____Discusión	**_____Taller**	**_____Tesis o Disertación**
_____Seminario	**_____Internado**	**_____Estudio Independiente**
_____Práctica Supervisada		

15 Total de Horas Contacto: __45____

16 Equivalencia en Horas de Crédito para la carga académica del Profesor: ___3___

17 Descripción del Curso en Español (que no se exceda de 1,000 caracteres):

Estudio integral de los principios y técnicas de ingeniería de software DevOps para el desarrollo, la integración, y la entrega rápida y continua de sistemas de software para uso en producción. Este curso prepara a los estudiantes para diseñar e implementar la infraestructura DevOps utilizando contenedores de software, micro servicios, integración continua, entrega continua, sistemas de registro, y herramientas de colaboración.

17 Descripción del Curso en Inglés (que no se exceda de 1,000 caracteres):

Comprehensive study of DevOps software engineering principles and techniques for the rapid and continuous development, integration, and delivery of software systems for production use. This course prepares students to design and implement DevOps infrastructure using software containers, microservices, continuous integration, continuous delivery, logging systems, and collaborations tools.

18 Prerrequisitos*	**18Correquisitos***
Ninguno	

***Especifique la Codificación Alfanumérica Correcta**

19 Requisitos especiales: _____
_____

20 Modalidad en la que el Curso se ofrecerá (Puede marcar más de una opción):

__X__Curso Presencial __X__Curso Híbrido _X___Curso a Distancia

21 Cargos por laboratorio: ____ Sí __X__No

22 Posibilidad de Equivalencia (en la unidad o en otras unidades del sistema):
___ Sí _X_No

Cursos:_____

Unidad(es) que lo(s) ofrece(n): _____

23 Equipo, materiales e instalaciones mínimas requeridas:

Facilidades computacionales existentes del Departamento de Ciencia e Ingeniería de Computación.

24 Cantidad de Estudiantes por sección: _ 3___ Cupo Mínimo __30__ Cupo Máximo

25 Sistema de Calificación:

_X___Letra (A, B, C, D o F) **____ Aprobado (S), No Aprobado (NS)**

____ Aprobado (P), No Aprobado (NP) **____Aprobado (PS: Aprobado Sobresaliente; PN: Aprobado Bueno), No Aprobado (NP)**

____Aprobado (P), Fracasado (F) **____Otro (Especifique)_____**

26 Curso a Inactivar sujeto a la creación del nuevo curso:

_X____No Aplica **_____Si; especifique el curso a inactivar: _____**

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

27 APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL DEPARTAMENTO	**NOMBRE Y FIRMA** **Emmanuel Arzuaga, Ph.D**	**FECHA** **11/15/2022**
Director de Departamento		
28APROBACIÓN Y CERTIFICACIÓN A NIVEL DE LA FACULTAD	**NOMBRE Y FIRMA**	**FECHA**
Decano de la Facultad		
29 APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL SENADO ACADÉMICO	**NOMBRE Y FIRMA**	**FECHA**
Presidente del Comité de Cursos		

PARA USO DEL DECANATO DE ASUNTOS ACADÉMICOS

30 Codificación: _____ **Fecha de Codificación_____**

Funcionario que procesó la solicitud: **Fecha de envío al Departamento y Facultad:**

_____ **_____**

University of Puerto Rico
Mayagüez Campus
College of Engineering
Department of Computer Science and Engineering
Software Engineering Graduate Program

COURSE SYLLABUS

COURSE TITLE:	Development and Operations
ALPHA-NUMERIC CODIFICATION:	INSO 6010
NUMBER OF CREDITS-CONTACT HOURS:	Three credits / 45 hours
PREREQUISITES, COREQUISITES AND OTHER REQUIREMENTS:	None

COURSE DESCRIPTION:

Spanish: Estudio integral de los principios y técnicas de ingeniería de software DevOps para el desarrollo, la integración, y la entrega rápida y continua de sistemas de software para uso en producción. Este curso prepara a los estudiantes para diseñar e implementar la infraestructura DevOps utilizando contenedores de software, micro servicios, integración continua, entrega continua, sistemas de registro, y herramientas de colaboración. Este curso podrá ofrecerse en cualquiera de las siguientes modalidades: presencial, híbrida o a distancia.

English: Comprehensive study of DevOps software engineering principles and techniques for the rapid and continuous development, integration, and delivery of software systems for production use. This course prepares students to design and implement DevOps infrastructure using software containers, microservices, continuous integration, continuous delivery, logging systems, and collaborations tools. This course may be offered in any of the following modalities: face-to-face, hybrid or online.

COURSE OBJECTIVES:

Students will:

- Identify use-cases for DevOps methods in production settings.
- Design and implement micro services to develop secure, modular application that can be scaled up based on user-demand.
- Apply continuous integration methods to merge code changes, automate builds, and run standardize test cases.
- Apply continuous delivery to build, test, and deploy updated software packages into production environments.
- Design, and implement containers as building blocks for software components and micro-services
- Use logging and monitoring tools to analyze the performance behavior of software systems.
- Use collaboration tools to communicate, within the organization, the status of deployed systems, new tasks/responsibilities, operational considerations, and bug reports.

TEXT BOOK:

1. Gaurav Agarwal, *Modern DevOps Practices*, Packt Publishing, 2021.
2. John Arundel, Justin Domingus, *Cloud Native DevOps with Kubernetes*, O'Reilly Media, 2019.

Course time frame and thematic outline:

TIME DISTRIBUTION			
Theme	**Face-to-Face**	**Hybrid**	**Online**
I. Introduction to DevOps	3 hours	3 hours (face-to-face)	3 hours
II. Containers	3 hours	3 hours (online)	3 hours
III. Organizing Applications into Microservices via containers	3 hours	3 hours (online)	3 hours
IV. Orchestration of Containers	6 hours	6 hours (online)	6 hours
V. Infrastructure as Code	3 hours	3 hours (online)	3 hours
VI. Securing networked applications	3 hours	3 hours (face-to-face)	3 hours
VII. Continuous Integration Techniques	3 hours	3 hours (face-to-face)	3 hours
VIII. Automation of Builds and Tests	3 hours	3 hours (face-to-face)	3 hours
IX. Continuous Deployments Techniques	6 hours	6 hours (face-to-face)	6 hours
X. Logging and System Monitoring	3 hours	3 hours (online)	3 hours
XI. Application Performance Profiling	3 hours	3 hours (online)	3 hours
XII. Autoscaling	3 hours	3 hours (online)	3 hours
XIII. Midterm Exams	3 hours	3 hours (face-to-face)	3 hours
Total contact hours	**45 hours**	**45 hours** (21 face-to-face = 47% and 24 online hours= 53%)	**45 hours**

INSTRUCTIONAL STRATEGIES:

Face-to-Face	Hybrid	Online

• Conferences • Lectures • Team Programming Projects • Quizzes • Exams	• Live and recorded Conferences • Lectures • Team Programming Projects • Quizzes • Exams	• Recorded Conferences • Lectures • Team Programming Projects • Quizzes • Exams

MINIMUM OR REQUIRED RESOURCES AVAILABLE:

RESOURCE	FACE-TO-FACE	HYBRID	ONLINE
Institutional learning management platform account (Ex. Moodle)	Institution	Institution	Institution
Institutional email account	Institution	Institution	Institution
Computer with high-speed internet access or mobile device with data service	Student	Student	Student
Programs or applications: free open source InteliJ IDE, GitLab, Jenkins	Student	Student	Student
Webcam or mobile with camera and microphone	Not applicable	Student	Student
Institutional learning management platform account (Ex. Moodle)	Institution	Institution	Institution

EVALUATION STRATEGIES: (Examples of evaluation techniques)

FACE to FACE	HYBRID	ONLINE

All three modalities will be evaluated based on the following activities:

Activity	Quantity	Weight
Quizzes	10-12	10% - 20%
Homeworks	5-10	0% - 20%
Midterm Exams	2	10% - 20%
Final Exam	1	10% - 20%
Term Projects	1	40% - 60%

REASONABLE ACCOMMODATIONS:

The University of Puerto Rico at Mayagüez (RUM) recognizes that each student has an inherited right to request reasonable accommodation according to Law 51: Law for Integral Educational Services for People with Disabilities. Every student has the right to receive reasonable accommodation if he/she presents the necessary evidence to be evaluated by the Office of Services to Students with Disabilities (OSEI-RUM), and the related information can be found at the following link: https://www.uprm.edu/cms/index.php/page/85. If your case is approved by OSEI-RUM, you will

receive reasonable accommodation in your courses and evaluation, and you must contact each professor for course registered. For additional information contact OSEI-RUM at Sánchez Hidalgo 410 or via telephone 787-832-4040 extension 3107.

ACADEMIC INTEGRITY:

The University of Puerto Rico promotes the highest standards of academic and scientific integrity. Article 6.2 of the UPR Student General Bylaws (Board of Trustees Certification 13, 2009-2010) states that academic dishonesty includes, but is not limited to: fraudulent actions; obtaining grades or academic degrees by false or fraudulent simulations; copying the whole or part of the academic work of another person; plagiarizing totally or partially the work of another person; copying all or part of another person's answers to the questions of an oral or written exam by taking or having someone else take the exam on his/her behalf; as well as enabling and facilitating another person to perform the aforementioned behavior. Any of these behaviors will be subject to disciplinary action in accordance with the disciplinary procedure established by the UPR Student General Bylaws.─.

To ensure the integrity and security of user data, all hybrid, distance and online courses must be offered through the institutional learning management platform, which uses secure connection and authentication protocols. The system authenticates the identity of the user (student and professor) using the username and password assigned by the institution. The users are responsible for keeping their password safe, protected, and not to share it with other people.

POLICY AGAINST DISCRIMINATION BASED ON SEX, SEXUAL ORIENTATION, AND GENDER IDENTITY:

«The University of Puerto Rico prohibits discrimination based on sex, sexual orientation, and gender identity in any of its forms, including that of sexual harassment. According to the Institutional Policy Against Sexual Harassment at the University of Puerto Rico, Certification 130 (2014-2015) from the Board of Governors, any student subjected to acts constituting sexual harassment, may turn to the Office of the Student Ombudsperson, the Office of the Dean of Students, or the Coordinator of the Office of Compliance with Title IX for an orientation or formal complaint».

GRADING SYSTEM

☒ Quantifiable (letters, A, B, C, D, F) ☐ Not Quantifiable

CONTINGENCY PLAN IN CASE OF AN EMERGENCY

In case of an emergency or class interruption, the professor can apply Bylaw 19-85 of the UPRM. This bylaw states that up to 25% of a class can be offered online.

BIBLIOGRAPHY

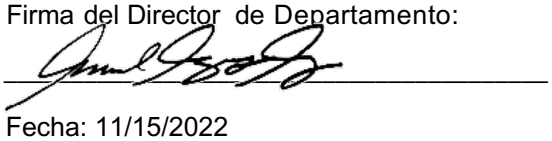
1. John Arundel, Justin Domingus, *Cloud Native DevOps with Kubernetes*, O'Reilly Media, 2019.
2. Julien Vehent, *Securing DevOps: Security in the Cloud*, Manning, 2018.
3. Gaurav Agarwal, *Modern DevOps Practices*, Packt Publishing, 2021.
4. Mikael Krief, *Learning DevOps*, Packt Publishing, 2019.
5. Electronic Portal to access technical research papers related to DevOps systems. Access to some papers might require valid subscription to ACM Digital Library, or IEEE Xplore. UPRM currently has access to these electronic digital libraries.

