**UNIVERSITY OF ABERDEEN, SCHOOL OF ENGINEERING**

**COURSE HANDBOOK SESSION 2013-14**

**EG3521 Engineering Thermodynamics**

**CREDIT POINTS**

10

**COURSE CO-ORDINATOR**

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**COURSE ORGANISER**

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**CONTRIBUTORS**

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**PRE-REQUISITE**

EG2003

**CO-REQUISITE**

None

**COURSES FOR WHICH THIS COURSE IS A PRE-REQUISITE**

EG40JK

**NOTE**

Except with the permission of the Head of School of Engineering, this course is available only to students following an Honours degree programme in engineering.

**AIMS**

This course aims to provide Mechanical Engineering students with an in-depth treatment of: 1) the applications of thermodynamics to flow processes; 2) the production of power from heat; 3) refrigeration and liquefaction processes. The course also gives a broad introduction to psychrometry with an applications focus on heating, ventilation and air conditioning.

**DESCRIPTION**

The course begins with a detailed discussion of the Production of Power from Heat which includes: revision of the Carnot-engine cycle and the basic steam power plant; the Rankine cycle; modifications of the Rankine cycle to increase efficiency including superheat/re-heat & feed water heating; steam power plants & internal combustion engines; internal combustion engines including the Otto Engine, the Diesel engine and the gas-turbine engine (Brayton cycle). Following on from the production of power from heat is a module on Refrigeration and Liquefaction processes which use power to move heat from low temperature to high temperature, this module includes: the Carnot refrigerator; the vapour-compression cycle; refrigerant choice; absorption refrigeration; the Linde liquefaction process; the Claude liquefaction process. The course continues with applications of thermodynamics to flow processes including: duct flow of compressible fluids in pipes, nozzles and throttling devices; Turbines; Compression processes including compressors, pumps and ejectors. The course concludes with a module on Psychrometry which includes: basic definitions; wet bulb temperature; adiabatic saturation temperature; humidity data for the air-water system (humidity-temperature chart & humidity-enthalpy diagram); mixing of humid streams; humidification & dehumidification.

**LEARNING OUTCOMES**

By the end of the course students should:

**A: have knowledge and understanding of:**

* Balance equations used in the analysis of duct flow of compressible fluids.
* Fundamental thermodynamics of turbine expansion processes including the application of the 1st law for a steady flow process.
* Fundamental thermodynamics of compression processes including the application the 1st law for a steady flow process.
* The Carnot cycle and why it is not practical to operate.
* The Rankine cycle and the modifications which can be incorporated to boost its efficiency.
* The Otto, Diesel and Gas-turbine (Brayton cycle) engines.
* The fundamental thermodynamics of refrigeration and liquefaction processes.
* The quantities used to report the effectiveness of refrigeration processes.
* Factors affecting refrigerant choice.
* The Linde and Claude liquefaction processes.
* Standard terms used in psychrometry, humidification and water cooling.

**B: have gained intellectual skills so that they are able to:**

* Apply balance equations for duct flow of compressible fluids to pipe flow, flow through nozzles and throttling processes.
* Describe turbine expansion processes and undertake calculations on such systems.
* Describe compression processes including compressors, pumps and ejectors and undertake calculations on such systems.
* Describe the Carnot and Rankine cycles using process flow and thermodynamic diagrams.
* Describe the modified Rankine cycle using process flow and thermodynamic diagrams.
* Describe the Otto, Diesel and Brayton cycles using thermodynamic diagrams.
* Describe refrigeration processes using process flow and thermodynamic diagrams.
* Select refrigerants and processes for a given refrigeration duty/application.
* Describe liquefaction processes using process flow and thermodynamic diagrams.
* Undertake simple heat and mass balances on humidification/dehumidification systems.

**C: have gained practical skills so that they are able to:**

* Quantitatively analyze systems incorporating duct flow of compressible fluids.
* Use standard tables and equations to perform analysis of turbine expansion and compressions processes.
* Apply the 1st law of thermodynamics for a steady flow process to a variety of systems incorporating the duct flow of compressible fluids.
* Undertake calculations relating to efficiency and the application of the 1st law of thermodynamics for a steady flow process to the individual components of the Rankine and modified Rankine cycle.
* Undertake thermodynamic calculations on the Otto, Diesel and Brayton cycles.
* Compute the effectiveness of refrigeration processes.
* Apply the first law of thermodynamics for a steady flow process to the individual components of a refrigeration/liquefaction process.
* Use information sources to procure the data required to undertake thermodynamic calculations on refrigeration/liquefaction processes.
* Use psychrometric charts to undertake design and analysis of humidification/dehumidification systems.

