ICED

International Competition of Engineering Diagnostics

Syllabus

2025-2026

Engineering Disciplines Covered

Aerospace Engineering • Civil Engineering • Electrical Engineering •
Biomedical Engineering • Mechanical Engineering

Contents

1. Aerospace Engineering

1.1. Overview

Aerospace engineering is a field that focuses on the design, development, and analysis of aircraft and spacecraft. It integrates principles from mechanical engineering, fluid dynamics, materials science, and control systems to address challenges related to flight. While the field includes both aeronautics (flight within Earth's atmosphere) and astronautics (spaceflight), this competition will primarily focus on aeronautics. Topics will center around the fundamentals of aircraft performance, flight mechanics, aerodynamics, and propulsion systems relevant to atmospheric flight.

1.2. Key Concepts

1.2.1 Math

1. Fundamentals of limits & differentiation:

   - rates of change and tangents to curves

   - limit laws

   - one-sided limits

   - continuity

   - derivative as a function

   - common derivatives

   - differentiation rules

2. Fundamentals of integration:

   - Sigma Notation and Limits of Finite Sums

   - Indefinite Integrals

   - Definite Integral Substitutions and the Area Between Curves

   - Techniques of integration

   - Applications of integration (Work and Fluid Forces, Moments and Centers of Mass, Solids of Revolution)

3. Vectors (Operations & Relations).

1.2.2 Physics

1. Classical Mechanics Fundamentals:

   - Laws of Motion

   - Acceleration

- Mass and Forces

- Equilibrium State

- Action and Reaction

- Resolution of Forces

2. Fluid mechanics:

- Fluid Statics

- Flow Measurement

- Freely Discharging Flow

- Fluid Friction

- Pumps & turbomachinery

- Fluid Flow: Single vs. Multiphase flow

- Fluid Mixing

- Particle Flow

- Rheology and Non-Newtonian Fluids

- Pressure Distribution in a Fluid

- Dimensional Analysis and Similarity

- Compressible vs. Incompressible Flow

- Laminar vs. Turbulent Flow

- Models of Fluid: Control Volumes and Fluid Elements

1.2.3 Engineering

1. Aerodynamics fundamentals (Aeronautics):

- Pressure distribution

- Airfoil Theory

- Flow over Airfoils Analysis

- Flow over Wings Analysis

- Lift & Drag Forces

- Angle of Attack

- Super & Hypersonic Flow and Shock Waves

- Vortex Filament, Biot-Savart Law, and Helmholtz's Vortex theorems

- Circulation

- Kutta–Joukowski Theorem

- Induced Drag

- Boundary Layers

- Vehicles Aerodynamics (real-life applications)

2. Design Optimization (simulations):

   - Parametric sweeps

   - sensitivity analysis

   - multi-objective methods

1.3. Suggested References

- **Math Books**

  – Thomas Calculus: Late Transcendentals

  – Cengage Learning Calculus by James Stewart

  – Infinite Powers: How Calculus Reveals the Secrets of the Universe by by Steven Strogatz

- **Physics Books**

  – Fluid Mechanics by Frank M. White

  – Solved Practical Problems in Fluid Mechanics by Carl J. Schaschke

- **Engineering Books**

  – Fundamentals of Aerodynamics by John David Anderson

  – Model Aircraft Aerodynamics by Martin Simons

  – Vehicle Aerodynamics - Testing, Modification & Development: For road, racing and alternative transport by Julian Edgar

2. Civil Engineering

2.1. Overview

Civil engineering is a field of Enginering focused on solving issues regarding tunnels, bridges, dams, housing units, and generally any static structural. It combines the use of material science, statics, rock mechanic, and more to accomplish the most optimal solution. Civil engineering is why there are good transportation, clean water, sturdy houses, and safe dams.

2.2. Key Concepts

2.2.1 Statics

1. Forces equilibrium in 2D,3D

2. Force resolution in 2D, 3D

3. Internal stress, Internal Moment calculations

4. Truss analysis

5. Frame analysis

2.2.2 Material science

1. Stress, strain in materials

2. Material mechanical properties

3. Failure theories: mohr-coloumb, von mises, Teresca.

4. Fracture mechanics

2.2.3 Types of structures

1. Domes

2. Arches

3. Bridges

4. Dams

5. Mass

6. Truss

7. Frame

8. Load bearing structures (walls, foundations, slabs)

2.3. Suggested References

- **William callister introduction to material science**
- **Russell hibbler engineering statics**

3.   Electrical Engineering

3.1. Overview

Electrical Engineering is a core discipline of engineering that applies the principles of physics and mathematics to the study, design, and application of devices and systems that utilize electricity and electromagnetism. The field is fundamentally governed by Maxwell's Equations, which provide a complete mathematical description of how electric and magnetic fields are generated and altered by each other and by charges and currents. It encompasses a vast spectrum of technologies, ranging from the macroscopic scale of global power grids to the nanoscale of semiconductor device fabrication.

