UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 Examination in Engineering: March 2026

Module Number: ME3301 **Module Name: Applied Thermodynamics**

[3 hours]
Answer all questions. Each question carries 10 marks.

Q1. a) Describe following terms,

i. Complete combustion
ii. Dissociation
iii. Stoichiometric air
iv. Enthalpy of combustion
v. Higher heating value

[5.0 Marks]

b) Liquid propane (C_3H_8) at 25°C enters a combustion chamber at a rate of 0.05 kg/min. It is mixed and burned with **50% excess air**, which enters the combustion chamber at 7°C.

An analysis of the combustion gases reveals that all the hydrogen in the fuel burns to H_2O but only 90 percent of the carbon burns to CO_2, with the remaining 10 percent forming CO. If the exit temperature of the combustion gases is 1227°C

i. Write the Chemical equation for stoichiometric reaction between C_3H_8 and air.
ii. Write the Balanced equation for the actual combustion process with 50 percent excess air.
iii. Calculate the Air –fuel ratio for the combustion process.
iv. Calculate the mass flow-rate of air entering the combustion chamber.

[5.0 Marks]

Q2. a) Compare advantages and disadvantages of open feed water heater over closed feed water heater.

[3.0 Marks]

b) Consider an ideal reheat-regenerative Rankine cycle with one open feed water heater. The boiler pressure is 12 MPa, the condenser pressure is 10 kPa, the reheater pressure is 1 MPa, and the feed water pressure is 0.5 MPa. Steam enters the high-pressure turbine at 500°C and 12 MPa and expands to 1 MPa. Then it is reheated to 500°C. The steam expands in the second-stage turbine to 0.5 MPa where a fraction

is extracted into the feed water heater and the remainder expands in the third-stage turbine to the condenser pressure of 10 kPa.

i. Sketch the cycle on a T-s diagram indicating saturation lines.

ii. Determine the fraction of steam extracted in feed water heater and thermal efficiency of the cycle.

[7.0 Marks]

Q3. a) Draw the P-v diagrams relevant to actual and ideal cycles for Spark-Ignition engines.

[3.0 Marks]

b) Define the compression ratio in an internal combustion engine? Discuss on how compression ratio affects the efficiency of Spark-Ignition engine.

[2.0 Marks]

c) An engine operates on air standard diesel cycle. The pressure and temperatures at the beginning of compression are 95 kPa and 27°C respectively. The compression ratio is 15. If the maximum temperature during the cycle is 1527°C, determine

i. The Net work done by the diesel cycle.

ii. The Thermal efficiency of the cycle.

iii. The mean effective pressure. Take cp = 1.005 kJ/kg.K, cv=0.717 kJ/kg.K and γ =1.4

[5.0 Marks]

Q4. a) What are the differences between open gas cycle and closed gas cycle?

[2.0 Marks]

b) For a gas turbine works on ideal Brayton cycle, show the efficiency is given by following equation.

$$\eta = 1 - \frac{1}{r_p^{(k-1)/k}}$$

Where, rp – Pressure ratio

k - Specific heat ratio

[3.0 Marks]

c). Consider an ideal gas-turbine cycle with two stages of compression and two stages of expansion. The pressure ratio across each stage of the compressor and turbine is 3. The air enters each stage of the compressor at 300 K and each stage of the turbine at 1200 K. Determine the back work ratio and the thermal efficiency of the cycle if a regenerator with 75 percent effectiveness is used. k =1.4 and cp = 1.005 kJ/kg.K

[5.0 Marks]

Q5. A velocity-compounded impulse turbine has two rows of moving blades with a row of fixed blades between them. The nozzle delivers steam at 660 m/s at an angle of 17° with the plane of rotation of the wheel. The first row of moving blades has an outlet angle of 18°, and the second row has an outlet angle of 36°. The row of fixed blades has an outlet angle of 22°. The mean radius of the blade wheel is 155 mm, and it rotates at 4,000 r/min. The steam flow rate is 80 kg/min, and its velocity is reduced by 10% over all the blades. Determine the following from the velocity diagrams,

i. The axial thrust on the shaft in N.
ii. The total force applied on the blades in the direction of the wheel in N.
iii. The power developed by the turbine in kW.
iv. The blading efficiency.
v. The average blade velocity in m/s.

[10.0 Marks]