COURSE DETAILS

" MACHINE LEARNING FOR PRODUCT AND PROCESS ENGINEERING "

SSD ING-IND/25, ING-IND/26, ING-IND/27

DEGREE PROGRAMME: CHEMICAL ENGINEERING MASTER'S DEGREE

ACADEMIC YEAR 2023-2024

GENERAL INFORMATION – TEACHER REFERENCES

TEACHER: FRANCESCO DI NATALE
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GENERAL INFORMATION ABOUT THE COURSE

INTEGRATED COURSE (IF APPLICABLE): MACHINE LEARNING FOR PRODUCT AND PROCESS ENGINEERING
MODULE: MACHINE LEARNING FOR PROCESS DESIGN AND OPTIMIZATION
SSD OF THE MODULE (IF APPLICABLE): ING-IND/25
CHANNEL (IF APPLICABLE): FG
YEAR OF THE DEGREE PROGRAMME: II
SEMESTER: II
CFU: 2

INTEGRATED COURSE (IF APPLICABLE): MACHINE LEARNING FOR PRODUCT AND PROCESS ENGINEERING

MODULE: MACHINE LEARNING FOR FORMULATED PRODUCT DEVELOPMENT

SSD OF THE MODULE (IF APPLICABLE): ING-IND/26

CHANNEL (IF APPLICABLE): FG

YEAR OF THE DEGREE PROGRAMME: II

SEMESTER: II

CFU: 2

INTEGRATED COURSE (IF APPLICABLE): MACHINE LEARNING FOR PRODUCT AND PROCESS ENGINEERING

MODULE: GAUSSIAN-PROCESS-AIDED OPTIMIZATION OF CHEMICAL REACTIONS AND PRODUCTS

SSD OF THE MODULE (IF APPLICABLE): ING-IND/27

CHANNEL (IF APPLICABLE): FG

YEAR OF THE DEGREE PROGRAMME: II

SEMESTER: II

CFU: 2

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

There are no required preliminary courses.

PREREQUISITES (IF APPLICABLE)

There are no prerequisites.

LEARNING GOALS

Starting from significant case studies, the course introduces the computational instruments and techniques for data analytics and data science applications to product and process engineering.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

The course provides students with the basic knowledge and methodological tools to understand the most relevant aspects of the application of data analytics and data science techniques (in particular, machine/deep learning) for the design/optimization and analysis of characteristic systems of product and process engineering.

Applying knowledge and understanding

The course provides students with the methodological tools to apply appropriate data analytics and data science techniques for the analysis and design/optimization of systems characteristic of product and process engineering through appropriate software tools.

COURSE CONTENT/SYLLABUS

- Elementi introduttivi sulle tecniche di data analytics e data science per l'ingegneria di prodotto e di processo.

- Data analytics: data collection, cleaning, and visualization, feature selection and extraction (feature engineering), supervised and unsupervised learning algorithms.

- Data Science: examples of machine learning models (linear regression, decision trees, XGboost, k-nearest neighbors, etc), examples of deep learning models (artificial neural networks, convolutional neural networks).

- Presentation of case studies related to

- *surrogate models for the analysis of chemical plant performances,*
- *application of deep learning techniques in the formulated liquids industry,*
- *integration of surrogate models in the closed-loop optimization of formulated products and chemical,*
- *Gaussian processes as surrogate models for the prediction of chemical-physical properties of products of industrial interest and yield and selectivity of chemical processes.*

- Examples of application of the aforementioned machine learning techniques to datasets relating to product and process engineering.

READINGS/BIBLIOGRAPHY

- Course notes
- Suggested textbooks

TEACHING METHODS

- Frontal lessons
- Tutorials on the use of computational tools
- Hands-on sessions in the classroom

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

*For **integrated courses**, there should be one exam.*

Exam type	
written and oral	
only written	
only oral	
project discussion	X
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	
	Numerical exercises	

(*) multiple options are possible

b) Evaluation pattern:

The final mark will be weighted on CFU of each module and therefore will be made up of: Module A 2 CFU 33.3%, Module B 2 CFU 33.3%, Module C 2 CFU 33.3%.

