Government College of Engineering, Amravati

(An Autonomous Institute of Government of Maharashtra)

Third Semester B. Tech. (Mechanical Engineering)

Winter – 2017

Course Code: MEU 302

Course Name: Engineering Thermodynamics

Time: 2 Hrs. 30 Minutes **Max. Marks: 60**

Instructions to Candidate

1) All questions are compulsory.
2) Assume suitable data wherever necessary and clearly state the assumptions made.
3) Diagrams/sketches should be given wherever necessary.
4) Use of Steam Tables, Properties of Air Tables, Mollier Diagram, logarithmic table, drawing instruments and non-programmable calculators is permitted.
5) Figures to the right indicate full marks.

1. a) Answer the following concept questions briefly (*One mark each*): **06**

(i) Which process requires more energy: completely vaporizing 1 kg of saturated liquid water at 1 atm pressure or completely vaporizing 1 kg of saturated liquid water at 8 atm pressure?

(ii) An ideal gas at a given state expands to a fixed final volume first at constant pressure and then at constant temperature. For which case the work done is greater?

(iii) Consider an adiabatic turbine operating steadily. Does the work output of the turbine have to be equal to the decrease in the energy

Contd..

of the steam flowing through it?

(iv) In the absence of any friction and other irreversibilities, can a heat engine have an efficiency of 100 percent? Explain.

(v) A system undergoes a process between two fixed states first in a reversible manner and then in an irreversible manner. For which case is the entropy change is greater? Why?

(vi) Is it possible to create entropy? Is it possible to destroy it?

(b) A 80 m^3 vessel contains 4 kg of refrigerant R-134a at a pressure of 160 kPa. Determine (i) the temperature of the refrigerant (ii) the quality (iii) the enthalpy of the refrigerant, and the (iv) volume occupied by the vapor phase. 06

2. (a) A piston–cylinder device, with a set of stops on the top, initially contains 3 kg of air at 200 kPa and 27°C. Heat is now transferred to the air, and the piston rises until it hits the stops, at which point the volume is twice the initial volume. More heat is transferred until the pressure inside the cylinder also doubles. Determine the work done and the amount of heat transfer for this process. Also, show the process on a *P-v* diagram. Take the gas constant of air R= 0.287 kPa.m^3/kg.K. 06

(b) Write the energy balance equation for a single stream general steady flow system. Explain the various terms appearing in the equation. Apply the steady-flow energy equation to (i) Nozzle & (ii) Throttle Valve. 06

OR

(c) Air at 80 kPa and 127°C enters an adiabatic diffuser steadily at a rate of 6000 kg/h and leaves at 100 kPa. The velocity of the airstream is decreased from 230 to 30 m/s as it passes through the diffuser. Find (*a*) the exit temperature of the air and (*b*) the exit area of the diffuser. 06

3. (a) In the steam power plant, the condenser is the device where a large quantity of waste heat is rejected to the rivers. Can we not just take the condenser out of the plant and save all that waste energy? Using Carnot cycle and P-v diagram of the cycle, justify the answer. 06

(b) A geothermal power plant uses geothermal water extracted at 160°C at a rate of 440 kg/s as the heat source and produces 22 MW of net power. If the environment temperature is 25°C, determine (i) the actual thermal efficiency (ii) the maximum possible thermal efficiency and (iii) the actual rate of heat rejection from this power plant. 06

OR

(c) Consider a steam power plant that operates between the pressure limits of 10 MPa and 20 kPa. Steam enters the pump as saturated liquid and leaves the turbine as saturated vapor. Determine the ratio of work delivered by the turbine to the work consumed by the pump. Assume the process to be reversible. 06

4. (a) Establish the inequality of Clausius, and elaborate on the applicability of the inequality 08

$$\oint \frac{\delta Q}{T} \leq 0$$

for a reversible and irreversible process.

(b) The following remarks are about entropy. Elaborate on these remarks: 0

- Processes can occur in certain directions only, not in any direction.
- Entropy is a non-conserved property.
- The performance of engineering systems is degraded by the presence of irreversibilities.

