

**THERMODYNAMICS AND HEAT POWER ENGINEERING
(ELE2204)**

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:

$12 \times 1 = 12$

Choose the correct alternative for the following

- (i) The value of $\oint (\delta Q - \delta W)$ for a cyclic process is
 - (a) always positive
 - (b) always negative
 - (c) always zero
 - (d) any non-zero value
- (ii) A reversible refrigerator has COP of 9 with the freezer temperature of -3°C. The ambient temperature is
 - (a) 27°C
 - (b) 30°C
 - (c) 35°C
 - (d) 37°C
- (iii) The set of independent intensive properties that cannot be used to designate the state of a saturated liquid-vapour mixture is
 - (a) P and v
 - (b) P and T
 - (c) P and x
 - (d) T and v
- (iv) A pure substance must have homogeneous
 - (a) molecular structure
 - (b) chemical composition
 - (c) phase
 - (d) all of these.
- (v) In an impulse turbine, steam expands _____
 - (a) wholly in nozzle
 - (b) partly in the nozzle and partly in blades
 - (c) wholly in blades
 - (d) none of the mentioned.
- (vi) _____ is regulated in nozzle governing.
 - (a) Pressure
 - (b) Temperature
 - (c) Flow rate
 - (d) None of the mentioned
- (vii) The terms bleeding in a steam turbine refers to
 - (a) Leakage of steam
 - (b) Steam doing no useful work
 - (c) Steam extracted for preheating feed water
 - (d) Removal of wet steam in the low pressure of turbine.

(viii) In case of Induced draught, where is the fan/blower installed?
(a) Near the base of chimney (b) At the top of the chimney
(c) At the grate (d) At the base of the boiler

(ix) Which of the following is not a heat recovery equipment?
(a) Economizer (b) Air preheater
(c) Feed water heater (d) Steam separator.

(x) Identify the boiler mounting
(a) Super heater1 (b) Feed check valve
(c) Feed pump (d) Economiser.

Fill in the blanks with the correct word

- (xi) Work done in a free expansion is - _____.
- (xii) Efficiencies of all reversible heat engines working between same pair of temperatures are _____.
- (xiii) An ideal Rankine cycle is composed of two isentropics and two _____.
- (xiv) An economiser is installed in a boiler primarily for _____ of fuel consumption.
- (xv) When the nozzle is operated with the maximum mass flow, the nozzle is said to be _____.

Group - B

2. (a) Define a thermodynamic system and classify different systems. What is meant by a thermodynamic process? Give examples. *[(C01)(Remember/LOCQ)]*

(b) Consider a gas enclosed in a piston-cylinder arrangement. The gas is initially at a pressure of 150 kPa and occupies a volume of $0.03\ m^3$. The gas is now heated until its volume increases to $1.2\ m^3$. Calculate the work done by the gas if the volume of the gas is inversely proportional to the pressure. *[(C03)(Apply/IOCQ)]*

$$6 + 6 = 12$$

3. (a) Write the Kelvin Planck and Clausius statements of second law of Thermodynamics. Show that the violation of one leads to the violation of the other. [(CO1)(Remember/IOCQ)]

(b) A blower handles 1.5 kg/s of air at 20°C and consumes a power of 16 kW. The inlet and outlet velocities of air are 120 m/s and 170 m/s respectively. Find the exit air temperature, assuming adiabatic conditions. Given that, c_p of air =1.005 kJ/(kg.K). [(CO4)(Apply/IOCQ)]

$$6 + 6 = 12$$

Group - C

4. (a) Determine the state of steam, i.e., whether it is wet (with dryness fraction), dry or superheated (with degree of superheat), as the case may be in the following cases.

- (i) Steam at 10 bar with specific volume $0.175 \text{ m}^3/\text{kg}$
- (ii) Steam at 15 bar and 220°C

(iii) Steam at 300°C and enthalpy 2600 kJ/kg [(CO4)(Apply/LOCQ)]

(b) Two boilers are supplying steam with equal mass flow rate to a main pipe steadily. Boiler-1 is supplying superheated steam at 350°C while boiler-2 is supplying unsaturated steam. The pressure in the boilers and the main pipe is 20 bar. Temperature of the steam in main pipe is 250°C. Find the temperature and dryness fraction of the steam supplied by boiler-2. [(CO4)(Apply/LOCQ)]

6 + 6 = 12

5. (a) What are the four basic components of a steam power plant? What is the reversible cycle that represents the simple steam power plant? Draw the flow, $P - v$, $T - s$ and $h - s$ diagrams of this cycle. [(CO3)(Apply/LOCQ)]

(b) A steam power generating station uses the following cycle:

Steam at boiler outlet --- 150 bar, 550°C

Reheat at 40 bar to 550°C

Condenser pressure is 0.1 bar. Using Mollier chart (or otherwise) and assuming ideal processes, find (i) quality at turbine exhaust, (ii) cycle efficiency, and (iii) steam rate. [(CO3)(Analyse/LOCQ)]

6 + 6 = 12

Group - D

6. (a) Combustion gases expand in a propulsion nozzle from 3.8 bar and 450°C to a back pressure of 1 bar at the rate of 16 kg/s. Assuming the inlet velocity is negligible, and taking coefficient of discharge is 0.98 and a nozzle efficiency is 0.93, calculate the required throat and exit areas of the nozzle. Took $C_p = 1.11 \text{ kJ/kg K}$ and specific heat ratio is 1.333. [(CO6)(Evaluate/HOCQ)]

(b) Define nozzle efficiency. [(CO1)(Remember/LOCQ)]

10 + 2 = 12

7. (a) Draw the velocity diagram of single stage impulse turbine and setup expression for the axial thrust, tangential force, work done and diagram efficiency. [(CO3)(Apply/LOCQ)]

(b) Make a comparison between the impulse and reaction steam turbines. [(CO1)(Remember/LOCQ)]

6 + 6 = 12

Group - E

8. (a) The following data relate to a boiler trial: Mean temperature of flue gas 550 K, Temperature of cold air 300 K, Air supplied per kg of fuel is 18, Fuel consumption is 1800 kg/hr, Draught required is 100 mm of water, Mechanical efficiency is 80%.

Calculate motor power for forced and induced draught fans allowing 10% leakage of air in both the cases. Assume, specific volume of air at N.T.P = $0.7734 m^3/kg$. [(CO6)(Evaluate/HOCQ)]

(b) State the advantages of water tube boiler over fire tube boiler. [(CO1)(Remember/LOCQ)]

8 + 4 = 12

9. (a) Exhaust steam having a quality of 0.9 enters a surface condenser at an absolute pressure of 0.13 bar and comes out as water at 45°C. The circulating water enters at 30°C and leaves at 40°C. Estimate the quantity of circulating water and the condenser efficiency. *[(CO5)(Analyze/IOCQ)]*

(b) Write a short note on Surface condensers. *[(CO1)(Remember/LOCQ)]*

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	35.42	45.83	18.75