OGGETTO: BANDO DI SELEZIONE PUBBLICA VOLTO AL CONFERIMENTO DI INCARICHI DI INSEGNAMENTO NELL'AMBITO DELLA SCUOLA DI DOTTORATO DEL POLITECNICO DI BARI, A.A. 2026/2027 – CODICE PROCEDURA: DID.SCUDO.26.01 – SCADENZA ORE 12:00 DEL 14.09.2026

IL RETTORE

VISTO il D.P.R. 11.07.1980, n. 382 *"Riordinamento della docenza universitaria, relativa fascia di formazione nonché sperimentazione organizzativa e didattica"*;

VISTA la Legge 09.05.1989, n. 168, "*Istituzione del Ministero dell'Università e della Ricerca scientifica e tecnologica*";

VISTA la Legge 07.08.1990, n. 241, *"Nuove norme in materia di procedimento amministrativo e di diritto di accesso ai documenti amministrativi"* e ss. mm. ii.;

VISTA la Legge 19.11.1990, n. 341, *"Riforma degli Ordinamenti didattici universitari"*;

VISTO il Decreto del Ministro dell'Università e della Ricerca Scientifica e Tecnologica del 04.10.2000, e successive modificazioni, concernente "*Rideterminazione e aggiornamento dei settori scientifico-disciplinari e definizione delle relative declaratorie, ai sensi dell'art. 2 del Decreto Ministeriale 23 dicembre 1999*";

VISTO il D.P.R. 28.12.2000, n. 445, *"Testo Unico delle disposizioni legislative e regolamentari in materia di documentazione amministrativa"* e ss. mm. ii.;

VISTO il D.l g s. 30.03.2001, n. 165, recante norme generali sull'ordinamento del lavoro alle dipendenze delle amministrazioni pubbliche, e ss. mm. ii.;

VISTO il D.lgs. 30.06.2003, n. 196 *"Codice in materia di protezione dei dati personali"* e ss. mm. ii.;

VISTA la Legge 15.04.2004, n. 106, "*Norme relative al deposito legale di documenti di interesse culturale destinati all'uso pubblico*";

VISTA la Legge 30.12.2010, n. 240 "*Norme in materia di organizzazione delle università, di personale accademico e reclutamento, nonché delega al Governo per incentivare la qualità e l'efficienza del sistema universitario*", in particolare l'art. 23, comma 2;

VISTO il Decreto Interministeriale 21.07.2011, n. 313 *"Trattamento economico spettante ai titolari dei contratti per attività di insegnamento – art. 23, comma 2, Legge 30 dicembre 2010, n. 240"*;

VISTO il D.R. n. 582 del 28.09.2018 "*Codice Etico e di comportamento*";

VISTO il vigente Statuto del Politecnico di Bari, emanato con D.R. n. 175 del 14.03.2019, in vigore dal 15.04.2019;

VISTO il "*Regolamento di Ateneo relativo ai ricercatori di ruolo e alla determinazione della retribuzione aggiuntiva ex art. 6, comma 4, Legge 240/10*", emanato con D.R. n. 419 del 06.12.2011;

VISTO il "*Regolamento recante norme per la disciplina dello stato giuridico, diritti e doveri dei professori e dei ricercatori di ruolo*" emanato con D.R. n. 507 del 10.09.2018;

VISTO il "*Regolamento per la disciplina del conferimento di incarichi di insegnamento*", emanato con D.R. n. 283 del 29.07.2014, per la parte analogicamente applicabile alla presente procedura;

VISTO il "*Regolamento Didattico di Ateneo – parte generale – del Politecnico di Bari*", emanato con D.R. n. 385 del 17.07.2015;

VISTO il "*Regolamento dei Corsi di Dottorato di Ricerca del Politecnico di Bari*", emanato con D.R. n. 286 del 01.07.2013;

VISTO il "*Regolamento della Scuola di Dottorato del Politecnico di Bari*", emanato con D.R. n. 145 del 25.02.2020;

VISTA la delibera del Consiglio di Amministrazione del 02.07.2014, relativa al p. 55 *"Ripartizione budget e costo per CFU incarichi di insegnamento"*;

VISTO il D.R. n. 412/2026, con cui è stata decretata la composizione del Consiglio della Scuola di Dottorato e nominato, a far data dal 06.06.2026, Direttore della stessa il Prof. Vito GALLO;

VISTA la nota prot. n. 26173/2026, con cui il Direttore della Scuola di Dottorato, Prof. Vito GALLO, ha chiesto di procedere all'avvio della prima selezione volta al conferimento degli insegnamenti previsti per l'A.A. 2026/2027;

ATTESTATA la sussistenza della copertura finanziaria ai fini degli affidamenti di incarico a titolo oneroso;

E M A N A

per l'A.A. 2026/2027, il seguente bando di selezione per il conferimento degli incarichi di insegnamento, da erogarsi in lingua inglese, presso la Scuola di Dottorato del Politecnico di Bari, elencati nella tabella in calce al presente avviso.

Ai sensi del Regolamento del Politecnico di Bari per la disciplina del conferimento di incarichi di insegnamento emanato con D.R. n. 283 del 29.07.2014, i suddetti incarichi possono essere attribuiti a titolo gratuito o a titolo oneroso.

ART. 1
Requisiti di partecipazione

Possono essere destinatari degli incarichi di cui sopra:

a. professori, ricercatori universitari di ruolo nonché i ricercatori a tempo determinato *ex* art. 24 L. n. 240/2010 in servizio presso il Politecnico di Bari, mediante domanda di affidamento a titolo gratuito o oneroso; gli incarichi a titolo oneroso possono essere conferiti ai professori solo qualora l'impegno didattico da affidare ecceda il loro impegno orario complessivo;
b. professori e ricercatori di altre Università ovvero dipendenti di ruolo di altre Pubbliche Amministrazioni o Enti Pubblici mediante domanda di affidamento a titolo gratuito o oneroso;
c. soggetti in possesso di adeguati requisiti scientifici e professionali, che non rientrano nelle tipologie precedenti, ivi compreso il personale tecnico-amministrativo e i collaboratori ed esperti linguistici di ruolo presso il Politecnico di Bari o altra Università, mediante contratto di diritto privato a titolo oneroso.

Gli incarichi a professori o ricercatori di altre Università, in regime di impegno a tempo pieno, possono essere attribuiti previa acquisizione del nulla osta da parte dell'Ateneo o dell'Amministrazione di appartenenza.

Gli incarichi al personale tecnico-amministrativo e collaboratori ed esperti linguistici possono essere attribuiti previo accertamento dell'assolvimento degli obblighi di servizio presso il Politecnico di Bari.

In applicazione di quanto previsto dall'art. 3, comma 4 del "*Regolamento per la disciplina del conferimento di incarichi di insegnamento*", non sono ammessi a partecipare alle procedure selettive di cui al presente bando coloro che abbiano un grado di parentela o affinità fino al quarto grado compreso con un componente degli organi della Scuola di Dottorato del Politecnico di Bari, ovvero con il Rettore, con il Direttore Generale o un componente del Consiglio di Amministrazione del Politecnico di Bari.

Gli incarichi di insegnamento non sono altresì conferibili a studenti iscritti a corsi di Dottorato di ricerca, con o senza borsa, in adesione a quanto previsto dal vigente "*Regolamento dei Corsi di Dottorato di Ricerca*" (emanato con D.R. n. 288/2022) del Politecnico di Bari.

Questa Amministrazione garantisce parità e pari opportunità tra uomini e donne per l'accesso al lavoro e il trattamento sul lavoro.

ART. 2

Modalità e termini di presentazione della domanda

La domanda di partecipazione, corredata dei titoli, dei documenti e delle eventuali pubblicazioni ritenute utili ai fini della valutazione, deve essere presentata esclusivamente tramite la piattaforma informatica PICA all'indirizzo: https://pica.cineca.it.

La domanda e i relativi allegati devono essere caricati in piattaforma **entro il termine perentorio delle ore 12:00 di lunedì 14.09.2026**. Non sono ammesse modalità di presentazione diverse; non saranno considerate le candidature pervenute oltre il citato termine di scadenza.

Per registrarsi alla piattaforma è necessario disporre di un indirizzo di posta elettronica. Fino alla scadenza è possibile salvare la domanda in modalità "*bozza*"; la candidatura è considerata validamente presentata solo dopo l'invio e il passaggio allo stato "*presentata*". Le domande rimaste in bozza sono considerate non presentate.

La data di presentazione è certificata dal sistema informatico che invia automaticamente una ricevuta all'indirizzo e-mail indicato dal candidato. Decorso il termine di scadenza, non sarà più possibile modificare o inviare la domanda. Il candidato può inoltre ritirare la domanda già presentata e, se il termine non è ancora scaduto, presentarne una nuova.

L'accesso tramite SPID non richiede la sottoscrizione della domanda. Negli altri casi, la domanda deve essere sottoscritta mediante firma digitale oppure, in mancanza, mediante firma autografa sul modulo generato dal sistema, successivamente scansionato e ricaricato in piattaforma in formato PDF.

Eventuali problemi tecnici possono essere segnalati al servizio di Supporto Cineca, reperibile in fondo alla pagina web https://pica.cineca.it/poliba/.

Il candidato dovrà allegare alla domanda di concorso, esclusivamente a mezzo caricamento in piattaforma PICA, la seguente documentazione:

a. *curriculum* dell'attività didattica, scientifica e professionale, redatto in lingua italiana, con l'esplicita indicazione che tutto quanto in esso dichiarato corrisponde a verità ai sensi degli articoli 46 e 47 del D.P.R. n. 445/2000;
b. eventuali documenti e titoli che si ritengono utili ai fini della selezione. Per titoli si intendono, ad esempio, i titoli di studio, qualifiche professionali, titoli di specializzazione, di abilitazione, di formazione, di aggiornamento, ecc.;
c. eventuale elenco delle pubblicazioni scientifiche;
d. copia di un documento di identità in corso di validità.

Non è consentito il riferimento a titoli, certificati, documenti o pubblicazioni già presentati presso questa o altra Amministrazione, o a documenti allegati ad altra domanda di partecipazione ad altra selezione.

Tutti i documenti devono essere allegati in formato PDF-A accessibile; ogni allegato non dovrà superare la dimensione massima indicata in piattaforma.

ART. 3

Valutazione dei candidati e conferimento degli incarichi

La valutazione delle domande sarà correlata alle specifiche esigenze e obiettivi didattici connessi agli insegnamenti o all'attività formativa per i quali è bandita la selezione.

In ogni caso, in via prioritaria, l'assegnazione sarà fatta a professori e ricercatori del Politecnico di Bari, purché in regime di impegno a tempo pieno. La richiesta da parte di docenti del Politecnico di Bari ha precedenza rispetto a quella di docenti di altri Atenei.

Il Consiglio della Scuola di Dottorato valuterà la competenza scientifica e didattica dei candidati in base ai titoli indicati da ciascuno nel proprio *curriculum* e delibererà l'affidamento.

Fermo restando quanto previsto dall'art. 6 del vigente "*Regolamento per la disciplina del conferimento degli incarichi di insegnamento",* il Consiglio della Scuola di Dottorato, avvalendosi eventualmente di apposita Commissione, procederà alla valutazione comparativa dei candidati sulla base di:

a. *curriculum* didattico scientifico;
b. eventuali pubblicazioni;
c. competenze possedute;
d. altri titoli;
e. "*Opinione degli Studenti*" nel caso che il candidato abbia ricoperto l'incarico dell'insegnamento richiesto nei precedenti anni accademici.

Il possesso del titolo di Dottore di Ricerca, dell'abilitazione ovvero di titoli equivalenti conseguiti all'estero, costituisce titolo preferenziale, per i soggetti non professori o ricercatori universitari, ai fini dell'attribuzione del contratto di cui all'art. 23, comma 2 della Legge n. 240/2010.

Costituirà ulteriore elemento di giudizio, oltre a quelli indicati alle lettere da a) a e) del presente comma, l'elevata qualificazione professionale.

Nel caso di partecipazione di un unico candidato per insegnamento, il Consiglio della Scuola di Dottorato valuterà l'idoneità e delibererà in merito all'affidamento.

Qualora vi siano più candidati per il medesimo incarico di insegnamento, la procedura selettiva sarà svolta da una Commissione composta dai Coordinatori dei Dottorati di Ricerca afferenti alla Scuola e dal Direttore della stessa, in qualità di Presidente. Ultimata la procedura selettiva, la Commissione formula al Consiglio della Scuola di Dottorato una motivata graduatoria dei candidati idonei.

La graduatoria ha validità esclusivamente per l'A.A. 2026/2027. In caso di rinuncia o di risoluzione del rapporto nel corso dell'anno accademico, l'incarico può essere conferito ad altro idoneo, secondo l'ordine di graduatoria. La graduatoria sarà resa pubblica sul sito web www.poliba.it, sezione "*Albo online*", il giorno dopo l'approvazione da parte del Consiglio della Scuola di Dottorato, nella prima seduta utile dopo la scadenza dei termini.

La graduatoria sarà considerata definitiva qualora, decorsi cinque giorni dalla data di pubblicazione della medesima, non siano state presentate istanze di revisione da inviare al Direttore della Scuola di Dottorato presso l'Amministrazione Centrale del Politecnico di Bari sita in via Amendola, 126/B – 70126 Bari, con le stesse modalità di presentazione della domanda di cui all'art. 2, precisando sulla busta, in caso di spedizione a mezzo servizio postale, la dicitura "*Ricorso relativo alla graduatoria della procedura selettiva per il conferimento dell'incarico di insegnamento di " _____ " A.A. 2026/2027*", presso la Scuola di Dottorato del Politecnico di Bari.

Il conferimento degli incarichi di cui al presente avviso sarà subordinato alla conclusione dell'iter di accreditamento, per l' A.A. 2026/2027, dei Corsi di Dottorato di Ricerca con sede amministrativa presso il Politecnico di Bari.

Questa amministrazione, pertanto, non provvederà alla formalizzazione degli incarichi in caso di mancato accreditamento del relativo ciclo dei Corsi di Dottorato, ovvero di modifiche sostanziali degli insegnamenti erogabili, incompatibili con quanto previsto dalla tabella allegata al presente decreto.

Qualora, quindi, venga meno la necessità, la convenienza o l'opportunità, il Politecnico di Bari si riserva di non procedere al conferimento dell'incarico.

ART. 4
Diritti e doveri

Il soggetto cui è affidato l'incarico è tenuto all'osservanza dei doveri previsti dal Regolamento didattico di Ateneo, dal Regolamento di Ateneo recante norme per la disciplina dello stato giuridico, diritti e doveri dei professori e ricercatori di ruolo e dal Regolamento dei Corsi di Dottorato di Ricerca afferenti alla Scuola di Dottorato del Politecnico di Bari, accettandone il calendario delle attività didattiche nonché l'architettura didattica del corso con particolare riferimento alle lezioni, esercitazioni e seminari, al tutorato, al ricevimento ed all'assistenza agli studenti, alla partecipazione all'esame finale, nonché alla presentazione della documentazione dell'attività svolta.

Il collaboratore non può svolgere attività in concorrenza con il committente né diffondere notizie ed apprezzamenti attinenti ai programmi ed alle organizzazioni di esso, né compiere atti in pregiudizio dell'attività del committente medesimo.

È fatto divieto di *"prestare consulenza o collaborazione all'attività didattica e assistenza alla preparazione di esami universitari, alla redazione di tesi e progetti di tutorato a favore di società o enti che prestino servizi a pagamento agli studenti"* ovvero agli studenti stessi del Politecnico di Bari.

Tanto al fine di escludere che siano perseguiti interessi diversi da quelli del Politecnico di Bari, al fine di trarne vantaggio per sé o per altri.

Il docente a contratto è tenuto ad eseguire personalmente la prestazione.

La stipula dei contratti per attività di insegnamento non produce diritti in ordine all'accesso ai ruoli universitari.

Il soggetto cui è affidato un incarico di docenza assume la qualifica di "*professore a contratto*" per il solo periodo di svolgimento dell'attività, salvo quanto previsto per i ricercatori a tempo indeterminato, agli assistenti del ruolo ad esaurimento, ai tecnici laureati *ex* art. 50, D.P.R. n. 382/80, nonché ai professori incaricati stabilizzati che hanno svolto tre anni di insegnamento ai sensi dell'art. 12, L. n. 341/90, e dall'art. 6, comma 4, L. n. 240/2010.

Il docente a contratto è tenuto a prestare la propria opera per tutto l'anno accademico e in accordo con le specificità dell'organizzazione temporale del corso di studi e a presiedere le commissioni d'esame relative all'anno accademico per il quale è stipulato il contratto; a tali contratti si applicano gli artt. 2230 e ss. c.c..

Per tutti i soggetti titolari di un incarico, in riferimento al periodo della prestazione, il Politecnico di Bari provvede direttamente alla copertura assicurativa per gli infortuni e responsabilità civile verso terzi.

ART. 5
Compenso

Gli incarichi a titolo oneroso di cui alla presente selezione, saranno retribuiti, in conformità al Decreto Interministeriale n. 313 del 21 luglio 2011 e giusta delibera del Consiglio di Amministrazione del 02.07.2014, con il seguente costo orario:

- **€ 25,00/ora** per incarichi di insegnamento attribuiti a professori e ricercatori del Politecnico di Bari o di altre Università ed esperti esterni di alta qualificazione, relativi ad insegnamenti per cui siano stati registrati, nel triennio accademico precedente, un numero di esami minore o uguale a 80 esami/anno;
- **€ 30,00/ora** per incarichi di insegnamento attribuiti a professori e ricercatori del Politecnico di Bari o di altre Università ed esperti esterni di alta qualificazione relativi ad insegnamenti per

cui siano stati registrati, nel triennio accademico precedente, un numero di esami maggiore a 80 esami/anno.

La liquidazione dei compensi è subordinata all'attestazione ai fini della normativa vigente e in regime di autocertificazione, da parte del contraente/affidatario, dell'avvenuto completamento del carico didattico svolto nell'anno accademico di riferimento.

Il docente del Politecnico di Bari a cui sia stato affidato l'incarico può, a sua scelta, rinunciare alla corresponsione del relativo compenso e richiederne la devoluzione alla Struttura di appartenenza per l'utilizzo dello stesso per proprie finalità di ricerca.

ART. 6
Trattamento dei dati personali

I dati personali trasmessi dai candidati con le domande di partecipazione alla selezione, relativi allegati e C.V., saranno trattati esclusivamente ai sensi del D.lgs. n. 196 del 30.06.2003, così come modificato dal D.lgs. n. 101 del 10.08.2018 e integrato dalle disposizioni del Regolamento UE 2016/679 (GDPR), per le finalità di gestione della presente procedura selettiva. Il conferimento di tali dati è obbligatorio ai fini della valutazione dei requisiti di partecipazione, pena l'esclusione dalla selezione.

L'interessato gode dei diritti di cui alle sopra citate norme.

ART. 7
Disposizioni finali e pubblicità

Per tutto quanto non previsto dal presente bando e per quanto compatibile, si applica la vigente normativa universitaria, nonché il "*Regolamento per la disciplina del conferimento di incarichi di insegnamento*" emanato con D.R. n. 283 del 29.07.2014.

Il presente bando è pubblicizzato per via telematica sul sito web del Politecnico di Bari www.poliba.it.

Per ogni ulteriore informazione rivolgersi alla Responsabile del procedimento, Dott.ssa Nadia GIORGIO – e-mail: nadia.giorgio@poliba.it – tel. 080 596 3034.

Bari,

Il Rettore
Prof. Ing. Umberto FRATINO

Fratino Umberto
06.08.2026
11:48:23
GMT+02:00

Direzione per gli Affari Interni
Settore Reclutamento, Carriere e Formazione del personale
Ufficio Contratti di Lavoro Autonomo e Borse di Studio

R.P.A.	Responsabile di Ufficio	Responsabile del Settore
f.to *Dott.ssa Nadia GIORGIO*	f.to *Dott.ssa Luciana CAMPOBASSO*	f.to *Sig. Michele DELL'OLIO*

SCUOLA DI DOTTORATO

Elenco degli insegnamenti

ScuDo POLIBA

Anno accademico 2026/2027

Politecnico di Bari

Politecnico di Bari
Via Edoardo Orabona, 4
70126 Bari BA, Italia

tel +39 0805962111 - post-lauream@poliba.it
www.poliba.it

Indice dei corsi di dottorato

Anno accademico 2026/2027

Corso di dottorato	Pagina
DCMCEI	3
CTI	14
DRIEI	28
DRIG	46
DRIME	61
DRISA	73
DRISS	85
DRSATE	99
SSI	113
DAuSy	125
Insegnamenti trasversali ScuDo	139

CORSO DI DOTTORATO: DCMCEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Advanced Transportation Accessibility-Equity Assessment**						
SSD	CEAR-03/B	**Ore**	20	**CFU**	2	**Anno/Semestre**	First/First
Livello 2026/2027		2		**Paniere 2026/2027**		2	
Obiettivi							
The final scope is to equip students with advanced analytical tools and critical perspectives essential for addressing the interplay between transportation systems and social equity in diverse territorial contexts.							
Syllabus							
This course delves into the field of Transport Accessibility and Equity Assessment, providing an in-depth exploration of key concepts, methodologies and tools. The aims of the course are: Exploring the Principles of Accessibility-Based Transportation Planning (e.g., 15 minutes city); Utilizing Evaluation Tools and Performance Indicators for Measuring Progress Toward Transportation Equity Goals (e.g., threshold measures, gravity measures, PTAL, Lorenz Curve, Gini Index); Provide with transportation policy evaluation tools that account for the costs and benefits of equitable planning (e.g. through cost-benefit analysis and multicriteria evaluations).							
Bibliografia							
Scientific papers, slides and support material from the lecturer							

CORSO DI DOTTORATO: DCMCEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Complex Network Theory: Theory, Methods and Applications						
SSD	CEAR-01/B	Ore	20	CFU	2	Anno/Semestre	First
Livello 2026/2027		2		Paniere 2026/2027		7	

Obiettivi

The integration of both mathematical and technical tools, as well as the growing availability of data, make it possible to study and interpret an enormous number of complex systems, where the main component is topology, that is, the way in which elements are connected and interact with each other. This course offers an overview of all the Complex Network Theory tools and their use in the study and analysis of real systems from a topological perspective, starting from water systems, which represent complex networks composed of several interconnected components, structured in non-trivial configurations, whose behavior is largely influenced by their connective structure, spatial limits, and interactions between components. This course aims to address the following points: − Introduction to CNT. Euler and the problem of the Königsberg bridges. Graphical representation and adjacency matrix. Basic concepts and study of topological properties. − Centrality metrics as tools to identify the most important elements in complex real systems. Degree, Betweenness, Closeness and Harmonic. − Construction of predictive models for understanding complex real systems. How the connective structure is fundamental to determine vulnerability and robustness. Regular, random, small-world (principle of six degrees of separation) and scale-free networks. − Communities and clustering for system analysis and management. Detecting the presence of communities is essential for discovering the internal connections of complex structures and facilitating practical applications in many disciplines. − Time series and their representation in CNT: Visibility algorithms. Overview of the different fields of application: social systems, road networks, distribution systems, biological organisms, technological networks, computer networks, epidemiology, etc.

Syllabus

This course aims to address the following points: − Introduction to CNT. Euler and the problem of the Königsberg bridges. Graphical representation and adja-cency matrix. Basic concepts and study of topological properties. − Centrality metrics as tools to identify the most important elements in complex real systems. Degree, Betweenness, Closeness and Harmonic. − Construction of predictive models for understanding complex real systems. How the connective structure is fundamental to determine vulnerability and robustness. Regular, random, small-world (principle of six degrees of separation) and scale-free networks. − Communities and clustering for system analysis and management. Detecting the presence of communities is essential for discovering the internal connections of complex structures and facilitating practical applications in many disciplines. − Time series and their representation in CNT: Visibility algorithms. Overview of the different fields of application: social sys-tems, road networks, distribution systems, biological organ-isms, technological networks, computer networks, epidemiology, etc.

Bibliografia

Scientific papers, slides and support material from the lecturer.

CORSO DI DOTTORATO: DCMCEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Innovative and recyclable methods and materials for Engineering applications**						
SSD	MATH-04/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	First/First
Livello 2026/2027		2		**Paniere 2026/2027**		6	

Obiettivi

The course aims to provide PhD students with advanced knowledge and tools for the design, characterization, and modeling of innovative and recyclable materials for Civil Engineering applications. Emphasis will be placed on the multiscale nature of such materials and on the integration of physics-based and data-driven approaches to describe their thermo-hygro-mechanical behavior. Students will gain familiarity with the fundamental mechanisms governing damage and degradation processes, as well as with modern modeling strategies that combine continuum mechanics, bio-inspired design concepts, and machine learning techniques. The ultimate goal is to promote a multidisciplinary understanding of sustainable materials, enabling the development of new solutions for resilient and environmentally responsible civil engineering systems.

Syllabus

1. Multiscale methods for the design and characterization of innovative and recyclable materials; 2. Thermo-hygro-mechanical properties of innovative and bio-inspired materials for Civil Engineering; 3. Damage effects induced by temperature, mechanical stress and chemical phenomena; 4. Design and characterization of materials with complex structures based on data modelling approaches.

Bibliografia

Ashby, Michael F., and David RH Jones. "Engineering Materials 2: An introduction to microstructures." Processing and Design 3 (2005). Chapters 21 to 24. Beatty, M. F. (1987). "Topics in Finite Elasticity: Hyperelasticity of Rubber, Elastomers, and Biological Tissues—With Examples." ASME. Appl. Mech. Rev. December 1987; 40(12): 1699–1734. De Tommasi, D., Puglisi, G., & Saccomandi, G. (2015). Multiscale mechanics of macromolecular materials with unfolding domains. Journal of the Mechanics and Physics of Solids, 78, 154-172. O. Giustolisi D. A. Savic: A symbolic data-driven technique based on evolutionary polynomial regression. Journal of Hydroinformatics, 8(3):207–222, 2006

CORSO DI DOTTORATO: DCMCEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Smart IoT Systems for the Digital and Green Transition**						
SSD	IINF- 03/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	First
Livello 2026/2027		2		**Paniere 2026/2027**		3	

Obiettivi

The course aims to equip Ph.D. students with an in-depth understanding of the Internet of Things (IoT) ecosystem, including device design, communication protocols, data acquisition, and modern network architectures such as cloud, edge, and fog computing. It emphasizes IoT applications across diverse domains, scalability and reliability considerations, and security frameworks and standards. By the end of the course, students will be able to design, implement, and secure IoT solutions for research and real-world applications

Syllabus

1. Introduction to IoT (3 Hours) • Overview of Computer Networking and Internet Ecosystem • IoT Device Design and Development • IoT Communication Cycle • Applications of IoT Across Domains • Importance of Smart Infrastructure
2. Sensors and Data Acquisition (3 Hours) • IoT Components and Scope • Role of Sensors in IoT Applications • Data Acquisition Techniques • Sensor Deployment and Monitoring Concepts
3. IoT Communication Protocols and Standards (6 Hours) • 6LoWPAN and IoT Protocol Stack • Wireless Technologies for IoT • Scalability and Reliability Considerations
4. Modern Network Architectures: Cloud, Edge, and Fog (3 Hours) • Cloud Computing Fundamentals • Edge and Fog Computing Concepts • Cloud Services: SaaS, PaaS, IaaS • Cloud Deployment Models: Public, Private, Community, Hybrid • Cloud Architecture Standards (NIST, ITU-T)
5. IoT Security (5 Hours) • Fundamental Security Requirements • ETSI Security Perspective • ITU-T Security and Privacy Requirements • IoT Security Framework • Cloud Security: Issues, Concerns, and Data Protection

Bibliografia

CORSO DI DOTTORATO: DCMCEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Elements of digital transition in civil engineering						
SSD	CEAR-01/B	Ore	20	CFU	2	Anno/Semestre	Second/First
Livello 2026/2027		3		Paniere 2026/2027		/	

Obiettivi

The course is designed to provide a solid foundation for applying key machine learning and data modelling techniques within the civil and environmental engineering sectors. It introduces the history and defining features of the digital transition, along with its main tools, such as complex network theory, artificial intelligence, and multi-objective optimization, that underpin modern machine learning approaches. These concepts will be presented to equip students with practical insights for real-world applications in civil engineering. Participants will gain hands-on experience with machine learning methods, focusing on ANN-MOGA and EPR-MOGA. The course will also cover essential steps for building databases that support data-driven modelling, as well as techniques for data interpretation and analysis. The ultimate goal is to enable PhD students to develop effective, transferable solutions that implement efficient processes for addressing diverse technical challenges. Advanced case studies in civil and environmental engineering may be used in class as reference points, actively engaging students in the application of ANN-MOGA and EPR-MOGA to realworld problems. Students are strongly encouraged to bring input–output datasets from physical phenomena relevant to civil engineering for use in the in-class exercises.

