CORSO DI DOTTORATO DI RICERCA IN INGEGNERIA MECCANICA, ENERGETICA E GESTIONALE
Coordinatore Prof. Ing. Giovanni BERSELLI

PhD Doctorate on Mechanical, Energy and Management Engineering
Regulation for PhD IMEG didactic activities and

General remarks

Students are required to collect a minimum of **30 CFU per year and 180 CFU in tota3**. Structured training activities include attending classes, national and/or international schools on advanced topics, workshops. The number of Credits from UNIGE (CFUs) to be obtained is distributed as follows:

- *Structured training activities*: minimum 30CFUs
- *Lab activities, research and publication of the results*: up to 120CFUs
- *PhD thesis development, writing, reviewing and defence*: up to 30CFUs.

All activities must be planned in agreement with the Tutor.

Structured training activities: minimum 30CFUs

Structured training activities belong to the following typologies, giving the acknowledgement of an amount of CFUs as shown below.

A. **PhD courses**, specifically offered by the *PhD Program in Mechanical, Energy and Management Engineering*, where 1 CFU corresponds to 3 hours of course.
B. **PhD courses** issued by other Doctorate Schools, if relevant to the student's research subject, where 1 CFU=3 hours, **subjected to the approval of the PhD Coordinator.**
C. **Courses that are part of one of the *M.Sc. programs*** (*Corsi di Laurea Magistrale*) offered at the University of Genova, **in agreement with the Tutor and with the approval of the PhD Coordinator**. Given CFUs are those reported for the course on the official University website.
D. **PhD Schools**. 3 CFUs can be assigned for every day of the school, or 1 CFU each 3 hours of school/workshop, up to a maximum of 15 CFUs per school/workshop. PhD Schools must **be approved by the PhD Coordinator**. A certificate of attendance of the school must be presented for the CFUs to be assigned.

CFU conversion table for Structured Training Activities

PhD IMEG	CFU per activity	CFU
PhD courses offered by IMEG	1CFU=3h	**30CFU mandatory**
Courses offered by other PHD Schools	1CFU=3h (IMEG Coordinator approval required)	
Courses offered by MSc degree courses	As declared from source (IMEG Coordinator approval required)	
PhD Summer Schools listed in IMEG curriculum	2CFU x day OR 1CFU x 3hours Maximum 15CFU	
Other PhD Summer Schools	2CFU x day OR 1CFU x 3hours Maximum 15CFU (IMEG Coordinator approval required)	

Lab activities, research and publication of the results: up to 120CFUs

Research, Lab Activities and Dissemination belong to the following typologies

A. Research activity, in terms of attended seminars, advanced training courses, participation (as listener or speaker) to Scientific Meeting, Workshops, Conferences;
B. Mobility periods abroad, either long or short term;
C. Publications (only published or accepted papers are considered);
D. Lab activities - co-supervision of student, as agreed with the Tutor.

CFU conversion table for Lab activities, research and publication of the results:

PhD IMEG	CFU per activity	CFU
Attended seminars	2CFU	**30CFU Maximum**
Advanced training courses	2CFU for short courses OR 2CFU x day for long courses	
Participation in Scientific Meetings, Workshops, Conferences	2 CFU x day	
Mobility for research periods Abroad	2 CFU x working day	**60CFU Maximum**
Publications (as co-author)	25CFU for journal papers 15CFU for conference proceeding 10CFU for submitted journal paper 5CFU for poster presentation	**30CFU Minimum**
Co-supervision of students	10CFU per student (Tutor approval required)	**30CFU Maximum**
Lab activities	Up to 10CFU per activity (Tutor approval required)	
Bonus	10CFU for awards/prizes	**30CFU Maximum**

PhD IMEG Courses offer

PhD courses constitute a third-level University education process which differs from the former two, Bachelor's and the Master's ones, in that they are specifically oriented to the development of research-oriented competences and skills. This implies on the one way an interdisciplinary approach, on the other an attitude to looking for new solutions, rather than the acquisition of the current ones, that should be criticized rather than uncritically adopted. This is in line with initial historical missions of the Universities that were basically consortia of students and teachers, looking together to know solutions for unsolved problems.