**D: have gained or improved transferable skills so that they are able to:**

* work effectively in a group
* communicate effectively *via* technical report

**SYLLABUS**

**Module 1: Introduction and Principles:** First and second laws of thermodynamics; ideal gas processes; steam tables (2 lectures).

**Module 2: The production of power from heat:** revision of the Carnot-engine cycle and the basic steam power plant; the Rankine cycle; modifications of the Rankine cycle to increase efficiency including superheat/re-heat & feed water heating; internal combustion engines including the Otto Engine, the Diesel engine and the gas-turbine engine (Brayton cycle). (7 lectures)

**Module 3: Refrigeration & Liquefaction:** the Carnot refrigerator; the vapour-compression cycle; refrigerant choice; absorption refrigeration; the Linde liquefaction process; the Claude liquefaction process. (5 lectures)

**Module 4: Applications of thermodynamics to flow processes:** duct flow of compressible fluids in pipes, nozzles and throttling devices; Turbines; Compression processes including compressors, pumps and ejectors. (6 lectures)

**Module 5: Psychrometry:** basic definitions; wet bulb temperature; adiabatic saturation temperature; humidity data for the air-water system (humidity-temperature chart & humidity-enthalpy diagram); mixing of humid streams; humidification & dehumidification. (2 lectures)

**TIMETABLE**

* 22 one-hour lectures, 8 one-hour tutorials and 2 three-hour practicals.

**ASSESSMENT**

*First Attempt:* 1 three-hour written examination paper (WEP, 80%), continuous assessment (CA, 20%) and Problem-Solving Exercise (PSE, 1 CAS Mark, optional)

*Resit:* 1 three-hour written examination paper (WEP, 80%), continuous assessment (CA, 20%) %) and Problem-Solving Exercise (PSE, 1 CAS Mark, optional) marks.

Final CAS Mark (FCM) is calculated as:

Penalties for late or non-submission of in-course work are as follows:

1. For late submission, 1 CAS mark will be deducted for each late day (including weekends);
2. For non-submission, a CAS mark of 0 will be awarded and may lead to a refusal of a Class Certificate.

If late or non-submission is due to medical or other circumstances out with your control you must submit a medical certificate or other formal evidence to the Engineering School Office as soon as is practicable but no later than the end of Revision Week (44).

**FORMAT OF EXAMINATION**

There will be FIVE questions. All questions carry 20 marks.

Notes:

1. Candidates are permitted to use approved calculators. Starting in academic year 2014-15, the School of Engineering list of approved calculators for use in examinations will consist of a single calculator, the Casio FX-991 ES PLUS. So from September 2014 the only calculator that you may take to your desk in an examination is this Casio calculator. Note that examiners will be aware of the capabilities of the machine and will assume that you are able to operate this calculator in an examination. All students should ensure that they have such a calculator and that they are familiar with its operation.
2. Candidates are permitted to use psychrometric charts, steam, refrigeration and air thermodynamic tables, which will be made available to them.
3. Steam charts and tables are provided to candidates.

**PLEASE NOTE THE FOLLOWING**

1. You **must not** have in your possession at the examination any material other than that expressly permitted by the examiner. Where this is permitted, such material **must not** be amended, annotated or modified in any way.
2. During the course of the examination, you **must not** have in your possession or attempt to access any material that could be determined as giving you an advantage in the examination.
3. You **must not** attempt to communicate with any candidate during the examination, either orally or by passing written material, or by showing material to another candidate, nor must you attempt to view another candidate’s work.

**Failure to comply with any of the above will be regarded as cheating and may lead to**

**disciplinary action as indicated in the Academic Quality Handbook**

(http://www.abdn.ac.uk/registry/quality/)**.**

**RECOMMENDED BOOKS**

This course is well supported by any standard engineering thermodynamics textbook.

Recommendation;

1. J.M. Smith, H.C. van Ness, M.M. Abbott (2005) Introduction to Chemical Engineering Thermodynamics, Wiley, 7th Edition;
2. I. Muller, W.H. Muller (2009) Fundamentals of Thermodynamics and Applications, Springer;
3. Y.A. Cengel, M.A. Boles (2010) Thermodynamics – An Engineering Approach, McGraw-Hill Higher Education, 7th Edition;
4. H. Devoe (2012) Thermodynamics and Chemistry, Free PDF Textbook, 2nd Edition;
5. R.K. Rajput (2007) Engineering Thermodynamics, Laxmi Publications Ltd, 3rd Edition;
6. M.J. Moran, H.N. Saphiro, D.D. Boettner, M.B. Bailey (2012) Principles of Engineering Thermodynamics, Wiley, 7th Edition.