Syllabus

The programme addresses digital transition in civil engineering through complex networks, artificial intelligence, machine learning and multi-objective optimization. It includes ANN-MOGA, EPR-MOGA, database development, data-driven modelling, data analysis and interpretation. Practical exercises on real datasets help students understand tools, methods and use cases for solving complex, real-world engineering problems effectively

Bibliografia

Scientific papers, slides and support material from the lecturer.

CORSO DI DOTTORATO: DCMCEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Innovation of business models in the civil infrastructure sector**						
SSD	IEGE-01/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**		/	

Obiettivi

This module aims to provide concepts, approaches and techniques for the generation, management, analysis and innovation of business models in the civil infrastructure sector. Specifically, during the course the main reference frameworks for the definition of a business model will be presented as well as the patterns of existing business models with particular focus on the civil infrastructure sector. The innovation dynamics of business models will also be explored in depth, providing useful elements for structuring the evolution process, especially in reference to the adoption of the most recent digital technologies enabling a digital innovation path in the civil infrastructure sector. The module will include alternating theoretical lessons with practical sessions (examples, case studies and project work). Below is the summary structure of the module: − Business models (definitions and frameworks). − Business model patterns (with focus on the civil infrastructure sector). − Innovation of business models and digital innovation in the sector.

Syllabus

The programme alternates theoretical lessons and practical sessions, including examples, case studies and project work. It covers business model definitions and frameworks, business model patterns with specific attention to civil infrastructure, and processes for innovating business models through digital innovation enabled by recent technologies in the civil infrastructure sector applications.

Bibliografia

Scientific papers, slides and support material from the lecturer.

CORSO DI DOTTORATO: DCMCEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Innovative approaches and digital tools for ecological land planning**						
SSD	CEAR-12/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**		/	

Obiettivi

The contribution of land planning to climate adaptation and mitigation strategies: − The challenges of climate change to land planning; − The role of cities in adaptation and mitigation policies; Approaches and tools for ecological planning: − Different interpretations of the ecological transition in the plans: modernization vs. capitalization; − Nature-based solutions in city planning; − The urban bioregion: eco-territorial approach, ecosystem services, multifunctionality; Potential and critical elements of the digital transition to support ecological planning: − GIS/webgis, open data, social networks, etc. to support inclusive approaches to planning, coordination between Public Administration sectors dealing with territorial governance, sharing and transparency of decisions and monitoring systems; − Digital divide, difficulty in involving users in the creation and use of digital systems, data updating.

Syllabus

The programme covers climate change challenges for land planning, cities' adaptation and mitigation roles, ecological-transition interpretations, nature-based solutions, and eco-territorial approaches. It also examines GIS, WebGIS, open data and social networks for participation, interdepartmental coordination, decision transparency and monitoring, alongside digital-divide issues, user engagement and data updating processes and practices.

Bibliografia

Scientific papers, slides and support material from the lecturer.

CORSO DI DOTTORATO: DCMCEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Low carbon structural design and retrofitting of concrete infrastructures using advanced composites**						
SSD	CEAR-07/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second/Second
Livello 2026/2027		3		**Paniere 2026/2027**		/	
Obiettivi							
The main contents of the course are: − Introduction to low-carbon structural design. − Fibre-Reinforced Materials in civil engineering construction. − Innovative reinforcement for resilient concrete structures. − Retrofitting concrete structures using advanced composites.							
Syllabus							
The programme covers four main topics: introduction to low-carbon structural design; fibre-reinforced materials in civil engineering construction; innovative reinforcement for resilient concrete structures; and retrofitting of concrete structures using advanced composites. These contents frame the course around sustainable structural solutions and composite-based strengthening techniques for concrete infrastructure applications and rehabilitation.							
Bibliografia							
Scientific papers, slides and support material from the lecturer.							

CORSO DI DOTTORATO: DCMCEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Meteomarine forcing and design of maritime constructions**						
SSD	CEAR-01/B	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second/First
Livello 2026/2027		3		**Paniere 2026/2027**		/	

Obiettivi

The course aims to provide the first basic preparatory knowledge of the marine environment (study of waves, currents, transport, sediments, etc.) and the elements necessary for the design of maritime works, both port and coastal defense against erosion. During the course, the interaction between the fundamental physical phenomena and their description through analytical models, long-term statistical analysis for the evaluation of extreme events and the numerical approaches used in the field of coastal engineering to evaluate the environmental loads on structures induced by waves, currents and wind. The course will also deal with the resilience of coastal structures to climate change (e.g., sea level rise and increase in extreme sea storms), with reference to current design criteria and future research developments.

Syllabus

➢ Lesson 1 Wave mechanics and wave transformation processes from deep water to shallow water ➢ Lesson 2 Design principles of coastal and port structures (statistical analysis of extreme events - calculation of loads for the design of structures - wave/structure interaction) ➢ Lesson 3 Effects of climate change on the design and management of coastal and port structures. ➢ Lesson 4 Advanced mathematical models and numerical approaches in coastal engineering ➢ Lesson 5 Hands on Coastal Modelling

Bibliografia

Coastal Engineering Manual

CORSO DI DOTTORATO: DCMCEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Open Source and Innovative tools for simulating transport systems**						
SSD	CEAR-03/B	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second/First
Livello 2026/2027		3		**Paniere 2026/2027**		/	
Obiettivi							
The aim of this course is to equip participants with a good under standing of innovative and Open-Source tools specifically de signed for simulating transport systems to analyse performances of new technologies and digitalization of transport infrastructure and systems.							
Syllabus							
The course will delve into: − the role of digital twins in simulating real-world transport scenarios. − advanced methodologies for harnessing and analysing extensive datasets (Big data) to understand mobility phenomena. − command-line interface (CLI) tools, primarily controlled by typing commands (e.g. SUMO, Python, R). − graphical user interface (GUI) tools, primarily controlled by point and clicking (e.g. AequilibraE, QGIS). − web application programming interfaces (API) and web user interface (WUI) tools During the course participants will gain knowledge on these tools to mapping and simulate transport system, fostering a good grasp of their application in achieving efficiency and sustainability within the mobility planning sector.							
Bibliografia							
Scientific papers, slides and support material from the lecturer.							

CORSO DI DOTTORATO: DCMCEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Road infrastructure for intelligent mobility**						
SSD	CEAR-03/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second/First
Livello 2026/2027		3		**Paniere 2026/2027**		/	
Obiettivi							
The course aims to illustrate the main techniques and technolo-gies for the construction and management of road infrastructures in the presence of connected, automatic and semi-automatic vehicles (Smart roads, Smart tunnels, ITS, C ITS, adaptive lanes, etc.). The problems linked to the technological transition will also be il-lustrated with reference to both the existing road heritage and the coexistence of vehicles with different technological capabilities.							
Syllabus							
Introduction: Smart Roads and Smart Mobility. Smart Roads' Regulations and Characteristics of a Smart Road Connected and Autonomous Vehicles (CAVs) Road Safety in presence of CAVs Road Safety Assessment Examples in presence of CAVs							
Bibliografia							
• Le Smart Road: stato dell'arte e scenari futuri (10.1007/978-3-031-96144-1)							

CORSO DI DOTTORATO: CTI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Contextual Design and Heritage: identity and material culture of the territories**						
SSD	CEAR-08/D	**Ore**	20	**CFU**	2	**Anno/Semestre**	First
Livello 2026/2027		2		**Paniere 2026/2027**		5	

Obiettivi

The course aims to explore the role of design in the enhancement of material culture as recommended by the 2003 UNESCO Convention for the Safeguarding of the Intangible Cultural Heritage, with a particular focus on Southern Contexts. The “intangible cultural heritage means the practices, representations, expressions, knowledge, skills – as well as the instruments, objects, artefacts and cultural spaces associated therewith – that communities, groups and, in some cases, individuals recognize as part of their cultural heritage”. The Heritage dimension proposed by the UNESCO Convention is a “phenomenal extension” of the field of knowledge, conservation, enhancement and re-activation of material culture in which contextual design is developing a prominent role. Contextual Design is an important field of contemporary research developed in North Europe, in the Design Academy of Eindhoven. The aim is to investigate the meaning of the material and immaterial artifacts of design in relation to the identities of the territories and to the historical and cultural stratification that distinguishes them. Contextual Design and Cultural Heritage thus become a strategic combination to face the modern challenges of enhancing territorial contexts against the current phenomena of globalization and spectacularization of culture.

Syllabus

- Theoretical frameworks of contextual design and cultural heritage. - UNESCO Convention for the Safeguarding of the Intangible Cultural Heritage (2003) and its implications for design research. - Material and immaterial dimensions of territorial identity. - Design strategies for the enhancement, conservation and re-activation of cultural heritage. - Contextual design methodologies and place-based approaches. - Contemporary case studies on heritage-led regeneration, with particular reference to Southern European contexts. - Workshops and seminar discussions on design as a tool for preserving and interpreting local identities.

Bibliografia

CORSO DI DOTTORATO: CTI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Design for Historical and Contemporary Heritage Landscapes**						
SSD	CEAR-09/A	**Ore**	20	**CFU**	1	**Anno/Semestre**	First/Second
Livello 2026/2027		2		**Paniere 2026/2027**		5	

Obiettivi

KNOWING AND TRANSFORMING A HERITAGE LANDSCAPE The course has as the aim to extend the idea of heritage from the architectural dimension to that of the landscape and therefore to bring the value of the individual artifact back to that of the historical and cultural context in which it is located. Through the lessons, we will try to identify interpretative categories necessary for the recognition of a physical and semantic connection between "things" that, read together, contribute to the recognition of a unitary condition of built heritage landscape. It is mainly on the basis of these assumptions that the course intends to investigate theories and design techniques aimed at the conservation, enhancement and resignification of landscapes. Furthermore, in order to grasp the meaning of some forms that have sedimented within heritage landscapes, we will try to grasp the profound formal meaning of some heritage landscapes through the exercise of "reading" technical cartography and historical maps. All that, keeping in mind that “reading” is inevitably a critical interpretation and that we read things with our eyes and elaborate images with the mechanisms that our mind, unique and unrepeatable, uses in its design.

Syllabus

I LEZIONE I paesaggi patrimoniali della Mongolia_Mongolia heritage landscapes II LEZIONE Il paesaggio patrimoniale della Valle d’Itria. Esercizio di lettura tipo-morfologica Valle d’Itria Heritage Landscape. Exercise in Typo-Morphological Reading III LEZIONE Progetto per il Tratturo della Traiana a Canosa di Puglia (Lezione/sopralluogo) IV LEZIONE_ L’”Inquerito sobre á arquitectura popular portuguesa” o la ricerca di una poetica in Tavora e Siza. La Casa del Tè a Boa Nova come paradigma di integrazione tra architettura e paesaggio. The “Inquerito sobre á arquitectura popular portuguesa” or the search for a poetics in Tavora and Siza. The Tea House in Boa Nova as a paradigm of integration between architecture and landscape V LEZIONE Attività laboratoriale_Esercizio di lettura cartografica del paesaggio patrimoniale del Basso Salento Laboratory activity Exercise in cartographic reading of the heritage landscape of the Lower Salento VI LEZIONE_ Attività laboratoriale_Esercizio di lettura cartografica del paesaggio patrimoniale del Basso Salento Laboratory activity Exercise in cartographic reading of the heritage landscape of the Lower Salento

Bibliografia

CORSO DI DOTTORATO: CTI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Historical research and study of the Ancient architecture**						
SSD	CEAR-11/A / ARCH-01/D	**Ore**	20	**CFU**	2	**Anno/Semestre**	First/Semester
Livello 2026/2027		2		**Paniere 2026/2027**		5	

Obiettivi

The Historical Research and the Study of Ancient Architecture course offers a comprehensive exploration of the architectural and urban developments that defined the ancient Mediterranean. Through a thematic and chronological approach, PhD students will examine case studies spanning from the Archaic period to Late Antiquity, focusing on how architectural elements reflect cultural, political, and economic shifts. The course begins with the study of Agrigento's architectural ornamentation, revealing the stylistic evolution of Sicilian cities from early Greek influences to Romanization. Moving eastward, we analyze the urban design and monumental aspects of ports in the eastern Mediterranean during the Hellenistic and Imperial periods, examining how these spaces balanced functionality with grandeur to serve regional power dynamics. Further discussions center on the interplay between theater, palace complexes, and royal power in Hellenistic capitals, highlighting how architecture was used to craft landscapes of influence and authority. In the early Imperial Hispania, students will delve into forensic typology, applying both traditional and innovative methodologies to understand civic space organization. This is complemented by an examination of Italic Hellenistic architecture, which emphasizes the integration of regional construction practices with multidisciplinary research approaches. The course culminates with a study of Late Antique monumental spaces, exploring recent research on the transformation of civic and aesthetic frameworks in the urban centers of this era. Through lectures, discussions, and case studies, students will gain an in-depth understanding of how architecture shaped—and was shaped by—the historical narratives of ancient Mediterranean societies. At the end of the course, a roundtable discussion will allow participants to engage with each other and synthesize their insights on the broader themes of the course.

Syllabus

"The Most Beautiful Among Mortal Cities: Architectural Decoration in Sicily from the Archaic Age to Romanization. The Case of Agrigento" "The Theatre and the Basileus. The Creation of a Landscape of Power in the Hellenistic Capitals" "Ἔργον δὲ μέγα ἦ βασίλειον. Urban Design and Monumental Aspects of Ports in the Eastern Mediterranean between the Hellenistic and Imperial Ages" "Monumental Space in the Late Antique City: Approaches, Methodologies, and Research Results" "Buildings for Munera and Venationes in the Greco-Roman East: Amphitheatres, Hybrid Buildings, and Repurposed Buildings" "Excelsissimi loci. Tools and Methods for the Study of Forum Typology in High-Imperial Hispania"

Bibliografia

CORSO DI DOTTORATO: CTI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Stereotomic Design. New frontiers of stone architecture**						
SSD	CEAR-09/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	First
Livello 2026/2027		2		**Paniere 2026/2027**		8	
Obiettivi							
The course aims to show the unexpressed potential of the structural stone for contemporary architecture. The whole course will be divided into three parts: a first historical introduction and evolution of stereotomic architecture; a second part relating to the three-dimensional infographic parametric/variational modeling techniques of complex vaulted spaces; and a last part relating to the realization of design' projects by the students reviewed by the teacher. The best projects will be 3D printed or real-dimension built and exhibited in the most important trade fairs of the sector							
Syllabus							
Introduction to Stereotomy - Definition of stereotomy - Historical overview - Selected case studies and applications Design Approach - Fundamentals of 3D modeling (Rhinoceros) - Introduction to parametric modeling and form finding (Grasshopper) Hands-on Design Session - Development of a 3D model of a stereotomic vault by the students - Optional 3D printing of a scaled physical prototype							
Bibliografia							

CORSO DI DOTTORATO: CTI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Theories and methods in structural design: modeling and experimental issues**						
SSD	CEAR-06/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	First
Livello 2026/2027		2		**Paniere 2026/2027**		1	
Obiettivi							
The shape of masonry constructions and the influence of the curvature in the load bearing capacity of arches, domes and vaults. Seismic actions and masonry constructions. Mechanical behavior of masonry: heterogeneity, different behavior in tension / compression, non-linear mechanical response, anisotropy, failure modes, damage. Modeling strategies: micromechanical models, FEM and DEM implementation of micromechanical models, macro-mechanical models, multiscale models, NT (No-Tension) and RNT (Rigid No Tension) models, macro-elements. Limit Analysis: static and kinematic approaches. From the static approach of Limit Analysis to the relation between shape and structures in masonry arches and vaults (and back to graphic statics).							
Syllabus							
The classroom activities will deal with: - Influence of the curvature in the capacity of arches, domes and vaults - Seismic actions and masonry constructions - Dynamic behavior of masonry constructions - Implementation in Matlab of rocking models - Examples							
Bibliografia							

CORSO DI DOTTORATO: CTI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Theories and methods of design for the Antique**						
SSD	CEAR-09/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	First/First
Livello 2026/2027		2		**Paniere 2026/2027**		5	
Obiettivi							
The course aims to investigate some of the topics about Design for the Antique, focusing on the works of some Masters of Architecture of Modernity and Contemporary ages. Its goal is a reflection on their theoretical background and their composition techniques and methods.							
Syllabus							
- Lesson 1 (07/04/2026): Composing with fragments / For a topology of Time - Lesson 2 (14/04/2026): Excavate to know, excavate to transform - Lesson 3 (21/04/2026): Protect and Rebuild: topics of Archaeological shelters - Lesson 4 (28/04/2026): For an idea of composite form - Lesson 5 (05/05/2026): Between Archaeology and Landscape - Lesson 6 (12/05/2026): Debris - Lesson 7 (15/05/2026): The survival of the Antique. The agency of ruins in archaeological design (seminar with prof. Monica Centanni, et al.)							
Bibliografia							
1. Augé, M. (2004), Rovine e macerie. Il senso del Tempo, Bollati Boringhieri 2. Ricci, A. (2006), Attorno alla nuda pietra. Archeologia e città tra identità e progetto, Donzelli 3. Ugo, V. (2010), Architettura e Temporalità, Unicopli							

CORSO DI DOTTORATO: CTI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Theories and techniques of the project for the fragile cities and territories**						
SSD	CEAR-09/A	**Ore**	20	**CFU**	1	**Anno/Semestre**	First
Livello 2026/2027		2		**Paniere 2026/2027**		6	

Obiettivi

The recent disastrous phenomena, accentuated by atmospheric changes as well as by neglect and improper transformation processes, have highlighted the fragility of our cities and our territories, especially those of the so-called “inland areas”. The awareness that not only human lives and production activities are at risk but also the identity of the places is growing stronger and, for this reason, a paradigm shift for the safety and risk mitigation project is required. The course will illustrate an innovative approach aimed to combine Safety and Identity, based on the conception of the project of mitigation of risks (seismic, hydrogeological) as an opportunity of strengthening of the identity characters of fragile cities and territories. According to this approach, the safety works built in order to mitigate the hydrogeological risk can define a place in the landscape as well as “monumentalize” its natural forms. The project of mitigation of the seismic risk of the urban fabric of the Apennine cities could be an occasion to renovate the form of the city itself and its spaces. Indeed, combining safety and identity means convert the technical forms of the safety project into architectural forms, capable to exalt the characters of the places that they transform.

Syllabus

- Theories and principles for the design of fragile cities and territories. - Risk assessment and mitigation strategies for seismic, hydrogeological and climate-related hazards. - The relationship between safety, identity and landscape transformation. - Design approaches for resilient urban and territorial regeneration. - Architectural and urban design strategies for inland areas and vulnerable settlements. - Analysis of national and international case studies on risk mitigation and territorial enhancement. - Seminar discussions on resilience, sustainability and place-based design.

Bibliografia

CORSO DI DOTTORATO: CTI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Analysis and representation techniques for architectural research						
SSD	CEAR-10/A	Ore	20	CFU	2	Anno/Semestre	Second/Second
Livello 2026/2027		3		Paniere 2026/2027		-	

Obiettivi

The course aims to stimulate a critical attitude in the study of the city and architecture, providing to the young researcher a repertoire of analysis techniques and representation models to support research. The techniques of survey of the existing, laser scanner and photo-modeling, are joined to those of the inexistent, graphic analysis and graphic reconstruction, providing the tools and methods for a research of architectures in praesentia that can be studied and analyzed also metrically, that those in absentia designed and never realized. The course aims to analyze and graphically return the different components of architecture and the city, and with the tools of drawing and modeling investigate the historical / evolutionary process or the ideation / composition process too. These are fundamental cognitive moments for the study of an architecture or a part of the city and at the same time to analyze the complex personality of its author. Practical exercises alternate with lectures encouraging young researchers to use the techniques of analysis and graphic representation, articulating and stimulating their critical skills in reading an architecture and / or the city or a portion of it.

Syllabus

The following topics will be covered by proposed course: - Introduction to digital surveying with a focus on aerial and terrestrial photogrammetry. - Overview of basic mathematical tools for stereoscopic restitution and potential errors. Coordinate systems used in photogrammetry. - Notes on photographic techniques and color theory. Digital images: acquisition and geometric and radiometric characteristics, image processing and analysis techniques. - Camera orientation procedures. - Introduction to terrestrial laser scanning, a complementary technique to photogrammetry for creating 3D surveys in construction, architectural, and industrial contexts. - Survey campaign design for buildings with simple and complex geometry. - Reconstruction of 3D surface models. - Visualization and management of point clouds and generation of meshes, textures, and derived products. - Possibilities for integrating digital photogrammetry with other techniques. - Photogrammetry applications to real case studies.

Bibliografia

CORSO DI DOTTORATO: CTI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Historical research and study of contemporary architecture and city**						
SSD	CEAR-11/A ARCH-01/D	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**		-	

Obiettivi

The Historical Research and the Study of Ancient Architecture course offers a comprehensive exploration of the architectural and urban developments that defined the ancient Mediterranean. Through a thematic and chronological approach, PhD students will examine case studies spanning from the Archaic period to Late Antiquity, focusing on how architectural elements reflect cultural, political, and economic shifts. The course begins with the study of Agrigento's architectural ornamentation, revealing the stylistic evolution of Sicilian cities from early Greek influences to Romanization. Moving eastward, we analyze the urban design and monumental aspects of ports in the eastern Mediterranean during the Hellenistic and Imperial periods, examining how these spaces balanced functionality with grandeur to serve regional power dynamics. Further discussions center on the interplay between theater, palace complexes, and royal power in Hellenistic capitals, highlighting how architecture was used to craft landscapes of influence and authority. In the early Imperial Hispania, students will delve into forensic typology, applying both traditional and innovative methodologies to understand civic space organization. This is complemented by an examination of Italic Hellenistic architecture, which emphasizes the integration of regional construction practices with multidisciplinary research approaches. The course culminates with a study of Late Antique monumental spaces, exploring recent research on the transformation of civic and aesthetic frameworks in the urban centers of this era. Through lectures, discussions, and case studies, students will gain an in-depth understanding of how architecture shaped—and was shaped by—the historical narratives of ancient Mediterranean societies. At the end of the course, a roundtable discussion will allow participants to engage with each other and synthesize their insights on the broader themes of the course.

Syllabus

"The Most Beautiful Among Mortal Cities: Architectural Decoration in Sicily from the Archaic Age to Romanization. The Case of Agrigento" "The Theatre and the Basileus. The Creation of a Landscape of Power in the Hellenistic Capitals" "Ἔργον δὲ μέγα ἦ βασίλειον. Urban Design and Monumental Aspects of Ports in the Eastern Mediterranean between the Hellenistic and Imperial Ages" "Monumental Space in the Late Antique City: Approaches, Methodologies, and Research Results" "Buildings for Munera and Venationes in the Greco-Roman East: Amphitheatres, Hybrid Buildings, and Repurposed Buildings" "Excelsissimi loci. Tools and Methods for the Study of Forum Typology in High-Imperial Hispania"

Bibliografia

CORSO DI DOTTORATO: CTI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**The architecture of construction**						
SSD	CEAR-08/C	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**		-	

Obiettivi

The course includes a first part with focus on the Form of Construction, i.e. the formal codes that constitutes the basic topics of structural forms; the second part deals with the knowledge of structural elements and the corresponding compositional techniques. The formal fundamentals comprise essentially the masonry wall system, the trilith system and the frame system, which are declined in specific and possible variations, depending on the use of materials and production techniques. At the same time, other formal principles focus on covering systems: the flat roof, the pitched roof, the vault, the dome. The course starts with a historic excursus that explains the origins of these structural fundamentals, the consolidation processes and the development due to the strengthening of techniques. A special attention shall be given to the best practices of the 20th century, in circumstances where the structural conception assumes a particular relevance in meeting the needs of "the architecture of techniques", i.e. skyscrapers, factories, commercial warehouses, religious buildings etc.

Syllabus

The course includes a first part with focus on the Form of Construction, i.e. the formal codes that constitutes the basic topics of structural forms; the second part deals with the knowledge of structural elements and the corresponding compositional techniques. The formal fundamentals com-prise essentially the masonry wall system, the trilith system and the frame system, which are declined in specific and possible variations, depending on the use of materials and production techniques. At the same time, other formal prin-ciples focus on covering systems: the flat roof, the pitched roof, the vault, the dome. The course starts with a historic excursus that explains the origins of these structural fundamentals, the consolidation processes and the development due to the strengthening of techniques. A special attention shall be given to the best practices of the 20th century, in circumstances where the structural conception assumes a particular relevance in meeting the needs of "the architecture of techniques", i.e. skyscrapers, factories, commercial warehouses, religious buildings etc.

Bibliografia

CORSO DI DOTTORATO: CTI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	The architecture of structural forms						
SSD	CEAR-09/A	Ore	20	CFU	2	Anno/Semestre	Second/Second
Livello 2026/2027		3		Paniere 2026/2027		-	

Obiettivi

The didactic project of the course assumes the relationship between space and the constructive forms of architecture as a problematic core, through a point of view that recognizes construction as the most powerful expressive resource for the representation of the spatial character of buildings. The thought on the structure, therefore, seems to be problematized in a dialectical tension between the disciplines of architecture and engineering, whose common language is that of matter and its possible formal definitions. The purpose of the course is to develop a particular approach to research on architectural design that is able to recognize, problematically, the relationship between space and the design of its structural systems, from type to construction. By declining the constructive paradigms of history and their cultural areas of reference, it is possible to identify some interpretative lines that feed the most recent structural experiments on matter, between the definition of its possible forms and the search for their own figurative identity. Just think of the research on the forms of reinforced concrete carried out in Switzerland since the beginning of the twentieth century, where the technical forms of the structure (also in the construction of bridges and infrastructure works) exceed their aesthetic autonomy, interpreting the relationship with the landscape in which they are located. Between Architecture and the Art of structures.

Syllabus

• Character and Construction. The Bridge as the Invention of a New Place; • Rooting in the earth: The desire to contemplate the horizon. For a modern idea of living; • Rooting in the earth: nature and geography in the experience of the Paulista house; • The construction of the Hall; • Isostatic Ribbed Floors. From Pier Luigi Nervi to Livio Vacchini; • Architecture and engineering in the era of "Structural conception": the order of the new Italian industrial architecture; • The construction of the suspended building: ancient, modern Broletto.

Bibliografia

AA. VV., The Engineer and the Architect, a cura di Flury A., Birkhäuser, Basel 2012. CONZETT Jürg, Architettura nelle opere d'ingegneria, a cura di Chiorino M. A., Umberto Allemandi, Torino 2007. DE VENUTO Tiziano, Livio Vacchini. Architettura come costruzione, Libria, Melfi 2023. DE VENUTO Tiziano, Case in Ticino, Libria, Melfi 2023. EMERY Nicola, Progettare, costruire, curare. Per una deontologia dell'architettura, Casagrande, Bellinzona 2007. FRAMPTON Kenneth, Tettonica e architettura. Poetica della forma architettonica nel XIX e XX secolo, Milano, Skira editore. GARGIANI Roberto, "Perret, Le Corbusier, Mies van der Rohe: nuovi ordini architettonici", in Fanelli Giovanni, e Gargiani Roberto, Storia dell'architettura contemporanea, Roma-Bari, Giuseppe Laterza &figli, 2004. HAN Byung-Chul, La salvezza del bello, trad.it. di V. Tamaro, Nottetempo, Milano 2019. MARTÍ ARÍS Carlos, La centina e l'arco. Pensiero, teoria, progetto in architettura, a cura di Pierini O. S., Marinotti, Milano 2007. MUTTONI Aurelio, L'Arte delle strutture. Introduzione al funzionamento delle strutture in architettura, a cura di Minazzi F., Mendrisio Academy Press, Mendrisio 2006. NERVI Pier Luigi, Scienza o arte del costruire? Caratteristiche e possibilità del cemento armato, a cura di Neri G., Milano, CittàStudi 2014. VACCHINI Livio, Capolavori. 12 architetture fondamentali di tutti i tempi, Melfi, Libria 2017. SALVADORI Mario, Perché gli edifici stanno in piedi, Milano, Bompiani 2016.

