Ph.D. PROGRAMMES

DIPARTIMENTO DI INGEGNERIA

UNIVERSITÀ DI PALERMO – CICLO XLI (41°)

OFFERTA FORMATIVA (TERZO LIVELLO)/ DOCTORAL OFFER (THIRD CYCLE)

PHD IN ADVANCES IN STRUCTURE AND INFRASTRUCTURE ENGINEERING (ASIE)

Code	Program Involved	Title of the Course	N° hours	CFU	Lecturer(s)	Brief Synopsis	Tentative period	Language
A1	ASIE	**Corso breve su Elementi di Matlab per l'ingegneria**	12	2	*Prof. Alberto di Matteo (University of Palermo) Contact email: alberto.dimatteo@unipa.it*	Il corso si pone l'obiettivo di introdurre gli elementi basilari della programmazione in linguaggio MATLAB e le sue applicazioni in problemi tipici dell'Ingegneria Civile. La trattazione dei vari argomenti avviene in maniera graduale anche attraverso esempi applicativi. Si parte dalle nozioni elementari sui fondamenti dell'ambiente e del linguaggio MATLAB per pervenire all'uso in applicazioni non banali	April 2026	EN/IT
A2	ASIE	**Elementi di modellazione FEM per la meccanica strutturale mediante il codice open source FEAP.**	28	4	*Prof. Francesco Parrinello (University of Palermo) Contact email: francesco.parrinello@unipa.it*	FEAP è un codice di calcolo open source agli elementi finiti che opera in campo lineare e non-lineare per la risoluzione di numerose applicazioni nell'ambito dell'ingegneria civile, meccanica, e dei materiali. Il corso è orientato sull'utilizzo del software per la risoluzione per via numerica di applicazioni riguardanti la meccanica strutturale, con particolare riferimento a: • Tecniche di modellazione e analisi lineare e non lineare. • Modellazione e implementazione di nuovi modelli costitutivi,. • Elementi finiti misti e ibridi. • Analisi di problemi di contatto. • Sviluppo e modellazione di elementi nuovi elementi finiti. Il corso, composto da 7 lezioni di 4 ore, verrà svolto in modo interattivo con i partecipanti, al fine di renderlo particolarmente efficace e	Febraury 2026	EN/IT

						fruibile per i nuovi utenti, oltre che significativamente produttivo per utenti con conoscenze base precedentemente acquisite.		
A3	ASIE	**Analisi non lineare per l'ingegneria sismica e introduzione a OpenSees / Nonlinear analysis for Earthquake Engineering and Introduction to OpenSees**	16	31	*Prof. Fabio Di Trapani (University of Palermo) Contact email: fabio.ditrapani@unipa.it*	Il corso prevede l'introduzione agli approcci di modellazione non lineare di strutture intelaiate con particolare riferimento all'ambito sismico. Sono approfondite anche le tipologie di analisi nonlineare quasi statica (monotonica e ciclica) e dinamica e la relativa modellazione non lineare a plasticità concentrata e a plasticità distribuita (elementi force-based e displacement-based). Il corso prevede l'introduzione all'uso di OpenSees con implementazione pratica delle tematiche affrontate / The course provides an introduction to nonlinear modeling approaches for framed structures, with a particular focus on seismic applications. It also covers in depth the types of nonlinear analysis, both quasi-static (monotonic and cyclic) and dynamic, along with the corresponding nonlinear modeling using concentrated and distributed plasticity (force-based and displacement-based elements). The course also introduces the use of OpenSees, with practical implementation of the topics covered.	March 2026	EN/IT
A4	ASIE	**Uso di FRCM nel rinforzo strutturale delle murature**	8	1	*Dr. Jennifer D'Anna (University of Palermo) Contact email: jennifer.danna@unipa.it*	Il corso si propone di fornire un quadro completo e aggiornato sull'impiego dei materiali compositi FRCM (Fabric-Reinforced Cementitious Matrix) per il rinforzo strutturale delle murature, con particolare attenzione agli aspetti tecnici, normativi e applicativi. Durante il corso verranno analizzati i principi teorici alla base del comportamento meccanico dei materiali FRCM, le caratteristiche dei componenti (reti in fibra, matrici inorganiche) e i criteri di progettazione secondo le normative vigenti, tra cui le linee guida del CNR e il quadro normativo europeo. Verranno inoltre trattati casi studio e prove sperimentali, al fine di analizzare i vantaggi offerti dai sistemi FRCM in termini di efficacia, compatibilità e durabilità, nonché le principali criticità	December 2025	EN/IT

						dell'applicazione di questi sistemi su murature portanti		
A5	ASIE	**The transition from linear to circular economy. A new approach to manage resources and process in the civil engineering**	8	1	*Prof. Gaetano Di Mino (University of Palermo) Contact email: gaetano.dimino@unipa.it*	Il Corso è finalizzato a fornire un percorso formativo rivolto prevalentemente al management delle costruzioni oggi più direttamente coinvolte nella Transizione Ecologica, con particolare riferimento a una gestione innovativa dei flussi di materia e dei rifiuti. Il Corso offre una strumentazione concettuale e tecnica mirata alla trasformazione dei modelli organizzativi ed economici delle imprese di costruzioni, nonché all'adozione di procedure idonee, anche alla luce delle nuove norme introdotte attraverso il recepimento delle recenti direttive europee sull'argomento.	February 2026	EN/IT
A6	ASIE	**Vulnerabilità sismica e tecniche di intervento**	8	1	*Prof. Piero Colajanni (University of Palermo) Contact email: piero.colajanni @unipa.it*	Il corso si propone di analizzare le più recenti tecniche di valutazione della vulnerabilità sismica di strutture intelaiate, evidenziando i pregi e limiti delle tecniche in campo lineare e non lineare, alla analisi modale con spettro di risposta e l'analisi statica non lineare, con particolare riferimento alle indicazioni contenute nella ultima versione del Eurocodice 8 di prossima emanazione. Verranno poi forniti metodi di progetto avanzati per la riduzione della vulnerabilità sismica di telai inc.a. mediante l'impiego di controventi dissipativi per isteresi	January 2026	EN/IT
A7	ASIE	**Modern strategies of seismic vulnerability mitigation and seismic design of structures**	8	1	*Prof. Liborio Cavaleri (University of Palermo) Contact email: liborio. cavaleri@unipa.it*	Short course on modern strategies of seismic vulnerability mitigation and seismic design of structures	November 2026	EN/IT
A8	ASIE	**Introduzione al Machine Learning & Soft Computing per l'Ingegneria Strutturale / Introduction to Machine Learning & Soft Computing for Structure engineering.**	12	2	*Prof. Giuseppe Quaranta (Università La Sapienza di Roma) giuseppe.quaranta@uniroma1.it*	Il corso prevede l'introduzione ai metodi di Machine Learning e Soft Computing con applicazioni specifiche all'ingegneria strutturale. Vengono presentati i principali algoritmi di apprendimento supervisionato e non supervisionato, con particolare attenzione alle reti neurali, agli alberi decisionali e ai metodi ensemble. Sono inoltre introdotte le tecniche di soft computing per l'ottimizzazione strutturale con particolare riferimento algoritmi metaeuristici evolutivi. Il corso prevede inoltre l'introduzione all'uso di ambienti di calcolo scientifico come Python e librerie specifiche	June 2026	EN/IT

						(scikit-learn, TensorFlow) con implementazione pratica delle tematiche affrontate su dataset reali e simulati / The course provides an introduction to Machine Learning and Soft Computing methods with specific applications to Structure engineering. It presents the main supervised and unsupervised learning algorithms, with particular focus on neural networks, decision trees, and ensemble methods. Soft computing techniques for Structure optimization are also introduced, with particular emphasis on evolutionary and metaheuristic algorithms. The course includes an introduction to scientific computing environments such as Python and major libraries (scikit-learn, TensorFlow), with practical implementation of the topics covered using real and simulated datasets.		
A9	ASIE	**Introduction to the Use of OpenSeesPy for Structure Analysis**	8	1	*Ing. Concetta Oddo* *(University of Palermo)* *Contact email:* *concetta.oddo@unipa.it*	This course provides a fundamental conceptual foundation for understanding and applying the scripting workflow involved in Structure analysis using OpenSeesPy. The course introduces essential Python syntax relevant to Structure modeling and guides participants through the key steps involved in defining and analyzing Structure models. Participants will then explore Structure analysis procedures, including static analysis, as well as eigenvalue and modal The course further covers non linear dynamic time history analysis	February 2026	EN/IT
A10	ASIE	**Processi Chemo-Meccanici in mezzi porosi/Chemo-Mechanical Processes in Porous Media**	12	2	*Angelica Tuttolomondo* *(Politecnico di Losanna)* *Contact email:* *angelica.tuttolomondo@epfl.ch*	The course provides an introduction to chemo-mechanical processes in porous media, with a focus on their relevance in civil and environmental engineering applications. It begins with an overview of real-world problems where these coupled processes play a critical role, followed by the fundamental principles governing chemo-mechanical behavior in porous materials. The course continues with specific examples in the field of geomechanics, with particular emphasis on the chemo-mechanics of active clays. The theoretical background is complemented by illustrative examples and includes some of	January 2026	EN/IT

						the most recent scientific advances in the field.		
A11	ASIE	**Elements of Classical Plasticity Theory**	12	2	*Prof. Guido Borino (University of Palermo) Contact email: guido.borinoino@unipa.it*	The short course is aimed to provide a clear conceptual foundation of the nonlinear constitutive behavior of Structure materials. In particular the physical phenomena of yield stress, flow plastic strains, strain hardening, plastic dissipation and irreversibility will be rooted in the concept framework of nonlinear solid mechanics and thermodynamics of irreversible processes. The theory will also applied for the analysis structure in plane stress and for bending beams and frames. Nonlinear elastic plastic Structure analysis and limit state theorems will be proved and analytically applied to simple elastic-plastic structures. Finally few elements of computational Plasticity.	February 2027	EN/IT
A12	ASIE	**Tecniche di valutazione dell'affidabilità e del rischio sismico delle strutture / Methos for Structure realiability and sesimic risk assessment**	12	2	*Dr. Antonio Pio Sberna (Politecnico di Torino) Contact email: antonio.sberna@polito.it ·*	Il corso introduce i principali strumenti teorici e applicativi per la valutazione dell'affidabilità sismica delle strutture civili. Vengono introdotti i fondamenti di probabilità applicata all'ingegneria, i metodi di analisi dell'incertezza, le tecniche di selezione condizionata degli accelerogrammi e le principali metodologie probabilistiche per la valutazione della risposta strutturale (Cloud Analysis, Incremental Dynamic Analysis, Multiple Stripe Analysis). Vengono inoltre approfondite le misure di intensità (IM) e di risposta strutturale (EDP), insieme ai modelli per l'analisi del rischio sismico. Il corso prevede esercitazioni pratiche in relazione agli argomenti trattati. The course introduces the main theoretical and practical tools for the assessment of seismic reliability of civil structures. It covers the fundamentals of probability applied to engineering, methods for uncertainty analysis, ground motion selection techniques, and the most common probabilistic methodologies for Structure response evaluation (Cloud Analysis, Incremental Dynamic Analysis, Multiple Stripe Analysis). Further topics include intensity measures (IM), engineering demand parameters (EDP), and seismic risk models.	November 2026	EN/IT

