

**THERMAL AND ELECTRICAL ENERGY FUNDAMENTALS
(REEN 5144)**

Time Allotted : 2½ hrs

Full Marks : 60

Figures out of the right margin indicate full marks.

*Candidates are required to answer Group A and
any 4 (four) from Group B to E, taking one from each group.*

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

Group – A

1. Answer any twelve:

12 × 1 = 12

Choose the correct alternative for the following

- (i) For a grey surface
(a) emissivity is constant (b) absorptivity equals reflectivity
(c) emissivity equals transmittivity (d) reflectivity equals emissivity.
- (ii) Irreversibility is associated with a process is due to
(a) mechanical and fluid friction
(b) unrestricted expansion
(c) transfer of species due to concentration difference
(d) all of these
- (iii) Two moles of an ideal gas is expanded reversibly and isothermally from 1 L to 10 L. The enthalpy change of the process is
(a) 11.4 kJ (b) -11.4 kJ
(c) 0 kJ (d) 4.8 kJ.
- (iv) All the following are the units of thermal conductivity except
(a) kcal/m-hr-°C (b) kJ/m-hr-K
(c) kW/m-s-K (d) BTU/ft-s-°R.
- (v) The unit of thermal diffusivity is
(a) hr/m² (b) m/hr²
(c) hr²/m (d) m²/hr.
- (vi) Norton's equivalent circuit consists of
(a) equivalent current source and impedance in series
(b) equivalent voltage source and impedance in parallel
(c) equivalent current source and impedance in parallel
(d) equivalent voltage source and impedance in series.
- (vii) Hysteresis loss in a magnetic circuit can be reduced by using
(a) laminated core (b) silicon steel (c) oil (d) solid steel.

- (viii) Admittance is the reciprocal of
 (a) inductive reactance (b) reactive power
 (c) capacitive reactance (d) impedance.
- (ix) In a balanced 3-phase system, the emfs are
 (a) 30° apart (b) 60° apart
 (c) 90° apart (d) 120° apart.
- (x) If an electrical network consists of no source of excitation, the network is called as
 (a) active network (b) passive network
 (c) unilateral network (d) bilateral network.

Fill in the blanks with the correct word

- (xi) Solar collector receives heat from sun mainly by _____.
- (xii) Mode of heat transfer in which the fluid moves under the influence of changes in fluid pressure produced by external work is called _____.
- (xiii) In a pure capacitive circuit the current leads the supply voltage by an angle of _____.
- (xiv) Superposition theorem is not applicable for _____.
- (xv) The resolution for n bit system D/A converter is _____.

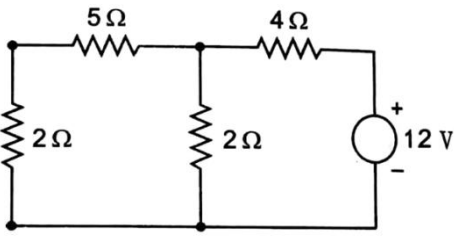
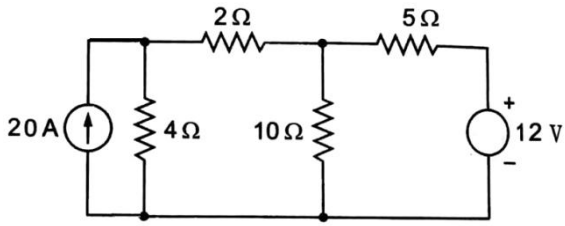
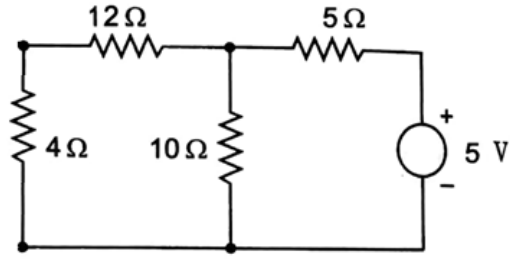
Group - B

2. (a) What is Wien's Displacement law? Starting from the concept of spectral distribution of black body emissive power, establish Wien's Displacement law. [[CO1](understand/LOCQ)]
- (b) An artificial spherical satellite orbiting the earth is shifted towards mars. What shall be the temperature as it approaches the mars if its temperature near the earth was 325 K. The pertinent data is: distance of earth from the sun = 149.6×10^6 km, distance of mars from the sun = 227.9×10^6 km. Note that emissivity of the satellite does not vary with temperature. [[CO1](Evaluate/HOCQ)]
7 + 5 = 12
3. (a) What is thermal diffusivity? State the fourier law of heat conduction and also define heat transfer coefficient. [[CO1](Remember/LOCQ)]
- (b) A glazed window, made of 8 mm thick glass of thermal conductivity 1.5 W/m K, has its outside surface maintained at 5°C so that frosting is reduced. The surrounding are at -10°C with convective heat transfer coefficient $55 \text{ W/m}^2 \text{ K}$. The desired condition is attained by providing uniform heat flux at the inner surface of the window which is fitted into a room where the air temperature is 25°C with a convection coefficient of $12.5 \text{ W/m}^2 \text{ K}$. Calculate the heating required per m^2 area. [[CO1](Evaluate/IOCQ)]
5 + 7 = 12