SCHEDA DELL'INSEGNAMENTO (SI)
BIO INSPIRED GENERATIVE DESIGN FOR ADDITIVE MANUFACTURING

SSD: DISEGNO E METODI DELL'INGEGNERIA INDUSTRIALE (ING-IND/15)

DENOMINAZIONE DEL CORSO DI STUDIO: INGEGNERIA MECCANICA PER LA PROGETTAZIONE E LA PRODUZIONE (M64)
ANNO ACCADEMICO 2022/2023

INFORMAZIONI GENERALI - DOCENTE

DOCENTE: GLORIA ANTONIO
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INFORMAZIONI GENERALI - ATTIVITÀ

INSEGNAMENTO INTEGRATO: NON PERTINENTE
MODULO: NON PERTINENTE
CANALE: FG A-Z
ANNO DI CORSO: I
PERIODO DI SVOLGIMENTO:
CFU: 9

INSEGNAMENTI PROPEDEUTICI

“None”

EVENTUALI PREREQUISITI

“None”

OBIETTIVI FORMATIVI

The Course deals with the Bio-Inspired Generative Design (GD), a design method that mimics nature’s evolutionary approach to design, and Additive Manufacturing. GD is used to design complex shapes and optimized forms according to forces, cost, weight, environmental impact and other data that may influence the design. Starting from design goals and using machine learning algorithms, GD will allow to explore all of the possible combinations of solutions in order to find the best option. Taking advantage of the Additive Manufacturing processes which allow to

manufacture complex geometries, in many cases technically unfeasible using conventional manufacturing methods, such shapes can be realised. Thus, the main steps from concept design to Additive Manufacturing will be developed. The presented concepts will be exploited to develop a project work, in which the students, grouped in teams, will work together on a specific case study. The CREAMI and RICREAMI laboratories will be available to the students.

RISULTATI DI APPRENDIMENTO ATTESI (DESCRITTORI DI DUBLINO)

Conoscenza e capacità di comprensione

Knowledge and understanding

The student must demonstrate that he/she has achieved an adequate knowledge of strategies towards the design for Additive Manufacturing with a special emphasis on the following features: - Knowledge of technical language for the communication of technical information at the international level; - Knowledge of the basic methodologies of Design for Manufacturability and Assembly/Design for Additive Manufacturing; - Knowledge and understanding of International Standards; - Knowledge of the basic principles in design and development of sustainable and smart products; - Knowledge of the basic methodologies for the assessment of the functional analysis of Additive Manufactured Products; - To define biomimetic and bio-inspired approach; - To distinguish among different cellular structures - lattice structures - To describe topology optimization algorithms; - To illustrate the main features of generative design; - To outline the potential of developing custom-made and lightweight products.

Capacità di applicare conoscenza e comprensione

Applying knowledge and understanding

At the end of the Course the student must demonstrate that he/she has acquired notions of Bio-Inspired Generative Design for Additive Manufacturing and, in particular, the following abilities: - Knowledge and planning of the functional design of additive manufactured components of mechanical systems and products by applying the basic principles of bio-inspired and generative design; - Understanding of the effect of the manufacturing errors on the functional and mechanical characteristics of the additive manufactured products; - Interpretation of concepts for the design of smart and sustainable products towards the ecological transition; - Understanding of verification methodologies and technical reference standards; - To modify conventional methodologies and to rewrite/organise novel functional analyses for innovative products, as a consequence of product reimagination from a new standpoint: - To solve technical problems related to the simultaneous optimization of several response variables (e.g., mechanical and further functional features) as well as to the development of multi-material structures; - Correct use of the developed products according to the specific applications, and production of reference documentation; - Management and implementation of several algorithms to develop innovative products.