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
HOJA DE TRÁMITE PARA LA CREACIÓN DE CURSOS

CURSO: INSO 6015 - Machine Learning and Operations

DEPARTAMENTO: Ciencia e Ingeniería de Computación

FACULTAD: Ingeniería

	COMENTARIOS
Fecha en que el proponente somete la propuesta de Creación de Curso: Fecha: 8/15/2022	
Firma del Director de Departamento:  Fecha: 11/15/2022	
Firma del Decano de Facultad: _____ Fecha:	
Fecha en que la solicitud es recibida en la Secretaría del Senado Académico: Fecha:	
Fecha en la que la solicitud es recibida por el Comité de Cursos del Senado Académico: Fecha:	
Firma del Presidente de Comité de Cursos del Senado Académico: _____ Fecha:	
Fecha en que la solicitud es recibida por el Decanato de Asuntos Académicos: Fecha:	

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
DECANATO DE ASUNTOS ACADÉMICOS

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

1 **Unidad: Recinto Universitario de Mayagüez**	1 **Colegio: Ingeniería**
1 **Departamento: Ciencia e Ingenieria de Computación** **Programa: MS/PhD en Ingeniería de Software**	1 **Profesor (es)** **Proponente(s): Manuel Rodriguez Martinez, Heidy Sierra, Ahmed ElSaid**
2 **Fecha de Solicitud: 8/15/2022**	3 **Fecha de Vigencia del Curso: 8/2023**
4 **Título Completo en Español: Aprendizaje Automatizado y Operaciones**	
5 **(Título Abreviado a 26 Espacios): MLOps**	
4 **Título Completo en Inglés: Machine Learning and Operations**	
5 **(Título Abreviado a 26 Espacios): MLOps**	
6 **Materia Principal del Curso (en clave alfa): INSO**	
7 **Justificación para la Creación del Curso:**	
Provide graduate students in Software Engineering with in-depth knowledge of the principles and techiques for the rapid and continuous development, integration, and delivery of Machine Learning production systems.	
8 **Nivel del Curso (marque con una X): 1 2 3 4 5 Subgraduado** — **X 6 7 8 9 Graduado**	
9**Ubicación del curso, sea requisito, electivo o de continuación, en la secuencia curricular autorizada:** **(S=Semestres V=Verano) Período: ____S1 __X__S2 ____V**	
A partir del año de estudio de acuerdo con la secuencia: **_X__1ro _X__2do ___3ro ___4to ___5to ___6to ___Otro ___ N/A**	
10 **Codificación Alfanumérica: INSO 6015**	11 **Cantidad de Créditos: 3**
12 **Tipo de Curso: _____Requisito ___X___Electivo _____División de Educación Continua**	
13 **Tipo de créditos: __X__ Fijo ____Variable**	**Si es Variable, ¿puede repetirse con crédito? ___Si ___No**
	Si contesta si, indique la cantidad máxima que se puede repetir: _____
14 **Distribución de Horas Contacto Semanales dedicadas a la enseñanza:**	
__X___Conferencia	**_____Laboratorio** **_____Investigación**

_____Discusión	**_____Taller**	**_____Tesis o Disertación**
_____Seminario	**_____Internado**	**_____Estudio Independiente**
_____Práctica Supervisada		

15 Total de Horas Contacto: __45____

16 Equivalencia en Horas de Crédito para la carga académica del Profesor: ___3___

17 Descripción del Curso en Español (que no se exceda de 1,000 caracteres):
Estudio integral de los principios y técnicas de ingeniería de software de MLOps para el desarrollo, la integración y la entrega rápido y continua de sistemas de producción de aprendizaje automático. Este curso prepara a los estudiantes para diseñar e implementar canales de procesamiento de datos, etiquetado y validación efectiva de datos, aumento de muestras de datos, búsqueda de modelos, análisis de modelos, administración de recursos computacionales, servicio de modelos, administración y entrega de modelos, monitoreo y registro de eventos.

17 Descripción del Curso en Inglés (que no se exceda de 1,000 caracteres):
Comprehensive study of MLOps software engineering principles and techniques for the rapid and continuous development, integration, and delivery of Machine Learning production systems. This course prepares students to design and implement data processing pipelines, effective data labeling and validation, data augmentation, model search, model analysis, resource management, model serving, model management and delivery, and monitoring and logging.

18 Prerrequisitos*	**18Correquisitos***
Ninguno	

***Especifique la Codificación Alfanumérica Correcta**

19 Requisitos especiales: _____
_____

20 Modalidad en la que el Curso se ofrecerá (Puede marcar más de una opción):

__X__Curso Presencial __X__Curso Híbrido _X___Curso a Distancia

21 Cargos por laboratorio: ____ Sí __X__No

22 Posibilidad de Equivalencia (en la unidad o en otras unidades del sistema):
___ Sí _X_No

Cursos:_____

Unidad(es) que lo(s) ofrece(n): _____

23 Equipo, materiales e instalaciones mínimas requeridas:

Facilidades computacionales existentes del Departamento de Ciencia e Ingeniería de Computación.

24 Cantidad de Estudiantes por sección: _ 3___ Cupo Mínimo __30__ Cupo Máximo

25 Sistema de Calificación:

_X___Letra (A, B, C, D o F) **____ Aprobado (S), No Aprobado (NS)**

____ Aprobado (P), No Aprobado (NP) **____Aprobado (PS: Aprobado Sobresaliente; PN: Aprobado Bueno), No Aprobado (NP)**

____Aprobado (P), Fracasado (F) **____Otro (Especifique)_____**

26 Curso a Inactivar sujeto a la creación del nuevo curso:

_X____No Aplica **_____Si; especifique el curso a inactivar: _____**

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

27 APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL DEPARTAMENTO	**NOMBRE Y FIRMA** **Emmanuel Arzuaga, Ph.D**	**FECHA** **11/15/2022**
Director de Departamento		
28APROBACIÓN Y CERTIFICACIÓN A NIVEL DE LA FACULTAD	**NOMBRE Y FIRMA**	**FECHA**
Decano de la Facultad		
29 APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL SENADO ACADÉMICO	**NOMBRE Y FIRMA**	**FECHA**
Presidente del Comité de Cursos		

PARA USO DEL DECANATO DE ASUNTOS ACADÉMICOS

30 Codificación: _____ **Fecha de Codificación_____**

Funcionario que procesó la solicitud: **Fecha de envío al Departamento y Facultad:**

_____ **_____**

University of Puerto Rico
Mayagüez Campus
College of Engineering
Department of Computer Science and Engineering
Software Engineering Graduate Program

COURSE SYLLABUS

COURSE TITLE:	Machine Learning and Operations
ALPHA-NUMERIC CODIFICATION:	INSO 6015
NUMBER OF CREDITS-CONTACT HOURS:	Three credits / 45 hours
PREREQUISITES, COREQUISITES AND OTHER REQUIREMENTS:	None

COURSE DESCRIPTION:

Spanish: Estudio integral de los principios y técnicas de ingeniería de software de MLOps para el desarrollo, la integración y la entrega rápido y continua de sistemas de producción de aprendizaje automático. Este curso prepara a los estudiantes para diseñar e implementar canales de procesamiento de datos, etiquetado y validación efectiva de datos, aumento de muestras de datos, búsqueda de modelos, análisis de modelos, administración de recursos computacionales, servicio de modelos, administración y entrega de modelos, monitoreo y registro de eventos. Este curso podrá ofrecerse en cualquiera de las siguientes modalidades: presencial, híbrida o a distancia.

English: Comprehensive study of MLOps software engineering principles and techniques for the rapid and continuous development, integration, and delivery of Machine Learning production systems. This course prepares students to design and implement data processing pipelines, effective data labeling and validation, data augmentation, model search, model analysis, resource management, model serving, model management and delivery, and monitoring and logging. This course may be offered in any of the following modalities: face-to-face, hybrid or online.

COURSE OBJECTIVES:

Students will:

- Identify use-cases for MLOps methods in production settings for Machine Learning (ML).
- Identify the lifecycle of a ML model, from development and training to production use.
- Design and implement data processing pipelines to extract, clean, and integrate data for model training and inference.
- Apply continuous integration methods to train, update, tune, and maintain the code for ML models.
- Apply continuous delivery to build, test, and deploy updated ML modes into production applications.
- Design, and implement methods to label data, augment data, and validate data for training models.
- Use logging and monitoring tools to analyze the performance behavior of the models and determine re-training requirements.

TEXT BOOK:

1. Noah Gift, and Alfredo Deza, *Practical MLOps: Operationalizing Machine Learning Models 1st ed*, O'Reilly Media, 2021.

2. Mark Treveli, *Introducing MLOps: How to Scale Machine Learning in the Enterprise 1st ed*, O'Reilly Media, 2020.

Course time frame and thematic outline:

TIME DISTRIBUTION			
Theme	**Face-to-Face**	**Hybrid**	**Online**
I. Introduction to DevOps	3 hours	3 hours (face-to-face)	3 hours
II. Containers	3 hours	3 hours (online)	3 hours
III. Organizing Applications into Microservices via containers	3 hours	3 hours (online)	3 hours
IV. Orchestration of Containers	6 hours	6 hours (face-to-face)	6 hours
V. Infrastructure as Code	3 hours	3 hours (online)	3 hours
VI. Securing networked applications	3 hours	3 hours (face-to-face)	3 hours
VII. Continuous Integration Techniques	3 hours	3 hours (face-to-face)	3 hours
VIII. Automation of Builds and Tests	3 hours	3 hours (face-to-face)	3 hours
IX. Continuous Deployments Techniques	6 hours	6 hours (face-to-face)	6 hours
X. Logging and System Monitoring	3 hours	3 hours (online)	3 hours
XI. Application Performance Profiling	3 hours	3 hours (online)	3 hours
XII. Autoscaling	3 hours	3 hours (online)	3 hours
XIII. Midterm Exams	3 hours	3 hours (face-to-face)	3 hours
Total contact hours	**45 hours**	**45 hours** (18 face-to-face = 40% and 27 online hours= 60%)	**45 hours**

INSTRUCTIONAL STRATEGIES:

Face-to-Face	Hybrid	Online
• Conferences • Lectures • Team Programming Projects • Quizzes • Exams •	• Live and recorded Conferences • Lectures • Team Programming Projects • Quizzes • Exams •	• Recorded Conferences • Lectures • Team Programming Projects • Quizzes • Exams •

MINIMUM OR REQUIRED RESOURCES AVAILABLE:

RESOURCE	FACE-TO-FACE	HYBRID	ONLINE
Institutional learning management platform account (Ex. Moodle)	Institution	Institution	Institution
Institutional email account	Institution	Institution	Institution
Computer with high-speed internet access or mobile device with data service	Student	Student	Student
Programs or applications: free open source InteliJ IDE, GitLab, Jenkins	Student	Student	Student
Webcam or mobile with camera and microphone	Not applicable	Student	Student
Institutional learning management platform account (Ex. Moodle)	Institution	Institution	Institution

EVALUATION STRATEGIES: (Examples of evaluation techniques)

FACE to FACE	HYBRID	ONLINE

All three modalities will be evaluated based on the following activities:

Activity	Quantity	Weight
Quizzes	10-12	10% - 20%
Homeworks	5-10	0% - 20%
Midterm Exams	2	10% - 20%
Final Exam	1	10% - 20%
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REASONABLE ACCOMMODATIONS:

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(OSEI-RUM), and the related information can be found at the following link: https://www.uprm.edu/cms/index.php/page/85. If your case is approved by OSEI-RUM, you will receive reasonable accommodation in your courses and evaluation, and you must contact each professor for course registered. For additional information contact OSEI-RUM at Sánchez Hidalgo 410 or via telephone 787-832-4040 extension 3107.

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To ensure the integrity and security of user data, all hybrid, distance and online courses must be offered through the institutional learning management platform, which uses secure connection and authentication protocols. The system authenticates the identity of the user (student and professor) using the username and password assigned by the institution. The users are responsible for keeping their password safe, protected, and not to share it with other people.

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GRADING SYSTEM

☒ Quantifiable (letters, A, B, C, D, F) ☐ Not Quantifiable

CONTINGENCY PLAN IN CASE OF AN EMERGENCY

In case of an emergency or class interruption, the professor can apply Bylaw 19-85 of the UPRM. This bylaw states that up to 25% of a class can be offered online.

BIBLIOGRAPHY

1. Noah Gift, and Alfredo Deza, *Practical MLOps: Operationalizing Machine Learning Models 1st ed*, O'Reilly Media, 2021.

2. Mark Treveli, *Introducing MLOps: How to Scale Machine Learning in the Enterprise 1st ed*, O'Reilly Media, 2020.

3. Trevor Grant, Holden Karau, Boris Lublinsky, Richard Liu, Ilan Filonenko, *Kubeflow for Machine Learning*, O'Reilly Media, 2020.