5. (a) What is (i) Useful Work (ii) Reversible Work and (iii) Irreversibility? Obtain the expression for Useful work and Irreversibility and define the relevant terms. 0

(b) Define Second law efficiency in the context of the statement 'the first law efficiency alone is not a realistic measure of performance of engineering devices, for work-producing and for work-consuming devices. Consider two heat engines both having a thermal efficiency of 30%, with Engine A supplied with heat from a source at 600 K and Engine B is supplied with heat from a source at 1000 K. Both engines reject heat to a medium at 300 K. Prove that Engine A has higher second law efficiency than Engine B 0

OR

(c) Draw an ideal Rankine cycle on T-s diagram. List the various processes which are part of the cycle. Carry out the energy analysis of the cycle and obtain the equation for efficiency of the cycle. List the causes for deviation of actual vapor cycles from the ideal one. 06

Government College of Engineering, Amravati

(An Autonomous Institute of Government of Maharashtra)

Third Semester B. Tech. (Mechanical Engineering)

Winter – 2016

Course Code: MEU302

Course Name: Engineering Thermodynamics

Time: 2 hr. 30min. **Max. Marks: 60**

Instructions to Candidate

1) All questions are compulsory.
2) Assume suitable data wherever necessary and clearly state the assumptions made.
3) Diagrams/sketches should be given wherever necessary.
4) Use of logarithmic table, drawing instruments and non-programmable calculators is permitted.
5) Figures to the right indicate full marks.

1. **a** Answer the following concept questions briefly (*one mark each*): **06**

i In what kind of a pot will a given volume of water boil at a higher temperature: a tall and narrow one or a short and wide one? Explain.

ii Which process required more energy: completely vaporizing 1 kg of saturated liquid water at 1 atm pressure or completely vaporizing 1 kg of saturated liquid water at 8 atm pressure? **06**

iii Is it possible to compress an ideal gas isothermally in an adiabatic piston-cylinder device? Explain. **06**

iv Would you expect the temperature of air to drop as it undergoes a steady-flow throttling process? Explain.

v Does a heat engine that has a thermal efficiency of 100% necessarily violate (i) first law and (ii) the second law of thermodynamics? Explain.

vi Is a process that is internally reversible and adiabatic necessarily isentropic? Explain.

b 1 (b) A $1m^3$ tank containing air at 25°C and 500 kPa is connected through a valve to another tank containing 5 kg of air at 35°C and 200 kPa. Now the valve is opened, and the entire system is allowed to reach thermal equilibrium with the surroundings, which are at 20°C. Determine the volume of the second tank and the final equilibrium pressure of the air. Take R = 0.287 kPa. m^3/kg.K. **06**

2 a What is polytropic process? Develop the general expression for the work done during a polytropic process. A piston cylinder device initially contains 0.07 m^3 nitrogen gas at 130 kPa and 120°C. The nitrogen is now expanded to a pressure of 100 kPa poly-tropically with a polytropic exponent of 1.4. Determine the final temperature and boundary work done during this process. Take R = 0.2968 kJ/kg/K. **06**

b Write the energy balance equation for any kind of system undergoing any kind of process (i) in the rate form (ii) on the unit mass basis & (iii) for a closed system undergoing a cycle and explain the **06**

terms involved in the equation.

OR

	c	A 0.5 m^3 rigid tank contains refrigerant-134a initially at 160 kPa and 40% quality. Heat is now transferred to the refrigerant until the pressure reaches 700 kPa. Determine the mass of the refrigerant in the tank.	06
3.	a	What is the conservation of mass principle? Stating all assumptions and explaining the terms involved in it, derive the general relation for conservation of mass for a fixed control volume: $\frac{d}{dt}\int_{CV}\rho\, dV + \int_{CS}\rho\,(\vec{V}.\vec{n}) = 0$	08
	b	Refrigerant R-134a at 800 kPa and 25°C is throttled to a temperature of - 20°C. Determine the pressure and internal energy of the refrigerant at the final state.	04
4.	a	Heat engines differ considerably from one another but which are their common characteristics? Internal combustion engines do not operate on a thermodynamic cycle, why they are included in the category of heat engines, Which is the ideal heat engine? Draw a schematic sketch of the *ideal heat engine* with all components. Represent and explain all energy interactions. Define and obtain the relation for thermal efficiency of the *ideal heat engine*.	06
	b	Which are the two statements known as the Carnot principles? A geothermal power plant uses geothermal water extracted at 160°C at a rate of 440 kg/s as the heat source and produces 22 MW of net power. If the environment temperature is 25°C, determine (a) the actual thermal efficiency	06

(b) the maximum possible thermal efficiency, and (c) the actual rate of heat rejection from this power plant. Use saturated liquid properties for water.