PROGRAMMA-SYLLABUS

The course contents will cover the following aspects: · Key Advantages of the Additive Manufacturing (AM) techniques. · Design for Manufacturability and Assembly (DfMA) / Design for Additive Manufacturing (DfAM). · Design for Additive Manufacturing in sustainable and smart product design and development: Trends and Opportunities. · DfAM and International standards. · Understanding the influence of AM roughness, geometrical and dimensioning tolerances, mechanical properties, process parameters on DfAM. · From Darwin's Theory of Natural Selection to Generative Design. Nature-Inspired Metaheuristic Algorithms. Genetic Algorithms. Generative Design. · Cellular Structures. Lattice structures and 3D CAD Modelling. · Geometrically Hybrid Lattice Structures and Solid-Lattice Hybrid Structures. · Topology Optimization Algorithms. Gradient-Based Optimization Algorithms. Optimality Criteria Methods. Integrated Design Methods. · Bioinspired architectures for sustainable and smart products · Design for Additive Manufacturing of custom-made advanced, lightweight and multi-material structures. · Practical lessons based on project work concerning innovative architectures for sustainable and smart products.

MATERIALE DIDATTICO

All students will find technical information and/or teaching material related to classroom presentations and exercises on the teacher's website and/or TEAMS platform. ASTM and UNI-EN-ISO standards will be available.

MODALITÀ DI SVOLGIMENTO DELL'INSEGNAMENTO-MODULO

a) Frontal lessons for about 70 percent of the program hours, and classroom exercises for the remaining 30 percent. b) Exercises for practical insight into the theoretical features, with the aim to discuss about technical works and to manage learning tests towards the self-assessment.

VERIFICA DI APPRENDIMENTO E CRITERI DI VALUTAZIONE

a) Modalità di esame

- ☐ Scritto
- ☑ Orale
- ☑ Discussione di elaborato progettuale
- ☐ Altro

In caso di prova scritta i quesiti sono

- ☐ A risposta multipla
- ☐ A risposta libera
- ☐ Esercizi numerici

b) Modalità di valutazione

The minimum requirements for passing the exam concern the following features: i) knowledge of the basic principles of the Design for Additive Manufacturing, bio-inspired and generative design; ii) knowledge of dedicated algorithms and optimality criteria methods; iii) ability to design cellular and lattice structures with optimized properties. The students must use textbooks, manuals or

collection of technical standards during the oral test. The students with SLD (Specific Learning Disorders) or disabilities can use teaching support material, such as synoptic tables and multimedia devices, with the aim to help the learning process. The oral test focuses on the subjects of the program and starts from the discussion of a project work made by the students.

SCHEDA DELL'INSEGNAMENTO (SI)
STATISTICA PER LA TECNOLOGIA

SSD: STATISTICA PER LA RICERCA SPERIMENTALE E TECNOLOGICA (SECS-S/02)

DENOMINAZIONE DEL CORSO DI STUDIO: INGEGNERIA MECCANICA PER LA PROGETTAZIONE E LA PRODUZIONE (M64)
ANNO ACCADEMICO 2022/2023

INFORMAZIONI GENERALI - DOCENTE

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INFORMAZIONI GENERALI - ATTIVITÀ

INSEGNAMENTO INTEGRATO: NON PERTINENTE
MODULO: NON PERTINENTE
CANALE: FG A-Z
ANNO DI CORSO: II
PERIODO DI SVOLGIMENTO: SEMESTRE I
CFU: 12

INSEGNAMENTI PROPEDEUTICI

Nessuno

EVENTUALI PREREQUISITI

Nessuno

OBIETTIVI FORMATIVI

Il corso èdi tipo metodologico-applicativo e ha come obiettivo quello di: trasferire all'allievo le nozioni fondamentali del calcolo delle probabilità, dell'analisi dei dati e dell'inferenza statistica e delle loro possibili applicazioni in campo ingegneristico, con particolare riferimento ai fenomeni tecnologici ed al controllo statistico della qualità.

RISULTATI DI APPRENDIMENTO ATTESI (DESCRITTORI DI DUBLINO)

Conoscenza e capacità di comprensione

Alla fine del corso lo studente dovrà dimostrare di conoscere i modelli probabilistici e gli strumenti e metodi statistici elencati nel programma. Dovrà altresì dimostrare di averne compreso le proprietà e caratteristiche, le ipotesi sulle quali sono fondati, le finalità di utilizzo ed i limiti applicativi.

