BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF SCIENCE AND ENGINEERING

AEH 103

Department Of Engineering and Physics
Bachelor of Science (Honours) in Agricultural Engineering
Electrical and Electronic Principles

3 HOURS (100 MARKS)

JUN 2024

INSTRUCTIONS

Answer any ***FOUR*** questions. Each question carries 25 marks.

Question 1

a. With reference to electric current and convectional current, explain the significance of the electron theory in the study of electricity. [5 marks]

b. When a current of 5 A exists in a 10-Ω resistance for 4 minutes, determine:
   i. charge and [2 marks]
   ii. number of electrons that pass through any section of the resistor in this time. [3 marks]

c. If a rectangular carbon block with dimensions 1.0 cm × 1.0 cm × 50 cm has a resistivity of 3.5×10^{-5} Ω-m, calculate the resistance between:
   i. the two square ends, [3 marks]
   ii. two opposing rectangular faces. [3 marks]

d. A current of 1 A flows in a copper conductor of cross-section 1 cm^2, length 10 km and a free electron density of copper = 8.5×10^{28} per m^3. For the electric charge, calculate:
   i. The velocity, [4 marks]
   ii. The time (years) to travel from one end of the conductor to the other. [5 marks]

Question 2

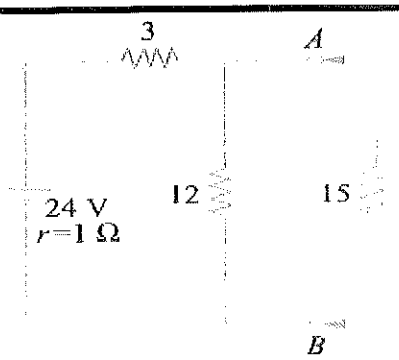
a. Explain, giving applications, the theory of circuit current flow in liquids. [3 marks]

b. With reference to temperature-coefficient of resistance, use practical examples to explain the effect of rise in temperature of:
   i. Pure metals, [3 marks]
   ii. Alloys, and [3 marks]
   iii. Electrolytes. [3 marks]

c. A voltage source delivers 4 A when the load connected to it is 5 Ω and 2 A is delivered when the load becomes 20 Ω. Calculate:
   i. maximum power which the source can supply, [5 marks]
   ii. power transfer efficiency of the source with R_L of 20 Ω, [3 marks]
   iii. the power transfer efficiency when the source delivers 60 W. [5 marks]

Question 3

a. Using Thevenin theorem, calculate the current flowing through the 15 Ω resistor in Figure 1.



[7 marks]

Figure 1

b. A de-icing equipment fitted to a radio aerial consists of a length of a resistance wire so arranged that when a current is passed through it, parts of the aerial become warm. The resistance wire dissipates 1250 W when 50 V is maintained across its ends. If it is connected to a d.c. supply by 100 metres of this copper wire, each conductor of which has resistance of 0.006 Ω/m, calculate:
   i. the current in the resistance wire, [2 marks]
   ii. the power lost in the copper connecting wire, and [4 marks]
   iii. supply voltage required to maintain 50 V across the heater itself. [4 marks]

c. A room measures 4 m × 7 m × 5 m and the air in it has to be always kept 15°C higher than that of the incoming air. The air inside has to be renewed every 35 minutes. Neglecting radiation loss, calculate the rating of the heater suitable for this purpose. Take specific heat of air as 0.24 and density as 1.27 kg/m^3. [8 marks]

Question 4

a. Briefly explain the four effects of electric current. [8 marks]

b. If a hydroelectric generating station is supplied from a reservoir of capacity 6 million m^3 at a head of 170 m, calculate:
   i. the available energy in kWh if the hydraulic efficiency be 0.8 and the electrical efficiency 0.9, [5 marks]
   ii. the fall in reservoir level after a load of 12,000 kW has been supplied for 3 hours, the area of the reservoir is 2.5 km^2, [6 marks]
   iii. the power and energy equivalent per day for the reservoir supplied by a river at 1.2 m^3/s, assuming a constant head and efficiency. [6 marks]

Question 5

a. Given that a d.c. electromagnet wound with 1200 turns has a resistance of 80 Ω when the exciting voltage is 230 V and magnetic flux is 0.01 Wb. Calculate:
   i. the self-inductance of coil, [3 marks]
   ii. the energy stored in the magnetic field. [3 marks]

b. Calculate the line voltage for a star connected load that consists of three identical coils each of resistance 40Ω and inductance 164.5mH. It is given that the line current is 6.24 A and the supply frequency is 50Hz. [9 marks]

c. Three coils each having resistance 5Ω and inductive reactance 8Ω are connected (a) in star and (b) in delta to a 430V, three-phase supply. Calculate, for each connection, line and phase:
   i. Voltages, [5 marks]

ii. **Currents.** [5 marks]

Question 6

a. Distinguish between combinational logic and sequential logic. [6 marks]

b. Using balanced equations, describe the chemical changes that take place during charging of a lead acid battery. [6 marks]

c. For the circuit shown in Figure 2, show the:

i. Boolean expression, and [1 mark]

ii. The truth table of the expression. [4 marks]

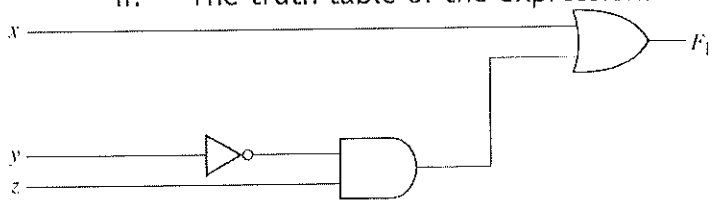


Figure 2

d. Simplify and prepare the truth table for the following Boolean expressions:

i. Z = ABC + ABC' +AB'C, [4 marks]

ii. F = x'y'z + x'yz + xy'. [4 marks]

END OF PAPER.