4. Hannes Hapke, Catherine Nelson*, Building Machine Learning Pipelines*, O'Reilly Media, 2020

5. Electronic Portal to access technical research papers.

    a. ACM Digital Library: https://dl.acm.org/
    b. IEEE Xplore Digital Library: https://ieeexplore.ieee.org

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
HOJA DE TRÁMITE PARA LA CREACIÓN DE CURSOS

CURSO: INSO 6030 - Web and Mobile Application Engineering

DEPARTAMENTO: Ciencia e Ingeniería de Computación

FACULTAD: Ingeniería

	COMENTARIOS
Fecha en que el proponente somete la propuesta de Creación de Curso: Fecha: 8/15/2022	
Firma del Director de Departamento: _____ Fecha: 11/15/2022	
Firma del Decano de Facultad: _____ Fecha:	
Fecha en que la solicitud es recibida en la Secretaría del Senado Académico: Fecha:	
Fecha en la que la solicitud es recibida por el Comité de Cursos del Senado Académico: Fecha:	
Firma del Presidente de Comité de Cursos del Senado Académico: _____ Fecha:	
Fecha en que la solicitud es recibida por el Decanato de Asuntos Académicos: Fecha:	

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
DECANATO DE ASUNTOS ACADÉMICOS

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

[1] **Unidad: Recinto Universitario de Mayagüez**	[1] **Colegio: Ingeniería**
[1] **Departamento: Ciencia e Ingenieria de Computación** **Programa: MS/PhD en Ingeniería de Software**	[1] **Profesor (es)** **Proponente(s): Manuel Rodriguez Martinez, Heidy Sierra, Ahmed ElSaid**
[2] **Fecha de Solicitud: 8/15/2022**	[3] **Fecha de Vigencia del Curso: 8/2023**
[4] **Título Completo en Español: Ingeniería de Aplicaciones Web y Móviles**	
[5] **(Título Abreviado a 26 Espacios): Ing Apps Web y Móviles**	
[4] **Título Completo en Inglés: Web and Mobile Application Engineering**	
[5] **(Título Abreviado a 26 Espacios): Web and Mobile App Eng**	
[6] **Materia Principal del Curso (en clave alfa): INSO**	
[7] **Justificación para la Creación del Curso:**	
Provide graduate students in Software Engineering with in-depth knowledge of the principles and techiques for the development of mobile and web applications in production systems.	
[8] **Nivel del Curso (marque con una X): 1 2 3 4 5 Subgraduado — X 6 7 8 9 Graduado**	
[9] **Ubicación del curso, sea requisito, electivo o de continuación, en la secuencia curricular autorizada:** **(S=Semestres V=Verano) Período: ____S1 __X__S2 ____V**	
A partir del año de estudio de acuerdo con la secuencia: **_X__1ro _X__2do ___3ro ___4to ___5to ___6to ___Otro ___ N/A**	
[10] **Codificación Alfanumérica: INSO 6030**	[11] **Cantidad de Créditos: 3**
[12] **Tipo de Curso: _____Requisito ___X___Electivo _____División de Educación Continua**	
[13] **Tipo de créditos: __X__ Fijo ____Variable**	**Si es Variable, ¿puede repetirse con crédito? ___Si ___No**
	Si contesta si, indique la cantidad máxima que se puede repetir: _____
[14] **Distribución de Horas Contacto Semanales dedicadas a la enseñanza:**	
__X___Conferencia	**_____Laboratorio** **_____Investigación**

_____Discusión	**_____Taller**	**_____Tesis o Disertación**
_____Seminario	**_____Internado**	**_____Estudio Independiente**
_____Práctica Supervisada		

15 Total de Horas Contacto: __45____

16 Equivalencia en Horas de Crédito para la carga académica del Profesor: ___3___

17 Descripción del Curso en Español (que no se exceda de 1,000 caracteres):
Estudio integral de los principios y técnicas de ingeniería de software para el desarrollo de aplicaciones móviles y web en sistemas de producción. Este curso prepara a los estudiantes para diseñar e implementar aplicaciones de varios niveles, REST APIs, capas de persistencia de datos distribuidos, APIs de sockets web seguros, interfaces de usuario basadas en la web, aplicaciones móviles híbridas y nativas, APIs para administrar el hardware del teléfono, la instrumentación y los sistemas de monitoreo.

17 Descripción del Curso en Inglés (que no se exceda de 1,000 caracteres):
Comprehensive study of software engineering principles and techniques for the development of mobile and web applications in production systems. This course prepares students to design and implement multi-tier applications, REST APIs, distributed data persistence layers, secure web sockets APIs, web-based user interfaces, hybrid and native mobile apps, APIs to manage phone hardware, instrumentation, and monitoring systems.

18 Prerrequisitos*	**18Correquisitos***
Ninguno	

***Especifique la Codificación Alfanumérica Correcta**

19 Requisitos especiales: _____
_____

20 Modalidad en la que el Curso se ofrecerá (Puede marcar más de una opción):

__X__Curso Presencial __X__Curso Híbrido _X___Curso a Distancia

21 Cargos por laboratorio: ____ Sí __X__No

22 Posibilidad de Equivalencia (en la unidad o en otras unidades del sistema):
___ Sí _X_No

Cursos:_____

Unidad(es) que lo(s) ofrece(n): _____

23 Equipo, materiales e instalaciones mínimas requeridas:

Facilidades computacionales existentes del Departamento de Ciencia e Ingeniería de Computación.

24 Cantidad de Estudiantes por sección: _ 3___ Cupo Mínimo __30__ Cupo Máximo

25 Sistema de Calificación:

_X___Letra (A, B, C, D o F) **____ Aprobado (S), No Aprobado (NS)**

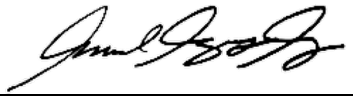
____ Aprobado (P), No Aprobado (NP) **____Aprobado (PS: Aprobado Sobresaliente; PN: Aprobado Bueno), No Aprobado (NP)**

____Aprobado (P), Fracasado (F) **____Otro (Especifique)_____**

26 Curso a Inactivar sujeto a la creación del nuevo curso:

_X____No Aplica **_____Si; especifique el curso a inactivar: _____**

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

27 APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL DEPARTAMENTO	**NOMBRE Y FIRMA** **Emmanuel Arzuaga, Ph.D**	**FECHA** **11/15/2022**
Director de Departamento		
28APROBACIÓN Y CERTIFICACIÓN A NIVEL DE LA FACULTAD	**NOMBRE Y FIRMA**	**FECHA**
Decano de la Facultad		
29 APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL SENADO ACADÉMICO	**NOMBRE Y FIRMA**	**FECHA**
Presidente del Comité de Cursos		

PARA USO DEL DECANATO DE ASUNTOS ACADÉMICOS

30 Codificación: _____ **Fecha de Codificación_____**

Funcionario que procesó la solicitud: **Fecha de envío al Departamento y Facultad:**

_____ **_____**

University of Puerto Rico
Mayagüez Campus
College of Engineering
Department of Computer Science and Engineering
Software Engineering Graduate Program

COURSE SYLLABUS

COURSE TITLE:	Web and Mobile Application Engineering
ALPHA-NUMERIC CODIFICATION:	INSO 6030
NUMBER OF CREDITS-CONTACT HOURS:	Three credits / 45 hours
PREREQUISITES, COREQUISITES AND OTHER REQUIREMENTS:	None

COURSE DESCRIPTION:

Spanish: Estudio integral de los principios y técnicas de ingeniería de software para el desarrollo de aplicaciones móviles y web en sistemas de producción. Este curso prepara a los estudiantes para diseñar e implementar aplicaciones de varios niveles, REST APIs, capas de persistencia de datos distribuidos, APIs de sockets web seguros, interfaces de usuario basadas en la web, aplicaciones móviles híbridas y nativas, APIs para administrar el hardware del teléfono, la instrumentación y los sistemas de monitoreo. Este curso podrá ofrecerse en cualquiera de las siguientes modalidades: presencial, híbrida o a distancia.

English: Comprehensive study of software engineering principles and techniques for the development of mobile and web applications in production systems. This course prepares students to design and implement multi-tier applications, REST APIs, distributed data persistence layers, secure web sockets APIs, web-based user interfaces, hybrid and native mobile apps, APIs to manage phone hardware, instrumentation, and monitoring systems. This course may be offered in any of the following modalities: face-to-face, hybrid or online.

COURSE OBJECTIVES:

Students will:

- Identify use-cases for web apps vs mobile apps use.
- Identify the lifecycle of a web or mobile app, from development to production use.
- Design, implement, and test REST API to expose the server-side functionality.
- Design, implement, and test web apps using reactive components.
- Design, implement, and test mobile apps using native and hybrid frameworks, including phone hardware management.
- Apply web security methods to protect the web and mobile apps.
- Apply continuous integration and continuous delivery to build, test, and deploy web and mobiles apps into production systems.
- Use instrumentation and monitoring tools to analyze the performance behavior of the apps.

TEXT BOOK:

1. Frank Zammetti, *Modern Full-Stack* Development, APress , 2020.

2. Chris Northwood, *The Full Stack Developer*, APress, 2018

Course time frame and thematic outline:			
TIME DISTRIBUTION			
Theme	**Face-to-Face**	**Hybrid**	**Online**
I. Introduction to middle-tiers applications	3 hours	3 hours (face-to-face)	3 hours
II. REST for backend services.	6 hours	6 hours (face-to-face)	6 hours
III. Securing REST endpoints.	3 hours	3 hours (online)	3 hours
IV. Data Persistence in web backends	3 hours	3 hours (online)	3 hours
V. Web apps using reactive components	6 hours	6 hours (online)	6 hours
VI. Application State Management	3 hours	3 hours (online)	3 hours
VII. Mobile apps with hybrid and native components	6 hours	6 hours (face-to-face)	6 hours
VIII. Managing phone hardware resources	6 hours	6 hours (online)	6 hours
IX. Continuous Deployments Techniques	3 hours	3 hours (online)	3 hours
X. Instrumentation and System Monitoring	3 hours	3 hours (online)	3 hours
XIII. Midterm Exams	3 hours	3 hours (face-to-face)	3 hours
Total contact hours	**45 hours**	**45 hours** (18 face-to-face = 40% and 27 online hours= 60%)	**45 hours**

INSTRUCTIONAL STRATEGIES:		
Face-to-Face	**Hybrid**	**Online**

• Conferences • Lectures • Team Programming Projects • Quizzes • Exams	• Live and recorded Conferences • Lectures • Team Programming Projects • Quizzes • Exams	• Recorded Conferences • Lectures • Team Programming Projects • Quizzes • Exams

MINIMUM OR REQUIRED RESOURCES AVAILABLE:

RESOURCE	FACE-TO-FACE	HYBRID	ONLINE
Institutional learning management platform account (Ex. Moodle)	Institution	Institution	Institution
Institutional email account	Institution	Institution	Institution
Computer with high-speed internet access or mobile device with data service	Student	Student	Student
Programs or applications: free open source InteliJ IDE, GitLab, Jenkins	Student	Student	Student
Webcam or mobile with camera and microphone	Not applicable	Student	Student
Institutional learning management platform account (Ex. Moodle)	Institution	Institution	Institution

EVALUATION STRATEGIES:

FACE to FACE	HYBRID	ONLINE

All three modalities will be evaluated based on the following activities:

Activity	Quantity	Weight
Quizzes	10-12	10% - 20%
Homeworks	5-10	0% - 20%
Midterm Exams	2	10% - 20%
Final Exam	1	10% - 20%
Term Projects	3-4	40% - 60%

REASONABLE ACCOMMODATIONS:

The University of Puerto Rico at Mayagüez (RUM) recognizes that each student has an inherited right to request reasonable accommodation according to Law 51: Law for Integral Educational Services for People with Disabilities. Every student has the right to receive reasonable accommodation if he/she presents the necessary evidence to be evaluated by the Office of Services to Students with Disabilities (OSEI-RUM), and the related information can be found at the following link: https://www.uprm.edu/cms/index.php/page/85. If your case is approved by OSEI-RUM, you will

receive reasonable accommodation in your courses and evaluation, and you must contact each professor for course registered. For additional information contact OSEI-RUM at Sánchez Hidalgo 410 or via telephone 787-832-4040 extension 3107.

