INTERNATIONAL UNIVERSITY OF EAST AFRICA
'Learning to Succeed'

FACULTY OF ENGINEERING

END OF SEMESTER EXAMINATIONS - APRIL 2025

PROGRAMME: BACHELOR OF ELECTRICAL AND CONTROL ENGINEERING

YEAR/SEM: YEAR 4/SEMESTER 2

COURSE CODE: MEC4241

NAME: POWER PLANT TECHNOLOGY

DATE: 2025-04-15

TIME: 9:00AM-12:00PM

INSTRUCTIONS TO CANDIDATES:

1. Read the instructions very carefully
2. The time allowed for this examination is STRICTLY three hours
3. Read each question carefully before you attempt and allocate your time equally between all the Sections
4. Write clearly and legibly. Illegible handwriting cannot be marked
5. Number the questions you have attempted
6. Use of appropriate workplace examples to illustrate your answers will earn you bonus marks
7. Any examination malpractice detected will lead to automatic disqualification.

DO NOT WRITE ANYTHING ON THE QUESTION PAPER

Section A Answer any two QUESTIONS FROM THIS SECTION

Question 1:

a) Explain the working principle of a Simple Rankine Cycle. Identify and describe its four main proce using a T-s (temperature-entropy) or P-v (pressure-volume) diagram. (7marks)

b) Discuss the significance of boiler pressure and condenser pressure in the efficiency of the Simple R Cycle. How do these parameters affect the thermal efficiency and performance of a steam power plant? (6marks)

c) A steam power plant operates on a Simple Rankine Cycle with steam entering the turbine at 3 MPa 600°C and exiting the turbine at 10 kPa. Assuming ideal conditions, determine the thermal efficien cycle. Use steam tables to find enthalpy values for the states involved. (7marks)

Question 2:

a) Describe the process of steam formation from water, highlighting the key stages involved. Explain latent heat plays a role in this transformation. (6marks)

b) A vessel contains water at 100°C under standard atmospheric pressure. Explain what happens whe continuously supplied to the water, including changes in temperature, phase, and energy transfer. H this process relate to the concept of saturated steam and superheated steam? (7marks)

c) A boiler heats 2 kg of water from 30°C to produce steam at 100°C under standard atmospheric pre Given that the specific heat capacity of water is 4.18 kJ/kg·K and the latent heat of vaporization of 100°C is 2260 kJ/kg, calculate the total heat energy required for this process. (7marks)

Question 3:

a) Explain the significance of the First Law of Thermodynamics in relation to heat engines. (7mari

b) Why is it impossible to construct a perfect heat engine? Relate your answer to the Second Law Thermodynamics. (7marks)

c) A gas undergoes a thermodynamic process where it absorbs 200 J of heat and does 80 J of work Determine the change in internal energy of the gas. (7markds)

Question 4:

a) Explain the working principle of a steam turbine and differentiate between impulse and reaction turbines. (7marks)

b) Derive the expression for turbine efficiency using the isentropic efficiency equation:

$$\eta_{turbine} = \frac{h_1 - h_2}{h_1 - h_2 s}$$

where h_1 is the inlet enthalpy, h_2 is the actual exit enthalpy, and h_2s is the ideal exit enthalpy. (7marks)

c) Discuss the effects of steam velocity, pressure drop, and blade erosion on turbine efficiency and lifespan. (6marks)

Section B Answer any Three QUESTIONS from this SECTION

Question 1:

(a) Explain the primary objectives of power plant control systems. (7marks)

(b) Describe the role of Automatic Voltage Regulators (AVR) in maintaining stable power generation. (7marks)

(c) Discuss the significance of load frequency control (LFC) in a power plant and how it helps maintain system stability. (6marks)

Question 2:

(a) Explain the working principle of photovoltaic (PV) solar cells and how they convert sunlight into electricity. (7marks)

(b) Discuss the key factors affecting the efficiency of a solar PV system. (6marks)

(c) Compare grid-connected and off-grid solar power systems, highlighting their advantages and disadvantages. (7marks)

Question 3:

(a) Derive the expression for the maximum power output of a solar PV cell based on th current-voltage (I-V) characteristics. (6marks)

(b) How does shading affect the performance of a solar panel, and what methods are us to mitigate its impact? (7marks)

(c) A solar panel has an open-circuit voltage of 40V and a short-circuit current of 8A. I maximum power point voltage is 32V and the corresponding current is 7A, calculate th maximum power output and the panel's efficiency given that the panel receives 1000 W of solar radiation over an area of 1.5 m^2. (7marks)

Question 4:

(a) Derive the expression for the thermal efficiency of an ideal simple gas turbine cycle. (7mark

(b) Discuss the effect of pressure ratio on the performance of a simple gas turbine cycle. (6mark

(c) What are the major losses in a simple gas turbine cycle, and how can they be minimized? (7mark