3.2. Key Concepts

3.2.1   Electromagnetism

1. **Electrostatics:**

   - Fundamental principles of electric charge and force (Coulomb's Law)
   - Analysis of electric fields, flux, and potential (Gauss's Law)
   - Behavior of conductors in electrostatic equilibrium

2. **DC Circuits:**

   - Basic quantities: current, voltage, resistance, and power (Ohm's Law)
   - Circuit analysis using Kirchhoff's Laws (KVL & KCL) for series/parallel networks
   - Transient analysis of RC circuits (charging, discharging, and time constants)

3. **Capacitance and Dielectrics:**

   - Principles of capacitance and energy storage in capacitors
   - Analysis of capacitor networks in series and parallel
   - Effects of dielectric materials on capacitance

4. **Magnetism and Induction:**

   - Properties of magnetic fields, flux, and forces on moving charges
   - Principles of electromagnetic induction (Faraday's & Lenz's Law)
   - Generation of electromotive force (EMF) from changing magnetic fields

5. **Electromagnetism:**

   - Unification of electricity and magnetism through Maxwell's Equations
   - Analysis of electromagnetic wave propagation
   - Introduction to transmission line theory

3.2.2 Electrical Engineering

1. Circuit Analysis Techniques:

   - Thévenin's, Norton's, and Superposition Theorems
   - Node and Mesh Analysis
   - AC Circuits and RLC Analysis
   - Resonance and Frequency Response

2. Semiconductors & Solid-State Devices:

   - Semiconductor Physics and P-N Junctions
   - Diode Characteristics and Applications (Rectifiers, Clippers)
   - Transistor (BJT MOSFET) Fundamentals and Applications

3. Analog Electronics & Applications:

   - Operational Amplifier (Op-Amp) Characteristics
   - Linear Op-Amp Circuits (Amplifiers, Integrators)
   - Filter Design and Bode Plots

4. Digital Logic & Systems:

   - Logic Gates and Boolean Algebra
   - Combinational Logic Circuits (Adders, Multiplexers)
   - Sequential Logic Circuits (Flip-Flops, Counters)
   - Finite State Machines (FSMs)

5. Introduction to Power Electronics:

   - Power Semiconductor Devices (MOSFETs, IGBTs, Thyristors)
   - AC-DC Converters (Rectifiers)
   - DC-DC and DC-AC Converters (Choppers Inverters)

3.3. Suggested References

- **Electromagnetism & Physics Foundations**

  – Griffiths, D. J. (2017). *Introduction to Electrodynamics* (4th ed.). Cambridge University Press.

  – Purcell, E. M., & Morin, D. J. (2013). *Electricity and Magnetism* (3rd ed.). Cambridge University Press.

- **Core Electrical Engineering Texts**

  – Nilsson, J. W., Riedel, S. A. (2019). *Electric Circuits* (11th ed.). Pearson.

  – Sedra, A. S., Smith, K. C. (2020). *Microelectronic Circuits* (8th ed.). Oxford University Press.

  – Mano, M. M., Ciletti, M. D. (2017). *Digital Design* (6th ed.). Pearson.

4.   Biomedical Engineering

4.1.   Overview

Biomedical Engineering is an interdisciplinary field at the intersection of engineering, biology, and medicine. It leverages principles of electrical, mechanical, chemical, and systems engineering to develop technologies that solve clinical problems. This track focuses on physiological signal interpretation, bioinstrumentation, and electrochemical sensing systems used in diagnostic and monitoring applications.

4.2.   Key Concepts

4.2.1   Signal System Analysis in Physiology

1. Cardiovascular Signal Processing:

   - ECG waveform interpretation

   - Analysis of systolic and diastolic blood pressure

   - Hemodynamic modeling of blood motion

2. Renal Function Estimation:

   - Concepts of nephrological diagnostics

   - Case studies on kidney health assessment

   - eGFR estimation using demographic and biochemical data

4.2.2   Bioinstrumentation and Electrochemical Sensing

1. Electrochemical Sensors and Interfaces:

   - Potentiometric sensors

   - Ion-selective electrodes (ISEs)

   - Amperometric sensor design and signal amplification

2. Sensor System Design:

   - Calibration and selectivity concepts

   - Real-time signal acquisition and processing

4.3. Suggested References

- **Biomedical Engineering Texts**

    - Harsányi, G. (2000). *Sensors in biomedical applications: Fundamentals, technology and applications.* CRC Press.