Capacità di applicare conoscenza e comprensione

Il corso intende trasmettere allo studente le competenze e le capacita operative necessarie per risolvere, con senso critico, semplici ma realistici problemi applicativi e/o per modellare ed analizzare fenomeni non deterministici non eccessivamente complessi. Alla fine del corso lo studente dovrà dimostrare di saper selezionare e/o costruire strumenti appropriati, seguendo i modelli di ragionamento forniti attraverso le esercitazioni e/o per mezzo degli esempi discussi in aula.

PROGRAMMA-SYLLABUS

[1.5 CFU] Algebra degli eventi. Elementi di calcolo combinatorio. Definizione di probabilità. Probabilità dell'unione. Probabilità condizionata. Probabilità dell'intersezione. Indipendenza stocastica. Teorema delle probabilità totali. Teorema di Bayes. Applicazioni in campo scientifico e tecnologico. Variabili aleatorie. Distribuzioni di probabilità. Media, varianza, covarianza, moda, mediana e quantili.

[1 CFU] Modelli di variabili aleatorie: bernoulliana, binomiale, geometrica, binomiale negativa, ipergeometrica, Poisson, uniforme, esponenziale, normale. Teorema del limite centrale. Modelli inferenziali: Chi-quadrato, T-Student e F-Fisher.

[2 CFU] Studio sperimentale di variabili aleatorie. Distribuzioni empiriche. Rappresentazioni grafiche. Popolazione, campionamento, campioni casuali e statistiche campionarie. Stima parametrica puntuale. Metodo dei momenti e della massima verosimiglianza. Stima parametrica per intervallo. Intervalli di confidenza per i parametri della popolazione gaussiana: variabili t di student e chi quadrato. Intervallo di confidenza per il parametro p della popolazione bernoulliana. Test delle ipotesi. Ipotesi nulla, ipotesi alternativa, errore del I tipo, errore del II tipo, livello di significatività e potenza di un test. Test sui parametri della popolazione gaussiana. Test per il confronto tra medie di popolazioni gaussiane. Test per il confronto tra varianze di popolazioni gaussiane: variabile aleatoria di Fisher.

[1.5 CFU] Controllo statistico della qualità: carte di controllo Shewhart per variabili ed attributi; indici di capacità di processo.

MATERIALE DIDATTICO

P. Erto, 2008, Probabilità e statistica per le scienze e l'ingegneria 3/ed, McGraw-Hill.
Altri libri raccomandati: Montgomery, D. C. (2014) Introduction to Statistical Quality Control. 7th edition. John Wiley &Sons.

MODALITÀ DI SVOLGIMENTO DELL'INSEGNAMENTO-MODULO

Didattica frontale (46/48 h), esercitazioni (22/24 h) e seminari applicativi (0/2/4 h).

VERIFICA DI APPRENDIMENTO E CRITERI DI VALUTAZIONE

a) Modalità di esame

- [x] Scritto
- [x] Orale
- [ ] Discussione di elaborato progettuale
- [ ] Altro

In caso di prova scritta i quesiti sono

- [x] A risposta multipla
- [ ] A risposta libera
- [x] Esercizi numerici

b) Modalità di valutazione

Il voto èformulato dalla Commissione d'Esame sulla base dell'esito della prova scritta (60%) e dell'adeguatezza delle risposte fornite dallo studente ai quesiti che gli sono stati formulati durante la prova orale (40%). Sono illustrati allo studente gli elementi che sono stati presi in considerazione per determinare il voto finale.

COURSE DETAILS

" STATISTICAL LEARNING FOR INDUSTRIAL ENGINEERING "

SSD SEC-S/02

DEGREE PROGRAMME: INGEGNERIA MECCANICA PER LA PROGETTAZIONE E LA PRODUZIONE

ACADEMIC YEAR 2022 - 2023

INFORMAZIONI GENERALI - DOCENTE

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INFORMAZIONI GENERALI - ATTIVITÀ

YEAR OF THE DEGREE PROGRAMME: I o II
SEMESTER: I
CFU: 6

REQUIRED PRELIMINARY COURSES

Statistica per la Tecnologia

PREREQUISITES

"none"

LEARNING GOALS

Problem-based learning course whose aim is to train students on the application (illustrated through open-source statistical software R) of interpretable statistical learning techniques for industrial engineering, possibly scalable up to big data frameworks. Every student should choose a data analysis project gathered along the course by experts in industrial engineering fields and develop it by working in a team. Students will have the opportunity to improve their ability to recognize and implement the most suitable statistical learning technique for the problem at hand as well as communicate the results and impact of their analysis also to non-statisticians.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

Students will have the opportunity to improve their ability to recognize and implement the most suitable statistical learning technique for the engineering problem at hand.

