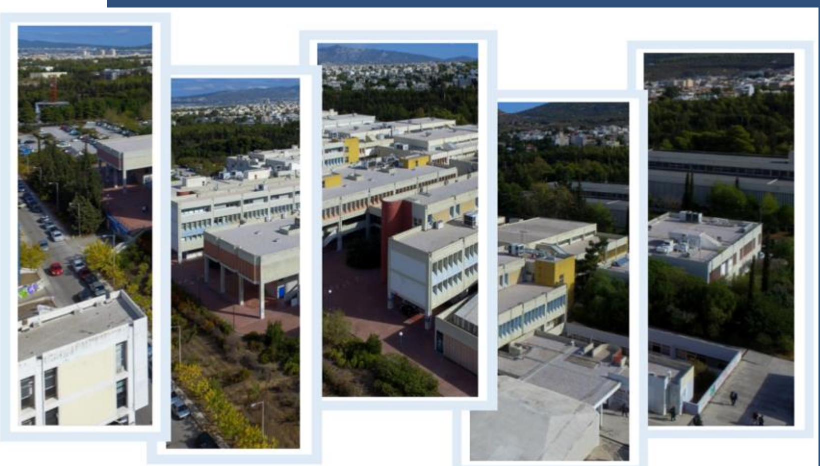
STUDIES GUIDE

2024-2025



School of Mechanical Engineering NTUA

National Technical University of Athens

Course Description

Each course code consists of four numbers (**XX.YY.ZZ.UU**) indicating:

XX: **School giving the Course**:

- 01 School of Civil Engineering
- 02 School of Mechanical Engineering
- 03 School of Electrical & Computer Engineering
- 04 School of Architecture
- 05 School of Chemical Engineering
- 06 School of Rural & Surveying Engineering
- 07 School of Mining & Metallurgical Engineering
- 08 School of Naval Architecture & Marine Engineering
- 09 School of Applied Mathematical & Physical Sciences

YY: **Section giving the course**: The School of Mechanical Engineers consists of six sections:

- 01 Industrial Management & Operational Research
- 02 Thermal Engineering
- 03 Mechanical Design & Automatic Control
- 04 Nuclear Engineering
- 05 Fluids
- 06 Manufacturing Technology

ZZ: **Code of the course**.

UU: **Semester of the course** according to the normal studies program.

The letters C or O indicate if it is Compulsory or Optional.

Brief summary of each course is followed by information about its laboratory exercises: these can be Compulsory (C) or Optional (O). The weight of the laboratory exercises in the calculation of the final course grade is also indicated.

The notation (GR) or (GR & EN) following the title of each course indicates whether the course is conducted in Greek only (GR) or in Greek and English (GR & EN).

Teaching staff indicated in paragraph concerns Special Laboratory Teaching Staff.

Industrial Management & Operational Research

(2.1.2160.3) Engineering Economics [C] (GR)

- Introduction to Engineering Economics.
- Marginal analysis of resource allocation in the production system.
- The value of inputs and the concept of productivity.
- Production costing. The value of outflows.
- Break-even analysis and utility theory.
- Financial Activity Assessment. Investment analysis.
- Cash flow analysis.
- Comparative economic assessment. Investment selection criteria.
- The Investment Plan: Basic concepts and definitions. Stages of investment plan preparation. The components of an Investment Plan. Planning, establishing and evaluating Investment Plans.
- Balance sheet and Profit & Loss account analysis. Financial Indicators.

K. Aravossis, A. Rentizelas, (V. Kapsalis)

(2.1.2072.5) Production/Operations Management & Business Administration I [C] (GR)

Introduction to Production/Operations Management & Business Administration. Work Organization. Work Study: Study of Methods, Study of Time. Quality Management and Control. Introduction to Production Planning and Control. The principles of the MRP system. Production Orders Scheduling. Inventory Management. Materials Management. Management Information Systems in Production. Supply Chain Management. Managing Health and Safety at Work. Production Cost Accounting - Break Even Analysis. Plants Capacity Planning.

Lab: C 15% of the Final Grade

N. Panayiotou, (S. Gayialis, G. Papadopoulos, G. Chatzistelios)

(2.1.2198.7) Data Bases [C] (GR & EN)

- Data Base General Principles.
- Data Base Management Systems Architecture.
- Management Applications and Data Bases.
- Elicitation of user requirements.
- Introduction to relational Data Base structures.
- Conceptual modelling with Entity Relationship diagrams (ERDs).
- Transforming ERDs into relational structures.
- Normal Forms and database schema normalization.
- Basics of DDL and DML SQL.
- Implementing Data Bases queries and user interfaces in the laboratory using commercial Data-Base management Systems.
- Coursework – designing and coding a specific database application.

Project/s: C 30 % of the Final Grade

D. Nathanail, (G. Chatzistelios)

(2.1.2209.8) Production/ Operations Management and Business Administration II [C] (GR)

Costing terminology. Cost Flow. Cost Assignment. Full Cost Accounting. Marginal Cost Accounting. Differential Costing. Job Costing. Process Costing. Project Costing. Standard Costing & Variance Analysis. Activity-Based Costing (ABC). Budgeting. Business Process Reengineering (BPR) & Business Process Improvement (BPI). Balanced Scorecard. Introduction to Internal Audit. Individual Assignment: Obligatory (Common assignment with module 2.1.2210.8: Management Information Systems in Production).
Laboratory of Metrotechnics.

Lab:C 15% of the Final Grade

N. Panayiotou

(2.1.2213.7) Quality Management [C] (GR)

The Quality Management course helps students to gain knowledge in one of the most important fields of engineering internationally. Graduates of the School will eventually work in Quality and use their education knowledge.
The course covers all the knowledge areas of quality management, namely quality standards and standardisation, quality design, quality assurance, quality control and improvement, quality costs, quality tools, analysis of an organisation's operating framework and identification of key stakeholders, management of human and other resources, communication and risk management. It is fully aligned with international standards of quality management systems (ISO 9001, ISO 19011).
The main purpose of the course is to introduce the basic principles, terminology and requirements of Quality Management Systems, and the use of quality tools and quality control techniques, both in the laboratory environment and in manufacturing and service provision.
The course is divided into two parts, one of which is conducted in the classroom and the other in the laboratory with the help of special software. The laboratory part covers about 20% of the total time of the course and complements the theoretical part, as it explains in practice how standardisation is applied and quality control is implemented.
The following concepts/modules are included:
Quality Management Systems (QMS). The concepts of Quality Control, Quality Assurance, and Quality Management. Definition and dimensions of quality.
International standards and the International Organization for Standardization (ISO).
The requirements of the ISO 9001 standard: Context and operational framework of the Organization: Scope, stakeholders, processes. Leadership: management commitment,

quality policy, roles and responsibilities. Design: risk management, quality objectives and planning of changes. Resources: Documented information, control of forms and records, documentation procedures. Professional competence and staff training procedures. Infrastructure and equipment capacity.
Operational planning and control of processes: Process approach. Variability of the production process. Capability and statistical control of the production process.
Requirements for products and services. Processes related to customers (review of contracts). Purchasing processes. Product and service production processes. Identification and traceability. Property owned by customers or external providers. Control of monitoring and measurement devices. Product monitoring and measurement, control of non-conforming products.
Performance evaluation: Internal Audit & Management review.
Certification procedures: granting and maintaining the quality system certificate.
Production Statistics. Quality and specifications. Quality control. Concept and technique of preventive control. Preventive control by measurement/by screening. Representative samples - Sampling methods. Characteristic curve, Acceptable Quality Level, Lot Tolerance Percent Defective. Risks of the deliverer and receiver. Average outgoing quality, Average Outgoing Quality Limit/.
Standard systems for acceptance sampling with screening; ISO 2859, Dodge-Roaming, Philips, MIL-STD-105E.

Project/s: C | 25% of the Final Grade

K. Kirytopoulos, (G. Chatzistelios, C. Tsogkas)

(2.1.2215.7) Introduction to Marketing (GR)

Main concepts, Marketing definitions and terminology. The Marketing environment. Marketing and Corporate Social Responsibility (CSR). Marketing and Production. Comparative advantage creation. Strategic Marketing (Vision, Mission, Objectives, PEST Analysis, SWOT Analysis, Business Model, Five Forces Analysis). 4Ps. Marketing Plan. Market Research. Industrial Marketing & Consumers Marketing. Consumers' buying behavior. Industrial buyers' buying behavior. Market segmentation in industrial markets & consumer markets and positioning. Adoption process, buying process and dissemination process of new industrial products and technological innovation. Pricing & distribution policies. Promotion techniques for consumer and industrial products. Marketing Information Systems (CRM). Marketing and New Economy.

Project/s: C 30% of the Final Grade

N. Panayiotou

(2.1.2308.8) Risk management & business continuity (GR)

Managing the uncertainty associated with project and business objectives is an important skill for the modern engineer. The course introduces students to the concept of risk, how to analyse and manage it. A comprehensive description of the systematic process of risk identification, analysis (qualitative and quantitative), response and monitoring is attempted. The course covers the management of project, process and business risks as well as the management of business continuity (readiness to deal with risks with a low probability of occurrence but a very high consequence). In addition to the basic tools used in the four stages of risk management, topics related to people's perception of risk (e.g. utility/expectancy theory), crisis management and specific issues such as black swans, perfect storms, etc. are addressed.

The course includes the following topics:

Notion of risk, risk management for engineering projects, enterprise risk management, business continuity, risk identification methods, risk analysis methods (qualitative - quantitative), risk evaluation, risk treatment, critical success factors and risk management culture, human biases in risk management, business impact analysis. Risk Breakdown Structure (RBS), Risk checklists, Probability - Impact matrix, Probability and impact scales, Monte Carlo simulation, Response strategies (avoid, mitigation, transfer), risk sheets, risk registers, risk perception / psychology.

Project/s: C 50 % of the Final Grade

K. Kirytopoulos

(2.1.2031.7) Operational Research II [C] (GR)

Basic Probability theorems. Theorems of conditional probabilities (Bayes Theorem). Total Probability Law. Random variables – Statistical Distributions (discrete and continuous). Links with Operational Research (with examples). Modern stochastic computational methods of Optimization. Introduction to Evolutionary algorithms. Mutation and Crossover. Evolutionary Strategies and Covariance Matrix Adaptation (CMA). Particle Swarm Optimization. Adaptive learning and mutations. Constraint Handling Techniques: (1) Penalties and Adaptive Penalties. (2) Feasibility Rules and Stochastic Ranking. Markovian processes for decision making. Markov chains. Applied Queuing Theory – Introduction. Processes of birth and death. Poisson and Non-Poisson prototypes. Other Statistical prototypes. Specific Queuing prototypes and implementation methods.

Project Based Analysis (30% of Course Grade)

A. Tolis, (V. Kapsalis)

(2.1.2128.8) Industrial Ergonomics [C] (GR & EN)

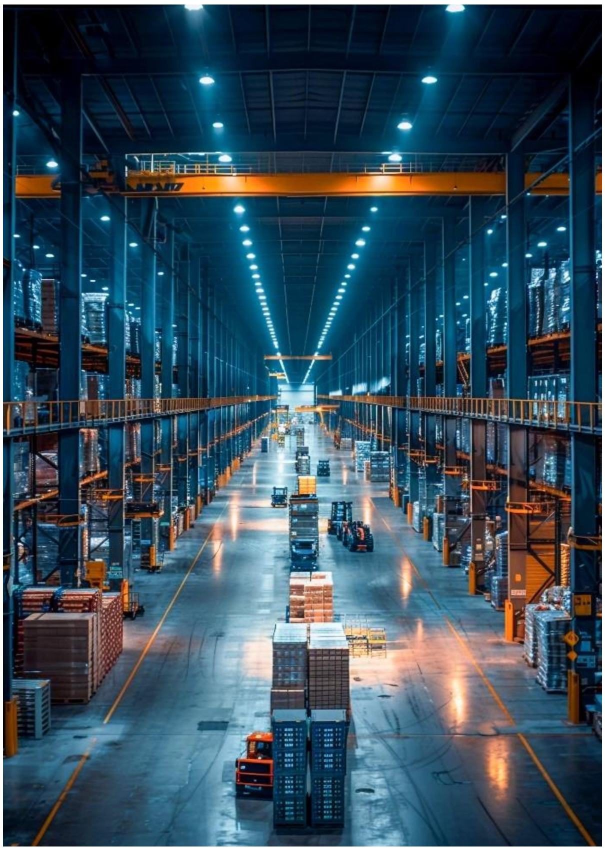
Introduction to Ergonomics. Generic Ergonomic Model. Ergonomic design of workplace and tools. Physical work - design to decrease physical workload. Thermal work environment (hazards, assessment and prevention measures). Psycho-acoustics and noise environment (hazards, assessment and prevention measures). Vision and lighting (designing physical and artificial lighting environment). Time and work (biological rhythms, night work, working hours and aging).

Lab: C 15% of the Final Grade Project/s: C 25% of the Final Grade

D. Nathanail, (S. Drivalou)

(2.1.2126.8) Production & Material Handling Systems [C] (GR)

Modern management of production and material management systems enables engineers to design efficient processes that reduce costs, optimize quality, maximize productivity, and minimize emissions and waste in modern facilities. This is particularly crucial in a world where competitiveness and sustainability are key factors for the success of a business organization. The course introduces the fundamental principles of managing such systems



from the perspective of a Production Mechanical Engineer, with a focus on the Industry 4.0 technologies that support them. The course content includes the following thematic subareas: Manufacturing / Warehousing Facilities Planning. The role of Warehouse/Distribution facilities in contemporary Supply Chain Management and Logistics. Introduction to the Facility Location problem. Plant and Warehouse Layout. Master Layout – Site and Building Parameters. Material Handling Equipment Sizing and Costing. Designing the Warehouse – Material – Equipment and Workforce Flows. Activity Relationship Analysis. Production, Warehouse and Auxiliary Space Requirements Determination. Dock and Yard Calculations. Detailed Layout. Visualizing the Layout Plan – Drawing and Simulation software. Warehouse Traditional Automations. Warehouse Information Management Systems. Introduction to Warehousing 4.0. Investment Decision Analysis.

Project/s: C 40% of the Final Grade

S. Ponis

(2.1.2307.8) Reverse Logistics & Circular Economy (GR)

The course covers the design of reverse and green logistics networks at both strategic and operational levels, through the lens of circular economy applications and modern e-business. It examines qualitative and quantitative methods, with learning facilitated through extensive use of case studies and workshops involving specialized software, including examples drawn from research conducted at NTUA. The course content includes the following thematic subareas: Introduction of the Reverse and Green Logistics concepts. Presentation of the characteristics of Closed Loop Supply Chains and the prevailing Circular Economy models (3Rs, 6Rs etc). Trends in Circular Economy and the environmental impact of Logistics. The role of Reverse and Green Logistics in the Circular Economy and e-Business strategy and operations. Green transportation. Methods for evaluating the efficiency of Reverse Logistics Networks - Green KPIs. ESG criteria and standards (Environmental, Social and Governance). Product Life Cycle Analysis and the role of Reverse Logistics. Qualitative methods for the eco-design of Logistics. Quantitative methods for designing reverse Logistics networks: strategic and operational level. Decision making methods in Logistics network design / redesign problems. Industrial Symbiosis Networks. New emerging Industry 4.0 technologies (IoT: Internet of Things) to support Reverse & Green Logistics.

Project/s: C 100% of the Final Grade

S. Ponis, A. Rentizelas

(2.1.2125.9) Business Games (GR)

In this course, students apply Business Administration methods, managing a hypothetical enterprise, using PC simulation. Groups of 5-6 students are managing their company, taking a series of decisions about key business operations (production, sales, marketing, finan cing, cooperation with banks, HR management, etc .) in conditions of uncertainty , competition and time pressure. Learning is done empirically and in a participatory way**,** while at the same time various related topics of theory are presented. Three games are taught in the course, one focusing on the production of a generic factory (Job-shop), one focusing on strategic decisions and one applying supply chain simulation techniques to illustrate the challenges of managing inventory and information flows. Participants take on roles such as retailer, wholesaler, distributor, and manufacturer, aiming to meet fluctuating customer demand while minimizing costs. Through these games, students become familiar with all levels of management decision making, taken by an engineer.

Lab: C 85% of the Final Grade Project/s: C 15% of the Final Grade

K. Kirytopoulos, S. Ponis, (V. Bellos, X. Tsogas)

(2.1.2090.9) Decision Support Systems [C] (GR)

The Decision Support Systems course is based on a solid Operational Research and Decision Support theoretical background and focuses on solving complex business problems using dedicated software tools, e.g. Excel Solver & Tableau. The course is consisted of the following learning sections: Introduction to contemporary Decision Support Systems. Introduction to Business and Data Analytics. Basic principles of Business Intelligence systems (structure, functionalities, interfaces). Business data analysis, data reporting and visualization - software tools. Laboratory exercises (applications in case studies) supported by Solver / Optimization software (Excel add-in) to support business decisions. Solving a variety of Linear Programming, Integer Programming, Goal Seek, Investment Analysis, Supply Chain, Logistics, Network and Project Management problems.

Lab: C 30% of the Final Grade

S. Ponis, K. Kirytopoulos

(2.1.2269.7) Project Management (GR & EN)

The Project Management course helps students to gain knowledge in one of the most important subjects related to engineers internationally, both in terms of substance and employment opportunities.

It is one of the courses that is fully aligned with the subject of engineering, as it is absolutely certain that graduates of the School will sooner or later be called upon to manage projects and apply the knowledge gained during their education. The course covers all the knowledge areas of project management i.e. scope, time, cost, stakeholder, quality, human resources, communication, risk, procurement and integration management.

It is fully aligned with international and national project management standards (ISO21502, PMBOK, ELOT1429). The main purpose of the course is to delve into the main methods/techniques of project management such as scope management (WBS), scheduling (Gantt, CPM, PERT), cost management (Cash flows, Time Phased Budget, EVM), resource management and planning and communication (RACI). The course is divided into two parts, one of which is carried out in the classroom and the other in the laboratory with the help of specific software. The laboratory part covers about 30% of the total time of the course and is fully aligned with the theoretical part as it explains to students how to use the software in the classroom.

The course includes the following modules:
Project management concepts and definitions, project management processes. National & International PM standards. Project management cycle – projects and business strategy. Organisational structures. Project Manager – Project Management Office. Staff motivation. Scope management – Work Breakdown Structure. Time management – Gantt - CPM – total and free slack – uncertainty in estimations – PERT. Cost management – Cash flows – Time phased budget - Earned Value Management (EVM). Resource management – resource allocation – Project risk management. Stakeholder & communication management – RACI – responsibility assignment matrix.

Laboratory / PM software: Introduction to project management software. Define activities. Enter activities, durations, dependencies. Calculate project duration, structure the project in phases, milestones, critical path. Resource loading. Costs. Baseline schedule – monitor actual progress. Types of activities, Person-hours. Resource availability, resource allocation, resource leveling. Reporting. Network diagram. Calendars. Lead/lag times. Earned Value Management.

Lab: C 25 % of the Final Grade

K. Kirytopoulos, (E. Bellos)

(2.1.2210.8) Management Information Systems in Production [C] (GR & EN)

Introduction to Enterprise Resource Planning (ERP) systems. Business process reengineering and reorganization. Analysis & Design of Information Systems. Analysis of database schemas. Process specifications. Management of information systems projects. Business process modeling with ARIS Information Systems Architecture. Software development methodology. ERP Systems Lab (PC Lab): The functionality of the ERP Logistics Applications: Materials Management (MM), Sales and Distribution (SD), Production Planning (PP), The functionality of the ERP Financial Applications: Costing - Controlling (CO). ERP Systems of Small and Medium sized Businesses. Implementation of ERP projects.

Project/s: C 30% of the Final Grade

N. Panayiotou, (S. Gayialis, G. Papadopoulos)

(2.1.2036.9) Cognitive Ergonomics & Human-Machine Interaction [C] (GR)

The course is an introduction to Human Factors / Cognitive Ergonomics for interactive systems design, coupling applied theories of cognition with design methodology. This includes introducing students to basic elements of human cognition such as perception, memory, semiotics, human errors, problem solving, diagnosis and decision making. Then the basic methodological process of Man-machine interface design is introduced following the user-centered design approach, starting from the collection of user needs followed by requirements analysis, conceptual design, prototyping and iterative design / evaluation up to detailed interface design issues. The course has a strong hands-on approach with numerous class exercises and empirical group-work projects.

Project/s: C 50 % of the Final Grade

D. Nathanail

(2.1.2229.9) Entrepreneurship and Green Innovation (GR)

Introduction to green innovation, circular economy innovative models and environmental economics. Analysis of open innovation models and types, intrapreneurship, ecosystem innovation programs, startup accelerators and technology acquisitions to solve environmental challenges. Analysis of the Innovation Ecosystem and funding opportunities by Venture Capital Funds. Generation and development of new innovative ideas in the field of environment, using business planning tools and methodologies.

Exercise: students collect real data and develop in groups a solid business plan for a green innovative company, operating in the Environment and Energy sectors. The business plan will be presented to the class.

Project/s: C 75% of the Final Grade

K. Aravossis, N. Panayiotou

((2.1.2260.7) Supply Chain Management & Logistics (Transportation - Distribution) [C] (GR & EN)

Modern supply chain management is perhaps the most critical function of a contemporary business. The course introduces the fundamental principles of modern supply chain management from the perspective of a Production Mechanical Engineer, with an emphasis on the Industry 4.0 technologies that support it. The course content includes the following thematic subareas: Introduction to contemporary Supply Chain Management (SCM) principles. Supply Chain performance management – key drivers and metrics. Supply Chain network design and planning. The facility location problem. The capacity allocation problem. Demand forecasting. Time series forecasting. Measures of forecast Error. Inventory management. Statistical Inventory Control – deterministic and stochastic inventory models.

The role of transportation in the supply chain. Vehicle routing & scheduling. Distribution Channels & processes. Purchasing decisions in SCM. Third Party logistics. The role of Information technology in SCM. Traceability (Bar Codes – Radio Frequency Identification principles and applications. Sustainability and the Supply Chain, Logistics 4.0: The future of logistics.

Project/s: C 40% of the Final Grade

S. Ponis

(2.1.2073.9) Production Planning and Control [C] (GR & EN)

The objectives of Production Planning and Control (PPC). Classification of production systems. Demand Management and Ordering. Aggregate Planning and Sales & Operations Planning (SOP). Master Production Schedule and Linking to the Budget (Budgeting). PPC in ERP systems. Bill of Materials and Routings. Engineering changes. Advanced topics of MRP method. Advanced topics of inventory management and purchasing. Hierarchical warehouse systems. Inventory control of slow movement materials (spare parts). Procurement management. Manufacturing planning within the supply chain. Work centers loading and capacity planning. Work orders scheduling/ Production orders sequencing.

Production Control. Production Office Organization. Production data collection and evaluation. Technical management of the factory. Reverse supply chain. Production and Corporate Social Responsibility.