The Courses offered are listed below and a brief description of each of them is also provided in the following. The list of the courses offered may vary over the years, as well as their detailed programme.

Subject	SSD	Instructor(s)	No. of hours
Constructal theory: second law of thermodynamics in nature	ING-IND/10	Luca Antonio Tagliafico	15
Leadership in Academic Career *(program to be defined).*	ING-IND/11	Walid Kamali	12
Spectral analysis of stationary and non-stationary signals: theoretical background and practical applications	ING-IND/12 ING-IND/13	Marta Berardengo Luigi Carassale Giovanni Battista Rossi	21
Design methodology for small-scale ground mobile robots	ING-IND/13	Luca Bruzzone	12
Optimization Methods for Mechanical Design	ING-IND/15	Giovanni Berselli	12
Industry 4.0: from key enabling technologies to digital twin	ING-IND/17	Flavio Tonelli	12
3D printed materials and their functional properties	ING-IND/22	Fabrizio Barberis	12
Macroeconomics	ING-IND/35	Silvano Cincotti	24
Crowdfunding for financing new ventures	ING-IND/35	Stefania Testa	8

The Courses will be provided in Mixed Modality (physical + virtual). Virtual Meetings are offered through the online platform MS Teams (code: ijlbqrn). Each course is provided every two years.

In the following pages the content and the **DRAFT** schedule of the above listed courses.

Important note:

- **A strict course schedule is not feasible & PhD courses are usually held for small classes.**
- **Students are encouraged to get in touch to the course lecturers for exact date/location.**
- **The coordinator will send a "reminder" to all IMEG Students about dates/location once the lecturer will finalize them.**

Constructal theory: second law of thermodynamics in nature

La seconda legge della termodinamica come criterio di ottimizzazione ("constructal theory")

Instructor: Luca Antonio TAGLIAFICO
Period: June (details to be defined at a later stage)
Number of hours: 15 – 5CFU
SSD: ING- IND/10

Summary:
Constructal theory is a hierarchical way of thinking that accounts for organization, complexity and diversity in nature, engineering and management. Early studies in thermodynamics, heat transfer and fluid flow demonstrated that any time a problem of flow from a concentrated resource to and extended field is needed, the second law of thermodynamics can be introduced to optimize geometry (flow passages) and different ways of transfer (molecular motion vs. viscous diffusion). Such theory, well known as the EGM (Entropy Generation Minimisation) criterion, often leads to solutions which are quite recognizable in nature. The constructal theory enlarge the application of EGM to more general systems and disciplines, in which any problem of area-to-point connection, such as the constitution of a tree, can be optimized deducing its final design from a principle, not duplicating natural optimization processes such as genetic algorithms.

Engineering tools: Basic engineering calculation tools (Matlab, Engineering Equation solver, …)
Readings:

- Lecture notes.
- Adria Bejan: Shape and Structure, From Engineering to Nature. Cambridge University Press, 2000

Syllabus

- Introduction to second law of thermodynamics;
- The objective and constraint principle - examples
- The Entropy Generation Minimization (EGM) criteria as a design objective;
- Structure in thermal systems;
- Structure in time: optimal frequency in volume-to-point intermittent resource distribution;
- Structure in transportation and economics.

The enrolment to the course is free, but registration is required via email at tgl@ditec.unige.it.
The course will be held with a minimum of 3 students.