						Practical exercises are provided to support the application of the covered topics.		
A13	ASIE	**Nonlinear Porous media mechanics as a basis for a wide class of multiphysics problems**	8	1	*Prof. Guido Borino* *(University of Palermo)* *Contact email: guido.borino@unipa.it*	The short course is aimed to provide a nonlinear poroelastic framework for quasi-static mechanical behavior of fluid satured porous continua. Poroelasticity problems are characterized by a coupling of fluid mass flow and elastic solid matrix deformation. The formulation, developed in a Thermodynamics consistent setting, is relevant to many classical and emerging applications. Some of the most common applications regards Geomechanics, Biomechanics and Chemomechanics problems . The course is focused on the theoretical aspects which are routed to the classical Biot's poroelastic theory. The Boundary Value Problem will be proposed in small strain as well as for finite strain Poro-Hyperelasticity.	December 2025	EN/IT
A14	ASIE	**Theory of linear viscoelasticity applied to concrete structures**	8	1	*Prof. Michele Fabio Granata* *(University of Palermo)* *Contact email: michelefabio.granata@unipa.it*	The brief course will provide the fundamental principles of linear viscoelastic theory as applied to concrete structures, along with its effects on statically indeterminate structures such as reinforced and prestressed concrete bridges. In particular, the course will delve into creep models recommended in the literature, the influence of viscoelastic behaviour on the Structure response of large structures such as tall buildings and bridges, considering prestressing losses and staged construction. Il corso breve fornirà i principi fondamentali della teoria della viscoelasticità lineare nel calcestruzzo e gli effetti sulle strutture a schema variato come i ponti in calcestruzzo armato e precompresso. In particolare, si approfondiranno i modelli di viscosità raccomandati in letteratura, l'influenza sul comportamento strutturale delle grandi strutture come edifici alti e ponti, le cadute di precompressione e le fasi costruttive.	April 2026	EN/IT
A15	ASIE	**Building your reputation through research products: Planning, Drafting, Revising, Publishing and**	8	1	*Prof. Davide Lo Presti* *(University of Palermo)* *Contact email: davide.lopresti@unipa.it*	Il corso di scrittura creativa introduce i dottorandi/e alle questioni connesse all'impostazione di un articolo scientifico, alla sua organizzazione in paragrafi, alla presentazione e alla discussione dei risultati	May 2026	EN/IT

		Disseminating your scientific papers				in relazione alle domande aperte che letteratura tecnico scientifica presenta in relazione al problema di ricerca descritto e affrontato		
A16	ASIE	**Introduction to Python for scientific computing**	12	2	*Prof. Emma la Malfa Ribolla (University of Palermo) Contact email: emma.lamalfaribolla@unipa.it*	Il corso introduce all'organizzazione, elaborazione e gestione di ampi volumi di dati. Sarà possibile apprendere i principi di base del linguaggio di Programmazione Python, uno dei linguaggi più diffusi per l'analisi dei dati. Saranno altresì approfondite le ultime tecnologie per la Big Data Analytics con Python, linguaggio multiparadigma ricco di librerie e facilmente integrabile nei sistemi reali. Gli argomenti includono: i tipi di dato in Python e le operazioni e i metodi di conversione, gli algoritmi e i diagrammi di flusso, le istruzioni per il controllo del flusso, input dati, gestione delle errori, cicli while e for, funzioni, variabili globali e locali, i moduli della Standard Library.	June 2026	EN/IT
A17	ASIE	**"GIS- based Analysis"**	8	1	*Gabriele D'Orso (University of Palermo) Contact email: gabriele.dorso@unipa.it*	L'obiettivo del corso è quello di presentare agli allievi uno strumento versatile ed utilizzabile per effettuare analisi spaziali inerenti ai diversi campi dell'ingegneria civile. Per le analisi si utilizzerà un software GIS open-source, QGIS. Attraverso la presentazione di casi studio, verranno fornite ai partecipanti del corso breve delle conoscenze su tale software, evidenziandone le potenzialità e i limiti come mezzo di supporto alle decisioni nei processi progettuali e pianificatori.	February 2026	IT/EN
A18	ASIE	**Nonconservative problems of dynamic stability**	12	2	*Prof. Massimiliano Zingales (University of Palermo) Contact email: massimiliano.zingales@unipa.it*	The short course is aimed to provide an analytical approach to the stability of non-conservative mechanical / Structure systems. In more details the basic concept of Eulerian stability will be framed in the context of Lagrangian Mechanics and Liapunov functionals. Basic non-conservative problems as discrete and continuum Leipholtz columns in presence of Rayleigh dissipation will be discussed. Additional problems involving anomalous memory dissipation will be also considered in the context of extended Lagrangian and Hamiltonian functionals.	July 2026	EN/IT

A19	ASIE	**Virtual Experiments: Why?**	8	1	*Prof. Antonina Pirrotta* *Dr. Salvatore Russotto* *(University of Palermo)* *Contact email:* antonina.pirrotta@unipa.it *Contact* *emailsalvatore.russotto@unipa.it*	Modeling and simulation are becoming increasingly important enablers for the analysis and design of complex systems. The connection between mathematics and reality is just experimental tests. The latter makes the difference between mathematical method and scientific method, that is experimental tests for validation is an important step of the scientific method. The scientific community generally agrees on the following classification of method components: •Characterizations; •Hypotheses; •Predictions; •Experiments. Then experiments are as important as theoretical formulation. Once predictions are made, they can be sought by experiments. The purpose of an experiment is to determine whether observations of the real world agree with or conflict with the predictions derived from an hypothesis. If they agree, confidence in the hypothesis increases; otherwise, it decreases. It is not easy to perform experiments especially for validating theory. Experiments should be designed to minimize possible errors, through the use of appropriate scientific controls. Furthermore, failure of an experiment does not necessarily mean the hypothesis is false. Experiments always depend on several hypotheses, e.g., that the test equipment is working properly, and a failure may be a failure of one of the auxiliary hypotheses. However, perform experimental tests is time and money consuming then one needs a mathematical model consistent with reality in such a way that mathematical model and simulation may can be considered as a virtual test. In application domains such as Structure design, automotive design, mechanical design, vibration control, biomechanics, the notion of a virtual experiment is a valuable tool for checking and optimizing extensively the complex designs before a realization is ever made. This "doing it right the first time" leads to tremendous cost savings and improved quality.	March 2026	EN/IT

						To aim at this, it is compulsory introducing mathematical formulation binding the real behavior. Once this theoretical formulation is reliable having confirmed experimental tests, then one can realize virtual experimental results.		
A20	ASIE	**Innovative materials for shear and flexural strenghtening of masonry Structure members**	12	2	*Prof. Lidia La Mendola (University of Palermo) Contact email: lidia.lamendola@unipa.it*	The short course is addressed to examine the innovative materials, as FRP, FRCM, TRM, CRM, etc used as reinforcement of the Structure elements in reinforced concrete and in masonry existing constructions. Starting from the study of the interface behavior, useful to understand the transmission of stresses between reinforcement and reinforced element, it will be presented the effectiveness in: - the flexural and shear reinforcement in r.c. beams; - the flexural and shear reinforcement in r.c. columns, the axial confinement; - the flexural and shear reinforcement in plane for masonry panels; - the flexural reinforcement out-of-plain in masonry panels; - the reinforcement in masonry arches and vaults. All the applications will be treated also with reference to the Eurocodes and specifical technical codes.	February 2027	EN/IT
A21	ASIE	**I modelli di micro-simulazione del traffico in Aimsun Next**	8	12	*Dr. Maria Luisa Tumminello (University of Palermo) Contact email: marialuisa.tumminello01@unipa.it*	I modelli di micro-simulazione del traffico rappresentano uno strumento utile e sempre più efficace per l'analisi delle condizioni operative e di sicurezza delle infrastrutture per la mobilità e i trasporti, non soltanto a livello puntuale ma anche di un'intera rete. Tali modelli, sviluppati con appositi software, Aimsun Next nel caso specifico, consentono ai progettisti di poter valutare un intervento stradale, sotto diversi profili, quali operatività, sicurezza etc.. prima ancora che esso venga realizzato. Pertanto, i modelli di micro-simulazione consentono valutazioni di interventi e risoluzioni di problematiche di interesse non soltanto dell'ingegneria civile ma anche di quella ambientale e dei materiali.	January 2027	EN/IT

A22	ASIE	**Modellazione agli elementi finiti di opere e sistemi geotecnici**	12	2	*Dr. Marco Rosone* *(University of Palermo)* *Contact email: marco.rosone@unipa.it*	L'obiettivo di questo corso è introdurre uno strumento di calcolo, illustrandone le potenzialità e i limiti nell'ambito della modellazione agli elementi finiti. Verranno fornite ai partecipanti conoscenze di base sulle strategie di modellazione applicabili tramite codici di calcolo commerciali, utili per condurre analisi di stabilità e deformazione finalizzate alla previsione del comportamento di opere e sistemi geotecnici.	November 2026	EN/IT
A23	ASIE	**Il ruolo del modello geotecnico di sottosuolo per la progettazione di opere di ingegneria civile.**	8	1	*Prof. Maurizio Ziccarelli* *(University of Palermo)* *Contact email:* *maurizio.ziccarelli@unipa.it*	Indagini finalizzate alla costruzione del modello geotecnico di sottosuolo; criteri per la definizione di un piano di indagini geotecniche; strumentazione per la misurazione di alcune grandezza fondamentali (spostamenti, pressioni interstiziali, pressioni totali, etc.); caratterizzazione meccanica del volume geotecnicamente significativo; criteri di scelta dei parametri geotecnici caratteristici e di progetto; adattamento del piano delle indagini in funzione delle informazioni man mano acquisite; importanza dei dettagli di costituzione del sottosuolo sulla stabilità di fondazioni superficiali e pendii; illustrazione di casi reali	February 2027	EN/IT
A24	ASIE	**Sicurezza strutturale di elementi in c.a. e c.a.p soggetti a degrado**	8	1	*Prof. Giuseppe Campione* *(University of Palermo)* *Contact email:* *valentina.giuseppe.campione@unipa.it*	L'oggetto del corso è quello di fornire strumenti semplici e speditivi,che nello spirito delle norme tecniche in vigore in Italia, consentano di verificare elementi in cemento armato ordinario e precompresso soggetti a corrosione delle barre d'armatura. Si propongono delle espressioni analitiche per tenere conto della riduzione di area di ferro, della tensione di snervamento e della duttilità delle barre d'armatura, oltre che della perdita di aderenza. Tali espressioni sono quindi introdotte nelle equazioni di verifica a flessione e taglio e pressoflessione di elementi monodimensionali in cemento armato ordinario e precompresso e sono validate sulla base dei risultati sperimentali disponibili in letteratura.	December 2026	EN/IT

PHD IN Chemical, Environmental, Biomedical, Hydraulic and Materials Engineering (CEBHyME)

