

VTU B.E/B.TECH QUESTION PAPER SET

CBCS SEMESTER III

Aerothermodynamics

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15AE33

Third Semester B.E. Degree Examination, Dec.2016/Jan.2017

Aerothermodynamics

Time: 3 hrs.

Max. Marks: 80

Note: 1. Answer FIVE full questions, choosing ONE full question from each module.

2. Use thermodynamics data hand book is permitted.

Module-1

- 1 a. Distinguish between : i) microscopic and macroscopic approaches of thermodynamics ii) intensive and extensive properties. (08 Marks)
- b. The readings T_A and T_B of two celsius thermometers A and B agree at ice point and steam point, but elsewhere are related by the equation $T_A = L + MT_B + NT_B^2$ where L, M and N are constants. When both the thermometer are immersed in a fluid, A registers 11°C while B registers 10°C . Determine the reading on A when B registers 37.4°C . (08 Marks)

OR

- 2 a. Distinguish between heat and work in thermodynamics. (04 Marks)
- b. Derive an expression for work done per unit mass for a reversible isothermal process taking place in a closed system containing an ideal gas. (04 Marks)
- c. A cylinder contains 1 kg of a certain fluid at an initial pressure of 20 bar. The fluid is allowed to expand reversibly behind a piston according to a law $PV^2 = \text{constant}$, until the volume is doubled. The fluid is then cooled reversibly at constant pressure until the Piston regains its original position : heat is then supplied reversibly with the piston firmly locked in position until the pressure rise to the original value of 20 bar. Calculate the net work done by the fluid, for an initial volume of 0.05 m^3 . (08 Marks)

Module-2

- 3 a. Derive an expression for heat transfer for a reversible polytrophic process taking place in a closed system containing an ideal gas. (06 Marks)
- b. In a system, executing a non – flow process the work and heat per degree change of temperature are given by $\frac{dW}{dT} = 200 \text{ W-S}^\circ\text{C}$ and $\frac{dQ}{dT} = 160\text{J}^\circ\text{C}$. What will be the change of internal energy of the system when the temperature changes from $T_1 = 55^\circ\text{C}$ to $T_2 = 95^\circ\text{C}$? (05 Marks)
- c. A cylinder containing the air comprises the system. cycle is completed as follows :
 i) 82000 N-m of work is done by the piston on the air during compression stroke and 45 kJ of heat are rejected to the surroundings
 ii) During expansion stroke 100000 N-m of work is done by air on the piston. Calculate the quantity of heat added to the system. (05 Marks)

OR

- 4 a. Specify the most widely used sign convention for work and heat interaction. (04 Marks)
- b. Derive steady flow energy equation. (06 Marks)
- c. In an air compressor air flows steadily at the rate of 0.5 kg/s through an air compressor. It enters the compressor at 6 m/s with a pressure of 1 bar and a specific volume of $0.85 \text{ m}^3/\text{kg}$ and leaves at 5 m/s with a pressure of 1 bar and a specific volume of $0.16 \text{ m}^3/\text{kg}$. The internal energy of the air leaving is 90 kJ/kg greater than that of the air entering. Cooling water in a jacket surrounding the cylinder absorbs heat from the air at the rate of 60 kJ/s . Calculate :
 i) The power required to drive the compressor ii) The inlet and output pipe cross-sectional areas. (06 Marks)

Module-3

- 5 a. Prove that Kelvin Planck and clausius statement of second law of thermodynamics are equivalent. (05 Marks)
- b. Represent schematically heat engine, heat pump and refrigerator. Give their performance equations. (05 Marks)
- c. A fluid undergoes a reversible adiabatic compression from 4 bar, 0.3 m^3 to 0.08 m^3 , according to the law, $PV^{1.25} = \text{constant}$. Determine : i) change in enthalpy ii) change in internal energy iii) change in entropy iv) heat transfer v) work transfer. (06 Marks)

OR

- 6 a. Prove that $\text{COP}_{\text{Heat pump}} = 1 + \text{COP}_{\text{refrigerator}}$. (04 Marks)
- b. Define entropy and hence prove that for a system executing a cyclic process $\oint \frac{\delta\phi}{T} \leq 0$. (06 Marks)
- c. The specific heats of a gas vary linearly with absolute temperature according to the following relations : $C_p = (0.85 + 0.00025 T) \text{ kJ/kg}^\circ\text{K}$
 $C_v = (0.56 + .00025 T) \text{ kJ/kg}^\circ\text{K}$
 If the entropy of the gas at 1 bar pressure and 273 K is zero, find the entropy of the gas at 25 bar and 750 K temperature. (06 Marks)

Module-4

- 7 a. Define the following : i) triple point ii) critical temperature iii) dryness fraction iv) saturation temperature. (04 Marks)
- b. Name the widely used thermodynamic property diagrams for a pure substance, and sketch them. (04 Marks)
- c. A vessel having a capacity of 0.05 m^3 contains a mixture of saturated water and saturated steam at a temperature of 245°C . The mass of the liquid present is 10 kg. Find the following: i) The pressure ii) the mass iii) the specific volume iv) the specific enthalpy v) the specific entropy vi) specific internal energy. (08 Marks)

OR

- 8 a. Write notes on the following : i) Clausius – Clapeyron equation ii) Maxwells equations. (08 Marks)
- b. For mercury, the following relation exists between saturation pressure (bar) and saturation temperature (K) : $\log_{10}P = 7.0323 - 3276.6/T - 0.652 \log_{10}T$ calculate the specific volume V_g of saturation mercury vapour at 0.1 bar. Given that the latent heat of vapourisation at 0.1 bar is 294.54 kJ/kg . Neglect the specific volume of saturated mercury liquid. (08 Marks)

Module-5

- 9 a. With the help of T–S and P–V diagrams, derive an expression for the air standard efficiency of a diesel cycle. (08 Marks)
- b. In a constant volume ‘OTTO cycle’ the pressure at the end of compression is 15 times that at the start, the temperature at the beginning of compression is 38°C and maximum temperature attained in the cycle is 1950°C . Determine : i) compression ratio ii) thermal efficiency of the cycle iii) work done. Take γ for air = 1.4. (08 Marks)

OR

- 10 a. Why is Carnot cycle not practicable for a steam power plant? Briefly explain. (02 Marks)
- b. Discuss the effect of : i) boiler pressure ii) condenser pressure iii) superheat on the performance of a Rankine cycle (06 Marks)
- c. A simple Rankine cycle works between pressure 28 bar and 0.06 bar, the initial condition of steam being dry saturated. Calculate the cycle efficiency, work ratio and specific steam consumption. (08 Marks)

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CBCS Scheme

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15AE33

Third Semester B.E. Degree Examination, June/July 2017
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/Charts/Tables is permitted.