For more information, contact Luca A. Tagliafico at tgl@ditec.unige.it

Spectral analysis of stationary and non-stationary signals: theoretical background and practical applications

Instructors: Giovanni Battista ROSSI, Luigi CARASSALE, Marta BERARDENGO
Period: February (details to be defined at a later stage)
Number of hours: 21 – 7 CFU
SSD: ING-IND/12, ING-IND/13

Summary

In the experimental investigation of dynamic processes, such as, e.g., vibration, sound, human movement, or sea-waves, it is necessary to use representations of the phenomenon that best convey the required information for research, design, testing or management purposes. Spectral analysis is often the preferred choice for that. Performing a good spectral analysis is a complex professional or scientific task, which requires an integration between (prior) knowledge of the process and mastering of available analyzing techniques. Providing such a skill is a major goal of this course. Furthermore, dynamic phenomena may be either stationary or non-stationary (evolutionary). Examples of the latter include the case of engine startup or shutdown, as well as when sudden or rapidly changing phenomena appear. In such cases, an interesting alternative to the analysis methods originated by the Fourier transform, is given by the wavelet transform, which provides a consistent mathematical framework to analyze transient phenomena, both from a qualitative and quantitative point of view.
This course aims at providing, in a unified framework, the mathematical techniques useful to represent and interpret dynamic phenomena. The presentation of the theoretical background will be followed by laboratory sessions in which students will apply the learned concepts to practical case studies.

Syllabus

- Fourier transform and spectral representation of dynamic phenomena: periodic, transient impulsive, stochastic stationary. Effects of time sampling and of a limited observation time.
- Algorithms and implementations: working principles and criteria for proper use, including data preprocessing, setting of transformation parameters and presentation of results.
- Time-frequency localization and joint representation: Heisenberg uncertainty principle, analytic signals and instantaneous frequency.
- Time-frequency transformations: short-time Fourier transform, wavelet transform
- Spectral estimation: criteria for reducing the variance of spectrum estimates, local averaging and smoothing.
- Worked examples, based on simulated signals and on actual data, concerning vibration, human movement and sea-waves motion, developed in the MatLab environment.

The enrolment to the course is free, but registration is required by sending an e-mail to one of the instructors (g.b.rossi@unige.it, luigi.carassale@unige.it, marta.berardengo@unige.it) not later than January. Course will be held with a minimum of four students.

For more information contact any of the instructors.

Design methodology for small-scale ground mobile robots

Instructor: Luca BRUZZONE
Period: September (details to be defined at a later stage)
Number of hours: 12 – 4CFU
SSD: ING- IND/13

Summary

The world market of service robotics is growing remarkably in the last years, and this trend is expected to continue. In particular, small-scale ground mobile robots are the most widespread category of service robots, with important application fields such as homeland security, inspection, surveillance, reconnaissance, also in the presence of radioactive or chemical contamination. As a consequence, a key research area is the development of innovative locomotion systems for unstructured environments, capable of conjugating conflicting requirements: speed and energetic efficiency on flat and compact grounds, capability of crossing obstacles (in particular steps and stairs) and terrain irregularities, mobility on soft and yielding terrains. The course presents the features of the main locomotion principles (wheeled, W, tracked, T, and legged, L) and discusses examples of their possible hybrid combinations (WL, WT, LT, LWT). Then the main issues in the development of a locomotion system for a ground mobile robot are outlined, independently of its specific payload, applying the methodology to case studies.

Engineering tools: Matlab
Readings:

- Lecture notes.
- Bruno Siciliano, Oussama Khatib, *Springer Handbook of Robotics*, 2nd edition, Springer, 2016.

Syllabus

- Locomotion systems for ground mobile robots: legs, wheels, tracks, and their hybrid combinations. Performance comparison in different environments.
- Examples of hybrid locomotion systems.
- Outline of the design methodology for the mechanical architecture of ground mobile robots.
- Stability analysis during obstacle climbing. Case study: step/stair climbing.
- Embodiment design, constructive solutions and prototyping issues.

The enrolment to the course is free, but registration is required by sending an e-mail to Luca Bruzzone (luca.bruzzone@unige.it). Course will be held with a minimum of 3 students.