Code	Program Involved	Title of the Course	N° hours	CFU	Lecturer(s)	Brief Synopsis	Tentative period	Language
C1	CEBHyME	**Preparation and characterization of (bio)polymer-based micro- and nanostructured systems**	18		*Prof. Roberto Scaffaro* *Dr. Emmanuel Fortunato Gulino* *(University of Palermo)* *Contact email:* *roberto.scaffaro@unipa.it* *emmanuelfortunato.gulino@unipa.it*	L'obiettivo del corso è fornire una conoscenza di base sugli ultimi progressi nel campo dei sistemi micro e nanostrutturati basati su (bio)polimeri. Recentemente, la scienza e la tecnologia dei micro/nano-compositi a base di (bio)polimeri sta emergendo come uno degli ambiti di ricerca di maggior impatto, soprattutto a causa della crescente domanda di materiali avanzati. Verranno quindi introdotti e discussi i principali metodi di fabbricazione e caratterizzazione dei materiali compositi, insieme alla costruzione di una mappa generica delle relazioni processo-struttura-proprietà, utile per progettare materiali multifunzionali per applicazioni avanzate, tra cui trattamento acqua/aria, sensori , biomedicina, somministrazione di farmaci, accumulo/conversione di energia.	February 2026	EN
C2	CEBHyME	**Nanoscience & nanomaterials: pushing the boundaries of technology**	8		*Prof. Clelia Dispenza* *Dr. Emanuela Muscolino* *(University of Palermo)* *Contact email: clelia.dispenza@unipa.it*	Il corso mira a fornire un'introduzione alle nanoscienze e alle nanotecnologie, spiegando perché i materiali ridotti alla nanoscala possono improvvisamente mostrare proprietà molto diverse rispetto a ciò che mostrano su una macroscala, comprendendo alcuni sviluppi attuali e sfide non affrontate. La partecipazione a questo corso frantuma il termine monolitico "nanotecnologia" nella miriade di sfaccettature che è in realtà.	February – March 2026	EN
C3	CEBHyME	**Critical issues and new perspectives in environmental remediation technologies**	10		*Prof. Michele Torregrossa* *Prof. Giorgio Mannina* *Prof. Alida Cosenza* *Prof. Santo Fabio Corsino* *Prof. Daniele Di Trapani* *(University of Palermo)* *Contact email:* *michele.torregrossa@unipa.it* *santofabio.corsino@unipa.it*	Il corso presenta le principali criticità emerse negli ultimi anni nell'ambito delle tecnologie consolidate per la tutela ambientale e le nuove proposte che possono essere attuate per garantire il raggiungimento di obiettivi di recupero ecosostenibile.	July 2026	EN

C4	CEBHyME	**Peculiar hydro-morphodynamic processes in rivers**	8		*Prof. Donatella Termini* *(University of Palermo)* *Contact email:* *donatella.termini@unipa.it*	Lo scopo del corso è quello di fornire le informazioni di base per comprendere i principali processi di evoluzione nei fiumi naturali. L'evoluzione morfologica del fiume avviene a seguito di processi di "adattamento spontaneo" che si verificano a causa di azioni naturali (come quelle indotte dai cambiamenti climatici) e/o di origine antropica. Nei fiumi si possono generare forme diverse e complesse a seconda delle caratteristiche cinematiche del flusso e dei fenomeni di erosione/deposizione indotti. I diversi scenari che si presentano durante i processi evolutivi influenzano fortemente l'habitat del sistema fluviale e le aree limitrofe.	July 2026	EN
C5	CEBHyME	**New hydropower systems and applications**	8		*Prof. Tullio Tucciarelli* *(University of Palermo)* *Contact email:* *tullio.tucciarelli@unipa.it*	New paradigms in water and energy management make energy management more and more connected to the water management in dams, as well as in transport and distribution pipe networks (water-energy nexus). In the course inter-disciplinary basis will be provided for the knowledge of the emerging design methodologies in the field of hydraulic plants including pumps and turbines. The following topics will be covered: Kinematics and dynamics of rotomachinery, Eulero theorem. Overview of turbine and pump types. Electric management of pumps and turbines. Guide-vanes and regulation systems in turbines. Hydropower production with Pump As Turbines (PATs) Hydropower production and hydraulic regulation in pipes with turbines Cross-Flow and PRS turbine design Similarity theory for pumps and turbines Inverter design for pumps	July 2026	EN
C6	CEBHyME	**Salinity Gradient Power: Fundamentals, main technologies and applications**	8		*Prof. Alessandro Tamburini* *Prof. Giorgio Micale* *Prof. Andrea Cipollina* *(University of Palermo)* *Contact email:* *alessandro.tamburini@unipa.it*	L'obiettivo del corso è quello di consentire ai dottorandi di avere un primo contatto con questa nuova forma di energia rinnovabile e le relative tecnologie. Più precisamente, le lezioni saranno suddivise in tre argomenti principali: (i) Fondamenti di Salinity Gradient Power, (ii) principali tecnologie SGP con focus sull'elettrodialisi inversa, (iii) applicazioni e	July 2026	EN

						prospettive. Il corso aiuterà gli studenti ad apprendere la termodinamica oltre l'SGP e i fondamenti delle tecnologie in grado di sfruttarlo, a padroneggiare le basi dei fenomeni di trasporto rilevanti e a fare semplici calcoli per stimare l'energia teorica disponibile in uno scenario specifico e le quantità effettivamente recuperabili.		
C7	CEBHyME	**Neural Network for Machine Learning: Introduction to Artificial Neural Network, design and implementation in Matlab**	8		*Prof. Dario Pumo* *(University of Palermo)* *Contact email: dario.pumo@unipa.it*	La rete neurale artificiale (ANN) è una branca dell'intelligenza artificiale che cerca di imitare la capacità del cervello umano di elaborare rapidamente le informazioni in entrata in modo semplificato e di imparare dall'esperienza. In particolare, le ANN sono sistemi di calcolo di ispirazione biologica, che svolgono vari compiti (ad es. elaborazione del segnale, riconoscimento di modelli, regressione, classificazione, raggruppamento, previsione, ecc.). Le ANN sono modelli basati sui dati non lineari maturi, flessibili e potenti che sono stati applicati con successo per risolvere compiti complessi nel campo della scienza e dell'ingegneria. Lo scopo del corso è fornire le basi per la progettazione e l'implementazione di ANN (utilizzando il software MATLAB), mostrando le potenzialità ei vantaggi di questo approccio di modellazione.	July 2026	EN
C8	CEBHyME	**Combined processing for the preparation of biopolymeric porous structures for biomedical applications**	18		*Dr. Elisa Capuana* *(University of Palermo)* *Contact email: elisa.capuana@unipa.it*	Il corso introduce ai biopolimeri porosi, che stanno ricevendo un crescente interesse in diversi campi tecnologicamente avanzati, compresi i dispositivi biomedici. In questo contesto, l'ingegneria dei tessuti dell'interfaccia (ITE) è un campo in rapido sviluppo che mira alla produzione di dispositivi progettati per riparare o rigenerare zone malate o danneggiate all'interfaccia di diversi tipi di tessuto. Il corso illustrerà lo sviluppo dei dispositivi porosi bio-ispirati su misura con proprietà meccaniche simili ai tessuti naturali combinando diversi approcci di elaborazione.	February 2026	EN
C9	CEBHyME	**Theory and practice of electrochemical impedance spectroscopy**	10		*Prof. Monica Santamaria* *Prof. Francesco Di Franco* *Dr. Andrea Zaffora* *(University of Palermo)*	Il corso introdurrà la spettroscopia di impedenza elettrochimica (EIS) e la sua applicazione allo studio dei processi elettrochimici e non. Verranno discussi i dettagli relativi al metodo corretto di	July 2026	EN

					Contact email: monica.santamaria@unipa.it	acquisizione e analisi dei dati. Di seguito i contenuti principali: 1) Background (Variabili complesse, Equazioni differenziali, Statistica, Circuiti elettrici, Elettrochimica); 2) Considerazioni sperimentali (Strumentazione Elettrochimica, Disegno Sperimentale); 3) Modelli di processo (analoghi di circuiti equivalenti, modelli cinetici, impedenza di diffusione, dispersione a tempo costante, funzioni di trasferimento generalizzate). Il corso prevede sia lezioni frontali che sessioni numeriche e pratiche.		
C10	CEBHyME	**Sensor and Biosensors**	8		*Prof. Rosalinda Inguanta* *Dr. Bernardo Patella* *(University of Palermo)* *Contact email: rosalinda.inguanta@unipa.it*	Lo scopo di questo breve corso è fornire le nozioni di base per comprendere i principi di funzionamento delle principali tipologie di sensori e dare uno sguardo allo sviluppo della ricerca in questo settore. Verranno inoltre presentati e discussi casi di studio su sensori per l'analisi degli alimenti, per l'analisi degli inquinanti ambientali (nelle acque, nei suoli) e per l'identificazione di biomarcatori utili alla diagnosi precoce di malattie specifiche, come ad esempio malattie neurodegenerative e respiratorie. Sei ore saranno dedicate alla didattica frontale e due ore saranno di attività pratica in laboratorio su apposito sensore.	June 2026	EN
C11	CEBHyME	**Water depollution by Advanced Oxidation Technologies**	10		*Prof. Vittorio Loddo* *(University of Palermo)* *Contact email: vittorio.loddo@unipa.it*	Il corso presenta i trattamenti delle acque mediante processi di ossidazione avanzati (AOP) basati su reazioni chimiche e fotochimiche. Vengono descritti i processi più utilizzati e per ciascuno di essi verranno analizzati i principali meccanismi di reazione, principi, vantaggi, svantaggi, prestazioni, formazione di sottoprodotti, accoppiamento con altre tecnologie e applicazioni al disinquinamento delle acque e delle acque reflue riportandone i principali risultati di studi pubblicati nella letteratura di riferimento.	July 2026	EN
C12	CEBHyME	**Degradation and stabilization of polymers, biopolymers and composites towards sustainability and materials circularity**	8		*Prof. Nadka Tz. Dintcheva* *Dr. Giulia Infurna* *(University of Palermo)* *Contact email: nadka.dintcheva@unipa.it*	The module provides basic knowledge on natural ageing, controlled degradation and stabilisation of polymers, biopolymers and composites for sustainable applications such as green composites, biomedical devices and photovoltaic modules. It attempts to provide points for reflection on the importance of	February 2026	EN