Project/s: C 30% of the Final grade

N. Panayiotou, (S. Gayialis, G. Papadopoulos)

(2.1.2268.8) Occupational Safety and Health (GR & EN)

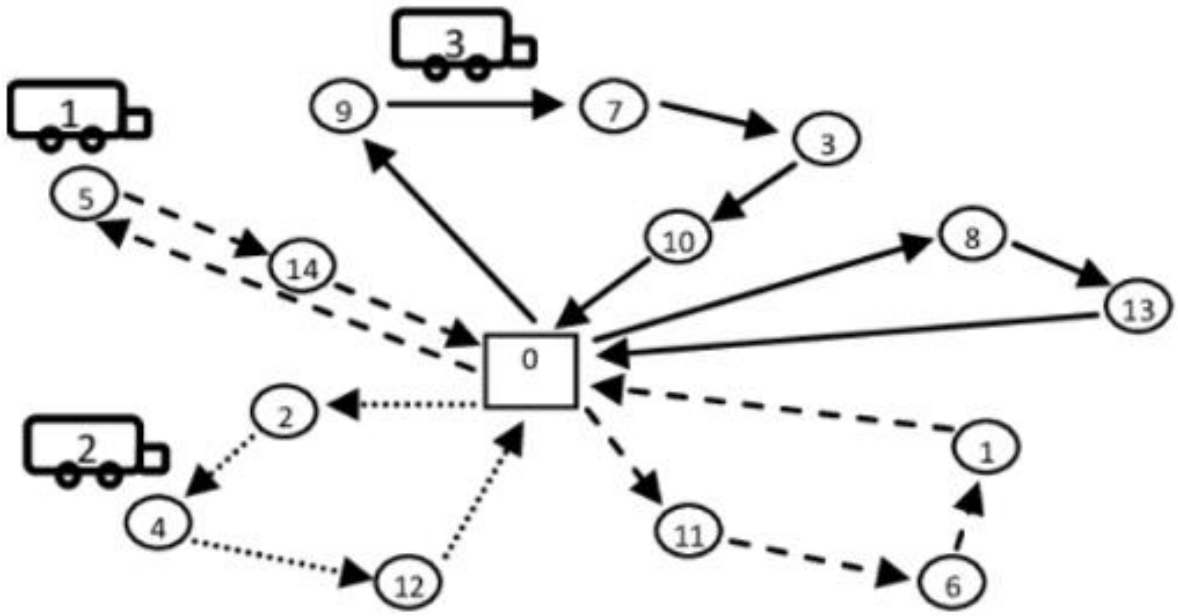
Historical background, Ethics. Safety & Health and organizational efficiency. Technical, Behavioral and Systemic approaches to the problem of Occupational Safety and Health (OSH). Statistical analysis of occupational accidents and work related diseases. Proactive OSH metrics. OSH Accident analysis methods (cause-effect, event trees, fish-bone & bow-tie diagrams). Industrial occupational risk assessment methods. Basic OSH legislative & regulatory issues. The cost/ benefit of OSH. OSH management systems at the enterprise (OHSAS 18001, ISO 45001). System safety and resilience. Elements on human error and procedure deviation/ violation. Analysis of large scale industrial and transportation accidents. Swiss Cheese model and Sociotechnical intervention methods.

Project/s: C 40 % of the Final Grade

D. Nathanail, (S. Drivalou)

(2.1.2030.6) Operational Research I [C] (GR)

Introduction to the scientific field of Operations Research (OR): Definitions, history of OR science. Methodological approaches, taxonomy of OR problems. Mathematical modelling, Mathematical Formulation of Optimization problems. Introduction to Linear Programming: Theory of Linear programming. Solving linear problems-The simplex method (regular and revised). Artificial Models, Two-Phase and big M methods. Duality theory and sensitivity analysis. Optimization Conditions Karush-Kuhn-Tucker.



Dual Simplex and Primal-Dual Simplex. Irregular types of linear programming models. Typical integer problems. Principles of simulation. Discrete event simulation. Network Analysis: minimum spanning tree problem, shortest path problem, maximum flow problem, traveling salesman problem. Decision Trees. Dynamic programming.

Project/s: C 30% of the Final Grade

A. Tolis, A. Rentizelas, (V. Kapsalis)

(2.1.2279.9) Digital Transformation & Electronic Business [C] (GR)

The course covers fundamental knowledge in the field of e-Business and digital transformation achieved through its implementation in private or public organizations. It aims to familiarize students with the core concepts of e-Business and provide an understanding of the operational methods that can be utilized at both strategic and tactical levels. Students will develop familiarity with both Greek and English e-Business terminology and gain insight into the role of engineers in implementing e-Business technologies. In addition to building a strong theoretical foundation, the course fosters critical and creative thinking. Lectures introduce all necessary theoretical concepts, supported by extensive case studies that require active student participation. A key component of the course involves group projects, where teams of three students develop a detailed business plan for an e-business. These projects are presented in a 20-minute session during the final weeks of the semester and students are encouraged to demonstrate innovation and creativity in their plans while considering the real-world conditions of local and global markets. The course content includes the following thematic subareas:

Main concepts, E-Business & E-Commerce Definitions. E-Business Strategy Implementation. E-business models analysis with the use of the Internet. E-Retailing. E-Learning. Collaborative Commerce and Management of E-Supply Chains. Content Management Systems. Infrastructure and Software for the Implementation of E-Business Applications. Security and E-Payments. M-Commerce. E-Business Evaluation & Key Performance Indicators (KPIs). Considerations about E-Business applications and future trends. The course includes a ten-week assignment concerning the development of an e-business plan of a new or existing enterprise with an emphasis on the innovation of the offered products and/or services.

Project/s: C 100% of the Final Grade

N. Panayiotou, S. Ponis

Thermal Engineering

(2.2.2097.2) Applied Thermodynamics of Pure Substances [C] (GR)

- Basic concepts and definitions.
- Zeroth and First Laws of Thermodynamics; thermodynamic temperature scale; entropy; volumetric work and technical work; thermodynamic temperature scale.
- Second Law of Thermodynamics; reversible and irreversible phenomena.
- Third Law of Thermodynamics.
- Ideal gas; cyclic processes; Carnot cycle for any working substance; reversible and irreversible phenomena.
- Thermodynamic probability; theoretical entropy of mixing; entropy of irreversible processes; Maxwell relations and Tds equations; two-phase thermodynamics, vaporization, diagrams, and steam tables.
- Phase change of pure substances.
- Equation of state for real gases.
- Vapour theory; T-S and H-S diagrams (Mollier).
- Exergy.
- Heat capacities of real gases.
- Thermodynamic power cycles using gas.
- Thermodynamic power cycles using steam.
- Thermodynamic cooling cycles.
- Thermodynamic representation of reversible processes.
- Joule-Thomson throttling.
- Thermodynamics of compressible fluids; nozzles.

E. Koronaki, (N. Komninos, G. Antonakos)

(2.2.2043.7) Applied Thermodynamics of Mixtures [C] (GR)

Mixture definition. Homogeneous and heterogeneous mixtures. Gibbs phase rule. free enthalpy of Gibbs and relation to other thermodynamic mixtures. Ideal and non-ideal mixtures. Ideal mixtures and Raoult's law. Specific volatility of ideal mixture. VLE equilibrium diagrams of ideal mixtures. Trouton's rule. Statistical determination of entropy and free enthalpy of mixing in ideal mixtures. Energy balance and entropy changes in gaseous mixtures of ideal gases.

Non-ideal mixtures. Properties of excess of free enthalpy, enthalpy, and entropy. Thermodynamic classification of mixtures. Partial molar properties. Activity coefficients and deviation from Raoult's law. Relative volatility of non-ideal mixtures. Isothermal p−x diagrams and isobaric T−x equilibrium diagrams. Classification of mixtures based on p−x equilibrium diagrams. Azeotropic mixtures. Description of the UNIFAC statistical method for determining activity coefficients.

Thermodynamic analysis of binary mixture processes. Heat of mixing. Heat of vaporization. Construction, interpretation, and use of composition-enthalpy diagrams. Graphical and analytical representation of processes (mixing, vaporization, throttling, absorption). Description of the operation of ammonia-water refrigeration systems. Description of LiBr-H_2O refrigeration systems.

Methods of binary mixtures separation. Enrichment-depletion units. Study of enrichment-depletion columns using the McCabe-Thiele approximate method and the Ponchon exact method.

(T. Roumpedakis)

(2.2.2212.9) Pollution Abatement Technology for Thermal Plants [C] (GR & EN)

1: ENERGY & ENVIRONMENT
- Environmental impact of thermal plants
- Energy technologies and measures for reducing the environmental impact
- Thermodynamic properties of water-steam
- Preliminary knowledge

2: CLIMATE CHANGE
- International Environmental Policy. European Environmental Policy & Objectives.
- Environmental legislation.
- Emissions Trading System (ETS)

3: THERMAL POWER PLANTS COMBUSTION SYSTEMS

Overview of solid fuel combustion systems: grate combustion, fluidized bed, pulverized fuel

Comparison of solid fuel combustion systems

Combustion systems for liquid and gaseous fuels

Fuel gasification technology

4: CO2 EMISSIONS

CO_2 emissions from thermal power plants and reduction methods

EU directives on emissions trading and CO_2 capture and storage (CCS)

Reduction of specific CO_2 emissions through appropriate use of renewable fuels

CO_2 capture and storage technologies in thermal power plants.

Utilization of CO_2 – Carbon Capture and Utilization (CCU)

Cost comparison of conventional thermal plants and CO_2 capture-equipped units

5: CONVENTIONAL POLLUTANT EMISSIONS
- Particulate emissions from thermal plants and mitigation methods
- Particles from combustion in thermal stations and pollution abatement systems (electrostatic precipitators, bag filters, cyclones).

- Mechanisms of formation and capture capabilities of main gas pollutants (NOx, SO2). Acid dew point and factors that affect it.

6: NON-CONVENTIONAL POLLUTANT EMISSIONS

Emissions of HCl and HF, mercury, dioxins, and furans

Volatile Organic Compounds (VOCs)

Polycyclic Aromatic Hydrocarbons (PAHs)

7: ENERGY RECOVERY AND WASTE MANAGEMENT

Introduction to Municipal Solid Waste (MSW) management

Classification of solid waste

Production and utilization of MSW in Europe and Greece

Composition of Mixed Municipal Solid Waste

Legal framework

Solid recovered fuel from municipal waste

Energy recovery from municipal waste through incineration, gasification, and anaerobic digestion technologies

8: LIFE CYCLE ANALYSIS

Introduction – Overview of Life Cycle Analysis

Methodology, common impact categories, and methods of environmental impact assessment. Benefits of implementing LCA

Applications of LCA in energy production and management

9: POLLUTANT MEASUREMENT METHODS IN THERMAL FACILITIES

Gas sampling (O_2, CO_2 measurement)

Particulate emissions measurement using isokinetic sampling; determination of total particulate mass concentration

Size distribution analysis of suspended particulate matter

Measurement of mass concentration of NO_x, N_2O, SO_2 in flue gases

Manual methods for determining halogen compounds (HCl, HF, etc.)

Measurement of mass concentration of PCDDs/PCDFs and PCBs

Measurement of mass concentration of heavy metals and total mercury (Hg)

10: LEGISLATION

Legal framework governing emissions from thermal power plants

Lab: O Project/s: O 10 % of the Final Grade

S. Karellas, (P. Vourliotis, S.Ch. Hatzilaou)

(2.2.2162.8) Combustion Theory, Combustion Systems [C] (GR)

Characteristics, classification and physical mechanisms of combustion phenomena. Combustion thermo-chemistry. Stoichiometry. Chemical kinetics. Transport phenomena. Laminar and turbulent diffusion and premixed flames. Mathematical modeling of combustion phenomena. Combustion of liquid and solid fuels. Combustors and conventional combustion systems for gas and liquid fuels. Contemporary combustion and thermo-chemical conversion technologies (e.g. gasification, fuel cells). Emissions from combustion systems.

Lab: C 30 % of the Final Grade Project: C 30 % of the Final Grade

D. Kolaitis, (G. Zannis, D. Katsourinis, D. Giannopoulos)

(2.2.2284.8) Environment and Development (Interdepartmental Course) (GR)

Development and Environment (legal, social, economic, political and cultural aspects). Sustainable development and critical analysis. Environmental and developmental aspects.

Managerial and Technological Tools (potential and challenges). Analysis of specific areas - developmental incidents - environment - practices. Technological and ethical obligations of the engineer.

Obligatory projects assigned to interdisciplinary groups of students related to the specific material presented in the lectures. Lectures in the form of controversy on relevant environmental issues (eg climate change, renewable energy sources, fossil fuel use, nuclear energy use, maritime environmental impact, water resources management, natural disasters, zero energy and positive energy balance buildings, smart cities, recycling and energy recovery solid waste, etc).

Project/s: C 100% of the Final Grade

S. Karellas, M. Papadopoulou, A. Papagiannis

(2.2.2032.6) Internal Combustion Engines [C] (GR)

General principles of operation, and configuration of modern spark ignition (SI) and diesel engines; Slider-crank mechanism; Two-stre and four-stre operation; Forces of the slider-crank mechanism; Dual fuel engines and gasoline direct injection (GDI) SI engines; Electronically controlled fuel injection in Diesel and SI engines; Engine ancillary systems (valve operation, cooling, lubrication, starting); Cylinder arrangements; Mechanical supercharging, and turbocharging; Wankel rotary engine; Combined cycle plants with internal combustion (IC) engines; Applications of IC engines; Outlo and challenges of IC engines; Modern diesel engines with electronic control; Thermodynamics fundamentals; Combustion of ideal air mixtures with temperature dependent specific heat capacities; Ideal engine cycles (Otto, Diesel, dual, Atkinson); Real operation/cycle of IC engines; Cylinder pressure recording with conventional and modern techniques; Work, mean effective pressure, torque, power, specific fuel consumption, mechanical losses and mechanical efficiency, similarity, power density; Energy balance; Combustion issues in SI and Diesel engines; Conventional and alternative fuels; Mixture preparation and formation; Combustion chamber design, power control, operation curves; Emission of pollutants and CO_2; Antipollution techniques (internal measures and after-treatment devices).

Lab: C 10 % of the Final Grade

E. Giakoumis, D. Hountalas, (N. Komninos, A. Doukelis)

(2.2.2191.7) Thermal Radiation and Applications (GR)

General principles of thermal radiation. Black body radiation. Wien's displacement law. Stefan-Boltzmann law. Kirchoff's law. Radiation exchange between two or more surfaces. Electrical analogy. View factors. Hottel method. Thermal radiation in gases. Infrared thermography.

Lab: O Project/s C 30% of the final grade

D. Hountalas, D. Kolaitis, (D. Katsourinis, D. Giannakopoulos)

(2.2.2293.9) Principles of Fire Engineering (GR & EN)

Introduction to combustion. Fires, compartment fires, wild land fires. Industrial accidents. Explosions. Combustion thermo-chemistry. Heating value. Adiabatic flame temperature. Free radicals. Toxicity of combustion products. Ignition requirements. Fire tetrahedron. Ignition and auto-ignition temperatures. Flammability limits. Fire suppression agents. Fire initiation and fire spreading mechanisms. Mass, momentum and energy transport phenomena. Fundamental physical phenomena governing the combustion of liquid and solid fuels. Pyrolysis reactions. Main fire stages: Ignition, growth, fully developed fire, decay. General characteristics of compartment fires. Ventilation effects. Flashover. Backdraft. Main characteristics of the developing flow- and thermal-field. Fire risk analysis. Heat release rate. Fire load. Standard gas temperature curves. Numerical simulation methodologies. Fires in means of transportation. Fires in road and rail tunnels. Human behavior during a fire. Behavior of materials exposed to fire. Reaction to fire tests. Fire resistance tests. Temperature-dependent thermo-physical properties. Fire behavior of common construction materials. Fire legislation and legal requirements. Passive and active fire safety protection.

Project: C 40 % of the Final Grade Lab: C 40 % of the Final Grade

D. Kolaitis, (J. Zannis)

(2.2.2086.5) Thermal Energy Conversion in Power Plants [C] (GR)

- INTRODUCTION:
  Background theory, Fo
  and Conversion of Ene
  Energy sources. Globa
  energy demand -
  consumption.
  General description of
  thermal energy conver
  systems.
  Thermodynamic
  properties of water-ste
- THERMODYNAMICS
  Thermodynamics
  Fundamentals
  Clausius-Rankine Thermodynamic Cycle. Steam cycle in Steam Power Plants (SPPs).
  Clausius Rankine Cycle efficiency.
  Efficiency improvement concepts
  Specific heat consumption.
- THERMAL POWER PLANT
  Evolution of electricity generation plants.
  Components of thermal power plants.
  Calculations in SPPs, condensation, cooling water.
- STEAM BOILERS
  Historical evolution of the construction of steam boilers
  Design criteria for contemporary steam boilers.
  Classification of modern steam boilers.
  Working fluid circulation types (natural, artificial, forced).
  Feed water quality.
  Pumps, Fans.
- ENERGY FLOW in STEAM BOILERS - COMBUSTION
  Energy balance in steam boilers
  Types and analysis of thermal losses
  Gross and net efficiency of steam boiler, self-consumption
  Physico-chemical composition and fuel properties
  Stoichiometric combustion. Air-fuel ratio. Combustion calculations. Co-firing
- COMBINED CYCLE POWER PLANTS – COGENERATION
  Gas turbine units, components of a gas turbine
  Heat Recovery Steam Generator (HRSG).
  Cogeneration of heat and power
  Power plants configurations – comparative analysis
  Efficiency of Combined Cycle – Cogeneration
- Economics: PEAK LOAD & GRID – ENERGY STORAGE

Energy sources. Meeting global energy needs.
Economics of electricity generation
Flexibility in power generation.
Sector coupling. Energy mix. The Greek energy system.
The necessity of energy storage.
Introduction to large-scale energy storage.

- ENVIRONMENT
  Exhaust emissions and Environmental Impact.
  The Hydrogen Strategy.
- MODERN Thermal Power Plants – Decentralized Thermal Systems
  Thermal Power Plants with renewable fuels, Hybrid Thermal Power Plants with various renewable energy sources.
  Introduction to Decentralized Thermal Systems

Lab: O Project: O

E. Kakaras, S. Karellas, (P. Vourliotis A. Doukelis, P. Pallis)

(2.2.2091.7) Dynamics of Reciprocating Internal Combustion Engines (GR)

Kinematic analysis of reciprocating engine mechanism. Analysis of forces (gas, inertial, gravitational), and their transmission through the various parts of the mechanism. Bearing stress - polar diagrams. Ignition order (various examples for in-line and V-type engines). Crankshaft torque. Non-uniform rotation of the crankshaft. Balancing – examples (in-line, V-type and radial engines), counterbalance systems, partial balancing, symmetrical / anti-symmetrical crankshaft, practical applications. Crankshaft torsional vibrations – Applications, calculation, methods of mitigation.

Project/s: O 15% of the Final Grade

D. Hountalas, E. Giakoumis, (D. Giannopoulos)

(2.2.2081.7) Transport Phenomena (GR)

Introduction to transport phenomena – transport rates. Conservation equations with emphasis on non-dimensionalised equations. Velocity – temperature – concentration boundary layer equations. Flow over a horizontal flat plate. Turbulent transport analogy. Heat – mass transfer analogy for the flow over a horizontal plate. Introduction to mass transport in laminar and turbulent flows. Fick's law of diffusion – steady state mass diffusion. Mass diffusion without homogeneous chemical reactions. Catalytic reactions. Mass diffusion in homogeneous chemical reactions. Evaporation of liquid droplets. Introduction to combustion – mass conservation of a single droplet – droplet combustion.

Project/s: C | 30% of the Final Grade

D. Hountalas, D. Kolaitis, (D. Katsourinis)

(2.2.2195.8) Basic Principles of Refrigeration [C] (GR)

Introduction to industrial cooling applications. Vapour compression cooling systems. Basic cooling cycle. Cooling cycle with subcooling and superheating. Real cooling cycle. Multi-stage vapour compression systems. Refrigerants. Calculation of cooling capacity. Gas compression cooling cycle. Stirling Circle. Basic air humidification cycle. High / low-pressure air humidification cycle. Air humidification with partial expansion. Minimum work required for gas liquefaction. Ejector compression systems. Thermoelectric cooling. Magnetic cooling. Absorption cooling. NH3/H2O and H2O/LiBr refrigeration systems. Adsorption/desorption cooling. Psychrometrics. Sensible heating. Cooling and dehumidification. Bypass factor.

Lab: O Project/s: O

X. Tzivanidis, K. Braimakis, (G. Zannis)

(2.2.2236.7) Combustion/Pollution of Internal Combustion Engines [C] (GR)

General principles of the combustion chemistry. Dissociation of combustion products. General overview of engine types, Diesel and Spark Ignition. Combustion in spark ignition engines, lean-burn and direct injection engines. Design of spark ignition engine combustion chambers with emphasis on the reduction of pollutants and fuel consumption. Engine knocking and auto-ignition, octane number. Fuel injection and ignition systems. Thermodynamic analysis of spark ignition engine combustion. Description of combustion in Diesel engines. Engine knocking, cetane number. Diesel engines combustion chambers. Fuel injection in Diesel engines, conventional and state-of-the-art common rail systems. Fuel distribution and evaporation, Fuel jet penetration, Air-fuel mixing, Ignition delay. European emission ("Euro") standards, Driving cycles and certification procedure. Mechanisms of pollutants formation (CO, HC, NOx, particulate matter) from internal combustion engines - influence of engine operating parameters on the formation of pollutants. Pollutants control: Exhaust gas after-treatment systems (three-way catalytic converter, diesel oxidation catalyst, diesel and gasoline particulate filter, selective catalytic reduction (SCR), lean NO_X trap, scrubber) and internal measures (exhaust gas recirculation (EGR), water injection, etc.). Internal combustion engines fuels and biofuels. CO_2 emissions from engines (legislation, standards, methods of reduction).

D. Hountalas, E. Giakoumis, (N. Komninos, D. Giannopoulos)

(2.2.2186.8) Computational Methods for Transport Phenomena (GR)

Transport by molecular motion, transport in laminar or turbulent flow - Hyperbolic, parabolic and elliptic equations - Variational methods for steady-state and time-dependent transport phenomena (weak formulation, functionals, the Ritz method, the method of weighted residuals). Finite difference method (discretization, steady-state and transient diffusion, Steady-state and transient transport by diffusion and convection) - Finite element method (physical or direct approach, variational formulation, steady-state and transient transport phenomena) - Boundary element method - Errors, convergence and stability of numerical methods - Computer programs for each method - Applications.