For more information contact Luca Bruzzone (luca.bruzzone@unige.it)

Optimization Methods for Mechanical Design
Tecniche di Ottimizzazione per la Progettazione Meccanica

Instructor: Giovanni BERSELLI
Period: March (details to be defined at a later stage)
Number of hours: 12 – 4CFU
SSD: ING- IND/15

Summary

Computer-Aided Design (CAD) and Engineering (CAE) software have unquestionably become essential tools for product design. CAD/CAE technologies are extensively used in several fields, including aerospace, automotive, earth-moving machines, and automated plants. Virtual prototypes can simulate mechanical and mechatronic systems starting from the geometrical and parametric representation of parts, the study of complex devices during their motion, up to the verification and the OPTIMIZATION of their behaviour. To date, various software environments are available (in some cases also open-source) that allow performing sensitivity/feasibility analyses, as well as mono/multi-objective optimization studies while integrating several simulation tools (i.e. parametric solid modelling, structural computations, motion analyses), thus allowing a faster and more efficient engineering design process and drastically reducing product development times.
Within this scenario, this training course will allow to learn the basic background of the main engineering optimization techniques, also offering the possibility for hands-on training with some of the most popular CAD/CAE packages available for the scientific and industrial community.
Engineering tools: PTC Creo – Ansys WorkBench (WB) - Matlab
Readings:

- Lecture notes and video tutorials provided by the lecturers.
- G. Pahl and W. Beitz, Engineering Design: A Systematic Approach, 2nd ed. Springer, 1998.

Syllabus

- Introduction to optimization methods;
- Design of Experiments, Response Surface Modelling;
- Deterministic, stochastic optimization and multi-objective optimization;
- Robust Design Analysis;
- Guidelines for addressing an optimization problem in Engineering Design;
- Introduction to the optimization tools integrated into CAD/CAE software;
- Hands-on Experience via an application case study - design of parts with complex geometry and pre-defined structural compliance.
    - Method A: optimization using PTC Creo + Ansys WB.
    - Method B: optimization using a Matlab Script

The enrolment to the course is free, but registration is required via email at giovanni.berselli@unige.it not later than February. The course will be held with a minimum of 3 students.

For more information, contact Giovanni Berselli at giovanni.berselli@unige.it

Industry 4.0: from key enabling technologies to digital twin

Instructor: Flavio TONELLI
Period: January (details to be defined at a later stage)
Number of hours: 12 – 4CFU
SSD: ING- IND/17

Summary

Challenges for the cyber-physical manufacturing enterprises of the future: Cyber Physical Systems, Digital Twin, Industrial IOT integration, manufacturing example to practically explain the usage of 4.0 enabling technologies in supporting or creating new industrial business opportunities based on new product/process/operations interaction.

Engineering tools:
Basic mathematics; preferred moderate modeling and simulation skills.
Readings:
- Lecture notes and charts.

Syllabus

- Introduction to Industry 4.0;
- Key enabling technologies (focus on IoT);
- Cyber Physical Systems (CPS);
- Digital Twins (DT of product, process, performance);
- Integrating CPS, DT, IoT to support existing product/service propositions;
- New industrial business opportunities.

The enrolment to the course is free, but registration is required via email flavio.tonelli@unige.it. The course will be held with a minimum of 3 students.

For more information, contact Flavio Tonelli at flavio.tonelli@unige.it

3D printed materials and their functional properties
Materiali stampati in 3D e loro proprieta' funzionali

Instructor: Fabrizio BARBERIS
Period: January (details to be defined at a later stage)
Number of hours: 12 – 4CFU

Summary:

In the last 25 years Additive Manufacturing - AM matured as a technology able to deposit molded materials in a layer-by-layer process by following Project instruction provided by a virtual solid model. AM was originally born as a substitute of Rapid Prototyping techniques when the target was mainly to obtain a solid shape of the discussed project. To date the situation is different and AM is adopted to create functional parts not only in general industrial applications but also in sensitive tasks like energy, transports, aerospace and also medicine. Different names are used, Direct Manufacturing as well as Advanced Manufacturing, to generally indicate the AM process but the adopted technologies are quite different and therefore also the possible benefits. The main attractive item of AM is the chance to rebuild the Project by applying this new technology but a serious limit exists in the final microstructure of the printed materials and therefore in the overall mechanical and functional properties. The Course will evaluate the main technologies available on the market to print polymers and metals, highlighting the main features and differences in terms of the material microstructure and the overall mechanical and functional properties. Analysis of the main features of 3D printed materials as well as problems related to these technologies will be discussed with the students, commenting several examples coming from the industry as well as from medical applications.
GeAM - Genova Additive Manufacturing facilities will be introduced and shown to the students in order to enhance the overall Course experience.