						understanding degradation, which is directly related to the failure of polymers, biopolymers and composites in service conditions. It also briefly discusses the application of a controlled degradation strategy to solve the negative environmental impact of polymers, biopolymers and composites and to implement an integrated circular approach for material recovery.		
C13	CEBHyME	**Polymeric materials and resource efficiency**	10		*Prof. Giada Lo Re* *(Chalmers University of Technology – Sweden)* *Contact email: giadal@chalmers.se*	Premessa e obiettivo: è in corso una forte discussione sullo sviluppo ecologicamente sostenibile, che influenza fondamentalmente tutte le attività della società odierna e che si prevede continuerà nel prossimo futuro. Una parte importante e fondamentale dello sviluppo sostenibile sembra essere l'impegno a fare un uso corretto e deliberato delle risorse disponibili, ad esempio combinando il riutilizzo dei prodotti, il riciclo dei materiali e il recupero dell'energia. In questo ambito, i materiali polimerici hanno un ruolo importante da svolgere, ad esempio per quanto riguarda la riduzione dell'uso di plastiche sintetiche e la loro sostituzione con bioplastiche, l'aumento e il miglioramento dei mezzi per il riciclaggio delle plastiche senza perdere le proprietà funzionali dei materiali e la promozione del riutilizzo multiplo dei prodotti in plastica. I limiti di tutte queste ambizioni possono essere discussi da una prospettiva scientifica.	Apr-Jun 2026	EN
C14	CEBHyME	**Organ-on-Chip: a potential alternative to traditional animal testing**	8		*Prof. Francesco Lopresti* *(University of Palermo)* *Contact email: francesco.lopresti@unipa.it*	Otto candidati farmaci su nove che entrano nella fase di sperimentazione clinica falliscono, principalmente a causa della scarsa sicurezza ed efficacia. Questo è dovuto al basso valore predittivo dei modelli animali utilizzati nello sviluppo dei farmaci. Sebbene esistano metodi tradizionali di analisi in vitro, questi non offrono la complessità necessaria per imitare i processi fisiologici olistici che si verificano nel corpo umano, in particolare le interazioni organo-organo. Pertanto, sono necessari metodi predittivi più avanzati per studiare l'efficacia dei farmaci nella fase preclinica. I recenti sviluppi nei modelli dinamici Organ-on-Chip (OoC) sono molto promettenti. Un OoC si basa sullo sviluppo di	February 2026	EN

						una coltura di uno o più sistemi cellulari in una piccola camera o bioreattore irrorato con un flusso laminare di terreni di coltura, in grado di fornire livelli adeguati di nutrienti e di stress di taglio. Questo corso breve offre una panoramica dei sistemi disponibili e viene discusso il difficile percorso verso un sistema pienamente convalidato.		
C15	CEBHyME	**Green hydrogen production, storage and end uses across the energy system**	9		*Prof. Rosalinda Inguanta* *Dr. Roberto Luigi Oliveri* *(University of Palermo)* *Contact email:* *rosalinda.inguanta@unipa.it*	Scopo del corso è di fornire le informazioni di base sui metodi di produzione di idrogeno, con particolare attenzione all'idrogeno verde, e sui principali metodi di storage. Saranno inoltre discussi alcuni casi studio di microgrid e isole energetiche con accoppiamenti fonti rinnovabili-idrogeno. Il corso sarà suddiviso in tre sessioni: due (6 ore) di didattica frontale e una (3 ore) di attività pratica in laboratorio.	June 2026	EN
C16	CEBHyME	**Microalgal biotechnology: from reactor design to industrial applications**	6		*Dr. Serena Lima* *(University of Palermo)* *Contact email: serena.lima@unipa.it*	Le microalghe sono microorganismi fotosintetici di grande interesse processistico. Esse sono in grado di crescere rapidamente fissando la CO_2 e di produrre un'ampia gamma di composti ad alto valore aggiunto che sono ampiamente sfruttati nell'industria cosmetica, nutraceutica e alimentare. Inoltre, la biomassa microalgale presenta alti contenuti di oli che possono essere sfruttati come combustibile. L'obiettivo del Corso è di fornire una visione approfondita delle possibili applicazioni della biomassa microalgale affrontandone la diversità, le potenzialità di sfruttamento e le modalità di coltivazione. Inoltre, ci si soffermerà sul reactor design e su specifici esempi di processi che interessano le microalghe.	March 2026	EN
C17	CEBHyME	**Project Planning**	8		*Prof. Gianluca Li Puma* *(University of Palermo)* *Contact email:* *gianluca.lipuma@unipa.it*	This short module gives the basic elements on how to design a project including: Project network diagram; Critical path analysis; Project flexibility using floats and slacks; Resource loading histogram; Project uncertainty; Minimum cost of Expediting; and Overall project optimisation.	March 2026	EN
C18	CEBHyME	**Preparation and submission of a manuscript to a high impact journal**	6		*Prof. Gianluca Li Puma* *(University of Palermo)* *Contact email:* *gianluca.lipuma@unipa.it*	This short module gives key skills on the preparation of high-quality manuscripts for publication in high-impact, international peer-review journals, including: How to structure and write an impactful research article, the Title, an effective and succinct Abstract, how	March 2026	EN

						to structure the Introduction, the Material and Methods, the Results and Discussion, the Conclusions and the References sections. It also comprises the article submission procedure, the peer-review process and post publication tips to increase the visibility and impact of the published article.		
C19	CEBHyME	**Cardiac Mechanics and Implants**	20		*Prof. Gaetano Burriesci* *(University of Palermo)* *Contact email:* *gaetano.burriesci@unipa.it*	The course provides an introduction to fluid mechanics and its application to physiological models, to the rheological properties of blood, and an insight of the cardiovascular system and its modelling. The interaction between physiological flows and artificial systems will also be analysed, identifying the most important parameters to control in the design of medical devices. Applications to cardiovascular implantable devices such as artificial heart valves are examined. Emphasis will be placed on a physical rather than mathematical understanding of the relevant phenomena, to allow a realistic appraisal of flow dynamics in the body. By the end of the module students will have a sound knowledge and understanding of fluid dynamics in physiological systems, and the interaction between physiological flows and medical devices.	Apr-May 2026	EN
C20	CEBHyME	**Thermodynamics and kinetics of photoelectrochemical processes**	12		*Prof. Monica Santamaria* *Prof. Francesco Di Franco* *Prof. Marianna Bellardita* *Dr. Andrea Zaffora* *(University of Palermo)* *Contact email:* *monica.santamaria@unipa.it*	Photo-electrochemical technologies are promising solutions for solar fuel (e.g. hydrogen) production and involve a large number of physical and chemical phenomena. We provide an overview of chemical phenomena including photo-induced electron transfer, charge separation, recombination, equilibrium reactions between species in solutions and adsorption reactions. On the other hand, we focus on the transport of photocarriers in semiconductors as well as of both non-ionic and ionic species in solution. In this respect, we critically review macroscale continuum models for transport phenomena combined with kinetic descriptions including their possible coupling with models at even lower scales. A special attention will be paid to the case of water photo-splitting for green hydrogen production.	July 2026	EN

C21	CEBHyME	**Electrochemistry for the environmental sustainability.**	9		*Dr. Federica Proietto* *(University of Palermo)* *Contact email:* *federica.proietto@unipa.it*	The reduction of GHGs emissions and the remediation of contaminated sites are two of the main global concerns. This module gives the insight elements on: i) the electrochemical valorization of CO2-waste gaseous stream into value-added chemicals, such as formic acid and syngas (CO2_Valorsation); ii) the remediation of contaminated soils and marine sediments with phenolic compounds, total petroleum hydrocarbons, polycyclic aromatic hydrocarbons as well as heavy metals (Soil/Sediment_Remediation) The module will be divided in three times: 1. CO2_Valorisation: interactive lecture of 3 hours; 2. Soil/Sediment_Remediation: interactive lecture of 3 hours; 3. Activities in laboratory of 3 hours.	November 2025	EN
C22	CEBHyME	**Sostenibilità dei processi industriali, verso la transizione dall'economia lineare a quella circolare**	9		*Dr. Claudia Prestigiacomo* *(University of Palermo)* *Contact email:* *claudia.prestigiacomo01@unipa.it*	La trasformazione dell'economia lineare in economia circolare e la crescita sostenibile delle società moderne è una delle più grandi sfide attuali. L'integrazione di fonti rinnovabili di energia nei processi chimici industriali e la valorizzazione delle matrici residuali prodotte si pongono al centro di questa diatriba. L'obiettivo di questo corso è quello di formare gli studenti sui recenti progressi tecnologici nelle seguenti aree: - Tecnologie di valorizzazione dei rifiuti biogenici e non biogenici: carbonizzazione idrotermale, liquefazione idrotermale, gassificazione idrotermale, carbonizzazione, pirolisi, gassificazione, processi biologici; - Processi di produzione di biodiesel da olio vegetale; - Integrazione di tecnologie solari a concentrazione in processi chimici industriali di interesse	Settembre 2026	EN
C23	CEBHyME	**Crystallization technology for mineral recovery from brines**	15		*Prof. Giuseppe Battaglia* *(University of Palermo)* *Contact email:* *giuseppe.battaglia03@unipa.it*	This short course will strengthen knowledge of (reactive) crystallization fundamentals through real-world applications for the recovery of minerals from concentrated waste solutions (brines). The course will cover fundamentals relating to (i) crystallization phenomena (e.g. nucleation, growth, aggregation, agglomeration phenomena), (ii)	January-February 2026	EN

						the influence of the mixing on particles characteristics, (iii) the influence of zetapotential on particle agglomeration, (iv) the influence of supersaturation on crystal habits. Real applications will be covered: the reactive crystallization of Mg(OH)2, the crystallization of Li2CO3 and the crystallization of MgCO3 as a CO2 storage approach. The scale-up study from lab- to pilot-scale of the crystallization of Mg(OH)2 compounds will encompass all fundament knowledge in view of industrial commercialization of minerals.		
C24	CEBHyME	**Sustainable composites reinforced with natural fibers and fillers**	9		*Prof. Luigi Botta* *Prof. Vincenzo Fiore* *Prof. Maria Chiara Mistretta* *(University of Palermo)* *Contact email:* *luigi.botta@unipa.it* *vincenzo.fiore@unipa.it* *mariachiara.mistretta@unipa.it*	Il corso mira a fornire una panoramica delle principali tipologie di fibre e filler naturali impiegati nello sviluppo di materiali compositi a matrice polimerica, sia termoplastica che termoindurente. Verranno presentate le principali tecniche di manifattura e analizzate le proprietà più rilevanti di questa classe di materiali compositi.	April 2026	EN

PHD IN ENERGY

Code	Program Involved	Title of the Course	N° hours	CFU	*Lecturer(s)*	Brief Synopsis	Tentative period	Language
E1	Energy	**Technologies for smart grids**	8	1	*Giuseppe Sciumè* *(University of Palermo)* *contact email:* *giuseppe.sciume01@unipa.it*	The course will present various technologies for smart grids, among which: Vehicle-to-X, IoT applications to buildings and grids, BAC and TBM systems, energy blockchain, Renewable Energy Communities.	01/2026 - 01/2027	EN
E2	Energy	**Inductive Power Transfer Systems for EV charging**	6	1	*Filippo Pellitteri* *Nicola Campagna* *(University of Palermo)* *contact email:* *filippo.pellitteri@unipa.it*	The class will cover: - State of the art on the wireless charging - Resonant Inductive Power Transfer Systems - Coils design and simulation through Matlab/Simulink - Compensation topologies - Bifurcation phenomenon - Dynamic wireless charging - Energy management and supervision strategies - Foreign Object Detection algorithms	03/2026 - 03/2027	EN
E3	Energy	**Multilevel power converters: Part 1**	6	1	*Antonino Oscar Di Tommaso* *Giuseppe Schettino* *(University of Palermo)* *contact email:* *antoninooscar.ditommaso@unipa.it*	Multilevel Power Inverters represent an innovative and promising technology in the power conversion field. They are gradually finding applications both in the field of energy transmission and distribution, and in the field of electric drives, thanks to their improved performance, if compared with traditional inverter. The course covers the following topics: - state of the art of multilevel power converters; - applications fields; - topology structures; - mathematical model and implementation;	07/2026 - 07/2027	EN
E4	Energy	**Multilevel power converters: Part 2**	6	1	*Antonino Oscar Di Tommaso* *Giuseppe Schettino* *(University of Palermo)* *contact email:* *antoninooscar.ditommaso@unipa.it*	The part 2 of the course on multilevel power inverters will cover: - modulation techniques; - innovative modulation algorithms; - impact of multilevel power converters in electrical drive applications	07/2026	EN
E5	Energy	**E-mobility: energy scenarios**	8	1	*Massimo Caruso* *Claudio Nevoloso*	The class introduces the e-mobility concept and deals with the electric automotive market	06/2026 –	