Module-1

- 1 a. With suitable sketches/examples distinguish between :
 i) Closed and open systems ii) path and point functions iii) Thermal and mechanical equilibrium. (06 Marks)
- b. State zeroth law of thermodynamics and extract the concept of temperature from it. Name any four types of thermometers and their corresponding thermometric property. (05 Marks)
- c. Sir Isaac Newton proposed a temperature scale in 1709. On this scale, temperature was a linear function of Celsius scale. The reading on this at Ice point (0°C) and normal human body temperature (37°C) were 0°N and 12°N respectively. Obtain the relation between the Newton scale and Celsius scale. (05 Marks)

OR

- 2 a. Derive an expression for : i) Shaft work ii) Spring work. (05 Marks)
- b. Air in a cylinder at an initial volume of 0.01m^3 and the initial pressure 6MP expands following a quasi-static process given by $PV^{1.4} = \text{constant}$. If the final volume of the gas is 0.025m^3 . Determine the work done by gas. (05 Marks)
- c. Show that work is a path function and not a property. (03 Marks)
- d. Write down two similarities and two dissimilarities between heat and work. (03 Marks)

Module-2

- 3 a. Write the first law of thermodynamics for a closed system undergoing
 i) a cycle ii) a process. (04 Marks)
- b. A stationary mass of gas is compressed from an initial state of 0.3m^3 and 0.105MPa to a final state of 0.15m^3 and 0.105MPa , the pressure remaining constant during the process. There is a transfer of 37.6kJ of heat from the gas during the process. How much does the internal energy of the gas change? (05 Marks)
- c. A mass of 0.5kg of pure substance at pressure $P = 1\text{bar}$ and $T = 323\text{K}$, Occupies volume $V = 0.15\text{m}^3$. Given internal energy = 31.5kJ , evaluate specific enthalpy. (04 Marks)
- d. Define specific heat at i) Constant pressure and ii) Constant volume. (03 Marks)

OR

- 4 a. Write down Steady Flow Energy Equation and explain all the terms involved. (04 Marks)
- b. How do you apply SFEE for : i) Steam Nozzle ii) Steam turbine? (05 Marks)
- c. A turbine operates under steady flow conditions receiving steam at the following state: pressure 1.2MPa , temperature 188°C , enthalpy 2785kJ/kg , velocity 34m/s and elevation 3m . The steam leaves the turbine in the following state: pressure 20KPa , enthalpy 2512kJ/kg , velocity 100m/s and elevation 0m . Heat is lost to the surroundings at the rate of 0.29kJ/s . If the steam flow rate is 0.42kg/s . determine the power output from the turbine. (07 Marks)

Module-3

- 5 a. State Kelvin Plank and Clausius statements of second law of thermodynamics and show that they are equivalent. (06 Marks)
- b. Represent schematically and explain: i) heat engine ii) refrigerator. Prove that: $(COP)_{HP} = (COP)_R + 1$. (05 Marks)
- c. A reversible refrigerator operates between 35°C and -12°C . If heat rejected to 35°C is 1.3 kW determine the rate at which heat is leaking into the refrigerator. (05 Marks)

OR

- 6 a. State and prove Clausius inequality. (04 Marks)
- b. Describe the working of Carnot engine and show that $\eta = 1 - \frac{T_2}{T_1}$. Represent Carnot cycle in P-V and T-S diagram. (04 Marks)
- c. Define entropy and prove that it is a property of the system. (03 Marks)
- d. For an ideal gas undergoing finite change of state from 1 to 2 derive an expression for change in entropy. (05 Marks)

Module-4

- 7 a. Define the following : i) Pure substance ii) Saturation pressure
iii) Triple point iv) Critical point. (04 Marks)
- b. Sketch and explain P-T diagram of water. (06 Marks)
- c. Find the enthalpy and entropy of steam when the pressure is 2MPa and the specific volume is $0.09 \text{ m}^3/\text{kg}$. (06 Marks)

OR

- 8 a. Derive and explain Maxwell's equations. (08 Marks)
- b. Show that for an ideal gas, $C_p - C_v = R$. (04 Marks)
- c. 1 kg of air at a pressure of 8 bar and temperature 100°C undergoes a reversible polytropic process following the law $PV^{1.2} = \text{constant}$. If the final pressure is 1.8 bar determine final specific volume, temperature and increase in entropy. Assume $R = 0.287 \text{ kJ/kg K}$ and $\gamma = 1.4$. (04 Marks)

Module-5

- 9 a. Explain Air standard cycle. (04 Marks)
- b. Explain working of diesel cycle with the help of P-V and T-S diagrams. Derive an expression for the efficiency of diesel cycle in terms of its compression and cut-off ratios. (08 Marks)
- c. A diesel engine has a compression ratio of 14 and cut off takes place at 6% of stroke. Find its Air-standard efficiency. (04 Marks)

OR

- 10 a. Explain Rankine cycle with the help of a sketch and T-S diagram. Derive an expression for thermal efficiency of Rankine cycle. (06 Marks)
- b. Consider a steam power plant operating on a simple Rankine cycle. Steam enters the turbine at 3MPa and 350°C and is condensed in the condenser at a pressure of 75 KPa. Determine the thermal efficiency of the cycle. (06 Marks)
- c. How can we increase the efficiency of the Rankine cycle? (04 Marks)

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CBCS Scheme

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15AE33

Third Semester B.E. Degree Examination, Dec.2017/Jan.2018
Aerothermodynamics

Time: 3 hrs.

Max. Marks: 80

- Note: 1. Answer FIVE full questions, choosing one full question from each module.
 2. Use of thermodynamic data handbook/charts/tables is permitted.*

Module-1

- 1 a. With a neat diagram, explain the working of constant volume gas thermometer for the measurement of temperature. (08 Marks)
 b. In 1709, Sir Issac Newton proposed a new temperature scale. On this scale, the temperature was a linear function of Celsius scale. The reading on this at ice point 0°C and normal human body temperature (37°C) were 0°N and 12°N respectively. Obtain the relation between the Newton scale and the Celsius scale. (08 Marks)

OR

- 2 a. Starting from a convenient common state point on a PV diagram, show the four expansion processes for $n = 0$, $n = 1$, $n = r$ and $n = \infty$. What are these processes called and also discuss the work done during these processes? (08 Marks)
 b. A spherical balloon has an initial diameter of 25 cm and contains air at 1.2 bar. When heated, the diameter increases to 30 cm. During heating, the pressure is found to be proportional to diameter. Calculate the work done. (08 Marks)

Module-2

- 3 a. Show that internal energy is a property of the system. (08 Marks)
 b. The properties of a certain fluid are related as follows: $U = 196 + 0.718T$ and $PV = 0.287(T + 273)$, U is specific internal energy in kJ/kg, P is pressure in kN/m², V is specific volume in m³/kg. A closed system consisting of 2 kg of this fluid expands in an irreversible adiabatic process related by $PV^{1.2} = C$. The initial conditions are 1 MPa and 200°C and final pressure is 100 kPa. Determine the work transfer and change in internal energy for the process. (08 Marks)

