Indian Maritime University

(A Central University, Govt of India)

End Semester Examinations – JUNE 2023

Programme Name: B Tech (ME)

Semester: III

Subject Code: UG11T4304

Subject Name: Applied Thermodynamics

Date: 16.06.2023 Max Marks: 70

Duration: 03 Hrs Pass Marks: 35

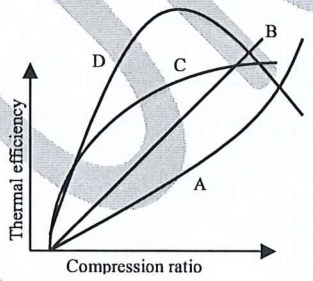
General Instructions

(i) All Sections (A, B & C) are to be attempted.
(ii) Options, if any, are specified in respective section.
(iii) Steam/Air tables can be used.

Section A

Ten MCQs of 01 Mark each – Choose the correct answer as applicable

1. Which curve/line in the graph shown below shows variation of thermal efficiency versus compression ratio for otto cycle for fixed value of pressure ratio and adiabatic index



a) A b)B c) C d) D

2. In a reciprocating air compressor, the effect of the clearance volume will:

a) Cause some of the air to expand in an isochoric process
b) Cause increased delivery of compressed air
c) Cause the air to drawn into the compressor in a polytropic expansion process
d) Cause air to expand in a polytropic process leading to losses.

3. The efficiency of a Rankine cycle can be improved by _____.
(A) increasing the temperature at which heat is supplied and increasing the temperature at which heat is rejected
(B) decreasing the temperature at which the heat is supplied and decreasing the temperature at which the heat is rejected

(C) increasing the temperature at which heat is supplied and decreasing the temperature at which the heat is rejected
(D) decreasing the temperature at which heat is supplied and increasing the temperature at which the heat is rejected

4. On an inversion curve drawn for maximum cooling by Joule-Kelvin expansion the number of inversion temperatures for each pressure is

a) Zero b) one c) two d) three

5. The common feature of vapour power cycle and a gas power cycle is:

a) Both of them operate between a high pressure and a low pressure
b) Both of them operate on a working fluid in the same phase
c) Both of them can be classified as internal combustion heat engines
d) Brayton cycle validates the Carnot cycle general interpretations but Ranking cycle dos not.

6. Which of the following options is correct with regard to a Regenerative Rankine Cycle?

a. Full mass flow rate multi-staged expansion in turbines
b. Full mass flow rate multi-staged pumps supplying feed water to boiler
c. Bleed steam from turbine directly mixing with the condensate
d. Fraction of the mass flow rate of water through the boiler

7. The relationship between Helmholtz (A) and Gibbs function (G) for internal energy (U), enthalpy (H), temperature (T), entropy (S), Pressure (P) and Volume (V) is

a. $A = G + TS$
b. $A = G - TS$
c. $G = A + PV$
d. $G = A - PV$

8. Choose the most appropriate correct choice from the following statements.

a. A mixture has a specific boiling point
b. A solution has a specific boiling point
c. A solution has no specific boiling point, bubble point and dew point define the respective liquid-vapor phase change for a range of molar fractions at a fixed pressure.
d. If you fix pressure, a mixture will have a specified temperature for boiling.

9. The unit of the isothermal compressibility is
(A) m^{-3}
(B) Pa^{-1}
(C) m^3Pa^{-1}
(D) $m^{-3}Pa^{-1}$

10. Rayleigh flow is:

a. flow of a real gas through a constant-area duct with heat transfer and negligible friction
b. flow of an ideal gas with constant specific heats through a constant-area duct without heat transfer and with friction
c. flow of an ideal gas with constant specific heats through a constant-area duct with heat transfer and negligible friction
d. flow of a real gas without heat transfer and with friction

Section B

Attempt all five questions. Each question carries 2 marks.

11. Draw the PV and TS diagram for Ericsson cycle and Stirling cycle

12. Define Free Air Delivered (F.A.D).

13. State the Amagat's law of partial volumes.

14. Define Raoult's Law.

15. Derive the expression for stagnation temperature of an ideal gas with constant specific heat.

Section C

Attempt any 05 questions. Each question carries 10 marks.

16. An ideal Otto cycle heat engine with air as working fluid has a clearance volume of $0.05m^3$ and swept volume of $0.20m^3$. The ambient pressure and the temperature are 1 atm and 40 deg.C respectively. The temperature at the end of constant volume heat addition is 1500 deg.C. Assume $\gamma = 1.4$.

a) Temperature at the end of each process in the cycle. Verify the thermal efficiency of the cycle assuming air standard assumptions by numerically and that achieved by Otto cycle efficiency by direct formula i.e.,$1 - 1/r^{(\gamma-1)}$ (10marks)

17. FAD requirement for a ship is specified by designer as 0.25 Nm^3/s. The ships' operating conditions are ambient pressure 1.02 bar and a temperature of 40 deg. C. A single stage reciprocating air compressor delivering at a pressure of 7 bar is required. The clearance volume of is 5% that of the swept volume. The electrical motor to drive the compressor is having 600 RPM. For these conditions the shipyard need to analyse the actual air requirement and compressor performance. Find:

a) Volumetric efficiency of the compressor
b) Specific work input to the compressor
c) Isothermal efficiency of the compression.

R for air = 287 J/kg K. Choose a polytropic exponent of 1.25.

(3+4+3 marks)

18. A Rankine Cycle operates between pressures of 80 bar and 0.1 bar. The maximum cycle temperature is 600°C. If the steam turbine and condensate pump efficiencies are 0.9 and 0.8 respectively, calculate the specific work and thermal efficiency. Relevant steam table extract is given below.

p(bar)	t(°C)	Specific volume (m^3/kg)		Specific enthalpy (kJ/kg)			Specific entropy (kj/kg K)		
		v_f	v_g	h_f	h_{fg}	h_g	s_f	s_{fg}	s_g
0.1	45.84	0.0010103	14.68	191.9	2392.3	2584.2	0.6488	7.5006	8.1494
80	295.1	0.001385	0.0235	1317	1440.5	2757.5	3.2073	2.5351	5.7424

80 bar, 600°C	v	0.486 m^3kg
Superheat	h	3642 kJ / kg
table	s	7.0206 kJ / kgK

19. Derive first Tds equation $TdS = CvdT + T\left(\frac{\partial P}{\partial T}\right)_v dV$ and second TdS equation

$TdS = CpdT - T\left(\frac{\partial v}{\partial T}\right)_T dP$. (10marks)

20. A rigid tank contains 2 kmol of N_2 and 6 kmol of CO_2 gases at 300 K and 15 MPa. Estimate the volume of the tank on the basis of: a) the ideal-gas equation of state, b) Kay's rule, and c) compressibility factors and Amagat's law

(2.5+2.5+2.5+2.5 marks)

21.

a). What does the Joule-Thomson coefficient represent? (5 marks)
b). Explain the importance of the Henry's law. (5 marks)

22.a)State and explain Raoult's law, use sketches of the system to explain.

b) In an oil tanker ship with 15 bar saturated steam system and vacuum condenser operating at 10 kPa, steam to the turbine driven pump enters through a convergent-divergent nozzle. Assuming frictionless adiabatic expansion from the boiler pressure to the condensing pressure inside the nozzle, calculate:

i. Diameters of the section of the nozzle at a point where the pressure is 8 bar
ii. Exit diameter for the nozzle.

Given the mass flow rate of the steam is 0.25 kg/s and nozzle critical pressure ratio for wet steam = 0.582

(5 +5marks)