Applying knowledge and understanding

Students will be able to work in a team, to get the skills for the decision-making developing a real-case data analysis project as well as communicate the results and impact of their analysis.

COURSE CONTENT/SYLLABUS

***Overview and Course Objectives**. What Is Statistical Learning. Supervised Versus Unsupervised Learning. Importance of interpretable statistical Learning. Statistical Process Monitoring and Control.*

***Elements of Unsupervised Learning**. Principal Component analysis. Clustering Methods.*

***Elements of supervised learning**. Multivariate Linear Regression models. Least Squares Estimation. Inferences About the Regression Model. Cross-Validation. Linear Model Selection and Regularization. Best Subset Selection. Stepwise Selection. Choosing the Optimal Model. Shrinkage Methods. Ridge Regression. The Lasso. Selecting the Tuning Parameter. Dimension Reduction Methods. Principal Components Regression. Partial Least Squares. Considerations in High Dimensions. An Overview of Classification methods.*

***Engineering Approach to Modern Process Monitoring and Control**. The multivariate quality-control problem. The Hotelling control chart. Regression adjustment. Interpretation of out-of-control signals. Latent structure methods.*

***Beyond multivariate data analysis**. Introduction to functional data analysis. Statistical monitoring of functional data. Engineering examples through software environment.*

READINGS/BIBLIOGRAPHY

Johnson, R.A., Wichern, D.W. (2007) Applied Multivariate Statistical Analysis (6th edition), Prentice Hall, Upper Saddle River.
Montgomery, D. C. (2014) Introduction to Statistical Quality Control. 7th edition. John Wiley & Sons.
James, G., Witten, D., Hastie, T., Tibshirani, R. (2013) An introduction to statistical learning. New York: Springer.

TEACHING METHODS

Problem-based learning. Flipped classroom. Lectures. Lab Sessions and Seminars. Peer-grading. Team work. Interactive and anonymous quiz games.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam type	
written and oral	X
only written	
only oral	
project discussion	X
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	X
	Open answers	
	Numerical exercises	X

(*) multiple options are possible

b) Evaluation pattern:

The final grade is formulated by the Examination Committee according to the scores achieved by the student in the peer-graded project discussion, the written exam, and the successive discussion during the oral exam. The final evaluation is discussed and highlighted to each student.

SCHEDA DELL' INSEGNAMENTO DI Chimica e Tecnologia della Catalisi

TITOLO INSEGNAMENTO IN INGLESE Chemistry and Technology of Catalysis

Docente: Vincenzo Busico

SSD	CFU	Anno di corso			Semestre		Lingua
		I	II		I	II	Italiano
CHIM/03	6	X				X	

Insegnamenti propedeutici previsti: Nessuno

OBIETTIVI FORMATIVI

L'insegnamento ha due obiettivi principali: 1) Fornire i fondamenti della catalisi organometallica su superfici, con particolare riferimento a catalizzatori solidi nanostrutturati ed a sistemi catalitici supportati su matrici vetrose a morfologia controllata, utilizzando come esempi di applicazione due processi produttivi industriali di largo volume (catalisi Fischer-Tropsch e Ziegler-Natta); 2) Introdurre i metodi di High Throughput Experimentation integrati con strumenti di Intelligenza Artificiale (es. Machine Learning, Deep Learning) per lo screening veloce e l'ottimizzazione mediante modellazione statistica predittiva di formulazioni catalitiche organometalliche.