Project/s: C 20 % of the Final Grade

Ch. Tzivanidis, (G. Zannis)

(2.2.2183.9) Air-Conditioning [C] (GR)

Thermal comfort - Psychrometrics (thermodynamic properties of moist air, humidity parameters, psychrometric charts, typical air-conditioning processes) – Air duct design (frictional losses, dynamic losses, duct design methods) - Climatic conditions - Solar heat gain - Air-conditioning loads (heat gain, cooling load, heat extraction rate, ASHRAE load calculation method, loads from walls - fenestration - lighting - people - appliances - ventilation and infiltration, transfer function method) - Air-conditioning systems: direct expansion, all-water (fan-coil units), all-air (variable volume or variable temperature, dual conduit, multi-zone systems), air-water (induction unit), heat pump – Applications (design of installations) – Laboratory.

Lab :C 10 % of the Final Grade Project/s: C 10% of the Final Grade

Ch. Tzivanidis, K. Braimakis, (G. Zannis)

(2.2.2025.8) Decentralized Thermal Energy Systems (GR & EN)

Energy utilization of biomass and residues. The properties of biomass as a fuel and its energy upgrade. Biomass combustion systems (grate, fluidized bed, pulverized fuel, other technologies), Gasification (autothermal - allothermic) of solid biomass, biogas production and direct use or upgrade. Operation of decentralized thermal systems for biomass and other thermal renewable energy sources. Combined heat, power, cooling generation and multi-generation. CHP legislation. Economic evaluation of decentralized thermal systems. Small-scale energy storage systems. Utilization of waste heat from thermal processes, Industry.
Laboratory exercises (Fluidized bed, Rankine Organic Cycle installation function),
- Semester project on thermodynamic development, selection of appropriate components (piping, pumps, expanders), design (alternator, frame and unit sizing) and financial evaluation of an integrated decentralized thermal system.

Lab: O Project/s: O 10% of the Final Grade Subject: C 50% of the Final Grade

E. Kakaras, S. Karellas, (P. Vourliotis, A. Doukelis, P. Pallis)

(2.2.2285.8) Gas Exchange & Supercharging of Internal Combustion Engines (GR)

Gas exchange in four-stre engines. Volumetric efficiency, influence of various parameters (fuel type, heat losses, friction, valve timing, injection timing, residual exhaust gas, exhaust gas recirculation). Exhaust gas and exhaust emissions, silencers, exhaust gas recirculation. Gas exchange in two-stre engines - performance parameters and scavenge models. Supercharging and turbocharging Intercooling. Compressor and turbine operating maps (variable geometry compressors and turbines, waste-gate valves). Supercharging system selection for different applications. Matching examples (mechanical supercharger, turbocharger). High-performance - assisted turbocharging). Exhaust manifold configuration. Efficiency/CO_2 emissions, mechanical and thermal stress, and supercharged engines torque curves. Gasoline engine supercharging problems. Transient response of turbocharged engines and methods to improve it.

Lab: O 15 % of the Final Grade

E. Giakoumis, D. Hountalas, (A. Doukelis)

(2.2.2272.9) Thermal Energy in Buildings (GR)

External and internal boundary conditions: climate data, indoor and outdoor temperature, solar radiation, ground temperature, etc. Thermal properties of building materials. Insulation materials. Convection heat transfer coefficients of external and internal structural surfaces. Analytical, numerical and experimental methods of thermal analysis of buildings. Transfer functions. Thermal resistance circuit methods. Steady state and transient heat transfer to the building shell. Periodic heat transfer. Conduction and convection heat transfer. Radiation heat transfer. Air penetration. Thermal behaviour of glass panes. Thermal bridges. Steady state and transient heat transfer in the interior of buildings. Convection. Radiation. Thermal effect of indoor mass of buildings. Thermal characteristics of buildings and their individual structural components. Thermal loss coefficient, effective and apparent heat capacity, time-constant, thermal lag, etc. Thermal storage capacity of building elements and the whole building. Bioclimatic design of buildings. Passive thermal systems. Night cooling and thermal mass of buildings. Thermal response of buildings to typical external disturbances. Reverse thermal building problem: Identification of building materials given the thermal behavior of buildings. Dynamic indoor thermal response to internal thermal load fluctuations. Internal building surface heat capacity. Dynamic models of the thermal behavior of buildings. Building shell models and indoor models. Thermal mass models (inertia). Thermal resistance circuit modelling. Energy savings. Thermal control of buildings.

Project/s: C 30 % of the Final Grade

Ch. Tzivanidis, K. Braimakis, (G. Zannis)

(2.2.2182.9) Solar Energy (GR)

Solar radiation (basic concepts, angles, direct and diffuse radiation, spectral distribution, attenuation by the atmosphere, tilted and tracking systems, correlations, measurement of solar radiation, values in the Athens area) - Theory of flat-plate collectors (heat transfer analysis, temperature distribution on the absorber plate, collector efficiency factor, heat removal factor and flow factor, collector efficiency, measurement of collector performance, various designs of flat plate collectors) - Concentrating collectors - Solar systems for space and service water heating (design methods, the f-chart method) - Design methods for thermal solar systems (Utilizability, the f-chart method) - Energy storage - Other applications (Solar cooling, conversion to mechanical energy, solar ponds, passive systems, economics).

Lab: C 10% % of the Final Grade Project/s: C 10% of the Final Grade

Ch. Tzivanidis, K. Braimakis, (G. Zannis)

(2.2.2009.9) Industrial Refrigeration Systems (GR)

- Components of refrigeration installations.
- Compressors: reciprocating, rotary drum, screw, and centrifugal.
- Condensers: air-cooled and water-cooled.
- Evaporators: air cooling and water cooling.
- Throttling, control, regulation, and protection devices and components for refrigeration installations.
- Cooling of industrial storage spaces: cooling loads, industrial refrigerators, general principles.
- Location selection criteria, layout, and sizing of chambers; construction elements; pre-cooling, cooling, freezing.
- Controlled atmosphere cooling; storage and handling conditions for perishable products.
- Refrigerant leaks and environmental impacts.
- Open and closed refrigeration systems with liquid absorbents and solid adsorbent materials; solar cooling systems with thermal storage.

Laboratory Exercises:

- Performance and operational behaviour testing of a solar cooling system with solid adsorbent material, vacuum thermal solar collectors, and PVT, as well as a thermal storage system with phase-change materials.
- Performance and operational behaviour testing of an open-cycle cooling system with silica gel desiccant material in a rotating desiccant wheel.
- Performance testing of an open-cycle cooling system with liquid desiccant material LiCl.
- Performance and operational behaviour testing of a basic vapour compression refrigeration system.

- Building Energy Modelling (BEM) software: EnergyPlus, OpenStudio.
- Participation in the ASHRAE International Student Competition for net-zero energy buildings and minimal environmental footprint.

Lab: Y 40% of the Final Grade Project/s: Y 60% of the Final Grade

E. Koronaki, (G. Antonakos)

(2.2.2044.7) Thermodynamics Software (GR)

Programming with open-source software, PYTHON, in energy applications.

- Introduction to Python programming:
  - Installation of Python and programming
  - Basic types of variables
  - Basic language structures
- Programming in Python:
  - Essential libraries (numpy, matplotlib, scipy, openpyxl, pandas, pytorch, etc.)
  - Connecting to external files (excel, text, csv)
  - Calling other languages within Python (C++, Fortran, Julia)
  - Connecting with repositories (github, google colab)
- Creating beginner applications:

- Simple mathematical problems (e.g., finding prime numbers, solving simple equations)
- Codes for solving:
- Newton-Raphson
- Levenberg-Marquardt
- Bezier curves
- Fourier transformations
- Solving Ordinary Differential Equations

- Introduction to thermodynamics with Python:
  - IAPWS in Python
  - Creating a water vapor chart (Mollier type) via Python (matplotlib)
  - Assignment: given the state equation for R134a, create the corresponding chart
- Lesson 5 – Solving Thermodynamic Problems:
  - Rankine cycle with reheating
  - Plotting on a chart
  - Complete performance analysis

Absorption engines. Description of H_2O-LiBr units, creation of computational codes, modeling their behavior. Extension of applications to double-effect units and to modern cogeneration installations. Stirling engines: Introduction. Types of engines (A, B, C). Power engines. Refrigeration engines. Crankshaft engines (CSEs) and free-piston engines (FPSEs). Solar systems (Dish-Stirling). Low-temperature differential engines. Cogeneration. Reduced-emission engines. Isothermal and adiabatic analysis. Thermal losses. Application of these analyses to thermal engines like GPU-3 and Ford-Philips 4-215 and the refrigeration engine PPG-102. Generalized and specific state equations. Calculation of thermal and thermodynamic properties of real gases. Thermodynamics of compressible gases. Chemical potential. Fugacity of pure gases and binary mixtures. State equations of binary mixtures. Free surface phenomena and their thermodynamics. Computational code for thermodynamic properties of water-steam. Examples of modeling power and refrigeration systems. Cogeneration plants for power, heating, and cooling. Open cycle units with solid and liquid desiccant materials. Geothermal heat pumps and ground source heat exchangers. Examples of modeling solar thermal collectors, both flat and parabolic trough type, as well as photovoltaic systems. Modeling of solar cooling systems.
Methodology for calculating thermal and cooling loads of a residence. Optimization of building energy efficiency. Nearly zero-energy buildings.
Project/s: C 100 % of the Final Grade

(T. Roumpedakis)

(2.2.2132.4) Heat Transfer [C] (GR)

Steady-state conduction in plane walls and composite structures, Transient Conduction. Graphic and numerical approaches. Critical Thickness of Insulation. Convection. Theory of Similarity. Dimensionless numbers: Nusselt, Prandtl, Grashof. Forced Convection: Inside ducts/pipes, Cross-flow over cylindrical bodies and Parallel flow over flat surfaces. Natural Convection over flat and cylindrical bodies. Phase Change (boiling, condensation). Heat Exchangers: Heat Exchanger Types, Operation, Logarithmic Mean Temperature Difference (LMTD). Parallel-flow, counter-flow, and cross-flow heat exchangers with/without fluid stream mixing. NTU (Number of Transfer Units) method. Effectiveness. Radiation fundamentals. Max Planck's law. Stefan–Boltzmann law. Kirchhoff’s law. Wien’s displacement Law.

S. Karellas, (A. Nikoglou)

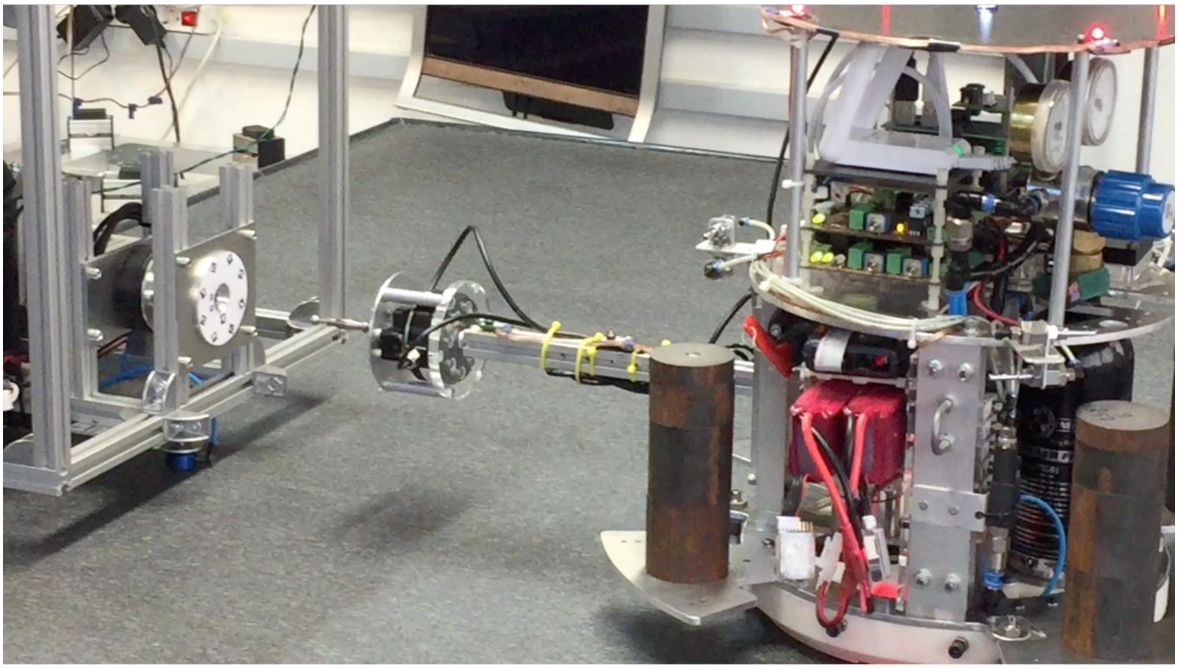
(2.2.2042.9) Energy Storage Systems [C] (GR & EN)

Overview of energy storage technologies, mechanical storage (pumped hydro storage, compressed air energy storage, liquid air energy storage, flywheel energy storage), electrochemical storage (classic and flow batteries), electrical storage (superconducting magnetic energy storage, supercapacitors), chemical storage (hydrogen storage, green hydrogen, Power-to-X), thermal energy storage (sensible, latent, thermochemical storage), power-to-heat, high-temperature heat pumps, district heating networks, techno-economic analysis of stand-alone battery and PV-battery energy storage systems (stand-alone, energy system-coupled, behind-the-meter, front-of-the-meter) for residential and industrial application, dispatch strategy optimization.

Project/s: C 80 % of the Final Grade

S. Karellas, K. Braimakis, (A. Nikoglou)

Mechanical Design & Automatic Control



(2.3.2238.1) Introduction to Computing [C] (GR)

Introduction to Computing. Numbering Systems. Binary arithmetic and coding. Computer Architecture. Processor architecture and operation. Typical processors. Peripheral Devices. Computer communications & Networks. Introduction to scientific computations using C programming language the MATLAB™ environment. Computing applications in Mechanical Engineering. Laboratory sessions: Scientific Applications using C programming language and introduction to MATLAB™.

Lab: C 25 of the Final Grade

I. Poulakakis

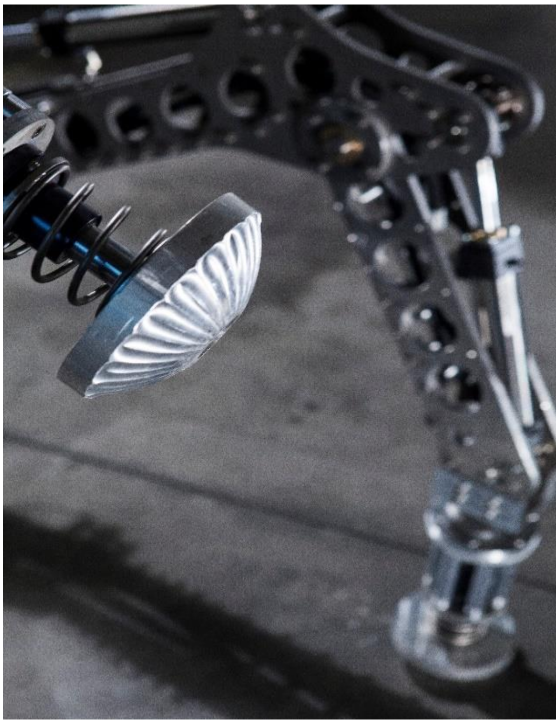
(2.3.2304.9) Hydraulic and Pneumatic Systems [KMM (Y)] (GR)

Introduction to hydraulic-pneumatic motion and power transmissions. Mass and energy flow in power hydraulics. Hydraulic fluids (properties and selection). Transient phenomena and water hammer effect. Hydraulic power generation using positive displacement pumps. Geometry and flow calculations (including flow ripple) and volumetric efficiency for gear, vane and piston pumps (swash-plate and bent-axis). Piping and fittings. Flow and pressure control valves (check valves, pressure reliefs, flow control valves etc.) Ancillary equipment of hydraulic systems (tanks, filters, heat exchangers etc.) Design and selection of hydraulic actuators (cylinders and hydraulic motors). Hydraulic accumulators and their use in power circuits. Control of hydraulic power and actuators (analog and servo-valves), meter-in / meter –out configurations. Piston, rod and static seals for high pressure hydraulics. Hi-lo arrangements and synchronization of motions. Pneumatic compressors. Air reservoirs and air-conditioning systems for industrial pneumatics. Pneumatic cylinders and motors. Valves and pneumatic automation. Design of pneumatic circuits.

Labs: C Projects (2), 30% of the Final Grade each

V. Spitas, (G. Kaisarlis)

(2.3.2167.4) Machine Elements I [C] (GR)



Introduction to mathematical modeling of mechanical parts and assemblies. Engineering materials and their selection methods. Loading and failure models on machine elements. Design for life and Fail safe engineering design approaches. Calculation of static and fatigue loading. Calculation of the fatigue strength of parts using Woehler, Soderberg and Goodman-Smith diagrams. Elements of fracture mechanics and Paris charts. Stress intensity and stress concentration coefficients in machine elements. Cumulative effect of fatigue and Palmgren-Miner rule. Strength calculation for combined loading. Shafts and axles. Calculation of wended joints and adhesive layers. Mechanics and calculation of threads and bolted connections. Shaft-hub connections (keys, splines, friction elements, press-fits). Couplings, cluthes and brakes. Ball-roller bearings and dry sliding bushings. Rotary seals for shafts. Springs and other flexible machine elements. Wire ropes and linear flexible machine elements and their applications.Protective coatings for machine elements.

Lab: C 70 % of the Final Grade

V. Spitas, (G. Kaisarlis)

(2.3.2078.5) Machine Elements II [C] (GR)

Introduction to motion and power transmission systems. Power flow in mechanical systems and efficiency. Belt drives and friction drives. Law of gearing and matrix equations of gear meshing. Contact surfaces, rolling curves and meshing gear tooth profiles. Contact ratio and stages of tooth meshing. Kinematical Analysis and calculation of sliding velocity and efficiency. Gear types (cylindrical spur-helical gears, bevel and spiral bevel gears, worm-gear sets, hypoids, spiroids etc) and their calculation under common loading types (bending strength, pitting, scoring etc). Compliance, profile modifications and load distribution on gear teeth. Transmission errors and gear tolerances. Gear manufacture. Gear failure and inspection. Chain drives. Speed reducers and gearboxes. Planetary mechanisms and differentials. Special drives (harmonic, cyclo-drive etc). Lubrication and introduction to tribology. Journal Bearings and air bearings.

Lab: C 70 % of the Final Grade

V. Spitas, (G. Kaisarlis)

(2.3.2023.7) Advanced Control Systems [C] (GR)

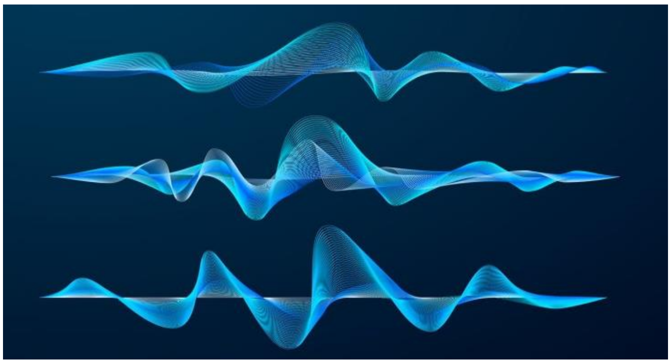
Modeling of dynamical systems, power state variables, bond graphs, derivation of state space equations, linear systems analysis, solution of state space equations, controllability and observability, classical and modern control, state feedback control, optimal control & the general optimal control problem, linear-quadratic optimal control problem, optimal regulator, relation to classical control, optimal control and reference input tracking systems, state reconstruction – observers, applications.

I. Poulakakis, (M. Drosakis)

(2.3.2089.8) Vibrations of Mechanical Systems [O] (GR)

The need of dynamic analysis in the design of a structure, and the phases of dynamic analysis in the design of a structure. The use of Newton's law for the equation of motion of 1-Degree of Freedom (DoF) system, the use of the method of infinitesimal work for the analytical model in a system of bodies (with or without hypotheses of known mode). Evaluation of free and harmonically excited response of 1-DoF systems, Evaluation of response in "slow" and "fast" changing loads, and in random loads. Analytical models for the vibration of continuous mediums. Axial, lateral, and torsional vibrations of beams with distributed parameters. Vibrations of strings. Numerical evaluation of response in 1-DoF system using Euler's method, applying random loads.

Numerical algorithms (averaging method, linear acceleration method). Self-excited vibrations, internal, external, and parametric resonance. Vibrations of a dynamic systems with nonlinear characteristics – dynamic stiffening and compliance. Numerical evaluation of response in frequency domain (real and complex Fourier analysis). The use of Laplace transformation in the response evaluation of 2-DoF system. Modelling Multiple DoF (MDoF) systems applying the Lagrange equations. Free vibration and eigen-problem in MDoF systems, properties of eigenmodes, fundamental natural frequency using Rayleigh method.Calculation of multiple natural frequencies applying the Rayleigh-Ritz method. Numerical calculation of "large" eigen-problem – numerical recipes. Calculation of response in "large" systems subjected in harmonic or random excitation – method of mode superposition. Understanding the role of excitation location in the quality (modes) of response. The use of Finite Element Method (FEM) in the dynamic modelling of complex structures. The beam Finite Element in axial and bending load – shape functions. Assembly of global mass, stiffness, damping, gyroscopic (in rotating structures) matrices. Methods of time integration of equations of motion defined by FEM. Material damping and "numerical" damping. Assessment of dynamic stability of a structure.



Calculation of stresses in a vibrating structure. Static and dynamic condensation of numerically "large" systems – methos for model order reduction, component mode synthesis. Introduction in active (smart) structures, piezoelectric materials, active beams, active composite materials, and structronics. Response of structures in seismic excitation.

Four (4) optional PC Lab and four (4) optional homework (≤40%), compulsory written exam (≥60%)

A. Chasalevris

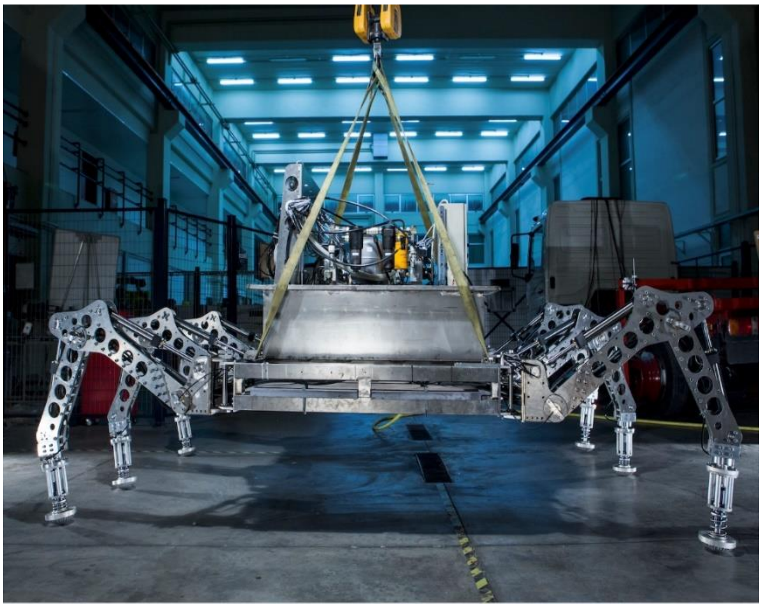
(2.3.2169.8) Transport and lifting machines [C] (GR & EN)

Basic technologies of conveying and lifting systems and machines. Structure, technologies and calculation of wire ropes and cables. Horizontal and inclined conveyor belts (modeling of operation, transient phenomena, design and calculation). Ancillary equipment and supporting structures for conveyor belts and conveyor systems in general. Angle of repose / surcharge and modeling of the behavior of granular materials in industrial conveying systems. Calculation of transient (dynamic) phenomena and selection of motors / speed reducers. Roller conveying systems and cableways. Pretensioning systems and their calculation. Pneumatic conveying systems. Modelling and design of positive or negative (vacuum) pressure systems including selection and design of fans/ blowers, bag-filters, cyclone dust collectors, silos, air-gliders, feeders and other ancillary equipment. Conveyor screws (horizontal – inclined – vertical) and their calculation – design. Bagging machines. Basic technologies of lifting machines and systems. Calculation and design for lifts and escalators. Lifting platforms and mechanisms. Safety regulations and handling of loads. Traction and lifting winches. Design of cranes and gantry cranes. Chain bucket elevators.

