MECH32102

Engineering Thermodynamics

Credits: **10**

FHEQ Level: **6**

Prerequisite units: **None**

Corequisite units: **None**

Required by: **MECH60562**

Aims

To develop an understanding of the fundamental and advanced Thermodynamics concepts and their application to thermodynamic systems and cycles including advanced power systems and their thermodynamic cycles. To simplify (where appropriate) and apply the general forms of the first and second laws of thermodynamics with reference to a particular engineering application. To use mass and energy balances, and entropy transport (including irreversibility) to provide quantitative analysis of established and novel power systems. To develop rules for determining nonreacting gas mixture properties from knowledge of mixture composition and the properties of the individual components and calculate the enthalpy of reaction, enthalpy of combustion, and the heating values of fuels. To be able to apply the principles of the conservation of mass and energy to various air-conditioning processes.

Syllabus

Pure Substances

- Phases of a pure substance
- Phase-change processes of pure substances
- Property diagrams for phase change processes
- Property tables
- The ideal gas equation of state
- Compressibility factor
- Other equations of state
- Polytropic Processes

Second Law

- Introduction to the second law
- Thermal energy reservoirs
- Heat engines

- Refrigerators and heat pumps
- Perpetual motion machines
- Reversible and irreversible processes
- The Carnot cycle; The Carnot principles
- The thermodynamic temperature scale
- The Carnot heat engine
- The Carnot refrigerator and heat pump;

Gas Power Cycles

- Basic considerations in the analysis of power cycles
- The Carnot cycle and its value in engineering
- Air-standard assumptions
- An overview of reciprocating engines
- Otto cycle: The ideal cycle for spark-ignition engines
- Diesel cycle: The ideal cycle for compression-ignition engines
- Stirling and Ericsson cycles
- Brayton cycle: The ideal cycle for gas-turbine engines
- The Brayton cycle with regeneration
- The Brayton cycle with intercooling, reheating, and regeneration
- Ideal jet-propulsion cycles.
- The Carnot vapor cycle
- Rankine cycle: The ideal cycle for vapor power cycles
- Deviation of actual vapor power cycles from idealized ones
- How can we increase the efficiency of the Rankine cycle?
- The ideal reheat Rankine cycle
- The ideal regenerative Rankine cycle

Gas Mixtures

- Composition of a gas mixture: Mass and mole fractions
- P-v-T behaviour of gas mixtures: Ideal and Real Gases
- Properties of gas mixtures: Ideal and Real Gases

Vapour Mixture&Airconditioning

- Dry and atmospheric air
- Specific and relative humidity of air

- Dew-point temperature
- Adiabatic saturation and wet-bulb temperatures
- The psychrometric chart
- Human comfort and air-conditioning
- Air-conditioning processes
- Simple heating and cooling
- Heating with humidification
- Cooling with dehumidification
- Evaporative cooling
- Adiabatic mixing of airstreams
- Wet cooling towers

EBL on Steam Power Plant Design:

Use of an in-house MATLAB code to examine effects of input parameters on cycle efficiencies and net work output of a variety of subcritical steam power plant designs.

Intended Learning Outcomes (ILOs)

On successful completion of this unit, a student will be able to…	Topic
Solve problems based on the Brayton cycle; the Brayton cycle with regeneration; and the Brayton cycle with intercooling, reheating, and regeneration and analyse jet-propulsion cycles.	**Advanced Power Cycles** **Related AHEP4 Topics:** → *02. Analysis* → *05. Design In Context* → *06. Integrated Systems*
Use the psychrometric chart as a tool to determine the properties of atmospheric air and apply the principles of the conservation of mass and energy to various air-conditioning processes.	**Airconditioning** **Related AHEP4 Topics:** → *03. Modelling* → *04. Evaluation* → *05. Design In Context*

On successful completion of this unit, a student will be able to…	Topic
Apply the conservation of mass to reacting systems to determine balanced reaction equations and define the parameters used in combustion analysis, such as air–fuel ratio, percent theoretical air, and dew-point temperature.	**Combustion** **Related AHEP4 Topics:** → *01. Applied Science* → *04. Evaluation*
Apply the rules for determining mixture properties to ideal-gas mixtures and real-gas mixtures and predict the P-v-T behaviour of gas mixtures based on Dalton’s law of additive pressures and Amagat’s law of additive volumes.	**Gas Mixtures** **Related AHEP4 Topics:** → *01. Applied Science* → *04. Evaluation*
Analyse both closed and open gas power cycles and solve problems based on the Otto, Diesel, Stirling, and Ericsson cycles.	**Gas Power Cycles** **Related AHEP4 Topics:** → *02. Analysis* → *03. Modelling* → *06. Integrated Systems* → *13. Integrated Solutions*
Apply the ideal-gas equation of state in the solution of typical problems.	**Ideal Gas** **Related AHEP4 Topics:** → *01. Applied Science* → *04. Evaluation* → *06. Integrated Systems*
Demonstrate the procedures for determining thermodynamic properties of pure substances from tables of property data.	**Pure Substances** **Related AHEP4 Topics:** → *01. Applied Science* → *02. Analysis* → *04. Evaluation*

On successful completion of this unit, a student will be able to...	Topic
Apply the second law of thermodynamics to cycles and cyclic devices.	**Second Law** **Related AHEP4 Topics:** → *01. Applied Science* → *02. Analysis* → *06. Integrated Systems*
Define and calculate the specific and relative humidity of atmospheric air and calculate the dew-point temperature of atmospheric air.	**Vapour Mixture** **Related AHEP4 Topics:** → *02. Analysis* → *03. Modelling* → *06. Integrated Systems*

Teaching Activities

Activity	Hours
Assessment — Exam	2
Tutorial	6
Assessment — Coursework	12
Lecture	12
Assessment — Revision/Preparation	20
Independent Study	48

Assessments

Format	Weight	Description	Learning Outcomes
Exam	80%	Written Exam	**Course Unit ILOs:** → Advanced Power Cycles → Airconditioning → Combustion → Gas Mixtures → Gas Power Cycles → Ideal Gas → Pure Substances → Second Law → Vapour Mixture **Related AHEP4 Topics:** → *01. Applied Science* → *02. Analysis* → *03. Modelling* → *04. Evaluation* → *05. Design In Context* → *06. Integrated Systems* → *13. Integrated Solutions*
Report	20%	Coursework	**Course Unit ILOs:** → Advanced Power Cycles → Gas Power Cycles → Second Law **Related AHEP4 Topics:** → *01. Applied Science* → *02. Analysis* → *03. Modelling* → *05. Design In Context* → *06. Integrated Systems* → *08. Ethics* → *09. Risk Management* → *11. Inclusion* → *12. Practical Investigation*

Format	Weight	Description	Learning Outcomes
			→ *13. Integrated Solutions* → *15. Engineering Management* → *16. Effective Working* → *17. Effective Communication*