CBCS SCHEME

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15AE33

# Third Semester B.E. Degree Examination, July/August 2022
## Aerothermodynamics

Time: 3 hrs. Max. Marks: 80

***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. Define:
(i) Intensive and extensive property
(ii) Open and closed system
(iii) Path and point functions
(iv) Control volume and control surface
using suitable illustrative sketches. **(08 Marks)**

b. Fahrenheit and centigrade thermometers are immersed in a fluid. The Fahrenheit scale reads numerically twice that of the centigrade scale. Find the temperature of the fluid expressed in Rankine R and Kelvin K. Assume T(R) = 1.8 T(K). **(08 Marks)**

**OR**

2 a. Discuss briefly on the following types of work: (i) Shaft work (ii) Electrical work. **(08 Marks)**

b. A perfect gas is undergoing a process for which $T \alpha V^{-2/5}$. Find the work done if the gas is compressed from 100 bar, 4 $m^3$ at state 1 to 2 $m^3$. Find the final pressure. **(08 Marks)**

### Module-2

3 a. Using the First law concept, show that energy is a property. **(08 Marks)**

b. Explain what are the different modes of energy. **(04 Marks)**

c. State and explain 'Two-property Rule' **(04 Marks)**

**OR**

4 a. Derive steady-flow energy equation for an open system, stating the assumptions made. **(08 Marks)**

b. In a steady-flow process a working fluid flows at 220 kg/min rejecting 100 kJ/s of heat. The inlet and outlet conditions are $v_1$ = 220 m/s, $p_1$ = 6 bar, $u_1$ = 2000 kJ/kg, $v_1$ = 0.36 $m^3$/kg, $v_2$ = 140 m/s, $p_2$ = 1.2 bar, $u_2$ = 1400 kJ/kg, $v_2$ = 1.3 $m^3$/kg. Find the power capacity of the system in MW. **(08 Marks)**

### Module-3

5 a. Write Kelvin-Plank and Clausius statements of second law of thermodynamics. Show that a perpetual motion machine of second kind violates Kelvin-Plank statement. **(08 Marks)**

b. Verify the following claim of an inventor regarding his new engine. Power developed is 76 KW, fuel consumed is 8 kg/h, fuel heating value 50000 kJ/kg, temperature limits 725°C and 25°C. Comment on the claim. **(08 Marks)**

**OR**

6 a. State Clausius inequality and prove it. **(08 Marks)**

b. A heat engine is operating between 600 K and 300 K, receiving 450 kJ/cycle of heat. For the following hypothetical situation, verify Clausius inequality:

(i) 210 kJ/cycle of heat rejected

(ii) 105 kJ/cycle of heat rejected

(iii) 315 kJ/cycle rejected **(08 Marks)**

## Module-4

7 a. Plot a P-T diagram for a pure substance and show fusion line, vaporization line, critical point and triple point. Further define each of them. **(08 Marks)**

b. A spherical shell of 40 cm radius contains saturated steam and water at 250°C. Calculate the mass of each if their volumes are equal. **(08 Marks)**

**OR**

8 a. Using the relations $C_P - C_V = T\left(\frac{\partial V}{\partial T}\right)_P \left(\frac{\partial P}{\partial T}\right)_V$ for an ideal gas show that $C_P - C_V = R$. **(08 Marks)**

b. A tank of 0.34 $m^3$ contains $H_2S$ at 22°C. When 2.3 kg of gases are drawn out, the temperature in the tank becomes 15°C and pressure 10 bar. Find the mass of the gas in the tank initially and its initial pressure. **(08 Marks)**

## Module-5

9 a. For a petrol engine cycle, show that the thermal efficiency is a function of compression ratio and the index $\gamma$ only. Draw the cycle (thermodynamic processes) on a P-V diagram. **(08 Marks)**

b. A Carnot engine rejects heat to the sink at 32°C and has a thermal efficiency of 52.3%. If the work output of the engine is 120 kJ, find:

(i) The maximum working temperature

(ii) Heat added in kJ

(iii) The entropy change during heat rejection. **(08 Marks)**

**OR**

10 a. With the aid of a schematic diagram, explain the working of a reheat cycle. Represent the same on a T-S diagram. Further make cycle analysis and find out the thermal efficiency in terms of enthalpies. **(08 Marks)**

b. In a power plant working on a reheat cycle, the turbine develops 650 kJ/kg of work between the inlet and reheater and 760 kJ/kg between the reheater and condenser. After reheating steam enters the low pressure turbine at 2 MPa and 500°C and expands down to a condenser pressure of 8 kPa. Determine the cycle efficiency, ignoring the pump work. **(08 Marks)**

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