OR

- 4 a. Write the steady flow energy equation for an open system and explain the terms involved in it. Simplify SFEE for the following systems: i) steam turbine, ii) nozzle. (08 Marks)
 b. A vertical cylinder fitted with a frictionless piston, contains gas at pressure 200 kN/m^2 . The upper surface of piston is exposed to atmosphere. The gas executed a cycle by undergoing the following process in sequence.
 i) With the cylinder insulated, 1.2 kJ of stirring work is done on the gas by a paddle wheel, projecting through cylinder wall. As a result, the gas temperature rises and piston moves slowly upwards. The increase in volume is 0.0028 m^3 .
 ii) With the insulation removed and paddle wheel stationary, heat transfer from gas restores gas to original state.
 Find work during process (i) and (ii) heat during process (ii). (08 Marks)

Module-3

- 5 a. State the Kelvin-Planck and Clausius statements of the second law of thermodynamics and show that the violation of the former results in the violation of the later. (08 Marks)
- b. Two reversible engines A and B are in series. A receives 200 kJ from HTR at 421°C, B rejects heat to sink at 4.4°C. If the work of A is twice of B, find intermediate temperature efficiency of A and B, heat rejected to sink. (08 Marks)

OR

- 6 a. State and prove Clausius inequality. What is the significance of Clausius inequality? (08 Marks)
- b. 10 gram of water at 20°C is converted into ice at -10°C in a constant pressure process of one atmosphere, calculate change in entropy for the process assuming that $C_{pw} = 4.187 \text{ kJ/kg.K}$ for ice half of that of water. (08 Marks)

Module-4

- 7 a. Define: i) Critical point, ii) Trippe point, iii) Dryness fraction, iv) Pure substance. (08 Marks)
- b. Derive Vander Waal's constants in terms of critical properties. (08 Marks)

OR

- 8 a. Write Maxwell relations and explain the terms involved. (08 Marks)
- b. A rigid vessel of volume 0.3 m^3 contains 10 kg of air at 300 K. Determine the pressure that would be exerted by air on the vessel, using (i) Perfect gas equation, (ii) Vander Waal's equation. Take for air, $R = 287.1 \text{ J/kg.K}$, molecular weight = 28.96, Vander Waal's constants, $a = 135.8 \text{ kN m}^4/(\text{kg mol})^2$, $b = 0.0365 \text{ m}^3/\text{kg.mol}$. (08 Marks)

Module-5

- 9 a. With the help of P-V and T-S diagrams, derive an expression for the air standard efficiency of a petrol engine (Otto cycle). (08 Marks)
- b. The minimum pressure and temperature of the air standard Carnot cycle are 1 bar and 15°C respectively. The pressure after isothermal compression is 3.5 bar and the pressure after isentropic compression is 10.5 bar. Determine: (i) efficiency, (ii) mean effective pressure and the power developed, if the Carnot engine makes 2 cycle per second. Take for air, $R = 0.287 \text{ kJ/kgK}$ and $\gamma = 1.4$. (08 Marks)

OR

- 10 a. Draw a neat line diagram and T-S diagram for a practical regenerative Rankine cycle with open feed water heater. Also write the energy balance equation. (08 Marks)
- b. A 40 MW steam power plant working on Rankine cycle operates between boiler pressure of 4 MPa and condenser pressure of 10 kPa. The steam leaves the boiler and enters the steam turbine at 400°C. The isentropic efficiency of steam turbine is 85%. Determine: —
i) The cycle efficiency
ii) The quality of exhaust steam from the turbine
iii) Steam flow rate in kg/hr considering pump work.

Properties of steam,

Pressure (bar)	t_s (°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
40	250.3	0.00125	0.049	1087.4	1712.9	2800.3	2.797	3.272	6.069
0.1	45.83	0.0010	14.675	191.8	2392.9	2584.7	0.649	7.502	8.151

(08 Marks)

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CBCS Scheme

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15AE33

Third Semester B.E. Degree Examination, June/July 2018 Aero Thermodynamics

Time: 3 hrs.

Max. Marks: 80

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

Module-1

- 1 a. Distinguish between : i) Intensive and Extensive properties ii) Diathermal and Adiabatic wall. (04 Marks)
- b. State Zeroth law of thermodynamics and extract the concept of temperature from it. (06 Marks)
- c. The temperature T on a thermometric scale is defined as $T = a \ln k + b$, where a and b are constants. The values of k are found to be 1.83 and 6.78 at 0°C and 100°C respectively. Calculate the temperature for a value of $K = 2.42$. (06 Marks)

OR

- 2 a. Bring out two similarities and two dissimilarities between heat and work. (04 Marks)
- b. Derive an expression for displacement work in a polytropic process $pV^n = \text{constant}$. Show on a p - v diagram four expansion processes for $n = 0$, $n = 1$, $n = 1.4$ and $n = \infty$. Name each of the process. (08 Marks)
- c. A shaft transmitting 600 hp rotates at 3600 rpm. Determine the torque applied to the shaft. (04 Marks)

Module-2

- 3 a. Write the first law of thermodynamics for any process in :
i) closed system ii) Open system. (04 Marks)
- b. A stationary mass of gas is compressed without friction from initial state of 0.3m^3 and 0.105MPa to a final state of 0.15m^3 and 0.105MPa , the pressure remaining constant during the process. There is a transfer of 37.6kJ of heat from the gas during the process. How much does the internal energy of the gas change? (06 Marks)
- c. A domestic refrigerator is loaded with food and the door closed. During a certain period of time the machine consumes 1kWh of energy and the energy of the system decreases by 5000kJ . Determine the magnitude and direction of heat transfer for the process. (06 Marks)

OR

- 4 a. Write Steady Flow Energy Equation and explain all the terms involved. (04 Marks)
- b. Apply SFEE for : i) Adiabatic Nozzle ii) Steam turbine. (06 Marks)
- c. A small turbine runs an aircraft refrigeration system. Air enters the turbine at 4bar and 40°C with velocity 200m/s . If the work output of the turbine is 52kJ/kg of air, calculate the heat transferred per kg of air. (06 Marks)

Module-3

- 5 a. Represent schematically and give performance equation for :
i) Heat engine ii) Refrigerator iii) Heat pump. (04 Marks)
Prove that $(\text{COP})_{\text{HP}} = (\text{COP})_{\text{Refrigerator}} + 1$.
- b. State Kelvin Planck and Clausius statements of second law of thermodynamics and show that they are equivalent. (06 Marks)

1 of 2

Important Note: 1. On completing your answers, you must sign and date your answer sheet. 2. If you are unable to write your name, you may reveal the name of the evaluator and/or equations written eg, $42+8=50$, will be treated as malpractice.