ACADEMIC INTEGRITY:

The University of Puerto Rico promotes the highest standards of academic and scientific integrity. Article 6.2 of the UPR Student General Bylaws (Board of Trustees Certification 13, 2009-2010) states that academic dishonesty includes, but is not limited to: fraudulent actions; obtaining grades or academic degrees by false or fraudulent simulations; copying the whole or part of the academic work of another person; plagiarizing totally or partially the work of another person; copying all or part of another person's answers to the questions of an oral or written exam by taking or having someone else take the exam on his/her behalf; as well as enabling and facilitating another person to perform the aforementioned behavior. Any of these behaviors will be subject to disciplinary action in accordance with the disciplinary procedure established by the UPR Student General Bylaws.─.

To ensure the integrity and security of user data, all hybrid, distance and online courses must be offered through the institutional learning management platform, which uses secure connection and authentication protocols. The system authenticates the identity of the user (student and professor) using the username and password assigned by the institution. The users are responsible for keeping their password safe, protected, and not to share it with other people.

POLICY AGAINST DISCRIMINATION BASED ON SEX, SEXUAL ORIENTATION, AND GENDER IDENTITY:

«The University of Puerto Rico prohibits discrimination based on sex, sexual orientation, and gender identity in any of its forms, including that of sexual harassment. According to the Institutional Policy Against Sexual Harassment at the University of Puerto Rico, Certification 130 (2014-2015) from the Board of Governors, any student subjected to acts constituting sexual harassment, may turn to the Office of the Student Ombudsperson, the Office of the Dean of Students, or the Coordinator of the Office of Compliance with Title IX for an orientation or formal complaint».

GRADING SYSTEM

☒ Quantifiable (letters, A, B, C, D, F) ☐ Not Quantifiable

CONTINGENCY PLAN IN CASE OF AN EMERGENCY

In case of an emergency or class interruption, the professor can apply Bylaw 19-85 of the UPRM. This bylaw states that up to 25% of a class can be offered online.

BIBLIOGRAPHY

1. Frank Zammetti, *Modern Full-Stack* Development, APress , 2020.
2. Chris Northwood, *The Full Stack Developer*, APress, 2018
3. Adam Boduch, Roy Derks, *React and React Native*, Packt, 2020
4. Davig Flanagan, *JavaScript the Definite Guide 7th ed*, O'Reilly, 2020.
5. Mario Casciaro, Luciano Mammino, *Node.js Design Patterns 3rd ed*, Packt, 2020.
6. Electronic Portal to access technical research papers.
    a. ACM Digital Library: https://dl.acm.org/
    b. IEEE Xplore Digital Library: https://ieeexplore.ieee.org

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
HOJA DE TRÁMITE PARA LA CREACIÓN DE CURSOS

CURSO: INSO 6040 - Health-Related Application Engineering

DEPARTAMENTO: Ciencia e Ingeniería de Computación

FACULTAD: Ingeniería

	COMENTARIOS
Fecha en que el proponente somete la propuesta de Creación de Curso: Fecha: 8/15/2022	
Firma del Director de Departamento: _____ Fecha: 11/15/2022	
Firma del Decano de Facultad: _____ Fecha:	
Fecha en que la solicitud es recibida en la Secretaría del Senado Académico: Fecha:	
Fecha en la que la solicitud es recibida por el Comité de Cursos del Senado Académico: Fecha:	
Firma del Presidente de Comité de Cursos del Senado Académico: _____ Fecha:	
Fecha en que la solicitud es recibida por el Decanato de Asuntos Académicos: Fecha:	

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
DECANATO DE ASUNTOS ACADÉMICOS

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

1 **Unidad: Recinto Universitario de Mayagüez**	1 **Colegio: Ingeniería**
1 **Departamento: Ciencia e Ingenieria de Computación** **Programa: MS/PhD en Ingeniería de Software**	1 **Profesor (es)** **Proponente(s): Manuel Rodriguez Martinez, Heidy Sierra, Ahmed ElSaid**
2 **Fecha de Solicitud: 8/15/2022**	3 **Fecha de Vigencia del Curso: 8/2023**
4 **Título Completo en Español: Ingeniería de Aplicaciones Relacionadas a la Salud**	
5 **(Título Abreviado a 26 Espacios): Ing Apps Rel a la Salud**	
4 **Título Completo en Inglés: Health-Related Application Engineering**	
5 **(Título Abreviado a 26 Espacios): Health-Related App Eng**	
6 **Materia Principal del Curso (en clave alfa): INSO**	
7 **Justificación para la Creación del Curso:**	
Provide graduate students in Software Engineering with in-depth knowledge of the principles and techiques for building health applications in terms of the data context such as images, time series analysis of physiological data, text and electronic health records.	
8 **Nivel del Curso (marque con una X): __ 1 __ 2 __ 3 __ 4 __ 5 Subgraduado** **X 6 7 8 9 Graduado**	
9**Ubicación del curso, sea requisito, electivo o de continuación, en la secuencia curricular autorizada:** **(S=Semestres V=Verano) Período: __X__S1 ____S2 ____V**	
A partir del año de estudio de acuerdo con la secuencia: **_X__1ro _X__2do ___3ro ___4to ___5to ___6to ___Otro ___ N/A**	
10 **Codificación Alfanumérica: INSO 6040**	11 **Cantidad de Créditos: 3**
12 **Tipo de Curso: _____Requisito ___X___Electivo _____División de Educación Continua**	
13 **Tipo de créditos: __X__ Fijo ____Variable**	**Si es Variable, ¿puede repetirse con crédito? ___Si ___No**
	Si contesta si, indique la cantidad máxima que se puede repetir: _____
14 **Distribución de Horas Contacto Semanales dedicadas a la enseñanza:**	

__X___Conferencia	_____Laboratorio	_____Investigación
_____Discusión	_____Taller	_____Tesis o Disertación
_____Seminario	_____Internado	_____Estudio Independiente
_____Práctica Supervisada		

[15] **Total de Horas Contacto: __45____**

[16] **Equivalencia en Horas de Crédito para la carga académica del Profesor: ___3___**

[17] **Descripción del Curso en Español (que no se exceda de 1,000 caracteres):**

La medicina moderna requiere sistemas altamente regulados y complejos para procesar, analizar, representar e interpretar la información. En este curso, los estudiantes conocerán los retos en términos del análisis de datos en diferentes dominios, incluyendo pero no limitado a imágenes, análisis de series temporales de información fisiológica, texto y registros de electrónicos. Se discutirán los retos y ventajas del uso de la inteligencia artificial para resolver problemas en el área de la medicina. Los temas incluirán conceptos fundamentales de los sistemas aprendizaje profundo, aprendizaje automático, aprendizaje supervisado, aprendizaje distribuido, análisis de imágenes, representación de datos de texto, estrategias para resolver problemas que involucran datos multimodales y proyectos interdisciplinarios utilizando IA.

[17] **Descripción del Curso en Inglés (que no se exceda de 1,000 caracteres):**

Advances in medicine demands highly regulated and complex systems to handle, analyze, represent and interpret healthcare data. In this course students will be introduced to the challenges in health applications in terms of the data context such as images, time series analysis of physiological data, text and electronic health records. AI approaches to solve healthcare problems will be discussed. The topics will include fundamental concepts of deep learning, Machine learning, supervised learning, distributed learning, image analysis, text data representation, strategies to solve problems that involve multimodal data and interdisciplinary projects using AI.

[18] **Prerrequisitos***	[18] **Correquisitos***
Ninguno	

***Especifique la Codificación Alfanumérica Correcta**

[19] **Requisitos especiales: _____**
_____

[20] **Modalidad en la que el Curso se ofrecerá (Puede marcar más de una opción):**

__X__Curso Presencial __X__Curso Híbrido _X___Curso a Distancia

[21] **Cargos por laboratorio: ____ Sí __X__No**

[22] **Posibilidad de Equivalencia (en la unidad o en otras unidades del sistema):**
___ Sí _X_No

Cursos:_____

Unidad(es) que lo(s) ofrece(n): _____

[23] **Equipo, materiales e instalaciones mínimas requeridas:**

Facilidades computacionales existentes del Departamento de Ciencia e Ingeniería de Computación.

[24] **Cantidad de Estudiantes por sección: _ 3___ Cupo Mínimo __30__ Cupo Máximo**

25 Sistema de Calificación:

_X___Letra (A, B, C, D o F) **____ Aprobado (S), No Aprobado (NS)**

____ Aprobado (P), No Aprobado (NP) **____Aprobado (PS: Aprobado Sobresaliente; PN: Aprobado Bueno), No Aprobado (NP)**

____Aprobado (P), Fracasado (F) **____Otro (Especifique)_____**

26 Curso a Inactivar sujeto a la creación del nuevo curso:

_X____No Aplica **_____Si; especifique el curso a inactivar: _____**

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

27 APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL DEPARTAMENTO	**NOMBRE Y FIRMA** **Emmanuel Arzuaga, Ph.D**	**FECHA** **11/15/2022**
Director de Departamento		
28APROBACIÓN Y CERTIFICACIÓN A NIVEL DE LA FACULTAD	**NOMBRE Y FIRMA**	**FECHA**
Decano de la Facultad		
29 APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL SENADO ACADÉMICO	**NOMBRE Y FIRMA**	**FECHA**
Presidente del Comité de Cursos		

PARA USO DEL DECANATO DE ASUNTOS ACADÉMICOS

30 Codificación: _____ **Fecha de Codificación_____**

Funcionario que procesó la solicitud: **Fecha de envío al Departamento y Facultad:**

_____ **_____**

University of Puerto Rico
Mayagüez Campus
College of Engineering
Department of Computer Science and Engineering
Program in Software Engineering

COURSE SYLLABUS

(This sample syllabus is an example for a 3-credit hour course that can be offered in three modalities: face-to-face, hybrid and online.)

COURSE TITLE:	Health-Related Application Engineering
ALPHA-NUMERIC CODIFICATION:	INSO 6040
NUMBER OF CREDITS-CONTACT HOURS:	Three credits / 45 hours
PREREQUISITES, COREQUISITES AND OTHER REQUIREMENTS:	None

COURSE DESCRIPTION:

Spanish: La medicina moderna requiere sistemas altamente regulados y complejos para procesar, analizar, representar e interpretar la información. En este curso, los estudiantes conocerán los retos en términos del análisis de datos en diferentes dominios, incluyendo pero no limitado a imágenes, análisis de series temporales de información fisiológica, texto y registros de electrónicos. Se discutirán los retos y ventajas del uso de la inteligencia artificial para resolver problemas en el área de la medicina. Los temas incluirán conceptos fundamentales de los sistemas aprendizaje profundo, aprendizaje automático, aprendizaje supervisado, aprendizaje distribuido, análisis de imágenes, representación de datos de texto, estrategias para resolver problemas que involucran datos multimodales y proyectos interdisciplinarios utilizando IA.
Este curso podrá ofrecerse en cualquiera de las siguientes modalidades: presencial, híbrida o a distancia.

English: Advances in medicine demands highly regulated and complex systems to handle, analyze, represent and interpret healthcare data. In this course students will be introduced to the challenges in health applications in terms of the data context such as images, time series analysis of physiological data, text and electronic health records. AI approaches to solve healthcare problems will be discussed. The topics will include fundamental concepts of deep learning, Machine learning, supervised learning, distributed learning, image analysis, text data representation, strategies to solve problems that involve multimodal data and interdisciplinary projects using AI.
This course may be offered in any of the following modalities: face-to-face, hybrid or online.

COURSE OBJECTIVES:

Students will:

- Identify the challenges of data analysis in healthcare applications
- Explain the recent advances of AI in health applications
- Identify recent deep learning (DL) and machine learning (ML) models (covered in the course) and their application in health.
- Identify, select and apply appropriate AI methodologies and tools to solve problems in healthcare applications (discussed in the course).
- Identify, analyze and explain the limitations of some AI models in terms of performance and explain their advantages and limitations.
- Communicate and propose effective computing solutions for health applications
- Identify and compare AI methods from the literature relevant to health applications

TEXT BOOK: A list of technical research papers and lecture notes will be provided to the students.