CORSO DI DOTTORATO: CTI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**The post-growth paradigm in planning research**						
SSD	CEAR-12/B	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second/First
Livello 2026/2027		3		**Paniere 2026/2027**		-	

Obiettivi

Gli ultimi quarant'anni hanno segnato radicalmente la città e la disciplina urbanistica. A partire da una lettura critica della lunga stagione di studi che ha chiuso il secolo scorso decretando la fine del progetto urbano e, guardando a come i temi emergenti sono trattati nelle ricerche più recenti, il corso cerca di capire quanto e in che modo siano cambiati il discorso sulla città contemporanea, con ciò tentando di chiarire come le interpretazioni aggiornate del fenomeno urbano possano aprire nuove strade al progetto. Il corso approfondirà i temi del paradigma della post-crescita contemporanea, delle sue cause e delle sue manifestazioni materiali; verranno inoltre delineati i percorsi della ricerca contemporanea nelle direzioni di un rinnovato rapporto con l'esistente, della valorizzazione del patrimonio territoriale, dell'integrazione e della contaminazione con le discipline che affrontano i temi della sostenibilità e del cambiamento climatico, della società. L'obiettivo formativo del corso è quello di offrire ai dottorandi gli strumenti per comprendere la complessità del mondo contemporaneo e acquisire la capacità di sviluppare un pensiero autonomo e consapevole rispetto ai nodi problematici e alle sfide che esso pone. Il corso si propone quindi di approfondire le principali fenomenologie del paradigma della post-crescita nella città e nel territorio, e allo stesso tempo di discutere le linee di ricerca che le discipline del territorio hanno avviato negli ultimi decenni.

Syllabus

Sono previste lezioni frontali e seminari, strettamente integrati, che si avvalgono anche del contributo di docenti esperti italiani con un punto di vista rilevante sui temi del corso, per permettere un'ampia riflessione tra dottorandi e relatore sui temi trattati.

Bibliografia

CORSO DI DOTTORATO: CTI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**AI and Creativity**						
SSD	CEAR-09/A	**Ore**	20	**CFU**	1.5	**Anno/Semestre**	First/First
Livello 2026/2027		1		**Paniere 2026/2027**		/	

Obiettivi

The course aims to equip students with both theoretical and practical tools to understand and effectively control artificial intelligence, integrating it within a structured and comprehensive creative process. Midjourney will serve as the primary platform for image generation, while additional forms of AI will be examined to illustrate their diverse applications across creative fields. The course will also include hands-on 3D modeling sessions using Rhinoceros and will address the ethical implications of AI, fostering a critical and informed approach to its use in design and visual communication.

Syllabus

PROGRAM AI: global framework (theoretical session) • Basic notions (history and evolution of Artificial Intelligence in the creative field) • Types of AI, uses and experiences • AI and architectural design Midjourney (practical session) • What is Midjourney and comparison with other software (ChatGPT, ComfyUI, Nano Banana) • Use of the software (from basics to advanced commands) From the 2D image to the 3D model (practical session) • Generation and selection of the right image • Analysis and interpretation of the image (color theory and photographic composition) • Realization of a 3D model starting from the selected image

Bibliografia

CORSO DI DOTTORATO: CTI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Theory of Formativeness**						
SSD	CEAR-09/A	**Ore**	20	**CFU**	1.5	**Anno/Semestre**	First
Livello 2026/2027		1		**Paniere 2026/2027**		/	
Obiettivi							
It seems lost today, in architecture as generally in arts, a unitary point of view on which to found a theory on. That civil conscience that has always been the basis of the art of building seems no longer part of the collective heritage. This condition is recognizable in the contradictory experience of contemporary architecture. For this reason, the class aims to try to outline a "classical" theory of architectural research; a classicism that does not renounce, rather it investigates, the culture of modernity, trying to measures itself against this alleged contradiction. All the architecture that we can include within the “classic” experience (that we can also define “rational experience”) is characterized by a peculiarity: the intelligibility of forms, along with we define a method of formativeness. According to this idea of architecture, there’s no advancement of forms without an advancement of knowledge - without an increasingly higher level of self-awareness. Hence the need for a theory of architectural research. The method of formativeness we want to investigate regards three major chapters of architecture: The relationship among architecture, city and landscape; The “construction issue”; The question of the project with the Ancient.							
Syllabus							
The method of formativeness we want to investigate regards three major chapters of architecture: The relationship among architecture, city and landscape;The “construction issue”; The question of the project with the Ancient.							
Bibliografia							

CORSO DI DOTTORATO: DRIEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Management of future telecommunication systems via pervasive intelligence**						
SSD	IINF-03/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	First/First
Livello 2026/2027				**Paniere 2026/2027**			

Obiettivi

The course illustrates the emerging technologies and methodologies based on pervasive intelligence for the management of future telecommunication systems, with particular focus on: • the context of 5G and Beyond networks and the enabling technologies, • traffic analysis at the mobile edge, • anticipatory resource allocation at the edge, • Radio Access Network slicing management, • practical examples.

Syllabus

- Course presentation, Introduction to 5G and Beyond net-works - Traffic analysis at the mobile edge - Anticipatory resource allocation at the edge, Radio Access Network slicing management - Dynamic resource provisioning via Network Digital Twin - Management of Terrestrial and Non-Terrestrial Networks - XAI in 6G Network Architectures, Practical examples, Final exams

Bibliografia

Scientific papers provided by the lecturer

CORSO DI DOTTORATO: DRIEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Optimization and control of smart energy systems						
SSD	IINF 04/A	Ore	10	CFU	1	Anno/Semestre	First
Livello 2026/2027		2		Paniere 2026/2027		1	

Obiettivi

The course will focus on models, techniques and tools for the simulation and optimization of energy systems in smart buildings and smart mobility applications. At the end of this course students will achieve the basics for modeling and simulating such energy systems using engineering tools (e.g., Matlab, SUMO). Each lesson will consist in lecture and software exercises.

Syllabus

Study and analysis of the following topics: - Challenges in the energy management of smart buildings - Modeling, simulating and controlling energy systems in home/buildings - Challenges in the energy management of smart e-mobility systems - Modeling, simulating and controlling e-mobility systems

Bibliografia

- Moss, K. (2006). Energy management in buildings. Taylor & Francis. - Yue Cao, Yuanjian Zhang, Chenghong Gu, Automated and Electric Vehicle: Design, Informatics and Sustainability, Springer 2023.

CORSO DI DOTTORATO: DRIEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Game Theory for Controlling Autonomous Systems						
SSD	IINF 04/A	Ore	10	CFU	1	Anno/Semestre	Second
Livello 2026/2027		3		Paniere 2026/2027		-	
Obiettivi							
This course is designed to provide PhD students with the necessary modeling and methodological tools for analyzing and designing algorithms to solve game equilibrium problems. The course will include lectures, numerical examples, simulations, and analysis of case studies.							
Syllabus							
1. Introduction and motivation 2. Background a. Convex Optimization: Convex sets and functions. Set-valued mappings. Normal cone and tangent cone operators. Pro-jection and proximal operators. Lagrangian duality and KKT conditions. b. Monotone Operator Theory: Fixed points, zeros, and con-traction mappings; averaged and nonexpansive mappings; fixed point theorems and algorithms. 3. Nash equilibrium a. Nash equilibrium problem, and best response mapping. b. Applications and models: Linear complementarity problems and variational inequalities. c. Existence and uniqueness of equilibria. d. Algorithms. 4. Generalized Nash equilibrium a. Background, Generalized Nash equilibrium problem. b. Applications and models: Quasi-variational inequalities and mixed complementarity problems. c. Existence and uniqueness of equilibria. d. Algorithms.							
Bibliografia							

CORSO DI DOTTORATO: DRIEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	OpenRAN Technologies for Enabling Sustainable and Intelligent 6G Networks						
SSD	IINF 03/A	Ore	20	CFU	2	Anno/Semestre	Second
Livello 2026/2027		2		Paniere 2026/2027		3	

Obiettivi

The course aims to introduce students and practitioners to the main concepts, architectures, and applications of Open Radio Access Networks, with particular attention to their role in future sustainable and intelligent 6G networks. Participants will acquire a general understanding of OpenRAN technologies, their benefits, and the main challenges related to their implementation and operation.

Syllabus

- Introduction to mobile and radio access networks - OpenRAN concepts and architectures - Virtualization and software-based network functions - Intelligent and automated network management - OpenRAN for future 6G networks - Sustainability, performance, and security aspects - Applications and case studies

Bibliografia

CORSO DI DOTTORATO: DRIEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Power Systems Simulation Tools**						
SSD	IIND-08/B	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second
Livello 2026/2027		2		**Paniere 2026/2027**		6	
Obiettivi							
The aim of the course is to provide information on the data management and results interpretation of power system simulation tools for the different analysis of load flow, continuation load flow, short circuit, small signal stability, dynamic stability. The classroom activities will deal with: • Operation of power systems • Models of regulation • Explication of data for different analysis • Building of a co-simulation environment • Examples Scientific papers and books on the selected arguments will be used as reference. The examination method is represented by a synthetic report on a chosen topic.							
Syllabus							
The classroom activities will deal with: • Operation of power systems • Models of regulation • Explication of data for different analysis • Building of a co-simulation environment • Examples							
Bibliografia							
Scientific papers and books on the selected arguments will be used as reference							

CORSO DI DOTTORATO: DRIEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Fundamentals of Information Security and Data Privacy						
SSD	IINF 05/A	Ore	10	CFU	1	Anno/Semestre	First
Livello 2026/2027		3		Paniere 2026/2027		3	

Obiettivi

This course delves into the dynamic interplay between Artificial Intelligence (AI), Machine Learning (ML), and data security and privacy, highlighting both the challenges and opportunities these technologies present. The rapid advancements in Information and Communication Technologies (ICTs) are transforming society, delivering profound societal and economic benefits. This evolution is fueled by the vast availability of rich, heterogeneous data and the pervasive adoption of AI-ML approaches for data generation, analysis, and processing. However, this technological leap presents a double-edged sword in the realm of data protection. On one hand, AI-ML applications introduce new privacy and security risks, such as potential data exposure during the learning process or vulnerabilities like data poisoning attacks, which can compromise model accuracy and integrity. On the other hand, AI-ML techniques also offer transformative opportunities, enabling innovative solutions for cybersecurity and privacypreserving data sharing. This course offers a comprehensive overview of the research issues, challenges, and opportunities at the intersection of AI-ML, data security, and privacy. Participants will explore the dual nature of AI-ML's impact, gaining insights into both the potential threats and the groundbreaking solutions it can provide for safeguarding information in the era of smart technologies. The course combines theoretical lectures with practical insights. Participants will engage with real-world case studies and hands-on sessions, enabling them to implement and evaluate interpretability techniques. A final project will require students to analyze a case study using the acquired knowledge and tools.

Syllabus

The course begins with an introduction to the complex interplay between Artificial Intelligence (AI), Machine Learning (ML), and data security and privacy. This section highlights how AI-ML technologies are transforming the landscape of data-centric applications, offering profound benefits while also introducing significant risks. Participants will explore the dual nature of AI-ML's impact, delving into case studies that illustrate privacy breaches and cybersecurity advancements driven by these technologies.
The second part of the course examines privacy and security risks inherent in AI-ML applications. Topics include data exposure during the learning process, vulnerabilities such as adversarial attacks and data poisoning, and the ethical challenges posed by these risks. This section also incorporates discussions on the regulatory frameworks, such as GDPR and NIS2, that guide responsible AI-ML deployment in data-intensive environments.
The couse concludes with to AI-ML techniques designed to enhance data security and privacy. Participants will be introduced to privacy-preserving methodologies, including differential privacy, federated learning, and secure multi-party computation. The course also explores AI-driven cybersecurity solutions, such as anomaly detection, threat prediction, and data encryption. Practical examples of privacy-enhancing technologies (PETs) and cryptographic methods will provide participants with hands-on insights into innovative tools for safeguarding information.

Bibliografia

None

CORSO DI DOTTORATO: DRIEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Additive Manufacturing for Modern ICT Systems**						
SSD	IINF 02/A	**Ore**	10	**CFU**	1	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**		/	
Obiettivi							
The course aims to provide PhD students with a comprehensive, application-oriented overview of Additive Manufacturing technologies for the fabrication of advanced devices for modern communication systems. It will cover the theoretical foundations, enabling technologies, and design and manufacturing strategies for antennas, arrays, guided-wave structures, and dielectric lenses, with particular emphasis on material and process selection, as well as fabrication accuracy.							
Syllabus							
Classification of Additive Manufacturing techniques. Measurement of the electromagnetic properties of materials used in devices fabricated through Additive Manufacturing. Design of 3D-printable electromagnetic devices. From design to fabrication: selection of slicing parameters. Laboratory activities.							
Bibliografia							
Scientific publications, lecture slides/notes, and supporting materials provided by the lecturer.							

CORSO DI DOTTORATO: DRIEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Deep Neural Networks**						
SSD	IINF 05/A	**Ore**	10	**CFU**	1	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**		/	
Obiettivi							
The course intends to introduce students and practitioners to the field and applications of Deep Neural Networks. The course participants will be able to design and implement Deep Neural Networks to address various and different tasks autonomously. The lessons alternate theoretical lectures and implementation examples.							
Syllabus							
Introduction to Deep Learning and Neural Networks Optimizers Activation Functions Regularization strategies Tensorflow/Pytorch and building Neural Networks from scratch Deep Sequence Models: Recurrent Neural Networks, GRUs, Long Short Term Memory Deep Computer Vision, Image classification and detection Deep Generative Models: GANs Deep Reinforcement Learning Encoder-Decoder, Machine Translation Attention, Transformer, BERT							
Bibliografia							
Christopher M. Bishop, Hugh Bishop, Deep Learning: Foundations and Concepts, Springer							

CORSO DI DOTTORATO: DRIEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Design of optical fiber devices with Finite Element Method						
SSD	IINF-02/A	Ore	10	CFU	1	Anno/Semestre	Second/First
Livello 2026/2027		3		Paniere 2026/2027		/	

Obiettivi

The course proposes an overview of some professional softwares such as CST Studio Suite for the design of electromagnetic devices. Both antennas and microwave devices will be proposed for design and study, with particular focus millimeter and sub-millimeter wave antennas. The participants will learn how to design and sim ulate electromagnetic devices with many practical examples.

Syllabus

Basic mathematical and physical concepts; Fundamentals of light propagation in optical fibers; Introduction to the Finite Element Method (FEM); General structure of a FEM problem (mesh, bound ary conditions, solvers); Optical waveguides: modeling principles; FEM modeling of fiber-optic devices; Numerical simulation exam ples (guided modes, losses, dispersion); Study of advanced application cases: fiber-optic sensors; Guided exercises; Multiphysics anal ysis applied to optical devices (optical-thermal and optical-mechanical coupling); Development of a mini numerical project by the stu dents.

Bibliografia

Optical Fiber Communications Principles and Practice, Third Edi tion, JOHN M. SENIOR, ISBN: 978-0-13-032681-2.

CORSO DI DOTTORATO: DRIEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Electromagnetic design via professional softwares						
SSD	IINF-02/A	Ore	10	CFU	1	Anno/Semestre	Second/First
Livello 2026/2027		3		Paniere 2026/2027		/	
Obiettivi							
The course proposes an overview of some professional software such as CST Studio Suite for the design of electromagnetic devices. Both antennas and microwave devices will be proposed for design and study, with particular focus millimeter and sub-millimeter wave antennas. The participants will learn how to design and sim-ulate electromagnetic devices with many practical examples.							
Syllabus							
• Overview of electromagnetic devices • Introduction to antenna design with CST Studio Suite • Recall on scattering parameters and antenna parameters • Simulation of a horn antenna • Simulation of a patch antenna • Thermal analysis of patch antenna							
Bibliografia							
Slides and supporting material from lecturer.							

CORSO DI DOTTORATO: DRIEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Introduction to Modern Generative AI**						
SSD	IINF- 05/A	**Ore**	10	**CFU**	1	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**		6	
Obiettivi							
The course aims to introduce students and practitioners to the main concepts, methods, and applications of modern Generative Artificial Intelligence. Participants will acquire a general understanding of generative models and their potential use in different application domains. The course combines theoretical elements with practical examples and case studies.							
Syllabus							
Introduction to Generative Artificial Intelligence Main approaches and models Methods and tools for content generation Applications of Generative AI Practical examples and case studies Limitations, reliability, and ethical aspects							
Bibliografia							

CORSO DI DOTTORATO: DRIEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Non-integer order systems and controllers						
SSD	IINF 04/A	Ore	10	CFU	1	Anno/Semestre	Second
Livello 2026/2027		3		Paniere 2026/2027		-	

Obiettivi

The course concerns non-integer-order systems. These systems can propose engineering solutions to modeling and control problems that often improve those based on integer-order calculus. Basic tools of fractional calculus are introduced, and some methods and models are described for different engineering fields. Models for practical applications are proposed. Moreover, approaches to design and realize non-integer-order (fractional-order) controllers are described. These controllers show higher flexibility, increased robustness, and ability to obtain a better trade-off between stability and dynamic performance with respect to widespread PID controllers. As case-studies, the course uses applications in automotive and mechatronic systems.

Syllabus

- Fractional calculus, modeling by non-integer order systems, non-integer order controllers - Design of non-integer order controllers and case studies - Realization of non-integer order controllers - Case studies, exercises, simulation, discussion - Application: control of an automotive system

Bibliografia

- R. Caponetto, G. Dongola, L. Fortuna, I. Petráš, Fractional Order Systems: Modeling and Control Applications. Singapore: World Scientific, 2010. - C. A. Monje, Y. Q. Chen, B. M. Vinagre, D. Xue, V. Feliu, Fractional-order Systems and Controls: Fundamentals and Applications. London, UK: Springer-Verlag, 2010. - Reference papers.

CORSO DI DOTTORATO: DRIEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Numerical Methods for Big Data**						
SSD	MATH-05/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second/First
Livello 2026/2027				**Paniere 2026/2027**			
Obiettivi							
The course will describe the numerical methods that facilitate the analysis of big data, network analysis and many machine learning applications. Their implementation in Matlab will be addressed, together with the use of modern Matlab toolboxes for large and sparse data; applications to the solution of real-life problems will be considered. Each lesson shall consist in lecture and numerical examples.							
Syllabus							
Numerical methods for Large Linear Systems (Iterative methods and Preconditioning) Singular Value Decomposition and Compression Methods Principal component analysis and dimensionality reduction							
Bibliografia							
Lars Elden, Matrix Methods in Data Mining and Pattern Recognition, Philadelphia, SIAM, 2019 Saad Yousef, Numerical Methods for Large Eigenvalues Problems, Philadelphia, SIAM, 2011. Revised Edition S.L. Brunton, J.N. Kutz, Data-Driven Science and Engineering: Machine Learning, Dynamical Systems, and Control, 2019 Slides and support material from lecturer							

CORSO DI DOTTORATO: DRIEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**SILICON PHOTONICS MODULE 1: Fundamentals of Silicon Photonics MODULE 2: Photonic Integrated Circuits**						
SSD	IINF- 01/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**		-	

Obiettivi

PhD-level course on silicon photonics and photonic integrated circuits (PICs), with emphasis on device fundamentals and a foundry-oriented design workflow. Learning outcomes: • Understand guiding, dispersion, and loss mechanisms in high-index-contrast waveguides. • Design/assess key passive and active devices (couplers, interferometers, resonators, modulators, photodetectors). • Use circuit abstractions (transfer/scattering matrices, compact models) to move from components to PICs and system metrics. • Understand the PIC development chain: PDK-driven design, layout/verification, fabrication, packaging, and characterization.

Syllabus

Syllabus Module 1 - Fundamentals of Silicon Photonics (10 hours, 1 CFU) • Platforms and ecosystem: SOI/SiN/Ge-on-Si, CMOS compatibility, foundries and PDKs. • Waveguides & passive devices: modes, dispersion/loss, bends, couplers (DC/MMI), crossings, grating/edge coupling. • Interferometric/resonant devices: MZI, ring resonators, Bragg gratings; filters and sensing basics. • Active devices/effects: thermo-optic tuning; carrier-based modulation (PN/PIN); overview of detectors and laser integration. Module 2 - Photonic Integrated Circuits (10 hours, 1 CFU) • Circuit design methodology: hierarchy, building blocks, tolerance-aware design, variability; key circuit metrics and link budgeting. • Circuit simulation (frequency/time domain), compact models, and co-design considerations; layout/verification basics (GDSII/DRC). • Overview of fabrication, packaging, testing, and de-embedding; case studies + mini-project discussion with short student presentation.

Bibliografia

• L. Chrostowski, M. Hochberg, Silicon Photonics Design: From Devices to Systems, Cambridge University Press, 2015. • G. T. Reed, A. P. Knights, Silicon Photonics: An Introduction, Wiley.

CORSO DI DOTTORATO: DRIEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Spintronics applications						
SSD	IIET-01/A	Ore	10	CFU	1	Anno/Semestre	Second
Livello 2026/2027		3		Paniere 2026/2027		/	

Obiettivi

This course follows the introduction provided in the course of Micromagnetic Modeling and deals with basic concepts of Spintronics, from an interdisciplinary perspective focused on electrical engineering and physics. Spintronics represents an emerging research frontier with the potential to impact a broad range of applications. Students will use micromagnetic models to study and design spintronic devices for applications such as storage, microwave oscillators and detectors. They will also perform numerical simulations by means of a micromagnetic solver and use MATLAB for post-processing the output data. Each lesson shall consist in lecture and numerical examples.

Syllabus

Ferromagnetism Micromagnetic energies Brown's equations Dynamical equation: Landau-Lifshitz-Gilbert Examples of spintronic applications (memories, rectifiers, amplifiers etc.) Application of micromagnetic models to study and reproduce spintronic devices Numerical simulations in C, C++ and CUDA Post-processing with MATLAB or Python

Bibliografia

G. Bertotti, "Hysteresis in Magnetism", Elsevier, ISBN 978-0-12-093270-2, 1998, DOI https://doi.org/10.1016/B978-0-12-093270-2.X5048-X
A. Aharoni, "Introduction to the Theory of Ferromagnetism", Oxford University press, ISBN 9780198508090, 2nd Ed. 2000.
David Jiles, "Introduction to Magnetism and Magnetic Materials", CRC Press, ISBN 9781482238877.
Dey. Puja, J. N. Roy. "Spintronics", Springer Singapore, ISBN 9789811600715, 2021
E.Y. Tsymbal, I. Žutić, "Spintronics Handbook, Spin Transport and Magnetism: Volume Three: Nanoscale Spintronics and Applications" (2nd ed.). CRC Press. ISBN 9780429441189.
K. Wang, Y. Meiyin Yang, L. Jun (eds.), "Spintronics: materials, devices, and applications". John Wiley & Sons, 2022. ISBN 9781119698975.
Slides and support material from lecturer.

CORSO DI DOTTORATO: DRIEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Supervised Methods for Machine Learning**						
SSD	IINF- 05/A	**Ore**	10	**CFU**	1	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**		3	

Obiettivi

The course will provide a broad introduction to machine learning. The course will cover Supervised learning, Machine Learning systems design and evaluation, By the end of the course, the course participants will be able to design and implement Machine Learning-based applications autonomously. The lessons alternate theoretical lectures and implementation examples.

Syllabus

Machine Learning classification Linear regression Logistic Regression Overfitting and Underfitting, Bias and Variance trade-off Regularization ML System Design, Machine learning diagnostics, Evaluation Neural Networks

Bibliografia

Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements Of Statistical Learning Second edition, Springer-Verlag ISBN 978-0-387-84858-7 https://web.stanford.edu/~hastie/ElemStatLearn/
Stuart Russell, Peter Norvig, Artificial Intelligence: A Modern Approach Fourth edition, Pearson Global Edition: ISBN 9781292401133 Rome: Pearson Italia, 2010. ISBN 9788871925936 http://aima.cs.berkeley.edu/index.html
Kevin P. Murphy, Machine Learning A probabilistic Perspective, MIT Press, ISBN 10: 0262018020 ISBN 13: 9780262018029, https://mitpress.mit.edu/books/machine-learning-1 Slides and support material from lecturer.

CORSO DI DOTTORATO: DRIEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Techno-economic advancements in electric power system**						
SSD	IIND- 08/B	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**		-	

Obiettivi

The aim of the course is to provide insights into the transformation of power system operation and management, encompassing two main fields: • organization of electric power system planning and operation with different levels of electricity markets for the provision of energy and services. • methodologies and procedures for operation and control of multi-energy microgrids, in AC or DC configurations.

Syllabus

The classroom activities will be divided into two modules.
Module 1 – Electric power system market and planning (10 hours – 1 CFU): • Power system development and scenario approach • Power system regulation services and reserves • Structure of electricity markets, new regulation services and markets for flexibility
Module 2 - Microgrids structure and operation (10 hours – 1 CFU): • Planning and management of multi-energy microgrids • Specific aspects of DC microgrids and electric vehicles • The role of microgrids in markets and enhanced grid integration through ancillary services

Bibliografia

Scientific papers and books on the selected arguments will be used as reference

CORSO DI DOTTORATO: DRIEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Research Methodology**						
SSD	IIET-01/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	First/First
Livello 2026/2027				**Paniere 2026/2027**			
Obiettivi							
This course aims at providing PhD students with the knowledge of fundamentals of Research Methodology and how to use them effectively in their own scientific research. Examples are inserted when necessary.							
Syllabus							
❖ Introduction ❖ Research Theory ❖ Ethics and Research ❖ Research Methods ❖ Research Instruments ❖ Research Project ❖ Scientific Proposal Drafting							
Bibliografia							
Will be provided at the beginning of the course							

CORSO DI DOTTORATO: DRIG

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**A user- centered approach to Ergonomics assessment in the Industry 5.0 paradigm**						
SSD	IIND-03/B	**Ore**	20	**CFU**	2	**Anno/Semestre**	First/Second
Livello 2026/2027		2		**Paniere 2026/2027**		4	

Obiettivi

The Industry 4.0 program and the perspectives of the innovative I5.0 approach are significantly changing the role played by the operator on the smart factory shopfloor. The introduction of the mass-customization paradigm and the fast changes in the production cycle require new operators' capabilities. In particular, the I4.0 operator is requested to be a smart element in the production cycle, able to adapt to sudden changes by means of decisional capabilities. In order to strengthen such capabilities, it is necessary to optimize the working conditions so as to free operators from unnecessary tasks and allow them to use their physical and cognitive resources in an optimal manner. The Human Performance Envelope (HPE) constitutes the set of factors that define the conditions in which the operator acts and encompasses environmental, social, physical, and cognitive aspects. In order to optimize the operator's performance, it is essential to understand the processes that govern the definition of the HPE, thus allowing both designing efficient solutions and applying rigorous validation procedures. Thanks to technological innovations (e.g. low-cost tracking systems and physiological signals platforms), nowadays it is possible to apply an integrated approach for the HPE assessment using both traditional and novel methods. The course will be composed of 3 modules aiming at providing Ph.D. students with the necessary knowledge to validate in their scientific research the effectiveness of solutions designed in order to improve the operator's performance with particular attention to the HPE. Module I. Introduction and theoretical bases. The role of the Operator in the I4.0 smart factory. Introduction to the concept of HPE and its fundamental components —the physical and the cognitive workload. Basic principles of the Cognitive Load Theory. The ISO standard 11226 Ergonomics — Evaluation of static working postures. Module II. Assessment methods for physical ergonomics. Post-hoc measures (the Borg-CR 10 scale), direct methods, observational methods (the Rapid Upper Limb Assessment metrics), and innovative applications for the observational methods (the ErgoSentinel tool). Module III. Assessment tools for cognitive ergonomics. Post-hoc measures (the NASA Task Load Index, the Multiple Resource Questionnaire), task performance measures (Completion time, Error Rate, reaction Time, the dual-task design); direct methods (the electrocardiographic signal and the Heart Rate Variability Analysis approach). By the end of the course, Ph.D. students will have a broadened knowledge in the field of the Industry 4.0 paradigm through the awareness of the new role of the operator and the knowledge of the HPE concept. Furthermore, they will be able to handle tools for physical and cognitive workload assessment and for designing an experimental setup in order to validate innovative solutions for HPE improvement. The course programme will be composed of 3 modules aiming at providing Ph.D. students with the necessary knowledge to validate in their scientific research the effectiveness of solutions designed in order to improve the operator's performance with particular attention to a user centric design approach.