Engineering tools: Dime- Dicca Lab as well as GeAM facilities
Readings:

- Lecture notes and video tutorials provided by the teacher

Syllabus:

- Principal targets in 3D printing: technical vs commercial
- Introduction to Additive Manufacturing technologies
- Intro to 3D metal printing
- Microstructure of 3D printed metals and the industrial experience
- 3D printing with polymers – the medical experience in tailored medicine with external and internal temporary scaffolds.
- Main materials advantages and problems arising by 3D printing
- Hands-on Experience via an application case study – the GeAM Project.

The enrolment to the course is free, but registration is required via email at fabrizio.barberis@unige.it not later than May. The course will be held with a minimum of 3 students.

For more information, contact Fabrizio Barberis (fabrizio.barberis@unige.it)

Macroeconomics

Instructor: Silvano CINCOTTI
Period: January (details to be defined at a later stage)
Number of hours: 24 – 8CFU
SSD: ING- IND/35

Summary

Macroeconomics is the economics field that considers the economy as a whole, i.e., the study of the aggregate of individual economic decisions. Attention is payed to the different sectors of the economy (i.e., real, credit, financial and public sector), aggregate output and employment, national income, inflation and deflation, recessions and depressions, money and the banking system, budget deficits and surplus, growth and the international economy. Furthermore, the course investigates the role of government and economic policy, the different and coexisting decision processes of the economic-agents and the interaction among sectors/markets. Throughout the course, emphasis is dedicated to the strengths and weaknesses of alternative traditions in macroeconomics, and the relationship of economic theory, history and policy. Now is an exciting time to study macroeconomics!

Syllabus

- Introduction to Economics
- Scarcity and Choice
- Demand and Supply
- Introduction to Macroeconomics
- The circular flow of income and the Keynesian multiplier
- Government intervention and fiscal policy
- Money: Economic functions and creation process
- The Central Bank and the money market equilibrium
- Equilibrium in the goods and money markets and understanding public policy: the IS-LM model
- The WS-PS model of the labour market
- The Phillips curve, the NAIRU and the role of expectations
- Aggregate Demand and Aggregate Supply
- Credibility and long-run reform
- Imports, exports, exchange rates and the Mundell-Fleming model
- Stylized facts of growth and the Solow model
- Agent-based macroeconomics

The enrolment to the course is free, but registration is required by sending an e-mail to silvano.cincotti@unige.it not later than 20 December. Course will be held with a minimum of 3 students.

For more information, contact Professor Silvano Cincotti (silvano.cincotti@unige.it)

Crowdfunding for financing new ventures

Instructor: Stefania Testa
Period: May (details to be defined at a later stage)
Number of hours: 9 – 3CFU
SSD: ING- IND/35

Summary
Crowdfunding represents a fundamental change in the way technologies and products are brought to the market. Crowdfunding is a financial instrument in its infancy but there is already a relevant body of knowledge about its role in providing venture capital for projects or startups. The goal of this course is to provide a theoretical grounding as well as guiding business principles which can be utilized to create a CF campaign for a startup.

Syllabus

- Introduction to Crowdfunding (CF) Model
- CF Cons
- CF Pros
- Comparison with traditional forms of financing
- Who should consider CF
- CF typologies and main platforms
- Preparing for your CF campaign
- Insights from campaigns that failed
- Case study

The enrolment to the course is free, but registration is required by sending an e-mail to stefania.testa@unige.it not later than May. The course will be held with a minimum of 3 students.

