THERMAL AND ELECTRICAL ENERGY FUNDAMENTALS
(REEN 5144)

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) Absorptivity of a surface is equal to its emissivity
(a) for a polished surface (b) at one particular temperature
(c) under thermal equilibrium condition (d) for a rough grey surface

(ii) The law governing the distribution of radiant energy over the wavelength for a black body at fixed temperature is referred to as
(a) Plank's law (b) Wein's displacement law
(c) Kirchoff's law (d) Lambert's law

(iii) If the temperature of a hot body is increased by 50%, the amount of radiation emitted by it would be increased by nearly
(a) 50% (b) 100% (c) 200% (d) 500%

(iv) Two moles of an ideal gas is expanded reversibly and isothermally form 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

(v) 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

(vi) In a pure capacitive circuit the current
(a) is always in phase with the supply voltage
(b) always lags behind the supply voltage by an angle 90^0
(c) always leads the supply voltage by an angle 90^0
(d) may lag or lead the supply voltage by an angle 90^0

(vii) Admittance is the reciprocal of
(a) inductive reactance (b) reactive power
(c) capacitive reactance (d) impedance

(viii) The magnetic energy stored in a coil is given by
(a) $\frac{1}{2}LI^2$ (b) $\frac{1}{2}IL^2$ (c) $\frac{1}{2}BH^2$ (d) $\frac{1}{2}HB^2$

(ix) If the peak value of a sine wave is 100 volts, then its rms value will be
(a) 70.7 V (b) 141.42 V (c) 100 V (d) 57.73 V

(x) Kirchhoff's current law is used for
(a) Mesh analysis (b) Finding out equivalent current
(c) Finding out equivalent resistance (d) Nodal analysis

Group- B

2. (a) What is the physical significance of Nusselt number and Prandtl number related to convective heat transfer. [(CO1) (Understand/LOCQ)]

(b) Estimate the heat transfer from a 40 W incandescent bulb at 125°C to 25°C in quiescent air. Approximate the bulb as a 50 mm diameter sphere. Calculate the percentage of power lost by free convection. Use the following correlation for convection coefficient $Nu = 0.6(Gr\,\mathrm{Pr})^{0.25}$

Given, air parameters at mean temperature: kinematic viscosity = 20.55×10^{-6} m^2/s, thermal conductivity = 0.03 W/m-K, Pr = 0.693. (Symbols bear usual significance). [(CO1) (Evaluate/HOCQ)]

4 + 8 = 12

3. (a) Define total emissive power of a black body. Show that total emissive power of a back body is proportional to fourth power of its absolute temperature. Also determine analytically the value of constant of proportionality.
[(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 325K. 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.
[(CO3) (Evaluate/HOCQ)]

(2 + 6) + 4 = 12

Group - C

4. (a) 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. [(CO2) (Analyze/IOCQ)]

(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 to16000 kJ/h. Determine the power output (in MW) from the turbine. [(CO2) (Analyze/IOCQ)]

6 + 6 = 12

5. (a) One mole of an ideal gas (γ = 1.4) initially at 1bar, 300K is compressed reversibly and adiabatically till the pressure is 2bar and then it is cooled at constant volume to the initial pressure. Finally the gas is restored to initial state through an isobaric process. Calculate the work done by the gas. [(CO2) (Apply/IOCQ)]

(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 1.5kW. 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 °C. [(CO2) (Apply/IOCQ)]

(4 + 3) + 5 = 12

Group - D

6. (a) State and explain Superposition Theorem with proper circuit diagram. [(CO5) (Understand/LOCQ)]

(b) Find out the current through the 2Ω resistance using Thevenin's theorem for the circuit of Fig.1

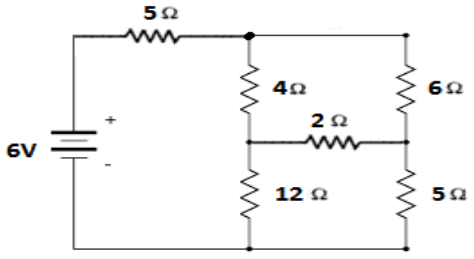

Fig. 1

[(CO5) (Remember/LOCQ)]

4 + 8 = 12

7. (a) Identify the current through 3 Ω resistor in the circuit of Fig. 2 using Nodal analysis.

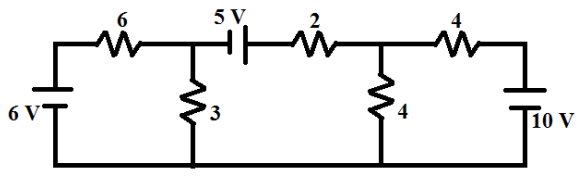

Fig. 2

[(CO5) (Apply/IOCQ)]

(b) Find the equivalent resistance across A-B terminals of following Fig. 3 using star-delta transformation.

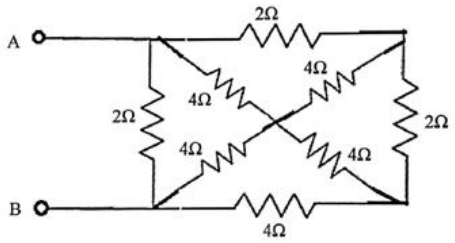

Fig. 3

[(CO5) (Understand/LOCQ)]

6 + 6 = 12

Group - E

8. (a) Compare electric circuit and magnetic circuit with respect to their similarities and dissimilarities. [(CO4) (Analyze/IOCQ)]

(b) An electromagnet (as shown in Fig. 4) has a cross-sectional area of 12 cm^2. Mean length of iron path is 50 cm. It is excited by a coil of 400 turns. When the current in the coils is 1 A, the resulting flux density gives a relative permeability of 1300 and $\mu_0 = 4\pi \times 10^{-7}$. Determine (i) reluctance of iron part of the magnetic circuit; (ii) reluctance of the air-gap; (iii) total reluctance; (iv) total flux and (v) flux density in the air-gap. Neglect leakage and fringing.

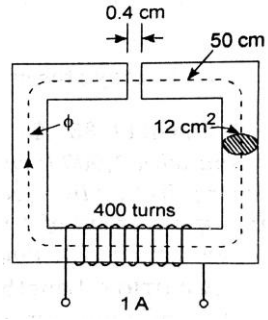

Fig. 4

[(CO4) (Evaluate/HOCQ)]

4 + 8 = 12

9. (a) Determine the rms, average, form factor and peak factor for the following waveform.

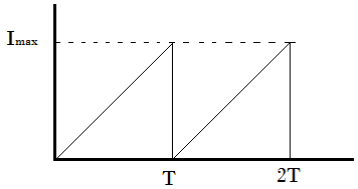

Fig. 3

[(CO6) (Evaluate/HOCQ)]

(b) A three-phase 220 V load has a power factor of 0.9. Two wattmeters are connected to measure the power which shows the input to be 10 kW. Identify the reading of each wattmeter. [(CO6) (Apply/IOCQ)]

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	31.25%	41.67%	27.08%

Course Outcome (CO):

After completion of 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 behaviour of laws of thermodynamics and its applications to process.
3. Solve the problems related power generation from renewable resources.
4. Understand the basics of DC and AC sources along with their applications on electrical circuits.
5. Solve the problems related to applications of network theorems and solving complex DC circuits.
6. 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

Department & Section	Submission Link
RE	https://classroom.google.com/c/NDE4MTgwNDM2MjI2/a/NDYzODMzODg1NTAz/details