Syllabus

The course programme will be composed of 3 modules aiming at providing Ph.D. students with the necessary knowledge to validate in their scientific research the effectiveness of solutions designed in order to improve the operator's performance with particular attention to a user centric design approach. Module I. Introduction and theoretical bases. The role of the Operator in the I4.0 smart factory. Introduction to the

Insegnamento	A user- centered approach to Ergonomics assessment in the Industry 5.0 paradigm
concept of HPE and its fundamental components —the physical and the cognitive workload. Basic principles of the Cognitive Load Theory. The ISO standard 11226 Ergonomics — Evaluation of static working postures. Module II. Assessment methods for physical ergonomics. Post-hoc measures (the Borg-CR 10 scale), direct methods, observational methods (the Rapid Upper Limb Assessment metrics), and innovative applications for the observational methods (the ErgoSentinel tool). Module III. Assessment tools for cognitive ergonomics. Post-hoc measures (the NASA Task Load Index, the Multiple Resource Questionnaire), task performance measures (Completion time, Error Rate, reaction Time, the dual-task design); direct methods (the electrocardiographic signal and the Heart Rate Variability Analysis approach).	
Bibliografia	
Scientific papers, slides and support material from the lecturer	

CORSO DI DOTTORATO: DRIG

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Advanced Additive Manufacturing and Reverse Engineering design and processes for the twin transition**						
SSD	IIND-04/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	First/First
Livello 2026/2027		2		**Paniere 2026/2027**		8	

Obiettivi

The course aim to provides PhD students with the knowledge about advanced Additive Manufacturing (AM) and Reverse Engineering (RE) processes mainly for new Repairing/Remanufacturing more sustainable solutions in circular industrial economy. In fact, the new Additive Manufacturing methods offer the best value-added, resource-efficient approach to end-of-life product recovery. The course project will be articulated in different topics: 1. Direct Energy Deposition (DED) solutions for repair and life extension. Among DED processes, Laser Powder Metal Deposition will be analysed in more detail because of its enormous capabilities, flexibility and efficiency.

Syllabus

Module 1: Strategic Framework & Metrology of Data • The Twin transition & Circular industrial economy. • The digital thread. • Life Cycle Assessment (LCA). • Advanced Metrology and Reverse Engineering (RE). Module 2: Additive Manufacturing (AM) as an Enabling Technology • AM for Rapid Tooling. • Physics of AM Processes for tooling. • Systems Architecture. Module 3: Hybrid Systems & Functional Materials • Advanced injection molding: specifics of micro-molding vs. conventional molding. • Hybrid manufacturing systems: integration of AM (additive) and CNC Milling (subtractive) for mold manufactur-ing. • Advanced Materials: Developing composite structures using recycled polymers. Module 4: Industrial Applications • High-Value Case Studies: Aerospace, Automotive, Tool-ing, Biomedical & Telco.

Bibliografia

Scientific papers, slides and support material from the lecturer

CORSO DI DOTTORATO: DRIG

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Mathematical methods in deep learning						
SSD	MATH-03/A	Ore	20	CFU	2	Anno/Semestre	First/First
Livello 2026/2027		2		Paniere 2026/2027		1	

Obiettivi

This course, intended for Engineering Ph.D. Students, has the objective to provide the basic mathematical concepts needed to have a clear insight of the mechanism of neural networks in deep learning. This will help engineers in exploiting neural networks as a tool in a conscious way. The theory treated in the course is the following. 1) We will start by introducing the basic architecture of a feedforward neural network defined basing on weights. For this, we shall recall some basic facts in tensor algebra. 2) We will ex-plain some examples of Universal Approximation Theorems, highlighting the ideas behind the fact that a neural network is capable to approximate any continuous function. 3) We will introduce the concept of cost in a feedforward neural network, providing some examples of nonlinear costs. Among these, we will put some stress on the cross-entropy cost, recalling some basic facts in statistics about maximum likelihood estimation. 4) We will introduce some numerical methods for nonlinear optimization: the gradient descent, stochastic gradient descent, momentum update. 5) We will explain how all the previous ingredients are combined together in the feedforward-backpropagation algorithm used for data-driven learning. In parallel with the theory, we will illustrate how to implement it using the PyTorch library in some educational examples in image recognition and language models, putting some stress on the process of babysitting a neural network (initialization, normalization, checking overfitting). Projects proposed by the Ph.D. Students will be strongly encouraged.

Syllabus

The course will start with a general introduction to the objectives of data-driven machine learning and by explaining where neural networks and deep learning fit in this general framework. Then we will move on to the description of the basic building blocks of neural networks. We will introduce the concept of perceptron and of sigmoid neuron, and we will explain how these simple models can be used to build complex neural networks, with a gentle intro-duction to loss functions and the backpropagation algorithm. This will allow us to build a simple neural network that recognizes handwritten digits from the MNIST dataset with the aid of the Py-Torch library from Python. With this concrete example in mind, we will discuss in detail some of the most important key aspects of neural networks. We shall give an idea of the proof of the Universal Approximation Theorem, explaining how neural networks are able to approximate any continuous function. The proof will highlight the importance of the non-linearity in the activation functions of neural net-works. Then we will refer to some results in the literature that show the benefits of using deep neural networks over shallow ones. Next, we will move on to the choice of the loss function, discus-sing the choice of cross-entropy and log-likelihood loss functions. For this, we will recall some basic concepts of information theory and maximum likelihood estimation in statistics. After the choice of the loss function, we will discuss the optimization of weights in neural networks. We will introduce, in a general setting, the algorithm of gradient descent, explaining how it is used to minimize functions. We will discuss pros and cons of the basic gradient descent algorithm. Then we will introduce in detail the algorithm used in practice to optimize the weights of neural networks, the stochastic gradient descent algorithm. Finally, we will discuss some of the most important variants of this algorithm, such as momentum update. With these tools in hand, we will build a simple neural network from scratch. We will move on to regularization techniques in neural networks, discussing the concepts of regularization and dropout. Moreover, we will discuss the problem of

Insegnamento	Mathematical methods in deep learning

vanishing and exploding gradients in deep neural networks, and we will introduce the concept of batch normalization, explaining how it can be used to mitigate these problems. If time permits, we will discuss some further topics in deep learning, such as convolutional neural networks for image recognition and natural language processing. A lecture will be dedicated to the question of how neural networks represent features in the data, discussing the concept of superposition of features and the Johnson-Lindenstrauss lemma.

Bibliografia

General references - M. Nielsen, Neural Networks and Deep Learning, Determination Press, 2015. - I. Goodfellow, Y. Bengio, and A. Courville, Deep Learning, MIT Press, 2016. Introduction - Prima e seconda rivoluzione industriale (in Italian) https://www.treccani.it/enciclopedia/rivoluzione-industriale/ - Timeline of Machine Learning: https://en.wikipedia.org/wiki/Timeline_of_machine_learning - J. Schmidhuber. Annotated History of Modern AI and Deep Learning. https://arxiv.org/abs/2212.11279 - M. Roser. The brief history of artificial intelligence: the world has changed fast — what might be next?. Published online at Our-WorldinData.org. Retrieved from: https://ourworldindata.org/brief-history-of-ai - F. Duarte. Amount of Data Created Daily (2024). https://explod-ingtopics.com/blog/data-generated-per-day Machine learning - A. Quarteroni. Physics-based and data-driven mathematical models for the simulation of complex problems. C.I.M.E. Course. https://sites.google.com/unifi.it/cime/c-i-m-ecourses/c-i-m-e-courses-2024/pdes-control-and-deep-learning - T. Hastie, R. Tibshirani, and J. Friedman, The Elements of Statisti-cal Learning, Springer, 2009. Linear regression - T. Hastie, R. Tibshirani, and J. Friedman, The Elements of Statisti-cal Learning, Springer, 2009. Logistic regression - C. M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006. Cross-entropy - T. Cover and J. Thomas, Elements of Information Theory, Wiley, 1991. Optimization algorithms (general reference) - J. Nocedal and S. J. Wright, Numerical Optimization, Springer, 2006. Gradient descent and stochastic gradient descent - G. Garrigos, R. M. Gower. Handbook of convergence theorems for (Stochastic) Gradient Methods. https://arxiv.org/abs/2301.11235 Neural networks - M. Nielsen, Neural Networks and Deep Learning, Determination Press, 2015. - I. Goodfellow, Y. Bengio, and A. Courville, Deep Learning, MIT Press, 2016. Perceptron - F. Rosenblatt, The Perceptron: A Probabilistic Model for Infor-mation Storage and Organization in the Brain, Cornell Aeronauti-cal Laboratory, 1957. - M. Nielsen, Neural Networks and Deep Learning, Determination Press, 2015.å Universal approximation theorem - G. Cybenko, Approximation by superpositions of a sigmoidal function, Mathematics of Control, Signals, and Systems, 2(4), 303-314, 1989. - M. Nielsen, Neural Networks and Deep Learning, Determination Press, 2015. Datasets - Real estate dataset collected from https://www.kaggle.com/da-tasets/kirbysasuke/houseprice-prediction-simplified-for-regres-sion - MNIST dataset collected from https://www.kaggle.com/datasets/oddrationale/mnist-in-csv - Seoul Bike Sharing Demand dataset collected from https://ar-chive.ics.uci.edu/ml/datasets/Seoul+Bike+Sharing+Demand

CORSO DI DOTTORATO: DRIG

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Smart sustainable manufacturing						
SSD	IIND-04/A	Ore	20	CFU	2	Anno/Semestre	First
Livello 2026/2027		2		Paniere 2026/2027		7	

Obiettivi

The major issue of sustainable manufacturing activities is the management of useful information: the way we choose data to measure may strongly change the perception of its nature and influence. Thus sustainability, which is an emerging paradigm in manufacturing, is now leading the most of the scientific efforts in defining the assessment of sustainability and the collection of significant measures of transition toward actions that satisfies the economic, environmental, social and technological targets. Smartness paradigm in manufacturing, on the other hand, is deeply tied to the information management and use, provided the Digital Twins as well as Cyber Physical Systems are mostly based on data get from sensing systems and on their elaboration to predict the evolution of systems simulated. The class will bring the students to understand the main driving issues in assessing and managing sustainable manufacturing in the light of a smart transition. At the same time will put major issues to come in order to stimulate students in their scientific career to deepen open issues still remaining on the subject from a technological perspective. Contents 1CFU. Manufacturing processes and the main factors of production: material and energy. Manufacturing and sustainability. Production systems and their sustainable management. Smart manufacturing paradigms: I4.0 and 5.0. 1CFU Criteria for modeling manufacturing processes and their critical variables. Cyber Physical System and Cyber Physical Social System. Measurement of the ecological footprint of a process: carbon and water footprint. Sustainability Assessment of manufacturing processes based on 1 and 2nd law of thermodynamics.

Syllabus

Sustainable maufacturing; assessing manufacturing sustainability; Modeling manufacturing processes; Design ditigal twins for manufacturing processes

Bibliografia

Scientific papers, slides and support material from the lecturer

CORSO DI DOTTORATO: DRIG

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Technological changes and transition perspective						
SSD	IEGE-01/A	Ore	20	CFU	2	Anno/Semestre	First
Livello 2026/2027		2		Paniere 2026/2027		8	

Obiettivi

The technological change is continuously increasing its pace. New technologies and business models are impacting the economic and social systems in a deep and unexpected way as well as social systems are adapting and reacting to these changes. The aim of the course is firstly to adopt the epistemological point of view for the technological determinism to examine how technology, economy, and society interact each other when a change in technology occurs. Some cases will be presented and discussed (asbestos cement, iron, and automotive technologies). Then, the transition perspective is presented to explain how such changes can determine long-term and wide impact. The type and nature of the transition are discussed. The structural and ideological nature of a transition will be described to support a full understanding of the phenomena. Some tools to operationalize ideologies are introduced. The green and digital transition will be examined adopting this perspective. A specific analysis for the transitions towards the smart city and the new space economy will be discussed with students.

Syllabus

The course will focus on the role of technology change in the evolution of the society. In the first lecture, starting from an historical analysis, technology determinism will be analyzed to conclude that technology is only one of the driving forces of the history. In the second lecture, how technology is considered in the economic theory will be presented and discussed. Adopting an evolutionary approach, the role of technological changes is examined introducing technology paradigms and trajectories. Finally, the relationship between technological change and standardization will be introduced. In the third lecture, the need to include social aspects to understand the complex dynamics of technological change is presented discussing the concept of socio-technical landscape. The transition perspective is proposed to understand both structural and ideological changes. In the fourth and fifth lectures, two important transitions are presented and discussed: from linear to circular economy models, and from space economy to new space economy. In both cases, structural and ideological changes will be analyzed to explain what is missing in most of public debates and policies regarding transitions enabled by technological changes.

Bibliografia

Scientific papers, slides and support material from the lecturer

CORSO DI DOTTORATO: DRIG

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Empirical research on sustainable innovation and resilience**						
SSD	IEGE- 01/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**		/	
Obiettivi							
This module will deal with empirical research in the fields of sustainable innovation and consumer behavior, with a specific focus on surveys (questionnaire development, administration, and statistical data analysis) as well as main approaches and tools firms can consider in assessing and managing supply chain risks in order to achieve resilience in their supply chains.							
Syllabus							
In the fields of sustainable innovation and consumer behavior, primary data collection and analysis can be very important to conduct empirical research. In this module, a specific focus will be made on surveys. The following topics will be dealt with: survey design, questionnaire development, questionnaire administration, and statistical data analysis. The use of this methodology will be explained also through the presentation of research conducted on green innovation and sustainable consumer behavior. A deep knowledge of this methodology by PhD students will provide them with a tool whose usefulness is not limited to the fields of sustainable innovation and consumer behavior, but that can be easily applied to many other fields.							
Bibliografia							
Scientific papers, slides and support material from the lecturer							

CORSO DI DOTTORATO: DRIG

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	From qualitative to quantitative methods in business research						
SSD	IEGE-01/A	Ore	20	CFU	2	Anno/Semestre	Second/First
Livello 2026/2027		3		Paniere 2026/2027		/	

Obiettivi

The aim of the course is to provide PhD students with a set of building blocks for conducting, at the academic level, both quantitative and qualitative research in the areas of management, economics, and policy. As quantitative research, the course addresses three main issues of qualitative research. First, the course provides theoretical insights into different quantitative research methodologies and designs. Second, the course introduces PhD students to various methodologies for gathering data, observations, and evidence and for organising them in ways that can be used for quantitative analysis. Third, the course introduces PhD students to various quantitative methodologies – from regression analysis to text mining – to support PhD students in the development of practical skills as well as critical thinking for interpretation purposes. As to the qualitative research, PhD students will be introduced to the basic ideas behind the qualitative research in social science. Students will learn about data collection, description, analysis and interpretation in qualitative research. Qualitative research often involves an iterative process. The course will focus on the ingredients required for this process: data collection and analysis.

Syllabus

This course equips PhD students with the core building blocks for conducting rigorous academic research – quantitative, qualitative, and mixed methods – in management, economics, and policy. On the quantitative side, students explore the theoretical foundations of different research designs, learn strategies for gathering and structuring data and evidence, and apply a range of analytical techniques, developing both technical skills and the critical judgement needed to interpret results. On the qualitative side, students are introduced to the foundational principles of qualitative inquiry in the social sciences, working through the iterative cycle of collecting, describing, analysing, and interpreting non-numerical data. Finally, the course brings the two traditions together through mixed-methods research, teaching students how to combine and integrate quantitative and qualitative data through convergent, explanatory, and exploratory sequential designs.

Bibliografia

Scientific papers, slides and support material from the lecturer

CORSO DI DOTTORATO: DRIG

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Human-based Smart Manufacturing Systems						
SSD	IIND-05/A	Ore	20	CFU	2	Anno/Semestre	Second/First
Livello 2026/2027		3		Paniere 2026/2027		/	

Obiettivi

The course aims to provide students with a deep understanding of the principles and applications of Industry 5.0, emphasizing the integration between human in-telligence and smart technologies within modern manufacturing systems. It fo-cuses on the transition from Industry 4.0's automation and digitalization para-digm to a human-centric, resilient, and sustainable production model, enhancing both competitiveness and social value.

Syllabus

Rationale The fifth industrial revolution, known as Industry 5.0 (I5.0), encompass a vision for a human-centred, innovative, resilient, and competitive industry. I4.0 moved the focus from a traditional product-driven (mass) industrial production towards a "demand-driven" market that requires the fully-integrated systems able to adapt, in real-time, the production system to the demand change. The I5.0 ap-proach re-introduces the human-centred dimension as the key resource of a smart production systems adopting I4.0 technologies. In the transition from traditional to new production systems, two critical elements arise: the companies' "readiness degree", that is, the assessment of the potential benefits from the adoption of I4.0 technologies and the "human component". With the aim of successfully imple-menting ICT technologies allowing 'thing', 'services' and 'human' to be contin-uously remotely connected by i-cloud centralized systems, a reliable evaluation of both the potential increasing of the competitiveness degree and a reliable de-scription of the behaviour and of the knowledge and skills of the human compo-nent in the new work environment are required. Program: • 08 January 2026 Human Centric Impact of Assistive Technologies in Production and Logistics Systems • 09 January 2026 TPM & Industry 5.0 in FMCG (Fast-Moving Consumer Goods) Manufactur-ing • 23 January 2026 Industry 4.0, Internet of Things and Lifecycle Management. Digital Integra-tion of the Factory: towards the I5.0 Paradigm • 05 February 2026 Towards a holistic approach to measuring operators' wellbeing within the Industry 5.0 paradigm: Tools and methods • 06 February 2026 Human centric collaborative workplace: the human robot interaction system perspective

Bibliografia

Scientific papers, slides and support material from lecturer.

CORSO DI DOTTORATO: DRIG

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Lean production in the digital factory**						
SSD	IIND-05/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second/First
Livello 2026/2027		3		**Paniere 2026/2027**		/	

Obiettivi

The course provides PhD students with the core knowledge they need: i. to understand the concept of Lean Production (principles, models and tools); j. ii. to learn how to manage the process of continuous improvement of a smart production system; iii. to enable the Lean Transformation in the digital factory, product development process, and supply chain

Syllabus

The course provides PhD students with the core knowledge they need: i. to understand the concept of Lean Production (principles, models, and tools); ii. to learn how to manage the process of continuous improvement of a smart production system; iii. to enable the Lean Transformation in the digital factory, product development process, and supply chain.

Bibliografia

Scientific papers, slides and support material from the lecturer

CORSO DI DOTTORATO: DRIG

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Management and Business research						
SSD	IEGE-01/A	Ore	20	CFU	2	Anno/Semestre	Second/First
Livello 2026/2027		3		Paniere 2026/2027		/	
Obiettivi							
This course aims to introduce PhD students to a scientific approach to the study of management and business issues. The focus is on equipping students with the fundamental knowledge and skills for undertaking research in managemen and business and to critically evaluate research conducted by others. The course is divided into four interrelated segments: problem formulation/conceptualisation, implementation, analysis, publication, and communication of research findings. Ethic issues will be further discussed							
Syllabus							
Lezione n. 1 Problem Formulation & Conceptualizaion Lezione n. 2 Research Design Lezione n. 3 Research Implementation Lezione n. 4 Publication Strategies Lezione n. 5 Communication of Research Findings							
Bibliografia							
Scientific papers, slides and support material from the lecturer							

CORSO DI DOTTORATO: DRIG

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Smart and sustainable last-mile logistics**						
SSD	IIND-05/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**		/	

Obiettivi

The aim of the course is to provide the basic knowledge and advances on the principles and methods of freight and people last-mile logistics design and management in urban areas through innovative Industry 4.0 technologies.

Syllabus

Introduction to Last-mile logistics, ecommerce influence, urban areas constraints, smart cities opportunities, and Industry 4.0 technologies. 2. Innovative models of last mile delivery in urban areas. Perishable products management in food industries. Customer management: requirements, services provided, level of service and willing to pay. Retail product delivery management with e-commerce product integration. 3. Sustainable last-mile logistics: economic, environmental, and social impacts. 4. Smart mobility in urban areas for people and goods: case studies and project applications. 5. Sharing Systems, route planning and optimization models. 6. Sustainable KPI and software tools. 7. Simulation case study and project work. 8. Results and comments of the project work. Gaps, opportunities, and future research developments.

Bibliografia

Scientific papers, slides and support material from the lecturer

CORSO DI DOTTORATO: DRIG

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Design and management of research projects						
SSD	IIND-05/A	Ore	20	CFU	2	Anno/Semestre	First
Livello 2026/2027		2		Paniere 2026/2027			

Obiettivi

This course provides essential knowledge, methodologies, and tools for designing and managing research projects. The main learning objectives are as follows: Guide participants in crafting successful proposals and developing comprehensive plans for research projects to capitalize on available funding opportunities. Focus on the objectives, methodologies, conditions, and best practices of major research programs. Familiarize students with the EU financial framework. Equip pstudents with the principles and competencies of project cycle management. Develop the ability to precisely define the objectives, purpose, and requirements of a project. Introduce principles, techniques, and tools for the design and planning of research projects. Enhance competencies in key project monitoring and control techniques. Familiarize students with the successful dissemination principles of research projects.

Syllabus

Introduction to direct and European funds providing the essential knowledge, methodologies, and tools for designing and managing research projects. 2. Introduction to Horizon Europe funds, focusing on objectives, methodologies, conditions, and best practices of major research programs. 3. Description of Horizon Europe call for proposals case studies, guiding participants in crafting successful proposals and developing comprehensive plans for research projects to capitalize on available funding opportunities. 4. Introduction to territorial cooperation. 5. Description of the principles and competencies of project cycle management. 6. Development of the ability to precisely define the objectives, purpose, and requirements of a project. Introduce principles, techniques, and tools for the design and planning of research projects. Enhance competencies in key project monitoring and control techniques. Familiarize students with the successful dissemination principles of research projects. 7. Case study on industrial research.

Bibliografia

Scientific papers, slides and support material from the lecturer

CORSO DI DOTTORATO: DRIG

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Introduction to probability and statistical inference**						
SSD	MATH-03/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	First/First
Livello 2026/2027		2		**Paniere 2026/2027**			

Obiettivi

This course introduces the fundamental concepts of elementary probability theory and statistical inference.

Syllabus

(CDF), discrete uniform, Bernoulli, binomial, geometric, negative binomial, Poisson distributions and Poisson approximation to the binomial. Continuous random variables: probability density functions (PDF), cumulative distribution functions, uniform, exponential, normal (Gaussian), log-normal distributions, transformations of random variables, Jacobian method, central limit theorem and Gaussian approximation to the binomial. Properties of distributions: expectations, mean, mode, median, variance, higher moments, central moments, skewness, kurtosis, quantiles, percentiles, moment-generating functions, characteristic functions, cumulant generating functions. Inequalities and further distributions: Markov's and Chebyshev's inequality, weak law of large numbers, gamma, chi-squared, Student's t, Fisher-Snedecor F distributions and their relationships. Joint distributions: joint probability mass functions, joint probability density functions, marginal distributions, expected values, independent random variables, covariance, correlation, functions of multiple random variables, conditional distributions. Statistical inference: sample statistics, distribution of sample mean, sampling variability, estimators and their properties (consistency, bias, efficiency), Cramer-Rao lower bound, standard errors, maximum-likelihood estimation, method of moments, Fisher information. Confidence intervals: interval estimation, pivotal quantities, confidence intervals for normal parameters and proportions, one sided confidence intervals. Regression analysis: simple and multiple linear regression, least squares estimation, properties of regression estimators, confidence intervals in regression. Hypothesis testing: principles, simple and composite hypotheses, significance levels, power, Type I and Type II errors, p-values, test statistics, tests for means and proportions, analysis of variance (ANOVA), goodness-of-fit testing.

Bibliografia

• Probability and Statistics for STEM, 2nd ed. by Emmanuel N. Barron and John G. Del Greco, Springer, 2024 • Think Stats, 3rd edition, Allen B. Downey. • Lectures notes

CORSO DI DOTTORATO: DRIME

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Conservation laws in continuum mechanics and traffic modeling						
SSD	MATH-03/A	Ore	20	CFU	2	Anno/Semestre	First /First
Livello 2026/2027		2		Paniere 2026/2027		1	

Obiettivi

Introduction to Conservation Laws. Scalar conservation laws. Hyperbolic systems of conservation laws. Euler and Burgers equations. The Method of Characteristics. Semilinear equations with constant coefficients. Semilinear equations with variable coefficients. Quasilinear equations: creation of shock waves. Shock waves. Discontinuous solutions. Rankine-Hugoniot conditions. Shock waves. Entropies and entropy fluxes for scalar equations and systems. Entropy weak solutions. Kruzkhov entropies. Change of variables. Liu conditions: entropic shock waves. Kruzkhov Theorem. Uniqueness and stability of entropy weak solutions. Change of coordinates. Oleinik Estimate. Oleinik estimate for conservation laws with convex fluxes. Uniqueness via Oleinik type estimates. Minimal entropy conditions. Riemann Problem. Shock and rarefaction waves. Solution of the Riemann problem for convex fluxes. Solution of the Riemann problem for general fluxes. Vanishing Viscosity. Vanishing viscosity approximants. Viscous shock waves. Convergence and error estimate. Numerical schemes. Viscosity solutions for Hamilton-Jacobi equations. Legendre Trasform. Lax-Oleinik Formula. Traffic Models. Fluidodynamic models for vehicular traffic. LWR model: shock and rarefaction waves. Moving bottleneck. Nonlocal models. Aw-Rascle model. Two phase models. Multipopulation models. Traffic on networks: shocks generated by the junctions. Stop and Go waves. Continuum Mechanics. Nonlinear elasticity. Gas dynamics. The p-system. Shock waves. Riemann invariants.

Syllabus

Euler and Burgers equations. The Method of Characteristics. Shock waves. Rankine-Hugoniot conditions. Entropy weak solutions. Oleinik Estimate. Riemann Problem. Vanishing Viscosity. Viscous shock waves. Convergence and error estimate. Legendre Trasform. Lax-Oleinik Formula. Fluidodynamic models for vehicular traffic. LWR model: shock and rarefaction waves. Moving bottleneck. Nonlocal models. Aw-Rascle model. Two phase models. Multi-population models. Traffic on networks: shocks generated by the junctions. Nonlinear elasticity. Gas dynamics. The p-system. Shock waves. Riemann invariants.

Bibliografia

1. A. Bressan. Hyperbolic Systems of Conservation Laws. The one-dimensional Cauchy problem. Oxford Lecture Series in Mathematics and its Applications, vol. 20, Oxford University Press, Oxford, 2000. 2. G. M. Coclite. Scalar Conservation Laws. SpringerBriefs in Mathematics. Springer (2024). 3. C. M. Dafermos. Hyperbolic Conservation Laws in Continuum Physics. Second edition. Grundlehren der Mathematischen Wissenschaften [Fundamental Principles of Mathematical Sciences], vol. 325, SpringerVerlag, Berlin, 2005. 4. L. C. Evans. Partial differential equations. Graduate Studies in Mathematics, vol. 19, American Mathematical Society, Providence, RI, 1998. 5. M. Garavello, K. Han, and B. Piccoli. Models for vehicular traffic on networks. AIMS Series on Applied Mathematics 9. Springfield, MO: American Institute of Mathematical Sciences (AIMS), 2016. 6. H. Holden and N. H. Risebro. Front tracking for hyperbolic conservation laws. Applied Mathematical Sciences, vol. 152, Springer-Verlag, New York, 2002. 7. D. Serre. Systems of conservation laws - 1 & 2. Cambridge University Press, Cambridge, 2000.