					(University of Palermo) *contact email:* *massimo.caruso16@unipa.it*	development, the evolution of EV charging systems and the concept of vehicle-to-grid.	06/2027	EN
E6	Energy	**Advancing Sustainable Energy Systems through Efficient Resource Use and Monitoring of Their Operation**	6	1	*Pietro Catrini* *(University of Palermo)* *contact email:* *pietro.catrini@unipa.it*	The course will provide an overview of methods for the assessment of the rational use of energy and the promotion of energy-saving measures in real systems	09/2026 – 09/2027	EN
E7	Energy	**Solar energy systems and data analytics: technologies, data-driven modeling, forecasting, and predictive diagnostics**	6	1	*Stefania Guarino* *(University of Palermo)* *contact email:* *stefania.guarino@unipa.it*	This course explores the intersection of solar energy technologies and advanced data analytics, highlighting how data-driven approaches can optimize performance, forecasting, and maintenance of solar systems. The session begins with a broad perspective on renewables in the energy transition, focusing on solar energy's unique characteristics—from irradiance variability to performance metrics—and key technologies like photovoltaics (PV), concentrated solar power (CSP), and solar thermal systems. The discussion then shifts to cutting-edge applications, blending experimental research with computational modeling. Case studies include solar thermal asphalt systems (experimental heat harvesting), bifacial PV in agrivoltaics (Python-based yield simulations), and time-series forecasting (using tools like Prophet) paired with anomaly detection for technical and weather-related disruptions. For CSP dish-Stirling systems, the course covers experimental validation, hybrid analytical-neural modeling, and techno-economic optimization, emphasizing sustainability trade-offs. Throughout, the focus remains on transforming raw data into useful information for predictive maintenance, energy yield optimization, or system design.	10/2026 – 03/2027	EN
E8	Energy	**Energy modelling and sustainability assessment of** **Positive Energy Districts**	9	1	*Francesco Guarino* *(University of Palermo)* *contact email:* *francesco.guarino@unipa.it*	The class will be based on the concept of Positive Energy Districts with a specific focus on the available definitions and their scientific implications, technical feasibility as well as a description of the most effective technologies to be used in different geographical contexts. Fundamentals of positive energydistricts energy modeling will follow with general considerations as well as applications to	06/2026	EN

						specific tools packages. Lastly, the sustainability perspective (including environmental, economics and social) of Positive Energy Districts performance assessment will be investigated. This part of the class deals with energy modelling and sustainability assessment of PEDs.		
E9	Energy	**Passive building envelope systems for climate change resilience**	5	1	*Giorgia Peri* *(University of Palermo)* *contact email:* *giorgia.peri@unipa.it*	The course aims to address the following aspects: • Energy efficiency and thermal comfort; • Climate Change and extreme metereological events; • Retrofit of buildings with regard to energy effciency and thermal comfort in the light of climate change and extreme metereological events taking place; Contribution made by the use of green roofs and cool roofs to climate change resilience.	12/2026 – 12/2027	EN
E10	Energy	**Innovative Applications of Heat Pumps in Renewable Energy Systems**	6	1	*Maurizio La Villetta* *(University of Palermo)* *contact email:* *maurizio.lavilletta@unipa.it*	The course will provide an overview of the main procedures for designing air conditioning systems based on air-to-water heat pumps. The course will start on defining the current diffusion of heat pumps considering the regulatory framework in Europe and Italy. The course will analyse the classification of heat pumps based on operating principles, thermodynamic cycles and performance indicators for innovative Renewable Energy Systems. Also, the potential benefits of Demand Response using heat pumps and thermal energy storage in buildings will be analysed by considering the thermal comfort of the occupants using a dynamic simulation model.	11/2026 - 11/2027	EN
E11	Energy	**Computational FluidDynamics of Conjugate Heat Transfer Problems**	12	2	*Andrea Quartararo* *(University of Palermo)* *contact email:* *andrea.quartararo@unipa.it*	The class will cover: • General description of conjugate heat transfer problems. • Simulation workflow for conjugate heat transfer problems with finite-volume numerical codes. Practical application on high heat flux heat sink components.	02/2026 – 02/2027	EN
E12	Energy	**Data Acquisition Lab**	8	1	*Giovanni Artale* *(University of Palermo)* *contact email:* *giovanni.artale@unipa.it*	The course will present advanced applications of Labview.	05/2026 – 05/2027	EN

E13	Energy	**Definitions, fundamentals and technologies of Positive Energy Districts**	6	1	*Francesco Guarino* *(University of Palermo)* *contact email:* *francesco.guarino@unipa.it*	The class will be based on the concept of Positive Energy Districts with a specific focus on the available definitions and their scientific implications, technical feasibility as well as a description of the most effective technologies to be used in different geographical contexts. Fundamentals of positive energy districts energy modeling will follow with general considerations as well as applications to specific tools packages. Lastly, the sustainability perspective (including environmental, economics and social) of Positive Energy Districts performance assessment will be investigated. This part of the class deals with definitions, fundamentals and technologies of PEDs.	03/2026 – 03/2027	EN
E14	Energy	**Advanced dynamics of electric power systems**	8	1	*Rossano Musca* *(University of Palermo)* *contact email:* *rossano.musca@unipa.it*	The course focuses on advanced algorithms and software tools for dynamic simulations of electric systems. The course includes the development of simulation models in Neplan and Simscape Electrical of Matlab/Simulink.	10/2026 – 12/2026	EN
E15	Energy	**New challenges in HVDC systems**	8	1	*Pietro Romano* *(University of Palermo)* *Antonino Imburgia* *(University of Palermo)* *Giuseppe Rizzo* *(EOSS srl)* *Contact email:* *pietro.romano@unipa.it*	The aim of the course is to present the salient characteristics that future high-voltage DC connections will have to possess in relation to the use of new materials for the construction of cables and accessories and the use of new technologies for monitoring the operating state. The most modern technologies for detecting the main causes of cable ageing, such as partial discharge and space charge, will be presented.	09/2026 – 09/2027	EN
E16	Energy	**Matlab and Arduino laboratory for solving electrical circuits**	8	1	*Fabio Viola* *Giuseppe Schettino* *(University of Palermo)* *Contact email:* *fabio.viola@unipa.it*	The course is based on the use of advanced systems such as Matlab and Arduino for the solution of electrical problems. The objectives are multiple: 1) learn how to use a virtual lab like simscape / simulink 2) The course uses the Matlab grader platform to define innovative methods of self-assessment and management of tasks in the classroom 3) The arduino laboratory aims to start the first basic knowledge on the programming of microcontrollers for diagnostics on systems and machines	12/2026 – 12/2027	EN
E17	Energy	**Engineering challenges of Nuclear Fusion Reactor**	12	2	*Pietro Alessandro Di Maio* *Gaetano Bongiovì*	Fundamentals of nuclear fusion reactors based on closed magnetic confinement	01/2026 –	

					(University of Palermo) *Contact email:* *pietroalessandro.dimaio@unipa.it*	systems for the conversion of nuclear fusion energy into electric energy to be delivered to the grid Overview of the main reactors components and systems (plasma facing components, blanket, divertor, magnets, vessel) and survey of the most critical engineering challenges in their design and operation	01/2027	EN
E18	Energy	**Energy transition and decarbonization**	5	1	*Sonia Longo* *(University of Palermo)* *Contact email: sonia.longo@unipa.it*	Research activities and policy goals and actions on energy transition and decarbonization. Background and fundamentals on the energy transition, the definition of decarbonization and circular strategies, tools for measuring effective reduction of GHGs emissions with a specific policy/action.	06/2026 – 06/2027	EN
E19	Energy	**Electric Powertrain: Structure and Design**	7	1	*Massimo Caruso* *Claudio Nevoloso* *(University of Palermo)* *Contact email:* *massimo.caruso16@unipa.it*	The course covers the following topics: a) Introduction to electric powertrain b) Electric motors in the automotive field c) Power electronic converters for automotive d) Storage systems for automotive e) The design phase	02/2026 – 02/2027	EN
E20	Energy	**Optimization of energy systems**	12	2	*Francesco Montana* *(University of Palermo)* *Contact email:* *francesco.montana@unipa.it*	The course will provide an overview of optimization algorithms with a specific focus on energy applications. The first part of the course will be focused on a brief theoretical background on main concepts – convex and non-convex problems, duality, linearity, simplex algorithm, genetic algorithms, simulation-based optimization, single and multi-objective optimization, optimal planning. The second part of the course will be based on many examples and exercises performed on the following platforms: MS Excel, MATLAB, MOBO. The exercises will concern the following topics: renewable energies, building energy demand, microgrids and distributed energy resources.	11/2026 – 01/2027	EN
E21	Energy	**Energy Performance Certification of Buildings**	6	1	*Giuseppina Ciulla* *(University of Palermo)* *Contact email:* *giuseppina.ciulla@unipa.it*	The course aims to provide, with reference to the legislation in force in Italy, all the tools necessary for the analysis of energy performance of buildings. Tools, procedures, methodologies and practical examples will be described.	02/2026 – 02/2027	EN
E22	Energy	**Specialized software for network analysis in static**	12	2	*Antony Vasile* *(University of Brescia)* *Contact email:*	Specialized software plays a crucial role in modern electrical engineering. This course will provide insight about design, analysis, and	12/2026 –	EN

		and short-circuit conditions			*antony.vasile@unibs.it*	optimization of electrical networks in static conditions, with power flow simulations of complex systems and a dedicated module on safety and coordination of protections devices.	12/2027	
E23	Energy	**Methods and tools for the assessment of indoor environmental quality**	10	2	*Marina Bonomolo* *(University of Palermo)* *Contact email:* *marina.bonomolo@unipa.it*	The class will be focused on the study of assessment of indoor environmental quality and, in particular, on methods and technologies for optimize efficient and smart systems design and for the post-occupancy evaluation. Furthermore, the course will introduce innovative methods (such as digital twin and predictive methods).	04/2026 – 04/2027	EN
E24	Energy	**Energy and environmental resilience to climate change in the built environment**	8	1	*Laura Cirrincione* *(University of Palermo)* *Contact email:* *laura.cirrincione@unipa.it*	The course will cover the following aspects: - Global, European, and national policies and regulatory frameworks regarding the concepts of sustainability and resilience in the built environment - Similarities and distinctions between the concepts of energy and environmental sustainability and resilience in the built environment - Up to date smart solutions and technologies to improve energy and environmental resilience to climate change in the built environment (indoor and outdoor) - Assessment of buildings resilience to climate change using ad hoc selected indicators - Simulative applications for the evaluation of alternative mitigation scenarios to optimize decision processes.	02/2026 – 02/2027	EN
E25	Energy	**Fundamentals of the Monte Carlo Method for engineering**	12	2	*Pierluigi Chiovaro* *(University of Palermo)* *Contact email:* *pierluigi.chiovaro@unipa.it*	The class will cover: • Elements of probability theory and statistics. • Monte Carlo integration. • Sampling from probability density functions and cumulative functions; transformations of probability density functions. • Neutron transport integral equation and random walk. Monte Carlo methods applied to the problem of thermal conduction.	01/2026 – 01/2027	EN