Course time frame and thematic outline: (Sample of Distribution)

	TIME DISTRIBUTION		
Theme	**Face-to-Face**	**Hybrid**	**Online**
I. Review of health data challenges and AI in healthcare	3 hours	3 hours (face-to-face)	3 hours
II. AI, ML and DL fundamental concepts	4 hours	4 hours (online)	4 hours
III. Medical Imaging classification and segmentation, Analysis of tissue morphology and other medical imaging applications	6 hours	6 hours (face-to-face)	6 hours
IV. Time series analysis: Temporal models	3 hours	3 hours (face-to-face)	3 hours
V. Phenotype and clinical/bio-marker discovery, Relevance to personalized medicine	3 hours	3 hours	3 hours
VI. Electronic health records	4 hours	4 hours (face-to-face)	4 hours
VII. Text data representation	3 hours	3 hours	3 hours
VIII. Disease spreading modeling	4 hours	4 hours	4 hours
IX. Applications: Wearables, mobile apps health	6 hours	6 hours	6 hours
X. Multimodal data	3 hours	3 hours	3 hours
XI. Midterm Exams	3 hours	3 hours (face-to-face)	3 hours
XII. Introduction to AI libraries and platforms	3 hours	3 hours	3 hours
Total contact hours	**45 hours**	**45 hours** (18 face-to-face = 40% and 27 online hours= 60%)	**45 hours**

INSTRUCTIONAL STRATEGIES:

Face-to-Face	Hybrid	Online
♦ Conferences ♦ Lectures ♦ Team programming projects ♦ Quizzes ♦ Exams	♦ Live and recorded Conferences ♦ Lectures ♦ Team programming projects ♦ Quizzes ♦ Exams	♦ Recorded Conferences ♦ Lectures ♦ Team programming projects ♦ Quizzes ♦ Exams

MINIMUM OR REQUIRED RESOURCES AVAILABLE:

RESOURCE	FACE-TO-FACE	HYBRID	ONLINE
Institutional learning management platform account (Ex. Moodle)	Institution	Institution	Institution
Institutional email account	Institution	Institution	Institution
Computer with high-speed internet access or mobile device with data service	Student	Student	Student
Programs or applications: Python, TensorFlow/Numpy	Student	Student	Student
	Not applicable	Student	Student
Webcam or mobile with camera and microphone	Not applicable	Student	Student

EVALUATION STRATEGIES: (Examples of evaluation techniques)

FACE to FACE	HYBRID	ONLINE

All three modalities will be evaluated based on the following activities:

Activity	Quantity	Weight
Quizzes	6-8	10% - 20%
Midterm Exams	1-2	20% - 30%
Final Exam	1	10% - 20%
Assignments	4-6	30% - 50%

REASONABLE ACCOMMODATIONS:

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GRADING SYSTEM

☒ Quantifiable (letters, A, B, C, D, F) ☐ Not Quantifiable

CONTINGENCY PLAN IN CASE OF AN EMERGENCY

In case of an emergency or class interruption, the professor can apply Bylaw 19-85 of the UPRM. This bylaw states that up to 25% of a class can be offered online.

BIBLIOGRAPHY

1. L. K. Holley, S. Becker, *I-First Healthcare,* 1st Edition, O'Reilly Media, Inc, 2021.
2. B. Nordlinger, C.Villani, D. Rus, *Healthcare and Artificial Intelligence*, Springer, Cham, 2020.
3. C. Xiao, J. Sun, *Introduction to Deep Learning for Healthcare*, Springer, 202.
4. J. Tony J. Cleophas and Aeilko H. Zwinderman. *Machine Learning in Medicine - a Complete Overview. Springer*, 2020.
5. K. C. Santosh, N. Das, S. Ghosh, *Deep Learning Models for Medical Imaging*, 1st Edición, Academic Press, 2021.
6. Database http://www.cvlibs.net/datasets/kitti/
7. NIH Data sets: https://www.nihlibrary.nih.gov/resources/subject-guides/health-data-resources

Electronic references: Electronic Portal to access technical research papers.

a. ACM Digital Library: https://dl.acm.org/
b. IEEE Xplore Digital Library: https://ieeexplore.ieee.org

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
HOJA DE TRÁMITE PARA LA CREACIÓN DE CURSOS

CURSO: INSO 6050 - Software Engineering for Edge Systems

DEPARTAMENTO: Ciencia e Ingeniería de Computación

FACULTAD: Ingeniería

	COMENTARIOS
Fecha en que el proponente somete la propuesta de Creación de Curso: Fecha: 8/15/2022	
Firma del Director de Departamento: _____ Fecha: 11/15/2022	
Firma del Decano de Facultad: _____ Fecha:	
Fecha en que la solicitud es recibida en la Secretaría del Senado Académico: Fecha:	
Fecha en la que la solicitud es recibida por el Comité de Cursos del Senado Académico: Fecha:	
Firma del Presidente de Comité de Cursos del Senado Académico: _____ Fecha:	
Fecha en que la solicitud es recibida por el Decanato de Asuntos Académicos: Fecha:	

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
DECANATO DE ASUNTOS ACADÉMICOS

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

1 **Unidad: Recinto Universitario de Mayagüez**	1 **Colegio: Ingeniería**
1 **Departamento: Ciencia e Ingenieria de Computación** **Programa: MS/PhD en Ingeniería de Software**	1 **Profesor (es)** **Proponente(s): Manuel Rodriguez Martinez, Heidy Sierra, Ahmed ElSaid**
2 **Fecha de Solicitud: 8/15/2022**	3 **Fecha de Vigencia del Curso: 8/2023**
4 **Título Completo en Español: Ingeniería de Sistemas en la Frontera de la Nube**	
5 **(Título Abreviado a 26 Espacios): Ing Sis Frontera de Nube**	
4 **Título Completo en Inglés: Software Engineering for Edge Systems**	
5 **(Título Abreviado a 26 Espacios): Soft Eng for Edge Systems**	
6 **Materia Principal del Curso (en clave alfa): INSO**	
7 **Justificación para la Creación del Curso:**	
Provide graduate students in Software Engineering with in-depth knowledge of the principles and techiques for building applications in Edge Computing, with a focus on big data analytics and distributed computing.	
8 **Nivel del Curso (marque con una X):** __ 1 __ 2 __ 3 __ 4 __ 5 **Subgraduado** X 6 __ 7 __ 8 __ 9 **Graduado**	
9**Ubicación del curso, sea requisito, electivo o de continuación, en la secuencia curricular autorizada:** **(S=Semestres V=Verano) Período: ____S1 __X__S2 ____V**	
A partir del año de estudio de acuerdo con la secuencia: **_X__1ro _X__2do ___3ro ___4to ___5to ___6to ___Otro ___ N/A**	
10 **Codificación Alfanumérica: INSO 6050**	11 **Cantidad de Créditos: 3**
12 **Tipo de Curso: _____Requisito ___X___Electivo _____División de Educación Continua**	
13 **Tipo de créditos: __X__ Fijo ____Variable**	**Si es Variable, ¿puede repetirse con crédito? ___Si ___No**
	Si contesta si, indique la cantidad máxima que se puede repetir: _____
14 **Distribución de Horas Contacto Semanales dedicadas a la enseñanza:**	
__X___Conferencia	**_____Laboratorio** **_____Investigación**

_____Discusión	**_____Taller**	**_____Tesis o Disertación**
_____Seminario	**_____Internado**	**_____Estudio Independiente**
_____Práctica Supervisada		

15 Total de Horas Contacto: __45____

16 Equivalencia en Horas de Crédito para la carga académica del Profesor: ___3___

17 Descripción del Curso en Español (que no se exceda de 1,000 caracteres):
Estudio integral de los principios de ingeniería de software para computación en la frontera de la nube, con énfasis en análisis de datos a gran escala y computación distribuida. Este curso prepara a los estudiantes para diseñar e implementar sistemas orientados a dispositivos de computación en la frontera incluyendo aspectos de computación en la nube, sincronización, manejo de recursos, resistencia a fallas, servicios, análisis de datos de múltiples sensores y sus aplicaciones.

17 Descripción del Curso en Inglés (que no se exceda de 1,000 caracteres):
Comprehensive study of existing frameworks and applications in Edge Computing, with a focus on big data analytics and distributed computing. This course prepares students to design and implement computing systems over edge devices and the cloud including synchronization, resource management, fault tolerance, services, multi-sensor data analytics and their applications.

18 Prerrequisitos*	**18Correquisitos***
Ninguno	

***Especifique la Codificación Alfanumérica Correcta**

19 Requisitos especiales: _____
_____

20 Modalidad en la que el Curso se ofrecerá (Puede marcar más de una opción):

__X__Curso Presencial __X__Curso Híbrido _X___Curso a Distancia

21 Cargos por laboratorio: ____ Sí __X__No

22 Posibilidad de Equivalencia (en la unidad o en otras unidades del sistema):
___ Sí _X_No

Cursos:_____

Unidad(es) que lo(s) ofrece(n): _____

23 Equipo, materiales e instalaciones mínimas requeridas:

Facilidades computacionales existentes del Departamento de Ciencia e Ingeniería de Computación.

24 Cantidad de Estudiantes por sección: _ 3___ Cupo Mínimo __30__ Cupo Máximo

25 Sistema de Calificación:

_X___Letra (A, B, C, D o F) **____ Aprobado (S), No Aprobado (NS)**

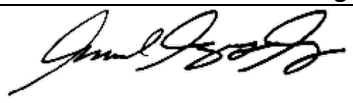
____ Aprobado (P), No Aprobado (NP) **____Aprobado (PS: Aprobado Sobresaliente; PN: Aprobado Bueno), No Aprobado (NP)**

____Aprobado (P), Fracasado (F) **____Otro (Especifique)_____**

26 Curso a Inactivar sujeto a la creación del nuevo curso:

_X____No Aplica **_____Si; especifique el curso a inactivar: _____**

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

27 APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL DEPARTAMENTO	**NOMBRE Y FIRMA** **Emmanuel Arzuaga, Ph.D**	**FECHA** **11/15/2022**
Director de Departamento		
28APROBACIÓN Y CERTIFICACIÓN A NIVEL DE LA FACULTAD	**NOMBRE Y FIRMA**	**FECHA**
Decano de la Facultad		
29 APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL SENADO ACADÉMICO	**NOMBRE Y FIRMA**	**FECHA**
Presidente del Comité de Cursos		

PARA USO DEL DECANATO DE ASUNTOS ACADÉMICOS

30 Codificación: _____ **Fecha de Codificación_____**

Funcionario que procesó la solicitud: **Fecha de envío al Departamento y Facultad:**

_____ **_____**

University of Puerto Rico
Mayagüez Campus
College of Engineering
Department of Computer Science and Engineering
Software Engineering Program

COURSE SYLLABUS

COURSE TITLE:	Software Engineering for Edge Systems
ALPHA-NUMERIC CODIFICATION:	INSO 6050
NUMBER OF CREDITS-CONTACT HOURS:	Three credits / 45 hours
PREREQUISITES, COREQUISITES AND OTHER REQUIREMENTS:	None

COURSE DESCRIPTION:

Spanish: Estudio integral de los principios de ingeniería de software para computación en la frontera de la nube, con énfasis en análisis de datos a gran escala y computación distribuida. Este curso prepara a los estudiantes para diseñar e implementar sistemas orientados a dispositivos de computación en la frontera incluyendo aspectos de computación en la nube, sincronización, manejo de recursos, resistencia a fallas, servicios, análisis de datos de múltiples sensores y sus aplicaciones. Este curso puede ofrecerse en cualquiera de las siguientes modalidades: presencial, híbrido o a distancia.

English: Comprehensive study of existing frameworks and applications in Edge Computing, with a focus on big data analytics and distributed computing. This course prepares students to design and implement computing systems over edge devices and the cloud including synchronization, resource management, fault tolerance, services, multi-sensor data analytics and their applications. This course may be offered in any of the following modalities: face-to-face, hybrid or online.

COURSE OBJECTIVES:

Students will:

- Identify the fundamental components of edge computing systems in the context of cloud computing.
- Explain the communication protocols that are present in edge devices
- Use security policies for edge systems in high-level programming language frameworks.
- Design and implement multi-sensor data analytics models for edge computing.
- Design and implement a basic edge system based on available architectures.
- Explain the tradeoffs in resource management of edge systems.
- Explain the tradeoffs in edge data processing models.
- Perform edge systems benchmarking activities.

TEXT BOOK: None. A list of technical research papers and lectures notes will be provided to the students.