- c. A reversible refrigerator operates between 35°C and -15°C . If heat rejected to 35°C is 1.5kw, determine the rate at which heat is leaking into refrigerator. (06 Marks)

OR

- 6 a. Define Entropy and prove that it is a property of the system. (04 Marks)
 b. For an ideal gas undergoing finite change of state from 1 to 2, derive an expression for change in entropy. (05 Marks)
 c. A block of iron weighing 100kg and having a temperature of 100°C is immersed in 50kg of water at a temperature of 20°C . What will be the change in entropy of the combined system of iron and water? Specific heats of iron and water are 0.4kJ/kg K and 4.18 kJ/kg K respectively. (07 Marks)

Module-4

- 7 a. Define : i) Pure substance ii) Saturation conditions iii) Triple point iv) Critical point v) Compressibility factors. (05 Marks)
 b. Sketch and explain P – T diagram of water. (05 Marks)
 c. Find enthalpy, entropy and volume of steam at 1.4MPa and 380°C . (06 Marks)

OR

- 8 a. Derive and explain Maxwell's equations. (08 Marks)
 b. Show that for an ideal gas $C_p - C_v = R$. (02 Marks)
 c. 1 kg of air at a pressure of 8 bar and temperature 100°C undergoes reversible polytropic process following the law $pv^{1.2} = \text{constant}$. If final pressure is 1.8 bar determine the final specific volume, Temperature and increase in entropy. Assume $R = 0.287\text{ kJ/kg k}$, $\gamma = 1.4$. (06 Marks)

Module-5

- 9 a. What are Air standard Assumptions? (04 Marks)
 b. Explain Working of a diesel engine with the help of p – v and T-S diagrams. Derive an expression for the efficiency of diesel cycle in terms of its compression and cut – off ratios. (07 Marks)
 c. A diesel engine has a compression ratio of 14 and cut – off takes place at 6% of stroke. Find Air -- standard efficiency. (05 Marks)

OR

- 10 a. Explain Rankine cycle with the help of a sketch and T – S diagram. Derive an expression for thermal efficiency of Rankine cycle. (06 Marks)
 b. What are the methods for increasing the efficiency of Rankine cycle? (04 Marks)
 c. Consider a steam power plant operating on a simple Rankine cycle. Steam enters the turbine at 3MPa and 350°C and is condensed in the condenser at a pressure of 75KPa. Determine the thermal efficiency of the cycle. (06 Marks)

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17AE/AS33

Third Semester B.E. Degree Examination, Dec.2018/Jan.2019
Aerothermodynamics

Time: 3 hrs.

Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.

2. Use of Thermodynamics Data Hand Book is permitted.

Module-1

- 1 a. Distinguish between:
- Open and closed systems
 - Intensive and extensive properties
 - Mechanical and thermal equilibrium. (10 Marks)
- b. A centigrade and a Fahrenheit thermometer dipped in a fluid recorded same numerical reading. Determine the temperature of the fluid expressed as Kelvin (K) and Rankine (R) and also find the identical numerical value shown by the thermometer. Absolute zero on K and R scale correspond to -459.7°F and -273.16°C . (10 Marks)

OR

- 2 a. Define work and heat. Write the similarities and dissimilarities (any four). (10 Marks)
- b. A fluid at 0.7 bar occupying 0.09m^3 is compressed reversibly to a pressure of 3.5 bar according to a law $pV^n = \text{constant}$. The fluid is then heated reversibly at constant volume until the pressure is 4 bar; the specific volume then being $0.5\text{ m}^3/\text{kg}$. The fluid is restored back to its initial state by a reversible expansion process as per $pV^2 = \text{constant}$. Sketch the cycle on a p-v diagram and find:
- The fluid mass
 - The value of n in the first process
 - The net work done. (10 Marks)

Module-2

- 3 a. State the first law of thermodynamics for a non-cyclic process and show that internal energy is a property of a system. (10 Marks)
- b. A tank contains 12kg of water used for determining mechanical-thermal energy equalities. The total work input is 40Nm. Assuming the system is adiabatic, find: i) the change in specific and total internal energy ii) If a heat loss of 0.1 J/kg is recorded, what is the internal energy change, both specific and total, now? (10 Marks)

OR

- 4 a. Starting from first law equation for a closed system undergoing a non-cyclic process, derive an equation for an open system under steady state, steady flow conditions. List all the assumptions made. (12 Marks)
- b. An air compressor with water jacket compresses 48.67 lps of air of specific volume $0.73\text{ m}^3/\text{kg}$. The enthalpy of air is increased by 105 kJ/kg. The heat transfer rate to the cooling water jacket and the surrounding is 190 kJ/min. Determine the power required to drive the compressor assuming negligible changes in kinetic and potential energies. The flow is steady state. (08 Marks)

Module-3

- 5 a. Define the two statements of II laws of thermodynamics. Further prove that violation of clausius statement also violates Kelvin-Plank statement. (10 Marks)
- b. An engine mounted on a ship has a thermal efficiency of 80% of that of the standard carnot cycle. The engine receives heat from the sea at 300K and rejects heat to the atmosphere at 280K. What quantity of heat must be extracted from the sea water to provide the required heating effect? The work output from the engine is dissipated using 500kg of water at 355K. Take C_p of sea water as 4.186 kJ/kg K. (06 Marks)
- c. With a simple block diagram represent PMM of II kinds. Why it is not possible? (04 Marks)

OR

- 6 a. Derive clausius inequality and hence prove that entropy is a property. (12 Marks)
- b. In a certain reversible process the rate of heat transfer to the system per unit temperature rise is constant at 2 kJ/°C. Determine the increase in entropy of the system if the temperature changes from 27°C to 127°C.
In a second process between the same end states if the above temperature rise is accomplished by using a string and stirrer, what is the change or increase in entropy? (08 Marks)

Module-4

- 7 a. Represent water existing in all phases at atmospheric pressure on a P-T diagram. Label all the three phases, fusion and vapourization lines, critical and triple point of water. (06 Marks)
- b. Define critical point and triple point of water. (04 Marks)
- c. A vessel contains 10kg of oxygen, 8kg of nitrogen and 25kg of carbon dioxide at 375K and 250kPa. Calculate the capacity of the vessel, the partial pressure of each gas present in the vessel and the total pressure in the vessel when the temperature is raised to 450K. (10 Marks)

OR

- 8 a. Distinguish between ideal and real gases. Write any two equations of state you know. (06 Marks)
- b. Define compressibility factor. Determine the compressibility factor of nitrogen at 10MPa and -80°C and 0.5 MPa and 35°C. For N_2 take $T_c = 126.30K$ and $P_c = 3.398 MPa$. (06 Marks)
- c. Using the relation $C_p - C_v = T \left(\frac{\partial V}{\partial T} \right)_p \left(\frac{\partial P}{\partial T} \right)_v$ for an ideal gas show that $C_p - C_v = R$. (08 Marks)

Module-5

- 9 a. Derive with usual notations an expression for the air standard efficiency of an Otto cycle. Represent the cycle on P-V and T-S diagrams. (09 Marks)
- b. In a petrol engine the temperature at the beginning and at the end of compression are 300K and 750K. Find the compression ratio and air standard efficiency. (06 Marks)
- c. State any six assumptions made in the analysis of air standard cycles. (05 Marks)

OR

- 10 a. With the help of T-S diagram deduce an expression for Rankine cycle efficiency. (10 Marks)
- b. The following data are extracted from a steam power plant:
Steam at boiler inlet: 150 bar and 550°C
Reheated to : 40 bar and 550°C
Condensed to : 0.1 bar
Assuming all processes as ideal and using Mollier chart/steam tables determine:
(i) Quality at turbine exhaust (ii) Cycle efficiency (iii) Steam rate. (10 Marks)

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17AE/AS33

Third Semester B.E. Degree Examination, June/July 2019
Aerothermodynamics

Time: 3 hrs.