Group - C

4. (a) An ideal gas continuously compressed in a centrifugal compressor from a pressure P_1 and temperature T_1 to a pressure P_2 . Determine the minimum power required to drive the compressor. [[CO2](Apply/HOCQ)]
- (b) Water at 85°C is pumped from a storage tank at the rate of 5 lt/s . The motor for the pump supplies work at the rate of 1.5 kW . The water passes through a cooler giving up heat at the rate of 190 kcal/s and is delivered to a second storage tank at an elevation 10 m above the first tank. What is the temperature of water delivered to the second tank? Take, C_p of water = 4.18 kJ/kg K . [[CO2](Evaluate/HOCQ)]
6 + 6 = 12
5. (a) Calculate the entropy change if 1 kg supercooled liquid water at -10°C and 1 bar is converted into ice at -10°C and 1 bar . Specific heat of ice and water are 2.1 kJ/kg K and 4.2 kJ/kg K respectively. Latent heat of fusion of water at 0°C is 333.43 kJ/kg . [[CO2](Evaluate/HOCQ)]
- (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. [[CO2](Analyze/HOCQ)]
5 + 7 = 12

Group - D

6. (a) Write the expressions to transform a star connected network into its equivalent delta network. [[CO3] (Remember/LOCQ)]
- (b) Using mesh analysis method, calculate the current through 5Ω resistor of the following circuit. [[CO3](Analyze/HOCQ)]
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- (c) Determine the voltage across 10Ω resistor using Superposition Theorem. [[CO3](Understand/LOCQ)]
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- 2 + 5 + 5 = 12**
7. (a) Determine the current through 12Ω resistor using Thevenin's Theorem. [[CO3](Evaluate/HOCQ)]
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- (b) State and Prove Maximum Power Transfer Theorem. [[CO3](Remember/LOCQ)]
6 + 6 = 12

Group - E

8. (a) What are the types of magnetic materials? [[CO4](Remember/LOCQ)]
 (b) Derive the expression of resonating frequency in R-L-C series circuit. [[CO4](Analyse/IOCQ)]
 (c) A resistance of 25 Ω, inductance of 0.15 H and a capacitance of 80 μF are connected in series across a 230 V AC, 50 Hz supply. Calculate (i) impedance of the circuit (ii) current flowing through the circuit (iii) power factor. [[CO4](Evaluate/HOCQ)]
 (d) List one similarity between Electric and magnetic circuits. [[CO4](Remember/LOCQ)]
 (e) Write the expression of reluctance in terms of dimensions of the magnetic circuit. [[CO4](Remember/LOCQ)]
 (f) State one property of magnetic lines of force. [[CO4](Remember/LOCQ)]
3 + 3 + 3 + 1 + 1 + 1 = 12
9. (a) Three coils, each having equal impedances of $(10+j10)\Omega$, are connected in star across a 400V, 50Hz three-phase line. Calculate (i) phase current, (ii) line current, (iii) power factor and (iv) active power (v) reactive power. [[CO4](Apply/IOCQ)]
 (b) Derive the relationship between phase voltage and line voltage in a balanced Star connected 3-phase system. [[CO4](Analyse/IOCQ)]
 (c) Write the expression of Eddy current loss. [[CO4](Remember/LOCQ)]
 (d) Sketch the phasor diagram under resonance condition of R-L-C series circuit. [[CO4](Apply/IOCQ)]
 (e) State two differences between electric and magnetic circuits. [[CO4](Remember/LOCQ)]
5 + 3 + 1 + 2 + 1 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	34.38	39.58	26.04

Course Outcome (CO):

After completing the course students will be able to

1. Apply the knowledge of different modes of heat transfer to design equipments for harnessing renewable energy.
2. Understand the basics of characteristics and behavior of laws of thermodynamics and its applications to process.
3. Understand the basics of DC and AC sources along with their applications on electrical circuits.
4. Solve the problems related to R-L-C circuits connected to single phase and three phase AC.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.