OR

c What is increase of entropy principle? Obtain the relation $\Delta S_{isolated} \geq 0$. **06**

5. a Refrigerant R-134a enters an adiabatic compressor as saturated vapour at 120 kPa and at a rate of $0.3\ m^3/min$ and exits at 1- MPa pressure. If the isentropic efficiency of the turbine is 80%, determine (a) the temperature of the refrigerant at the exit of the compressor (b) the power input in KW. **06**

OR

b The difference between the actual work and surrounding work is called as *Useful work*. In this context, briefly explain (i) Reversible work & (ii) Irreversibility and write their relations. A heat engine receives heat from a source at 1500 K at a rate of 700 kJ/s and it rejects the waste heat to a medium at 320 K. The measured power output of the heat engine is 320 kW, and the environment temperature is 25°C. Determine (i) the reversible power (ii) the rate of irreversibility and (iii) the second law efficiency of this heat engine. **06**

c With the help of T-s diagrams, explain the following methods used for improvement of efficiency of a power plant operating on a simple Rankine cycle (i) Lowering the condenser pressure & (ii) Increasing the boiler pressure. **06**

Government College of Engineering, Amravati

An Autonomous Institute of Government of Maharashtra)

Third Semester B. Tech. (Mechanical Engg.)

WINTER– 2015

rse Code: MEU 302

rse Name: ENGINEERING THERMODYNAMICS

: 2 Hrs. 30 Min. **Max. Marks: 60**

uctions to Candidate

1) All questions are compulsory.
2) Assume suitable data wherever necessary and clearly state the assumptions made.
3) Diagrams/sketches should be given wherever necessary.
4) Use of logarithmic table, drawing instruments and non-programmable calculators is permitted.
5) Figures to the right indicate full marks.
6) Use of steam tables, Mollier charts, compressibility charts, generalized enthalpy & entropy chart, etc is permitted.

1. a) Recognize whether the following quantities are properties or non-properties: 3
   (i) pdv + vdp
   (ii) pdv &
   (iii) vdp

   b) Derive the relation $pv^{\square} = C$ for a reversible adiabatic process 6

   c) Evaluate the temperature at which the Fahrenheit and Celcius scales agrees. 3

OR

d) Two Celsius thermometers A and B with temperature readings T_A and T_B agree at ice point and steam point, but else where they are related by $T_A = p + q * T_B + r * T_B^2$, *where p, q and r are constants.* When the thermometers are immersed in an oil bath, thermometers A shows a temperature of $51^\circ C$ while B shows $50^\circ C$. Determine the temperature T_A, *when* T_B *is* $50^\circ C$. 3

a) Derive an expression for heat transfer of a system during a polytropic expansion process. 5

b) Explain the following terms: 4

(i) First law for a cyclic heat engine

(ii) First law for a thermodynamic process

(iii) State function &

(iv) Latent heat of fusion

c) Find the internal energy per unit mass of steam at a pressure of *10 bar*, when the steam is superheated with $50^\circ C$ degree of superheat. The specific heat of superheated steam is *2.01 kJ/kg-K*. 3

Use only the following property table-

Pressure (bar)	Temp. (°C)	Specific volume (m^3/kg)	
		Liquid	*Sat. vapor*
10	179.91	0.001127	0.19444
		Specific enthalpy (kJ/kg)	
		Liquid	*Sat. vapor*
		762.81	2777.10
		Specific entropy (kJ/kg-K)	
		Liquid	*Sat. vapor*
		2.1386	6.5864

OR

d) Water at a rate of 10 kg/s is compressed adiabatically from 5 bar to 50 bar in a steady flow process. Calculate the power required, assuming 3

that the specific volume of water to be 0.001 m^3/kg, which remains constant. Neglect K.E & P.E.

3. a) Prove the equivalence of Kelvin-Planck and Clausius statements. 4

b) Define and discuss the following with at least two suitable examples: 2
   (i) non-flow process
   (ii) steady-flow process

c) A novel reversible heat engine plot on a *T-s* diagram is a circle. The maximum and minimum temperatures are *1100 K and 200 K* respectively. The maximum entropy change in the cycle is 2 kJ/K. Evaluate the heat added to the cycle, heat rejected, work done and thermal efficiency of the cycle. 6

4. a) Derive an expression of air-standard efficiency and mean effective pressure for Otto-cycle with neat p-v and T-s plots. 6

OR

b) Define irreversibility. Show that irreversibility of a process is given by the product of temperature of surrounding and the net entropy change. 6

c) A mixed-fuel-cycle is proposed to work for following thermodynamic conditions: 6
Working fluid is sucked at 1 bar, 27°C. The isentropic compression reduces the volume of air from 0.07 m^3 to 0.004 m^3. Constant pressure heat addition raise the temperature of air from 1433 K to 1873 K. Evaluate: ρ, r, $\eta_{thermal}$ & *mep*.
Also give reasons if thermal efficiency is found to be high.

