CBCS SCHEME

USN | | | | | | | | | |

18ME42

Fourth Semester B.E. Degree Examination, Jan./Feb. 2023
Applied Thermodynamics

Time: 3 hrs. Max. Marks: 100

Note: **1.** ***Answer any FIVE full questions, choosing ONE full question from each module.***
2. ***Use of thermodynamic data handbook is permitted.***

Module-1

1 a. Derive an expression for the efficiency of Otto cycle. **(08 Marks)**

b. A 4 cylinder 2 stroke petrol engine has a bore of 57 mm and stroke of 90 mm. Its rated speed is 2800 rpm and is tested at this speed against a brake, which has a torque arm of 0.356 m. The net brake load is 155 N and the fuel consumption is 6.74 lit/hr. The specific gravity of the petrol is 0.735 and it has a calorific value of 44200 kJ/kg. A Morse test is carried out and the cylinders are cut-off in order 1, 2, 3, 4 with corresponding brake torque loads 111, 106.5, 104.2, 111.3 N respectively. Calculate for this speed:

(i) The engine torque
(ii) BMEP
(iii) Brake thermal efficiency
(iv) BSFC
(v) Mechanical efficiency
(vi) Indicated thermal efficiency **(12 Marks)**

OR

2 a. Explain knocking in SI engine. What are effects of knocking? **(08 Marks)**

b. In an air standard diesel cycle, the compression ratio is 16 and at the beginning of isentropic compression the temperature is 25°C and the pressure is 0.1 MPa. Heat is added until the temperature at the end of constant pressure process is 1500°C. Calculate:

(i) The cut-off ratio
(ii) The heat supplied per kg of air
(iii) The cycle efficiency
(iv) The mean effective pressure **(12 Marks)**

Module-2

3 a. Derive an expression for the efficiency of Brayton cycle. **(08 Marks)**

b. In a gas turbine installation, the air is taken in at 1 bar and 15°C and compressed to 4 bar. The isentropic efficiency of the turbine and the compressor are 82% and 85% respectively. Determine: (i) Compression work (ii) Turbine work (iii) Thermal efficiency.

What would be the improvement in the thermal efficiency if a regenerator with 75% effectiveness is incorporated in the cycle? Assume maximum cycle temperature to be 825°K. **(12 Marks)**

OR

4 a. Explain how the regeneration will improve the efficiency of the Brayton cycle. **(06 Marks)**

b. With a neat sketch, explain the working of turbojet engine. **(04 Marks)**

c. In an open cycle gas turbine plant, air enters the compressor at 1 bar and 27°C. The pressure after compression is 4 bar. The isentropic efficiencies of the turbine and compressor are 85% and 80% respectively. Air-fuel ratio is 80:1. Calorific value of the fuel used is 42000 kJ/kg. Mass flow rate of air is 2.5 kg/s. Determine the power output from the plant and the cycle efficiency. Assume that C_p and γ values are same for both air and products of combustion. **(10 Marks)**

Module-3

5 a. With a schematic and T-S diagram, explain the working of reheat vapour power cycle and deduce an expression for cycle efficiency. **(10 Marks)**

b. Steam enters the turbine of a steam power plant, operating on Rankine cycle, at 10 bar, 300°C. The condenser pressure is 0.1 bar. Steam leaving the turbine is 90% dry. Calculate the adiabatic efficiency of the turbine and also the cycle efficiency, neglecting the pump work. **(10 Marks)**

OR

6 a. With the help of schematic diagram, T-S diagram explain regenerative vapour power cycle with one open feed water heater and derive an expression for its thermal efficiency. **(10 Marks)**

b. An ideal reheat cycle utilizes steam as the working fluid. Steam at 100 bar, 400°C is expanded in the HP turbine to 15 bar. After this it is reheated to 350°C at 15 bar and is then expanded in the LP turbine to the condenser pressure of 0.5 bar. Determine the thermal efficiency and steam rate. **(10 Marks)**

Module-4

7 a. With a neat sketch, explain the working of vapour absorption refrigeration system. **(10 Marks)**

b. It is required to design an air conditioning plant for an office room with the following conditions:

Outdoor conditions: 14°C DBT and 10°C WBT

Required conditions: 20°C DBT and 60% RH

Amount of air circulated 0.3 m^3/min/person

Seating capacity of the office = 60

The required condition is achieved first by heating and then by adiabatic humidifying. Determine the following:

(i) Heating capacity of the coil in KW and the surface temperature required if the bypass factor of the coil is 0.4.

(ii) Capacity of the humidifier. **(10 Marks)**

OR

8 a. With the help of schematic diagram and appropriate psychrometric diagram, explain summer air conditioning system for hot and dry outdoor conditions. **(10 Marks)**

b. A Freon-12 refrigerator producing a cooling effect of 20 kJ/s operator on a simple cycle with pressure limits of 1.509 bar and 9.607 bar. The vapour leaves the evaporator dry saturated and there is no under cooling. Determine the power required by the machine.

If the compressor operates at 300 rpm and has a clearance volume of 3% of stroke volume, determine the piston displacement of the compressor. For compressor assume that the expansion following the law $PV^{1.3}$ = constant. Given:

Temperature °C	P in bar	V_g in m^3/kg	Enthalpy kJ/kg		Entropy kJ/kg/K		Specific heat kJ/kg/K
			h_f	h_g	s_f	s_g	
–20	1.509	0.1088	17.8	176.61	0.073	0.7082	-
40	9.607	-	74.53	203.05	0.2716	0.682	0.747

(10 Marks)

Module-5

9 a. Derive the condition for minimum work in a 2 stage reciprocating air compressor. Using this condition obtain the expression for minimum work in a two stage compression. **(10 Marks)**

b. A single cylinder, single acting reciprocating air compressor is belt driven from an electric motor at 300 rpm. The cylinder diameter is 20 cm and the stroke is 24 cm. The air is compressed from one atmosphere to 8 atmosphere and the law of compression is $PV^{1.25}$ = constant. Find the power of the electric motor if the transmission efficiency is 96% and the mechanical efficiency of the compressor is 85%. Neglect clearance effect. **(10 Marks)**

OR

10 a. Explain different types of steam nozzles. **(06 Marks)**

b. Starting from steady flow energy equation, derive an expression for velocity of steam coming out of nozzle. **(06 Marks)**

c. An adiabatic steam nozzle is to be designed for a discharge rate of 10 kg/s of steam from 10 bar and 400°C to a back pressure of 1 bar. The nozzle efficiency is 0.92 and the frictional loss is assumed to take place in the divergent portion of the nozzle only. Calculate:

(i) Velocity of steam at throat and exit of the nozzle

(ii) Throat and exit area

Assume index of expansion = 1.3. **(08 Marks)**

* * * * *