Project/s: O 80% of the Final Grade

V. Spitas, (G. Kaisarlis, N. Rogas)

(2.3.2007.6) Modelling and Automatic Control of Systems [C] (GR)



Introduction, brief history, control system principles, mathematical models of physical systems, transfer functions, state equations, block diagrams, properties of feedback control systems, transient response, basic feedback controllers, root locus, methods for control system design, frequency response, compensator design, applications.

To attend this course, sufficient knowledge of the material of the following courses is strongly recommended:

Electric Circuits Circuits & Systems, Mathematics IV (Complex Functions), Introduction to Electronics.

Lab: O Project/s: O

E. Papadopoulos, (I. Davliakos, M. Drosakis)

(2.3.2029.6) Analysis of Mechanical Structures I [C] (GR)

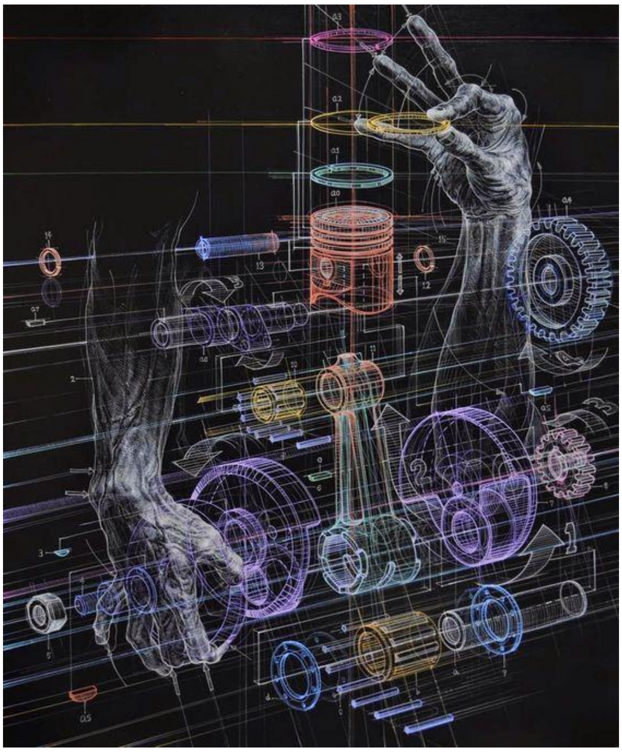
The meaning of Static and Dynamic Analysis of Structures. Idealization of structural members (bar, beam, plane stress, plate in bending, shell, string and membrane). Related theory of elasticity. Torsion of solid sections (Prandtl stress function solution), the membrane analogy, St Venant warping function. Stiffness matrix of bars and beams. Plane trusses and frames. Triangular elements in plane stress Elasticity (isotropic and anisotropic, stress concentration problem), in Heat transfer, and in Acoustics. Solution of Laplace-Poisson problems in mechanical engineering. Boundary conditions of the third type. Axisymmetric problems. Mass matrix and time integration. Three-dimensional problems. Coupled problems. Rectangular elements. Isoparametric elements and Gauss integration. Application in Navier-Stes problems. Fundamentals of automatic mesh generation. Architecture of finite element codes and programming. Demonstration of commercial software.

Project/s: O 15 % of the Final Grade

I. Kalogeris

(2.3.2219.3) Kinematics and Dynamics of Mechanisms [C] (GR)

Introduction in kinematics and dynamics (kinetics) of rigid bodies. Coordinate systems, types of motion, mobility, kinematic constraints. Translational motion, rotation about fixed axis, absolute and relative position and velocity. Generic planar motion. Calculation (discretization) of accelerations (translational, centrifugal, angular, Coriolis). Transformation of motion in planar mechanisms – loop closure equation. Groups of mechanisms, skeletal and vector representation of planar mechanisms . Kinematic cases of planar mechanisms and solution for position, velocity, and acceleration. Design of planar mechanisms. Instantaneous pole of rotation, stationary and moving polar trajectory. Rotation about fixed point (spherical motion), trajectory of velocity. Generic space motion (3D motion) – analysis of position, velocity, and acceleration. Derivative of a vector with respect to a rotated coordinate system. Tensor of moment of inertia (calculation, transformation, equivalents). Inertial forces in rigid bodies and mechanisms, D' Alembert's Principle. Equations of motion of rigid bodies, Euler's equations, Newton's equations. Linear and angular momentum, linear and angular impulse. Gyroscopic phenomena. Conservation of energy in conservative and non-conservative systems. Transformation of forces in planar mechanisms – internal forces.



Mechanical advantage, energy and power flow in mechanisms. Collision. Balancing of rotating and reciprocating masses. Energy balance – flywheels and fluctuation of rotating speed. Principle of infinitesimal works – Lagrange equations and Hamilton's principle.

Two (2) optional PC Lab and four (4) optional homework (≤40%), optional intermediate exam (20%), compulsory written exam (≥40%)

A. Chasalevris

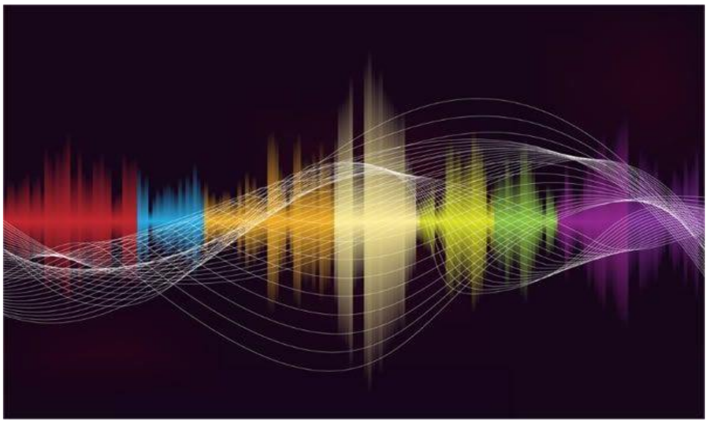
(2.3.2039.6) Introduction to Electronics [O] (GR)

Analog Circuits: Diodes (Zener, Photo-diodes, applications: inversion). Bipolar Transistor (CB, CC, CE). Low frequency Amplifiers. Operational Amplifiers (Applications to signal conditioning and control). Digital Circuits: Gates (hardware realization, Boolean Algebra). Medium Scale Integration Circuits (decoders, multiplexers, adders, ROM, PLAs). FLIP-FLOP. Sequential Circuits (Introduction, counters). Applications: Signal Conditioning & Transmission, TRIAC & Thyristors. Industrial control systems.
Laboratory sessions: a) Operational Amplifiers in control b) Inversion.

I. Antoniades, (M. Drosakis, A. Triantis)

(2.3.2306.7) Dynamics of Rotating Machines (GR)

Introduction to Machine Dynamics and Dynamic Design: The development of rotating machines in applications of low/medium/high speeds.



Design objectives in rotating components. Simple elastic rotor model (Jeffcott rotor): undamped and damped model with elastic or rigid bearings – free and excited vibration by unbalance – critical speeds – complex notation, orbit analysis – forward and backward whirling – models of internal and external damping and equations of motion. Multi-segment rotors with discs and bearings: discretized rotor models – finite element method and order reduction (condensation) in bending vibrations – equations of motion in multiple degree of freedom (MDoF) systems – free and unbalance vibration. Calculation of natural frequencies and modes – coupling of rotors in shaft trains and coupling of shafts and bearings. Vibrations of shafts of dissimilar moments of inertia (generators). Rotors in nonlinear bearings: unbalance response calculation, nonlinear equations of motion, methods for time integration, numerical methods in nonlinear dynamics, collocation and continuation methods – solution branches and bifurcations - applications of high speed. Torsional vibrations in MDoF systems: mechanisms for torsional excitation – torsional natural frequencies and modes, and design assessment in torsion. Basics in balancing: static balancing (wheels, flywheels, and single-piston engines), dynamic balancing of rigid shafts (crankshafts), balancing of flexible rotors - modal balancing. Gyroscopic phenomena: Jeffcott rotor (4 DoF model) – gyroscopic matrix G and damping matrix C+ΩG in MDoF systems – influence in natural frequencies (Campbell diagram). Bearings: types of sliding bearings (oil/gas/hydro-bearings) and advantages in machine dynamics. Basics in hydrodynamic lubrications-Reynolds equation. Design and selection of sliding bearings. Dynamic properties of ball bearings. Active Magnetic Bearings and rotor dynamic control. Permanent magnet bearings. Foundations and bearing pedestals: dynamic models – rigid and elastic pedestals, coupling of machine and foundation. Assessment of dynamic stability: self-exited vibrations, indexes and stability criteria, stability map, mechanisms of instability (oil/gas whirl), flow induced instability (steam/gas whirl), forces by gas flow and sealing, Morton phenomenon and spiral vibrations. Basic rotor dynamic calculations: unbalance response, Campbell diagram, orbits, natural modes in bending and torsion, modal parameters and sensitivity in operation.Stresses and safety factors for integrity and operability, constraints according to ISO and API standards. Acceptance of machine dynamic design (amplification factors, separation margins of critical speeds).

Three (3) PC Lab and three (3) homework (≤45%) O, written exam C (≥55%)

A. Chasalevris

(2.3.2305.9) Hybrid-Electric Vehicles [MMEEMM] (GR)

Introduction to the architecture of hybrid and electric vehicle powertrain. Calculation of basic components (power, torque, etc.). Engine-transmission systems. Energy storage systems (batteries, high speed flywheels, supercapacitors, etc.). Systematic energy management planning for the motion of the vehicle. Degree of hybridization. Energy recovery systems. Modeling - component analysis of hybrid - electric vehicles. Current technologies of hybrid vehicles. Sustainable Transportation.

Project (1): C 100% of the Final Grade

D. Koulocheris

(2.3.2289.7) Design for Manufacturing & Cost [C] (GR)

Product design specification. Conceptual, embodiment and detail design. Design principles. Principal design guidelines. Variant design. Value engineering analysis. Mechanical engineering design in conjunction with the technical characteristics of the manufacturing processes. Industrial Materials and Processes – selection and costing. Design for the Environment/DFE, Design for Manufacturing and Assembly/DFMA. Product documentation and Quality Control. Design for accuracy and interchangeability. Geometric dimensioning and tolerancing. Design for Manufacturing/Assembly cost reduction. DFC indices. Tolerance analysis and synthesis. Tolerances and machining accuracy. Tolerancing methods. Product testing. Prototyping. Additive Manufacturing/Rapid Prototyping & Tooling/3D Printing. Modern practices and information systems for product design, development, production and PLM. Reverse Engineering. Industrial Property, Patents.

Project/s: O 25 % of the Final Grade

V. Spitas, Ch. Provatidis, (G. Kaisarlis, S. Polydoras)

(2.3.2232.9) Flight Dynamics [C] (GR)

The course in an introduction to flight dynamics and focuses on level flight.

- Review of Aerodynamic Theory and Aircraft design.
- Flight equations: Terminology of aircraft kinematics and control; the ground and body fitted co-ordinate systems; the wind and stability additional systems – terminology and symbols definition; the 6 dof equations.
- Static stability, trimming and linearization of the equations; separating the longitudinal and lateral dynamics.
- The aerodynamic stability derivatives: the theoretical context; derivation of explicit formulas of derivatives; computational derivation using simulations.
- Longitudinal dynamics: the constant coefficient approach; the phugoid and short period modes; low order formulation; enhancing stability by design.
- Lateral dynamics: the constant coefficient approach; characterization of the modes; the Dutch roll vibrating mode.
- Open loop and closed loop flight control.
- Flight control requirements and quality of handling.
- Control equations for the longitudinal and lateral dynamics; formulation of auto-pilots.

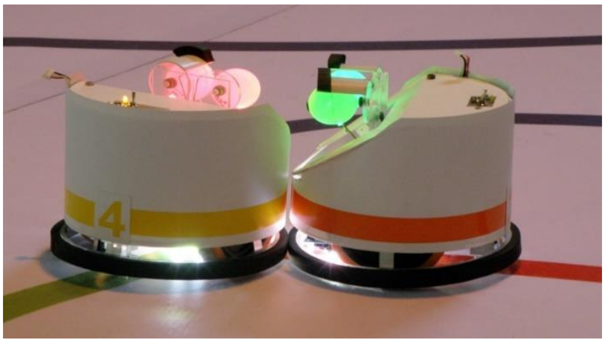
To attend this course, sufficient knowledge of the material of the following courses is strongly recommended: Introduction to Aircraft Design.

Project/s: C 50 of the Final Grade

I. Antoniadis, S. Voutsinas

(2.3.2242) Electric Circuits & Systems [C] (GR)

Models of circuit discrete elements. Resistors and energy storage elements. Sources. Systems of elements. Transformers. Linear circuit analysis via the linear graph method. Voltage division. Kirchhoff laws. Thevenin and Norton theorems. Linear system properties. Superposition. Stability. Circuit time response and sinusoidal steady state response. Frequency response. Transfer functions, filters. Three-phase networks. Average and reactive power.



Balanced and unbalanced loads. Lab exercises: circuit time and frequency response, parameter identification.To attend this course, sufficient knowledge of the material of the following courses is strongly recommended: Mathermatics A1 (Functions of one variable), Mathematics A2 (Linear Algebra & Analytic Geometry), Physics (Electricity and Magnetism with Optics).

Lab: O Project/s: O

I. Poulakakis, (I. Davliakos, A. Triantis)

(2.3.2245.3) Electromechanical Power Conversion Systems [C] (GR)

Fundamental principles of electromagnetism. Magnetic circuits and permanent magnets circuits. Electromechanical power conversion, development of torque and voltage. Electromagnetic actuators, electromagnets, voice coils. Generators, motors and loads. Torque-speed characteristics. Basic equations, equivalent circuits, characteristic curves, power flow, efficiency and losses in electric machines. DC generators and motors. Synchronous generators and motors. Three-phase and single-phase induction motors. Stepper, universal, and brushless motors. Introduction to drives and motor control. Lab exercises: motor response, parameter identification and characteristics of motors/generators.

To attend this course, sufficient knowledge of the material of the following courses is strongly recommended: Electric Circuits & Systems.

Lab: O

Ev. Papadopoulos, (I. Davliakos, A. Triantis)

(2.3.2310) Noise and Vibrations [C] (GR)

Fundamental Principles and Technologies of Anti-vibration Mounts. Basic concepts of Acoustics. Measurement and Analysis of Sound. Wave Phenomena and Wave Theory. Subjective Perception of Sound. Processing of Acoustic Signals. Passive Noise Control/Reduction. Noise Isolation (Soundproof Panels, Sandwich Panels, Elastic Mounts). Noise Absorption (Sound-absorbing Materials, Meta-materials, etc.). Acoustics of Rooms and Buildings. Sound from Structural Elements (Sound Scattering from Structural Elements, Acoustic-Structural Interaction). Active Noise Control (ANC)/Reduction (Linear and Non-linear ANC Methods, Local and Global ANC methods, Equipment, sensors, etc.).

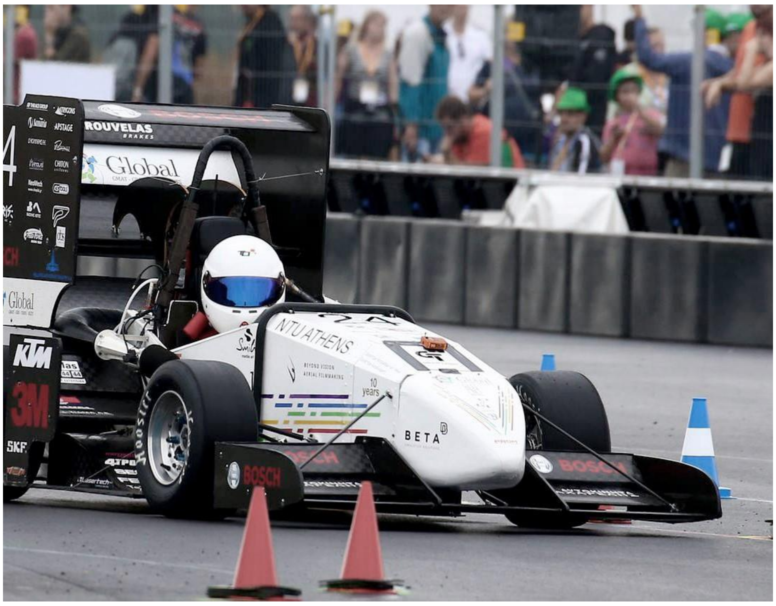
Microphones and Loudspeakers. Noise Pollution - Legislation (permissible limits, units of noise pollution measurement, human impacts, environmental noise, etc.).

- Laboratory Application/Demonstration of Active Noise Control
- Development of Simulation Models for evaluating various Active Noise Control (ANC) Methods in the Matlab/COMSOL computing environment.

I. Antoniadis, (Ch. Giakopoulos)

(2.3.2174.7) Theory of Ground Vehicles [C] (GR & EN)

Vehicle definition and classification. European Directives and International Regulations. Analysis of the subsystems of a vehicle (chassis, transmission, braking systems, suspension, steering, etc.). Introduction to tire mechanics (basic equations). Equations of planar motion of the vehicle motion, calculation of required torque / power on the axles. Vehicle performance (calculation of maximum speed values, acceleration, inclination, traction, etc.). Calculation - Selection of vehicle transmission system (gearbox - differential ratios). Optimization of vehicle transmission system (drive axles).



Calculation of maximum braking force and deceleration. Critical braking speed. Optimal braking - Distribution of total braking force on the axles of the vehicle. Use of specialized software for calculation /selection of vehicle subsystems. Introduction to hybrid vehicles (Architecture & Basic subsystems) - new driving technologies. Heavy vehicle superstructures (examples from the automotive industry - case studies).

The course is complemented with three (3) laboratory exercises concerning the determination of the centre of gravity of a vehicle, the stress analysis of a vehicle superstructure using strain gauges and the determination of the tire stiffness.

Lab exercises (3): C 20% of the final Grade Project (1): C 30% of the final Grade

D. Koulocheris

(2.3.2244.8) Dynamics and Design of Vehicles [C] (GR & EN)

Tire mechanics (basic theory - equations). Tire models (analytical, semi-analytical, Pacejka). Equations of vehicle motion in 3D space. Modeling of vehicle steering system, optimization. Calculation of vehicle stability (longitudinal, transverse). Modeling of vehicle suspension systems (passive, active, semi-active). Vehicle's handling. Ride comfort optimization. Dynamic behavior vehicle models (quarter / half / full car). Field measurements of characteristic quantities & estimation of the dynamic behavior of the vehicle. Introduction to traffic accident reconstruction. Use of dynamic simulation computer software. Applications - Case studies from the Greek construction industry of special vehicles (optimal design of dynamic behavior of a complete vehicle).

The course is complemented with three (3) laboratory exercises concerning the determination of the technical characteristics of a suspension of a heavy vehicle, the measurement of the dynamic behavior of a heavy vehicle and the determination of tire forces on a heavy vehicle.

Lab Exercises (3): C 20% of the final Grade Project (1): C 30% of the final Grade

D. Koulocheris

(2.3.2220.7) Signal Processing at Mechanical Systems [C] (GR)

Fundamentals of Signal Processing

Basic concepts and examples. Fourier analysis, spectra, windows. Digital signals and sampling theorem. Correlation and modulation. Time-frequency analysis and wavelets.

Vibration Measurement and processing

Sensors and processing architectures. International standards for measurement and analysis. Laboratory and industrial applications.

Sound and Noise Measurement and Analysis

Sound and Noise features and characteristic variables. International standards for measurement and analysis. Laboratory and industrial applications.

Diagnosis of mechanical faults

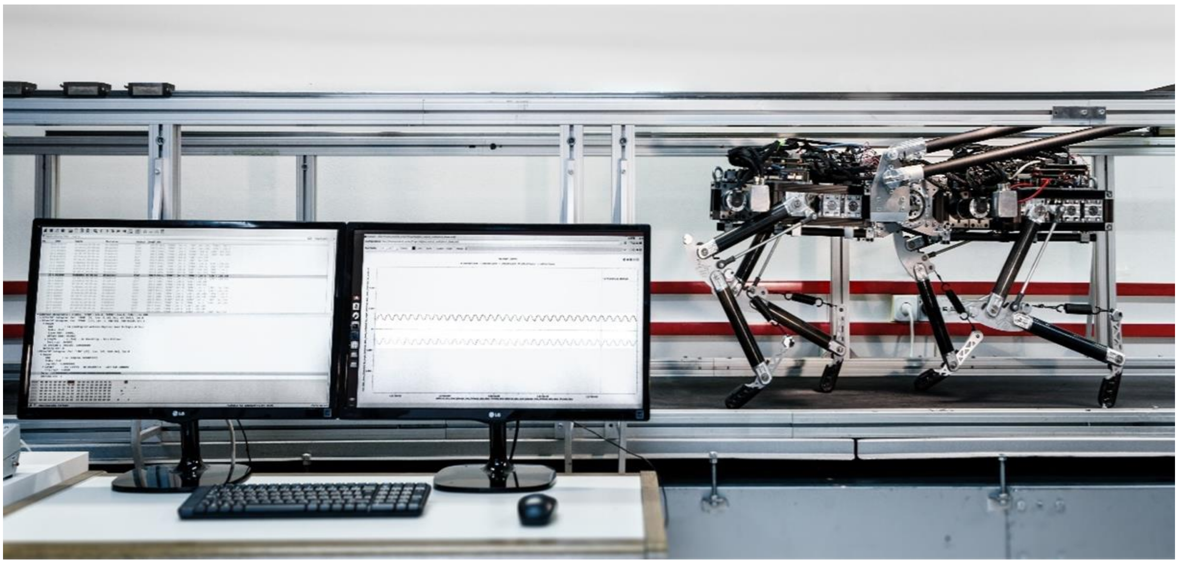
Basic concepts. International standards and empirical approaches. Dynamic models of machines under faults and response analysis. Typical faults of rotating machines. Unbalance, misalignment, loose supports. Bearing and gear faults. Faults in electrical motors.