PROGRAMMA

Parte 1. Modelli strutturali delle superfici di cristalli metallici e ionici. Solidi nanostrutturati. Supporti vetrosi a morfologia controllata. Adsorbimento fisico e chimico. Cinetica chimica delle reazioni su superfici. Catalisi Fischer-Tropsch. Catalisi di polimerizzazione Ziegler-Natta del propene.
Parte 2. Introduzione teorica e pratica alle metodologie di High Throughput Experimentation (HTE): obiettivi, strumentazioni, applicazioni. Digitalizzazione ed archiviazione di dati di HTE. Modellazione statistica di dati di HTE mediante algoritmi di Intelligenza Artificiale (es. Machine Learning, Deep Learning). Screening ed ottimizzazione di formulazioni catalitiche organometalliche mediante strumenti integrati di HTE/IA.

MODALITA' DIDATTICHE

Lezioni frontali. Esercitazioni.

MATERIALE DIDATTICO

Copia delle diapositive mostrate dal docente nelle lezioni frontali – Link ad ipertesti ed articoli di letteratura scientifica rilevanti. N.B. Tutto il materiale di cui sopra è reso disponibile agli studenti per il downloading dal sito web del docente alla data di inizio del semestre.

MODALITA' DI ESAME

L'esame si articola in prova	Scritta e orale		Solo scritta		Solo orale	X

In caso di prova scritta i quesiti sono	A risposta multipla		A risposta libera		Esercizi numerici	

TEACHING SUMMARY FOR THE COURSE Chemistry and Technology of Catalysis

Teacher: Francesco Cutugno

SSD	CFU	Year			Semester		Language
		I	II		I	II	Italian
CHIM/03	6	X				X	

Propaedeutic courses: None

OBJECTIVES

The course has two main objectives: 1) Provide the fundamentals of organometallic catalysis on surfaces, with special reference to nanostructured solids and supported systems on controlled-morphology glasses, and using as exemplifications two large-volume industrial processes (namely, Fischer-Tropsch and Ziegler-Natta catalysis); 2) Introduce the methods of High Throughput Experimentation integrated with instruments of Artificial Intelligence (e. g. Machine Learning, Deep Learning) for the rapid screening of organometallic catalyst formulations and optimization thereof by means of predictive statistical modeling.

PROGRAM

Part 1. Structural models of metallic and ionic crystal surfaces. Nanostructured solids. Controlled-morphology glass supports. Physical and chemical adsorption. Chemical kinetics on surfaces. Fischer-Tropsch catalysis. Ziegler-Natta catalytic polymerization of propene.

Part 2. Introduction to the theory and practice of High Throughput Experimentation (HTE): aims, equipment, applications. Implementation of digital HTE databases. Statistical modeling of HTE data by means of Artificial Intelligence algorithms (e. g. Machine Learning, Deep Learning). Rapid screening and optimization of organometallic catalyst formulations by means of integrated HTE/AI instruments.

TEACHING MODALITIES

Frontal lessons. Hands-on training.

TEACHING MATERIALS

Copies of all lecture slides. Link to relevant hypertexts and scientific publications.

Note: the aforementioned material will be made available for downloading prior to the course opening.

EXAM

The exam is given in form	Written and oral		Written only		Oral only	X

In case of written exams, the tests are	Multiple choice		Open answer		Numeric	

COURSE DESCRIPTION
TRANSPORTATION AND MOBILITY WITH UAS

SSD: TRASPORTI (ICAR/05)

DEGREE PROGRAMME: TRANSPORTATION ENGINEERING AND MOBILITY (P55)
ACADEMIC YEAR 2022/2023

COURSE DESCRIPTION

TEACHER: BIFULCO GENNARO NICOLA
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GENERAL INFORMATION ABOUT THE COURSE

INTEGRATED COURSE: U4955 - UNMANNED AICRAFT SYSTEMS FOR TRANSPORTATION AND MOBILITY
MODULE: U4956 - TRANSPORTATION AND MOBILITY WITH UAS
CHANNEL: FG A-Z
YEAR OF THE DEGREE PROGRAMME: I
PERIOD IN WHICH THE COURSE IS DELIVERED: SEMESTER II
CFU: 3

REQUIRED PRELIMINARY COURSES

None

PREREQUISITES

None

LEARNING GOALS

Unmanned Aircraft Systems (UAS) may in the relatively near future become a new mode of transport to effectively address the delivery of goods and, in the long term, the mobility of people. Consequently, the modelling of UAS is expected to be progressively incorporated into transport and mobility modelling frameworks for both planning and operational purposes.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

Students will understand modelling methods for the assessment of single-mode and intermodal performances of the systems, as well as methods and techniques for simulating the demand for mobility, the supply of transport services, the supply/demand interaction, the economic, territorial, and environmental impacts.

