Fakultät
Maschinenbau und
Verfahrenstechnik

Module Handbook

Bachelor Mechanical Engineering and Environmental & Process Engineering

Technical University of Applied Sciences Augsburg

For students starting from the winter semester 2024/25

Aerospace Structural Analysis

• Mechanics: basic and advanced concepts of stress, strain, displacement, and constitutive models

• Introduction to theory of elasticity and solutions

• Strength of materials / applied elasticity solutions: bars, beams (simple and advanced), torsion and shear members, thin-walled members, torsional and flexural shear flows

• Work and potential energy principles: principles of virtual and complementary virtual work and minimum potential energy

• Introduction to Finite Element Analysis: truss, beam, shell elements

▪ Introduction to composite laminates; trade-off with metallic structures

Aerospace Systems Design

- Design process
- Flight vehicle sizing
- Geometry selection
- Thrust-to-weight ratio and wing loading
- Initial sizing
- Configuration layout and loft
- Disciplinary considerations
- Aerodynamics
- Structures
- Controls

Agile Project Management

- Basics of project management
- Procedure models of project management
- General conditions and drivers for successful project implementation
- Scientific foundations of agile PM methods
- Basics of modern agile collaboration and communication
- Techniques and methods of agile project management

Automotive Electronics

• Introduction and overview

• Basics of automotive electronics and electronic systems in the automobile (hardware, software)

• Sensors in the automobile (technology and function)

• Local networks in the automobile (CAN, LIN, FlexRay, MOST etc.)

• Selected systems: Drive systems (combustion engine,
hybrid and electric drive), assistance, safety, information and communication systems and communication systems

• Diagnosis and troubleshooting in automotive electronics systems

Basics of Electrical Energy Storages

- Overview of energy storages
- Analysis of the different chemistries (Lead Acid, Nickel Metal Hydride, Lithium Ion, etc.)
- Identification and classification of the application requirements with special focus on automotive
- Battery selection and sizing
- Monitoring and balancing methods
- Safety issues and management
- Cell modelling and parameter identification
- Testing Methods

Composite Machining and Repair

Machining of fibre composites:

- Machining methods
- Machining with geometrically defined cutting edge
- Machining with geometrically undefined cutting edge
- Drilling of fibre-reinforced polymers
- Milling of fibre-reinforced polymers
- Grinding of fibre-reinforced polymers
- Machining of CMC materials
- Water jet cutting
- Laser cutting

Repair of fibre-reinforced composites:

- Patch repair of laminates
- Sandwich repair strategies
- Impact damage repair
- Basics of damage-tolerant laminate design
- Repair layers for a laminate
- Doppler and stiffeners
- Repair of primary and secondary structures
- Residual stiffness after repair

Composite Quality Control

Quality assurance of fibre-reinforced composites:

- Non-destructive testing methods for fibre-reinforced materials
- Ultrasonic testing, C-scan
- Passive optical thermography
- Active optical thermography (Lockin)
- X-ray testing, tomosynthesis
- Optical microscopy
- Machining of CMC materials
- Effects of damage in polymeric fibre-reinforced materials
- Effects of damage in ceramic fibre-reinforced materials
- Statistical test methods for fibre reinforced materials; A- and B- values
- Effects of fibre angle deviations in UD prepreg layers

Laboratory exercise "Non-destructive materials testing":

- Ultrasonic testing
- Thermographic testing
- Optical microscopy

Composite Structural Optimization

Structural Optimization of Fiber Composites:

- Fundamentals of Bionics
- Calculation of typical biological structures (culms, insect wings)
- Basics of numerical optimization
- Application of optimization methods to fiber composites
- Comparison of conventional design / optimized design of fiber composite components

Composite Technology

Fibre composite technology:

- Design philosophies Fibre composite
- Strength Criteria
- Mesh theory
- Classical laminate theory
- Stability analysis of fibre composites
- Buckling and post-buckling of fibre composite panels
- Fibre composite beams
- Design guidelines fibre composite

Laboratory exercise:

- Fibres and resin systems
- Textile semi-finished products
- 3D fibre reinforcement
- Manufacturing process of fibre composites
- Determination of the physical parameters permeability, capillarity, porosity
- RTM method
- VARI process
- Prepreg and autoclave technology
- Experimental determination of the permeability of technical textile

Development and Certification of Aeronautical Structures

- Material Selection for aeronautical structures
- Concepts for structural design
- Static substantiation of structures
- Fatigue evaluation and lifetime calculation
- Non-mechanical requirements
- Repair
- Lessons learned: Incidents and accidents

Energy Economics

- Energy demand, energy supply, energy import and export
- Energy reserves and ecological restrictions of energy economics
- Market development, pricing and possibilities of substitution
- Costs of different energy technologies
- Energy prices with and without subsidies
- Costs of CO2 avoidance of different energy technologies
- Acceptance of different energy technologies
- New energy technologies

<u>“Media-oriented” keywords:</u>

What are the costs of the energy turnaround?
What is the best strategy to avoid CO2?
How expensive will the energy be tomorrow?
Which energy technology will be accepted?
What will the energy system of tomorrow look like?