Course time frame and thematic outline:

TIME DISTRIBUTION

Theme	Face-to-Face	Hybrid	Online
I. Introduction to Cloud Computing	3 hours	3 hours (face-to-face)	3 hours
II. Cloudlets: a cloud approach on the edge	4.5 hours	3 hours (online)	3 hours
III. Edge Fault Tolerance	3 hours	3 hours (face-to-face)	3 hours
IV. Edge Networking.	3 hours	3 hours (online)	3 hours
V. Edge ML Systems and Frameworks	4.5 hours	4.5 hours (face-to-face)	4.5 hours
VI. Edge Security	3 hours	3 hours (online)	3 hours
VII. Edge Deployment Models	3 hours	1.5 hours (face-to-face)	1.5 hours
VIII. Edge Data	3 hours	3 hours (online)	3 hours
IX. Edge Data Processing Models	3 hours	3 hours (face-to-face)	3 hours
X. Sensor data ML	3 hours	3 hours (online)	3 hours
XI. Edge Architectures	3 hours	3 hours (online)	3 hours
XII. Edge Resource Management	1.5 hours	1.5 hours (online)	1.5 hours
XIII. Edge Applications	1.5 hours	1.5 hours (online)	1.5 hours
XIV. Edge services	1.5 hours	3 hours (online)	3 hours
XV. Edge Platform Examples	1.5 hours	3 hours (online)	3 hours
XVI. Midterm Exams	3 hours	3 hours (face-to-face)	3 hours
Total contact hours	**45 hours**	**45 hours** (18 face-to-face = 40% and 27 online hours= 60%)	**45 hours**

INSTRUCTIONAL STRATEGIES:

Face-to-Face	Hybrid	Online

♦ Conferences ♦ Lectures ♦ Team Programming Projects ♦ Quizzes ♦ Exams	♦ Live and recorded Conferences ♦ Lectures ♦ Team Programming Projects ♦ Quizzes ♦ Exams	♦ Recorded Conferences ♦ Lectures ♦ Team Programming Projects ♦ Quizzes ♦ Exams

MINIMUM OR REQUIRED RESOURCES AVAILABLE:

RESOURCE	FACE-TO-FACE	HYBRID	ONLINE
Institutional learning management platform account (Ex. Moodle)	Institution	Institution	Institution
Institutional email account	Institution	Institution	Institution
Computer with high-speed internet access or mobile device with data service	Student	Student	Student
Programs or applications: free open source InteliJ IDE	Student	Student	Student
Webcam or mobile with camera and microphone	Not applicable	Student	Student

EVALUATION STRATEGIES:

FACE to FACE	HYBRID	ONLINE

All three modalities will be evaluated based on the following activities:

Activity	Quantity	Weight
Quizzes	5-10	10% - 20%
Midterm Exams	2	10% - 20%
Final Exam	1	10% - 20%
Programming Projects	4-6	40% - 60%

REASONABLE ACCOMMODATIONS:

The University of Puerto Rico at Mayagüez (RUM) recognizes that each student has an inherited right to request reasonable accommodation according to Law 51: Law for Integral Educational Services for People with Disabilities. Every student has the right to receive reasonable accommodation if he/she presents the necessary evidence to be evaluated by the Office of Services to Students with Disabilities (OSEI-RUM), and the related information can be found at the following link: https://www.uprm.edu/cms/index.php/page/85. If your case is approved by OSEI-RUM, you will receive reasonable accommodation in your courses and evaluation, and you must contact each professor

for course registered. For additional information contact OSEI-RUM at Sánchez Hidalgo 410 or via telephone 787-832-4040 extension 3107.

ACADEMIC INTEGRITY:

The University of Puerto Rico promotes the highest standards of academic and scientific integrity. Article 6.2 of the UPR Student General Bylaws (Board of Trustees Certification 13, 2009-2010) states that academic dishonesty includes, but is not limited to: fraudulent actions; obtaining grades or academic degrees by false or fraudulent simulations; copying the whole or part of the academic work of another person; plagiarizing totally or partially the work of another person; copying all or part of another person's answers to the questions of an oral or written exam by taking or having someone else take the exam on his/her behalf; as well as enabling and facilitating another person to perform the aforementioned behavior. Any of these behaviors will be subject to disciplinary action in accordance with the disciplinary procedure established by the UPR Student General Bylaws.─.

To ensure the integrity and security of user data, all hybrid, distance and online courses must be offered through the institutional learning management platform, which uses secure connection and authentication protocols. The system authenticates the identity of the user (student and professor) using the username and password assigned by the institution. The users are responsible for keeping their password safe, protected, and not to share it with other people.

POLICY AGAINST DISCRIMINATION BASED ON SEX, SEXUAL ORIENTATION, AND GENDER IDENTITY:

«The University of Puerto Rico prohibits discrimination based on sex, sexual orientation, and gender identity in any of its forms, including that of sexual harassment. According to the Institutional Policy Against Sexual Harassment at the University of Puerto Rico, Certification 130 (2014-2015) from the Board of Governors, any student subjected to acts constituting sexual harassment, may turn to the Office of the Student Ombudsperson, the Office of the Dean of Students, or the Coordinator of the Office of Compliance with Title IX for an orientation or formal complaint».

GRADING SYSTEM

☒ Quantifiable (letters, A, B, C, D, F) ☐ Not Quantifiable

CONTINGENCY PLAN IN CASE OF AN EMERGENCY

In case of an emergency or class interruption, the professor can apply Bylaw 19-85 of the UPRM. This bylaw states that up to 25% of a class can be offered online.

BIBLIOGRAPHY

1. Chang, Wei and Wu, Jie, *Fog/Edge Computing for Security, Privacy and Applications*, Springer, 2020.
2. Mukherjee, Anwesha, De, Debashis, Ghosh, Soumya K., and Buyya Rajkumar, *Mobile Edge Computing*, Springer, 2021.
3. Zhang, Yuchao and Xu, Ke, *Network Management in Cloud and Edge Computing*, Springer, 2020.
4. Lea, Perry. *IoT and Edge Computing for Architects*, Packt Publishing, 2020.
5. ACM Special Interest Group on Mobility of Systems, Users, Data & Comp (SIGMOBILE) Digital Collection, https://sigmobile.org/
6. IEEE Internet of Things Digital Collection, https://ieee-iotj.org/
7. Electronic Portal to access technical research papers.
    a. ACM Digital Library: https://dl.acm.org/
    b. IEEE Xplore Digital Library: https://ieeexplore.ieee.org

Prepared by Emmanuel Arzuaga Cruz, on 03/07/2022.

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
HOJA DE TRÁMITE PARA LA CREACIÓN DE CURSOS

CURSO: INSO 6070 - Software-Defined Networks Engineering

DEPARTAMENTO: Ciencia e Ingeniería de Computación

FACULTAD: Ingeniería

	COMENTARIOS
Fecha en que el proponente somete la propuesta de Creación de Curso: Fecha: 8/15/2022	
Firma del Director de Departamento: _____ Fecha: 11/15/2022	
Firma del Decano de Facultad: _____ Fecha:	
Fecha en que la solicitud es recibida en la Secretaría del Senado Académico: Fecha:	
Fecha en la que la solicitud es recibida por el Comité de Cursos del Senado Académico: Fecha:	
Firma del Presidente de Comité de Cursos del Senado Académico: _____ Fecha:	
Fecha en que la solicitud es recibida por el Decanato de Asuntos Académicos: Fecha:	

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
DECANATO DE ASUNTOS ACADÉMICOS

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

[1] **Unidad: Recinto Universitario de Mayagüez**	[1] **Colegio: Ingeniería**
[1] **Departamento: Ciencia e Ingenieria de Computación** **Programa: MS/PhD en Ingeniería de Software**	[1] **Profesor (es)** **Proponente(s): Manuel Rodriguez Martinez, Heidy Sierra, Ahmed ElSaid, Kejie Lu**
[2] **Fecha de Solicitud: 8/15/2022**	[3] **Fecha de Vigencia del Curso: 8/2023**
[4] **Título Completo en Español: Ingeniería de Redes Definidas en Software**	
[5] **(Título Abreviado a 26 Espacios): Ing Redes Def Software**	
[4] **Título Completo en Inglés: Software-Defined Networks Engineering**	
[5] **(Título Abreviado a 26 Espacios): SDN Engineering**	
[6] **Materia Principal del Curso (en clave alfa): INSO**	
[7] **Justificación para la Creación del Curso:**	
Provide graduate students in Software Engineering with in-depth knowledge of the principles and techiques for building modern software-defined networking (SDN) systems.	
[8] **Nivel del Curso (marque con una X): 1 2 3 4 5 Subgraduado — X 6 7 8 9 Graduado**	
[9] **Ubicación del curso, sea requisito, electivo o de continuación, en la secuencia curricular autorizada:** **(S=Semestres V=Verano) Período: ____S1 __X__S2 ____V**	
A partir del año de estudio de acuerdo con la secuencia: **_X__1ro _X__2do ___3ro ___4to ___5to ___6to ___Otro ___ N/A**	
[10] **Codificación Alfanumérica: INSO 6070**	[11] **Cantidad de Créditos: 3**
[12] **Tipo de Curso: _____Requisito ___X___Electivo _____División de Educación Continua**	
[13] **Tipo de créditos: __X__ Fijo ____Variable**	**Si es Variable, ¿puede repetirse con crédito? ___Si ___No**
	Si contesta si, indique la cantidad máxima que se puede repetir: _____
[14] **Distribución de Horas Contacto Semanales dedicadas a la enseñanza:**	
__X___Conferencia	**_____Laboratorio** **_____Investigación**

_____Discusión	**_____Taller**	**_____Tesis o Disertación**
_____Seminario	**_____Internado**	**_____Estudio Independiente**
_____Práctica Supervisada		

15 Total de Horas Contacto: __45____

16 Equivalencia en Horas de Crédito para la carga académica del Profesor: ___3___

17 Descripción del Curso en Español (que no se exceda de 1,000 caracteres):
Estudio integral de los principios de ingeniería para desarrollar sistemas modernos de redes definidas por software (SDN). Este curso prepara a los estudiantes para analizar, diseñar e implementar funciones que se ejecutan en controladores SDN, conmutadores SDN y aplicaciones SDN.

17 Descripción del Curso en Inglés (que no se exceda de 1,000 caracteres):
Comprehensive study of engineering principles to develop modern software-defined networking (SDN) systems. This course prepares students to analyze, design and implement functions running on SDN controllers, SDN switches, and SDN applications.

18 Prerrequisitos*	**18Correquisitos***
Ninguno	

***Especifique la Codificación Alfanumérica Correcta**

19 Requisitos especiales: _____
_____

20 Modalidad en la que el Curso se ofrecerá (Puede marcar más de una opción):

__X__Curso Presencial __X__Curso Híbrido _X___Curso a Distancia

21 Cargos por laboratorio: ____ Sí __X__No

22 Posibilidad de Equivalencia (en la unidad o en otras unidades del sistema):
___ Sí _X_No

Cursos:_____

Unidad(es) que lo(s) ofrece(n): _____

23 Equipo, materiales e instalaciones mínimas requeridas:

Facilidades computacionales existentes del Departamento de Ciencia e Ingeniería de Computación.

