7. (a) Using Norton's theorem find the current through 2 Ω resistor of the circuit shown in Fig.3.

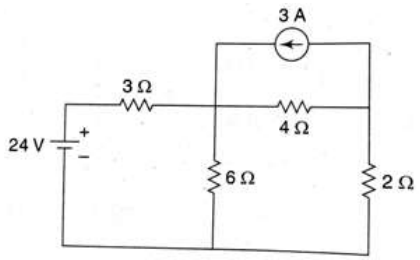

Fig.3

(b) State and prove maximum power transfer theorem for a DC circuit. Also show that the efficiency under this condition is 50%.

5 + (2 + 3 + 2) = 12

Group – E

8. (a) Prove that the current through a pure capacitor leads the applied alternating voltage by 90°. Also prove that the power consumed by a pure capacitor is zero.

(b) Draw impedance triangle and power triangle of a series R-L circuit and define power factor from those triangles.

(c) A series circuit has a resistance of 10 Ω, inductance of 50 mH and a capacitance of 100 μF is connected across a 200 V, 50 Hz supply. Find out (i) impedance (ii) current (iii) power factor (iv) active power and (v) reactive power of the given circuit.

4 + 3 + 5 = 12

9. (a) What are the properties of a parallel circuit under resonance?

(b) Each phase of a delta connected load comprises of a resistor of 50 Ω and a series capacitor of 50 μF. Calculate the line and phase currents when the load is connected to a 440 V, 3 phase, 50 Hz supply.

(c) In a magnetic circuit what is eddy current loss and hysteresis loss?

3 + 5 + 4 = 12

THERMAL AND ELECTRICAL ENERGY FUNDAMENTALS
(REEN 5142)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Measurement of thermodynamic property of temperature is facilitated by _____ law of thermodynamics.
(a) zeroth (b) first (c) second (d) third

(ii) An isentropic process is always
(a) reversible isothermal (b) reversible adiabatic
(c) irreversible isothermal (d) irreversible adiabatic.

(iii) Norton's equivalent circuit consists of
(a) equivalent current source and impedance in series
(b) equivalent current source and impedance in parallel
(c) equivalent voltage source and impedance in series
(d) equivalent voltage source and impedance in parallel.

(iv) A circuit consists of a coil of 70 Ω resistance and 2 H inductance in series with a capacitor of 0.05 μF capacitance. The resonant frequency is
(a) 147 Hz (b) 159 Hz (c) 171 Hz (d) 135 Hz.

(v) In a three-phase system line voltages are
(a) 30° apart (b) 60° apart (c) 90° apart (d) 120° apart.

(vi) In a polytropic process equation Pv^n = constant, if n is infinitely large, the process is termed as
(a) constant volume (b) constant pressure
(c) constant temperature (d) adiabatic.

(vii) Gases deviate from ideal behaviour at high pressure. Which of the following is correct for non-ideality?
(a) At high pressure, the collision between the gas molecules becomes enormous

(b) At high pressure, the gas molecules move only in one direction
(c) At high pressure, the volume of gas becomes insignificant
(d) At high pressure the intermolecular interaction become significant.

(viii) The Carnot engine whose cold reservoir is at 7°C has an efficiency of 40%. The approximate temperature of the hot reservoir is
(a) 427°C (b) 320°C (c) 220°C (d) 194°C.

(ix) Three equal resistances of 6Ω are connected in delta. What is the resistance in one of the arms in an equivalent star circuit?
(a) 10 Ω (b) 2 Ω (c) 9 Ω (d) 27 Ω.

(x) Flux in the magnetic circuit is analogous to the _____ in the electrical circuit.
(a) current (b) voltage
(c) resistance (d) conductance

Group – B

2. (a) One kg of an ideal gas (Mol.Wt. 44) contained in a closed system undergoes a reversible isobaric process. During the process 48 kJ of internal energy is decreased. Determine the work done during the process. Given c_p = 840 J/kgK.

(b) A turbine, operating under steady flow conditions, receives 4500 kg of steam per hr. The steam enters the turbine at a velocity of 2800 m/min, an elevation of 5.5 m and a specific enthalpy of 2800 kJ/kg. It leaves the turbine at a velocity of 5600 m/min, an elevation of 1.5 m and a specific enthalpy of 2300 kJ/kg. Heat losses from the turbine to the surroundings amounts to 16000 kJ/h. Determine the power output (in MW) from the turbine.

5 + 7 = 12

3. (a) Show that in a two-stage reciprocating compressor, the minimum total work results when the pressure ratios in each stage are equal and are given by the square root of the overall pressure ratio.

(b) It is desired to compress one mole of air (ideal gas with γ = 1.4) from 1 bar 25°C to 5 bar 25°C. This can be achieved by the following processes. Determine the work done in each case.
(i) Isothermal compression
(ii) Adiabatic compression followed by isochoric cooling

7 + 5 = 12

Group – C

4. In a process industry one unit delivers a gas A at 1 bar and 1000 K at a rate of 2 kmol/s and the second unit delivers a gas B at 1 bar 800 K at a rate of 3 kmol/s. The ambient atmosphere is at 300 K. If the hot gas is considered source and the

ambient atmosphere as sink, then calculate the maximum power obtainable from a heat engine if
(i) A and B gases are used as separate source
(ii) A and B gases are mixed and the mixture is used as source
Assume both gases are ideal gas with γ = 1.4.

(6 + 6) = 12

5. (a) Show that the theoretical work required for an adiabatic single stage compressor working with an ideal gas is given by

$$W = \frac{\gamma R T_{in}}{\gamma - 1}\left[1 - \left(\frac{P_{out}}{P_{in}}\right)^{\frac{\gamma-1}{\gamma}}\right]$$

where, P_{in} and P_{out} are the inlet and outlet pressure of the compressor, T_{in} is the inlet temperature of the gas and γ is the heat capacity ratio of the ideal gas.

(b) 10 kg of air which is initially at 100 kPa and 300 K is heated until the temperature reaches to 600 K. Determine the heat supplied and work done in the following process (i) Constant volume process (ii) Constant pressure process.

6 + 6 = 12

Group – D

6. (a) Define ideal voltage source. Why a practical voltage source is different from ideal voltage source?
Find the resistance across terminals A-B for the circuit shown in Fig.1.

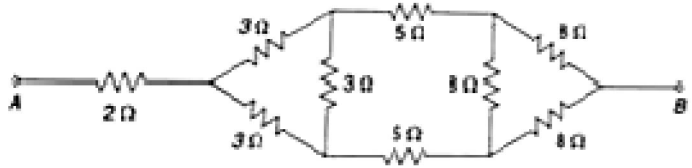

Fig.1

(b) Using mesh analysis method find the unknown loop currents shown in Fig.2.

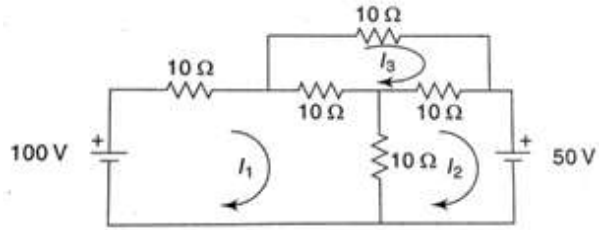

Fig.2

(1 + 2 + 3) + 6 = 12