Applications of pattern analysis and machine learning in machine fault identification

Feature selection and extraction and extraction (CDET, PCA, ICA). Fundamentals of machine learning (K-means Clustering, Support Vector Machines, Neural Networks) and anomaly detection. Applications in machine fault identification.

Lab: C 30 % of the Final Grade

I. Antoniadis, (Ch. Giakopoulos)



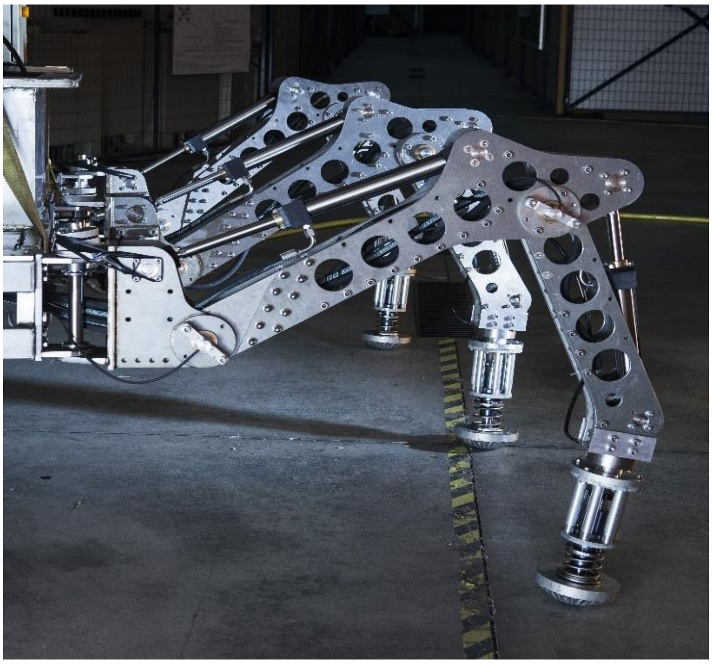
(2.3.2249.8) Microprocessors Based Control [C] (GR)

Introduction to control systems using microprocessors -μP and microcontrollers –μC (ADC, DAC, Sampling & Hold–S/H). Introduction to microprocessor and microcontroller architecture and programming. Assembly and interfacing of MC86HC11. Signal representation in digital systems, Z-transform, frequency domain analysis, state equations of sampled systems, time domain analysis. Stability, Controllability & Observability. Design and Implementation of Sampled Data control systems. State observation (observers – Kalman filtering) Model Identification. Introduction to Adaptive Control. Laboratory sessions: a) design and simulation of a digital control system for a medium scale plant (e.g. aircraft), b) assembly programming for μP & μC and simple controller implementation (e.g. alarm, servo-motor control), c) on-line identification of the dynamic parameters of 2-DOF manipulator.

I. Antoniadis, (M. Drosakis, A. Triantis)

(2.3.2274.9) Robotics [C] (GR)

Introduction to robotic systems (manipulators, vehicles, underwater, aerial): Direct and inverse kinematics in three dimensions: position and orientation. Direct and inverse differential kinematics: Jacobians, singularities, workspace.



Dynamics of serial arms. Kinematics and dynamics of wheeled robots. Linear and nonlinear position control of robotic systems. Force control. Actuators and sensors. Motion and trajectory design. Programming, architecture and integration of robots. Demonstrations of modern robotic systems. Control and Programming.

To attend this course, sufficient knowledge of the material of the following courses is strongly recommended: Mathematics A2 (Linear Algebra), Mechanics A, Modelling and Automatic Control of Systems.

Lab: O

Ev. Papadopoulos, I. Poulakakis, (I. Davliakos)

(2.3.2192.8) Analysis of Mechanical Structures II [C] (GR)

Plane load carriers (membrane, thin plate, laminate plate, shell). Partial differential equations of stress equilibrium for thin plates in bending, torsion and in-plane loading. Analytical solutions for typical boundary conditions. The finite element method. Buckling of columns and plates. Large-displacement analysis. Contact analysis. Elastoplastic analysis. Time integration. Adaptive finite elements. Isogeometric Analysis and CAD-based macroelements. The Boundary Element Method in elasticity and potential problems. Bending, shear and torsion of open and closed, thin-walled beams. Stress analysis of aircraft components. Shear stress distribution at a built-in end of a closed section beam. Structural Optimization under stress-, displacement-, eigenvalue- and buckling- constraints. Fully stressed design. Optimality criteria in trusses and frames. Non-linear mathematical programming methods. Stochastic optimization methods. Shape optimization. Topology optimization. General rules in FEM modeling. Hands on commercial codes in the PC-lab (practice, two- out of the four hours, weekly). Optional homework, either using commercial FEM codes (SolidWorks, ANSYS) or programming via MATLAB and other computer languages.

Project/s: O 40%-50 % of the Final Grade

I. Kalogeris

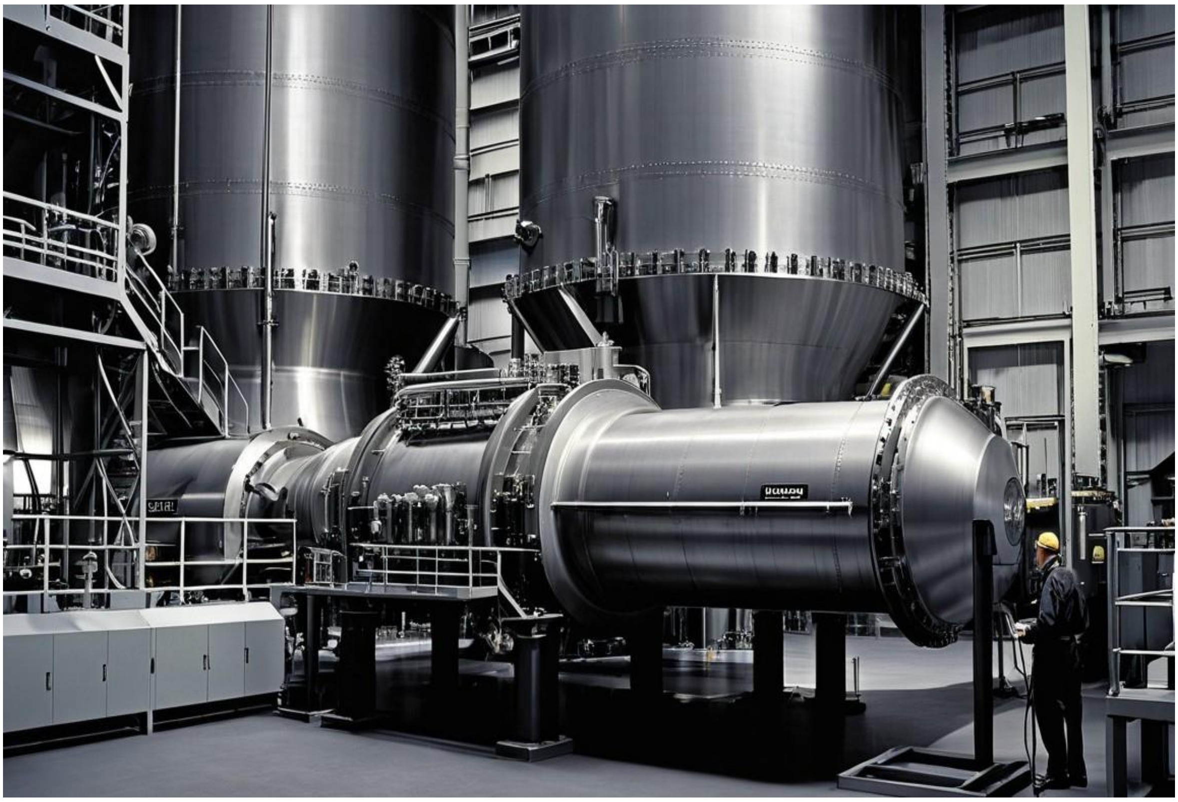
(2.3.2311.9) Design for Additive Manufacturing and Applications [C] (GR)

Review of the basic additive manufacturing (AM)/ rapid prototyping (RP) techniques, printing heads and 3D-printing machines. AM materials (polymers, elastomers, ceramics, metals, mortars etc.) and methods for finishing coarsely manufactured surfaces. Selection of suitable AM method and material. Introduction to rapid tooling (RT). Elements of reverse engineering (RE) and basic RE technologies and machines (touchprobe, laserscanner), accuracy and repeatability of the measurements, measuring techniques on CMMs. Postprocesssing of the

obtained point-cloud, triangle model and grid repairing techniques, development of CAD models and parametric surface models. Design for AM. Identification of the critical functional tolerances and calculation of fits on functional assemblies. Design simplification and adaptation to the available RP technologies / machines. Placement and support of the objects on AM machines. Techniques for avoiding part warping during and after AM, design of part supports and selection of infill pattern and density. Numerical modeling of RP parts using FEM and assessment of residual stresses-strains and strength. Design assessment.
Project/s: O 100% of the final Grade

V. Spitas, (G. Kaisarlis, S. Polydoras)

Nuclear Engineering



(2.4.2241.3) Operating Systems and Programming Languages [C] (GR)
Special topics in procedural programming using the C language. Comprehensive analysis of the program execution cycle across various operating systems. Detailed discussion on the syntactical and lexical rules of the C language, including how the compiler functions. Analysis of program structure, syntax, and semantics. Presentation of variable and constant declarations, operators, and expressions. Analysis of special topics in arithmetic and logical expressions, as well as control structure. Detailed analysis of functions, including differences in parameter passing (by value and by reference). Introduction to arrays (one-dimensional and multi-dimensional) and pointers. Program creation and analysis techniques for file processing and dynamic memory management. Introduction to data structures: complexity basics, lists and their variations (singly/doubly linked lists, circular lists), stacks, queues, heaps, graphs and graph problems (minimum spanning tree, shortest path), and binary trees. In-depth exploration of algorithm theory (algorithm complexity, performance analysis, Big O and Omega notation). Presentation of sorting methods, including bubble sort, quicksort, and mergesort. Discussion on programming techniques and multiprocessing systems.
Lab: Introduction to AWK and Bash scripting languages for file preprocessing (mainly log files). Presentation of challenging technical problems in the C language. Analysis of SQL queries/language and database connections (MongoDB, MariaDB, SQLite) with programming languages like C. Analysis of binary files to detect errors and memory leaks using tools like Valgrind. Presentation of languages for specialized problems (AI, Optimization Problems, Machine Learning for Predictive Maintenance, Virtual Prototyping, and Digital Twins) and low-code programming tools like Node-RED. Finally, presentation of programming techniques for AI-Powered Prompts.

Lab: O 100 % of the Final Grade

N. Petropoulos, (V. Moulos)

(2.4.2079.5) Statistics and Measurement in Engineering [C] (GR)

(a) Theory: Introduction to Statistics. Descriptive statistics. Probability theory. Probability distributions. Measurement statistics and statistical tests. Error analysis and error propagation. Linear regression and correlation. Multiple regression. Planning and conducting experiments. Comparative experiments. Factorial experiments. Simulation - Computer simulation techniques. On-line measurements and real-time data acquisition, processing and control. (b) Laboratory work: Application of the laws of statistics in engineering measurements - Comparative and factorial experiments - Real-time computer based measuring systems.

Lab: O 20 % of the Final Grade

M. I. Anagnostakis, P. Rouni

(2.4.2075.7) Physical Principles of Nuclear Power Reactor Plants [C] (GR)

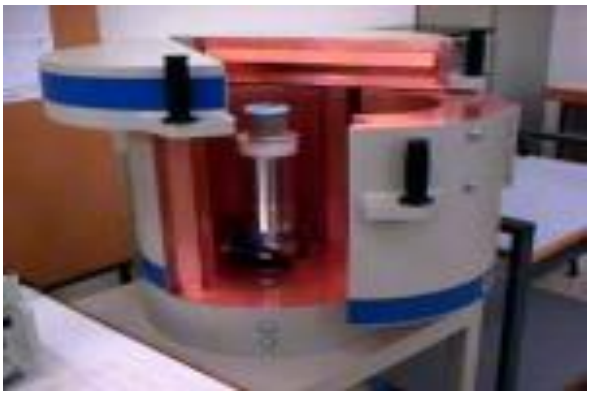
Basic atomic and nuclear physics concepts. Nuclear reactions. Fission and Fusion. Fission Nuclear Reactors. Neutron population physics. Diffusion of monoenergetic neutrons. Neutron moderation. Neutron thermalization. Thermal neutron diffusion.

To attend this course, sufficient knowledge of the material of the following courses is strongly recommended: Mathematics C (Ordinary and Partial Differential Equations).

D. Mitrakos, N. Petropoulos

(2.4.2298.7) Interactions of Ionizing Radiation with Matter, Radiation Protection – Dosimetry (GR & EN)

Radioactive decay. Sources of radiation. X-Ray production. Interaction of α-particles, β-particles, photons, neutrons and fission fragments with matter. Energy absorption in matter. Radiation damage. Monte-Carlo simulation of the interaction of radiation with matter. Introduction to radiation biology. Dosimetry and dosimetric units (Air Kerma, Exposure, Absorbed Dose, Equivalent Dose). Internal and external dosimetry, dosimetric calculations and portable instruments. Principles of radiation protection, dose limits and relevant legislation. Radiation shielding calculations. Safe use of radioactive sources. Laboratory Training.



Lab: O

M. I. Anagnostakis, P. Rouni

(2.4.2001.8) Nuclear Power Reactor Set-up and Operation [C] (GR)

Nuclear power reactor types, components, and set-up. reactor theory, neutron diffusion approximation, solution of the diffusion equation, criticality calculations and reactor sizing using one or two neutron energy groups, reflected core, non-homogeneous core, reactor kinetics, point kinetic equation, reactor response and feedback mechanisms.

D. Mitrakos N. P. Petropoulos

(2.4.2262.9) Nuclear power reactors thermal-hydraulics and multiphase flows (GR & EN)

Principal characteristics of power reactors (power cycles, coolant systems, reactor cores, fuel assemblies, reactor types, principles of reactor thermal design and performance). Heat generation and distribution in the core of nuclear reactors. Heat removal from the core. Thermal-hydraulic response and feedback mechanisms. Inadequate heat removal and

associated phenomena. Reactor emergency cooling systems. Boiling on heated surfaces, heterogeneous nucleation, bubble generation and departure, wall boiling models. Flow boiling analysis, mixture models, two-fluid models. Aerosol flows and dynamics in reactor containment. Basic principles of nuclear safety.
Laboratory exercise.

Lab: O 20 % of the Final Grade Project/s: O 30 % of the Final Grade

D. Mitrakos

(2.4.2262.9) Nuclear power reactors thermal-hydraulics and multiphase flows (GR & EN)

Principal characteristics of power reactors (power cycles, coolant systems, reactor cores, fuel assemblies, reactor types, principles of reactor thermal design and performance). Heat generation and distribution in the core of nuclear reactors. Heat removal from the core. Thermal-hydraulic response and feedback mechanisms. Inadequate heat removal and associated phenomena. Reactor emergency cooling systems. Boiling on heated surfaces, heterogeneous nucleation, bubble generation and departure, wall boiling models. Flow boiling analysis, mixture models, two-fluid models. Aerosol flows and dynamics in reactor containment. Basic principles of nuclear safety.

Laboratory exercise.

Lab: O 20 % of the Final Grade Project/s: O 30 % of the Final Grade

D. Mitrakos

(2.4.2263.8) Medical Imaging and radiation therapy (GR)

Introduction to radiation physics, radiobiology and medical imaging. X-ray tube: principles of operation and applications. Radiographic image: film, image intensifier, digital imaging, image quality. Medical radiography units: fluoroscopy, mammography, bone densitometry. Tomography: principles of tomography, tomography units, image reconstruction.
Medical accelerators: principles of operation, applications, Cyclotron, Linear Accelerator (LINAC).
Radiopharmaceuticals: production, use and radiation protection. Gamma-camera. Imaging techniques: PET and SPECT. Nuclear Magnetic Resonance (NMR), Magnetic Resonance imaging (MRI). PET-CT and PET-MRI systems. Ultra-sound imaging.
Radiotherapy: principles, radiotherapy with X-rays, β-particles, heavy particles, radiotherapy planning. Brachytherapy. Radiopharmaceuticals for radiotherapy. Radiation protection in radiotherapy.
Laboratory training.
Lab: O

M. I. Anagnostakis

(2.4.2287.8) Nuclear Measurement Systems (GR & EN)

Nuclear radiation detectors. Radiation measurement statistics and detection limits. Gas detectors. Scintillation detectors. Semiconductor detectors. Neutron detectors. Radon measurement instrumentation. Portable Instruments for radiation detection. Radionuclide determination techniques: α-spectrometry, γ-spectrometry. Total-α and total-β measurements. Liquid scintillation. Radiochemical methods. Radon concentration measurement techniques and radon exhalation measurements. Nuclear related techniques for trace elements determination: Instrumental Neutron Activation Analysis (INAA), X-ray fluorescence (XRF). Laboratory Exercises.

To attend this course, sufficient knowledge of the material of the following courses is strongly recommended: Interactions of Ionizing Radiation with Matter, Radiation Protection – Dosimetry.

Lab: C 40 % of the Final Grade

M. I. Anagnostakis

(2.4.2275.9) Radioactivity in the environment (GR & EN)

Natural radioactivity, artificial radioactivity and technologically enhanced natural radioactivity. Nuclear and radiological accidents. Radioactive contamination from the operation of Nuclear Power Plants and of non-nuclear installations. Enhancement of natural radioactivity due to industrial processes (NORM). Radioactive contamination from the use of radioactive materials.

Radioactive effluents. Dispersion and kinetics of natural and artificial radionuclides in the environment. Radionuclides as tracers of atmospheric and other processes. Radioenvironmental surveys. High background areas. Statistical analysis and mapping of radioenvironmental measurements. Radioactivity of building materials. Radon in the living environment, radon indoors and remediation techniques. Radioactive aerosols. Nuclear analytical techniques for the determination of trace elements in the environment. Laboratory training.

Lab: O 10% of the final Grade Project/s: C 40% of the final Grade

M. I. Anagnostakis, P. K. Rouni, D. Mitrakos

Fluids

(2.5.2110.4) Fluid Mechanics I [C] (GR)

Historical review, achievements – Physics and Chemistry of fluids – Continuum Mechanics – Kinematics – Basic laws in integral and differential form: conservation laws of mass, momentum, moment of momentum, energy (1st and 2nd law) – Constitutive relations – Newtonian and non-Newtonian fluids – Applications, simplifications: Euler and Bernoulli equations – Navier-Stes equations – Analytic solutions of Navier-Stes equations – Irrotational flow of incompressible fluids – Superposition of simple potential flow fields - Similarity laws – Flow stability – Turbulent flows – The boundary layer concept – Laminar boundary layer over a flat plate (theory of Blasius) – Turbulent flow in pipes – Forces on moving bodies – Moving frames of reference – Discontinuities – One dimensional isentropic flow of compressible fluid and Laval nozzle.

To attend this course, sufficient knowledge of the material of the following courses is strongly recommended: Mathematics A1, Mathematics A2, Mathematics B, Mathematics C.

D. Bouris, V. Riziotis, M. Manolesos , Ch. Manopoulos, (I. Prospathopoulos)

(2.5.2013.1) Introduction to Mechanical Engineering [C] (GR)

Content of the studies of Mechanical Engineering. Mechanical Engineers' knowledge and skills. Introduction to manufacturing. Modelling: basic principles and theories. Elements of systems theory and thinking. Basic functions of mechanical products and installations. Elementary assessment tools. Basic physical lows used in Mechanical Engineering and application examples. Lessons learned from successful and unsuccessful examples mechanical constructions. Machine shop exercise.

Project/s & Subjects: O	40 % of the Final Grade

N. Marmaras, D. Bouris, P. Benardos, (S. Drivalou)

(2.5.2131.5) Hydraulic Turbomachines [C] (GR)

Introduction to Hydraulic Turbomachines: Historical review, modern types and principles of operation. The fundamental equations for incompressible fluid. Energy flow and torque development. Relative motion in rotating impeller, relative flow equations, velocity triangles. Basic equations, operation principles, performance and efficiency, and characteristic operation curves of centrifugal pumps. Geometric & dynamic similarity in pumps. Dimensionless parameters. Selection of motor and rotation speed. Calculation of main dimensions of a centrifugal pump. Design of the impeller and of the inlet and outer sections.
The pumping installation. Pump selection and operation point. Pump co-operation in parallel and in series connection. Cavitation in pumps: analysis, criteria and calculations. Pump station configuration and operation - Automations. Transient phenomena & hydraulic hammer.
Description of a typical hydroelectric installation and of various hydro turbine types. Performance and efficiency, characteristic operation curves, similarity, dimensionless parameters and cavitation in hydro turbines. Automations and control. Design principles and calculation of main dimensions of hydro turbines. Reversible pump-turbine machines. Hydrodynamic torque converter and hydraulic brake. Team project (3-5 students, weight 20%): Calculation and design of a hydrodynamic machine (centrifugal pump / fan, or crossflow pump / fan or Pelton, or Francis hydro turbine, or hydraulic wheel) using literature and software.
Individual project, weight 10%: Pump selection and pumping station configuration. Laboratory exercise, weight 10%. Measurements and construction of the characteristic operation curves of a centrifugal pump. To attend this course, sufficient knowledge of the material of the following courses is strongly recommended: Mathematics A1, Mathermatics A2, Mathematics B, Mechanics A, Mechanical Design I, Mechanical Design II, Fluid Mechanics I, Electromechanical Power Conversion Systems.

Lab: C 10%: of the Final Grade Team Project/s: C 30% of the Final Grade

I. Anagnostopoulos, Ch. Manopoulos, (P. Chasapogiannis, A. Raptis)

(2.5.2045.6) Thermal Turbomachines [C] (GR)

Introduction to the morphology, operation and aerothermal analysis of thermal turbomachines. Types of thermal turbomachines, compressor, turbine, steam-turbine. Fundamental governing equations. One-dimensional flow in thermal turbomachines. Flow analysis in two-dimensional cascades. One-dimensional flow analysis in axial and radial compressors. One-dimensional flow analysis in axial and radial turbines. Single- and multi-stage turbomachines. Turbine and compressor similarity. Basic mechanical features. Experiment in the Lab: Experimental determination of a compressor characteristic curve. Project on turbomachinery computations.
To attend this course, sufficient knowledge of the material of the following courses is strongly recommended: Fluid Mechanics I, Applied Thermodynamics of Pure Substances.

Lab: C 5% of the Final Grade Project/s: C 5% of the Final Grade

K. Giannakoglou, (Ch. Romesis)

(2.5.2016.7) Fluid Mechanics II [C] (GR)

- Boundary Layer Flow
- Transition to Turbulence / Stability
- Turbulence Modelling
- Applications (Jet Flow, Wake Flow)
- External Compressible Flows
- Flow Control

To attend this course, sufficient knowledge of the material of the following courses is strongly recommended: Fluid Mechanics I, Numerical Analysis.

