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) All the following are the units of thermal conductivity except
(a) Kcal/m-hr-ºC (b) kJ/m-hr-K
(c) kW/m-s-K (d) BTU/ft-s-ºR

(ii) For a grey surface
(a) emissivity is constant (b) absorptivity equals reflectivity
(c) emissivity equals transmitivity (d) reflectivity equals emissivity

(iii) Throttling process is a
(a) irreversible isothermal process
(b) reversible isentropic process
(c) reversible constant enthalpy process
(d) irreversible constant enthalpy process

(iv) 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

(v) 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

(vi) 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

(vii) In RLC series resonance the current will be
(a) maximum (b) minimum
(c) zero (d) below maximum

(viii) For delta connected load the relation between line and the phase current is
(a) $I_L = \sqrt{3} I_{ph}$ (b) $I_{ph} = \sqrt{3} I_L$ (c) $I_L = \sqrt{3/I_{ph}}$ (d) $I_L = I_{ph}/\sqrt{3}$

(ix) For maximum power transfer, the Thevenin's equivalent resistance of the network must be equal to
(a) half of the load resistance (b) the load resistance
(c) Infinity (d) zero

(x) The reluctance of a magnetic circuit is given by
(a) $\frac{\boldsymbol{l}}{\boldsymbol{\mu_r \mu_0 A}}$ (b) $\frac{\phi}{N}$ (c) $\frac{\boldsymbol{l}}{\boldsymbol{\mu_0 A}}$ (d) $\frac{\boldsymbol{l}}{\boldsymbol{\mu_r A}}$

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.

(b) Two large parallel plates at 800K and 600K temperature have emissivities 0.5 and 0.8 respectively. A radiation shield having emissivity 0.1 on one side and 0.05 on the other side is placed between the plates. Calculate the heat transfer rate per square meter with and without the radiation shield.

(2 + 5) + 5 = 12

3. (a) What is thermal diffusivity? State the fourier law of heat conduction and also define heat transfer coefficient.

(b) Within a condenser shell, water flows through one hundred thin-walled circular tube (diameter 225 mm and length 5 m) which have been arranged in parallel. The mass flow rate of water is 65 kg/s, and its inlet and outlet temperature are known to be 22ºC and 28ºC respectively. Predict the average heat transfer coefficient associated with the flow. Use the following correlation $Nu = 0.023(\mathrm{Re})^{0.8}(\mathrm{Pr})^{0.4}$

Given, water parameters at mean temperature: dynamic viscosity = 903.01×10^{-6} kg/m-s, thermal conductivity = 2.19 kJ/m-hr-K W/m-K, density = 996 kg/m^3, Pr = 6.2. (Symbols bear usual significance)

(2 + 3) + 7 = 12

Group – C

4. (a) Show that, for an irreversible non cyclic process $\Delta S > \int \frac{dQ}{T}$ where, ΔS is the entropy change of the system, Q is the heat interaction with the surrounding and T is temperature of system.

(b) An hydrocarbon oil (c_p = 2512 J/kg K) is cooled from 422 K to 399 K in a heat exchanger at the rate of 2500 kg/h. Cooling water at the rate of 5000 kg/h enters the exchanger at 294 K. Assume there is no heat loss in the heat exchanger.

(i) What is the rate of change of entropy (in W/K) of the system?

(ii) How much maximum power could be obtained if the cooling of hydrocarbon oil is carried out by a heat engine rejecting heat to a sink at 294 K?

5 + 7 = 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) A sample of coal contains 80% carbon, 10% hydrogen and rest is ash. Determine the volumetric composition of flue gas if the coal is completely burned in a furnace with 30% excess air of that theoretically required.

6 + 6 = 12

Group – D

6. (a) Determine the current passing through R_L=2 Ω resistor of the network of Fig. 1 by using Thevenin's theorem.

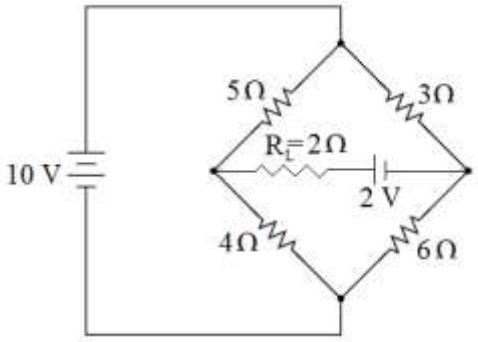

Fig. 1

(b) State and prove Maximum Power Transfer theorem for a DC network.

7 + (2 + 3) = 12

7. (a) Obtain Thevenin's equivalent circuit across terminals a-b in the Fig. 3.

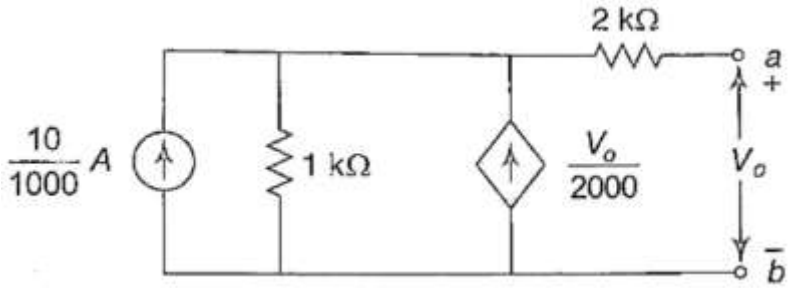

Fig. 3

(b) Determine the resistance between A and B in the network shown in Fig. 4

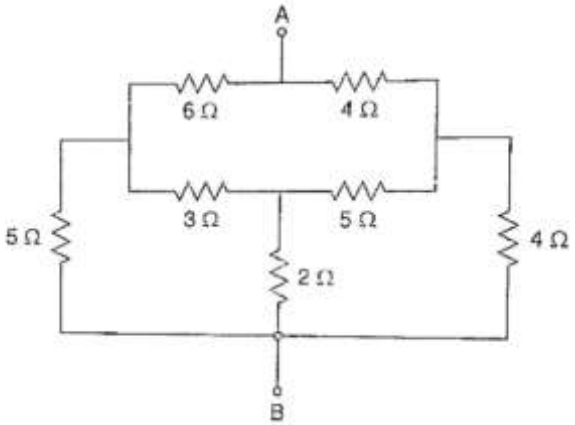

Fig. 4

6 + 6 = 12

Group – E

8. (a) In a circuit applied voltage is given by (0+j10) V and the current is (1+j0.5) A. Determine the value of R and X and also indicate whether X is inductive or capacitive.

(b) Fine the relation between line and phase voltage for star connected 3-phase load

(4 + 2) + 6 = 12

9. (a) For RLC series circuit the value of resistance, inductance and capacitance are 10 Ω, 2 H and 100 μF respectively. If the applied voltage is 100 V calculate the value of current at resonance, the resonance frequency and the power absorbed by the load at resonance.

(b) Define the self inductance and mutual inductance.
An air gap 1.1 mm long and 40 sq. cm in cross-section exists in a magnetic circuit. Determine (i) Reluctance S of the air-gap and (ii) mmf required to create a flux of 10×10^{-4} Wb in the air gap.

6 + (2 + 4) = 12

Department & Section	Submission Link
RE	https://classroom.google.com/w/MjQ0MzYyMTk4Mzgy/tc/MjY0NDU3MjMwODcw/details