Engineering Design 3

- Gearbox design
- Resource consumption and service life optimised design of a design system
- Gear and bearing design
- Shaft design and calculation
- Selection and strength verification of other machine elements
- Calculation of machine elements with computer programmes
- Gear lubrication
- CAD design
- Documentation of results

Finite Element Method

- Finite Element Analysis (FEA) process
- Fundamental FEA concepts
- Displacement shape functions
- Types of finite elements
- Implicit & explicit problems
- Idealization and meshing of CAD
- Types of analysis
- Checks before, during and after analysis
- Working with FE-Software HyperWorks performing analyses for simple problems

Flight Control and State Estimation

- Flight dynamics (flight characteristics, stability, maneuverability)
- Controls, control forces, trimming feature
- Forces and torques on aircrafts
- Coordinate systems and transformation
- Steady state longitudinal and lateral motion
- Equations of motion
- Flight control (set point controls, sensors, autopilot, actuators)
- Validation of the flight-mechanical parameters during flight test, determining the Eigenmode parameters during flight test
- Helicopter (thrust, momentum theory, blade element theory, ground effect, noise emissions)

Flight Mechanics

- Flight dynamics (flight characteristics, stability, maneuverability)
- Controls, control forces, trimming feature
- Forces and torques on aircrafts
- Coordinate systems and transformation
- Steady state longitudinal and lateral motion
- Equations of motion
- Flight control (set point controls, sensors, autopilot, actuators)
- Validation of the flight-mechanical parameters during flight test, determining the Eigenmode parameters during flight test
- Helicopter (thrust, momentum theory, blade element theory, ground effect, noise emissions)

Introductory Course to Astronautics

- History of astronautics
- Present situation of astronautics industry
- Spacecraft propulsion, staging principle
- Physics of the higher atmosphere, satellite orbits
- History and design of launcher systems
- Spacecraft reentry, subsystems of a spacecraft
- Satellite orbit and orientation control, sensor systems
- Energy supply, communication systems, thermal control
- Structure mechanics
- Manned spacecraft

Introductory Course to Human Space Flight

• Human Space Flight Basics (Basic terminology)

• Space environment and human adaptivity, astronaut selection and training

• Manned space travel systems

• Working in space (Zero gravity and reduced gravity), life in space (Zero gravity), regeneration in space (sport and sleep), sustainment systems

• Extra Vehicular Activity (Moon and Mars)

• Space stations and habitats

• Layout of manned space missions, Space Human Factor

Engineering (Aerospace ergonomics)

Oil Hydraulics

• Overview: Structure; History and Applications; Basic attributes of hydraulic systems; Structures and functions; Definitions

• Basics: Hydraulic fluids; Laws of Hydrostatics; Laws of Hydrodynamics

• Pumps and engines: Overview; Piston machines; Gear machines; Vane machines; Screw machines; Operational characteristics

• Hydraulic cylinders: Rectilinear cylinders; Rotating cylinders; Design and mounting

• Valves: Types of valves and controls; Directional control valves; Check valves; Flow control valves; Pressure valves

• Additional components: Hydraulic pipes and hoses; Seals; Accumulators; Oil tanks; Heat exchangers

• Open and closed loop control systems: Flow variation; Open loop control systems for pumps with variable displacement; Closed loop control systems for pumps with variable displacement

• Design of hydraulic systems: Basic circuits; Design of hydraulic systems

Pneumatics

• Overview: Structure; History and Applications; Basic attributes; Definitions

• Basics: Air compression; Speed of sound; Laws of air flow; Calculations; Symbols in circuit diagrams

• Compressors: Principles and types; piston, vane, screw; ejector; axial and radial compressor; Compressed air processing; air quality; drying; lubrication and oiling; filtering; cooling

• Actuators: Pneumatic cylinders; Cylinders without piston rods; Rotating cylinders; Grippers; General remarks; Air motors; Vacuum actuators; Miscellaneous

• Valves: Types and actuation; Directional control valves; Check valves; Flow valves; Pressure valves; Miscellaneous; Operational characteristics.

• Line systems: System; Pipes; Hoses

• Sensors: Pressure; Flow; Temperature; Fittings; Number; Rotational speed; Transducer; Position; Applications

Regenerative Power Engineering II

- Overview of renewable energies
- Photovoltaics
- Hydropower
- Wave energy
- Geothermal energy
- Tidal energy

Tribology

- Lubrication
- Lubrication production
- Chemical structure of lubrication
- Purposeful lubrication selection
- Applying lubrication/Lubrication systems
- Preparation/disposal of lubrication
- Biodegradable lubrication
- Contact strain of components
- Seals
- Corrosion
- Wear mechanisms/ types of wear
- Component damages/ Damage analysis