2E5 THERMO-FLUIDS [5 credits]

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Module organisation
The module runs for the second half (12 weeks) of the academic year and comprises of three lectures and one tutorial per week plus two two-hour laboratories (total of 48 hours contact time).

Module description, aims and contribution to programme
This module is developed to introduce the students to the thermal fluid sciences and is organised into two main subsections: fluid mechanics and thermodynamics. The fluid mechanics part deals with both hydrostatics as well as the principles of conservation of mass and momentum, laminar and turbulent flows, pipe flows and boundary layers for case of fluids in motion. The thermodynamics section of the module deals with the properties of matter, phase change, equations of state, energy transfer, the first and second laws of thermodynamics and the analysis of engineering devices and systems.

Learning outcomes
Upon completion of this module, students will be able to:
1. Analyse, generate mathematical models, solve problems, and communicate the solutions of simple fluid based engineering problems including pressures and forces on submerged surfaces.
2. Understand the principal of basic measurement devices such as venturi meters and Pitot static tubes.
3. Determine forces generated in systems such as jets and propellers.
4. Distinguish between ideal and real flows and evaluate practical problems associated with pipe flow systems.
5. Conceptualise and describe practical flow systems such as boundary layers and their importance in engineering analysis.
6. Evaluate fluid properties and solve basic problems using property tables, property diagrams and equations of state.
7. Analyse, generate mathematical models, solve problems, and communicate the solutions to practical closed systems and steady-flow devices by applying the conservation of energy principle.
8. Understand the limitations of engineering devices and systems based on the 2nd law of thermodynamics.
9. Understand the concept of thermal efficiency and coefficient of performance and the environmental and socio-economic implications associated with desired system output (i.e. power/cooling) verses required ‘cost’ input (ie electrical/fuel).
10. Understand basic laboratory procedure and safety.
11. Perform laboratory tasks as a group.
12. Acquire, tabulate and analyse useful data in the laboratory.
13. Communicate information, analyse data and provide physical interpretation of measurements in technical laboratory reports.
14. Utilise internet resources for general module material.

**Module content**

**Fluid Mechanics**
- Introduction: Definition of a fluid, fluid properties, equation of state;
- Hydrostatics: Measurement of pressure, thrust on submerged surfaces;
- Principles of Fluid Motion: Description of fluid flow; continuity equation; Euler and Bernoulli equations; Pitot total head and static tubes, venturi-meters, orifice plates;
- Momentum Equation: Momentum equation for steady flow; applications to jet flows, impinging flows in pipe bends; momentum theory of propellers;
- Laminar and Turbulent Flows: Reynolds demonstration of flow regimes; criterion for laminar/ turbulent flow; Reynolds number;
- Pipe Flows: Fully developed flow; laminar pipe flow; turbulent pipe flow, friction factor, friction losses, other losses;
- Boundary Layers and Wakes: Description of the boundary layer; laminar and turbulent boundary layers; physical, displacement & momentum thickness; effect of pressure gradient – separation and wake formation; drag forces.

**Thermodynamics**
- Introduction: Properties of matter, the state postulate, energy, processes and thermodynamic systems;
- Properties of Pure Substances: property tables, property diagrams, phase change, equations of state (ideal gas);
- Energy: Energy transfer by heat, work and mass;
- The First Law of Thermodynamics: Closed system, open system, steady-flow engineering devices;

**Teaching strategies**
The module encompasses a diverse variety of teaching and learning strategies. This is accomplished by coordinating formal lectures with teamwork-based problem-solving tutorial sessions supplemented by ‘hands-on’ laboratory experimentation and technical report writing.
Associated laboratory/project programme
- Spark Ignition Engine Test;

Assessment
Assessment is by means of a two-hour end-of-year written examination (85%) and continuous assessment (15%) based on technical reports on the experiments.

Recommended textbooks
Fundamentals of Fluid Mechanics, Munson, Young, Okiishi, Huebsch, Wiley
Thermodynamics: an Engineering Approach, Cengel and Bowles, McGraw-Hill

Further information
http://www.tcd.ie/Engineering/undergraduate/baiyear2/2E5