Max. Marks: 100

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

Module-1

- 1 a. With a neat sketch, explain the working of a thermocouple. (06 Marks)
b. With a neat sketch, explain Quasi-static process. (06 Marks)
c. The temperature of a fluid is measured with a Celsius thermometer as well as Fahrenheit thermometer. If the numerical reading is same for both thermometers, determine the temperature in degree Celsius and degree Fahrenheit. (08 Marks)

OR

- 2 a. A spherical balloon has an initial diameter of 25 cm and contains air at 1.2 bar. When heated, the diameter increases to 30 cm. During heating, the pressure is found to be proportional to diameter. (06 Marks)
b. With a neat PV diagram, derive an expression for work done in isothermal process and polytropic process. (08 Marks)
c. A gas is compressed from 0.3 m^3 to 1 m^3 . The process follows $p = av^{-2}$, where $a = 8 \text{ kPa/m}^2$. Calculate work done. (06 Marks)

Module-2

- 3 a. State first law of thermodynamics and explain Joules experiment with a neat sketch. (06 Marks)
b. Prove that internal energy is a property of the system. (06 Marks)
c. Write the steady flow energy equation for an open system and explain the terms involved in it. Simplify SFEE for the following systems: (i) Steam turbine (ii) Nozzle. (08 Marks)

OR

- 4 a. The properties of a certain fluid are related as follows: $U = 196 + 0.718 T$ and $PV = 0.287 (T + 273)$, U is specific internal energy in kJ/kg, P is pressure in kN/m², V is specific volume in m³/kg. A closed system consisting of 2 kg of this fluid expands in an irreversible adiabatic process related by $PV^{1.2} = C$. The initial conditions are 1 MPa and 200°C and final pressure is 100 kPa. Determine the work transfer and change in internal energy for the process. (10 Marks)
b. A vertical cylinder fitted with a frictionless piston, contain gas at pressure 200 kN/m². The upper surface of piston is exposed to atmosphere. The gas executes a cycle by undergoing the following process in sequence.
i) With the cylinder insulated, 1.2 kJ of stirring work is done on the gas by a paddle wheel projecting through cylinder wall. As a result, the gas temperature rises and piston moves slowly upwards. The increase in volume is 0.0028 m^3 .
ii) With the insulation removed and paddle wheel stationary heat transfer from gas restores gas to original state.
Find work during process (i) and (ii), heat during process (ii). (10 Marks)

Module-3

- 5 a. Using Kelvin Plank statement, show that heat transfer through finite temperature difference is irreversible. (06 Marks)
- b. State and prove Clausius inequality. What is the significance of Clausius inequality? (06 Marks)
- c. Two reversible engines A and B are in series. A receives 200 kJ for HTR and 421°C , B rejects heat to sink at 4.4°C . If the work of A is twice of B, determine intermediate temperature, efficiency of A and B, heat rejected to sink (08 Marks)

OR

- 6 a. State the Kelvin Plank and Clausius statements of the second law of thermodynamics and show that the violation of the former results in the violation of the later. (10 Marks)
- b. A heat pump working on a reversible cycle takes heat from a reservoir at 5°C and delivers heat to HTR at 60°C . The heat pump is driven by a heat engine taking heat from source at 840°C and rejects heat to LTR at 60°C . The engine also drives a machine of 30 KW capacity. If the heat pump extracts 17 kJ/s from LTR at 5°C , find: (i) Rate of heat flow from reservoir at 840°C (ii) Rate of heat rejected to sink at 60°C . (10 Marks)

Module-4

- 7 a. Derive Vander Waal's constants in term of critical properties. (06 Marks)
- b. A balloon of spherical shape 6m in diameter is filled with hydrogen gas at a pressure of 1 bar absolute and 20°C . At a later time, the pressure of gas is 94% of its original value of pressure at the same temperature.
- i) What mass of the original gas must have escaped if the dimensions of the balloon is not changed?
- ii) Determine the amount of heat removed to cause the same drop in pressure at constant volume.
- Take $CV = 10,400 \text{ K/kg.K}$ (06 Marks)
- c. Write Maxwell relations and explain the terms involved. (08 Marks)

OR

- 8 a. Explain the law of corresponding states with a generalized compressibility chart. (06 Marks)
- b. The volumetric analysis of a gaseous mixture yields the following results $\text{CO}_2 = 12\%$, $\text{N}_2 = 82\%$, $\text{O}_2 = 4\%$, $\text{CO} = 2\%$. Determine the analysis on mass basis, the molecular weight and gas constant for the mixture. Assume the ideal gas behavior. (06 Marks)
- c. Define and explain: (i) Critical point (ii) Triple point (iii) Dryness fraction (iv) Latent heat. (08 Marks)

Module-5

- 9 a. With the help of T-S and P-V diagrams, evaluate an expression for the air standard efficiency of a diesel cycle. (10 Marks)
- b. A 40 MW steam power plant working on Rankine cycle operates between boiler pressure of 4 MPa and condenser pressure of 10 kPa. The steam leaves the boiler and enters the steam turbine at 400°C . The isentropic efficiency of the steam turbine is 85%. Determine: (i) The cycle efficiency (ii) The quality of steam from the turbine (iii) Steam flow rate in kg per hr. consider pump work. (10 Marks)

OR

- 10 a. Sketch the flow diagram and corresponding T-S diagram of a reheat vapour cycle and evaluate an expression for reheat cycle efficiency. (10 Marks)
- b. Draw a neat line diagram and T-S diagram for a practical regenerative Rankine cycle with open feed water heater. Also write the energy balance equation. (10 Marks)

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17AE33

Third Semester B.E. Degree Examination, Dec.2019/Jan.2020
Aerothermodynamics

Time: 3 hrs.