For more information, contact Professor Stefania Testa (stefania.testa@unige.it)

To the attention of PhD Board: Procedure and rules to propose a PhD course

1. **PhD courses** specifically structured for PhD IMEG doctoral students must have an interdisciplinary interest for almost all of the curricula (teaching courses of specific interest of a single curriculum are not considered here). The proposal of a new PhD IMEG course must be submitted to the PhD Coordinator, who shall present the course to the PhD Doctoral Board for approval. The form of the proposal shall be similar to those already attached in the present offer. PhD IMEG courses list can be updated every year according to the University of Genoa time scheduling for PhD courses. Courses issued by other Doctorate Schools can be proposed by PhD IMEG Board members, and added to the list, subject to the approval of the PhD IMEG Board.
2. **Courses that are part of one of the *M.Sc. programs*** already available at University of Genoa will be suggested to the student by the tutor, with the aim to grow-up specific basic knowledge needed for the PhD thesis research activity. The learning plan will be yearly presented to the PhD Coordinator to be signed, after PhD Doctoral Board approval.
3. **PhD Schools and workshops** can be freely proposed by the tutors. The PhD Board must approve the acknowledgment of CFUs for such Schools/Workshops. A list of the Schools and Workshops (already approved by the Board), together with the corresponding CFUs, is available and yearly updated. The list is updated on the basis of new proposals presented by the tutors and approved by the Board.

To the attention of PhD Students

On the table below, students can find an **example** of PhD activities for 1 year course

Structured training activity	**MIN 30 CFU**
Lab activities / research / publication	**MAX 120 CFU**
PhD Thesis Development	**FIXED 30CFU**

Typology	Activity	Description	CFU
YEAR 1			
Structured training activity	IMEG PhD Course	Design methodology for small-scale ground mobile robots. (12h = 4CFU)	**4**
Structured training activity	PhD Summer School	8th International Summer School of Neuroengineering	**15**
Lab activities / research / publication	Conference Proceeding	Title, Conf. Location	**15**
Lab activities / research / publication	Journal Paper	Title, Journal	**25**
Lab activities / research / publication	Award	Title, eventually Conf. Location or Journal	**10**
TOTAL CFU x YEAR 1 (MIN of 30 CFU)			**69**
YEAR 2			
Structured training activity	PhD Course offered by other PhD School (e.g. PhD in Bioengineering)	Grant Writing. (12h = 4CFU)	**4**
Structured training activity	MSC Course in Mechanical Engineering	Design of Automatic Machinery and Robots	**6**
Lab activities / research / publication	Participation at Workshop / Conference	Workshop on Composite Materials – AIAS Conference (2 Days)	**4**
Lab activities / research / publication	Seminar	Online Seminar on Advanced Techniques in Computational Fluid Dynamics	**3**
Lab activities / research / publication	Advanced training	Plastic Anisotropy And Damage From Single Crystal To Engineering Scale – CISM Center (2 days)	**4**
Lab activities / research / publication	Master degree thesis co-supervision	Master Thesis title “Kinematic Analsys of a Hook Joint”	**8**
Lab activities / research / publication	Poster	8th International Summer School of Machine Design	**5**
TOTAL CFU x YEAR 2 (MIN of 30 CFU)			**33**
YEAR 3			
Structured training activity	IMEG PhD Course	Crowdfunding for financing new ventures	**3**
Lab activities / research / publication	Mobility	Research period abroad – 6 months	**60**
PhD Thesis Development	Thesis writing	Thesis Title	**30**
TOTAL CFU x YEAR 3 (MIN of 30 CFU)			**93**
OVERALL CFU			
Structured training activity	CFU YEAR 1 + YEAR 2 + YEAR 3 = 32 REQUIREMENT: MIN OF 30 CFU		**32**
Lab activities / research / publication	CFU YEAR 1 + YEAR 2 + YEAR 3 = 126 REQUIREMENTS: MIN OF 30 CFU in PUBLICATIONS - MAX OF 120 CFU OVERALL		**120**
PhD Thesis Development	30 CFU		**30**
TOTAL CFU (MIN of 180 CFU)			**182**