M. Manolesos

(2.5.2303.7) Aerodynamics (GR & EN)

- Flow around 2D airfoils - qualitative characteristics of boundary layer (flow separations, laminar to turbulent flow transition)– airfoil performance characteristics (lift/drag).
- Steady and unsteady low speed external aerodynamics. Equations and boundary conditions of the potential incompressible flow.
- Generation of lift (Kutta-Joukowski theorem).
- Linear 2D airfoil theory
- Steady 2D flow around airfoils.
- Unsteady 2D flow around airfoils – wake development (Theodorsen).
- Vorticity theorems.
- Linear 3D wing theory – Prandtl's lifting line method and applications.
- Actuator disc – blade element theory for the calculation of the propeller performance.
- Numerical application of lifting line theory for the analysis of the 3D fixed and rotating wing problems.
- The numerical boundary element (BEM0 method. Application in 2D and 3D problems.
- Viscous-inviscid interaction methods
- Grid based CFD methods for the analysis of external aerodynamics problems
- 2D airfoil performance measurements in the wind tunnel.

Project/s: C 50 % of the Final Grade

V. Riziotis

(2.5.2021.5) Applied Fluid Mechanics [C] (GR)

Laminar and turbulent flow in pipes (link with the course of Fluid Mechanics I) – Dimensional analysis and importance of Re number – Pressure drop calculation in a pipe.
The notion of turbulence – Turbulent flow in a pipe – Pressure drop calculation in a pipe in turbulent flow conditions – Generalized Bernoulli equation.
Pipeline calculation (calculation of flow and pressure drop in simple pipeline) – simplification of networks (sequential and parallel pipes) – Concentrated losses in pipes – Calculation of pressure and energy line in a pipeline – Applications of simple networks.
Numerical methods for the analysis of networks with loops (Hardy-Cross and Newton-Raphson) – Applications of numerical analysis of networks.
Applications of networks including pumps.
Equations of 1-D compressible adiabatic flow in ducts. Equations of 1-D compressible isothermal flow in ducts – Ideal and real gasses flow. Application examples of compressible flows in ducts.
Equations of 1-D flows in open channel. Dimensional analysis – Importance of Froude number. Calculation of critical and uniform depth in an open channel – Equations of non-uniform flow in open channels – Equations of hydraulic jump. Application examples of open channel flows. Mathematical description of hydraulic shock (water hammer). Analysis of water hammer with the method of characteristics. Application in simple configurations.

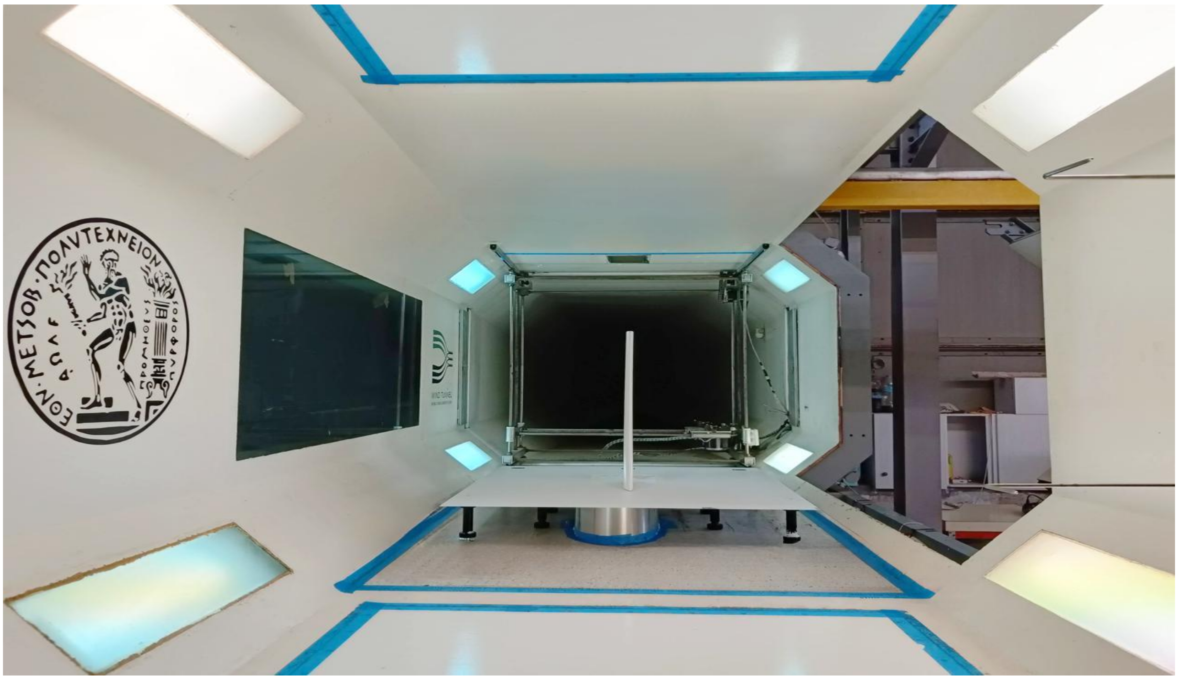
V. Riziotis, I. Anagnostopoulos, (I. Prospathopoulos)

(2.5.2185.9) Computational Methods in Turbomachinery (GR)

Boundary layer and viscous flow theory. Incompressible and compressible viscous layers in compressor and turbine bladings. Differential and integral methods for viscous flow modeling in turbomachines. Grid generation. Viscous-inviscid interaction methods in turbomachinery. Turbulence and transition modeling in turbomachines. Secondary flows and relevant computational methods. Tip-clearance flows in turbomachines and their modeling. Advanced case studies. Demonstration in OpenFOAM.

K. Giannakoglou

(2.5.2189.7) Experimental Fluid Mechanics (GR)



- General Concepts of Experimental Fluid Mechanics
- Wind Tunnel
- Characteristics of Measurement Equipment and Systems
- Measurement Methods in Experimental Fluid Mechanics
- Uncertainty Assessment
- Report Writing

To attend this course, sufficient knowledge of the material of the following courses is strongly recommended: Fluid Mechanics I.

Project/s: C 25 % of the Final Grade

N. Aretakis, Ch. Manopoulos, M. Manolesos, D. Bouris

(2.5.2111.7) Computational Fluid Dynamics [C] (GR)

Numerical solution of flow problems.

- Formulation of flow equations, alternative forms, special cases (incompressible-compressible flows, inviscid flows, laminar and turbulent flows).
- Classification of PDEs: Elliptic, Parabolic, Hyperbolic equations.
- The finite difference method: Taylor expansion of functions; truncation, order of scheme, algebraic construction of schemes, application to 1 and 2-dimensional problems, boundary conditions and their implementation, tridiagonal systems, ADI and Gauss-Seidel schemes.
- The finite volume method: formulation of the integral form of the discrete equations, recognition of fluxes, reconstruction schemes on faces using Green-Gauss theorem, application to 1- and 2-dimentional flows.
- Solution of compressible flows: the method of characteristics; application to 1D problems; the Godunov scheme; Higher order schemes; flow and flux limiters; TVD schemes; the Riemann problem and its Roe approximation.
- Solution of incompressible flows: the need for upwinding in advection-diffusion problems, the pressure correction scheme on staggered grids, the collocated version and the Rhie-Chow correction.

- Time integration: Explicit and implicit schemes, stability and the CFL criterion, dual stepping and time true simulations.
- Turbulence modeling: introduction to space and time averaging in turbulence; the turbulent kinetic energy equation; one and two equation turbulence models: the k-ε and k-ω models; introduction to advanced turbulent modeling: the DES and LES approaches.

To attend this course, sufficient knowledge of the material of the following courses is strongly recommended: Fluid Mechanics I, Numerical Analysis.

Projects: C 3 projects amounting to 70% of the Final Grade

S. Voutsinas, (I. Prospathopoulos)

(2.5.2202.8) Principles of Jet Propulsion [C] (GR)

Thrust generation, equations for thrust calculation, factors influencing thrust. Comparative presentation of different jet-engine layouts. Description of the main parts of a jet engine. Cycle analysis and performance calculations. Parametric design studies. Inlets analysis, design principles, subsonic, supersonic. Exhaust nozzles, operational principles, convergent, convergent divergent. Mixers. Layout and operational principles of compressors, burners and turbines. Blade cooling. Component matching for equilibrium operation. Cycle analysis and performance calculations for different operating conditions, reduced performance parameters. On-aircraft engine operation for different flight conditions.
To attend this course, sufficient knowledge of the material of the following courses is strongly recommended: Applied Thermodynamics of Pure Substances, Thermal Turbomachines, Fluid Mechanics I.

Project/s: C 30 % of the Final Grade

N. Aretakis, K. Mathioudakis, (Ch. Romesis)

(2.5.2194.9) Multi-phase Flows (GR & EN)

Introduction to multiphase flow: description, categorization and application examples. Dispersed phase: properties, characterisation, coupling with carrier phase. Statistical characteristics of dispersed phase distributions. Particles in a continuous phase: dynamics, thermodynamics, interactions with fluids, particles and solid boundaries (erosion, deposition). Carrier phase: equations, integration methods. Numerical simulation: Lagrange-Euler. Continuous phase equations (coupling with dispersed phase). Dispersion mechanisms: molecular and turbulent diffusion, numerical simulation. Measurement methods.
Project : Numerical simulation of particle motion in basic flow fields of incompressible fluids.
To attend this course, sufficient knowledge of the material of the following courses is strongly recommended: Fluid Mechanics I, Computational Fluid Dynamics.

Project/s: C 50 of the Final Grade

D. Bouris

(2.5.2187.6) Environmental Technology [O] (GR)

Current environmental problems, causes and sources of pollution. Mesoscale environment and the atmospheric boundary layer. Microscale environment and the urban boundary layer. Buildings and bluff body aerodynamics. Principles of mass transfer in the environment. Pollutant dispersion. Air quality in the indoor environment. Aerosols and pollution control devices and equipment.

Lab: C Project/s: O 35% of the Final Grade

D. Bouris

(2.5.2100.8) Design of Thermal Turbomachines (GR)

Basic principles of compressor and turbine design. Selection of rotational speed and annulus dimensions. Determination of number of stages. Flow angle calculation across blade height (quasi-three-dimensional flow). Radial equilibrium equation. Comparison of different radial distributions of peripheral velocity. Investigation of compressibility effects. Blade profile selection using cascade experimental data. Blade design. Calculation of efficiency using empirical loss equations and experimental data. Calculation of performance maps. Laboratory exercise: measuring the flow field inside an axial compressor stage. Computational project: design of an axial compressor or turbine.

To attend this course, sufficient knowledge of the material of the following courses is strongly recommended: Thermal Turbomachines.

Project/s: O 50% of the Final Grade

N. Aretakis, K. Mathioudakis, (Ch. Romesis)

(2.5.2217.9) Aircraft Engine Operation 90 [C] (GR)

Operation analysis of turbo combustion engines and calculation methods of the operation performance. Computational models of aircraft engines, modeling of engine components, determination of engine characteristics and methods for developing computer models of the operation of aircraft engines.Principles of operation and types of auxiliary systems for aircraft engines. Engine use in relation to a specific aircraft, according to its mission analysis. Environmental impact of engines by emissions of gas pollutants as well as noise emissions. Engine certification.

To attend this course, sufficient knowledge of the material of the following courses is strongly recommended: Principles of Jet Propulsion.

Project/s: C 30 % of the Final Grade

N. Aretakis, K. Mathioudakis, (Ch. Romesis)

(2.5.2148.4) Numerical Analysis [C] (GR)

Systems of linear equations: Direct (Gauss elimination, factorization) and iterative (Jacobi, Gauss-Seidel, SOR) solution methods. Eigenproblems and the power method. Interpolation and polynomial regression: Taylor, Lagrange, Newton and Hermite polynomials. Spline interpolation. Nonlinear equations: bisection, regula-falsi, fixed-point iterative methods, Newton-Raphson, the secant and Schroder methods. The Newton's method for systems of nonlinear equations. Numerical differentiation and integration. Approximation of derivatives. Simple rules for numerical integration. Gaussian quadrature. Integration of improper integrals. Differential equations. The Initial-value problem, Numerical errors. One-step methods (Taylor, Runge-Kutta). Multistep methods (Adams, prediction-correction). Regression theory. Least-squares regression (polynomial, exponential). Least-squares with orthogonal polynomials. Boundary-value problems. Partial derivatives approximation. The linear shooting method. Finite difference methods.

Project/s & Subjects: O 30 % of the Final Grade

K. Giannakoglou

(2.5.2178.8) Wind Energy [C] (GR & EN)

- Familiarization with wind turbine (WT) technology and a description of the operation of their main subsystems.
- Development of the Wind Energy market in Greece, Europe, and globally.
- Wind potential and the fundamental characteristics of wind.
- Statistical analysis of wind data.

- Aerodynamics of wind turbines, with an emphasis on horizontal-axis wind turbines (HAWT).
- Application of the momentum disk method and blade element method.
- Design of wind turbine power curves and power control methods.
- Calculations of energy production from wind turbines.
- Simplified cost models for wind turbines.
- Integration of wind farms into small autonomous grids / Wind power curtailment.
- Analysis of wake losses in wind farms and simplified wake interaction models.
- The electrical system of wind turbines and their interaction with the grid.
- Offshore wind farm technologies.
- Economic analysis of wind energy investments.

Project/s: C 60 % of the Final Grade

V. Riziotis, M. Manolesos, (G. Caralis, P. Chasapogiannis)

(2.5.2218.9) Aeroelasticity and Aeroacoustics [C] (GR & EN)

<u>Aeroelasticity</u>

- Aeroelastic coupling in a one degree of freedom (d.o.f.) system (steady and unsteady flow).
- Dynamics of systems with multiple d.o.fs– Hamilton Principle - Langrange equations- natural frequencies and mode shapes of systems with multiple d.o.fs
- Aeroelastic coupling in systems with multiple d.o.fs.
- Aeroelastic stability – Examples of aeroelastic instabilities –stall flutter and classical flutter.
- Aeroelastic analysis of the rotating blade – simplified models.
- Aeroelastic modeling of the rotor-pylon problem.
- Aeroelastic analysis of continues systems – beam equations and numerical analysis using finite element method. Aeroelastic coupling in continues systems.
- Servo-aero-elastic analysis of rotors. Application in wind turbine and helicopters
- Applications using multibody hGAST software.

<u>Aeroacoustics</u>

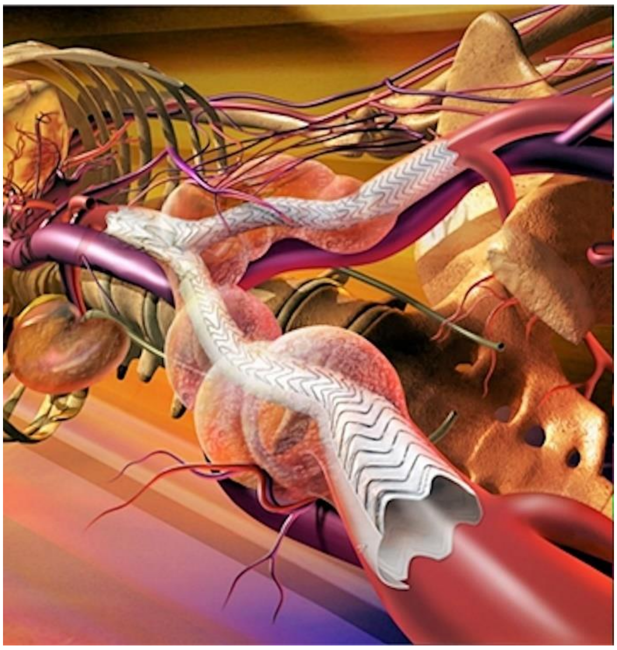
- Definition of sound / Fundamental principles.
- Linear acoustics.
- Measurement and assessment of noise / levels synthesis.

- Non-homogenous wave equation / Acoustic monopoles, dipoles and tetrapoles
- Generalized equations of Ffowcs Williams-Hawkings.
- Noise generation sources in rotating blades / wind turbines, helicopters.
- Noise propagation in the atmosphere / basic principles .
- Natural damping mechanisms.
- Numerical solution of Euler acoustic equations.
- Ray theory.
- Parabolic equations method
- Applications in wind farms and airports

V. Riziotis, (I. Prospathopoulos)

(2.5.2231.9) Biofluid Mechanics and Biomedical Engineering (GR)

Biofluid-Mechanics. Elements of Anatomy and Physiology of the circulatory system. Blood rheology. Structure and mechanical properties of the blood vessel wall.



Wave propagation in arteries. Pulsating blood flow in arteries. The circulatory system, regulation, modeling. The heart as a pump. Microcirculation. Fluid mechanics of thrombogenesis and atherogenesis. Measurement in circulatory system. Urodynamics. Bio-fluid Mechanics of respiration and voice. Bio-fluid mechanics of hearing and smelling. Bio-fluid mechanics of other biological fluids. Diagnostics and Bio-fluid Mechanics. Devices and equipment of Biomedical Fluid mechanics. Respiratory ventilators. Haemodialysers (artificial kidney). Peristaltic and infusion pumps. Biomedical measurements (stethoscopes, pressure recording, flowmeters, ultrasonics). Cardiac artificial valves, artificial grafts, replacements, biocompatibility. Artificial organs. Assist devices. Extracorporeal equipment. Devices and equipment of urodynamics. Lithotripters – Suction and drainage technology.

To attend this course, sufficient knowledge of the material of the following courses is strongly recommended: Mathematics A1, Mathematics B, Mechanics B, Mechanics C, Fluid Mechanics I.

Project/s: O 40-50 % of the Final Grade

Ch. Manopoulos, (A. Raptis)

(2.5.2253.7) Optimization Methods in Aerodynamics (GR)

Inverse design and optimization problems in aerodynamics. Objectives in design problems. Shape optimization problems with inviscid and viscous flow considerations. Numerical optimization: mathematical background, optimization without or with constraints, single- and multi-variate optimization, single- and multi-objective optimization, iterative optimization methods (sequel to methods known from the Numerical Analysis course), existence and uniqueness of the optimal solution, advantages and limits of numerical optimization methods. Automatic differentiations, direct differentiation, the complex variable method, the continuous and discrete adjoint method. Applications. Stochastic optimization methods based on evolutionary algorithms and artificial intelligence. Advantages and disadvantages. Applications.

Project/s: O 50 % of the Final Grade

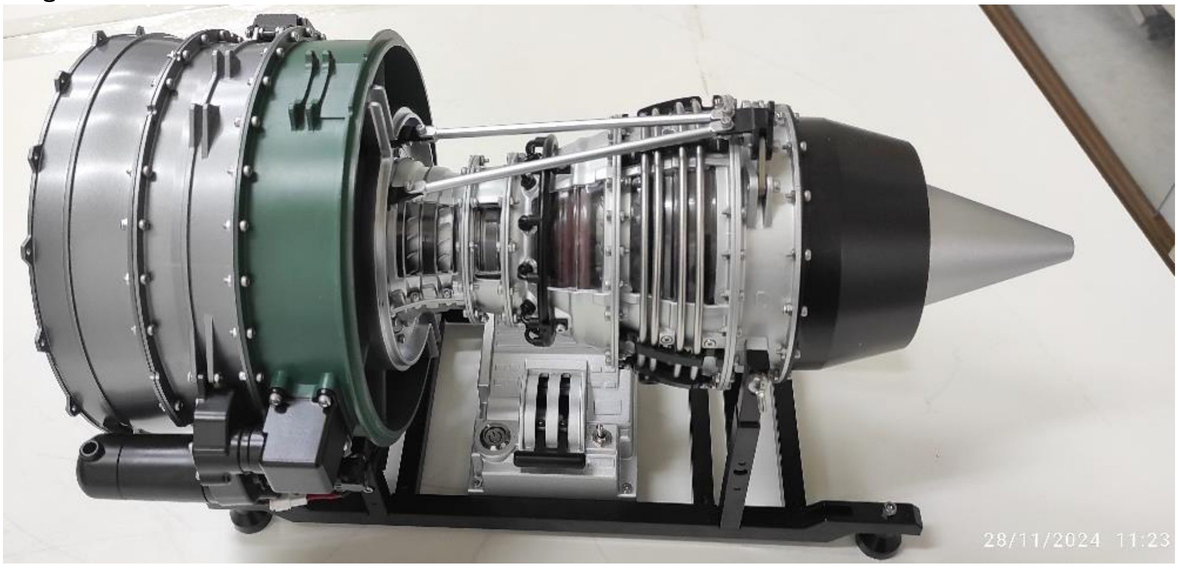
K. Giannakoglou

(2.5.2216.9) Gas and Steam Turbine Operation [C] (GR)

Gas Turbines: Types and layout of gas turbines. Cycle analysis, performance parameters. Features of compressors and turbines. Blade cooling. Combustion, combustion chambers, fuels. Operation under varying loads, control methods. Performance simulation. Gas turbine set up, subsystems.

Steam turbine: Steam cycles and steam turbine. Stage analysis, types, operation. Performance parameters, losses, efficiency. Operation under varying loads, control. Performance simulation. Wet steam turbine features.

Principles of maintenance, condition monitoring and fault diagnosis of gas and steam turbines. Performance diagnostics. Aerothermodynamic diagnostics and vibration diagnostics.



To attend this course, sufficient knowledge of the material of the following courses is strongly recommended: Applied Thermodynamics of Pure Substances, Fluid Mechanics I, Thermal Turbomachines.

N. Aretakis, K. Mathioudakis, (Ch. Romesis)

(2.5.2251.8) Hydroelectric Power [C] (GR)

Hydroelectric energy: current conditions and prospects for further development. Advantages and disadvantages of its utilization. Hydraulic potential of rivers, lakes and oceans.

Basic configurations and categorization of conventional hydroelectric plants, based on size (power), type (with or without reservoir), usage (e.g. pumped storage), type of hydro turbines.

Civil engineering: dams, water intake, penstocks, surge tank, hydroelectric power station.

Hydro Turbines: Types, operation range and limitations, standardization for Small Hydropower Plants. Electrical and electronic equipment: generators, transformers, power factor, measuring equipment, automation and control. Auxiliary equipment of hydroelectric power station. Main hydrodynamic installations. Transient flow phenomena. Hydraulic hammer and protection.

Hydrological analysis: Hydrological cycle, hydrological data and models, flow duration curve, drainage measurement. Techno-economic analysis of hydroelectric plants / units and Levelised Cost of produced Energy. Methodology of planning and optimal sizing of small hydropower plants.