Max. Marks: 100

- Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
 2. Use of thermodynamics data hand book/charts /tables is permitted.*

Module-1

- 1 a. Explain the following with suitable examples.
 i) Open system ii) Closed system iii) Isolated system. (08 Marks)
- b. A readings t_A and t_B of two Clausius thermometer A and B agree at ice point and steam point but else where they are related by the equation $t_A = L + mt_B + nt_B^2$ where L, m and n are constant when both the thermometric are immersed in oil A indicates 55°C and B indicates 50°C , determine the values of constants L, m and n and also the temperature reading on thermometer A when B reads 25°C ? (12 Marks)

OR

- 2 a. A system undergoes a process in which the pressure and volume are related by an equation of the form $PV^n = C$. Derive an expression for displacement work during this process. (10 Marks)
- b. A Spherical balloon of 0.5m diameter contains air at a pressure of 500KPa the diameter increase to 0.55m in a reversible process during which pressure is proportional to diameter. Determine the work done by the air during this process. (10 Marks)

Module-2

- 3 a. Show that energy is a property of system. (10 Marks)
- b. A cylinder contains 1kg of a certain fluid at an initial pressure of 20 bar. The fluid is allowed to expand reversibly beyond a distance according to a law $PV^2 = C$ until the volume is double. The fluid is then cooled reversibly at constant pressure until the piston regains its original position, heat is then added with the piston firmly locked in position until the pressure rises to original value of 20 bar. Sketch the cycle on the PV diagram and calculate the net work done by the fluid for an initial volume of 0.5m^3 . (10 Marks)

OR

- 4 a. Obtain an expression for steady flow work from the steady flow energy equation. (10 Marks)
- b. A closed system undergoes a cyclic process 1 – 2 – 3 – 1 it is given that $Q_{1-2} = 30\text{kJ}$, $Q_{2-3} = 10\text{kJ}$, $W_{1-2} = 5\text{kJ}$, $W_{3-1} = 25\text{kJ}$, and $dV_{3-1} = 15\text{kJ}$, determine Q_{3-1} , Q_{2-3} $(dv)_{1-2}$ and $(dv)_{2-3}$. (10 Marks)

Module-3

- 5 a. State Kelvin plank and Clausius statements of second law of thermodynamics and show that they are equivalent. (08 Marks)
- b. A reversible engine operates between temperature T_H and T_I with $T_H > T_I$. The energy rejected from this engine is utilized for driving another reversible engine which operates between the temperature limits T_I and T_L with $T_I > T_L$. For this arrangement show that.
 i) The temperature T_I is the arithmetic mean of the temperature T_H and T_L , if both the engines produce equal amount of work.
 ii) The temperature T_I is geometric mean of the temperature T_H and T_L when both the engines have the same thermal efficiency. (12 Marks)

1 of 2

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
 2. Any revealing of identification, appeal to evaluator and /or equations written eg. 42+8 = 50, will be treated as malpractice.

OR

- 6 a. State and prove Clausius inequality. (10 Marks)
 b. A reversible engine receives 430kJ of heat per cycle from a source maintained at 327°C engine rejects heat to a sink maintained at a temperature of 27°C for each of the following cases of heat rejection. Find whether the cycle is reversible, irreversible (or) impossible using the Clausius inequality.
 i) Heat rejected is 220kJ/cycle
 ii) Heat rejected is 105kJ/cycle
 iii) Heat rejected is 315kJ/cycle. (10 Marks)

Module-4

- 7 a. Define the following :
 i) Pure substance
 ii) Triple point
 iii) Critical point. (06 Marks)
 b. Sketch and explain P-T diagram of water. (06 Marks)
 c. Find the enthalpy, specific volume, and internal energy if the pressure of steam is 50 bar and temperature is 443°C. (08 Marks)

OR

- 8 a. Show that the change in entropy when a perfect gas undergoes a polytropic change $PV^n = \text{constant}$ is given $S_2 - S_1 = \frac{\gamma - n}{n - 1} C_v \ln\left(\frac{T_1}{T_2}\right)$ (10 Marks)
 b. Determine the change entropy of 1kg of perfect gas which is compressed according to the law $PV^{1.3} = C$ from initial pressure of 1 bar and volume of 0.85m³ to a final volume of 0.5m³. Find also the work done and heat supplied during this process. Assume $C_v = 0.7\text{kJ/kgK}$ and $\gamma = 1.4$. (10 Marks)

Module-5

- 9 a. With the help of P-V and T-S diagram, explain the working of diesel cycle. Derive an expression for the efficiency of diesel cycle in terms of its compression and cut off ratio's. (12 Marks)
 b. An ideal heat engine works on Carnot cycle between the temperature limits of 1100°C and 150°C. If 4000kJ/min heat is added to the engine at the higher temperature determine :
 i) Power developed by the engine
 ii) The quantity of heat rejected
 iii) The change in entropy during heat rejection. (08 Marks)

OR

- 10 a. With the help of P-V and T-S diagram, derive an expression for the air standard efficiency of a otto cycle. (10 Marks)
 b. An otto cycle has upper and lower temperature limits of T_3 and T_1 . If maximum work per kg of air is to be done. Show that intermediate temperature is give by $T_2 = T_4 = \sqrt{T_1 T_3}$.
 If the temperature limits are 1500K and 300K find the maximum power developed for air circulation of 0.35kg/min [Take $C_v = 0.706\text{ kJ/kgK}$]. (10 Marks)

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17AE/AS33

Third Semester B.E. Degree Examination, Aug./Sept. 2020 Aero Thermodynamics

Time: 3 hrs.

Max. Marks: 100

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

Module-1

- 1 a. What is thermodynamic system? Explain the types of thermodynamic system. (05 Marks)
- b. State zeroth law of thermodynamics and extract the concept of temperature from it. (05 Marks)
- c. In 1709, Sir Issac Newton proposed a new temperature scale. On this scale, the temperature was a linear function of Celsius scale. The reading on this at ice point (0°C) and normal human body temperature (37°C) were 0°N and 12°N respectively. Obtain the relation between the Newton scale and the Celsius scale. (10 Marks)

OR

- 2 a. Distinguish between Heat and Work. (04 Marks)
- b. Derive an expression for displacement work in a polytropic process $PV^n = \text{constant}$. Show on a P-V diagram, four expansion process for $n = 0$, $n = 1$, $n = 1.4$ and $n = \infty$. Name each of the process. (08 Marks)
- c. A spherical balloon has an initial diameter of 25 cm and contains air at 1.2 bar. When heated the diameter increases to 30 cm. During heating the pressure is found to be proportional to diameter. Calculate the workdone. (08 Marks)

Module-2

- 3 a. Write the first law of thermodynamics for any process in : (i) Closed system (ii) Open system. (04 Marks)
- b. Explain Joules experiment with a neat sketch. (08 Marks)
- c. Prove that internal energy is a property of the system. (08 Marks)

OR

- 4 a. Write the steady flow energy equation for an open system and explain the terms involved in it. Simplify SFEE for the following systems:
(i) Steam turbine (ii) Nozzle (10 Marks)
- b. The properties of a certain fluid are related as follows: $U = 196 + 0.718T$ and $PV = 0.287(T + 273)$, U is specific internal energy in KJ/kg, P is pressure in KN/m², V is specific volume in m³/kg. A closed system consisting of 2 kg of this fluid expands in an irreversible adiabatic process related by $PV^{1.2} = C$. The initial conditions are 1 MPa and 200°C and final pressure is 100 KPa. Determine the work transfer and change in internal energy for the process. (10 Marks)

1 of 2

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and/or equations written eg, 42+8 = 50, will be treated as malpractice.