CORSO DI DOTTORATO: DRIME

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Optimization theory**						
SSD	MATH-03/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	First
Livello 2026/2027		2		**Paniere 2026/2027**		1	

Obiettivi

Mathematical Formulation. Control of production and consumption. Reproductive strategies in Social Insects. Pendulum. Moon lander. Rocket railroad car. Controllability of Linear Systems. Observability. Bang-Bang Principle. Time Optimal Control. Calculus of Variations and Hamiltonian Dynamics. Pontryagin Maximum Principle. Control of production and consumption. Linear Quadratic Regulator. Maximum Principle with transversality conditions. Distance between two sets. Commodity trading. Hamilton-Jacobi-Bellmann equation. Dynamic programming. Connections between dynamic programming and the Pontryagin Maximum Principle. Differential games. Isaacs equations. Games and the Pontryagin Maximum Principle. War of attrition and attack.

Syllabus

Mathematical Formulation. Control of production and consumption. Reproductive strategies in Social Insects. Pendulum. Moon lander. Rocket railroad car. Controllability of Linear Systems. Observability. Bang-Bang Principle. Time Optimal Control. Calculus of Variations and Hamiltonian Dynamics. Pontryagin Maximum Principle. Control of production and consumption. Linear Quadratic Regulator. Maximum Principle with transversality conditions. Distance between two sets. Commodity trading. Hamilton-Jacobi-Bellmann equation. Dynamic programming. Connections between dynamic programming and the Pontryagin Maximum Principle. Differential games. Isaacs equations. Games and the Pontryagin Maximum Principle. War of attrition and attack.

Bibliografia

Handwritten lecture notes of G. M. Coclite.

CORSO DI DOTTORATO: DRIME

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Contact Mechanics and Interfacial Phenomena**						
SSD	IIND- 02/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second
Livello 2026/2027		2		**Paniere 2026/2027**		/	

Obiettivi

The course focuses on the contact mechanics of smooth and rough deformable solids. The effects of interfacial interactions, such as adhesion and friction, on the contact behavior are also studied. Probability theory for rough surface analysis is also briefly discussed.

Syllabus

Repulsive Contacts: Flat punch contact theory Hertzian contact theory Adhesive Contacts: Introduction to adhesive interactions (Lennard-Jones potential) Interfacial energy balance (energy release rate) Tabor parameter and adhesive contact mechanics (JKR vs. DMT approach) Frictional Contacts: Introduction to dry frictional interactions In-plane and out-of-plane coupling in contact mechanics Rough surface analysis: Surface roughness as a stochastic (ergodic) process Power spectral density (PSD), PSD momentums, and statistical parameters

Bibliografia

Johnson, K.L. (1985). Contact Mechanics. Cambridge University Press. ISBN 978-0-521-25576-9 Maugis, D. (2003). Contact, Adhesion and Rupture of Elastic Solids. Springer Science & Business Media. ISBN 3-540-66113-1. Bhushan, Bharat. "Surface Roughness Analysis and Measurement Techniques." Modern Tribology Handbook, Two Volume Set. CRC Press, 2000. 79-150.

CORSO DI DOTTORATO: DRIME

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Numerical Approaches to Solid and Applied Mechanics: Boundary Element Methods (BEM)**						
SSD	IIND-02/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second/First
Livello 2026/2027		2		**Paniere 2026/2027**		/	

Obiettivi

Theory of BEM (6 hours). Linearity and superposition principle: integral formulation of mechanical problems. Green's function. Translation Invariance. Solution schemes of the integral convolution: Fourier vs Real space. Adaptive mesh. BEM Applications: Contact Mechanics (6 hours). BE methods for contact mechanics: formulation for linear elastic and viscoelastic materials, role of the geometric domain (smooth and rough contacts), meshing and solution schemes. Boundary Element (BE) vs Finite Element (FE) methodologies: advantages and drawbacks. Coupling BEM And Other Numerical Methods (4 hours). Numerical coupling to study finite domains: BEM and FEM; BEM and molecular dynamics (MD). The case of soft lubrication: coupling BEM and finite difference (FD). BEM Applications: Structural Mechanics (4 hours). BEM for modal analysis including fluid-structure interaction: the test case of the modal analysis for a beam immersed in a viscous fluid.

Syllabus

Theory of BEM (6 hours). Linearity and superposition principle: integral formulation of mechanical problems. Green's function. Translation Invariance. Solution schemes of the integral convolution: Fourier vs Real space. Adaptive mesh. BEM Applications: Contact Mechanics (8 hours). BE methods for contact mechanics: formulation for linear elastic and viscoelastic materials, role of the geometric domain (smooth and rough contacts), meshing and solution schemes. Boundary Element (BE) vs Finite Element (FE) methodologies: advantages and drawbacks. Coupling BEM And Other Numerical Methods (4 hours). Numerical coupling to study finite domains: BEM and FEM; BEM and molecular dynamics (MD). The case of soft lubrication: coupling BEM and finite difference (FD). BEM Applications: Structural Mechanics (2 hours). BEM for modal analysis including fluid-structure interaction: the test case of the modal analysis for a beam immersed in a viscous fluid.

Bibliografia

[]] Johnson, K.L.J., 1985. Contact Mechanics. Cambridge University Press. [2] Hamrock, B. J., Schmid, S. R., Jacobson, B. O. Fundamentals of Fluid Film Lubrication; CRC Press, 2004. [3] Putignano, C.; Afferrante, L.; Carbone, G.; Demelio, G. A new efficient numerical method for contact mechanics of rough surfaces. Int. J. Solids Struct. 2012, 49 (2), 338−343.

CORSO DI DOTTORATO: DRIME

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Hydrogen for Sustainable Transportation Systems						
SSD	IIND-06/A	Ore	20	CFU	2	Anno/Semestre	First/First
Livello 2026/2027		3		Paniere 2026/2027		-	

Obiettivi

Hydrogen is widely considered a key energy carrier for the decarbonization of hard-to-abate transport sectors such as heavyduty road transport, railways and maritime mobility, where full electrification is often technically or economically challenging. The course provides an overview of the hydrogen value chain applied to transportation, including production pathways, distribution infrastructures and storage solutions, with particular attention to their implications for mobility applications. After introducing the role of hydrogen in the energy transition of the transport sector, the course analyses the potential impact of hydrogen across different transport modes. The technological solutions currently under development are then presented, focusing on hydrogen-based propulsion systems. In particular, the course discusses hydrogen fuel cell technologies, with emphasis on Proton Exchange Membrane Fuel Cells (PEMFC) and their integration in automotive, railway and marine powertrains. The configuration of hydrogen-based propulsion architectures, hybridization strategies and power management systems are addressed. In addition, hydrogen internal combustion engines are introduced as an alternative technological pathway, highlighting their advantages in terms of technological maturity, compatibility with existing engine technologies and potential use of non-purified hydrogen. Overall, the course aims to provide doctoral students with a comprehensive understanding of hydrogen technologies for transport applications, including the main engineering challenges related to storage, system integration, durability and safety.

Syllabus

Introduction: the transports sector and the hydrogen scenario; The hydrogen production and distribution; Hydrogen impact in different transport sectors; Hydrogen storage solutions; Introduction on fuel Cell technology; PEMFC powertrains in the automotive Sector; PEMFC powertrains in railway sector; PEMFC powertrains in marine sector; Introduction to hydrogen internal combustion engines.

Bibliografia

• O'hayre, R., Cha, S. W., Colella, W., & Prinz, F. B. (2016). Fuel cell fundamentals. John Wiley & Sons. • Saponaro, G., Stefanizzi, M., Torresi, M., & Camporeale, S. M. (2024). Analysis of the degradation of a Proton Exchange Membrane Fuel Cell for propulsion of a coastal vessel. International Journal of Hydrogen Energy, 61, 803-819. • Anaclerio, G. (2025). Injection and combustion modelling in hydrogen internal combustion engines. • Hirose, K. (2010). Handbook of hydrogen storage: new materials for future energy storage. John Wiley & Sons. • Ferrari, G., Onorati, A., & D'Errico, G. (2022). Internal combustion engines. Società Editrice Esculapio.

CORSO DI DOTTORATO: DRIME

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Introduction to fluid-structure interaction**						
SSD	IIND-01/F	**Ore**	20	**CFU**	2	**Anno/Semestre**	First
Livello 2026/2027		3		**Paniere 2026/2027**		-	

Obiettivi

The objective of this course is to deliver the key topics concerning Fluid-Structure Interaction (FSI) problems for biophysical and engineering applications. The students are expected to understand the mechanisms underlying the fluidelastic effects in microscopic and human-scale applications, with the respective modelling approaches. The course will focus on simplified, low-dimensional models containing key aspects of real-world problems. Reference applications include bacterial locomotion, aeroelastic phenomena on airfoils, flow-induced vibrations of bridge decks, vibrations of conveying pipes. Numerical solutions will be addressed by means of a Matlab implementation.

Syllabus

• Basic concepts: transport equations of fluid flows, equilibrium equations of elastic solids, dimensionless groups; (1.5h) • FSI in linear flows: steady Stokes regime, drag anisotropy, reciprocal motions (the scallop theorem), local drag theory for slender bodies, bacterial locomotion by beating flagella. (4h) • FSI in nonlinear flows: linear and weakly nonlinear stability of a spring-mass-damper system, self-excited oscillations and instabilities, galloping, vortex-induced vibrations, added mass effects. (5h) • Case study: flow-induced vibrations of a 2 degrees-of-freedom airfoil. Model derivation and numerical solution. (2.5h) • FSI in pipes conveying fluid: model derivation, linear solution of pipe with supported ends, instability map. (3h) • Case study: steady reconfiguration of a flexible shell under wind load (6h). Model derivation and numerical solution. (4h)

Bibliografia

• Kim, S., & Karrila, S. J. (2013). Microhydrodynamics: principles and selected applications. Courier Corporation. • Païdoussis, M.P., 2003. Fluid-Structure Interactions: Slender Structures and Axial Flow. Volume 2. Academic Press, London, UK. • Bisplingho R. L., Ashley H. and Halfman R. L., “Aeroelasticity", Dover Publications Inc., New York

CORSO DI DOTTORATO: DRIME

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Offshore Wind Technologies						
SSD	IIND-06/A	Ore	20	CFU	2	Anno/Semestre	First
Livello 2026/2027		3		Paniere 2026/2027		-	

Obiettivi

Offshore wind energy has the potential to integrate a large part of the renewable electric energy that will be produced in the coming Years to meet the objectives of reducing global CO2 emissions. For Italy in particular, interest is focused on floating turbine technologies, which can play an important role in industrial development, with the integration of blue economy activities in ports and at sea. However, floating wind turbines still require fundamental research on platforms, turbines and mooring technologies to make them fully competitive for use in the Mediterranean, where wind speeds and sea states are lower than in northern Europe. The course provides an overview of floating turbine technologies, considering their advantages and disadvantages and their possible integration with other offshore power generation systems such as wave energy converters and floating photovoltaic platforms. The course covers aspects related to digital tools for identifying areas suitable for the development of marine renewable energy sources, tools for performance analysis and simulation, ranging from simplified models based on BEM to more accurate CFD simulations.

Syllabus

Overview on Offshore Wind in EU (Source: GSE – WindEnergy) Global context and potential of offshore wind Capacity factor Key challenges (Wind distribution, waves, currents, Accessibility & maintenance offshore) Environmental aspects (Seabed disturbance, Noise) Concepts and technologies Fixed-bottom vs floating wind technologies Floating platform concepts (Spar, Semi-submersible, TLP) Mooring systems Dynamic modelling and Digital twin Aero–hydro–elastic coupling Simulation codes (OpenFast, Qblade, Aqwa) Wind Farms Wake interaction modelling Bird Migration Routes Energy Storage Systems

Bibliografia

Offshore Wind Turbine Technology, MingWei Ge, Li Li, Hang Meng, Kai Long, Springer Singapore. DOI https://doi.org/10.1007/978-981-96-2175-0 Offshore Wind Energy. Environmental Conditions and Dynamics of Fixed and Floating Turbines, Finn Gunnar Nielsen, Universitetet i Bergen, Norway Floating Offshore Wind Energy. The Next Generation of Wind Energy, Joao Cruz, Mairead Atcheson, Part of the book series: Green Energy and Technology (GREEN), Springer Cham, DOI https://doi.org/10.1007/978-3-319-29398-1

CORSO DI DOTTORATO: DRIME

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Circular Manufacturing and Advanced Materials**						
SSD	IIND- 04/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**			

Obiettivi

The module aims to explore Twin Transition themes applied to production systems and provide doctoral students with the tools to manage advanced polymer products. This includes the entire lifecycle: from the recovery of industrial waste to its transformation into functional cellular structures (via foaming or additive manufacturing), with a specific focus on electromagnetic interference (EMI) shielding properties.

Syllabus

1. The Twin Transition in Manufacturing Green transition: principles of Circular Economy and Sustainable Manufacturing. Digital transition: role of Industry 4.0/5.0 in tracking and optimizing material lifecycles. Regulatory Landscape: European Green Deal and circularity standards for polymers. 2. Upcycling & Secondary Raw Materials Waste valorization: strategies for the recovery and purification of industrial polymer waste. Characterization: assessing the mechanical and thermal properties of recycled feedstocks. Contamination management: dealing with degradation and impurities in secondary materials. 3. Production of Functional Cellular Structures Foaming technologies: physical and chemical blowing agents in circular processes. Additive Manufacturing (AM): design for circularity using 3D printing (FDM, SLS) for lattice structures. Structure-Property relationship: tuning porosity and morphology for specific functional outcomes. 4. Advanced Applications: EMI Shielding Fundamentals: physics of electromagnetic interference and shielding mechanisms (reflection, absorption, multiple reflections). Material design: integrating conductive fillers into cellular matrices. Testing & measurement: laboratory techniques for evaluating shielding effectiveness.

Bibliografia

V. Marrocco, R. Surace, E. Brandonisio, R. Cannone, I. Marasco, C. Tonetti, V. Errico, S.L. Campanelli, G. Calò, I. Fassi, Assessing metal powder fraction and inclusion method for optimized morphology and electromagnetic interference (EMI) shielding effectiveness of recycled low-density polyethylene (LDPE)-based composite foams, Journal of Alloys and Compounds,Volume 1057,2026,ISSN 0925-8388 https://doi.org/10.1016/j.jallcom.2026.186793. V. Marrocco, R. Surace, E. Brandonisio, I. Marasco, C. Pagano, C. Tonetti, V. Errico, G. Calò, S. L. Campanelli, I. Fassi,Investigating EMI shielding performance of recycled polypropylene (PP) composite foams with reused metal powders, Materials & Design, Volume 254, 2025, 114106, https://doi.org/10.1016/j.matdes.2025.114106 V. Marrocco, R. Surace, G. Calò, E. Brandonisio, I. Marasco, F. Filograno, I. Fassi, Chemical Foaming of Carbon Fiber-Polylactic Acid (CF-PLA) Porous Structures and Their Feasibility as EMI Shields in the X-Band," in IEEE Access, vol. 12, pp. 78110-78121, 2024 doi: 10.1109/ACCESS.2024.3407365

CORSO DI DOTTORATO: DRIME

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Introduction to finite volume methods for flow simulations using o pen source software**						
SSD	IIND- 06/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**			

Obiettivi

The course is designed for graduate engineering students who are encountering finite volume method for the first time in their study. The approach emphasizes a gradual and effective learning process, aiming to minimize the time required to attain a solid foundational understanding. Clarity of exposition is prioritized over strict mathematical rigor, with continuous reference to the physical significance of the mathematical formulas presented. This approach enables students to independently produce acceptable results for most case studies of general interest. To enhance accessibility, the course focuses on OpenFOAM, a free and open-source software renowned for its extensive community of developers and users.

Syllabus

Preliminary Concepts Governing Equations of Fluid Dynamics The Finite Volume Method Linear Systems and Their Solution Pressure-Velocity Coupling OpenFOAM®

Bibliografia

Caramia, G., & Distaso, E. (2025). A Practical Approach to Computational Fluid Dynamics Using OpenFOAM®. Springer Nature Switzerland. Greenshields, C. & Weller, H. (2022). Notes on Computational Fluid Dynamics: General Principles. CFD Direct Ltd, Reading, UK Versteeg, H. K., & Malalasekera, W. (2007). Computational fluid dynamics. The finite volume method. Pearson Higher Ed. Moukalled, F., Mangani, L., & Darwish, M. (2015). The finite volume method. In The finite volume method in computational fluid dynamics: An advanced introduction with OpenFOAM® and Matlab. Springer International Publishing.

CORSO DI DOTTORATO: DRIME

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Residual stress evaluation by X- ray diffractometry**						
SSD	IIND- 03/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**			

Obiettivi

Almost every manufacturing process creates residual stresses notably by casting, welding and forming. However, despite their widespread occurrence, the fact that residual stresses occur without any external loads makes them easy to overlook and ignore. Modern residual stress measurement practice is largely based on the early historical roots. However, the modern techniques have attained a very high degree of sophistication due to greatly increased conceptual understanding, practical experience and much more advanced measurement/computation capabilities. The X-ray diffraction method provide the possibility for non-destructive procedures to measure residual stresses. “Non-destructive” implies that the component may be returned to service after the residual stresses are measured and the stress fields evaluated. Furthermore, the measure is rather cheap and fast. Due to these advantages, this method became the most widespread in the evaluation of the residual stresses in mechanical and aeronautical field. The course aims to provide the students with the foundations of measure of RS by x-ray diffraction. To acquire basic skills on x-ray diffraction. To learn the main problems and possible causes of error. At the end of the course, the student must be able to implement the measure of RS by x-ray diffraction, critically evaluate the results obtained and know how to expose them through the proper drafting of a technical report.

Syllabus

Introduction Principles Measurement of Lattice Strain Analysis of Regular dϕψ vs. sin2 ψ Calculation of the stress Effect of the Sample microstructure Apparatus XRD Depth Profiling Using Successive Material Removal Measurement Procedure Examples and practical consideration Laboratory

Bibliografia

Noyan, I. C., & Cohen, J. B. (1987). Residual stress: Measurement by diffraction and interpretation. Springer-Verlag, New York. Schajer, G.S. (Ed.). (2013). Practical residual stress measurement methods. John Wiley & Sons, Ltd. ASTM International. (2020). Standard test method for residual stress measurement by X-ray diffraction for bearing steels (ASTM E2860-20). ASTM International.

CORSO DI DOTTORATO: DRIME

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Response Surface Models and Advanced Optimization**						
SSD	IIND- 04/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**			

Obiettivi

The course delivers concepts regarding the calibration of accurate regression models and advanced tools of optimization. Deepening the former topic allows to formalize, for any type of problem, an accurate correlation between the input and output variables governing the phenomenon under investigation. Highlighting the main effects the inputs have on the response variables becomes therefore immediate. Moreover, the availability of a reliable and accurate regression model represents the base for the subsequent steps of problem optimization, that can be treated both as a single and multi-objective task. The course contents will be divided between theoretical and hands-on lectures, where the latter carried out exploiting the potentialities of the commercial integration platform modeFRONTIER. Graduates will be able to manage data from their own research and use them to calibrate accurate metamodels and, eventually, optimize their own process according to determined response variables.

Syllabus

The Design of Experiment: main advantages The Response Surface Method: calibration of regression models using approximating and interpolating algorithms. The Response Surface Method: Hands on. Problem optimization: main properties optimization algorithms should possess (accuracy vs. robustness) Gradient-based vs. Evolutionary Algorithms. Single-objective vs. Multi-objective optimization: single optimal value against the Pareto Front. Problem optimization: Hands-on

Bibliografia

Technical report from the integration platform modeFRONTIER Slides provided by the Teacher M. Mitchell “An introduction to genetic algorithms” Myers, Montgomery, Anderson-Cook “Response Surface Methodology – Process and Product Optimization using Designed Experiments”

CORSO DI DOTTORATO: DRIME

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Introduction to Partial Differential Equations and Applications						
SSD	MATH-03/A	Ore	20	CFU	2	Anno/Semestre	First/First
Livello 2026/2027		1		Paniere 2026/2027		/	

Obiettivi

Aim of this course is the introduction to the study of partial differential equations. The three main types of linear second order partial differential equations will be considered: parabolic (diffusion equation), elliptic (Laplace equation), and hyperbolic (wave equation), underling their theoretical and applied features.

Syllabus

Preliminary Calculus tools • Differential Calculus o Sobolev Spaces o Differential and integral relationships • · Function sequences and function series o Pointwise and uniform convergence o Fourier Series Partial Differential Equations • · Introduction and classification • · Transport Equation o Physical model o Solving the initial value problem o Transport equation with damping o Transport equation with concentrated source • · Heat Equation o Linear diffusion model o Separation variables o Maximum principle • · Laplace Equation o Harmonic functions o Separation variables o Maximum principle • · Wave Equation o d'Alembert's formula o Vibrating string o Energy conservation • L.C. Evans, Partial differential equations, American

Bibliografia

• L.C. Evans, Partial differential equations, American Mathematical Society, 2010. • S. Salsa, Equazioni a derivate parziali, Metodi, modelli e applicazioni, Springer, 2010. • S. Salsa, G. Verzini, Equazioni a derivate parziali, Complementi ed esercizi, Springer, 2005. • F. Tomarelli, Mathematical analysis tools for engineering, Società Editrice Esculapio, 2024.

CORSO DI DOTTORATO: DRISA

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**DoE and Robust Design applied to setup optimization for numerical and experimental testing**						
SSD	IIND-03/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	First/Second
Livello 2026/2027		2		**Paniere 2026/2027**		1	
Obiettivi							
The aim of the course is to provide skills in the definition of statistically robust setup and analysis of experimental and/or numerical plans in order to reduce the impact of the noise.							
Syllabus							
1. Basics of statistics a. Descriptive statistics and inferential statistics b. Hypothesis testing c. ANOVA (Analysis of Variance) 2. DoE via Factorial Design a. Full factorial design.(single factor experiments and Multi-factor experiments) b. Fractional factorial design c. Response Surface Methodology (RSM) 3. Robust Design a. Taguchi method b. System definition and classification of factors (signal, noise, control) c. Orthogonal array design (internal matrix and external matrix) d. Application of robust setup definition (either numerical or experimental) 4. Case Studies 5. Guided Implementation of an Individual Case Study and Evaluation							
Bibliografia							
Atkinson, A. C.; Donev, A. N.; Tobias, R. D. (2007). Optimum Experimental Designs, with SAS. Oxford University Press. pp. 511+xvi. ISBN 978-0-19-929660-6 Taguchi Methods: Design of Experiments. Amer Supplier Inst (1 novembre 1993). ISBN-10 : 0941243184 Statistical Quality Control: A Modern Introduction Hand outs from the lecturer							

CORSO DI DOTTORATO: DRISA

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Spatio-Temporal dynamics of lasers: modelling and applications						
SSD	PHYS-03/A, PHYS-04/A	Ore	20	CFU	2	Anno/Semestre	First/First
Livello 2026/2027		2		Paniere 2026/2027		1	

Obiettivi

The objectives of the course are: i) ability to describe the dynamics of lasers (and nonlinear optical devices) including coherent effects; ii) understanding spatiotemporal field dynamics in the paraxial approximation; iii) understand applications to pulse generation, multimode coherent dynamics, mode-locking, solitons and optical frequency comb (OFC) formation; iv) understand applications of gathered knowledge to modern semiconductor lasers of remarkable relevance (e.g. quantum dot lasers, quantum cascade lasers).

Syllabus

Derivation of fully coherent radiation/medium (MaxwellBloch) model. Coherent laser dynamics: Rabi oscillations, photon echo, self-induced transparency. Dynamical regimes in different classes of lasers: relaxation oscillations, giant pulses, Q-switching, optical chaos, mode-locking. Semiconductor laser modelling, applications to Quantum Dot/Quantum Cascade Lasers and optical frequency comb formation.

Bibliografia

- Course material provided by instructor Other partially referenced texts: - L.L.Lugiato, F.Prati, M.Brambilla “Nonlinear Optical Systems”, Cambridge Un. Press (2015) - W.W.Chow, S.W.Koch, “Semiconductor Laser Fundamentals”, Springer (99) - O.Svelto, “Principles of Lasers”, V ed., Springer (2009)

CORSO DI DOTTORATO: DRISA

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Advanced Topics in Coding Theory**						
SSD	MATH-03/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	First
Livello 2026/2027		2		**Paniere 2026/2027**		3	
Obiettivi							
The course introduces the fundamental concepts and algebraic structures underlying error-correcting codes, with a focus on algebraic coding techniques for deep-space communications. It also explores an important application of these ideas to secure data transmission, discussing modern code-based cryptographic schemes such as the McEliece cryptosystem.							
Syllabus							
Finite fields Linear codes and their parameters Cyclic codes BCH codes Reed–Solomon codes Post-Quantum Codes Applications in deep-space probe communications and post-quantum cryptography.							
Bibliografia							
• Luca Giuzzi, Codici Correttori, Springer (2006) • Scott A. Vanstone & Paul C. van Oorschot, An Introduction to Error-Correcting Codes with Applications, Kluwer (1989).							

CORSO DI DOTTORATO: DRISA

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**High-energy particle physics instruments and methods for space environment**						
SSD	PHYS-01/A, PHYS-03/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second/First
Livello 2026/2027		3		**Paniere 2026/2027**		/	
Obiettivi							
The course aims to provide an overview of basic principles of particle physics and of the main detectors used for space applications. Moreover, the explanation of the environmental verification strategy aims to give the students a complete overview of the steps needed to take a detector from construction to a correct on-orbit operation.							
Syllabus							
Basic elements of particle physics. Interaction of charged particles and photons with matter. Generalities on astroparticle physics. Detectors for space applications: scintillators, photon detectors, silicon detectors. Environmental verification strategy for space detectors: qualifica-tion and acceptance. Structural and mechanical verification re-quirements. Sinusoidal sweep vibration test, random vibration test, acoustic tests, mechanical shock tests. Electromagnetic com-patibility requirements. Vacuum, thermal and humidity verifica-tion requirements. Thermal balance, thermal vacuum, tempera-ture- humidity verification.							
Bibliografia							
Glenn F. Knoll, Radiation detection and measurements							

CORSO DI DOTTORATO: DRISA

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Hypersonic aerothermodynamics modelling and simulation						
SSD	IIND-01/F	Ore	20	CFU	2	Anno/Semestre	Second/Second
Livello 2026/2027		3		Paniere 2026/2027		/	

Obiettivi

The aim of the course is to provide fundamentals of the physics, chemistry, and gas dynamics of high-temperature gases in the context of hypersonic flows. The course provides an introduction to gas dynamics of high temperature gases with a specific emphasis to thermochemical non-equilibrium and gas surface interactions with examples of accurate numerical simulations.

Syllabus

(4h) Introduction to hypersonic flows and short review of basic gas dynamics: definition of hypersonic flow; Knudsen number, flow regimes and governing equations; quasi-onedimensional flow, area Mach number relation, normal shock waves, oblique shock, and expansion waves. (8h) Properties of high-temperature gases: microscopic description of gases, Boltzmann distribution, thermal and chemical non-equilibrium: classical multi-temperature model and introduction to State-to-State approaches. (3h) Gas dynamics of high-temperature flows: quasi-one-dimensional flow, normal shock waves, speed of sound, oblique shock and expansion waves. (3h) Gas surface interactions: catalytic and ablation phenomena. (2h) Overview of Computational Fluid Dynamics approaches for hypersonic flows and numerical examples.

Bibliografia

John D. Anderson J. “Hypersonic and High Temperature Gas Dynamics”, 2nd Ed 2006, AIAA Education Series “Plasma Modeling - Methods and applications”, Edited by G. Colonna and A. D’Angola, 2nd Ed 2022, IOP Series in Plasma Physics

CORSO DI DOTTORATO: DRISA

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Identification and propagation of optical photons in different media**						
SSD	PHYS-01/A, PHYS-03/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**		/	

Obiettivi

The course aims to provide the student with advanced knowledge of radiation measurements and detection techniques, from classic scintillation detectors to Silicon Photomultiplier devices. Scintillator materials are widely used in particle physics for ion identification and energy measurements. Next-generation space missions will employ plastic scintillator detectors (PSDs) equipped with the new Silicon Photomultipliers (SiPMs) technology to read out the scintillator light emission. Scintillator based detectors are also widely used for radiation monitoring for environmental or industrial purposes. The course requires an elementary background in radiation measurements, radiation-matter interactions and basic electronics.