    - Enderle, J. D., Bronzino, J. D. (Eds.). (2012). *Introduction to biomedical engineering* (3rd ed.). Academic Press.

    - Bard, A. J., Faulkner, L. R. (2001). *Electrochemical methods: Fundamentals and applications* (2nd ed.). Wiley.

- **Medical Reference Text**

    - Ralston, S. H., Penman, I. D., Strachan, M. W. J., Hobson, R. P. (Eds.). (2023). *Davidson's principles and practice of medicine* (24th ed.). Elsevier.

5. Mechanical Engineering

5.1. Overview

Mechanical Engineering is a discipline applying the principles of mechanics, dynamics, thermodynamics, and materials science. It is fundamentally guided by Newton's Laws of Motion and the Laws of Thermodynamics to design, analyze, and manufacture mechanical systems. The field broadly covers two major areas: the design of physical machines and structures (robotics and vehicle chassis) and the conversion and control of thermal energy (jet engines and refrigeration systems).

5.2. Key Concepts

5.2.1 Physics Concepts

1. Classical Mechanics:

    - Fundamental laws of motion ($F = ma$), work, energy, and power.

    - Analysis of static and dynamic forces, including friction and gravity.

    - Principles of oscillations, resonance, and load transfer in dynamic systems.

2. Thermodynamics and Heat Transfer:

    - The First and Second Laws of Thermodynamics governing energy and entropy.

    - Analysis of ideal heat engine cycles (e.g., Carnot, Otto, Diesel).

    - Fundamental modes of heat transfer: conduction, convection, and radiation.

3. Fluid and Aerodynamics:

    - Principles of fluid behavior, including pressure, flow, and Bernoulli's equation.

    - Analysis of aerodynamic forces, primarily lift and drag, on moving bodies.

    - Concepts of flow regimes (laminar vs. turbulent) and boundary layers.

4. Solid Mechanics and Materials Science:

    - The relationship between stress, strain, and material deformation.

    - Understanding material failure modes, including fatigue and fracture mechanics.

5.2.2 Mechanical engineering

1. Powertrain and Energy Systems:

    - Design of internal combustion and hybrid/electric powertrains.

    - Engineering of transmission, drivetrain, and energy recovery systems.

- Thermal management through the design of cooling systems and heat exchangers.

2. Chassis and Vehicle Dynamics:

   - Structural design of vehicle chassis for rigidity and crash safety.

   - Engineering of suspension, steering, and braking systems.

   - Implementation of active stability and traction control systems (ESP, ABS).

   - Application of aerodynamics for performance and efficiency.

3. Materials and Manufacturing:

   - Material selection and structural design for strength, weight, and durability.

   - Design against fatigue and failure, including surface treatments and NDT.

   - Application of manufacturing processes from casting to additive manufacturing.

4. Digital Engineering and Control:

   - Use of CAD and Finite Element Analysis (FEA) for design and simulation.

   - Principles of electronic control systems (ECUs, sensors, actuators).

   - Technology of energy storage systems and their battery management (BMS).

5.3. Suggested References

- **Mechanics & Thermodynamics Foundations**

  – Beer, F. P., Johnston, E. R., Mazurek, D. F., Cornwell, P. J. (2022). *Vector Mechanics for Engineers: Statics and Dynamics* (13th ed.). McGraw-Hill.

  – Moran, M. J., Shapiro, H. N., Boettner, D. D., Bailey, M. B. (2018). *Fundamentals of Engineering Thermodynamics* (9th ed.). Wiley.

- **Core Mechanical Engineering Texts**

  – Budynas, R. G., Nisbett, J. K. (2020). *Shigley's Mechanical Engineering Design* (11th ed.). McGraw-Hill Education.

  – Incropera, F. P., DeWitt, D. P., Bergman, T. L., Lavine, A. S. (2017). *Fundamentals of Heat and Mass Transfer* (8th ed.). Wiley.

  – Munson, B. R., Al-Shemmeri, T., Rothmayer, A. P. (2021). *Munson, Young and Okiishi's Fundamentals of Fluid Mechanics* (9th ed.). Wiley.