Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.TECH (EE-O+N)/SEM-4/ME-411,ME(EE)-411/2010

2010

THERMAL POWER ENGINEERING

Time Allotted : 3 Hours | Full Marks : 70

The figures in the margin indicate full marks.

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

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : $10 \times 1 = 10$

i) Lancashire boiler has how many number of fire tubes in it ?

a) One b) Two

c) Three d) Four.

ii) For the same compression ratio and heat input, the cycles in decreasing order of thermal efficiency, that is

a) Otto, Dual, Diesel b) Diesel, Otto, Dual

c) Dual, Diesel, Otto d) Otto, Diesel, Dual.

iii) Which is a not a part of petrol engine ?

a) Valve mechanism b) Fuel injector

c) Induction coil d) Air filter.

iv) In Rankine cycle the work output from the turbine is given by

a) change of internal energy between inlet and outlet

b) change of enthalpy between inlet and outlet

c) change of entropy between inlet and outlet

d) change of temperature between inlet and outlet.

v) In case of impulse turbine the pressure of the steam as it passes on the moving blades from entry to the exit

a) increases

b) decreases

c) remains same

d) may increase or decrease depending upon quality of entry steam.

vi) The value of K for a steam passing through a nozzle depends on

a) back pressure at the exit of nozzle

b) shape of the nozzle

c) state of drynes of steam

d) load on the prime mover.

vii) In a cyclone separator clean gas comes out of the

a) top

b) bottom

c) sides

d) does not come out at all.

viii) The main function of a condenser is

a) to create vacuum

b) to maintain vacuum

c) to condense steam to water to be re-used.

ix) Spark Ignition engine runs on

a) Otto cycle b) Diesel cycle

c) Reversed Carnot cycle d) Dual cycle.

x) Cochran boiler is a

a) horizontal fire tube boiler

b) horizontal water tube boiler

c) vertical water tube boiler

d) vertical fire tube boiler.

xi) On Mollier chart, flow through turbine is represented by

a) horizontal straight line

b) vertical straight line

c) straight inclined line

d) none of these.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

2. State the advantage of two-stroke cycle engines over four-stroke cycle ones.

3. Distinguish between S.I. and C.I. engines.

4. Draw a block diagram of an open cycle gas turbine with inter-cooling and reheating and also show the cycle on the T-S plane.

5. A sample of coal contains 78% carbon, 6% hydrogen, 1·2% nitrogen, 7·8% oxygen, and 4% incombustible. Find minimum quantity of air required for complete combustion of 1 kg of coal.

6. What is the function of air pre-heater ? How does air pre-heating save fuel ?

7. What is EGR ? How does it reduce NOx emission ? What are catalytic converter ?

8. Derive the efficiency of Petrol engine air standard cycle.

9. Write merits and demerits of fire tube and water tube boilers.

10. Differentiate between boiler mountings and accessories.

11. What is Knocking in SI and CI engine ? What is Octane and Cetane number ?

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

12. a) Explain
    - i) supersonic nozzle
    - ii) subsonic nozzle
    - iii) subsonic diffuser
    - iv) supersonic diffuser.

    b) What do you understand by
    - i) critical pressure ratio
    - ii) choked flow ?

c) A convergent-divergent nozzle receives steam at 5 bar, 200°C and expands isentropically into a space at 2 bar. Neglecting the inlet velocity draw the expansion in h-s diagram and find out the exit area required for a mass flow of 0·3 kg/s when the flow is in equilibrium through out.

Given Enthalpy at inlet condition 2855 kJ/kg, Enthalpy and specific volume at outlet condition 2645 kJ/kg and $v_1 = 0{\cdot}86\ m^3/kg$ respectively. 6 + 4 + 5

13. a) Obtain the expression for the natural draught in terms of height of water column. Also state the assumption made.

b) Determine the air fuel ratio for an oil fired steam boiler with the following data :

Chimney height	=	40 m
Draught	=	25 mm of water column
Mean chimney gas temperature	=	367°C
Ambient outside temperature	=	20°C

Also calculate the draught pressure in terms of the height of the column of hot gas.

c) Sketch and describe the working of any high presure boiler. 5 + 4 + 6

14. a) In an air-standard Diesel cycle, the pressure and temperature at the intake are 1·03 bar and 27°C respectively. The maximum pressure in the cycle is 47 bar, and heat supplied during the cycle is 545 kJ/kg. Determine the

i) compression ratio

ii) temperature at the end of the compression

iii) temperature at the end of combustion

iv) air standard efficiency.

b) A single cylinder 4-stroke diesel engine gave following results while running on full load.