Applying knowledge and understanding

Students will learn how to apply specific methodologies and tools for testing service patterns under technological, functional and economic constraints.

COURSE CONTENT/SYLLABUS

The module will discuss all the issues related to the simulation for planning and operational purposes of UAS services, with specific regard to methodologies and tools for the modelling of UAS supply, demand and demand/supply interaction. Supply will be defined at both the link and the network level. The module will concentrate on the following topics:

1. Supply models: link-level and network-level characterization of UAS;

2. Demand for UAS and demand elasticity with respect to UAS performances;

3. Supply/demand interaction and assessment of impacts and externalities.

READINGS/BIBLIOGRAPHY

Slides, lecture notes, technical papers, regulation documents.

TEACHING METHODS OF THE COURSE (OR MODULE)

Lectures, laboratory activities and exercises. Proposal of practical applications of the concepts learnt through simple exercises.

EXAMINATION/EVALUATION CRITERIA

a) Exam type

- [ ] Written
- [x] Oral
- [ ] Project discussion
- [ ] Other

In case of a written exam, questions refer to

- [ ] Multiple choice answers
- [ ] Open answers
- [ ] Numerical exercises

b) Evaluation pattern

COURSE DESCRIPTION
RESILIENCE OF TRANSPORTATION SYSTEMS

SSD: TRASPORTI (ICAR/05)

DEGREE PROGRAMME: TRANSPORTATION ENGINEERING AND MOBILITY (P55)
ACADEMIC YEAR 2022/2023

COURSE DESCRIPTION

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GENERAL INFORMATION ABOUT THE COURSE

INTEGRATED COURSE: NOT APPLICABLE
MODULE: NOT APPLICABLE
CHANNEL: FG A-Z
YEAR OF THE DEGREE PROGRAMME: I
PERIOD IN WHICH THE COURSE IS DELIVERED: SEMESTER II
CFU: 6

REQUIRED PRELIMINARY COURSES

None

PREREQUISITES

None

LEARNING GOALS

The course deals with the resilience of transport infrastructures. Starting from local aspects due to service stress, ageing deterioration and rare catastrophic events, the effect on networks and broad areas is estimated/forecasted, including the impact in terms of social and economic terms.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

Students gain knowledge about network resilience and understand how the local susceptibility of transport infrastructure propagates through networks. Students apply the acquired knowledge to a case study that explores the effects of failures in transport infrastructure and services.

Applying knowledge and understanding

The acquired knowledge enables students to further understand, also in the working environment, the methodological and operational principles of resilience-based design in modern transport networks. Students will be able to assess the resilience of transportation networks from the point of view of both public authorities and operators of infrastructures.

COURSE CONTENT/SYLLABUS

General Principles Theory of transportation systems applied to transportation resilience.

•local impact

•extended disruption (network impact)

Network re-configuration effects

•Dynamic processes toward a new equilibrium

•Instability

Wide-area KPI (Key Performance Indicators)

•Area-wide accessibility

•Transport times/costs

•Social and economic effects

Practical approaches

•Methods and tools based on traffic assignment matrices.

•Identification of the "strategic" network (transportation infrastructures and services to be preserved)

Laboratory activities and exercises, project development

READINGS/BIBLIOGRAPHY

Slides, lecture notes, technical papers.

TEACHING METHODS OF THE COURSE (OR MODULE)

Lectures, laboratory activities, project development and exercises.