E26	Energy	**Thermal-hydraulic System Codes for Nuclear Power Plants**	12	2	*Eugenio Vallone* *(University of Palermo)* *Contact email:* *eugenio.vallone@unipa.it*	The course will cover the following topics: • the balance of plant of a nuclear power plant; • system codes and their role in the design and safety assessment of a nuclear power plant; • basic theory of thermal-hydraulic system codes; fundamentals of nuclear power plant modelling.	04/2026 – 04/2027	
E27	Energy	**Design and performance analysis of low-enthalpy geothermal systems**	6	1	*Alessandro Buscemi* *(University of Palermo)* *Contact email:* *alessandro.buscemi@unipa.it*	This 6-hour intensive course guides doctoral students through the key steps of designing a low-enthalpy geothermal system. Starting by tracing the undisturbed soil temperature profile, in situ and laboratory methods for determining the thermal conductivity and diffusivity of soils are then explained. The course goes on to present basic sizing criteria for vertical borehole heat exchangers using numerical models in TRNSYS, and concludes with parameters for evaluating seasonal energy performance, illustrated through a case study.	01/2026 – 06/2026	

PHD IN INFORMATION AND COMMUNICATION TECHNOLOGIES (ICT)

Code	Program Involved	Title of the Course	N° hours	CFU	Lecturer(s)	Brief Synopsis	Tentative period	Language
I1	ICT	Bridging Human and Machine Vision	12	2	*Prof. Dario Zanca* *(FAU Erlangen-Nuremberg, Germany)* *Contact email: dario.zanca@fau.de*	The course is focused on Bridging Human and Machine Vision.		EN
I2	ICT	Variational analysis and optimization	12	2	*Prof. Antonella Nastasi* *(University of Palermo)* *Contact email: antonella.nastasi@unipa.it*	This course will cover the following aspects: • Introduction to calculus of variations. Integral functionals. • Energy functionals. • Optimization problems. EuleroLagrange equations. • Direct methods of the calculus of variations. • Critical point theory. Compactness conditions and Mountain Pass Theorem. Examples and open problems.	July	EN
I3	ICT	Biomedical signal analysis: heart rate variability assessment	10	1	*Prof. Riccardo Pernice* *(University of Palermo)* *Contact email: riccardo.pernice@unipa.it*	This course aims to introduce the most widely employed heart rate variability indexes in time, frequency and information -theoretic domain and show how they can be exploited for assessing the cardiac autonomic function. The course includes both lectures and practical sessions using MATLAB software.	November	EN
I4	ICT	Biomedical signal analysis: Reconstructing Complex System Dynamics from Time Series Analysis	10	1	*Prof. Yuri Antonacci* *(University of Palermo)* *Contact email: yuri.antonacci@unipa.it*	The aim of this course is to provide an overview of different advanced time series methods that are at the basis of the approaches currently available to study the dynamics of very different complex systems. Different methodologies will be reviewed, ranging from model -free to model -based data -driven, to artificial neural networks inspired models, describing the basic concepts and the advantages and limitations of different methods when applied to the study of physiological and non -physiological complex systems. The effectiveness of the approaches presented will be demonstrated with applications on: (i) physiological systems; (ii) electronic chaotic oscillators; (iii) climate dynamics. The course includes both lectures and practical sessions using MATLAB software.	September/October	
I5	ICT	Microwave and Millimeter-waves Solid State Power Amplifiers: Design, Fabrication, and Characterization	20	3	*Prof. Patrizia Livreri* *(University of Palermo)* *Contact email: patrizia.livreri@unipa.it*	The course deals with “Microwave and Millimeter-waves Solid State Power Amplifiers: Design, Fabrication, and Characterization”	June	EN

I6	ICT	Numerical simulations and applications: Finite element analysis	20	3	*Prof. Andrea Tognazzi* *(University of Palermo)* *Contact email: andrea.tognazzi@unipa.it*	This course is an introduction to the finite element method as applicable to a range of problems in physics and engineering sciences. The emphasis is on coding up the formulations in a modern, open -source environment that can be expanded to different applications, with a special attention to the problem of signal propagation.	June	EN
I7	ICT	Numerical simulations and applications: Labview	15	2	*Prof. Valentina Cosentino* *(University of Palermo)* *Contact email: valentina.cosentino@unipa.it*	The course introduces to LabVIEW programming.	July	EN
I8	ICT	Electronics for the Space: Mm-wave and THz technology	10	1	*Prof. Luciano Curcio* *(University of Palermo)* *Contact email: luciano.curcio@unipa.it*	This course aims to introduce students to the problems of generating, guiding and detecting electromagnetic radiation in the millimeter wave (mm -waves) and at Terahertz (THz) frequency bands. Recent techniques about signal -processing functionalities in the THz range will be also addressed. In particular, the course will cover: -Fields of application of mm-waves and THz -waves -Generation techniques -Receiver types THz time -domain spectroscopy and waveguides for broadband THz signal processing.	September	EN
I9	ICT	Emerging network technologies	20	3	*Prof. Ilenia Tinnirello* *Prof. Daniele Croce* *Prof. Stefano Mangione* *(University of Palermo)* *Contact email: ilenia.tinnirello@unipa.it*	This course will present some emerging trends in network technologies, and in particular open architectures for beyond - 5G cellular systems and solutions for massive IoT applications. It will also present some frontier topics, such as methodologies for zero -touch beyond -5g networks and quantum information.	September	EN
I10	ICT	Deep learning applications for the analysis of biomedical data	12	2	*Prof. Salvatore Contino* *(University of Palermo)* *Contact email: salvatore.contino01@unipa.it*	The proposed PhD course will deal with the use of technologies based on Deep Learning (DL) and Machine Learning (ML) on biomedical data. Specifically, it will deal with Machine Learning and Deep Learning algorithms used at the state of the art, with particular interest in the different types of chemicals, biological and medical data. The course will be structured in 12 hours, divided as follows: 1) Lecture 1 (3h). Perspective on Machine Learning and Deep Learning. Classification, Clustering and Semantic Segmentation. 2) Lecture 2 (3h). Biomedical data (structured and unstructured data). Pre -processing algorithms for data optimisation. 3) Lecture 3 (3h). DL and ML applications in chemistry and biology (Classification and Clustering). 4) Lecture 4 (3h). DL and ML applications for image analysis (Classification and Semantic Segmentation)	September/October	EN

I11	ICT	Privacy-Preserving Techniques for Data Analysis	12	2	*Prof. Vincenzo Agate* *(University of Palermo)* *Contact email: vincenzo.agate@unipa.it*	This course will present techniques for designing privacy -preserving systems and applications, and discuss the possibilities and limitations of their use. Topics covered in the course include secure multi -party computation techniques and related cryptographic algorithms, and in -depth discussion of specialized tools and libraries for building secure systems for analyzing user data in a privacy preserving manner.	February	EN
I12	ICT	Machine Learning Techniques based on FPGA	12	2	*Prof. Gianluigi Chiarello* *(University of Palermo)* *Contact email: gianluigi.chiarello@unipa.it*	The course aims to provide the state of the art on the implementation of Machine Learning (ML) and Deep Learning (DL) techniques in FPGA-type devices. This course aims to illustrate how ML techniques can be implemented in FPGA devices from a dual point of view. First, the course will focus on the technological aspect: the software and hardware tools available on the market will be presented and development methodologies will be illustrated, discussing practical cases. Secondly, the course will show the state of the art of ML applications on FPGAs through the analysis of concrete cases and examples of applications (of varying complexity).	April	EN
I13	ICT	Introduction to embedded system design based on SoC	21	3	*Prof. Gianluigi Chiarello* *(University of Palermo)* *Contact email: gianluigi.chiarello@unipa.it*	The course aims to introduce the design of embedded systems using Xilinx SoC and the tool Vivado. After a general description of the Xilinx SoC architecture, the functionalities offered by the Vivavdo will be analysed. The following lessons will deal with the main design and integration techniques of the main functions necessary for the design of embedded systems. There will be practical exercises on development boards based on Xilinx Zynq®-7000 All Programmable SoC.	February/March	EN
I14	ICT	Microwave Quantum Sensing for target detection	10	1	*Prof. Patrizia Livreri* *(University of Palermo)* *Contact email: patrizia.livreri@unipa.it*	The course deals with Microwave Quantum Sensing for target detection	June	EN

I15	ICT	Navigation and Control of Unmanned Aerial Vehicles (UAVs): a comprehensive approach.	10	1	*Prof. Kimon Valavanis (University of Denver, US) Contact email: kimon.valavanis@du.edu*	The course objective is twofold: i.) Provide a comprehensive study of unmanned fixed -wing and rotorcraft navigation and control techniques, including a review of kinematics, dynamics and equations of motion, sensors, identification, controller design and implementation, as well as advances in unmanned aviation technology. When focusing on multi -rotor UAVs, a detailed modeling approach based on Lagrange formulation is followed, which also accounts for rotor dynamics, gyroscopic effects, all types of drag, disturbances, and abrupt changes of mass. A comprehensive presentation of linear, linearized, nonlinear and soft -computing based controller designs are discussed, the focus being on helicopter, rotorcraft, and fixed -wing navigation and control designs. A comparison of advantages and limitations of implemented techniques follows, subsequently introducing a generalized 'one -fits -all' flight control system (FCS) in which the specific controller design approach is a plug - in - plug -out module. Implementation details and how to guarantee task execution given strict timing requirements is detailed. Case studies include simulation and experimental results for several prototype UAVs. ii.) Present a detailed methodology for designing and navigating/controlling a new type of fixed -wing aircraft with enhanced aerodynamic performance based on the concept of Circulation Control, which allows for lift enhancement, reduced takeoff and landing distance, delayed stall and increased effective payload. CC based aircraft design is followed by controller design that also includes identification of stability and control derivatives. Simulation results, experimental/wind -unnel and flight tests validate and verify the proposed methodology. Consequently, a general framework for controller design of a class of nonlinear systems with unstructured, time -varying uncertainties (aerodynamic uncertainties) is proposed, supported by obtained results. Prerequisites: Knowledge of feedback control systems is required. Knowledge of fundamentals of robotics is desirable, but not necessary. All required	April	EN