Sea wave energy. Hydrodynamics and energy content of marine waves, wave databases. Recommended devices and wave energy conversion units. Analysis of hydrodynamic performance. Examples of units in pilot and normal operation. Duration curve and estimation of the energy utilization (capacity) factor.
Tidal energy and sea currents. Global potential and basic configuration of electricity production plants. Technical and operational characteristics of hydrodynamic machines. Examples of units in pilot and normal operation. Duration curve and estimation of the energy utilization (capacity) factor.
Innovative hydrinetic devices producing small scale electric energy (low flow rate and/or low to ultra low hydraulc head). Operation principles, areas of application and technical characteristics.
Integration and operation of hydroelectric power plants into electricity systems: Main and auxiliary services. Cooperation with intermittent RES units, energy storage, hybrid RES-hydro power stations.
Environmental impacts of hydroelectric projects and power production plants. Protection and mitigation measures, depending on the units type and size.
Team project (3-5 students, weight 40%). Energy production and techno-economic evaluation / Optimal selection and dimensioning / Modeling, of hydroelectric units of various types, using literature, databases and software.
To attend this course, sufficient knowledge of the material of the following courses is strongly recommended: Hydraulic Turbomachines.

Team Project/s: C 40 % of the Final Grade

I. Anagnostopoulos, (G. Caralis)

(2.5.2252.7) New and Renewable Energy Sources (RES) (GR)

Introduction: RES and the energy problem - Historical evolution of energy technologies – The present situation: energy sources and energy consumption (worldwide, in Europe, in Greece) – Towards a sustainable energy future- The development of RES in Europe and in the world – RES in Greece – Short and long term perspectives of RES (worldwide, in Europe, in Greece). The potential of RES- Methods of analysis and estimation: wind potential – solar radiation – biomass – hydroelectric potential – geothermal resources – ocean waves/ ocean currents. Technologies - applications – systems of RES: Wind turbines- Passive solar systems – Bioclimatic architecture – Active solar thermal systems – Photovoltaic systems – Bioenergy – Small hydro – Marine energy systems – Geothermal energy– Hydrogen – Fuel cells. Techno-economic analysis of RES systems: Energy costs (conventional, environmental, external) –

Environmental impacts and their economic evaluation - Avoided costs of conventional fuels – Analysis of investments and their application in energy systems – Management of energy systems including RES.

Project/s: C 45 % of the Final Grade

(G. Caralis)

(2.5.2280.9) Gas Turbine Diagnostics (GR)

The need and importance for gas turbine engine condition monitoring. Relation to on-condition maintenance. Measured quantities and methods, data collection for monitoring. Systems and methods for condition assessment and fault diagnosis. Gas path analysis: direct methods, estimation methods, linear, non-linear. Trending.

Use of fast response measurements (sound, vibration). Elements of life assessment methods. Data evaluation, artificial intelligence methods. Jet engine testing, testing procedure, parameter corrections. The use of computers for monitoring methods support.

To attend this course, sufficient knowledge of the material of the following courses is strongly recommended: Mathematics A2, Statistics and Measurement in Engineering, Thermal Turbomachines, Dynamics and Vibrations.

Lab and Exercises: C 20 % of the Final Grade

N. Aretakis, K. Mathioudakis, (Ch. Romesis)

Manufacturing Technology

(2.6.2105.1) Metallic Engineering Materials [C] (GR)

Classification of materials. Crystalline structure of metals. Imperfections of crystal structure. Main physical properties of metallic materials. Mechanical properties and mechanical testing of metallic materials. Fracture of metals (ductile and brittle fracture and their characteristics). Equilibrium phase diagrams (binary and ternary). Study of the binary alloy Fe-C. Solid state phase transformations. Materials hardening mechanisms. Surface hardening processes for metallic materials (mechanical, thermal and thermo-mechanical). Industrial alloys (steels, cast irons, copper alloys, aluminum alloys, magnesium alloys, titanium alloys, super-alloys). Corrosion and protection of metallic materials.

Laboratory exercises: selection of three exercises from the following ones:

- Structure characterization of ferrous and non-ferrous alloys.
- Tension / compression testing of aluminium and steel alloys.
- Heat treatment of steels.
- Corrosion of metals.

Lab: C

G.-C. Vosniakos, D. Manolakos, A. Markopoulos, (P. Kostazos)

(2.6.2296.3) Non Metallic Technical Materials [C] (GR, EN)

- Polymers: Nomenclature of organic compounds, Polymerization reactions. Thermoplastics, thermosets, elastomers. Physical properties, crystallinity. Rheology, mechanical properties. Other properties, characterization of properties. Decomposition and recycling, Overview of forming methods. Typical applications (in mechanical engineering).
- Ceramic materials: Bonds, crystallinity, composition and structure of oxides, carbides, nitrides, silicates. Traditional versus advanced techniques. Typology: structural, functional, bioceramics, nano-ceramics, smart ceramics, etc. Physical, mechanical, electrical properties. Mechanisms of wear and failure. Raw material and overview of forming methods. Compression, sintering mechanisms.

- Composite materials: classification depending on matrix and reinforcement materials, laminates, fiber reinforcement, particle reinforcement, nanocomposites, bio-composites, etc. Determination of mechanical properties / failure and characterization / testing. Physical, thermal, electrical properties and characterization. Overview of forming methods. Typical applications in mechanical engineering. Life cycle analysis.
- Wood: Composition and microstructure, moisture, grains. Types (soft/hard). Physical (thermal, acoustic) and mechanical properties. Anisotropy. Overview of forming methods. Typical applications in mechanical engineering. Life cycle analysis.
- Special applications: Semiconductors and semiconducting devices. Magnetic materials. Superconductors.
- Biomaterials.
- Smart materials.
- Material Selection: Workflow. Related tools, databases and diagrams.
- Laboratory exercises:
  - Mechanical behavior of polymer matrix composite material.
  - Determination of the characteristic curve of a diode.
- Computational exercises:
  - Selection of materials for specific mechanical components

Lab: C

G.-C. Vosniakos, D. Manolakos, A. Markopoulos, (P. Kostazos)

(2.6.2156.5) Forming Processes by Plastic Deformation and Casting [O] (GR)

- Fundamental concepts of plasticity and applications in material forming processes by plastic deformation.
- Bulk metal forming processes (rolling, forging, extrusion, drawing, wire drawing). Friction/Lubrication. Residual stresses. Workpiece defects.
- Sheet metal forming processes (bending, shearing, deep drawing, stamping). Forming Limit Diagrams. Friction/Lubrication. Residual stresses. Workpiece defects.
- Metal casting processes: Consumable and permanent mold casting methods. Casting molds and design of gravity cast feeding systems. Castability. Casting equipment. Casting defects.
- Forming and casting processes for non-metallic materials:
  - Polymers: Overview. Extrusion, injection, thermoforming, compression.
  - Ceramics: Hydrated material, powders and glasses
  - Composites: polymer matrix, metal matrix and ceramic matrix.

Laboratory exercises: selection of 4 exercises from the following ones:
  - Metal plate rolling / Closed die forging / Metal billet extrusion
  - Deep drawing of sheet metal.
  - Metal casting in a consumable mold.
  - Polymer extrusion.
  - VARI of polymer matrix composite with fiberglass reinforcement.

Lab: C

G.-C. Vosniakos, D. Manolakos, A. Markopoulos, (P. Kostazos)

(2.6.2093.6) Manufacturing Processes: Material Removal, Welding and surface treatment processes [C] (GR, EN)

- Material removal processes using single-point and multi-point cutting tool with geometrically defined cutting edge. Cutting mechanics. Cutting tools and wear - Machinability. Turning, milling, drilling processes.

- Material removal processes using cutting tool with geometrically undefined cutting edges. Grinding mechanics. Grinding tools and wear. Finishing operations. Friction/lubrication. Cutting fluids. Residual stresses. Quality and integrity of machined surfaces.
- Material joining processes by welding: fusion welding, solid-state welding and soldering. Fusion - solidification of metallic materials. Welding technology (methods and equipment). Metallurgy of welds. Defects in welded parts. Weldability. Destructive and non-destructive testing of welds.
- Surface treatments: Solid state diffusion. Surface treatments for modifying properties. Coatings: methods, properties, characterization. Electrochemistry of coatings.
- Laboratory exercises: choice of 3 different exercises per year from the following:
  - Metal cutting on a lathe / milling machine / drilling: Cutting mechanics / tool wear
  - Grinding of metallic surfaces.
  - Fusion welding.
  - Electrolytic coatings.

Lab: C

G.-C. Vosniakos, A. Markopoulos, P. Benardos

(2.6.2222.8) Manufacturing Systems (GR)

Manufacturing System types, structure and operation. Equipment layout, product-, work- and information flow. Control levels. Cellular production: Group Technology, coding systems, Computer Aided Process Planning systems. Flexible Manufacturing Systems: flexibility types. Operations assignment and scheduling. Controller design based on Petri Nets. System Monitoring. Robotic Manufacturing Cells: industrial robot types, integration interfaces, on and off-line robot programming for machine tool tending and manufacturing processing. Analysis and Design of Manufacturing Systems using discrete event simulation. Computer Integrated Manufacturing: information integration, interfaces in Computer-Aided-X software systems, databases and local area communication networks. Optional assignments in four major topics of the syllabus.

Laboratory exercises: 1- Manufacturing System Simulation using specialised discrete event software. 2- Industrial robot programming for machine tool tending.

Lab: C 30 % of the Final Grade Project/s: O 10-70% of the Final Grade

D. Koulouriotis

(2.6.2207.8) Crash Analysis of Structures [C] (GR)

Fundamentals of Structural Plasticity. Elasto-plastic analysis of bar structures. Theorems of Limit Analysis. Limit analysis of bar structures. Limit analysis of plates and shells. Strain-rate effects. Residual strength of structures in the plastic domain. Introduction to Fracture Mechanics (basic principles, applications in materials failure). Creep, fatigue, failure. Crashworthiness of thin-walled structures. Impact energy-absorbing systems. Design and construction of active and passive safety systems. Crash tests. Basic principles of a specialized finite element code for modeling the crashworthiness of energy absorbing structures.

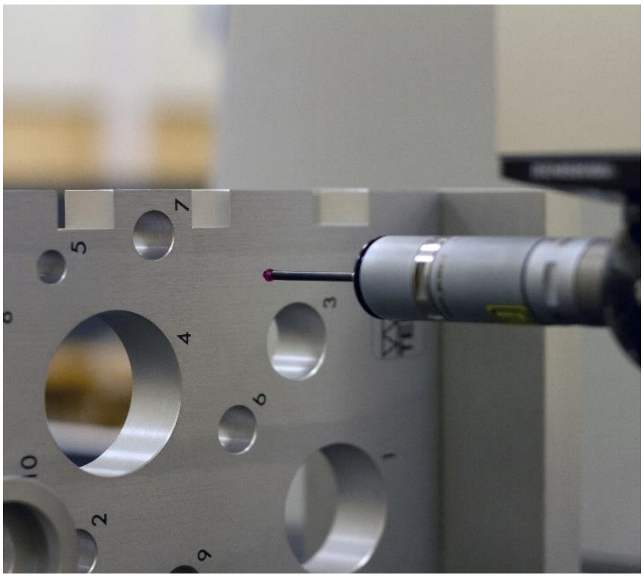
Laboratory exercises: 1. Static collapse of thin-walled structures. 2. Dynamic collapse of thin-walled structures.

Lab: C

(P. Kostazos)

(2.6.2035.7) Machine Tools [C] (GR)

- Modern machine tool types and kinematics. Technological evolution and impact in manufacturing.
- Machine tool structure: body, spindles, motors, guideways, sensors, position encoders, transmission. Fixtures and workholding elements.
- Computer Numerical Control of machine tools: Structure and functions of CNC systems. Interpolation methods and types. Motion control and adaptive control for manufacturing processes. Selection of CNC system main characteristics.
- Programming of CNC machine tools: Parametric programming and programming using CAM systems.



- Machine tool dynamics: Machining force fluctuation. Frequency response function. Forced vibrations. Chattering. Stability regions. Experimental determination of machine tool dynamic characteristics.
- Metrology of machine tools using laser interferometry: CNC axes positional accuracy. Angular errors. Composite errors. Volumetric error. Error/analysis and budgeting. Thermal errors. Use of metrology equipment.

Lab: C 20 % of the Final Grade Project/s: O 10-30% of the Final Grade

P. Benardos

(2.6.2277.9) Intelligent Manufacturing Systems (GR & EN)

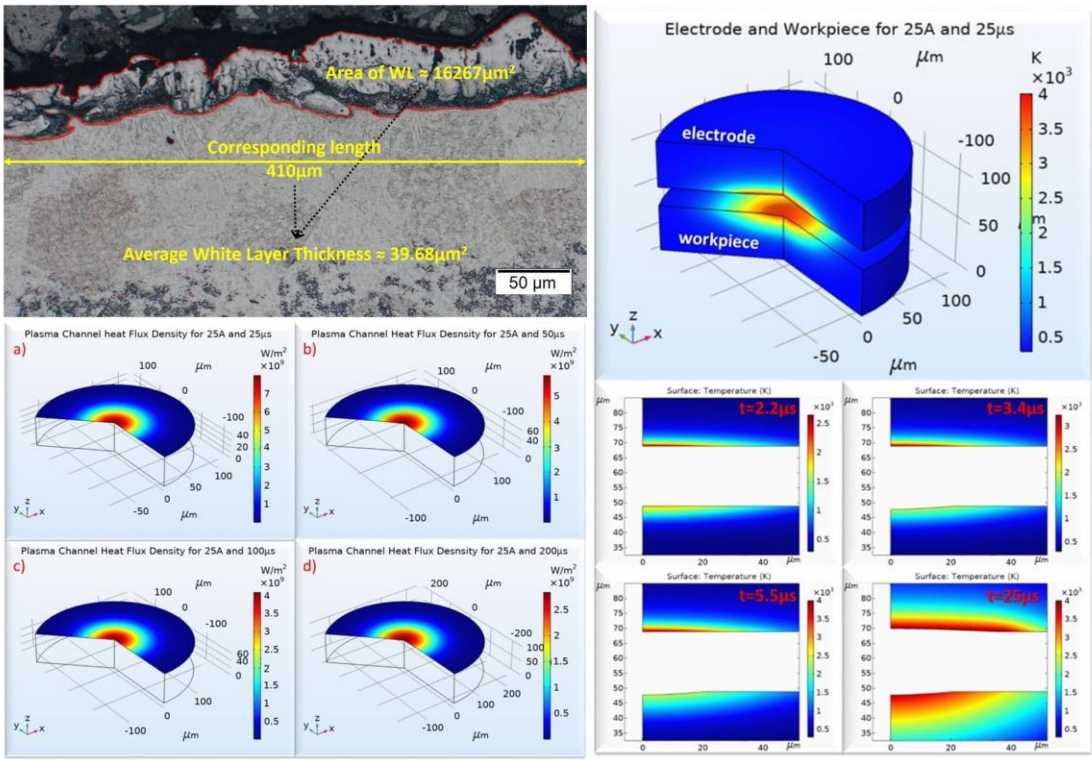
Problem solving in modern manufacturing systems using computational intelligence and other IT techniques. The students are introduced to advanced IT tools, such as: expert systems, artificial neural networks, evolutionary algorithms and fuzzy logic. Practical problem solving is emphasized through assigned coursework based on software development and use rather than in theoretical foundations of relevant tools and techniques. Standard topics dealt with are: Process Plan development. Definition and recognition of morphological features connected to particular manufacturing process types (material removal, sheet forming). Process parameter selection. Path planning, tool selection and feed scheduling in high speed milling. Machining time and surface quality criteria in machining operations. Manufacturing process control using quantitative and qualitative models. Transition from process parameter selection to process control. Manufacturing cell control: operation dispatching criteria (lead time, resource utilization etc.) Links to discrete event simulation. Manufacturing system design. Simplified process plans. Virtual Manufacturing Systems and case-based structure optimization. Manufacturing system diagnostics. Sensor based individual manufacturing process monitoring. Discrete state change monitoring in manufacturing systems.
To attend this course, sufficient knowledge of the material of the following courses is strongly recommended: Manufacturing Systems.

Lab: C 30 % of the Final Grade Project/s: C 70% of the Final Grade

D. Koulouriotis

(2.6.2278.9) Micro-Nanoprocesses [C] (GR & EN)

- Classification and distinction between macro-scale processes and processes that take place at the micro-nano scale.
- Scale phenomena that affect, differentiate, and have to be taken into account during the transition from macro-scale to micro- and nano-scale. How materials and the physical mechanisms are affected by the reference scale during material removal or material addition manufacturing processes.

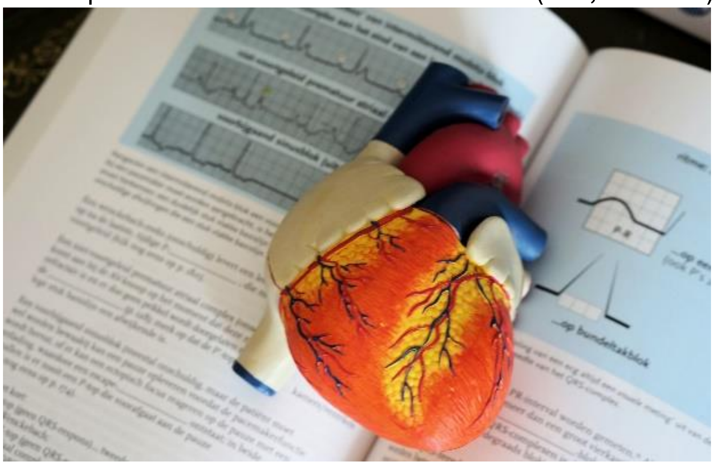


- Basic principles and definitions of the broader scientific field of Nanotechnology.
- Basic and typical methods and applications of Micro-nano Processes which include:
  - Photolithography with emphasis on the basic steps and fundamental principles of the process, i.e., photoresists, masks, etching, development, and silicon wafer etching conditions.
  - Microprocessor manufacturing using Photolithography.
  - Special topics in Photolithography with emphasis on improving radiation sources, resistances, and masks.
  - Mechanical Micro-cutting Processes with conventional processing mechanisms emphasizing on the study of scale phenomena.
  - Micro-cutting Processes with non-conventional machining methods.
- Microscopy and materials characterization methods:
  - Importance of microscopy in manufacturing in general, but especially in Micro-nano Processes.
  - Classification of different microscopy approaches.
  - Analysis of the Optical Microscopy method.
  - Analysis of the Scanning Electron Microscopy method (SEM).
  - Analysis of the Atomic Force Microscopy method (AFM).
- Highlighting the usefulness and additional value of Micro-nano Processes with real applications examples from the modern research and industrial environment.

(L. E. Papazoglou)

(2.6.2309.7) Additive Manufacturing Processes [O] (GR)

- History-development and typology.
- Material Extrusion (FDM, FFF): Mechanics of material flow through a nozzle. Printing of polymers, biopolymers and polymer matrix composites. 3D printer configuration and motion control. Robotic arms as 3D printers. Process parameters, 3D printer parameters and connection to part quality.
- Selective laser sintering and melting (SLS/SLM): Laser-matter interaction during sintering and melting. Melt pool, solidification, transformations of metallic materials. Sintering of non-metallic materials. SLS/SLM machines: configuration and control based on melt pool characteristics. Process parameters, machine parameters and connection to part quality.
- VAT polymerisation (SLA): Resin polymerisation using monochromatic light and other sources. SLA machines and control of layer thickness. Process parameters, printing parameters and connection to part quality.
- Other methods (direct energy deposition-DED, material jetting, binder jetting, sheet lamination): Physics of material joining. Functional principles of pertinent machines. Process parameters, constraints and part quality.
- CAD/CAM Interfaces: Layer design, path design, pertinent constraints and optimization. CAM systems and slicers for layer and path definition. Relevant standards (STL, AMF etc).
- Process selection – case studies: Comparison to conventional processes and to the rest of AM processes. Post-processing. Survey of the range of materials that can be processed in general applications. Special applications of materials and methods in biomechanics, biomedicine, aerodynamics. Future applications and new materials outlo.



To attend this course, sufficient knowledge of the material of the following courses is strongly recommended: Metallic Technical Materials, Non Metallic Technical Materials.

Lab: C 15 % of the Final Grade Project/s: C,O 20% of the Final Grade

G.-C. Vosniakos

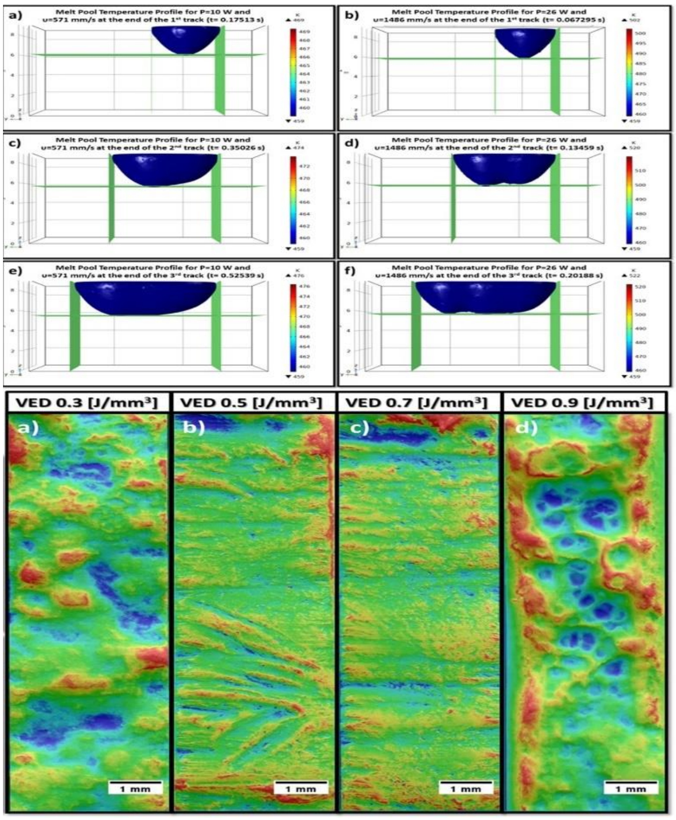
(2.6.2267.9) Technology and Mechanics of Composite Materials [C] (GR)

Fabrication of composite materials: Classification and terminology. Matrix and fibre materials. Fabricating processes. Advantages and limitations of composites. Industrial applications. Mechanical behaviour of composite materials: Elastic constants of an orthotropic lamina, stress-strain relations of anisotropic materials, failure criteria of orthotropic materials. Lamination theory for laminated composites (coding, stress-strain relations, equilibrium equations, combined stresses of composite plates and shells, failure criteria). Sandwich hybrid structures. Fatigue, impact, delamination. Effect of temperature/fire/moisture/aging on the degradation of composites. Experimental characterization of composite materials and related laboratory exercise. Construction and mechanical testing/properties of a composite material. Micro and macroscopic failure/fracture examination.

(P. Kostazos)

(2.6.2060.8) Non Conventional Manufacturing Processes [C] (GR)

- Definition of non-conventional processes and the reason for a clear distinction between conventional and non-conventional processes.
- Understanding the basic physical and chemical mechanisms that take place and are used in each of the different Non-Conventional Processes.
- Understanding the effect and interaction of the physical and chemical mechanisms on the final outcome and efficiency of the process.
- Understand the capabilities and limitations of each process and relate them to specific kinds of materials and specific manufacturing requirements.
- Understanding of the basic structure of Non-Conventional processing machine-tools and systems
- Understand the concept and advantages of designing hybrid systems and machining arrangements.