Module-3

- 5 a. Represent schematically and give performance equation for,
(i) Heat engine, (ii) Refrigerator, (iii) Heat pump.
Prove that $(COP)_{HP} = (COP)_{Refrigerator} + 1$ (04 Marks)
- b. State Kelvin Plank and Clausius statements of second law of thermodynamics and show that they are equivalent. (08 Marks)
- c. A reversible refrigerator operates between 35°C and -15°C . If heat rejected to 35°C is 1.5 kW, determine the rate at which heat is leaking into refrigerator. (08 Marks)

OR

- 6 a. Prove that entropy is a property of a system. (05 Marks)
- b. Define Clausius inequality and entropy of a system. Show that for an irreversible process,
 $ds \geq \frac{\delta Q}{T}$. (10 Marks)
- c. One kg of water at 273 K is heated to 373 K by first bringing it in contact with reservoir at 323 K and then reservoir at 373 K. What is the change in entropy of the universe? (05 Marks)

Module-4

- 7 a. Define : (i) Critical point, (ii) Trippl point, (iii) Dryness fraction,
(iv) Pure substance (v) Compressibility factor. (10 Marks)
- b. Derive Vander Waal's constants in terms of critical properties. (10 Marks)

OR

- 8 a. Write the Maxwell relation and explain the terms involved. (04 Marks)
- b. A rigid vessel of volume 0.3 m^3 contains 10 kg of air at 300 K. Determine the pressure that would be exerted by air on the vessel, using (i) Perfect gas equation, (ii) Vander Waal's equation. Take for air, $R = 287.1 \text{ J/kg.K}$, molecular weight = 28.96, Vander Waal's constants, $a = 135.8 \text{ kNm}^4/(\text{kgmol})^2$, $b = 0.0365 \text{ m}^3/\text{kg.mol}$ (08 Marks)
- c. 0.1 m^3 of air at 5 MPa, 356°C contained in a cylinder expands reversibly and isothermally to 0.25 MPa. Calculate for air (i) Work transfer, (ii) Heat transfer (iii) Change in entropy, assuming that air behaves as an ideal gas with $R = 287 \text{ J/kg.K}$. (08 Marks)

Module-5

- 9 a. With the help of T-S and P-V diagrams, evaluate an expression for the air standard efficiency of a Diesel cycle. (10 Marks)
- b. Compare Otto and Diesel cycles with the help of PV and TS diagram. (06 Marks)
- c. A Carnot engine rejects heat to the sink at 32°C and has a thermal efficiency of 52.3%. The work output from the engine is 120 KJ. Determine (i) The maximum working temperature of the engine and (ii) The heat added in KJ. (04 Marks)

OR

- 10 a. What are the methods for increasing the efficiency of Rankine cycle? (04 Marks)
- b. Consider a steam power plant operating on a simple Rankine cycle. Steam enters the turbine at 3 MPa and 350°C and is condensed in the condenser at a pressure of 75 KPa. Determine the thermal efficiency of the cycle. (06 Marks)
- c. Explain with T-S diagram, limitation of Carnot cycle and how we can overcome the same in Rankine cycle. (10 Marks)

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18AE/AS32

Third Semester B.E. Degree Examination, Dec.2019/Jan.2020
Aerothermodynamics

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 hand book is permitted.

Module-1

- 1 a. What are open system, closed system and isolated system? Give examples of each. (06 Marks)
- b. Show that $t^{\circ}C = 100 \frac{(x - x_1)}{(x_s - x_1)}$ (06 Marks)
- c. A resistance thermometer follows an equation ' R_t ' $R_t = R_o (1 + \alpha t)$ where R_t R_o are the values of resistance at temperature $t^{\circ}C$ and $0^{\circ}C$ respectively α is a constant, the thermometer is calibrated by immersing it in boiling water and boiling sulphur which have the temperature values of $100^{\circ}C$ and $445^{\circ}C$ at these temperature the thermometer indicates the resistance values of 14.7Ω and 29.2Ω respectively. Find the temperature of a fluid when the thermometer reads 23.5Ω . (08 Marks)

OR

- 2 a. With the help of neat sketch prove that free expansion has zero work transfer. (08 Marks)
- b. Obtain an expression for work done by the isothermal process. (04 Marks)
- c. A spherical balloon has a diameter of 20cm and it contains air at a pressure of 1.5 bar during a certain process the diameter of a balloon increases to 30cm during which the pressure in proportional to diameter. Calculate the work done by the air inside the balloon during this process. (08 Marks)

Module-2

- 3 a. Derive an expression for temperature ratio in terms of pressure ratio and volume ratio for an adiabatic process. (06 Marks)
- b. Prove that polytropic index $n = \frac{\ln(P_2/P_1)}{\ln(V_1/V_2)}$ (04 Marks)
- c. A cylinder contains 1kg of a certain fluid at an initial pressure of 20 bar. The fluids is allowed to expand reversibly behind a distance according to a law $PV^2 = C$ untill the volume is double. The fluid is then cooled reversibly at constant pressure untill the piston regains its original position, heat is the added with the piston firmly, locked in position untill the pressure rises to original value of 20 bar. Sketch the cycle on the PV diagram and calculate the net work done by the fluid for an initial volume of $0.5m^3$. (10 Marks)

OR

- 4 a. Write the steady flow energy equation for an open system and explain the terms involved in it. With suitable assumption simplify SFEE for the following systems.
 i) Nozzle ii) Turbine. (12 Marks)
- b. In a steady flow process the working fluid flows at a rate of 240kg/min the fluid rejects 120kJ/Sec of heat by passing through the control volume the conditions of the fluid at the inlet and the outlet are as follows.

	Inlet		Outlet
C_1	= 300m/Sec	C_2	= 150m/Sec
P_1	= 6.2 bar	P_2	= 1.3 bar
u_1	= 2100 kJ/kg	u_2	= 1500 kJ/kg
V_1	= $0.37m^3/kg$	V_2	= $1.2m^3/kg$

Neglecting any changes in potential Energy. Obtain the rate of work transfer in Mega Watt (MW). (08 Marks)

1 of 2

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
 2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

Module-3

- 5 a. State Kelvin Plank and Clausius statements of second law of thermodynamics and show that they are equivalent. (08 Marks)
- b. A reversible engine operates between temperature T_H and T_I with $T_H > T_I$. The energy rejected from this engine is utilized for driving another reversible engine which operates between the temperature limits T_I and T_L with $T_I > T_L$, for this arrangement show that :
- The temperature T_I is the arithmetic mean of the temperature T_H and T_L , if both the engines produce equal amount of work.
 - The temperature T_I is geometric mean of the temperature T_H and T_L when both the engines have the same thermal efficiency. (12 Marks)

OR

- 6 a. State and prove Clausius inequality. (08 Marks)
- b. Two reversible engine operate in series between a high temperature reservoir and a low temperature reservoir engine (A) reject heat to engine (B) through an intermediate reservoir maintained at temperature T_I . Engine (B) reject heat to low temperature reservoir which is maintained at temperature $T_L = 300K$, both the engines have the same thermal efficiency, if the work developed by engine (B) is 500kJ and the heat received by the engine (A) is 2000kJ from the high temperature reservoir maintained at temperature T_H obtain the work developed by engine (A), the heat rejected by engine (B), the intermediate temperature T_I and the source temperature T_H . (12 Marks)