						background information will be presented in class.		
I16	ICT	Qubit and entanglement: theory and applications	6	1	*Prof. Rosario Lo Franco* *(University of Palermo)* *Contact email: rosario.lofranco@unipa.it*	This course introduces qubits, entanglement, and their practical applications in quantum computing and quantum communication. Participants will delve into the foundational principles of qubits, explore the intriguing phenomenon of entanglement, and gain insights into how these concepts are harnessed in cutting -edge technologies such as quantum cryptography and quantum teleportation. Through a combination of theoretical discussions, mathematical formalism, and practical examples, this course aims to equip learners with a basic understanding of quantum phenomena, such as coherence and entanglement, and their real -world implications.	June	EN
I17	ICT	Advanced material investigations by Electron Microscopy: theoretical and experimental hints	12	2	*Prof. Simona Boninelli* *(IMM – CNR, Catania)* *Contact email: simona.boninelli@ct.infn.it*	Electron Microscopy has emerged has a crucial characterization technique in material science, providing highly resolved evidence of chemical, optical and morphological structure of matter from micron to atomic scale. In this course I will give an overview of physical fundamentals and electro -optical alignment lying at the basis of both Scanning Electron Microscope (SEM) and (Scanning) - Transmission Electron Microscope (S -TEM), equipped with spectroscopic tools such as Energy Dispersive X -ray Spectroscopy and Electron Energy Loss Spectroscopy. Analogies and differences between these two techniques will be emphasized. The morphology and chemical mapping of nanomaterials (nanowires, metal -oxides and metallic nanoalloys, nanobelts) and thin films (Si, Ge, SiC) will be presented pointing at their specific practical applications, spanning from microelectronics to power devices. Moreover, we will remote connect with the the Beyond nano Electron Microscopy Lab located at IMM -CNR in Catania, to follow live a S -TEM session to investigate the crystallographic atomic arrangement at the nanoscale and beyond. The tentative program is: 1st lesson: EM to overcome the resolution limit of light; 2nd lesson: Conventional S-TEM techniques for defects characterization; 3rd lesson: Spectroscopic analyses form chemical mapping; 4th lesson: Remote controlled STEM analysis	February	EN

I18	ICT	Computer-Aided Design of electronic circuits and systems	12	2	*Prof. Daniele Sciré* *(University of Palermo)* *Contact email: daniele.scire@unipa.it*	Il corso propone di fornire le competenze di base sulla progettazione e analisi di circuiti e sistemi elettronici tramite l'ausilio di software gratuiti di simulazione basati su SPICE (es. Microcap, LTSpice). Nel corso verranno trattati gli algoritmi e i metodi numerici usati dai software di simulazione circuitale sia nel dominio del tempo che della frequenza, i modelli dei dispositivi a stato solido più comunemente usati e l'applicazione di metodi statistici e di ottimizzazione alla progettazione di circuiti elettronici. Le lezioni frontali saranno integrate da esercitazioni sull'applicazione dei concetti visti a lezione sul software di simulazione. Al termine del corso gli allievi dottorandi avranno acquisito le conoscenze operative per utilizzare adeguatamente ed in modo accurato più comuni software di simulazione SPICE.	March	
I19	ICT	Machine learning techniques for cyber threat detection in distributed systems	12	2	*Prof. Andrea Augello* *(University of Palermo)* *Contact email: andrea.augello01@unipa.it*	This 12-hour course will focus on the use of machine learning to detect attacks in relevant cybersecurity domains. Topics covered in the course will include intelligent data analysis techniques for discovering critical events raced by the spread of false information, as well as the detection of malicious activities performed by humans in the internal perimeters of data centers.	March	IT/EN
I20	ICT	Quantum Devices and Circuits for metrology	6	1	*Prof. Emanuele Enrico* *Dr. Luca Fasolo* *(Istituto Nazionale di Ricerca Metrologica)* *Contact email: e.enrico@inrim.it*	The course deals with quantum devices and circuits for metrology.	March	EN

I21	ICT	Sicurezza Laser	9	1	*Prof. Mauro Mosca* *(University of Palermo)* *Dott. Gesualdo Rubonello* *(INAIL)* *Contact email: mauro.mosca@unipa.it*	I sistemi LASER forniscono prestazioni estremamente utili in moltissimi settori sia dell'industria, che della ricerca e della sanità. A fronte di queste applicazioni estremamente importanti e utili, è necessario determinare il valore di esposizione degli addetti e prevenire i potenziali danni della radiazione laser ai tessuti biologici, in particolare a occhi e cute che rappresentano gli organi maggiormente a rischio. La valutazione dei rischi di un sistema laser rappresenta un percorso critico e accurato che deve tener conto della tipologia del sistema, delle caratteristiche del fascio laser, della determinazione dei valori limite di esposizione, del calcolo e della misura del livello di esposizione, del calcolo e della verifica della distanza di sicurezza e della "Zona LASER Controllata", fino alla predisposizione di norme di sicurezza specifiche. Obiettivo del corso è fornire un approfondimento su vasta scala sulle normative e le tecniche di valutazione e misura dei sistemi LASER. Programma: •Natura della radiazione ottica •L'emissione stimolata •Principi di funzionamento di un LASER •Le caratteristiche di emissione della radiazione LASER •Tipologie di LASER •Pericoli connessi alle sorgenti LASER •Classificazione delle sorgenti LASER •Le normative nazionali e internazionali sulla sicurezza •Il D. Lgs.81/08 e s.m.i. sulla radiazione ottica artificiale coerente: valori limite di esposizione •Grandezze protezionistiche e unità di misura •Gli organi bersaglio: Occhio e cute •La fisiologia dei tessuti a rischio e gli effetti dell'esposizione alle radiazioni LASER •Focalizzazione della radiazione LASER da parte dell'occhio ed effetti sulla retina •Come gestire casi sospetti di esposizione accidentale •Sorveglianza Sanitaria e criteri di attuazione •I lavoratori particolarmente sensibili al rischio •Focalizzazione della radiazione laser da parte dell'occhio •Le modalità di interazione della radiazione ottica con il tessuto biologico (effetti fototermici, fotoacustici, fotoablativi, fotochimici). •Valori di Esposizione Massima Permessa, Limiti di esposizione, Limiti di Emissione Accessibile •Rischi diretti e indiretti	January	IT

						•Focalizzazione della radiazione LASER da parte dell'occhio ed effetti sulla retina •La norma CEI EN 60825-1 •Norme tecniche di riferimento per Dispositivi di Protezione Individuale (DPI) oculari •Definizione dei requisiti per il costruttore e i dati che deve fornire •Valutazione e calcolo dei DPI a protezione totale •Criteri di valutazione del rischio •Definizione di "Zona LASER Controllata" •Concetti base circa la valutazione dell'esposizione a radiazione LASER con emissione continua e pulsata (sorgente puntiforme, estesa, apparente, calcolo del "Valore Limite di Esposizione" (VLE) •DPI oculari: "Densità Ottica" e "Stabilità" •Calcolo della "Distanza Nominale di Rischio Oculare" •Misure ingegneristiche e organizzative volte alla riduzione del rischio •I requisiti degli ambienti destinati a ospitare un LASER •Come valutare le zone di rischio LASER •Casi studio: calcolo pratico del VLE e della densità ottica di un protettore oculare •Strumentazione di misura		
I22	ICT	Non Hermitian Hamiltonians and related topics (Mutuato da dottorato di scienze Fisiche e Chimiche)	20	3	*Prof. Fabio Bagarello* *(University of Palermo)* *Contact email: fabio.bagarello@unipa.it*	Contents • Mathematical preliminaries: Hilbert spaces, Biorthogonal bases, Bounded and unbounded operators • Deformed commutation relations: ladder operators arising from different commutation rules, and from their deformations • Coherent states for pseudo-bosons: bicoherent states and quantization of classical systems • Dynamics for non Hermitian Hamiltonians: transition probabilities; Schroedinger and Heisenberg dynamics; symmetries; constants of motions; algebraic dynamics; derivations. • Distributions and quantum mechanics: weak pseudo-bosons; weak bicoherent states • Physical models: applications to physical models: shifted harmonic oscillator; Supersymmetric pseudo-bosonic potentials; inverted harmonic oscillator	November – February	EN

PHD IN MECHANICAL, MANUFACTURING, MANAGEMENT AND AEROSPACE INNOVATION (M3AI)

Code	Program Involved	Title of the Course	N° hours	CFU	Lecturer(s)	Brief Synopsis	Tentative period	Language
M1	MEAI	**Computational Modelling of Composite and Heterogeneous Materials**	**8**	**1**	*Prof. Ivano Benedetti* *Prof. Alberto Milazzo* *(University of Palermo)* *Contact email:* *ivano.benedetti@unipa.it*	The course will introduce some recent developments on computational modelling of composite and polycrystalline materials, with a focus on the analysis of damage and fracture problems. Some specific concepts and techniques, such as the Generalised Unified Formulation for multilayered composites modelling and Cohesive Zone Modelling for the analysis of damage and fracture initiation in heterogeneous materials, will be introduced and recent and perspective applications will be discussed. Applications to low- and high-cycle fatigue, hydrogen embrittlement, multifunctional materials will be discussed.	May	EN
M2	MEAI	**Introduction to causal analysis**	**8**	**1**	*Dott. Salvatore Marcantonio* *(University of Palermo)* *Contact email:* *salvatore.marcantonio@unipa.it*	The Course aims at introducing causal analysis through graphical models according to Judea Pearl's methodology. It will cover: preliminaries, statistical and causal models, graphical models and their applications, the Effects of interventions, counterfactuals and their Applications. Theoretical arguments will be shown along with exercises and software presentation.	May	IT
M3	MEAI	**Fundamentals of Life Cycle Engineering techniques**	**8**	**1**	*Prof. Giuseppe Ingarao* *(University of Palermo)* *Contact email:* *giuseppe.ingarao@unipa.it*	The course aims at providing skills concerning products environmental impact analysis. The whole product life cycle as well as the inventory techniques for each phase life will be analyzed. The concept of material embodied energy, as well as the idea of dominant phase of a product/component life cycle will be analyzed. Life Cycle engineering (LCE) techniques will be presented as means to identify environmentally friendly solution while designing products/components. Comparatives industrial case studies will be thoroughly analyzed. Also, the Circular Economy paradigm will be analyzed; specifically, several Circular Economy strategies	May	EN

