POWER PLANT ENGINEERING
(MECH 4242)

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) The steam is compressed isentropically in a pump from saturated liquid at 0.08 bar to 100 bar. The pump work in kJ per kg of saturated water is approximately
(a) 10 (b) 0.1 (c) 100 (d) none of (a), (b) & (c).

(ii) Out of the following, which one is used for the part recovery of waste heat from flue gases of boiler?
(a) Feed pump (b) Super-heater (c) Blow-off valve (d) Evaporator.

(iii) While doing flue gas analysis by ORSAT apparatus, the pyrogallic acid absorbs _____ gas.
(a) O_2 (b) N_2 (c) CO_2 (d) CO

(iv) Average load in a year when divided by the rated capacity of the plant, is called.
(a) reserve factor (b) capacity factor
(c) demand factor (d) load factor.

(v) The steam is expanded isentropically from 80 bar, 500°C in a turbine to saturated vapour from where partial steam is extracted for regeneration. The pressure of the extracted steam is approximately
(a) 2.5 bar (b) 6.7 bar (c) 40 bar (d) 20 bar.

(vi) Artificial draught is produced by
(a) induced fan (b) forced fan
(c) both induced draught and forced draught fan (d) all of (a), (b) & (c).

(vii) Stage efficiency of an impulse turbine is
(a) $\eta_{nozzle} + \eta_{blade}$ (b) $\eta_{nozzle} \times \eta_{blade}$ (c) $\eta_{nozzle} - \eta_{blade}$ (d) none of (a), (b) & (c).

(viii) The outlet and inlet temperature of cooling water are 40° C and 25° C respectively. If the steam enters the condenser at 0.1 bar, then, the condenser efficiency is approximately
(a) 62% (b) 85% (c) 72 % (d) 92 %.

(ix) In a Parson's reaction turbine, the enthalpy drop in fixed blade is 20 kJ/kg. Enthalpy drop in moving blade in kJ/kg is
(a) 40 (b) 10 (c) 20 (d) 30.

(x) A plant has a peak load of 1000 MW but the average annual load is 350 MW. The annual load factor of the plant is
(a) 0.35 (b) 28.5 (c) 35 (d) 3.5.

Group- B

2. A regenerative cycle operates with steam supplied at 30 bar and 300°C, and the condenser pressure is 0.08 bar. The extraction points for two heaters (both open) are at 3.5 bar and 0.7 bar respectively. Calculate the thermal efficiency of the plant neglecting pump work. *[(CO1)(Evaluate/HOCQ)]*
12

3. In a reheat cycle, steam at 500°C expands in a h.p. turbine till it is saturated vapour. It is reheated at constant pressure to 400°C and then expands in alp turbine to 40°C. If the maximum moisture content at the turbine exhaust is limited to 15%, find (i) the reheat pressure, (ii) the pressure of steam at the inlet to the h.p. turbine, (iii) the net specific work output, (iv) the cycle efficiency, and (v) the steam rate. Assume all ideal processes. What would have been the quality, the work output, and the cycle efficiency without the reheating of steam? Assume that the other conditions remain the same.
[(CO1)(Evaluate/HOCQ)]
12

Group - C

4. (a) A chimney is producing a draught equivalent to 13 mm of water which is 80% of the theoretical draught that would have been produced. The chimney is filled with hot gas of 287° C . The temperature of air outside is 21°C. The boiler uses 18 kg of air per kg of fuel consumed. Find the height of the chimney.
[(CO2)(Evaluate/HOCQ)]

(b) Find the power required by the FD fan with the following data:
coal burning rate: 10 tons per hour ,
theoretical air required: 9.9 kg of air per kg of coal
excess air supplied: 30% ,
pressure head developed: 180 mm of water,
mechanical efficiency of the fan: 60%
ambient temperature: 30^0 C ,
ambient pressure: 760 mm of Hg. *[(CO2)(Evaluate/HOCQ)]*
6 + 6 = 12

5. The following readings were recorded during two hour trial on a boiler:
Feed water supplied = 14000 kg
Boiler working pressure = 10 bar
Dryness fraction of steam = 0.96