Syllabus

Introduction to optical photons: properties of light and optical photons, basic photon–matter interactions. Scintillator materials: scintillation process, types of scintillators, and main scintillator properties. Photon propagation in different media: light propagation in transparent and scintillating materials. Basics of optical fibers and waveguides. Silicon Photomultipliers (SiPMs): principles of SiPM technology, integration of SiPMs with scintillators, and main performance characteristics of SiPMs. Brief overview of applications in astroparticle physics, Cherenkov radiation detection and environmental and industrial radiation monitoring.

Bibliografia

• Glenn F. Knoll, Radiation detection and measurements • Stefan Gundacker and Arjan Heering 2020 Phys. Med. Biol. 65 17TR01, The silicon photomultiplier: fundamentals and applications of a modern solid-state photon detector

CORSO DI DOTTORATO: DRISA

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Integrated Photonics for Space						
SSD	IINF-01/A	Ore	20	CFU	2	Anno/Semestre	Second
Livello 2026/2027		3		Paniere 2026/2027		/	
Obiettivi							
The course aims to provide an overview of some of the recent technologies related to integrated photonics for space applications. Participants will acquire the related knowledge through theoretical lectures and application examples.							
Syllabus							
1. Integrated photonics in space systems 2. Technology platforms and photonic building blocks 3. Space environment, packaging and qualification 4. Integrated photonics for optical communications 5. Integrated photonics for sensing and scientific instrumentation 6. Microwave photonics and optical signal processing 7. Application case studies and guided design exercise							
Bibliografia							

CORSO DI DOTTORATO: DRISA

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Optical communications for space						
SSD	IINF-02/A	Ore	20	CFU	2	Anno/Semestre	Second/Second
Livello 2026/2027		3		Paniere 2026/2027		/	
Obiettivi							
The course aims to provide an overview of some of the recent technologies related to optical/photonic communication for space. Participants will acquire the related knowledge through theoretical lectures and numerical examples.							
Syllabus							
• Communications in free space; • Satellites communications with optical links; • Metasurfaces and periodic structures for beam steering; • LIDAR principles; • Laboratory activities.							
Bibliografia							
Scientific papers and books on the selected arguments will be used as reference							

CORSO DI DOTTORATO: DRISA

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Space Commercialization						
SSD	IEGE-01/A	Ore	20	CFU	2	Anno/Semestre	Second
Livello 2026/2027		3		Paniere 2026/2027		/	

Obiettivi

The aim of the course is to develop knowledge about the market challenges and the business opportunities offered to the new generation of European space entrepreneurs by the emerging space economy.

Syllabus

• Overview of the course: objectives and structure • Presentation of the Space Economy and introduction to New Space (2 hours) • New business models and technology trends (approx. 3 hours) – hands-on exercise: risk assessment of selected new space business models • Space finance landscape: overview of opportunities to fund innovation in space (approx. 3 hours) • Challenges to access finance faced by European space ventures (3 hours) • Overview of the European Institutional toolbox to foster commercialization of space (the ESA BIC model, Phi-Labs, Technology Transfer, Intellectual Property, competitions, challenges, export sales support approx. 4 hours) + guest lecturers • Introducing innovation in Space business (2 hours) • Business planning and business canvas (1-2 hours + practical exercise) • Measuring the Space economy (2 hours) + guest lecturer

Bibliografia

• Giovanni Fabrizio Bignami, Andrea Sommariva, L'economia dello spazio. Le sfide per l'Europa, ed. Castelvecchi, 2017. • Cobol Pongide, Marte oltre Marte. L'era del capitalismo multiplanetario, ed. DeriveApprodi, 2019. • Giorgio Petroni, Barbara Bigliardi, The Space Economy. From Science to Market, ed. Cambridge Scholars Publishing, 2019. • Messeni Petruzzelli, Antonio, Umberto Panniello, Space Economy. Storia e prospettive di business, ed. FrancoAngeli, 2019. • https://space-economy.esa.int/

CORSO DI DOTTORATO: DRISA

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Space Economy: past, present, future**						
SSD	IEGE-01/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**		/	
Obiettivi							
The objectives of the course are: i) to explain the evolution of the space industry since its inception; ii) to recognize the current trends and challenges of the space sector; iii) to identify humanity's short-term and long-term future ambitions in space, iv) to outline the role of Italy and Europe in the global Space Economy.							
Syllabus							
The Space Industry 1. The early days of the space industry: a. Sputnik; b. Apollo and Space Shuttle program, i. Deep dive on human spaceflight 2. Today's space industry: a. The aerospace band; b. International Space Station; c. Satellite platforms and satellite services; d. Rocket launchers: expendable, refurbishable, reusable 3. Short-term future: a. Artemis program for Moon exploration; b. Mars robotic exploration; c. In-space manufacturing and logistics 4. Long-term future: a. Permanent lunar and Martian habitats; b. Exploitation of extraterrestrial resources The Space Economy: 1. Domains of operation: civil, commercial, military, a. Deep dive on military space; 2. Business opportunities in the New Space Economy; 3. Space law: diplomacy, treaties, agreements; 4. Space and finance: future markets; 5. Space in Italy: organization, actors, and peculiarities							
Bibliografia							

CORSO DI DOTTORATO: DRISA

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Spacecraft Structural Dynamics & Loads						
SSD	IIND-01/D	Ore	20	CFU	2	Anno/Semestre	Second/Second
Livello 2026/2027		3		Paniere 2026/2027		/	

Obiettivi

The course aims to explain basic notions as well as some advanced concepts about structural dynamics and its importance in the development of the spacecraft structures (design, analysis, and test). Both numerical methods and experimental results will be presented.

Syllabus

Session 1 – June 16, 2026 (14.30 - 17.30) - Objectives of the course - Loads analysis: task and purpose - Spacecraft flight loads, design loads and test loads - Structural Dynamics & Loads Analysis - Spacecraft structures and margin of safety - Spacecraft mechanical environments and categorization - Basic concepts in vibration data analysis Session 2 – June 17, 2026 (14.30 - 17.30) - Real eigenvalue analysis - Linear frequency response analysis - Linear transient response analysis - Random vibration analysis (FEM) - Vibro-acoustics (FEM/BEM, SEA) - Shock response spectrum (and its applications) Session 3 – June 18, 2026 (14.30 - 17.30) - Equivalent sine input - Modal effective mass - Component Mode Synthesis (Craig Bampton Method) Session 4 – June 19, 2026 (14.30 - 16.30) - Quasi static loads - Fundamentals of specification development - Test Specifications in ESA / ECSS Projects - Mechanical Impedance (and introduction to “notching”) Session 5 – June 23, 2026 (14.30 - 17.30) - Qualification and Acceptance - Typical Requirements for Spacecraft Structures - Prototype vs. Proto-flight - Loads and factors - Design loads cycles - Mass Acceleration Curve - Random vibration specifications - Spacecraft / Launcher Coupled Loads Analysis - Exercise on Coupled Loads Analysis Session 6 – June 24, 2026 (14.30 - 17.30) - Spacecraft mechanical testing & verification by test - Static loads test - Sine vibration test and Sine-burst load test - Modal survey test & experimental modal analysis - Acoustic noise test & vibroacoustic environment - Random vibration test - Shock environment & shock tests Session 7 – June 25, 2026 (14.30 - 17.30) - Reduction of overtesting in vibration testing (“notching”) - Verification and validation of Finite Element models - Model Verification and Quality Checks - Model Validation - Model Updating Using Design Sensitivity and Optimisation - Final Verification and Verification Loads Cycle - Conclusions and bibliography

Bibliografia

CORSO DI DOTTORATO: DRISA

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Microwave Photonics in Space						
SSD	IINF- 01/A	Ore	20	CFU	2	Anno/Semestre	Second
Livello 2026/2027		3		Paniere 2026/2027		/	

Obiettivi

The course provides a theoretical and practical introduction to microwave photonics devices and their applications in space systems. The first part focuses on microwave photonics principles and technologies, with emphasis on space applications and future developments. The second part consists of laboratory activities on the design and simulation of simple microwave photonics components.

Syllabus

After an introductory overview of microwave photonics and its role in modern space systems, the course covers optical generation, distribution, processing, and detection of radio-frequency signals. A practical and application-oriented approach is adopted, addressing: • Advantages of microwave photonics compared with conventional RF and microwave technologies; • Fundamental building blocks, including optical sources, modulators, photodetectors, filters, delay lines, and integrated photonic circuits; • Photonic generation of microwave and millimetre-wave signals; • Optical beamforming networks and phased-array antenna systems; • Microwave photonic filtering and signal processing; • Integrated microwave photonic technologies for satellite payloads; • Applications to radar, remote sensing, navigation, and space situational awareness; • Examples of current and emerging microwave photonic architectures for space missions.

Bibliografia

Slides and scientific papers provided during the lessons.

CORSO DI DOTTORATO: DRISS

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Construction safety: legal and administrative aspects, technical standards**						
SSD	CEAR-06/A, GIUR- 14/A	**Ore**	30	**CFU**	3	**Anno/Semestre**	First
Livello 2026/2027		2		**Paniere 2026/2027**		6	

Obiettivi

Nowadays, the structural safety of constructions is a key problem, especially for critical infrastructures like bridges, industrial and energy production plants, etc.. Indeed, eventual collapses may involve risks not only for human lives but also for the preservation of the environment. This course proposes a multidisciplinary approach for giving effective answers to the safety of construction problems, involving different points of view, coming from the fields of structural engineering, technical standards, and legal aspects.

Syllabus

– Construction Safety: Challenges, Principles and Regulatory Framework – Technical Standards and Structural Reliability – Inspection, Monitoring and Risk Management – Legal Liability and Administrative Responsibilities – Failure Analysis and Lessons Learned – Future Perspectives: Sustainability, Resilience and Digitalization

Bibliografia

CORSO DI DOTTORATO: DRISS

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Energy Production: Storage, Emerging Technologies & Social Challenges**						
SSD	IIND-07/A–IEGE-01/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	First/Second
Livello 2026/2027				**Paniere 2026/2027**			

Obiettivi

This SCUDO course will deepen the fundamentals of distributed energy production and distribution of energy. The course aims to provide PhD students with methodologies to support a renewable energy transition for renewable energy communities (REC) looking at investigated in three different modules, emerging technologies for energy production (1), the energy storage opportunities and technologies (2) and social aspects behind the implementation of practices of (REC). The course will provide the tools to carry out an evaluation of the use of energy resources, making the PhD students aware of the methodologies for carrying out an energy production and management systems. The course therefore aims to provide specific technical knowledge on the application and use of the main renewable energy sources, encouraging critical development towards a path aimed at the efficient use of energy resources. During the course, through case studies, the ability to propose both managerial and technological-system interventions will be developed, and advanced tools for visualizing energy consumption will be presented, facilitating its monitoring.

Syllabus

The course provides an overview of distributed and renewable energy production, storage technologies, and the social dimensions of energy transition. It is structured into three macro-areas: 1. Emerging Technologies – renewable sources, hydrogen, e-fuels, and innovative energy conversion systems; 2. Energy Storage – electrical, thermal, and chemical storage technologies and their role in balancing renewable generation; 3. Social & Economic Challenges – community engagement, social acceptance, behavioral change, governance models, and policy frameworks for Renewable Energy Communities (RECs). Through lectures and case studies, PhD students will develop analytical and critical skills to design sustainable energy systems integrating technical innovation with societal needs.

Bibliografia

Scientific papers, slides and support material from the lecturer

CORSO DI DOTTORATO: DRISS

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Innovative devices for seismic risk protection						
SSD	CEAR-07/A	Ore	10	CFU	1	Anno/Semestre	First
Livello 2026/2027		2		Paniere 2026/2027		6	

Obiettivi

This course will introduce the use of innovative devices for seismic risk protection of Reinforced Concrete (RC) structure. In particular, the retrofitting of the latter will made using hybrid technological systems based on laminated timber panels. The main goals will be the evaluation of the structure's response and the consequent reduction of seismic risk.

Syllabus

Lecture 1: Fundamentals of Seismic Design and Structural Control Strategies Lecture 2: Seismic Isolation, Principles of seismic isolation Lecture 3: Energy Dissipation Systems Lecture 4: Laboratory Testing and Case Studies

Bibliografia

Chopra A.K., Dynamics of Structures: Theory and Applications to Earthquake Engineering, 5th ed., Pearson, 2017. Christopoulos C., Filiatrault A., Principles of Passive Supplemental Damping and Seismic Isolation, IUSS Press, Pavia, 2006. Naeim F., Kelly J.M., Design of Seismic Isolated Structures: From Theory to Practice, Wiley, 1999. Skinner R.I., Robinson W.H., McVerry G.H., An Introduction to Seismic Isolation, Wiley, 1993. Priestley M.J.N., Calvi G.M., Kowalsky M.J., Displacement-Based Seismic Design of Structures, IUSS Press, Pavia, 2007. Soong T.T., Active Structural Control: Theory and Practice, Longman, 1990.

CORSO DI DOTTORATO: DRISS

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Numerical and experimental modelling of heat transfer**						
SSD	IIND-06/A – IIND-07/B	**Ore**	20	**CFU**	2	**Anno/Semestre**	First/First
Livello 2026/2027		2		**Paniere 2026/2027**		1	

Obiettivi

This course introduces advanced numerical models for solving heat transfer problems across a range of thermal engineering applications, emphasizing model formulation, validation, and procedures for conducting high-fidelity simulations. It also familiarizes students with state-of-the-art computational tools and software for numerical heat transfer analysis. The experimental component covers measurement techniques and instrumentation required for thermal system characterization, enabling integration of numerical and experimental approaches for comprehensive model verification.

Syllabus

• Introduction to thermal engineering and the role of heat transfer within the broader discipline. • Overview of heat-transfer modelling and a practical taxonomy for classifying heat-transfer problems. • Typical workflow for heat-transfer analysis. • Experimental heat transfer: measurement methods, experimental techniques, and data analysis. • Numerical heat-transfer modelling: computational fluid dynamics (CFD) and system-level dynamic simulation approaches. • Overview and discussion of relevant commercial software packages, including ANSYS Fluent, COMSOL Multiphysics, and TRNSYS.

Bibliografia

CORSO DI DOTTORATO: DRISS

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Restoration of Historical buildings**						
SSD	CEAR-11/B	**Ore**	10	**CFU**	1	**Anno/Semestre**	First
Livello 2026/2027		2		**Paniere 2026/2027**		5	

Obiettivi

The course explores the main research trends in the restoration of historic buildings, developing a critical reflection on the methods and criteria that guide the conservation of built heritage. Through engagement with national and international scientific debate and significant case studies, the course aims to consolidate the ability to establish and critically evaluate research paths and intervention strategies for historic architecture.

Syllabus

The course content will be structured around the following topics: • Knowledge as the foundation of the restoration project: sources, interpretation, and the construction of critical judgment; • The restoration project between conservation, transformation, and reuse; • Criteria and methods for defining the restoration project within the context of contemporary debate; • Critical analysis of case studies and recent research experiences in the restoration of historic buildings.

Bibliografia

• G. Carbonara (a cura di), Trattato di Restauro Architettonico, 8 voll., UTET, Torino, 1996–2007. • A. Bellini, Tecniche della conservazione, FrancoAngeli, Milano, 2000. • P. Marconi, Materia e significato. La questione del restauro architettonico, Laterza, Roma-Bari, 1999. • M. Dezzi Bardeschi, Restauro: punto e da capo. Frammenti per una (impossibile) teoria, FrancoAngeli, Milano, 1991. • ICOMOS, International Charters for Conservation and Restoration (Carta di Venezia, 1964; Documento di Nara sull'autenticità, 1994; principali documenti internazionali di riferimento).

CORSO DI DOTTORATO: DRISS

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Characterization and modeling of light alloys**						
SSD	IIND-04/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second/Second
Livello 2026/2027				**Paniere 2026/2027**			
Obiettivi							
This course will be focused on the main experimental methodologies for the technological characterization of light alloys for automotive/aerospace/biomedical applications.							
Syllabus							
1. Introduction to sheet metal forming processes to produce lightweight components: overview of lightweight alloys, conventional and innovative sheet metal forming processes 2. Methodologies for characterization: mechanical characterization methods for cold and warm/hot forming processes 3. Evaluation of light alloys forming limits: Nakajima and Marciniak tests, bulge tests 4. Hands-on activities: Performing mechanical tests studied during the course on a light alloy, obtaining the mechanical properties of the alloy from experimental data							
Bibliografia							
I. Polmear, D. StJohn, J. Nie, M. Qian, Light Alloys (Fifth Edition), Butterworth-Heinemann, 2017, ISBN 9780080994314 Z. Marciniak, J.L. Duncan, S.J. Hu, Mechanics of Sheet Metal Forming (Second Edition), Butterworth-Heinemann, 2002, ISBN 9780750653008							

CORSO DI DOTTORATO: DRISS

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Bridges and critical infrastructures: seismic risk and windstructure interaction**						
SSD	CEAR-07/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**		/	

Obiettivi

This course aims to investigate the structural response of bridges and high-rise buildings under the simultaneous action of wind flow and seismic impulse. The main goal is to estimate the multi-hazard effects on flexible structures, the seismic and wind actions. The calculation of the induced vibration and the comfort limits for users and occupants will be discussed.

Syllabus

• Seismic hazard and the definition of seismic input for bridges and infrastructure • Seismic analysis methods: non-linear static analysis (pushover), linear and non-linear dynamic analysis (time-history) • Seismic isolation and protection/energy dissipation systems for bridges • Structural Health Monitoring (SHM) and Risk Mitigation for Critical Infrastructures - Multi-Hazard Analysis: Structural Response of Bridges and High-Rise Buildings under Simultaneous Actions - Vibration Control and Serviceability: Evaluating Induced Vibration and Comfort Limits for Users and Occupants

Bibliografia

Chopra A.K., Dynamics of Structures: Theory and Applications to Earthquake Engineering, 5th ed., Pearson, 2017. Christopoulos C., Filiatrault A., Principles of Passive Supplemental Damping and Seismic Isolation, IUSS Press, Pavia, 2006. Naeim F., Kelly J.M., Design of Seismic Isolated Structures: From Theory to Practice, Wiley, 1999. Skinner R.I., Robinson W.H., McVerry G.H., An Introduction to Seismic Isolation, Wiley, 1993. Priestley M.J.N., Calvi G.M., Kowalsky M.J., Displacement-Based Seismic Design of Structures, IUSS Press, Pavia, 2007. Soong T.T., Active Structural Control: Theory and Practice, Longman, 1990.

CORSO DI DOTTORATO: DRISS

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Heritage building assesment and control**						
SSD	CEAR-08/A	**Ore**	10	**CFU**	1	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**		/	
Obiettivi							
The module provides a general overview of the methodological workflow supporting the assessment and control of performances, risk vulnerabilities and pathologies in traditional and modern heritage buildings.							
Syllabus							
In detail, theoretical contents, experimental applications and international research experiences and studies will address the following specific topics: • The diagnostic process: conceptual, operational and normative framework; • Onsite investigation of masonry, reinforced concrete and timber buildings components: methods, techniques and operation protocols; • Digital 2D/3D reality-based for decay mapping and monitoring, multi-spectral imaging and multi-sensory data collection: research trends and relevant application. • Collaborative virtual platforms for data collection, analysis and management: WebGIS, BIM, VR/AR.							
Bibliografia							

CORSO DI DOTTORATO: DRISS

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Indoor comfort evaluation**						
SSD	IIND-07/B	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second
Livello 2026/2027				**Paniere 2026/2027**			

Obiettivi

The course will provide an introduction to the basic principles of indoor environment quality including thermal, visual, acoustic comfort as well as indoor air quality. After a brief introduction on the subjective/physiological parameters and their objective counterparts, a quick tutorial on measurement techniques will be provided.

Syllabus

Fundamentals of thermal comfort: Stationary and adaptive thermal models. Standardized measurement techniques according to ISO 7730. Fundamentals of visual comfort and lighting metrics. From illuminance to luminance distribution and glare assessment. Innovative techniques. Fundamentals of acoustic comfort. Noise control and sound insulation. Room acoustic criteria for comfortable listening environments. Overview of measuring techniques. Fundamentals of indoor air quality: pollutants and sources. Ventilation mechanisms and control strategies. Measurement tools.

Bibliografia

Philomena Bluyssen, The Indoor Environment Handbook: How to Make Buildings Healthy and Comfortable, Routledge 2015

CORSO DI DOTTORATO: DRISS

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Innovative materials**						
SSD	CEAR-06/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**		/	

Obiettivi

This course introduces doctoral students to constitutive modelling of materials, building on the foundational knowledge acquired by Master's students and laying the groundwork for modelling the response of innovative materials. In particular, it will cover solid mechanics under large deformations, fundamental of constitutive theories, internal constraints, and constitutive constraints. The course will also address time dependence (viscous behaviour), phase transitions and interactions with other physical phenomena (e.g. electromechanical couplings). These fundamentals will be applied specifically to the constitutive modelling of fibre-reinforced materials, polymeric materials, biological materials, hydrogels, electroactive materials and, ultimately, the mechanics of metamaterials.

Syllabus

This course introduces doctoral students to constitutive modelling of materials, building on the foundational knowledge acquired by Master's students and laying the groundwork for modelling the response of innovative materials.

Bibliografia

CORSO DI DOTTORATO: DRISS

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Innovative technologies for the built environment**						
SSD	CEAR-08/C	**Ore**	10	**CFU**	1	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**		/	

Obiettivi

This teaching proposal explores innovative technologies for built heritage in relation to building decarbonization, climate resilience, and circular economy principles. It focuses on strategies to reduce emissions, improve energy efficiency, and extend the lifecycle of materials in historic and modern buildings, promoting critical analysis through case studies and project-based activities. Particular attention is given to adaptive reuse and sustainable retrofitting practices (e.g., smart energy management systems, green roofs and facades, bio-based insulation materials). At the same time, integrated methodologies are analysed to assess the impacts of these strategies across multiple scales—from the building to the urban and territorial context—within a framework of ecological transition, responsible innovation, and resilience to future climate scenarios (Multiscale Climate Resilience). In summary, the objectives of this course are to provide advanced knowledge and a critical understanding of innovative technologies and strategies for the sustainable transformation of the built environment within the context of the ecological transition. Particular attention is paid to the integration of decarbonisation, the principles of the circular economy and climate resilience across different spatial scales.

Syllabus

The course will consist of four lessons on the following topics: - Built Heritage and Ecological Transition: Challenges and Opportunities - Decarbonisation and Energy Efficiency in Built Heritage - Circular and Sustainable Retrofitting Strategies - Multiscale Climate Resilience and Integrated Design

Bibliografia

CORSO DI DOTTORATO: DRISS

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Mechanical models for masonry structures**						
SSD	CEAR-06/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**		/	
Obiettivi							
Although masonry constructions represent the vast majority of the architectural heritage, to date the scientific community is still wondering about the definition of the most appropriate structural models, especially for the analysis of complex structures (arches, vaults, domes) and for the study of the effects of seismic actions. This course will offer to the Ph.D. students a state-of-the-art review of mechanical models for masonry structures, also giving suggestions for new research directions to be followed.							
Syllabus							
The shape of masonry constructions and the influence of the curvature in the load bearing capacity of arches, domes and vaults. Seismic actions and masonry constructions. Mechanical behavior of masonry: heterogeneity, different behavior in tension / compression, non-linear mechanical response, anisotropy, failure modes, damage. Modeling strategies: micromechanical models, FEM and DEM implementation of micromechanical models, macromechanical models, multiscale models, NT (No-Tension) and RNT (Rigid No-Tension) models, macro-elements. Limit Analysis: static and kinematic approaches. From the static approach of Limit Analysis to the relation between shape and structures in masonry arches and vaults (and back to graphic statics).							
Bibliografia							

CORSO DI DOTTORATO: DRISS

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Smart buildings						
SSD	IIND-07/B	Ore	20	CFU	2	Anno/Semestre	Second/Second
Livello 2026/2027				Paniere 2026/2027			

Obiettivi

Smart zero energy buildings combine energy efficiency measures and renewable energy generation to consume only as much energy as can be produced onsite through renewable resources over a specified time period. This course aims to provide participants with a comprehensive understanding of smart building technologies, their applications, and the role they play in creating sustainable, energy-efficient, and interconnected building systems. Participants will gain hands-on experience with smart systems and learn how to integrate, manage, and optimize building functions using modern technologies.

Syllabus

1. Fundamentals of Building Physics and Energy Systems • Overview of heat transfer mechanisms • Overview of psychrometrics and HVAC systems • Overview of thermal comfort, indoor air quality (IAQ) and indoor environmental quality (IEQ) 2. Introduction to Smart Buildings • Overview of smart buildings and key components • Evolution of building automation and control systems • Case studies: Smart buildings around the world • Introduction to SRI and EN ISO 52120-1:2022 3. Smart building technologies and protocols • Benefits of smart buildings: energy efficiency, sustainability, occupant comfort, and operational efficiency • Smart HVAC systems: optimizing heating, ventilation, and air conditioning systems in buildings • Smart lighting systems: energy-efficient lighting solutions with occupancy sensor • Facility management software: centralised control systems (BMS/BAS) • Communication protocols: BACnet, Zigbee, KNX, ZWave, etc. • Occupant-centric building management: user experience, personalisation, and adaptability 4. Hands-on design exercise: Creating a smart building blueprint, focusing on integrating smart systems (lighting, HVAC, RES) with energy-saving measures.

Bibliografia

• Marco Casini, “Smart Buildings: Advanced Materials and Nanotechnology to Improve Energy-Efficiency and Environmental Performance”, Woodhead Publishing • Tatari, M.; Agarwal, P.; Alam, M.A.; Ahmed, J. Review of Smart Building Management System. Lecture Notes in Networks and Systems 2022, 321, 167–176, doi:10.1007/978981-16-5987-4_18. • Sinopoli, J. Smart Buildings Systems for Architects, Owners and Builders. 2009, 1–231, doi:10.1016/C2009-020023-7. • Anu Prakash, Ashish Shrivastava, Anuradha Tomar, “Control of Smart Buildings”, 2022. doi:10.1007/978-98119-0375-5.

CORSO DI DOTTORATO: DRISS

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Tensegrity structures:fundamentals and analytical model**						
SSD	CEAR-06/A	**Ore**	10	**CFU**	1	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**		/	
Obiettivi							
This course introduces the fundamentals and applications of tensegrity structures, addressing design problems, self-equilibrium conditions, and mechanical response to external loads from both analytical and numerical perspectives. Basic concepts of tensegrity dynamics and actuation are also covered.							
Syllabus							
This course introduces the basic concepts and some applications of tensegrity structures, presenting their design problems. The self-equilibrium conditions and the mechanical response to external loads will be presented and developed from analytical and numerical point of view. Basic concepts of tensegrity dynamics, and their actuation will be illustrated.							
Bibliografia							
Scientific papers, slides and support material from the lecturer							

CORSO DI DOTTORATO: DRSATE

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Application of Cutting-Edge Methods in Structural Engineering**						
SSD	CEAR-07/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	First
Livello 2026/2027		2		**Paniere 2026/2027**		6	

Obiettivi

The course is articulated of 5 modules, each one characterized by theoretical and practical subjects. The course will be held with lectures in which the theoretical topics will be discussed and for each topic, computer exercises will be carried out.