Area of indicator card = 300 mm^2

Length of diagram = 40 mm

Spring constant = 1 bar/mm

Speed of the engine = 400 r.p.m.

Load on the brake = 370 N

Spring balance reading = 50 N

Diameter of brake drum = 1·2 m

Fuel consumption = 2·8 kg/hr

Calorific value of the cylinder = 41800 kJ/kg

Diameter of the cylinder = 160 mm

Stroke of the piston = 200 mm.

Calculate :

i) indicated mean effective pressure

ii) brake power and break mean effective pressure

iii) brake fuel consumption

iv) brake thermal and indicated thermal efficiencies.

7 + 8

15. a) The speed of a single stage impulse turbine is 3000 rev/min and the mean blade diameter is 1 m, the nozzle of the turbine is inclined at 20° to the plane of the wheel and the moving blade inlet and outlet angles are 35° and 30°. Assuming a friction factor of 0·8 determine (i) the power developed for a steam consumption rate of 9000 kg/hr, (ii) the blade or diagram efficiency, (iii) the axial thrust.

b) A gas turbine unit has a pressure ratio of 6 : 1 and the maximum cycle temperature of 600°C. The isentropic efficiencies of the compressor and turbine are 0·8 and 0·82 respectively. Calculate the power output in kW of an electric generator geared to the turbine when the air enters the compressor at 15°C at the rate of 16 kg/s. Take C_p = 1·005 kJ/kgK and γ = 1·4 for both expansion and compresion processes.

16. a) What are the different components of I.C. engine ?

b) What do you mean by volumetric efficiency and mean effective pressure ?

c) A six cylinder gasoline engine operates on the four stroke cycle. The bore of each cylinder is 80 mm and the stroke is 100 mm the clearance volume per cylinder is 70 c.c. At a speed of 4000 r.p.m. the fuel consumption is 20 kg/hr and the torque developed is 150 Nm. Calculate (i) brake power, (ii) brake mean effective presure, (iii) brake thermal efficiency. If the calorific value of the fuel is 43,000 kJ/kg, (iv) the relative efficiency on a brake power basis assuming the engine works on the constant volume cycle. 3 + 2 + 10

17. A binary-vapour cycle operates on mercury and steam. Saturated mercury vapour at 4·5 bar is supplied to the mercury turbine, from which it exhaust at 0·04 bar. The mercury condenser generates saturated steam at 15 bar which is expanded in a steam turbine to 0·04 bar. (i) Find the overall efficiency of the cycle, (ii) If 50,000 kg/h of steam flows through the steam turbine, what is the flow through the mercury turbine ? (iii) Assuming that all processes are reversible, what is the useful work done in the binary vapour cycle for the specified steam flow ? (iv) If the steam leaving the mercury condenser is superheated to

a temperature of 300°C in a superheater located in the mercury boiler, and if the internal efficiencies of the mercury and steam turbines are 0·85 and 0·87 respectively, calculate the overall efficiency of the cycle. The properties of saturated mercury are given below :

p (bar)	t (°C)	h_f (kJ/kg)		s_f (kJ/kgK)		v_f	v_s (m³/kg)
4.5	450 -	63.93	355.98	0.1352	0.5397	79.9 xlO-^{6}	0.068
0.04	216.9	29.98	329,85	0.0808	0.6925	76.5 x 1(H	5.173

18. a) Derive the standrd efficiency of Otto cycle.

b) In a constant volume Otto cycle the presure at the end of compression is 15 times that at the start, the temperature of air at the beginning of compresion is 38°C and the maximum temperature attained in the cycle is 1950°C. Determine

i) Compression ratio

ii) thermal efficiency of the cycle

iii) work done.

Take υ for air = 1·4 and C_υ = 0·717 kJ/kg K. 5 + 10