24 Cantidad de Estudiantes por sección: _ 3___ Cupo Mínimo __30__ Cupo Máximo

25 Sistema de Calificación:

_X___Letra (A, B, C, D o F) **____ Aprobado (S), No Aprobado (NS)**

____ Aprobado (P), No Aprobado (NP) **____Aprobado (PS: Aprobado Sobresaliente; PN: Aprobado Bueno), No Aprobado (NP)**

____Aprobado (P), Fracasado (F) **____Otro (Especifique)_____**

26 Curso a Inactivar sujeto a la creación del nuevo curso:

_X____No Aplica **_____Si; especifique el curso a inactivar: _____**

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

27 APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL DEPARTAMENTO	**NOMBRE Y FIRMA** **Emmanuel Arzuaga, Ph.D**	**FECHA** **11/15/2022**
Director de Departamento		
28APROBACIÓN Y CERTIFICACIÓN A NIVEL DE LA FACULTAD	**NOMBRE Y FIRMA**	**FECHA**
Decano de la Facultad		
29 APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL SENADO ACADÉMICO	**NOMBRE Y FIRMA**	**FECHA**
Presidente del Comité de Cursos		

PARA USO DEL DECANATO DE ASUNTOS ACADÉMICOS

30 Codificación: _____ **Fecha de Codificación_____**

Funcionario que procesó la solicitud: **Fecha de envío al Departamento y Facultad:**

_____ **_____**

University of Puerto Rico
Mayagüez Campus
College of Engineering
Department of Computer Science and Engineering
Program in Software Engineering

COURSE SYLLABUS

COURSE TITLE:	Software-Defined Networks Engineering
ALPHA-NUMERIC CODIFICATION:	INSO 6070
NUMBER OF CREDITS-CONTACT HOURS:	Three credits / 45 hours
PREREQUISITES, COREQUISITES AND OTHER REQUIREMENTS:	None

COURSE DESCRIPTION:

Spanish: Estudio integral de los principios de ingeniería para desarrollar sistemas modernos de redes definidas por software (SDN). Este curso prepara a los estudiantes para analizar, diseñar e implementar funciones que se ejecutan en controladores SDN, conmutadores SDN y aplicaciones SDN. Este curso podrá ofrecerse en cualquiera de las siguientes modalidades: presencial, híbrida o a distancia.

English: Comprehensive study of engineering principles to develop modern software-defined networking (SDN) systems. This course prepares students to analyze, design and implement functions running on SDN controllers, SDN switches, and SDN applications. This course may be offered in any of the following modalities: face-to-face, hybrid or online.

COURSE OBJECTIVES:

Students will:

- Understand the layered model of modern computer networks.
- Understand the functionality and implementation of the network layer in computer networks.
- Understand the architecture of the existing router-based network.
- Understand the architecture of the novel software-defined networks.
- Analyze, design, and implement SDN controller functions.
- Analyze, design, and implement SDN applications.
- Evaluate the performance of network layer protocols.
- Evaluate the performance of SDN systems.

TEXT BOOK:

1. Larry Peterson, Carmelo Cascone, Brian O'Connor, Thomas Vachuska, and Bruce Davie, *Software-Defined Networks: A Systems Approach*, Systems Approach Series, https://github.com/SystemsApproach/SDN, open-source License: CC BY-NC-ND 4.0, 2020.

Course time frame and thematic outline: (Sample of Distribution)

	TIME DISTRIBUTION		
Theme	**Face-to-Face**	**Hybrid**	**Online**
I. Introduction	3 hours	3 hours (face-to-face)	3 hours
	6 hours	6 hours (3 face-to-face, 3online)	6 hours

II. The network layer on the Internet			
III. The fundamentals of SDN	12 hours	12 hours (6 face-to-face, 6 online)	12 hours
IV. The SDN implementation	21 hours	21 hours (18 online and 3 face-to-face)	21 hours
V. Evaluation	3 hours	3 hours (face-to-face)	3 hours
Total contact hours	**45 hours**	**45 hours** (18 face-to-face = 40% and 27 online hours= 60%)	**45 hours**

INSTRUCTIONAL STRATEGIES:

Face-to-Face	Hybrid	Online
♦ Conferences ♦ Lectures ♦ Team work ♦ Individual tasks ♦ Assessment activities ♦ Practice activities ♦ Oral presentations	♦ Online instructional modules ♦ Professional article readings online ♦ Instructional Videos ♦ Team work ♦ Individual tasks ♦ Appraisal activities ♦ Practical activities ♦ Oral presentations ♦ Recorded and synchronous conferences	♦ Interactive instructional modules ♦ Professional article readings online ♦ Instructional videos ♦ Team work ♦ Individual tasks ♦ Appraisal activities ♦ Practical activities ♦ Oral presentations ♦ Recorded conferences ♦ Synchronous conferences

MINIMUM OR REQUIRED RESOURCES AVAILABLE:

RESOURCE	FACE-TO-FACE	HYBRID	ONLINE
Institutional learning management platform account (Ex. Moodle) (Cuenta en la plataforma institucional de gestión de aprendizaje) (Ej. Moodle)	Institution	Institution	Institution
Institutional email account	Institution	Institution	Institution
Computer with high-speed internet access or mobile device with data service	Student	Student	Student
Programs or applications: word processor, spreadsheets, presentation editor	Student	Student	Student
Built-in or external speakers	Not applicable	Student	Student
Webcam or mobile with camera and microphone	Not applicable	Student	Student

EVALUATION STRATEGIES: (Examples of evaluation techniques)

FACE to FACE	HYBRID	ONLINE

All three modalities will be evaluated based on the following activities:

Activity	Quantity	Weight
Quizzes	10-12	10% - 20%
Midterm Exams	2	10% - 20%
Final Exam	1	10% - 20%
Programming Projects	4-6	40% - 60%

REASONABLE ACCOMMODATIONS:

The University of Puerto Rico at Mayagüez (RUM) recognizes that each student has an inherited right to request reasonable accommodation according to Law 51: Law for Integral Educational Services for People with Disabilities. Every student has the right to receive reasonable accommodation if he/she presents the necessary evidence to be evaluated by the Office of Services to Students with Disabilities (OSEI-RUM), and the related information can be found at the following link: https://www.uprm.edu/cms/index.php/page/85. If your case is approved by OSEI-RUM, you will receive reasonable accommodation in your courses and evaluation, and you must contact each professor for course registered. For additional information contact OSEI-RUM at Sánchez Hidalgo 410 or via telephone 787-832-4040 extension 3107.

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To ensure the integrity and security of user data, all hybrid, distance and online courses must be offered through the institutional learning management platform, which uses secure connection and authentication protocols. The system authenticates the identity of the user (student and professor) using the username and password assigned by the institution. The users are responsible for keeping their password safe, protected, and not to share it with other people.

POLICY AGAINST DISCRIMINATION BASED ON SEX, SEXUAL ORIENTATION, AND GENDER IDENTITY:

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GRADING SYSTEM

☒ Quantifiable (letters, A, B, C, D, F) ☐ Not Quantifiable

CONTINGENCY PLAN IN CASE OF AN EMERGENCY

In case of an emergency or class interruption, the professor can apply Bylaw 19-85 of the UPRM. This bylaw states that up to 25% of a class can be offered online.

BIBLIOGRAPHY

1. Jason Edelmann, Scott S. Lowe, Matt Oswalt, "Network Programmability and Automation: Skills for the Next-Generation Network Engineer", O'Reilly Media; 1st edition (February 2, 2018)

2. Larry Peterson, Carmelo Cascone, Brian O'Connor, Thomas Vachuska, and Bruce Davie, "Software-Defined Networks: A Systems Approach", Systems Approach Series, https://github.com/SystemsApproach/SDN, open-source License: CC BY-NC-ND 4.0

3. Mininet: An Instant Virtual Network on your Laptop (or other PC), http://mininet.org/

4. OpenDayLight (ODL) SND controller, https://www.opendaylight.org/

5. F. Bannour, S. Souihi and A. Mellouk, "Distributed SDN Control: Survey, Taxonomy, and Challenges," in IEEE Communications Surveys & Tutorials, vol. 20, no. 1, pp. 333-354, Firstquarter 2018, doi: 10.1109/COMST.2017.2782482.

Electronic references: Electronic Portal to access technical research papers.

a. ACM Digital Library: https://dl.acm.org/
b. IEEE Xplore Digital Library: https://ieeexplore.ieee.org

Prepared by Dr. Kejie Lu on Mar. 05, 2022

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
HOJA DE TRÁMITE PARA LA CREACIÓN DE CURSOS

CURSO: INSO 6070 - Deep Learning Engineering

DEPARTAMENTO: Ciencia e Ingeniería de Computación

FACULTAD: Ingeniería

	COMENTARIOS
Fecha en que el proponente somete la propuesta de Creación de Curso: Fecha: 8/15/2022	
Firma del Director de Departamento: _____ Fecha: 11/15/2022	
Firma del Decano de Facultad: _____ Fecha:	
Fecha en que la solicitud es recibida en la Secretaría del Senado Académico: Fecha:	
Fecha en la que la solicitud es recibida por el Comité de Cursos del Senado Académico: Fecha:	
Firma del Presidente de Comité de Cursos del Senado Académico: _____ Fecha:	
Fecha en que la solicitud es recibida por el Decanato de Asuntos Académicos: Fecha:	

UNIVERSIDAD DE PUERTO RICO
RECINTO UNIVERSITARIO DE MAYAGUEZ
DECANATO DE ASUNTOS ACADÉMICOS

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

1 **Unidad: Recinto Universitario de Mayagüez**	1 **Colegio: Ingeniería**
1 **Departamento: Ciencia e Ingenieria de Computación** **Programa: MS/PhD en Ingeniería de Software**	1 **Profesor (es)** **Proponente(s): Manuel Rodriguez Martinez, Heidy Sierra, Ahmed ElSaid**
2 **Fecha de Solicitud: 8/15/2022**	3 **Fecha de Vigencia del Curso: 8/2023**
4 **Título Completo en Español: Ingeniería del Aprendizaje Profundo**	
5 **(Título Abreviado a 26 Espacios): Ing Aprendizaje Profundo**	
4 **Título Completo en Inglés: Deep Learning Engineering**	
5 **(Título Abreviado a 26 Espacios): Deep Learning Engineering**	
6 **Materia Principal del Curso (en clave alfa): INSO**	
7 **Justificación para la Creación del Curso:**	
Provide graduate students in Software Engineering with in-depth knowledge of the principles and techiques for building modern deep learning systems and applications.	
8 **Nivel del Curso (marque con una X): 1 2 3 4 5 Subgraduado** — **X 6 7 8 9 Graduado**	
9**Ubicación del curso, sea requisito, electivo o de continuación, en la secuencia curricular autorizada:** **(S=Semestres V=Verano) Período: __X__S1 ____S2 ____V**	
A partir del año de estudio de acuerdo con la secuencia: **_X__1ro _X__2do ___3ro ___4to ___5to ___6to ___Otro ___ N/A**	
10 **Codificación Alfanumérica: INSO 6080**	11 **Cantidad de Créditos: 3**
12 **Tipo de Curso: _____Requisito ___X___Electivo _____División de Educación Continua**	
13 **Tipo de créditos: __X__ Fijo ____Variable**	**Si es Variable, ¿puede repetirse con crédito? ___Si ___No**
	Si contesta si, indique la cantidad máxima que se puede repetir: _____
14 **Distribución de Horas Contacto Semanales dedicadas a la enseñanza:**	
__X___Conferencia	**_____Laboratorio**	**_____Investigación**

_____Discusión	**_____Taller**	**_____Tesis o Disertación**
_____Seminario	**_____Internado**	**_____Estudio Independiente**
_____Práctica Supervisada		

15 Total de Horas Contacto: __45____

16 Equivalencia en Horas de Crédito para la carga académica del Profesor: ___3___

17 Descripción del Curso en Español (que no se exceda de 1,000 caracteres):
Principios de la ingeniería del aprendizaje profundo con arquitecturas de redes neuronales profundas. Estudio de algoritmos y técnicas de implementación para redes neuronales completamente conectadas, redes convolucionales, redes recurrentes, métodos de incrustación de palabras, métodos de atención, redes adversarias generativas, y transformadores. Análisis de optimización de descenso de gradiente, selección de hiper-parámetros, sobreajuste, y modelado probabilístico. Uso de librerías en un lenguaje de programación de alto-nivel utilizando un modelo computacional de grafos dirigidos en Sistema de Computación Distribuida y de unidades de procesamiento gráfico ("GPU"). Discusión de publicaciones de investigación recientes en aprendizaje automático y su aplicación en la industria y la academia

17 Descripción del Curso en Inglés (que no se exceda de 1,000 caracteres):
Engineering Principles of deep learning with deep neural network architectures. Study of algorithms and implementation techniques for fully connected neural networks, convolutional networks, recurrent networks, word embeddings, attention methods, generative adversarial networks, and transformers. Analysis of gradient descent optimization, hyperparameters selection, overfitting, and probabilistic modeling. Use of software libraries and frameworks using computational models of directed graphs in distributed systems and graphical processing units ("GPU"). Discussion of recent research publications in machine learning and their application in industry and academia.