) What is meant by availability? Setup expressions for availabilities of a closed system and a steady flow open system. 6

OR

) Describe the methods adopted for improving the performance of the Rankine cycle. 6

c) The boiler produces dry and saturated steam at 30 bar. The steam expands in the turbine to a condenser pressure of 20 kPa. Compare the cyclic work done and thermal efficiency of the Carnot and Rankine cycle for these conditions. Also draw T-s plots for these cycles. *Use only the following property table-* 6

Pressure	Temp. (°C)	Specific volume (m^3/kg)	
		v_f	v_g
20 kPa	60.06	0.001017	7.649
		Specific enthalpy	
		h_f	h_{fg}
		251.38	2358.33
		Specific entropy	
		s_f	s_{fg}
		0.8319	7.0766
30 bar	233.9	Specific enthalpy	
		h_f	h_g
		1008.42	2804.2
		Specific entropy	
		s_f	s_g
		2.6457	6.1869

Government College of Engineering, Amravati
(An Autonomous Institute of Government of Maharashtra)

Third Semester B. Tech. (Mechanical Engineering)

Winter – 2013

Course Code: MEU 302

Course Name: Engineering Thermodynamics

Time: 2 hour 30 minutes **Max. Marks: 60**

Instructions to Candidate

1) All questions are compulsory.
2) Assume suitable data wherever necessary and clearly state the assumptions made.
3) Diagrams/Sketches should be given wherever necessary.
4) Use of Steam Tables and Properties of Air Tables and non-programmable calculators is permitted.
5) Figures to the right indicate full marks.

1.	**(a)**	Establish that energy is a property of the system. Explain the mechanisms of Energy Transfer, such as (i) Heat Transfer (ii) Work Transfer & (iii) Mass Flow.	**06**
	(b)	A 80 m^3 vessel contains 4 kg of refrigerant – 134a at a pressure of 160 kPa. Determine (i) the temperature of refrigerant (ii) the quality (iii) the enthalpy of the refrigerant, and (iv) the volume occupied by the vapor phase.	**06**
2.	**(a)**	Apply the steady flow energy equation to (i) Nozzle and (ii) Throttle Valve.	**03**

(b) Steam at 5 MPa and 400°C enters a nozzle steadily with a velocity of 80 m/s, and it leaves at 2 MPa and 300°C. The inlet area of the nozzle is 50 cm2, and heat is being lost at a rate of 120 kJ/s. Determine (*a*) the mass flow rate of the steam, (*b*) the exit velocity of the steam, and (*c*) the exit area of the nozzle. **09**

3. (a) Establish the first Carnot Principle that the efficiency of an irreversible heat engine is always less than the efficiency of a reversible heat engine operating between the same two reservoirs. **06**

(b) What are the implications of the equation $S_2 - S_1 \geq \frac{\delta Q}{T}$ in thermodynamics? What is the significance of inequality sign in this equation? For which type of processes the equality sign will hold and why? **06**

4. Steam enters an adiabatic turbine at 7 MPa, 600°C, and 80 m/s and leaves at 50 kPa, 150°C, and 140 m/s. If the power output of the turbine is 6 MW, determine (*a*) the mass flow rate of the steam flowing through the turbine and (*b*) the isentropic efficiency of the turbine. **12**

5. (a) What is (i) Useful Work (ii) Reversible Work and (iii) Irreversibility? Obtain the expression for Useful Work and Irreversibility and define the relevant terms. **06**

(b) A heat engine receives heat from a source at 1500 K at a rate of 700 kJ/s, and it rejects the waste heat to a medium at 320 K. The measured power output of the heat engine is 320 kW, and the environment temperature is 25°C. Determine (*a*) the reversible power, (*b*) the rate of irreversibility, **06**

and (*c*) the second-law efficiency of this heat engine.

OR

5. **(c)** Define (a) Compression ratio (b) expansion ratio & (c) Cut-off ratio, with respect to the Diesel cycle. What is the effect of compression ratio on the efficiency of the Diesel cycle? **06**

(d) Using a T-s diagram, discuss how the efficiency of a Rankine cycle can be improved by (a) Lowering the condenser pressure & (b) Increasing the Boiler Pressure. Discuss the relative merits and demerits of these suggested changes. **06**