UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 2 Examination in Engineering: February 2023

Module Number: ME2201

Module Name: Fundamentals of Engineering Thermodynamics

[Three Hours]

[Answer **all questions**, each question carries **12** marks]

Note: Provide neat sketches and state any reasonable assumptions made; Symbols have their usual meaning; Steam table is provided.

Q1 a) Briefly explain **two** practical applications of first law of thermodynamics.

[2.0 Marks]

b) Briefly explain the following terms. Provide **two** examples for each term.

i) Extensive properties

ii) Intensive properties

[3.0 Marks]

c) What is the difference between sensible heat and latent heat of a substance.

[2.0 Marks]

d) What is the difference between the terms "steady "and "uniform".

[2.0 Marks]

e) Two kilogram of a liquid of density 200 kg/m^3 is mixed with 2.5 kg of another liquid of density 250 kg/m^3. If the mixture volume is the sum of the initial volumes of the liquids, determine the mixture density.

[3.0 Marks]

Q2 a) During steady-state operation, a gearbox receives 120 kW through the input shaft and delivers power through the output shaft. For the gearbox as the system, the rate of energy transfer by convection is where h = 0.171 K is the heat transfer coefficient, A = 1.5 is the outer surface area of the gearbox, = 400 K is the temperature at the outer surface, and = 393 K is the temperature of the surrounding air away from the immediate vicinity of the gearbox. For the gearbox, calculate the heat transfer rate and the power delivered through the output shaft.

[4.0 Marks]

b) The rate of heat transfer between a certain electric motor and its surroundings varies with time as, . Where, t is in seconds and is in kW. The shaft of the motor rotates at a constant speed of 100 rad/s (about 955 revolutions per minute, or RPM) and applies a constant torque of 18 Nm to an external load. The motor draws a constant electric power input equal to 2.0 kW. For the motor, plot and , and the change in energy ΔE, as a function of the time from t = 0 to t = 120 s.

[8.0 Marks]

Q3 a) Steam enters a converging–diverging nozzle operating at steady state with the pressure of 60 bar, temperature of 500 °C, and a velocity of 15 m/s. The steam flows through the nozzle with negligible heat transfer and no significant change in potential energy. At the exit, pressure is 25 bar, and the velocity is 700 m/s. If

the mass flow rate is 3 kg/s, determine the exit area of the nozzle, in m^2.

[7.0 Marks]

b) Water flows into the top of an open barrel at a constant mass flow rate of 30 lb/s. Water exits through a pipe near the base with a mass flow rate proportional to the height of liquid inside: = *9 L*, where *L* is the instantaneous liquid height, in ft. The area of the base is 3 , and the density of water is 62.4 lb/. If the barrel is initially empty, plot the variation of liquid height with time.

[5.0 Marks]

Q4 a) Briefly explain the term "pure substance" with examples.

[1.0 Mark]

b) Briefly explain the following terms.
   i) Saturation temperature
   ii) Saturation pressure
   iii) Superheated vapour
   iv) Saturated vapour

[2.0 Marks]

c) Draw the phase diagram of a pure substance in *P—T* coordinates indicating the sublimation line.

[2.0 Marks]

d) A rigid tank of 0.03 m^3 volume contains a mixture of liquid water and water vapour at 80 kPa. The mass of the mixture in the tank is 12 kg. Calculate the heat added and the quality of the mixture when the pressure inside the tank is raised to 7 MPa.

[7.0 Marks]

Q5 a) What is a power cycle? Give **two** examples for real world systems with power cycle.

[3.0 Marks]

b) A steam power plant operates on Carnot cycle between boiler and condenser pressure of 70 bar and 0.5 bar.
   i) Sketch the layout of the equipment.

[1.0 Mark]

   ii) Sketch the theoretical cycle on a T-s diagram.

[2.0 Marks]

   iii) Determine the heat supplied to the boiler.

[2.0 Marks]

   iv) Determine the work done by the turbine.

[2.0 Marks]

   v) Determine thermal efficiency of the cycle.

[2.0 Marks]