Learning agreement
TUM

Cours obligatoires :

TUM		EPFL
~~Engineering Dynamics (MW2098)~~ ~~5 ECTS~~	~~The energy and variational principles of analytical mechanics have gone a long way since the axioms of Newton. Today they are found in the extremely successful test- and simulation software used in industry (e.g. experimental modal analysis, multi body simulations, finite element codes, etc.). The aim of the lecture is to equip the student with the most important basics and "thought concepts" for understanding the different methods and classifying them. The student will therefore be well prepared for a more thorough study of the different application fields of mechanical theories and specialization areas. An ambitious goal! Starting with the principle of virtual work, we will derive the Lagrange and Newton Euler equations step by step. These methods will allow us to derive the equations of motion for complex mechanical systems (automatically). By linearizing of the (often highly non-linear) equations we will be able to examine the stability of systems around an equilibrium position and introduce the fundamentally important concepts of modal analysis and model reduction. To conclude the lecture, we will derive analytical methods to solve the differential equations of motion for one-dimensional continua (bars and beams). The more generally applicable approximation methods such as Rayleigh-Ritz and the FEM, will be derived in the context of the virtual work principle and their convergence will be studied with the comparison to the analytical solutions. The lecture is structured as follows: 1) Analytical dynamics 2) Dynamics of rigid bodies 3) Linearized equations of motion around an equilibrium position 4) Stability of systems around an equilibrium position 5) Vibration modes and mode superposition 6) Linear dynamics of continuous systems and discretization~~	~~ME311 Dynamique des systèmes mécaniques~~
Dynamics of mechanical systems (0000001774) 5 ECTS	The development process of high-tech products can, in many cases, not be subdivided into separate "physical fields of expertise" anymore. Similarly, in structural dynamics the multi-physical couplings are often essential for understanding and designing the system behavior. Some prominent examples include: vibro-acoustics (e.g. in vehicle-acoustics), electro-mechanical couplings (e.g. in micro systems) or thermo-mechanical couplings (e.g. in satellites). The course is aimed at students of all technical fields of study (e.g. mechanical engineering, electrical engineering, physics, etc.). We start with the derivation of the most fundamental methods used in engineering dynamics, before the multi-physical couplings are studied in more depth. The course is structured as follows: 1. Basics of analytical mechanics (principle of virt. work and Lagrange equations) 2. Introduction to vibration analysis of structures (free and forced response) 3.	~~ME311 Dynamique des systèmes mécaniques~~

	Basics of rotor dynamics 4. Discretization methods for dynamical systems (Rayleigh Ritz and FEM) 5. Vibro-acoustics 6. Electrostatic forces in mechanical systems 7. Piezoelectric effects in smart structures 8. Thermo-mechanics	
Advanced Control (MW1420) 5 ECTS	Das Modul "Advanced Control" bietet eine Einführung in den Zustandsraumansatz für den Regler- und Beobachterentwurf linearer dynamischer Systeme. Ausgehend von typischen Steuerungsaufgaben stellen wir die Reglerstruktur mit zwei Freiheitsgraden (2DOF) vor. In einem einheitlichen Framework betrachten wir das Design von Feedforward- und Feedback-Controllern und nutzen verschiedene kanonische Zustandsdarstellungen für das Controller- und Observer-Design. Als Alternative zur Eigenwertplatzierung führen wir den LQR-Ansatz zur optimalen Auslegung von State-Feedback-Reglern ein und erweitern unsere Reglerstruktur, um Maßnahmen zu ergreifen, um externen Störungen entgegenzuwirken und das Einschwingverhalten des Regelkreises zu verbessern	ME321- Control systems
Nichtlineare Kontinuumsmechanik 5 ECTS	Kontinuumsmechanik ist eine Theorie, um das globale Verhalten, beispielsweise Verformungen, Spannungen oder Temperaturen, von Festkörpern, Fluiden oder Gasen unter externen Einwirkungen zu beschreiben. Nichtlineare Kontinuumsmechanik ist in der Lage, eine Vielzahl von technischen Anwendungen zu modellieren. Inhalt: (1)Grundlagen der Tensorrechung (2)Bewegung und Kinematik (3)Bilanzgleichungen (4)Konstitutive Beziehungen (5)Ein kurzer Blick auf spezielle Lösungen	ME331- Solid mechanics
Experimental vibration analysis (MW1995) 5 ECTS	After finishing this module lecture students are able to distinguish different types of vibration phenomena in the dynamics of machinery and structures. They can identify these different types for certain problems in real objects. Students are familiar with the basics to design a measurement plan for vibration analysis. Furthermore students have the ability to use this knowledge for analysis in real industrial problems. Students have a literature survey and a reference book for further problems in vibration analysis	ME332- Mécanique vibratoire
Heat mass transfer (MW1410) 5 ECTS	Einführung in die Mechanismen der Wärmeübertragung **Grundbegriffe der Wärmeleitung** • Fourier‘sches Gesetz der Wärmeleitung • Fourier‘sche Differentialgleichung • Zeitliche und örtliche Randbedingungen **Stationäre Wärmeleitung** • Einfache Geometrien (Platte, Zylinder, Kugelschale) • Péclet-Gleichungen (Platte, Zylinder, Kugelschale) • Zweidimensionale stationäre Wärmeleitung (Formfaktoren) **Konvektiver Wärmeübergang und Nußelt-Zahl**	ME341- Heat and mass transfer