Module-4

- 7 a. Define the following :
- Critical point
 - Triple point
 - Pure substance
 - Saturation pressure. (04 Marks)
- b. Find the enthalpy, specific volume and internal energy if the pressure of steam is 50 bars and temperature is 443°C. (08 Marks)
- c. Sketch and explain P-T diagram of water. (08 Marks)

OR

- 8 a. Derive and explain Maxwell's equation. (08 Marks)
- b. 1kg of ideal gas at pressure P_1 , Volume V_1 and temperature T_1 follows a reversible process to arrive at state (2) where the properties are P_2 , V_2 and T_2 starting from the realtion entropy change $ds = \frac{\sigma Q}{T}$, derive an expression for change in entropy in terms of pressure and volume. Using the derived expression prove that for an adiabatic process $PV^\nu = C$ where ν = ratio of specific heats. (12 Marks)

Module-5

- 9 a. With the help of PV and TS diagram, explain the working of diesel cycle. Derive an expression for the efficiency of diesel cycle in terms of its compression and cut off ratios. (12 Marks)
- b. An Otto cycle has upper and lower temperature limits of T_3 and T_1 . If maximum work/kg of air is to be done. Show that the intermediate temperature is given by $T_2 = T_4 = \sqrt{T_1 T_3}$.
- If the temperature limit are 1500k and 300k, find the maximum power developed for air circulation of 0.35kg/min (Take $C_v = 0.706$ kJ/kg K). (08 Marks)

OR

- 10 a. Explain Rankine cycle with the help of a sketch and T-S diagram. Derive an expression for thermal efficiency of Rankine cycle. (08 Marks)
- b. What are the methods for increasing the efficiency of Rankine cycle? (04 Marks)
- c. Consider a steam power plant operating on a simple Rankine cycle. Steam enters the turbine at 3MPa and 350°C and is condensed in the condenser at a pressure of 75KPA. Determine the thermal efficiency of the cycle. (08 Marks)

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18AE/AS32

Third Semester B.E. Degree Examination, Aug./Sept. 2020

Aerothermodynamics

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. Distinguish the following:
(i) Microscopic and Macroscopic approach. (06 Marks)
(ii) Intensive and Extensive properties. (06 Marks)
- b. With the help of relevant sketches, explain Quasi-static process. (06 Marks)
- c. A temperature scale of certain thermometer is given by the relation, $t = a \ln p + b$. where a and b are constants and P is the thermometric property of the fluid in the thermometer. If at the ice point and steam point the thermometer properties are found to be 1.5 and 7.5 respectively. What will be the temperature corresponding to the thermometer property of 3.5 on Celsius scale. (08 Marks)

OR

- 2 a. Derive an expression for work done during the following processes:
(i) Constant temperature process. (06 Marks)
(ii) Polytropic process. (06 Marks)
- b. Describe the similarities and dissimilarities between heat and work. (06 Marks)
- c. 200 KJ of work is supplied to a closed system. The pressure and volume relation is $P = 8 - 5 V$. P is in bar and V in m^3 . The initial volume is $0.5 m^3$. Calculate the final volume and pressure. (08 Marks)

Module-2

- 3 a. State I law of thermodynamics. Explain classic paddle experiment with relevant sketches. (06 Marks)
- b. Derive an expression for change in internal energy during adiabatic a Isentropic process with P-V diagram and prove that $PV^\gamma = C$ forth process. (06 Marks)
- c. 90 KJ of heat is supplied to a system at constant volume. The system rejects heat of 95 KJ at constant pressure and 18 KJ of work is done on it. The system is brought to original state by adiabatic process. Determine (i) Adiabatic work (ii) The values of internal energy at all and state of initial value is 105 KJ. (08 Marks)

OR

- 4 a. Define steady flow process and derive an expression for steady flow energy equation with usual notations. (08 Marks)
- b. Illustrate the application of steady flow energy equation for the following engineering system: (i) Nozzle and diffuser (ii) Turbine and compression. (04 Marks)
- c. 10 kg of fluid per minute goes through a reversible steady flow process. The properties of fluid at the inlet are $P_1 = 1.5$ bar, $\rho_1 = 26 kg/m^3$, $C_1 = 110$ m/S and $u_1 = 910$ kJ/kg and the fluid rejects 55 KJ/s of heat and rises through 55 meters.
At the exit the properties of fluid are $P_2 = 5.5$ bar, $\rho_2 = 5.5 kg/m^3$, $C_2 = 190$ m/s and $u_2 = 710$ KJ/kg. Determine (i) The change in enthalpy (ii) Work done during the process. (08 Marks)

1 of 2

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

Module-3

- 5 a. Write Kelvin-Planck and Clausius statements of second law of thermodynamics. Show that violation of Clausius statement leads to the possibility of a perpetual motion machine of second type. (10 Marks)
- b. Series combination of three Carnot engines A, B and C operates between temperatures of 1500 K and 300 K. If the amount of heat addition to each engine is in the ratio of 6 : 3 : 2. Calculate the intermediate temperature. (10 Marks)

OR

- 6 a. Obtain an expression for entropy change of a closed system when it undergoes a polytropic process. (10 Marks)
- b. A 50 kg metal block at a temperature of 500°C is quenched in 140 kg of oil at 30°C. C_p of metal = 0.5 KJ/kg°K, C_p of oil = 2.5 KJ/kg°K. Assuming number of heat losses. Calculate change in entropy for a system consisting of oil and casing. (10 Marks)

Module-4

- 7 a. With the help of a neat diagram, explain P-V-T surface and also describe the property diagrams in common use. (10 Marks)
- b. A vessel having a capacity of 0.05 m³ contains a mixture of saturated water and saturated steam at a temperature of 245°C. The mass of liquid present is 10 kg. Find the following (i) Processor (ii) Mass (iii) Specific volume (iv) Specific enthalpy (v) Specific entropy (vi) Specific internal energy. (10 Marks)

OR

- 8 a. With the help of a relevant sketch explain the process of determination of dryness fraction of steam using Throttling calorimeter. (10 Marks)
- b. With usual notations derive the following :
 (i) Entropy equations (Tds equation)
 (ii) Equation for internal energy.
 (iii) Equation for enthalpy. (10 Marks)

Module-5

- 9 a. With the help of P-V and T-S diagram derive an expression for air-standard efficiency of Otto cycle with usual notation. (10 Marks)
- b. An engine operating on the ideal diesel cycle has a compression ratio of 16:1. Heat is added during constant pressure process upto 8% of the stroke. If the engine inhales 0.04 m³/s at 101 KPa and 25°C, determine
 (i) The maximum pressure and temperature in the cycle.
 (ii) The thermal efficiency of the engine.
 (iii) The power developed. (10 Marks)

OR

- 10 a. With the help of a neat schematic P-V, T-S and h-S diagram, derive an expression for efficiency of Rankine cycle. (10 Marks)
- b. In a steam power cycle, the steam supply is at 15 bar and dry and saturated. The condenser pressure is 0.4 bar. Calculate the Carnot and Rankine efficiencies of the cycle. Neglect pump work. (10 Marks)