18 Prerrequisitos*	**18Correquisitos***
Ninguno	

***Especifique la Codificación Alfanumérica Correcta**

19 Requisitos especiales: _____
_____

20 Modalidad en la que el Curso se ofrecerá (Puede marcar más de una opción):

__X__Curso Presencial __X__Curso Híbrido _X___Curso a Distancia

21 Cargos por laboratorio: ____ Sí __X__No

22 Posibilidad de Equivalencia (en la unidad o en otras unidades del sistema):
___ Sí _X_No

Cursos:_____

Unidad(es) que lo(s) ofrece(n): _____

23 Equipo, materiales e instalaciones mínimas requeridas:

Facilidades computacionales existentes del Departamento de Ciencia e Ingeniería de Computación.

24 Cantidad de Estudiantes por sección: _ 3___ Cupo Mínimo __30__ Cupo Máximo

25 Sistema de Calificación:

_X___Letra (A, B, C, D o F) **____ Aprobado (S), No Aprobado (NS)**

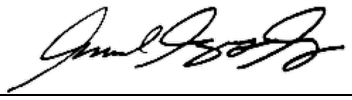
____ Aprobado (P), No Aprobado (NP) **____Aprobado (PS: Aprobado Sobresaliente; PN: Aprobado Bueno), No Aprobado (NP)**

____Aprobado (P), Fracasado (F) **____Otro (Especifique)_____**

26 Curso a Inactivar sujeto a la creación del nuevo curso:

_X____No Aplica **_____Si; especifique el curso a inactivar: _____**

SOLICITUD DE CREACIÓN, CODIFICACIÓN UNIFORME Y REGISTRO DE CURSOS

27 APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL DEPARTAMENTO	**NOMBRE Y FIRMA** **Emmanuel Arzuaga, Ph.D**	**FECHA** **11/15/2022**
Director de Departamento		
28APROBACIÓN Y CERTIFICACIÓN A NIVEL DE LA FACULTAD	**NOMBRE Y FIRMA**	**FECHA**
Decano de la Facultad		
29 APROBACIÓN Y CERTIFICACIÓN A NIVEL DEL SENADO ACADÉMICO	**NOMBRE Y FIRMA**	**FECHA**
Presidente del Comité de Cursos		

PARA USO DEL DECANATO DE ASUNTOS ACADÉMICOS

30 Codificación: _____ **Fecha de Codificación_____**

Funcionario que procesó la solicitud: **Fecha de envío al Departamento y Facultad:**

_____ **_____**

University of Puerto Rico
Mayagüez Campus
College of Engineering
Department of Computer Science and Engineering
Program in Software Engineering

COURSE SYLLABUS

COURSE TITLE:	Deep Learning Engineering
ALPHA-NUMERIC CODIFICATION:	INSO 6080
NUMBER OF CREDITS-CONTACT HOURS:	Ex: Three credits / 45 hours
PREREQUISITES, COREQUISITES AND OTHER REQUIREMENTS:	None

COURSE DESCRIPTION:

Spanish: Principios de la ingeniería del aprendizaje profundo con arquitecturas de redes neuronales profundas. Estudio de algoritmos y técnicas de implementación para redes neuronales completamente conectadas, redes convolucionales, redes recurrentes, métodos de incrustación de palabras, métodos de atención, redes adversarias generativas, y transformadores. Análisis de optimización de descenso de gradiente, selección de hiper-parámetros, sobreajuste, y modelado probabilístico. Uso de librerías en un lenguaje de programación de alto-nivel utilizando un modelo computacional de grafos dirigidos en Sistema de Computación Distribuida y de unidades de procesamiento gráfico ("GPU"). Discusión de publicaciones de investigación recientes en aprendizaje automático y su aplicación en la industria y la academia. Este curso podrá ofrecerse en cualquiera de las siguientes modalidades: presencial, híbrida o a distancia.

English: Engineering Principles of deep learning with deep neural network architectures. Study of algorithms and implementation techniques for fully connected neural networks, convolutional networks, recurrent networks, word embeddings, attention methods, generative adversarial networks, and transformers. Analysis of gradient descent optimization, hyperparameters selection, overfitting, and probabilistic modeling. Use of software libraries and frameworks using computational models of directed graphs in distributed systems and graphical processing units ("GPU"). Discussion of recent research publications in machine learning and their application in industry and academia. (This course may be offered in any of the following modalities: face-to-face, hybrid or online.)

COURSE OBJECTIVES:

Students will learn the fundamental techniques to design, build, and test deep neural networks in a modern computing platform that includes GPU nodes and uses computational models based on directed graphs for distributed training and production use. They will be able to apply these networks to solve classification problems related with computer vision, audio, video, natural language, and time series.

TEXT BOOK:

- Ian Goodfellow, Yoshua Bengio and Aaron Courville, Deep Learning, 1st Edition MIT Press, 2017. ISBN-13: 978-0262035613
- Seth Weidman, Deep Learning from Scratch: Building with Python from First Principles 1st Edition, O'Reilly Media, Inc. 2019, ISBN: 9781492041412

- Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 2nd Edition, O'Reilly Media, Inc.2019, ISBN: 9781492032649
- Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, An Introduction to Statistical Learning 1st Edition Springer, 2014, ISBN-13: 978-1461471370.

Course time frame and thematic outline:

	TIME DISTRIBUTION		
Theme	**Face-to-Face**	**Hybrid**	**Online**
I. Introduction to Deep Learning	1 hours	1 hours (face-to-face)	1 hours
II. Linear algebra concepts	3 hours	3 hours (face-to-face)	2 hours
III. Probability and statistics	4 hours	4 hours (online)	4 hours
IV. Review of Machine learning basics: linear regression, linear classification, multiclass classification, backpropagation and convolution	4 hours	4 hours (3 online + 1 face-to-face)	4 hours
V. Neural networks: perceptron and neural networks as a universal approximation	4 hours	4 hours (3 online + 1 face-to-face)	4 hours
VI. Training a neural network: perceptron learning, convergence and training	4 hours	4 hours (3 online + 1 face-to-face)	4 hours
VII. Introduction to Feed forward models, convolutional neural networks and recurrent neural networks	4 hours	4 hours (3 online + 1 face-to-face)	4 hours
VIII. Deep Learning Models:, convolutional neural networks	4 hours	4 hours (online)	4 hours
IX. Deep Learning Models: recurrent neural networks	4 hours	4 hours (online)	4 hours
X. Deep learning applications: Attention, word embeddings, transformers, and Language models	5 hours	5 hours (3 online + 2 face-to-face)	5 hours
XI. Advance topics and applications: Generative Adversarial Neural Networks, Distributed Training	4 hours	4 hours (online)	4 hours
XIII. Project Oral Presentations	2 hours	2 hours (face-to-face)	2
XIV. Exams	3 hours	3 hours (face-to-face)	3
Total contact hours	**45 hours**	**45 hours**	**45 hours**

		(15 face-to-face = 33% and 30 online hours= 77%)	

INSTRUCTIONAL STRATEGIES:

Face-to-Face	Hybrid	Online
• Conferences • Individual tasks • Assessment activities • Practice activities • Oral presentations	• Online instructional modules • Instructional Videos • Individual tasks • Practical activities • Oral presentations • Recorded and synchronous conferences	• Interactive instructional modules • Instructional videos • Individual tasks • Practical activities • Oral presentations • Recorded conferences • Synchronous conferences

MINIMUM OR REQUIRED RESOURCES AVAILABLE:

RESOURCE	FACE-TO-FACE	HYBRID	ONLINE
Institutional learning management platform account (Ex. Moodle)	Institution	Institution	Institution
Institutional email account	Institution	Institution	Institution
Computer with high-speed internet access or mobile device with data service	Institution/Student	Student	Student
Programs or applications: word processor, spreadsheets, presentation editor	Institution/Student	Student	Student
Built-in or external speakers	Not applicable	Student	Student
Webcam or mobile with camera and microphone	Not applicable	Student	Student

EVALUATION STRATEGIES:

FACE to FACE	HYBRID	ONLINE

All three modalities will be evaluated based on the following activities:

	Quantity	Percent
☒ Exams	2-3	25%-35%
☒ Final Exam	1	20%-25%
☒ Short Quizzes	0-6	0%-10%
☐ Oral Reports		
☐ Monographies		
☐ Portfolio		
☒ Projects	1	30%-40%
☐Journals		
☒Other, specify: Homework	0-10	0%-10%
TOTAL:		100%

REASONABLE ACCOMMODATIONS:

The University of Puerto Rico at Mayagüez (RUM) recognizes that each student has an inherited right to request reasonable accommodation according to Law 51: Law for Integral Educational Services for People with Disabilities. Every student has the right to receive reasonable accommodation if he/she presents the necessary evidence to be evaluated by the Office of Services to Students with Disabilities (OSEI-RUM), and the related information can be found at the following link: https://www.uprm.edu/cms/index.php/page/85. If your case is approved by OSEI-RUM, you will receive reasonable accommodation in your courses and evaluation, and you must contact each professor for course registered. For additional information contact OSEI-RUM at Sánchez Hidalgo 410 or via telephone 787-832-4040 extension 3107.

ACADEMIC INTEGRITY:

The University of Puerto Rico promotes the highest standards of academic and scientific integrity. Article 6.2 of the UPR Student General Bylaws (Board of Trustees Certification 13, 2009-2010) states that academic dishonesty includes, but is not limited to: fraudulent actions; obtaining grades or academic degrees by false or fraudulent simulations; copying the whole or part of the academic work of another person; plagiarizing totally or partially the work of another person; copying all or part of another person's answers to the questions of an oral or written exam by taking or having someone else take the exam on his/her behalf; as well as enabling and facilitating another person to perform the aforementioned behavior. Any of these behaviors will be subject to disciplinary action in accordance with the disciplinary procedure established by the UPR Student General Bylaws.─.

To ensure the integrity and security of user data, all hybrid, distance and online courses must be offered through the institutional learning management platform, which uses secure connection and authentication protocols. The system authenticates the identity of the user (student and professor) using the username and password assigned by the institution. The users are responsible for keeping their password safe, protected, and not to share it with other people.

POLICY AGAINST DISCRIMINATION BASED ON SEX, SEXUAL ORIENTATION, AND GENDER IDENTITY:

«The University of Puerto Rico prohibits discrimination based on sex, sexual orientation, and gender identity in any of its forms, including that of sexual harassment. According to the Institutional Policy Against Sexual Harassment at the University of Puerto Rico, Certification 130 (2014-2015) from the Board of Governors, any student subjected to acts constituting sexual harassment, may turn to the Office of the Student Ombudsperson, the Office of the Dean of Students, or the Coordinator of the Office of Compliance with Title IX for an orientation or formal complaint».

GRADING SYSTEM

☒ Quantifiable (letters, A, B, C, D, F) ☐ Not Quantifiable

CONTINGENCY PLAN IN CASE OF AN EMERGENCY

In case of an emergency or class interruption, the professor can apply Bylaw 19-85 of the UPRM. This bylaw states that up to 25% of a class can be offered online.

BIBLIOGRAPHY

1) Ian Goodfellow, Yoshua Bengio and Aaron CourvilleIan,Deep Learning, 1st Edition MIT Press, 2017. ISBN-13: 978-0262035613
2) Seth Weidman, Deep Learning from Scratch: Building with Python from First Principles 1st Edition, O'Reilly Media, Inc. 2019, ISBN: 9781492041412
3) Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 2nd Edition, O'Reilly Media, Inc.2019, ISBN: 9781492032649
4) Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, An Introduction to Statistical Learning 1st Edition Springer, 2014, ISBN-13: 978-1461471370.
5) Ethem Alpaydin, Introduction to Machine Learning, MIT Press, 2014, SBN-13: 978-0262012430.
6) Richard O Duda, Peter E. Hart and David G. Stork, Pattern Classification 2nd Edition John Wiley and Sons, New York, 2001, ISBN-13: 978-0471056690.
7) Earl Gose, Richard Johnsonbaugh, and Steve Jost, Pattern Recognition with Image Analysis 1st Edition Prentice Hall, 1996 ISBN-13 : 978-8120314849 [Classic Book].
8) Tom M. Mitchell, Machine Learning, New York: McGraw-Hill, 1997 [Classic Book]

Electronic references: Electronic Portal to access technical research papers.

1) ACM Digital Library: https://dl.acm.org/
2) IEEE Xplore Digital Library: https://ieeexplore.ieee.org