Syllabus

The overall program of the course is provided below: 1. Course Organization and Introduction • Organization of the course • Definition of complex problems in structural engineering • Introduction about cutting-edge methodologies 2. Use of automation in structural engineering • Basics of probability and statistics • Definition of sampling techniques • Procedures of automated modelling-analysis • Practical applications 3. Use of machine-learning in structural engineering • Machine learning techniques: classification and regression tasks • Surrogate models • Explainability techniques • Practical applications 4. Use of Computer Vision in structural engineering problems • Basics of computer vision algorithms • Definition of segmentation and detection techniques • Explainability techniques • Practical applications 5. Use of satellite data in structural engineering problems • Basics of satellite data • Data elaboration and application to structures • Practical applications

Bibliografia

R. Biswas, P. Samui, P. Asteris (2026). Machine Learning Applications in Structural Engineering. Elsevier

CORSO DI DOTTORATO: DRSATE

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Mechanics of innovative microstructured materials and generalized continua**						
SSD	CEAR-06/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	First
Livello 2026/2027		2		**Paniere 2026/2027**		6	

Obiettivi

The course covers the complex mechanical behaviour of innovative microstructured materials, focusing on mechanical metamaterials. Starting with the simplest examples, the course will show how, in metamaterials, the careful design of a specific microgeometry can produce mechanical responses that cannot be found in nature, such as negative Poisson's ratio, dispersive dynamic behaviour, negative thermal expansion coefficients, wave channelling, dynamic anisotropy and programmable behaviour. An accurate description of such unconventional behaviour often necessitates an extension to the classical mechanical models typically introduced in basic Solid Mechanics courses, by adopting non-local (à la Eringen) or higher-order (à la Cosserat or second-gradient elasticity) models. During the course, PhD students will deepen their knowledge of stability and wave dynamics in metamaterials through analytical (including Bloch-Floquet theory), numerical, and experimental approaches.

Syllabus

1) General concepts on metamaterials: definition, classification (mechanical and acoustic), band gaps, negative effective properties, auxetic behavior, and architected lattice materials. 2) Bloch-Floquet theory: periodic media, unit cell formulation, dispersion relations, Brillouin zones. 3) Wave propagation in 1D systems: mono- and diatomic chains. 4) Extension to 2D systems: periodic lattices, plane wave propagation, anisotropy, and computational evaluation of band structures. 5) Fundamentals of continuum mechanics: Cauchy and non-local/higher-order continuum models. 6) Stability analysis of periodic lattices: macro- and micro-bifurcations for different microgeometries. 7) Examples of applications of mechanical metamaterials in civil, mechanical, and aerospace engineering.

Bibliografia

• Brillouin, L. N. (1953). Wave propagation in periodic structures: electric filters and crystal lattices. • Hussein, M. I., Leamy, M. J., Ruzzene, M. (2014). Dynamics of phononic materials and structures: Historical origins, recent progress, and future outlook. Applied Mechanics Reviews, 66(4), 040802. • Marasciuolo, N., De Tommasi, D., Trentadue, F., Vitucci, G. (2025). Tailored multiscale instabilities in a grid metamaterial. Extreme Mechanics Letters, 75, 102284. • Mindlin, R.D. (1964). Micro-structure in linear elasticity. Archs ration. Mech. Analysis 16, 51–78.

CORSO DI DOTTORATO: DRSATE

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Microwave-Assisted Processes**						
SSD	CHEM-06/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	First
Livello 2026/2027		2		**Paniere 2026/2027**		6	
Obiettivi							
This course introduces students to microwave heating systems and their applications in scientific and industrial processes. Given the significant impact of microwaves on the development of new chemical processes, the course focuses on the chemical aspects of engineered and sustainable organic and inorganic syntheses, as well as the technologies developed for environmental remediation and biomass conversion.							
Syllabus							
Topic 1: Principles and development of MW heating (2h – 0.2CFU) Topic 2: Microwave reactors: components and set-up from lab to industrial Scale (2h – 0.2CFU) Topic 3: Microwave Application in Organic Syntheses: Microwaves in flow chemistry, Microwaves in green and sustainable chemistry and microwaves in polymer chemistry (8h – 0.6CFU) Topic 4: Microwave Application in Inorganic Syntheses: nanoparticle and inorganic compounds (4h – 0.4CFU) Topic 5: Microwave technology for environmental remediation (2h – 0.2CFU) Topic 6: Microwave-assisted biomass conversion (2h – 0.2CFU)							
Bibliografia							
• Microwave Chemistry, Cravotto, Carnaroglio (Eds.), 2017, ISBN 978-3-11-047992-8							

CORSO DI DOTTORATO: DRSATE

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Resilient railway transport systems**						
SSD	CEAR-03/B	**Ore**	20	**CFU**	2	**Anno/Semestre**	First
Livello 2026/2027		2		**Paniere 2026/2027**		2	

Obiettivi

The course covers theoretical and practical aspects of resilient railway operations optimization for PhD level. First, lectures will focus on fundamentals of railway planning, including line planning, timetabling, non-periodic and periodic event scheduling models, operational rules, and multimodal transport systems. Second, it will cover resilience aspects in railways including main challenges including operational, climate and adversarial. Overall, the course addresses conceptual, organisational and methodological aspects of railway operations.

Syllabus

Part 1: Railway fundamentals (8 hours) • Timetabling including non-periodic and periodic event scheduling models • Real-time traffic management and disruption management • Recent advancements in railway operations within future multimodal transport systems and related mathematical models. Part 2: Resilient railways (8 hours) • Resilience in transport systems • Climate changes and railways • Mathematical models for addressing resilience Part 3: Workshop / Interactive Activities (4 hours) • A hands-on workshop will be organized to deepen understanding of railway optimization problems. • Participants will work in small groups to model simplified railway timetabling problems and assess their vulnerability and resilience. • The workshop aims to connect theoretical knowledge with practical applications and encourage problem-solving skills.

Bibliografia

• Hansen, I. A.; Pachl, J. (2014), Railway Timetabling & Operations. Analysis - Modelling - Optimisation - Simulation - Performance Evaluation. 2nd edition. Eurailpress. • Bešinović, N. (2020). Resilience in railway transport systems: a literature review and research agenda. Transport Reviews, 40(4), 457-478.

CORSO DI DOTTORATO: DRSATE

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Advances in Geomatic Engineering**						
SSD	CEAR-04/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second
Livello 2026/2027				**Paniere 2026/2027**			

Obiettivi

Recent advances in space (satellite) technology, computing (software and hardware) technology and Geomatic engineering instrumentation technology have had a revolutionary impact on the practice of many engineering fields. The goal of this course is to provide the students the theoretical background and knowledge necessary to manage modern complex geospatial information and technology. The lectures will deal with the following research areas: Multimedia cartography and information delivery; Geospatial Information Science and Geographic Databases; Geospatial Web and Big Data; Technologies and methods in Remote Sensing (proximal/drone/aerial/satellite platforms); Survey and 2D/3D geospatial data processing; Geospatial data modelling and analysis. The advanced topics may serve as an introduction to research skills that may be useful at multidisciplinary level.

Syllabus

Elements of Geodesy Introduction to the concepts of Geodesy and Geomatics. An insight on Reference Systems and Reference Frames. Surveying and monitoring the territory and structures – ground/satellite-based methods The Global Navigation Satellite System: fundamentals, operating principles, and positioning techniques. Geomatics sensors and methodologies. Observing the earth from space: Synthetic Aperture Radar principles Multi-sensor techniques for the analysis of ground motion - a case study Slow ground motions impacting the safety of structures and people: an integration of geomatic techniques for the characterization of an instability phenomenon

Bibliografia

CORSO DI DOTTORATO: DRSATE

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Resilient and secure (historic) built environment in a multi-hazard perspective**						
SSD	CEAR-08/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**		/	

Obiettivi

The course provides PhD students with a theoretical and operational framework for understanding and assessing disaster risk in the historic built environment within a multi-hazard and multi-risk perspective. Starting from internationally recognised definitions and frameworks, the module introduces the conceptual foundations of risk and resilience in relation to secure and resilient cities. The course explores methods for single-risk assessment and extends them to multi-risk scenarios, including synchronous, asynchronous, cascading, and compound effects. Particular attention is given to the interaction between rapid-onset disasters (e.g., earthquakes, floods, terrorism) and slow-onset processes (e.g., heatwaves, urban heat island, pollution), and to their impact on historic districts, open spaces, and cultural assets. Through applied case studies in relevant national and international experiences, students will learn how to structure risk knowledge, parameterise hazard–vulnerability interactions, and define mitigation strategies under multi-risk conditions. The final part of the course addresses digitalisation and risk communication tools for decision-support systems, including GIS-based platforms, CityGML semantic modelling, and virtual/interactive environments, with the aim of translating scientific assessment into operational and policy-oriented guidance.

Syllabus

The course is organised into four thematic modules combining theoretical lectures and applied discussion. Module 1 – Risk, Resilience and International Frameworks • Definitions of disaster risk and resilience (ecological and urban perspectives) • The Sendai Framework and global disaster risk reduction strategies • Risk components: Hazard, Vulnerability, Exposure, Capacity • Disaster Risk Management (pre-, during-, post-disaster phases) • Multi-dimensionality of exposed elements (people, ecosystems, infrastructures, cultural assets) Module 2 – Methods for Disaster Risk Assessment • Probabilistic Risk Assessment (PRA) • Deterministic scenario-based models • ndicator-Based Approaches (IBA) and Multi-Criteria Decision Making (AHP, Fuzzy, Delphi) • Spatial analysis and GIS-based risk mapping • Cost-effectiveness and damage-based approaches • Behavioural and dynamic models • Application to case studies (e.g., terrorism risk in open urban spaces, seismic risk in historic districts) Module 3 – Multi-Hazard and Multi-Risk Scenarios • Multi-hazard vs. multi-risk concepts (cascading, compound, systemic effects) • Time dependency of risk (synchronous and asynchronous interactions) • Rapid Onset Disasters (ROD) and Slow Onset Disasters (SOD) • Scenario building and vulnerability mapping at building and district scale • Assessment of mitigation strategies and potential interferences among solutions • Case studies from Mediterranean historic districts Module 4 – Digitalisation and Risk Communication • Disaster risk communication in the DRM cycle • From scientists to policymakers and society • GIS-based risk platforms and thematic mapping • CityGML and semantic 3D modelling for built heritage • Virtual tours and parametric models for participatory awareness • Decision-support systems for resilient recovery planning Module 5 – Defining the Risk Dimension within the PhD Research Path This module is specifically dedicated to positioning the “risk dimension” within each participant’s doctoral research trajectory. In this aim, students will develop a short research-oriented conceptual framework

Bibliografia

Insegnamento	Resilient and secure (historic) built environment in a multi-hazard perspective
International Frameworks • United Nations Office for Disaster Risk Reduction, Sendai Framework for Disaster Risk Reduction 2015–2030. • Intergovernmental Panel on Climate Change, Glossary and Assessment Reports (risk and vulnerability definitions). Foundational Theories • Holling, C.S. (1973). Resilience and Stability of Ecological Systems. • Walker, B. et al. (2004). Resilience, adaptability and transformability in social-ecological systems. Risk Assessment in Built Heritage • Lagomarsino, S.; Giovinazzi, S. (2006). Macroseismic and mechanical models for the vulnerability assessment of buildings. • Bernabei, L. et al. (2021). Seismic risk of open spaces in historic built environments. • Cantatore, E.; Fatiguso, F. (2021). An energy-resilient retrofit methodology to climate change for historic districts. Digital Tools and Risk Mapping • Italian Ministry of Culture, La Carta del Rischio. • OGC, CityGML Standard Documentation.	

CORSO DI DOTTORATO: DRSATE

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Sustainable Technologies for Circular Economy in Waste Management						
SSD	IMAT-01/A	Ore	20	CFU	2	Anno/Semestre	Second
Livello 2026/2027		3		Paniere 2026/2027		/	

Obiettivi

Today's linear economic model (take-make-dispose) is wasteful and unsustainable. In a circular economy, the maximum value is extracted from resources in use, then products and materials are recovered and regenerated at the end of each service life. The transition from a linear economy to a circular economy is currently one of the biggest challenges in the field of waste management. In this perspective, the aim of this course is to develop scientific and technical aspects on the closing the loop of both urban and industrial waste. The goal is to ensure PhD students obtain a solid background in environmental technologies, with competencies for designing and tailoring new waste management systems, and with a specific view to the sustainability of processes and technologies. The course is developed on principles of Circular Economy and Sustainable Development, on circularity as a tool for saving non-renewable raw materials and reducing the waste production. In particular, the lessons discuss basic scientific principles and recent technological advances in current strategies for resource recovery from waste (for example: recycling of dry waste and composting of organic waste). Also, the course presents solutions to pressing problems associated with waste management and treatment, as well as the health impacts created by improper waste disposal and pollution. The major topics covered by the course are: 1) circular economy and sustainability: basics and application; 2) closing the loop: the circularity as a tool for saving raw material and natural resources and to reduce waste production; 3) industrial symbiosis and urban mining definition; 4) recovery and recycling of industrial and urban waste; 5) innovative and sustainable technologies: pre-treatment and selection, mechanical-biological treatment, energy recovery, disposal in landfills; 6) use of secondary raw materials.

Syllabus

The major topics covered by the course are: 1) circular economy and sustainability: basics and application; 2) closing the loop: the circularity as a tool for saving raw material and natural resources and to reduce waste production; 3) industrial symbiosis and urban mining definition; 4) recovery and recycling of industrial and urban waste; 5) innovative and sustainable technologies: the pre-treatment plants and selection, mechanical biological treatment, the energy recovery, the disposal in landfills; 6) main properties and fields of use of raw materials second.

Bibliografia

Industry 4.0 and Circular Economy: Towards a WastelessFuture or a Wasteful Planet? by Antonis Mavropoulos and Anders Waage Nilsen (2020). ISBN-13: 978-1119699279 Scientific papers provided by the lecturer

CORSO DI DOTTORATO: DRSATE

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Advanced methods in hydroclimatic analysis of groundwater systems						
SSD	CEAR-01/B	Ore	20	CFU	2	Anno/Semestre	Second
Livello 2026/2027		3		Paniere 2026/2027		/	

Obiettivi

Freshwater is a vital resource for sustaining life and economic development, but climate change and the growing global population contribute to its quality and quantity degradation, leading to potentially irreversible impacts. This course aims to introduced how to deal with Regional Climate Models, presenting a set of bias-correction methods and performance indices. Then, it presents advanced approaches to evaluate groundwater responses to climate variability in complex and data-scarce hydrogeological systems. It integrates hydroclimatic indicators, time-series analysis, and qualitative hydrogeological interpretation to identify response mechanisms and support climate-informed water management. Students learn to compute and interpret meteorological and groundwater indices, analyse groundwater-climate relationships using wavelet methods and seasonal-trend decomposition, and manage time series. It also presents groundwater quality assessment, including chemical indices and statistical methods. Case-based applications reinforce thematic understanding and support sustainable management in vulnerable regions.

Syllabus

The course consists of five 4-hour sessions. Session 1: From Climate Projections to Hydrological Insight The main goal of this session is to equip students with the knowledge and skills to work with Regional Climate Models by understanding downscaling concepts, identifying sources of uncertainty, applying bias-correction methods, and evaluating model performance through consistency checks between indices and time-series results. Session 2: Interpreting Hydroclimatic Signals of Variability and Drought The main goal of this session is to equip students with the knowledge and skills to compute, interpret, and apply hydroclimatic indicators, such as Standardized Precipitation Index (SPI), Standardized Precipitation-Evapotranspiration Index (SPEI), Rainfall Anomaly Index (RAI), and Palmer Drought Severity Index (PDSI) across multiple timescales, enabling the assessment of rainfall variability and drought severity to support hydrological and climate analysis. Session 3: Groundwater Drought Processes and Impacts The main goal of this session is to provide students with the knowledge and skills to assess groundwater droughts using indices such as the Groundwater Resource Index (GRI), Standardised Groundwater Level Index (SGI), and other relevant indicators like the Groundwater Drought Index (GDI) and Groundwater Anomaly Index (GAI). Session 4: Revealing Groundwater–Climate Connections Through Time-Series and Remote Sensing The main goal of this session is to train students in analysing groundwater-climate interactions using time-series and remote sensing data. Students learn to extract and quantify signals through techniques such as continuous wavelet transform and seasonal-trend decomposition (STL), integrating GRACE datasets to assess climate-driven groundwater variability. Session 5: Hydrogeochemical Assessment of Groundwater The main goal of this session is to train students to use groundwater chemistry to interpret hydrogeological processes and climate-driven responses using geo-environmental indices such as the Nitrate pollution index (NPI), Revelle index (RI), Water quality index (WQI) as well as multivariate statistical approaches.

Bibliografia

• Jiao, J. & Post, V. (2019). Coastal Hydrogeology. In Coastal Hydrogeology (p. I). Cambridge: Cambridge University Press. • Alfio, M.R., Pisinaras, V., Panagopoulos, A., Balacco, G. (2023). Groundwater level response to precipitation at the Hydrological Observatory of Pinios (central Greece). Groundwater for

Insegnamento	Advanced methods in hydroclimatic analysis of groundwater systems
Sustainable Development. Volume 24, 101081. https://doi.org/10.1016/j.gsd.2024.101081 • Papazotos, P., Vlachomitrou, M. Psarraki, D., Vasileiou, E., Perraki, M. Coupling Advanced Geo-Environmental Indices for the Evaluation of Groundwater Quality: A Case Study in NE Peloponnese, Greece. Environments 2025, 12, 14. https://doi.org/10.3390/environments12010014 • Parisi, A., Alfio, M.R., Balacco, G., Güler, C., Fidelibus, M.D. (2023). Analyzing spatial and temporal evolution of groundwater salinization through Multivariate Statistical Analysis and Hydrogeochemical Facies Evolution-Diagram. Sci Total Environ. 1;862:160697. https://doi.org/10.1016/j.scitotenv.2022.160697 • Course Handouts		

CORSO DI DOTTORATO: DRSATE

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Research and Tools in Risk and Environmental, Territorial and Building Development**						
SSD	Tutti gli SSD del DRSATE	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**		/	

Obiettivi

The course provides early-stage PhD students with methodological foundations and practical tools for conducting interdisciplinary research in the fields of risk, environmental, territorial, infrastructural, and building development. It supports students in understanding scientific approaches, analytical methods, and research frameworks relevant to the multidisciplinary nature of the doctoral programme. The course also helps students integrate into the research environment, refine their individual research projects, and develop teamwork, critical thinking, methodological integration, and scientific communication skills.

Syllabus

The course is organized into three complementary modules: Module 1 — Interdisciplinary research methods and tools Lectures on transversal themes related to research methods, scientific approaches, and analytical tools for environmental, territorial, infrastructural, and building-related studies. Contributions are delivered by members of the doctoral board and invited experts with interdisciplinary expertise. Module 2 — Applied research projects and case studies Presentations of ongoing and completed research projects developed within the Department. Principal investigators and research coordinators illustrate project objectives, methodological approaches, implementation strategies, collaborative practices, and main scientific outcomes. Module 3 — Interactive interdisciplinary workshop Group-based workshop in which doctoral students develop a preliminary interdisciplinary research proposal. The activity focuses on teamwork, critical thinking, methodological integration, and scientific communication. Each group presents and discusses its proposal with faculty members and participants.

Bibliografia

CORSO DI DOTTORATO: DRSATE

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Soil Suction in Unsaturated Soil Mechanics: Fundamentals and Measurement**						
SSD	CEAR-05/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**		/	

Obiettivi

The course addresses the theoretical foundations and experimental measurement of soil suction within the framework of unsaturated soil mechanics. Particular attention is devoted to the physical meaning of suction, stress state variables in partially saturated soils, and the Soil–Water Retention Curve (SWRC). The main laboratory techniques for suction measurement are discussed, including high capacity tensiometers, axis translation technique, filter paper method and dew point potentiometers, with emphasis on working principles, measurement ranges and experimental limitations. The role of suction in the hydro-mechanical behaviour of soils is also examined, highlighting its influence on shear strength, compressibility and hydraulic conductivity. The course aims to provide PhD students with a rigorous conceptual framework and critical awareness of suction measurement and interpretation in geotechnical and geo-environmental research.

Syllabus

Total duration: 20 hours (2 CFU). Module 1 – Fundamentals of Suction in Unsaturated Soils (6 h). Phases in unsaturated soils. Matric and osmotic suction. Thermodynamic interpretation. Capillarity and air-entry value. Soil–Water Retention Curve (SWRC). Hysteresis (conceptual aspects) Module 2 – Stress State Variables and Effective Stress (4 h). Stress state variables for unsaturated soils. Bishop's effective stress formulation. The χ parameter: interpretation and limitations. Comparison with Terzaghi's effective stress principle. Module 3 – Measurement of Soil Suction (6 h). Direct methods: High/low capacity tensiometers. Axis translation technique. Indirect methods: Filter paper method. Dew point potentiometer. For each technique: Working principle. Measurement range. Calibration and limitations. Sources of uncertainty. Cavitation issues. Module 4 – Implications for Hydro-Mechanical Behaviour (4 h). Suction contribution to shear strength. Volume change and collapse upon wetting. Conceptual link between SWRC and hydraulic conductivity.

Bibliografia

• Fredlund, D.G. & Rahardjo, H. (1993). Soil Mechanics for Unsaturated Soils. • Lu, N. & Likos, W.J. (2004). Unsaturated Soil Mechanics. • Selected recent journal papers provided by the lecturer.

CORSO DI DOTTORATO: DRSATE

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Towards decarbonization of buildings in the digital transition**						
SSD	CEAR-08/B	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**		/	

Obiettivi

This course provides knowledge about Sustainability and Circular Economy principles, methods and tools, and open research questions towards the decarbonization of the building sector during the life cycle management. It begins with key taxonomy and conceptual frameworks, followed by the normative framework (ISO standards and related regulations). Students learn the LCA methodology, including goal and scope definition, inventory analysis, impact assessment, and interpretation, as well as the use of major LCA databases. The course explores LCA applications for products and its integration with Building Information Modeling (BIM) for building assessment, and further technologies. It also introduces complementary Circular Economy tools such as Product Environmental Footprint (PEF) and Material Flow Analysis (MFA), and Key Performance Indicators (KPI). It examines the relationship between LCA and Environmental Assessment Rating Systems, including LEED and BREEAM.

Syllabus

• Sustainability and Circular Economy principles (3 hours): Sustainability challenges in the building sector. Life cycle thinking and decarbonization. Circular Economy strategies for materials, products and buildings. Main research challenges. • Standards and Regulatory Framework (2 hours): Main sustainability terminology and taxonomies. European policies and regulations. ISO 14040 and ISO 14044. Environmental Product Declarations and related standards. • Life Cycle Assessment Methodology (5 hours): Goal and scope definition. Functional unit and system boundaries. Life Cycle Inventory. Life Cycle Impact Assessment. Interpretation, sensitivity and uncertainty analysis. • LCA Databases and Product Assessment (2 hours): Primary and secondary data. Main LCA databases. Environmental Product Declarations. LCA applications for construction products. • Building LCA and BIM Integration (3 hours): Whole-building Life Cycle Assessment. Quantity take-off and material inventories. BIM–LCA workflows. Interoperability and environmental data management. Emerging digital technologies. • Circular Economy Assessment Tools (2 hours): Product Environmental Footprint. Material Flow Analysis. Material passports. Circularity indicators and KPIs. • Environmental Rating Systems (1 hour): Relationship between LCA and rating systems. • Exercise (2 hours): LCA of material, building component or building. Comparison of alternative scenarios. Discussion of results and research perspectives.

Bibliografia

• Scientific papers about the topic • Teacher slides • Regulations • Handbooks

CORSO DI DOTTORATO: DRSATE

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**How to build an ontology that lasts for design matters**						
SSD	CEAR-12/A	**Ore**	15	**CFU**	1.5	**Anno/Semestre**	First
Livello 2026/2027		1		**Paniere 2026/2027**		/	

Obiettivi

'Applied Ontology' is an approach developed within Artificial Intelligence and aimed to build symbolic representations of (a fragment of) reality. The use of applied ontology ensures that the result is conceptually coherent, semantically clear and computationally robust. In this course we introduce the motivations and methodology of applied ontology focusing on (a) the distinction between data and information; (b) the DOLCE ontology; (c) the conceptual analysis of simple scenarios of urban and social interest; (d) methodologies for ontology-based model construction; and (e) the use of software (e.g., Protege) for ontology construction.

Syllabus

THEORY - From data to knowledge; - The conceptual analysis of simple scenarios of urban and social interest, particularly in spatial planning and engineering design; - Methodologies for ontology-based model construction; LAB - The DOLCE ontology; - The use of software (e.g., Protege) for ontology construction.

Bibliografia

Borgo, S., Ferrario, R., Gangemi, A., Guarino, N., Masolo, C., Porello, D., Sanfilippo, E. M., & Vieu, L. (2022). DOLCE: A descriptive ontology for linguistic and cognitive engineering. Applied Ontology, 17(1), 45-69, • Staab, S., & Studer, R. (2013). Handbook on Ontologies. Berlin: Springer

CORSO DI DOTTORATO: SSI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Advanced Fiber Optic Technologies for Biosensing						
SSD	IINF-01/A	Ore	20	CFU	2	Anno/Semestre	First/First
Livello 2026/2027		2		Paniere 2026/2027		3	

Obiettivi

The goal of this course is to provide a theoretical and simulation- oriented introduction to biosensing with advanced optical fiber technologies. After a brief introduction to the optical fiber's characteristics, the course will focus on a few fiber optic architectures and their working principle for biosensing. This course will also introduce the basic parameters to assess the fiber optic sensors' performance with real-world applications. A few demonstrations of the sensor design will be performed through the simulation tool Comsol Multiphysics and Matlab coding to guide the students for the final project.

Syllabus

1) Introduction to the optical fibers from the Maxwell equations to provide basic concepts including vector and scalar modes. 2) Standard optical fiber materials and working principle of optical fibers for Biosensing. 3) Different fiber optic sensors e.g. photonic crystals, ring resonators and surface plasmon resonance will be introduced with the sensing enhancement principle. 4) The important parameters will be introduced to assess the sensing performance with real world application e.g. protein detection, remote sensing. 5) Few demonstrations will be performed with Comsol and Matlab to provide hands-on experience to the students and prepare them for the final project.

Bibliografia

Slides will be provided during the lessons

CORSO DI DOTTORATO: SSI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Fundamentals of Radio Localization and Sensing						
SSD	IINF-03/A	Ore	20	CFU	2	Anno/Semestre	First/First
Livello 2026/2027		2		Paniere 2026/2027		3	

Obiettivi

The course is designed to deliver to PhD students' knowledge on various aspects of radio localization and sensing using terrestrial wireless systems, from more traditional scenarios (e.g., WSN) up to the new emerging contexts of 5G and 6G cellular systems.

Syllabus

• Course overview and fundamentals of terrestrial wireless positioning systems: Introduction of the participants and the course; The role of terrestrial radio positioning as a complementary solution to GNSS. • Localization approaches based on time and signal strength information in single-input single-output systems: RSS-based methods; TOA-based methods; Hybrid RSS and TOA-based localization. • Localization using antenna arrays in sub-6 GHz systems: cooperative schemes and advanced signal processing approaches for dynamic multipath environments: Basics of antenna arrays for positioning; Dynamic Applications. • Localization in 5G mmWave multiple-input single-output systems - accurate low-complexity channel estimation and simultaneous localization and mapping: Sub-6GHz vs mmWave; SISO, MISO, SIMO, MIMO Systems; Array architectures; Channel parameter estimation in MISO 5G Systems; Positioning in MISO 5G Systems; Simultaneous localization and mapping in MISO 5G Systems. • Joint localization and synchronization using reconfigurable intelligent surfaces in 6G systems: Ingredients of 6G; Going deeper into RIS; RIS for localization and synchronization; Advanced channel models.

Bibliografia

- D. Dardari, E. Falletti, M. Luise, "Satellite and Terrestrial Radio Positioning Techniques – A Signal Processing Perspective", London, U.K, Elsevier, 2011. - C. Gentile, N. Alsindi, R. Raulefs, and C. Teolis, "Geolocation Techniques: Principles and Applications", New York, NY, USA, Springer-Verlag, 2013. - Yu, K., Lohan, E., & Oppermann, I. (2025). Handbook of Wireless Positioning. Springer Nature Singapore.

CORSO DI DOTTORATO: SSI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Physical Layer Security for wireless communication**						
SSD	IINF-02/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	First
Livello 2026/2027		2		**Paniere 2026/2027**		3	
Obiettivi							
The course will address different security techniques based on the physical layer, which are suitable to improve data security in wireless networks and in IoT (Internet of Things) applications. The course participants will gain knowledge of Physical Layer Security techniques. The course will consist of theoretical lectures and numerical hands-on examples.							
Syllabus							
- Introduction to Physical Layer Security (PLS) and applications - Secrecy notions - Secure array synthesis, beam forming and beam steering - Electromagnetic propagation models in indoor and outdoor environments - PLS keyless approaches - PLS key-based approaches							
Bibliografia							
Scientific papers, slides and support material from the lecturer.							