	• Strömungsphysik des konvektiven Wärmeübergangs • Korrelationen für die Nußelt-Zahl bei relevanten Konfigurationen **Freie Konvektion** • Freie, laminare Konvektion an der isothermen Wand • Boussinesq-Näherung der Grenzschichtgleichungen • Kennzahlen der freien Konvektion • Korrelationen für freie Konvektion **Wärmestrahlung** • Schwarze Körper • Diffuse Strahler • Kirchhoff'sches Gesetz • Wärmeübertragung durch Strahlung • Wellenlängenabhängigkeiten der Wärmestrahlung **Wärmeübertrager** • Dimensionslose Kennzahlen • Betriebscharakteristik • Mittlere logarithmische Temperaturdifferenz **Instationäre Wärmeübertragung** • Methode der Blockkapazität • Die dimensionslosen Kennzahlen von Biot und Fourier **Kennzahlen und Ähnlichkeitstheorie** • Dimensionsanalyse und Buckingham-Pi-Theorem • Auslegung von Modellversuchen • Darstellung experimenteller Ergebnisse • Reynolds-Analogie	
Fluid Mechanics 1-MW2021 6 ECTS	Die Studierenden verfügen nach erfolgreichem Bestehen der Vorlesung Grundlagen der Fluidmechanik I über: (1) Kenntnisse des grundsätzlichen Verhaltens flüssiger und gasförmierg Medien, (2) die Fähigkeit zur kinematischen Beschreibung von Strömungen, (3) die Fähigkeit zur dynamischen Analyse von Strömungen anhand der Erhaltungsgesetze für Masse, Impuls und Energie, (4) die Fähigkeit zur Beschreibung und Analyse einfacher kompressibler Strömungen, (5) die Fähigkeit zur Ermittlung einfacher exakter Lösungen der Navier-Stokes-Gleichungen, (6) das phänomenologische Verständnis des Effekts von Reibung und Turbulenz, (7) die Fähigkeit zur Analyse technischer Strömungen.	ME344- Mécanique des fluides incompressibles
Finite Elemente (MW0612) 5 ECTS	Inhalt der Veranstaltung ist die Modellierung von Strukturen, wie sie im Ingenieurwesen Verwendung finden, mit Hilfe der Finite-Element-Methode (FEM). Der inhaltliche Bogen spannt sich dabei vom Verständnis der Strukturmodelle bis hin zur Theorie und Funktionalität der FEM. Weiterführende Vorlesungen bauen auf dem Modul Finite Elemente auf. Inhalt: (1) Theoretische und numerische Ansätze zur Modellierung von Strukturen bzw. Festkörpern aus dem Ingenieurwesen (2) Interaktion von Modellierung, Diskretisierung und Lösung von Festkörpersystemen	ME372- Méthode des éléments finis