- Based on the above and taking into account the Non-Conventional Processes taught, the content is specialised in:
  - Physical Mechanisms of Electrodischarge Machining (EDM).
  - Physical Mechanisms of Fluid Jet Machining.
  - Introduction to laser systems and physical mechanisms during the interaction of high power density electromagnetic radiation with common engineering materials.
  - Physical and chemical mechanisms in chemical and electrochemical materials processing applications.

Lab: C

A. Markopoulos

Inter-Sectors Courses

(5.1.2161.8) Thermal and Chemical Processes [O] (GR)

Introduction to AspenPlus software through simulation of thermal and chemical processes related to energy storage technologies such as: Carnot-battery systems for energy/heat storage via high temperature heat pumps, Thermo-chemical storage, Waste heat recovery and thermal integration/upgrading, Chemical processes for synthetic fuel production (efuels), Fuel/gas separation/purification processes, Substitution of conventional fuels with synthetic fuels and hydrogen, Energy storage via compression.

Project/s: C 100 % of the Final Grade

*K. Braimakis, (*D. Katsourinis*)*

(2.3.2012.1 & 2.6.2012.1) Mechanical Design I [C] (GR)

Drawing standards (Paper size. Drawing scales. Types of lines and their use). Orthogonal and auxiliary views. Dimensioning of engineering drawings and dimensional tolerances. Section views. Fundamentals of descriptive geometry (Intersections and developments). Threads, Bolts, Nuts, Washers. Introduction to mechanical design. Computer aided design/drafting (CAD) and applications. Techniques for 3D CAD modeling of parts and creation of the relevant 2D drawings. Practice on 3D CAD software. The course is complemented with six (6) exercises of free hand sketching and drawings of real machine components and mechanical design labs.

Free hand sketch (5): E 15 %, CAD Drawing (1): C 15%

Oral Exams on mechanical design labs: C 10%

D. Koulocheris

(2.3.2147.2 & 2.6.2147.2) Mechanical Design II [C] (GR)

Drawing of bolted connections and machine elements (bearing, gears, pins, wedges, bearings). Assembly drawing. Drawings of welded components. Hole and shaft fits. Geometrical tolerances. Surface roughness. 3D CAD modeling of assemblies and welded structures. Use of Toolboxes. Creation of assembly drawings. Advanced tools for drawing & control. Practice on 3D-CAD software.

The course is complemented with six (6) exercises of free hand sketching and drawings of real machine assemblies and mechanical design labs.

Free hand sketch (5): E 15 %, CAD Drawing (1): C 15%
Oral Exams on mechanical design labs: C 10%

D. Koulocheris

(2.2.2261.7, 2.1.2261.7) Energy Management (GR)

- Introduction to Energy Management – Legislative & Regulatory Framework.
- Description of the Energy Profile of Facilities and Processes.
- Methodology of an Energy Audit – Data Collection & Analysis – Evaluation of Energy. Performance Indicators – Baseline demand.
- Examples of Energy Inspections and Audits in Various Facilities.
- Recommended Technologies and Measures for Energy Upgrading in Industry and Building Applications.
- Methodology, Techniques, and Mechanical Equipment for the Supply Chain of Fuels and Biofuels.
- Ways to Utilize Thermal Energy – Costing – Pricing of Thermal Energy.
- Study of Modern Electricity Markets – Daily Energy Scheduling.
- Electricity Market Clearing and Marginal Prices – Investment Analysis of Large Energy Projects.
- Extension of Topics 6–10 to Modern Flexible Loads – Methods of Energy Storage and Related Benefits.

S. Karellas, A. Tolis, (P. Pallis)

(2.4.2255.8) Materials Testing Using Radiografy and Ultrasound (GR & EN)

Radiography testing

Properties of ionizing radiation. X ray producing devices for industrial radiography. Principles of radiography techniques. Film radiography. Digital radiography basics. Exposure calculations. Quality control of radiography images. Interpretation of radiography images with emphasis on weldings images. Principles of computed tomography. Radiation protection basics. Quality standards and quality control. Radiography Laboratory work in four parts: 1) Film development. 2) Radiography of a standard step wedge specimen - measurement of optical density. 3) Radiography of weldings. 4) Radiography of a random specimen.

Ultrasound testing

Elements of ultrasound theory (wave propagation in elastic solid media - wave propagation properrties at frre boundaries and interfaces - critical propagation angles). Locating defects using ultrasound (ultrasound testing theory, ultrasound equipment, piezoelectric transducers, phased array ultrasonics, attenuation, scattering, dispersion, ultrasound testing set ups, assessments of detectable defects with focus on crack detection). Ultrasound Laboratory in one part: thickness measurements and locating of defects in weldings.

Lab: C

N.P. Petropoulos, D. Koulocheris

(2.5.2197.8, 2.6.2197.8) Introduction to the Aircraft [C] (GR)

This is an introductory course aiming at setting the basis for the subsequent courses related to the dimensioning of an aircraft, its propulsion system and the structural design. It is attempted to provide the students with fundamental knowledge on the basic quantities relevant to the geometry of the aircraft, basic physical principles and the performance of the aircraft and its components. Then, through a historical review of the evolution of aircrafts and analysis of its basic components, the progress in aircraft design and the current state-of-the-art, as well as the goals and expectations of aircraft design in the future are explained. Data

regarding costs of the aircraft design are presented and a preliminary dimensioning of the aircraft is attempted. Regarding aircraft materials, it is attempted to present the fundamental knowledge (on loading, operation and construction of structural elements, principles of static and dynamic analysis, crashworthiness) in order to evaluate the characteristics of each material, as well as explain the special requirements for the aircraft structures. Supersonic flows and applications in cases of flow around an axisymmetric body and aircraft wing.
To attend this course, sufficient knowledge of the material of the following courses is strongly recommended: Fluid Mechanics I.

S. Voutsinas, D. Manolakos, A. Markopoulos (P. Chasapogiannis)

(2.1.2291.8, 2.3.2291.8) Operation and Maintenance Management [C] (GR)

Introduction to plant operation & maintenance. Management of technical objects. Maintenance planning and control (preventive maintenance, order management, repair jobs). Organization of maintenance operation. Replacement of Equipment: replacement with similar equipment, replacement with advanced equipment, continuous technological improvement. Spare Parts Replacement and Equipment Maintenance: renewal theory, replacement of individual components, replacement of technical system components, inspection and maintenance problems. Reliability of Technical Equipment: definitions, calculation of reliability of technological systems, determination of optimum level of reliability. Analysis and evaluation of damages and investigation of their causes in machines and mechanical constructions. Use of instruments and industrial software. Typical types of machine and device / system components failure in industry. Real-time logging methods and sample failure recording and machine operation condition. Destructive and non-destructive testing methods. Calculation of residual life and decision change / replacement. Temporary repair - replacement solutions and their implementation methods. Lubrication and determination of inspection-refill-change intervals. Attention and risk indicators. Technical methods for dealing with exceptional failures in Industry.

A. Tolis, V. Spitas, (S. Gayialis, V. Kapsalis)

(2.0.2288.9) Innovative design of mechanical products [all courses] (GR)

- A design project by groups of 2-3 students, guided by Faculty of the School weekly
- The identification of an innovative product or service by the students themselves is encouraged, but specific topics are also suggested by Faculty memebers
- Supporting lectures: (a) TRIZ Method (b) Failure Mode and Effects Analysis, Quality Function Deployment (c) Design for Manufacture / Assembly Methods (d) Industrial Patenting.
- A lecture by invited industry experts.
- The School, through the relevant equipment of its laboratories, facilitates the manufacture of prototypes and covers any costs as far as possible.

Project/s: C 100 % of the Final Grade

G.-C. Vosniakos, D. Nathanail

(2.2301.9) Internship (equivalent course) (GR)

The objective of Internship is the acquisition of practical experience by the students in scientific areas related to the position of a Mechanical Engineer. The Internship can be offered after the completion of the 6th Semester in case that the student has not failed in more than nine (9) modules from the first six semesters. It is performed in places where the professional practice of a Mechanical Engineer takes place, such as factories, design offices, construction sites, laboratories of industrial research etc. Internship is supervised by an Instructor of the School of Mechanical Engineering. The evaluation of a student's Internship is performed by the supervisor and gets a "pass" or "fail" mark.

http://www.mech.ntua.gr/gr/studies/ugrads/praktikimech

Project/s: C 100 % of the Final Grade

Scientific Responsible: N. Panayiotou

(ALL SECTORS. 2301.8) Computational Project [all courses] (GR)

Professors

Courses given by other schools

(9.2.2008.1) Mathematics A1 (Functions of one variable) [C] (GR)

Convergence of real sequences, Cauchy sequences, completeness and Bolzano-Weierstrass theorem. Series of real numbers, convergence of series, special convergence tests (geometric series, telescopic series, ratio and root test, simple comparison test, limit comparison test, alternating series test of Leibniz, integral test). Absolute convergence. Power series, radius of convergence. Differentiation of a power series.

Taylor's formula. Real functions of one real variable. Overview of basic concepts of differential calculus. The main elementary functions (exponential, logarithmic, trigonometric and hyperbolic functions and their inverses). The indefinite integral. Integration by parts and change of variable. Integration of rational functions- partial fraction expansion. Integrals which can be converted into rational ones by rational, trigonometric or hyperbolic substitutions.

Definite integral. Riemann sums. The fundamental theorem of Integral Calculus. Change of variable. Applications to Geometry, Physics and Mechanics (calculating of: the arclength, the area of a planar surface, the volume of a solid of revolution, the area of a surface of revolution, mass center, moment of inertia, work of a power, etc). Integral form of Taylor remainder. Integration of a power series. Expansion of a function into Taylor and MacLaurin power series. Improper integrals. Convergence of improper integrals. Comparison convergence tests. Beta and Gamma functions. Applications.

I. Gasparis

(9.2.2143.1) Mathematics A2 (Linear Algebra & Analytic Geometry) [C] (GR)

- Matrices, matrix algebra (addition, scalar multiplication, matrix multiplication), invertible matrices, matrix trace, basic properties.
- Matrices of special forms, transpose matrix, Hermitian matrix.
- Determinants, basic properties, computation methods for determinants, adjoint matrix, computation of inverse matrix.
- Linear systems, Gauss elimination method, Cramer's method, homogeneous and inhomogeneous linear systems.
- Echelon form and reduced echelon form of matrices, matrix rank, Gauss-Jordan method and computation of inverse matrix.
- Vector spaces, subspaces, linear combination of vectors, linear independence of vectors, basis of vector space, dimension of a vector space.
- Linear maps, kernel and image of a linear map.
- Eigenvalues and eigenvectors of a square matrix, characteristic polynomial, Gayley-Hamilton Theorem, minimum polynomial, matrix diagonalization under similarity.
- Vectors in 3-dimensional space, definitions and basic properties.
- Inner product, cross product and mixed product of vectors.

- Straight lines and planes in 3-dimensional space.
- Curves and surfaces in 3-dimensional space.

P. Psarrakos, A. Doumas

(9.4.2170.2) Physics (Electricity and Magnetism with Optics) [C] (GR)

Simple harmonic oscillator, oscillations with damping and external force, quality factor and resonance. Coupled oscillations and normal vibrating modes (eigenfrequencies and normal coordinates). Mechanical waves in continuous elastic media in one dimension. Travelling waves: energy transfer, characteristic impedance of elastic media, reflection and transmission of travelling waves along a discontinuity. Wavepackets, dispersion, phase velocity, group velocity. Waves in two dimensions. Waves in three dimensions (acoustic, electromagnetic waves). Interference and diffraction (basic principles).

Lab Work: C 20% of the Final Grade

G. Smyrlis

(9.1.2048.1) History of Science and Technology (GR)

The course deals with the history of science from the Renaissance until the 20th century by systematically following landmark "episodes" such as the shift of the cosmological model and the scientific revolution, the theory of evolution, genetics, nuclear physics and modern cosmology. Meanwhile, the course also focuses on a sociological discussion of the relationship of science with war, technology and gender, which are issues that are closely related to the whole evolution of modern science.

G. Mavrogonatou

(9.1.2050.1) Sociology of Urban Civilization & Technology (GR)

The course investigates the societal and spatial aspects of technology as a complex phenomenon, which encompasses fundamental notions, such as social phenomena, the cultural turn, the distinction between tradition and modernity, the definition of science and technology, the relationship of technology with globalization, socio-geographical issues, as well as the technological determinism. These aspects of technology are examined along with an outline of the theories of the major Sociology contributors. The students' involvement in the discussion concerns issues of science and technology, urban space and technological parameters, as well as the ways that daily life and culture are influenced by them. The discussion that takes place during the course focuses on the ethical, political and cultural aspects of technology and science, as well as their implication in the process of collective identities' creation within the contemporary multicultural/globalized space. The course's discussions aim to a better comprehension of social exclusion within contemporary urban spaces, the relationship of environment with culture and civilization, the assessment of technology's impact on climate change, the role of communication networks in the shaping of social relations and identities, etc.

K. Theologou (cooperation with: Dr. A. S. Papazafiropoulou)

(9.1.2199.1) Introduction to Philosophy (GR)

The definition of philosophy and its basic ideas. Branches and periods of Western Philosophy. Systematic presentation and analysis of its central problems, such as the validity of knowledge, science, truth, the existence of God, causality, mind and matter, the external world, universal concepts, free will, language and reality, ethics. The significance and usefulness of Philosophy today.

(S. Stelios)

(9.1.2221.1) Political Economy

The aim of the course is to introduce students to the basic concepts of economic theory, giving them a concise picture of how the Greek and international economies work. Particular emphasis is given to understanding the market processes, the factors that shape the volume, the distribution and the evolution trends of the Gross Domestic Product, the role of the state in the economy and the processes of economic globalisation with a special emphasis on the European integration.

P. Michailides, (N. Progoulis)

(9.3.2248.1) Mechanics A - [C] (GR)

Part A - Statics:

Vector analysis. Forces, moments, force-systems reduction, reduction to a wrench. System and center of parallel forces, distributed loads. Structures/frames and support types, degrees of freedom in the two- and three-dimensional space. Statical determinacy and rigidity of structures/frames. Support-reaction forces, free body diagram, and equilibrium equations. Compound structures/frames, Gerber beams, three-pin frame. Statically determinant and rigid trusses (simple and compound), solution by the methods of joints, Ritter sections, and Henneberg bar exchange method. Beams and Frames, internal axial forces N, shear forces Q, bending moments, and M, Q, N diagrams. First moment of area, centroids. Second moment of area. Friction with applications to simple machines (wedges, square-threaded screws, belts).

Part B - Introduction to Dynamics of Particles:

Kinematics of particles: Position, displacement, velocity and acceleration in rectilinear and curvilinear motion. Plane and spatial Cartesian, radial, angular, and trajectorial components of velocity and acceleration. Motion in a translational coordinate reference, relative velocity and acceleration in rectilinear motion. Kinetics of particles: Newton's laws. Differential equations of motion in Cartesian, radial, angular, and trajectorial components. Linear and angular momentum (central forces). Work, kinetic energy, principle of work and kinetic energy. Potential energy, Principle of total mechanical energy for conservative and non-conservative forces. Principle of impulse and momentum (non-impulsive and impulsive forces). Impact.

G. Exadaktilos, (X. Makrides)

English Language [1st, 2nd, 3rd] (GR)

The English language course aims at familiarising students with language use in a variety of social contexts and communicative tasks (development of linguistic awareness). A range of practical activities in advanced syntactic structures are regularly provided along with activities designed to develop understanding and production of both spen and written language in social, academic and professional settings.

G. Togia

English Language [4th] (GR)

The aim of the course is to introduce students to technical terminology relating to the field of Mechanical Engineering through the use of texts from a variety of sources. More specifically, the course focuses on:

- Familiarising students with technical terminology specific to their discipline.
- Analysing the linguistic features of academic writing.
- Examining the structure and language of research articles and articles in popular science magazines.
- Examining the features of other academic genres, such as research abstracts and literature reviews.

By the end of the course, students will be able to:

- Understand what technical language is and how to approach academic/technical texts.
- Understand the features of academic writing.
- Extend their reading and writing skills.

G. Togia

(9.2.2292.2) Mathematics B [C] (GR)

The n-dimensional Euclidean space. Elementary topological concepts in Euclidean space. Real and vector-valued functions. Limits and continuity.

Differential Calculus: Partial derivatives and differentiability. Tangent planes and perpendicular vectors for smooth surfaces. The directional derivative. Partial derivatives of higher order. Differential operators (gradient, divergence, curl). The differential of a vector-valued function. The chain rule. Differentials of higher order. Taylor's formula. The inverse function theorem. The implicit function theorem. Local extrema for functions of two or three real variables. Extrema under constraints. Lagrange multipliers. Applications.

Integral Calculus: The double and the triple integrals (Riemann sums, Iterated integrals, Fubini's theorem, Jordan measurability). Multiple integration techniques on elementary domains. Change of variables formula. Applications to Geometry, Physics and Mechanics (Calculating area, volume, center of mass and moments of inertia). Curves and surfaces in Euclidian space of dimension at most three. Contour (path) integrals. Green's theorem.

Path independence of a contour integral. Applications to Geometry and Physics (calculating areas, arc-lengths, center of mass, moments of inertia, work done by a force etc.). Surface integrals. Gauss Theorem (divergence). Stes Theorem. Applications to Physics and Mechanics.

J. Gasparis

(9.3.2010.3) Mechanics C [C] (GR)

Unsymmetrical bending of beams. Bending and Tension/Compression. Elastoplastic bending. Method of the elastic curve. Transverse shear and shear flow of thin-walled beams. Torsion of thin-walled beams with open and closed sections. Beams under combined loadings. Failure criteria (von Mises, Tresca, Coulomb). Energy methods (Reciprocal theorems, unit load method), Principle of Virtual Forces, Statically Indeterminate Systems. Buckling of elastic beams.

P. Gourgiotis, (Ch. Markides)

(9.03.2297.2) Mechanics B (Introduction to the Mechanics of Deformable Body, Strength of Materials) (GR)

- Introduction to the mechanics of deformable solid bodies. Load types, supports, and various stress types are discussed, including assumptions and material properties. Definitions of isotropic, homogeneous, and continuous bodies are provided. Fundamental principles such as Saint-Venant's principle and the superposition principle are introduced, along with the concept of equivalent parallel force transfer, free body diagrams, the section method (Ritter), and internal stress magnitudes.
- Stress concepts, definitions, and applications include axial stress and strain in elastic bars and rods, with explanations of normal and shear stresses. Key terms like stress vector and stress tensor are covered in both 3D and 2D stress states, along with stress transformations, principal stresses and directions, and Mohr's circle.
- Strain fundamentals explore axial deformations (tensile and compressive) in elastic rods, thermomechanical behavior, and the theory of small deformations. The relationship between strains and displacements, stress-strain diagrams under axial load for simple elastic and elastoplastic structures (including loading, unloading, and residual stresses and strains), ductile and brittle materials, Hoe's law, and modulus of elasticity are also discussed. Definitions of strain in general stress, strain tensor in 3D and 2D, transverse deformations, Poisson's ratio, and bulk modulus are outlined. Strain transformations, principal strains, Mohr's circle are included. Strain recording equipment (strain gauges) is described.
- Generalized Hoe's law is presented, alongside fracture mechanisms of ductile and brittle materials, statically indeterminate problems, strain compatibility, and differential equations of equilibrium.
- Technical torsion theory for cylindrical rods covers shear stress, torsion, and torque in rods of variable cross-sections, elastoplastic torsion, and statically indeterminate problems.
- Technical theory of simple pure bending of beams with symmetric cross-sections along the axis includes 2^{nd} moment of area, stress-strain relations, radius of curvature, internal stress magnitudes, equilibrium equations, bending of composite cross-sections, and elastoplastic bending.
- Pressure vessels with thin and thick walls include stress determination and failure criteria for cylindrical and spherical vessels, and a summary of volumetric behavior.

G. Tsiatas, A. Antoniou

(9.2.2283.3) Mathematics C (Ordinary and Partial Differential Equations) [C] (GR)

Ordinary Differential Equations. Introduction: Basics, Orthogonal Trajectories, Initial-Boundary Value Problems. Linearity versus Nonlinearity and Natural Phenomena. First Order Ode's: Separable Variables, Exact Equations, Integrating Factor, Linear Equations, Bernoulli and Riccati Equations, Homogeneous Equations, Lagrange and Clairaut Equations. Linear Equations: Basics, Fundamental Theorems for homogeneous equations, Homogeneous Equations with Constant Coefficients, Nonhomogeneous equations: Undetermined Coefficients Method (Euler), Variation of Parameters Method (Lagrange). Series Solutions: Series and Sequences of Functions, Series Solutions near an ordinary point, Legendre Equation, Series Solutions near a regular singular point: Fuchs and Frobenius Theory, Bessel Equation. Systems of Odes: Basics, Elimination Method, Fundamental Theorems for Homogeneous Systems, Homogeneous Systems with Constant Coefficients, Nonhomogeneous Systems. Laplace Transform: Basics, Properties, Inverse Laplace Transform, Applications for Odes, Heaviside function, δ-Dirac Function, Convolution. Stability: Basics, Linear Systems, Almost Linear Systems- Linearization, Lyapunov Method. Partial Differential Equations: Introduction: Basic Equations of Mathematical Physics, Classification, Initial-Boundary Value Problems. D' Alembert Solution for the Wave equation. Fourier Series: Basics, Convergence theorems, Fourier Sine and Cosine Series, Bessel Inequality, Equality Parseval, Properties. Boundary Value Problems: Linear Boundary Value Problems, Eigenvalue Problems, Sturm-Liouville Problems: Properties, Regular-Periodic-Singular Eigenvalue Problems. Bounded Domain: Separation of Variables, Cartesian - Polar - Cylindrical - Spherical Coordinates for Elliptic, Parabolic, Hyperbolic Equations. Unbounded Domain: Laplace and Fourier Transforms and applications to Elliptic, Parabolic, Hyperbolic Equations.

D. Gintides, (E. Protopappas)

(9.1.2028.9) Elements of Law and Technical Legislation [9o ΜΜΠ (C)] (GR)

Fundamentals of Law. A general overview of the concept of law is followed, encompassing the explanation of the basic legal concepts and the main legal relationships that are created and included in the following branches of law: Public Law (Constitutional Law, Administrative Law). European Union law. Private law. Civil Law (General Principles, Law of Obligations, Property Law). Commercial Law (Commercial Law, Corporate Law, Securities Law). Workplace accidents / Engineer's responsibility. Technical legislation. Legislation for the Construction of Public Works (types of tendering procedures, contracting, abnormal development of the contract, contractors, etc.). European Community legislation on the construction of public works (European Union directives, adaptation decrees).

E. Tzanini