



# UNIVERSITY OF RUHUNA

## Faculty of Engineering

End-Semester 1 Examination in Engineering: July 2017

Module Number: ME1202

Module Name: Fundamentals of Engineering  
Thermodynamics

[Three Hours]

[Answer all questions, each question carries twelve marks, Note: Usual notations are employed in the Questions, Property tables are separately provided]

Q1.

- a) Briefly explain, the methods of increasing the Thermal efficiency of a Rankine cycle? [ Hint: You can use T-s diagrams for your explanation] [3 Marks]
- b) Consider a steam power plant operating on the basis of the ideal Rankine cycle. The steam enters the turbine at 6 MPa and 400°C and is condensed in the condenser at a pressure of 10 kPa. Determine,
- The thermal efficiency of this power plant.
  - The thermal efficiency of this plant, if steam is superheated to 600°C instead of 400°C .
  - The thermal efficiency of this plant, if the boiler pressure is raised to 20 MPa while the turbine inlet temperature is maintained at 600°C .
- [9 Marks]

Q2.

- a) Briefly describe the differences between extensive and intensive properties by providing examples. [1.5 Marks]
- b) List the main characteristics of open, closed, insulated, rigid and isolated types of system boundaries. [2.5 Marks]
- c) Illustrate P-v (Pressure vs, Volume) diagrams for Adiabatic, Isothermal, Isobaric and Isochoric processes and state the main characteristics of these processes. [2 Marks]
- d) An ideal gas with  $\gamma = 1.4$  occupies in a volume of 6.0 L at 25°C and 110kPa pressure. It is compressed adiabatically to 25% of the original volume, and then cooled at constant volume back to 25°C. Finally, it was allowed to expand isothermally to its original volume.
- Draw the P-v Diagram
  - Calculate, the amount of work done on the gas
- [6Marks]

Q3 a) You have given a task to explain the term "Entropy" to an Advanced Level Student in Sri Lanka. Explain how you envisage to do this task. [2 Marks]

b) An inventor claims to have developed a heat engine that receives 800kJ and heat from a source at 400K and produces 250kJ of network while rejecting the waste heat to a sink at 300K. Is this a reasonable claim? Why? [3 Marks]

c) Steam expands steadily in an isentropic manner in a turbine. The steam enters the turbine at 2MPa and 5kg/s. The steam exits the turbine in two stages; the first exit is at 700kPa and the second exit is at 70kPa and 100°C. Given that 5% of the steam flow rate exits at the first stage, determine the work produced by the turbine [List your assumptions for this analysis]. [7 Marks]

Q4. a) List, the Assumptions in the Air-Standard Cycles. [3.0 Marks]

b) The gas turbine cycle is referred to as the Brayton Cycle or sometimes the Joule Cycle. The Idealized Air Standard Brayton Cycle can be summarized in four processes as shown below,

1-2 Isentropic Compression (in a compressor)

2-3 Constant Pressure (isobaric) Heat Addition

3-4 Isentropic Expansion (in a turbine)

4-1 Constant Pressure (isobaric) Heat Rejection

In an Idealized Air Standard Brayton Cycle, the air enters the compressor at 0.1MPa, 20 °C. The pressure leaving the compressor is 1.0MPa and the maximum temperature in the cycle is 1100°C.

- i. Draw P-v and T-s Diagrams
- ii. Determine the pressure and temperature at each important state point in the cycle
- iii. Calculate the compressor work, turbine work, and cycle thermal efficiency

For Air take:  $C_p = 1.005 \text{ kJ/kgK}$  and  $k = 1.4$

[7.0 Marks]

c) Briefly explain the effect of the typical gas pressure ratio of gas turbine engine for its efficiency.

[2.0 Marks]

Q5. a) Provide two reasons, why the Carnot vapour power Cycle is not employed in practice.

[2.0 Marks]

b) Briefly describes the functions of following components in a vapour power cycle [Hint: Provide necessary sketches].

- i. Boiler
- ii. Condenser
- iii. Turbine
- iv. Pumps
- v. Cooling Tower

[3.5 Marks]

c) Write short note on following [ Hint: Provide necessary sketches].

- i. Vapour compression Refrigeration system
- ii. Layout of a basic Air Conditioning system
- iii. Type of Air-Conditioning systems and their applications

[3.5 Marks]

d) Assume that you have been asked to provide a recommendation for purchasing a new home refrigerator unit. Explain, what are the factors that you would consider for providing your recommendations?

[3.0 Marks]