Temp. of feed water entering economiser = 35°C
Temp. of feed water leaving economiser = 90°C
Temperature of steam leaving superheater = 250°C
Coal burnt = 1500 kg
Calorific value of coal = 33500 kJ/kg
Calculate:
(i) Enthalpy received by feed water in economiser boiler and superheater,
(ii) Percentage of heat utilized in economiser, boiler and superheater,
(iii) Overall thermal efficiency of plant,
(iv) Overall equivalent evaporation from and at 100°C. *[(CO4)(Evaluate/HOCQ)]*

12

Group - D

6. (a) Absolute velocity of steam 300 m/s is supplied through a nozzle to a single stage impulse turbine. The nozzle angle is 25°. The mean diameter of the blade rotor is 1 m and it has a speed of 2000 rpm. Find suitable blade angles for zero axial thrust. If the blade velocity coefficient is 0.9 and the steam flow rate is 36000 kg/hr, calculate the power developed. *[(CO3)(Evaluate/HOCQ)]*

(b) Air enters a frictionless adiabatic converging nozzle at 10 bar, 500 K with negligible velocity. The nozzle discharges to a region at 2 bar. If the exit area of the nozzle is 2.5 cm^2, find the flow rate of air through the nozzle. Assume for air Cp = 1005 J/kg K and Cv = 718 J/kgK. *[(CO3)(Analysis/IOCQ)]*

6 + 6 = 12

7. The following particulars refer to a two row velocity compounded impulse turbine

Steam velocity at the nozzle outlet	: 650m/s
Mean blade velocity	: 130 m/s
Nozzle angle	: 16°
Outlet angle, first row of moving blades	: 18°
Outlet angle, fixed guide blades	: 22°
Outlet angle, second row of moving blades	: 36°
Steam flow rate	: 2.6 kg/s

The ratio of relative velocity at the outlet to that at the inlet is 0.84 for all blades. Determine (i) the velocity of whirl (ii) the tangential thrust on the blades (iii) the axial thrust on blades (iv) the power developed and (v) the blading efficiency.

[(CO3)(Evaluate/HOCQ)]

12

Group - E

8. (a) A power station supplies the following loads to the consumers:

Time in Hours	0-6	6-10	10-12	12-16	16-20	20-22	22-24
Load (MW)	30	70	90	60	100	80	60

(i) Draw the load curve and estimate the load factor of the plant.

(ii) What is the load factor of a standby equipment of 30 MW capacity if it takes up all loads above 70 MW. Also find out the use factor of the stand by unit.

[(CO1)(Analyse/IOCQ)]

(b) Write short notes on with respect to hydro-electric power plant:
(i) Catchment Area
(ii) Reservoir
(iii) Dam
(iv) Spillways. *[(CO6)(Remember/LOCQ)]*

6 + 6 = 12

9. (a) During a trial on a condenser, the following readings were recorded:
Barometer Reading = 766 mm of Hg
Actual Vacuum recorded by gauge = 716 mm of Hg
Temperature of exhaust steam = 35^0C
Temperature of hot well = 29^0C
Inlet temperature of cooling water = 15^0C
Outlet temperature of cooling water = 24^0C
Calculate:
(i) vacuum efficiency
(ii) condenser efficiency. *[(CO5)(Evaluate/HOCQ)]*

(b) With the help of a neat diagram describe the functioning of liquid metal fast breeder reactor used in Nuclear power plant. *[(CO6)(Understand/LOCQ)]*

6 + 6 = 12

Cognition Level	*LOCQ*	*IOCQ*	*HOCQ*
Percentage distribution	*12.5*	*18.75*	*68.75*

Course Outcomes (CO):

After completion of the course, the students will be able to:-

CO1 Evaluate and Select different types of Power plants based on availability of fuels.
CO2 Design and Compare between Natural draft and Artificial draft Chimneys.
CO3 Differentiate and Evaluate the impulse and reaction turbine and nozzle performance.
CO4 Analyze the combustion process of coal in boiler and Calculate air requirement.
CO5 Design surface condensers and cooling towers and calculate the water flow requirement.
CO6 Compare the working principle of nuclear and hydel power plant.

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