	(3) 3D/2D Festkörper: Erhaltungsgleichungen, FE-Diskretisierung, Variationsprinzipien, Lösungskomponenten und Anwendungen (4) "Locking"-Phänomene, robuste Elementformulierungen (5) Balken- und Plattenmodelle (6) Einführung in die numerische Dynamik	
Electrical Machines EL8028 5 ECTS	Position dependent inductances, space vector description of electrical machines: fundamental wave and harmonic waves, force and torque calculation: fundamental torque and harmonic torques, laws of growth and scalability; General performance of electrical machines: rotating field machines (induction machine and electrically excited synchronous machine) , synchronous and asynchronous torques, windings: distributed windings and concentrated windings, permanent magnet excitation in electrical machines	EE382- Electrical Machines

Total cours obligatoires : 41 ECTS

Cours non obligatoires :

TUM	Description
Renewable Energy Technology 1 & 2 (MW1475 & MW1476) 6 ECTS	The objective of this lecture is provide an overview on the current state and application of renewable energy technology. The lecture not only focuses on technologies but also on environmental, social and economical factors that lead to the intensivied world wide harvesting of CO2-neutral energy sources as well as their potentials and limitations. The course RENEWABLE ENERGY TECHNOLOGY (taught in English) is split into two modules 3 ECTS each (one per semester), beginning with “RET I” in the Winter Semester. The attached module “RET II” will be offered in the Summer Semester. The course is supported by various institutions of the TUM: The Institute for Energy Systems, The Institute for Fluid Mechanics, The Institute for Energy Economics and Application Technology, The Institute for Wind Energy as well as the “Laboratory of Steam Boilers and Thermal Plants” from the National Technical University of Athens. The module “RET I” covers the following topics: • Fundamentals (historical overview, power plant fundamentals, climate, energy consumptions and forecasts, energy economics, electricity control, fossil and nuclear energy) • Energy from Biomass (properties of biomass, biomass potentials, fuel properties, heat production, power production by means of combustion, power production by means of gasification, biogas production by means of anaerobic fermentation) • Geothermal Energy (potential, exploitation, direct utilization, central heating, district heating, deep geothermal systems, power generation, combined heat and power, economic aspects, risks) • Wind Energy (basic facts, introduction to wind turbine aerodynamics, the wind resource, wind turbine types, configurations, components)
Introduction to python for data analysis- (WIHN0048) 6 ECTS	This course aims to give a comprehensive knowledge of Python and how the language can be used in Data Analysis. The module covers the following topics: - Basic Python syntax: • Variables, expressions and statements • Type

	- Python Data Structures • List and tuples • Dictionaries • Set - Python Programing Fundamental • Condition and Branching • Loops • Functions • Objects and Classes - Working with Data in Python • Understanding the data • Python packages • Importing and Exporting data in Python • Accessing databases - Analyzing data in Python • Data wrangling • Data analysis - Model Development - Model Evaluation - Data visualization
Internal combustion engines (8407670170) 5 ECTS	* Introduction to Internal Combustion Engines * Engine Kinematics & Mechanics * Engine Operating Parameters * Thermodynamic Principles * Fuels and Combustion * Heat Release and Heat Transfer * Gas Exchange Processes * Engine Emissions
Aircraft Systems (0000001719) 3 ECTS	The course covers aircraft systems and subsystems which are important for reliable and safe operation of transport aircraft. Beginning with a review on the historical development of aircraft and aircraft systems, the course presents a comprehensive view on the design and functionality of several systems and system components as well as their interaction and impact on aircraft top level. Furthermore, current technology trends and new system concepts and technologies are introduced. Topics: - Introduction to Aircraft Systems - Flight Control Systems - Propulsion and Fuel Systems - Power Generation and Distribution Systems

	- Environmental Control Systems - Landing Gear and Braking Systems - Avionics Systems - Safety and Emergency Systems

TOTAL: 61 ECTS