EXAMINATION/EVALUATION CRITERIA

a) Exam type

- ☐ Written
- ☑ Oral
- ☐ Project discussion
- ☐ Other

In case of a written exam, questions refer to

- ☐ Multiple choice answers
- ☐ Open answers
- ☐ Numerical exercises

b) Evaluation pattern

COURSE DESCRIPTION
STRUCTURAL HEALTH MONITORING FOR INFRASTRUCTURES

SSD: TECNICA DELLE COSTRUZIONI (ICAR/09)

DEGREE PROGRAMME: TRANSPORTATION ENGINEERING AND MOBILITY (P55)
ACADEMIC YEAR 2023/2024

COURSE DESCRIPTION

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GENERAL INFORMATION ABOUT THE COURSE

INTEGRATED COURSE: NOT APPLICABLE
MODULE: NOT APPLICABLE
TEACHING LANGUAGE: INGLESE
CHANNEL: FG A-Z
YEAR OF THE DEGREE PROGRAMME: I
PERIOD IN WHICH THE COURSE IS DELIVERED: SEMESTER I
CFU: 9

REQUIRED PRELIMINARY COURSES

None

PREREQUISITES

Basic background on structural engineering (Structures ICAR/09)

LEARNING GOALS

The course aims to provide general knowledge about the structural health monitoring of infrastructures with a particular focus on bridges.The fundaments of the static and dynamic behaviour of bridges, made of various construction materials and static schemes, are necessary to understand the causes of damage and degradation that have to be monitored during the life of the structure.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

The students are required to show that they have acquired the knowledge of methods of structural monitoring of bridges both through the traditional procedures by visual inspections and static measures and also by innovative methods based on dynamic measures and the use of drones or satellites.

Applying knowledge and understanding

Students are required to show the ability to develop numerical applications by experimental data and to approach the identification of degradation phenomena and their causes.

COURSE CONTENT/SYLLABUS

•Introduction to the structural health monitoring of infrastructures
•The approach and the importance of the structural health monitoring
•The structural performance of infrastructures
•Types of bridges
•Classification according the use
•Classification according the static pattern
•Classification according materials
•Structural and not structural elements of highway bridges
•Fundaments of structural behaviour of bridges
•Codes and Guidlines
•Old and new codes for the design of bridges
•Italian Guidlines for monitoring of existing bridges
•International documents
•Deterioration phenomena
•Fundaments of structural behaviour of construction materials
•Types of deterioration phenomena
•Deterioration of RC elements
•Deterioration of PC elements
•Deterioration of steel elements
•Deterioration of support systems
•Deterioration of dilatation joints
•In situ investigation
•The concept of knowledge level
•Tests on materials
•Investigation on the structural details
•Structural health monitoring by inspections
•Visual inspections
•Regularity of inspections
•Defects and evaluation of degradation
•Structural health monitoring by static measures

•The parameters to be measured
•The technique and instruments of measure
•Numerical modeling for damage detection
•Structural health monitoring by dynamic identification
•Fundaments of dynamic behavior of structures
•The technique and instruments of measure
•Numerical modeling for damage detection
•Innovative structural health monitoring systems
•Use of drones
•Setellite application
•Weigth-in-motion systems
•Smart Roads

READINGS/BIBLIOGRAPHY

Slides, lecture notes, technical papers.
Textbooks:
DYNAMICS OF STRUCTURES. RayW. Clough and Joseph Penzien, 1995 University Ave. Berkeley, CA 94704,USA.
DINAMICA DELLE STRUTTURE E INGEGNERIA SISMICA. Iunio Iervolino. 2021. Hoepli editore.
ICE MANUAL OF BRIDGE ENGINEERING, edited by Gerard Parke and Nigel Hewson, second edition 2008.
MAINTENANCE AND SAFETY OF AGING INFRASTRUCTURE, editors Dan M. Frangopol &Yiannis Tsompanakis, CRC Press 2014.

TEACHING METHODS OF THE COURSE (OR MODULE)

Lectures, interactive tutorials, laboratory activities and exercises

EXAMINATION/EVALUATION CRITERIA

a) Exam type

- ☐ Written
- ☑ Oral
- ☐ Project discussion
- ☑ Other : Exercises discussion

In case of a written exam, questions refer to

- ☐ Multiple choice answers
- ☐ Open answers
- ☐ Numerical exercises

b) Evaluation pattern

The evaluation will take account of knowledge and discussion capacity of the student.