						concerning the case of aluminum alloys Reuse/Recycle will be presented.		
M4	MEAI	**Non-Destructive Evaluation for Industry 4.0**	**8**	**1**	*Prof. Carmelo Mineo (University of Palermo) Contact email: carmelo.mineo01@unipa.it*	This course will discuss the evolution of Non-Destructive Evaluation (NDE) for the assessment of industrial production in the landscape of Industry 4.0. As it has happened in the history of industrial development, NDE will be critical for the success of the fourth industrial revolution, by providing the database needed for feedback in a networked production environment. This course will present a review of the recent scientific literature and of several current-day challenges (informatization, digitalization, standardization, networking, etc.) that are being tackled to adapt NDE to the requirements of the rising industrial revolution.	March	EN
M5	MEAI	**Multi-sided platform business models**	**8**	**1**	*Prof. Paolo Roma (University of Palermo) Contact email: paolo.roma@unipa.it*	The PhD course will provide an overview of the logic of multi-sided platforms and their business models. In a world where more and more businesses have been re-organized as multi-sided (platform) markets, the main purpose of the course is to offer PhD students a broad understanding of how multi-sided platforms can generate a competitive advantage and enhance marketability of new products and technologies. By exploring several important types of economy/business models enabled by Internet and organised as multi-sided platforms, such as sharing economy, app market, crowdfunding, the course will offer a set of guidelines on how to take advantage of multi-sided platforms in different fields of application to support innovation.	June	EN
M6	MEAI	**Sustainability Management**	**8**	**1**	*Prof.ssa Erica Mazzola (University of Palermo) Contact email: erica.mazzola@unipa.it*	The PhD course aims to provide PhD students with the knowledge and skills necessary to critically analyze sustainability initiatives within companies and contribute to the development of robust sustainability management practices. Through theoretical discussions and practical case studies, students will delve into the reasons why companies today are increasingly aware of sustainability issues. This awareness is driven, in part, by the prevalence of greenwashing scandals and the increasingly evident impacts of climate change. Furthermore, students will explore the	February	EN

						motivations behind companies' desires to disclose their sustainability efforts to stakeholders. Additionally, the PhD course aims to examine the various tools and strategies available to companies for sustainability disclosure, and will learn how to analyze a sustainability report.		
M7	MEAI	**Sailing Tomorrow**	**8**	**1**	*Prof. Antonio Mancuso* *(University of Palermo)* *Contact email:* *antonio.mancuso@unipa.it*	The PhD course will provide an overview of the design methodology in the field of sailing yacht particularly concerning high speed boats. The new opportunities provided by the use of lifting surfaces (the so-called foils) changes the design paradigm dramatically. An intensive use of advanced software aimed to improve both aero/hydro dynamics and structural performances become mandatory. During the course will be faced problems as far as shape, structures and rigging of a regatta sailing yacht are concerned. Will be show how the integration of CAD, FEM and CFD software allows designer to reach the final result in a faster way.	February	EN
M8	MEAI	**Introduction to Mechanics of Solids and Structures**	**20**	**2.5**	*Prof. Gaetano Burriesci* *(University of Palermo)* *Contact email:* *gaetano.burriesci@unipa.it*	This course applies the theories of statics to the analysis of the mechanical behaviour of basic deformable structures subjected to external loads. The course aims to provide students with a theoretical foundation enabling them to determine the response of engineering structures to external mechanical actions, the resulting deformations and the state of stress and strain produced into the structure's components. Students will also acquire the ability to predict and prevent common forms of structural static failure in basic engineering components.	Apr-May	EN
M9	MEAI	**Concept of measurement and related qualification in terms of uncertainty in engineering processes**	**8**	**1**	*Prof. Francesco Scardulla* *(University of Palermo)* *Contact email:* *francesco.scardulla@unipa.it*	No measurement provides an exact number and thus, several measurements performed in identical conditions provide different results. Hence the importance of the correct quantification of uncertainty in the technological, scientific and commercial fields, which calculation is regulated by international agreements and procedures. In this course, you will learn what information you need to calculate uncertainty, how to identify contributors to uncertainty, and how to	June	IT or EN upon request

						evaluate your calculations to prevent overestimating or underestimating uncertainty. This course is highly recommended for all students who have never faced the concept of measurement uncertainty.		
M10	MEAI	**Innovation in measurements: from the concept of the device to the design of a business model**	**8**	**1**	*Prof. Francesco Scardulla (University of Palermo) Contact email: francesco.scardulla@unipa.it*	During a PhD course or after its conclusion, it is possible to come up with an idea/technology that is believed to be innovative or revolutionary. Unfortunately, the only idea is not enough to bring it to the market through the launch of a startup. People don't know the steps and they are often intimidated by the whole process, letting the ideas die without any chance. In this course you will learn how to evaluate your business idea and protect it from potential competitors and what are all the first steps to take to found a start-up and let investors believing in it. The main topics that will be covered are: how to write an executive summary and a business model, how to build a pitch and how to present it, investments options, how to properly write a patent. The last lession will be devoted to a practical pitch session.	April	IT or EN upon request
M11	MEAI	**Sustainable Logistics and Transportation**	**12**	**1.5**	*Prof. Simona Mancini (University of Palermo) Contact email: simona.mancini@unipa.it*	The course will present the main issues arising in green and sustainable logistics and will analyze viable solutions to this issue, which include both the exploitation of more sustainable resources (such as electric vehicles) and a smarter usage of available resources. We will discuss the main advantages and disadvantages of exploiting electric vehicles, the issues to manage when dealing with such vehicles (en-route recharging planning, recharging slots reservation, recharging stations location) both in freight delivery and in public transport. The impact of different incentives, such as the introduction of toll zones or restricted areas for fuel-engine vehicles, will be discussed in details. Furthermore, open challenges and latest advances in City Logistics (multi-echelon distribution systems for long-haul transportation, collaboration among carriers, closed loop supply chains) will be discussed. Hints about reverse logistics will be provided. The course will integrate lectures with	February/March	EN

						discussion of recent journal papers reporting latest advances in the literature.		
M12	MEAI	**Advanced Mathematical Modeling for complex decision problems**	**12**	**1.5**	*Prof. Simona Mancini (University of Palermo) Contact email: simona.mancini@unipa.it*	The aim of the course is to give the students advanced modelling skills that can allow them to be able to provide mathematical formulations for decision problems they can face in their research field. The first part of the course will provide the needed knowledge to transform a textual description of a decision problem into a mathematical formulation. The second part will address specific problems such as production and scheduling problems, packing problems and vehicle routing problems. Given a single problem, different formulations will be provided and analyzed. Techniques to provide smarter formulation (i.e. formulations that can solve quicker the problems to the optimality) will be presented. Hints about formulations strengthening techniques and exact solving methods will be provided.	April/May	EN
M13	MEAI	**New trends in future metrology: measurements of non-physical quantities (measuring the unmeasurable)**	**8**	**1**	*Prof. Leonardo D'Acquisto (University of Palermo) Contact email: leonardo.dacquisto@unipa.it*	The measurement of quantities according to perception is of great interest for the optimal characterization of the interaction of persons with their living and working environment. It formally conflicts with the definition of physical quantity (PQ): " A physical quantity is a physical property of a material or system that can be quantified by measurement". Despite that, there is growing interest to a new approach to the development of a theory of measurements for non-physical quantities (NPQs). For these measurements it is not possible to ensure traceability because of their exclusive nature as substantiated by the subject. NPQs exist in the immaterial world in the sense they exist only in the mind of people either as a reflection of properties of real material world or as a personal understanding of the subject. Measurements of PQs and NPQs have clearly different fields of application. So, NPQ) have different fields of application. Measurements of NPQ are: a way to perceive the material world through its reflection in human minds and a way to perceive the immaterial world of each person through its	February	IT or EN upon request

						understanding (or lack of understanding) by other people.		
M14	MEAI	**The Power of Many: Advancing Innovation Through Crowdsourcing**	**8**	**1**	*Prof. Mariangela Piazza (University of Palermo) Contact email: mariangela.piazza@unipa.it*	The course delves into the theory, methods, and implications of crowdsourcing for innovation. It equips students with a comprehensive understanding of how crowdsourcing leverages collective intelligence to tackle complex problems and drive innovation across various domains. Through case studies and discussions, students will explore the intricacies of designing, managing, and analyzing crowdsourcing initiatives. By the end, students will be adept at harnessing diverse crowds to generate novel ideas, solve challenges, and pioneer groundbreaking innovations.	May	EN
M15	MEAI	**Engineering applications of the CFD analysis**	**12**	**1.5**	*Dr. Antonino Cirello (University of Palermo) Contact email: antonino.cirello@unipa.it*	The course will introduce some engineering applications of CFD analysis focusing even on specific hints to conduct consistent fluid dynamics analysis. Turbulence models, mesh characteristics and correct modeling of the boundary conditions will be introduced. Examples of these applications will be presented.	November	IT or EN upon request
M16	MEAI	**Prosthetic Implants and Design Methods: from clinical requirement to manufacturing**	**12**	**1.5**	*Dr. Agostino Igor Mirulla (University of Palermo) Contact email: agostinoigor.mirulla@unipa.it*	The proposed course aims to provide the workflow in the design and development of prosthetic limb, upper and lower limb implants that takes into consideration clinical, biocompatibility, and static and dynamic stress resistance requirements. The course will include theoretical notions pertaining to bone remodelling and osseointegration, surface finishes for the interaction of metallic and/or polymeric materials with biological tissues. In addition, image recognition, CAD modelling and numerical simulation software will be used for practical application of the knowledge gained.	November	IT
M17	MEAI	**R&D financing**	**16**	**2**	*Prof. Fabrizio Micari (University of Palermo) Contact email: fabrizio.micari@unipa.it*	Strategie ed opportunità di finanziamento della ricerca e sviluppo in ambito industriale ed accademico, con particolare riferimento ai progetti europei ed ad Horizon Europe con particolare focus su ERC	June/July	IT or EN upon request
M18	MEAI	**Innovative non-destructive testing techniques: Laser**	**12**	**1.5**	*Prof. Nicola Montinaro (University of Palermo) Contact email: nicola.montinaro@unipa.it*	Continuous technological advancements in the quest for new materials and high-performance manufacturing methods must be supported by effective quality control techniques. It is then	October	IT or EN upon request

		ultrasound and Laser thermography				crucial to develop methods that can be applied on the production line and for regular, non-invasive, and non-contact inspections to monitor and characterize material defects. This seminar will cover traditional non-destructive control techniques and introduce the innovative laser ultrasonic and laser thermography inspection technique, comparing it with other control methods and discussing its progress and applications in 3D printing parts, composite materials, and railway sector inspection. Depending on the number of participants, there may be an optional visit to the non-destructive inspection laboratory.		
M19	MEAI	**Multivariate Statistical Analysis**	**16**	**2**	*Prof. Giulia Marcon* *(University of Palermo)* *Contact email: giulia.marcon@unipa.it*	Multivariate statistical techniques are important tools in many application fields because they allow to describe and model the multivariate relationships among data. This course introduces the student to the most widespread supervised and un-supervised methods of multivariate analysis. During the course both the theoretical and mathematical aspects as well as the application and interpretation of the results will be addressed.	October	IT or EN upon request
M20	MEAI	**Introduction to Mechanics of Solids and Structures**	**20**	**2.5**	*Prof. Gaetano Burriesci* *(University of Palermo)* *Contact email:* *gaetano.burriesci@unipa.it*	This course applies the theories of statics to the analysis of the mechanical behaviour of basic deformable structures subjected to external loads. The course aims to provide students with a theoretical foundation enabling them to determine the response of engineering structures to external mechanical actions, the resulting deformations and the state of stress and strain produced into the structure's components. Students will also acquire the ability to predict and prevent common forms of structural static failure in basic engineering components.	Apr-May	EN