CORSO DI DOTTORATO: SSI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Real-time Simulation and Hardware-in-the-Loop testing for Smart Energy Systems**						
SSD	IIND-08/B	**Ore**	20	**CFU**	2	**Anno/Semestre**	First
Livello 2026/2027		2		**Paniere 2026/2027**		1	

Obiettivi

The course aims to give the fundamentals on the concepts of real-time simulation (RTS) and Hardware-in-the-Loop testing for applications in the fields of smart industry and smart energy systems. The students will also participate to laboratory activities where they will learn to use real-time simulation tools, prepare some basic projects and develop Hardware-in-the-Loop tests on cyber-physical systems. The lab activities will focus on applications for electrical power systems, but applications for any other engineering field can be foreseen (power electronics, mechanical, automotive, etc.).

Syllabus

Digital simulation, Real-time Simulations, Co-simulation, Geographical Distributed Co-Simulation. Classification of realtime simulation testing, Software-in-the-Loop (SIL), Hardware-in-the-Loop (HIL), Control Hardware-in-the-Loop (CHIL), Power Hardware-in-the-Loop (PHIL). Coupling methods, accuracy and stability of simulations. Modelling of an electrical power grid for real-time simulation. Coupling with physical devices. Use of communication network and Standard protocols (i.e Modbus TCP/IP). Seminars on the use of HIL/PHIL in the electrical industry. Prior knowledge of the Matlab/Simulink environment is suggested.

Bibliografia

Scientific papers and books on the field.

CORSO DI DOTTORATO: SSI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Smart zero-energy buildings						
SSD	IIND- 07/B	Ore	20	CFU	2	Anno/Semestre	First
Livello 2026/2027		2		Paniere 2026/2027		6	

Obiettivi

At the end of this course, students will be able to: 1. Assess the energy demand of buildings and to discuss strategies to achieve net-zero targets with smart energy management 2. Design multi-source smart renewable energy resources for buildings and carry out the design of multiple building renewable energy systems, including photovoltaics and solar thermal systems. 3. Calculate the carbon and energy balance of building HVAC systems and compare them within a life cycle approach 4. Calculate the emission factors of different energy systems and their respective trade offs

Syllabus

Smart zero energy buildings combine energy efficiency measures and renewable energy generation to consume only as much energy as can be produced onsite through renewable resources over a specified time period. This course aims to discuss how to address the energy issues in net-zero energy buildings (ZEB), using multicarrier energy systems with hydro-wind-solar-hydrogen-methane-carbon dioxide-thermal energies. The course aims to present approaches and solutions to make possible the evolution of the building sector away from a carbon-based (and GHG-intensive) approach. Multiple solutions will be investigated from traditional renewable hydro-wind-solar energy sources to new technologies such as fully-electrical systems or hydrogen-based systems. The course aims to present solutions for minimizing the released CO2 to the atmosphere due to buildings and in doing this, it will teach approaches to increase the energy resilience within the built environment.

Bibliografia

Building Energy Management Systems and Techniques: Principles, Methods, and Modelling, 2024, Elsevier,

CORSO DI DOTTORATO: SSI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**AI for ENERGY MANAGEMENT and ENERGY SAVING**						
SSD	IIND- 07/B	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**		/	

Obiettivi

Harness the future of sustainable energy with this course, which provides a comprehensive guide to integrating artificial intelligence for efficient energy storage and management systems.

Syllabus

AI-powered energy management systems (EMS) utilize machine learning and data analytics to monitor, predict, and optimize energy generation, distribution, and consumption in real-time. By automating HVAC, lighting, and industrial processes, AI can reduce energy waste by up to 25-30% in buildings and optimize renewable energy integration. These systems analyze weather, usage patterns, and electricity prices to enhance efficiency, reduce costs, and improve sustainability across industries. This course proposes a multilayer machine learning (ML) framework to forecast optimal EV charging schedules in PV–BESS–driven buildings by combining high-fidelity dynamic simulations, multi-objective optimization, and data-driven predictive control

Bibliografia

Artificial Intelligence for Energy Management,
Editor: R. Senthil Kumar, V. Indragandhi, R. Selvamathi, P. Balakumar
Wiley

CORSO DI DOTTORATO: SSI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Deep Reinforcement Learning for Control of Autonomous Systems						
SSD	IINF- 04/A	Ore	10	CFU	1	Anno/Semestre	Second
Livello 2026/2027		3		Paniere 2026/2027		/	

Obiettivi

Reinforcement learning deals with solving sequential decision problems when minimal prior information is available. Solving sequential decision problems means finding their optimal control policies. Using reinforcement learning algorithms, the optimal policy is learned through the cooperation between the agent (or controller) and the system to be controlled. Deep Reinforcement Learning (DRL) is a subfield of machine learning that combines reinforcement learning (RL) and deep learning. The course will propose the main modeling frameworks, investigate the most relevant deep reinforcement learning techniques and show some interesting applications.

Syllabus

- Markov chains: definition, properties and application. - Introduction to Reinforcement Learning and Deep Reinforcement Learning: states, actions, policies, reward, observations; - Real-word examples and implementation in engineering tools (e.g.,Python, Matlab)

Bibliografia

- Vincent François-Lavet, Peter Henderson, Riashat Islam, Marc G. Bellemare and Joelle Pineau (2018), “An Introduction to Deep Reinforcement Learning”, Foundations and Trends in Machine Learning: Vol. 11, No. 3-4, pp 219–354. - Scientific papers.

CORSO DI DOTTORATO: SSI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Distributed/Decentralized Control and Optimization of Large-Scale Systems						
SSD	IINF- 04/A	Ore	10	CFU	1	Anno/Semestre	Second
Livello 2026/2027		3		Paniere 2026/2027		/	

Obiettivi

This course aims at providing PhD students with modeling and methodological tools for formulating and solving large-scale optimization problems with a focus on the use of duality theory. During the course several optimization problems will be formalized, particularly referred to relevant issues within management and industrial engineering. Problem definition and resolution will be also implemented in simulation and engineering software (Matlab). The final goal is to provide PhD students with the necessary background for starting research in the field of duality-based decentralized and distributed optimization techniques to be applied to large-scale systems. Each lesson consists in lectures, numerical examples, simulation and analysis of case studies.

Syllabus

Systems schemes and architectures: centralized and non-centralized approach. Preliminaries on unconstrained and set constrained optimization and basics on convex optimization. Duality (Lagrange multipliers theory) and duality based algorithms: waterfilling, dual ascent method (DAM), Augmented Lagrangian Method (ALM), Alternating Direction Method of Multipliers (ADMM). Decentralized optimization problem set up and duality-based methods: DAM, ALM, and ADMM for separable convex programming. Distributed optimization problem set up and duality-based methods: distributed DAM, distributed ADMM, distributed waterfilling. Motivating examples and case studies.
Advanced schemes and architectures: Hierarchical approach. Non-linear optimization. Examples: resource distribution, task planning and scheduling problems. Introduction to parallel and distributed computation. Parallelization and decomposition in optimization problems. Hierarchical optimization and control. Multi-level programming. Motivating examples and case studies.

Bibliografia

Recommended books: - Bertsekas, D. P., & Tsitsiklis, J. N. (1989). Parallel and distributed computation: numerical methods (Vol. 23). Englewood Cliffs, NJ: Prentice Hall - Boyd S. & Vandenberghe L., Convex Optimization, Cambridge University Press, UK, 2004. Slides and supporting material from lecturer.

CORSO DI DOTTORATO: SSI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Modeling and Control of Underwater Robots						
SSD	IINF- 04/A	Ore	20	CFU	2	Anno/Semestre	Second/Second
Livello 2026/2027		3		Paniere 2026/2027		/	

Obiettivi

The course aims to provide PhD students with advanced theoretical and practical tools for the modeling and control of underwater robotic vehicles (AUVs and ROVs). Starting from the fundamental principles of marine craft modeling, the course introduces a simplified yet rigorous mathematical framework suitable for control design purposes. Particular emphasis is placed on: • 6-DOF nonlinear modeling of underwater vehicles; • Attitude representation; • Depth control; • Design of attitude and depth controllers; • Basic motion and trajectory control strategies; • MATLAB-based simulation and implementation exercises.
The objective is to enable students to: • Derive simplified dynamic models of underwater robots; • Design nonlinear and linear controllers for attitude and depth regulation; • Understand guidance and trajectory tracking concepts; • Implement and test control algorithms in MATLAB.

Syllabus

1. Modeling of Underwater Vehicles [6h] a. Reference frames b. Position and attitude representation c. 6-DOF kinematic and dynamic model d. Hydrodynamic effects: added mass, damping, restoring forces e. Simplified models for control design (attitude and depth dynamics)
2. Attitude and Depth Control [6h] a. Linearization around equilibrium configurations b. PID and cascaded control architectures c. Nonlinear control approaches d. Stability analysis e. Depth regulation and disturbance rejection
3. Motion and Trajectory Control [4h] a. Surge and speed control b. Guidance concepts (Line-of-Sight method) c. Path-following vs trajectory tracking d. Cascaded guidance and control architecture
4. MATLAB Laboratory Sessions [4h] a. Implementation of simplified dynamic models b. Attitude stabilization simulations c. Depth control design and tuning d. 2D trajectory tracking example

Bibliografia

T. I. Fossen, Handbook of Marine Craft Hydrodynamics and Motion Control, 2nd Edition, Wiley, 2021

CORSO DI DOTTORATO: SSI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Photonics for Industry 4.0						
SSD	IINF-02/A	Ore	20	CFU	2	Anno/Semestre	Second/Second
Livello 2026/2027		3		Paniere 2026/2027		/	

Obiettivi

The course focuses on the different photonic technologies that are utilized in advanced manufacturing and highperformance communication within the Smart Industry. Participants will gain knowledge about recent photonic technologies for the Smart Industry and beyond, as well as the use of microcontrollers in creating basic lidar-type devices. The course will comprise theoretical lectures and hands-on workshops conducted in small groups, which will encourage active participation and collaborative problem-solving.

Syllabus

• Introduction to Photonic applications in Industry 4.0 and beyond. • Light Detection and ranging principles and applications. • Light-based manufacturing: Laser additive and subtractive advanced fabrication. Semantic segmentation for automatic feature recognition in additive manufacturing. • Photonics for Automotive. Augmented reality principles. • Introduction to wireless optical communication, freespace optics and light fidelity (LiFi) • Arduino-like microcontrollers for smart industry • Hands-on workshops: practical realisation of a lidar-like prototype device employing Arduino microcontrollers and time-of-flight sensors for smart industry applications

Bibliografia

• LiDAR technologies and systems, P. McManamon, SPIE, 2019. • T. Masood and J. Egger, "Augmented Reality: Focusing on Photonics in Industry 4.0," in IEEE Journal of Selected Topics in Quantum Electronics, vol. 27, no. 6, 2021, doi: 10.1109/JSTQE.2021.3093721. • Optical Wireless Communications - An Emerging Technology, M. Uysal, C. Capsoni, Z. Ghassemlooy, A. Boucouvalas, E. Udvary, Springer International Publishing, 2016

CORSO DI DOTTORATO: SSI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Sensing Technologies: advanced materials and characterization techniques**						
SSD	CHEM-01/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	Second
Livello 2026/2027		3		**Paniere 2026/2027**		/	

Obiettivi

The course aims at providing the PhD students basic knowledge and skills about functional (nano)materials of application for sensor development as well as surface analytical techniques. Description of the state-of-the art nanomaterials, including properties and characterization tools, applied in this field will be provided. Students will be introduced to the field of sensing technology from the fundamentals to some case studies of interest, mainly (but not limited) to the context of Smart and Sustainable Industry. Moreover, advanced techniques typically employed for material and sensing interface characterization will be presented (e.g. Electron Microscopies, XPS, etc.)

Syllabus

The course will be given in the form of lectures with slides. In the first part, an introduction to nanomaterials and their characterization techniques will be provided. In the second part, introduction to sensors will be given followed by the implementation of nanomaterials in sensors and successful examples. In the final part, surface characterization techniques will be presented. Visits to lab facilities will be provided. • Nanomaterials: basic principles and properties • Nanomaterials and interfaces: characterization techniques (Electron Microscopies) • Sensor devices: basic principles • Nanomaterials for sensor development • Examples of smart sensors • X-ray photoelectron spectroscopy and other surface techniques

Bibliografia

- HANDBOOK OF NANOMATERIALS FOR SENSING APPLICATIONS, Edited by C.M. HUSSAIN & S.K. KAILASA, Elsevier 2021 - John F. Watts, John Wolstenholme, An Introduction to Surface Analysis by XPS and AES, John Wiley & Sons 2020

CORSO DI DOTTORATO: SSI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Time-series databases for sensor data analysis						
SSD	IINF-05/A	Ore	20	CFU	2	Anno/Semestre	Second/First
Livello 2026/2027		3		Paniere 2026/2027		/	

Obiettivi

Despite significant advances in sensor data modeling, most of the space-time data models proposed in the past decade rely on time-stamping of collected data values, simply reusing solutions available in relational databases. The main purpose of the course is to introduce basic notions about modeling time-series information, highlighting the complexity of managing spatiotemporal data and state-ofthe-art tools in this field. The course also provides theory, models and methods related to time series analysis detailing the main techniques used to extract value from raw data and to identify new useful information. Predictive analytics approaches, suitable for sensor data analysis, are described and applied to real-world case studies by means of hands-on practical exercises.

Syllabus

• Time-series database: features of time-series data - variability, seasonality, stationarity, autocorrelation; timeseries modeling approach - structured data, data stream; basic geospatial data types; time-series DBMS • Processing time-series data: data visualization and monitoring solutions; predictive analytics for sensor data • Using a time-series database: collect data from sensors and systems; query time series data; visualize and manage time series data; process, analyzing and acting on time series data in real time.

Bibliografia

A. Nielsen. Practical Time Series Analysis. O'Reilly Media, Inc. (2019) - ISBN: 9781492041658

CORSO DI DOTTORATO: DAuSy

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Control and Security of Cyber Physical Systems						
SSD	IINF-04/A	Ore	10	CFU	1	Anno/Semestre	AA26-27 / TBD
Livello 2026/2027		3		Paniere 2026/2027		/	

Obiettivi

The course highlights the importance of control and security in Cyber-Physical Systems, which tightly integrate decision-making and physical components for real-time monitoring and control. Special focus is given to opacity, a key notion for assessing whether an industrial "secret" can be discovered by a malicious intruder.

Syllabus

The aim of the course is to show the importance of control and security in Cyber Physical Systems (CPSs). CPSs are systems where a decision making(cyber/control)component is tightly integrated with a physical system(with sensing/actuation) to enable real-time monitoring and control. Therefore, control and security are crucial issues for commissioning these systems and for improving competitiveness of companies. In this context, the study of opacity is a fundamental notion to determine if an industrial "secret" can be discovered by a malicious observer (intruder).

Bibliografia

CORSO DI DOTTORATO: DAuSy

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Data-driven fault diagnosis and fault prognosis						
SSD	IINF-04/A	Ore	10	CFU	1	Anno/Semestre	AA26-27 / TBD
Livello 2026/2027		3		Paniere 2026/2027		/	

Obiettivi

This module introduces data-driven fault diagnosis and prognosis, covering data processing, feature extraction, and model training with MATLAB for condition-based and predictive maintenance. Students will learn to monitor system health, classify faults, and estimate remaining useful life through lectures and case studies.

Syllabus

This module aims at providing PhD students with the main concepts of data-driven fault diagnosis and fault prognosis which are at the base of modern condition-based and predictive maintenance. During the module, the students will learn how to apply a data-driven workflow to solve real case studies and to adapt it to the specific cases of fault diagnosis and fault prognosis. The workflow will include data processing, feature extraction and model training, with some insights on deployment complexity; problem resolution will also be implemented by using a common engineering software (MATLAB). The final goal is to provide PhD students with the necessary background to process sensors data and use them to monitor the condition of a physical system, classify possible undesired behaviours and eventually estimate the remaining useful life of specific components. Each lesson consists in lectures, numerical examples and analysis of case studies.

Bibliografia

CORSO DI DOTTORATO: DAuSy

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Gaussian processes for modeling and control of robotics systems						
SSD	IINF-04/A	Ore	20	CFU	2	Anno/Semestre	AA26-27 / TBD
Livello 2026/2027		3		Paniere 2026/2027		/	

Obiettivi

This course covers the fundamentals of Gaussian Process Regression applied to modeling and control of robotic manipulators, including inverse and forward dynamics identification. Students will apply these models to derive controllers through lectures and numerical examples in MATLAB and Python.

Syllabus

The course shall address the basis of Gaussian Process Regression applied to modeling and control of robotic manipulators. At end of this course, students will be able to apply Gaussian Process Regression to the following problems: Inverse dynamics identification; Estimation of forward dynamics model to simulate the evolution of a robotic system; Use such models to derive a controller. Lesson shall consist in lecture and numerical examples in MATLAB and Python.

Bibliografia

CORSO DI DOTTORATO: DAuSy

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Human autonomous system interaction						
SSD	IINF-04/A	Ore	10	CFU	1	Anno/Semestre	AA26-27 / TBD
Livello 2026/2027		3		Paniere 2026/2027		/	

Obiettivi

This course covers human-autonomy interaction, focusing on modeling humans and tasks, human-in-the-loop approaches, and the design of resilient, safe autonomous systems, particularly in ambient assisted living contexts.

Syllabus

The course aims at providing PhD students with the main concepts of the well-known technology for improving human-autonomy interaction with a special focus on autonomous systems. It is especially focused on technology and case studies relevant to complex, applied environments in which people interact with autonomous systems regularly, particularly in the context of ambient assisted living. The course focuses on approaches that include task inputs from humans: how to model humans and their tasks and at what level of details. Moreover, the human in-the loop approach will be introduced as a new scenario to facilitate the goal achievement, to reduce the anomalies and the unexpected responses from the system or inappropriate responses by the human to enhance human safety. New human-system engineering techniques are needed to ensure autonomous systems will be smoothly and readily adopted into society. Autonomous systems that work together in the environment should integrate the connections and interactions between them, over networks, with the physical environment, and with humans must be assured, resilient, productive, and fair in the autonomous future. Autonomous systems should be analysed including concept, context, requirements, design, integration, operationalization, validation, testing and evaluation. During the course, the students will learn how the human-autonomous system interaction is achieved and how it is articulated. The workflow will include data processing, feature extraction and model training for human-robot interaction tasks, with some insights on deployment complexity; problem resolution will also be proposed by using a common engineering software (MATLAB), and the ROS (Robot Operating System). Each lesson consists in lectures, numerical examples and analysis of case studies.

Bibliografia

CORSO DI DOTTORATO: DAuSy

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Intelligent Supervisory Systems**						
SSD	IINF-04/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	AA26-27 / TBD
Livello 2026/2027		3		**Paniere 2026/2027**		/	
Obiettivi							
This course provides a foundation in intelligent supervisory system techniques, teaching students to judge when AI is a suitable solution and to select appropriate methods for real-world domains.							
Syllabus							
This course aims to offer a foundation of intelligent supervisory system techniques and their application in various real-world domains and how to implement a solution with “intelligent” functionality. Students will learn to judge when intelligent functionality and artificial intelligence may be a good solution for a problem and be able to choose suitable artificial intelligence methods and techniques. Students will also acquire knowledge enabling them to develop the necessary skills to design and implement an intelligent supervisory system.							
Bibliografia							

CORSO DI DOTTORATO: DAuSy

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Introduction to autonomous systems**						
SSD	IINF-04/A	**Ore**	10	**CFU**	1	**Anno/Semestre**	AA26-27 / TBD
Livello 2026/2027		3		**Paniere 2026/2027**		/	
Obiettivi							
The course provides PhD students with the fundamental principles, technologies, and applications related to autonomous systems.							
Syllabus							
The course aims at providing PhD students with the fundamental principles, technologies, and applications related to autonomous systems.							
Bibliografia							

CORSO DI DOTTORATO: DAuSy

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Linear algebra for control applications**						
SSD	IINF-04/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	AA26-27 / TBD
Livello 2026/2027		3		**Paniere 2026/2027**		/	
Obiettivi							
This course introduces advanced linear algebra tools for Control and System Theory, covering formal theory, common algorithms used in MATLAB and Python, and their implementation.							
Syllabus							
The course will introduce advanced linear algebra tools that are commonly used in many applications in Control and System Theory. The course will address this topic from different perspective: Theory with formal proofs of many results, Algorithms to understand the most common algorithms used in MATLAB or Python for linear algebra, Implementation via MATLAB of algorithms and performance evaluation on large data sets.							
Bibliografia							

CORSO DI DOTTORATO: DAuSy

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Multiagent and multiobject estimation						
SSD	IINF-04/A	Ore	20	CFU	2	Anno/Semestre	AA26-27 / TBD
Livello 2026/2027		3		Paniere 2026/2027		/	

Obiettivi

This course provides an overview of advanced research in multi-agent and multi-object estimation, focusing on the Kullback-Leibler paradigm for fusing correlated information and the random-finite-set paradigm for representing multiple objects. Applications to distributed cooperative surveillance, monitoring, and navigation will be discussed.

Syllabus

The course will provide an overview of advanced research in estimation, specifically concerning the two topics of multi-agent and multi-object estimation. Multi-agent estimation deals with a network of agents with sensing, processing and communication capabilities that aim to cooperatively monitor a given system of interest. Multi-object estimation aims to detect an unknown number of objects present in a given area and estimate their states. Special attention will be devoted to the Kullback-Leibler paradigm for fusion of possibly correlated information from multiple agents and on the random-finite-set paradigm for the statistical representation of multiple objects. Applications to distributed cooperative surveillance, monitoring and navigation tasks will be discussed.

Bibliografia

CORSO DI DOTTORATO: DAuSy

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Learning in multi-agent systems						
SSD	IINF-04/A	Ore	20	CFU	2	Anno/Semestre	AA26-27 / TBD
Livello 2026/2027		3		Paniere 2026/2027		/	

Obiettivi

This course provides a thorough overview of learning and optimization in multi-agent systems, covering applications, the challenges of decentralized learning, and state-of-the-art solutions. Lessons combine theoretical lectures with numerical examples in Python, along with an overview of current research trends.

Syllabus

The aim of the course is to provide a thorough overview of learning and optimization in multi-agent systems. At the end of the course, students will be familiar with applications, with the challenges of decentralized learning, and the current state-of-the-art solutions. Additionally, they will have an overview of current research trends and opportunities. Lessons will merge theoretical lectures and numerical examples (using Python).

Bibliografia

CORSO DI DOTTORATO: DAuSy

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Non-linear Control**						
SSD	IINF-04/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	AA26-27 / TBD
Livello 2026/2027		3		**Paniere 2026/2027**		/	
Obiettivi							
This course introduces analytical tools for analyzing the stability of nonlinear dynamic systems and designing nonlinear controllers. Basic engineering examples and MATLAB exercises are provided to support the main approaches presented.							
Syllabus							
The course introduces analytical tools for the analysis and design of nonlinear control systems. At the end of the course students will understand how to analyze the stability of nonlinear dynamic systems and knowledge of some of the main approaches for designing nonlinear controllers. Basic engineering examples and Matlab exercises are provided.							
Bibliografia							

CORSO DI DOTTORATO: DAuSy

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Variable Structure Control						
SSD	IINF-04/A	Ore	10	CFU	1	Anno/Semestre	AA26-27 / TBD
Livello 2026/2027		3		Paniere 2026/2027		/	

Obiettivi

This course presents the theoretical and applicative framework of Variable Structure Control with Sliding Modes, covering the mathematical tools for analysis and design, as well as the limits and mitigation of the chattering phenomenon. Applications to real systems and observer design are also discussed.

Syllabus

Variable Structure Control (VSC) is a control technique who force a dynamical system to behave as a Variable Structure System (VSS) whose characteristics satisfy the required performance, in spite of a class of uncertainties in the system dynamics and external disturbances. In particular the system is forced to reach and remain constrained onto a properly chosen surface of the state space such that the movement on such a surface, i.e., the Sliding Mode (SM), is invariant and corresponds to specifications. The lectures will present the general theoretic and applicative framework of VSC with SMs, presenting it in the more general vision of the control systems. Some of the mathematical tools to analyze and design a VSC with SM will be presented and discussed, also by means of simple examples. The limits of the resulting switching control, the tools to analyze the approximate behavior and the approaches to mitigate the so-called chattering phenomenon will be presented and discussed. Finally, some applications of VSC to real systems and to observer design will be presented.

Bibliografia

CORSO DI DOTTORATO: DAuSy

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Distributed/Decentralized Control and Optimization of Large-Scale Systems						
SSD	IINF-04/A	Ore	10	CFU	1	Anno/Semestre	AA26-27 / TBD
Livello 2026/2027		3		Paniere 2026/2027		/	

Obiettivi

This course provides modeling and methodological tools for formulating and solving large-scale optimization problems using duality theory, with applications to management and industrial engineering formalized and solved in MATLAB. The final goal is to prepare PhD students for research in duality-based decentralized and distributed optimization for large-scale systems.

Syllabus

This course aims at providing PhD students with modeling and methodological tools for formulating and solving large-scale optimization problems with a focus on the use of duality theory. During the course several optimization problems will be formalized, particularly referred to relevant issues within management and industrial engineering. Problem definition and resolution will be also implemented in simulation and engineering software (Matlab). The final goal is to provide PhD students with the necessary background for starting research in the field of duality-based decentralized and distributed optimization techniques to be applied to large-scale systems. Each lesson consists in lectures, numerical examples, simulation and analysis of case studies.

Bibliografia

CORSO DI DOTTORATO: DAuSy

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Non-integer order systems and controllers**						
SSD	IINF-04/A	**Ore**	10	**CFU**	1	**Anno/Semestre**	AA26-27 / TBD
Livello 2026/2027		3		**Paniere 2026/2027**		/	
Obiettivi							
This course introduces fractional calculus and non-integer-order systems as engineering solutions that often outperform traditional integer-order approaches, presenting models and design methods for fractional-order controllers. These controllers offer greater flexibility, robustness, and stability-performance trade-offs than standard PID controllers, with case studies in automotive and mechatronic systems.							
Syllabus							
The course concerns non-integer-order systems. These systems can propose engineering solutions to modeling and control problems that often improve those based on integer-order calculus. Basic tools of fractional calculus are introduced, and some methods and models are described for different engineering fields. Models for practical applications are proposed. Moreover, approaches to design and realize non-integer-order (fractional-order) controllers are described. These controllers show higher flexibility, increased robustness, and ability to obtain a better trade-off between stability and dynamic performance with respect to widespread PID controllers. As case-studies, the course uses applications in automotive and mechatronic systems.							
Bibliografia							

CORSO DI DOTTORATO: DAuSy

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Game Theory for Controlling Autonomous Systems						
SSD	IINF-04/A	Ore	10	CFU	1	Anno/Semestre	AA26-27 / TBD
Livello 2026/2027		3		Paniere 2026/2027		/	
Obiettivi							
This course provides PhD students with the modeling and methodological tools needed to analyze and design algorithms for solving game equilibrium problems. Lessons combine lectures, numerical examples, simulations, and case study analysis.							
Syllabus							
This course is designed to provide PhD students with the necessary modeling and methodological tools for analyzing and designing algorithms to solve game equilibrium problems. The course will include lectures, numerical examples, simulations, and analysis of case studies.							
Bibliografia							

SEZIONE: Insegnamenti trasversali ScuDo

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	**Gender studies**						
SSD	IEGE-01/A	**Ore**	20	**CFU**	2	**Anno/Semestre**	First
Livello 2026/2027				**Paniere 2026/2027**			

Obiettivi

The course aims to provide students with the theoretical and operational tools to understand the concept of gender in its historical evolution and in its social, political and economic implications. At the end of the course the students and teachers will have acquired knowledge regarding feminist theories, women's studies, men's and masculinity studies relating to the social construction of male and female identities, and will be able to identify and critically analyse the different factors that contribute to generate any inequality and discrimination based on gender.

Syllabus

Bibliografia

Lectures, Discussions, Guest speakers (e.g., women in STEM fields, gender studies experts, …), Film screenings, Case study analysis, Group works. Visione del Film Club: “Il diritto di contare” (2017)