

JK LAKSHMIPAT UNIVERSITY, JAIPUR

INSTITUTE OF ENGINEERING AND TECHNOLOGY

End Term Examination (Regular), Nov.-Dec. 2015

B. Tech. in Mechanical Engineering, Semester III

Roll No.....

ME 301: ENGINEERING THERMODYNAMICS

Time: 3 hours

Max. Marks: 100

Instructions to students:

1. Do not write anything other than your roll number on question paper.
2. Assume suitable data wherever required and mention it clearly.
3. Writing appropriate units, nomenclature, and drawing neat sketches/schematics/ flow chart wherever, required are an integral part of the answer.
4. Steam table and H-S chart are permitted.
5. Scientific Calculator without programming of any type is allowed.

Q.1A Objective type multiple choice questions (10 questions @ 1 mark)

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- i. A system plus its environment constitutes; (a) an adiabatic system (b) a closed system (c) an isolated system (d) a segregated system (e) a homogenous system
- ii. Adiabatic volume expansion is associated with; (a) decrease in P and T (b) increase in both P and T (c) decrease in P but increase in T (d) increase in P but decrease in T.
- iii. A gas is enclosed in a cylinder by a piston. Work output will be available from the system (if there is no energy interaction) only at the expense of the internal energy and that process will be; (a) isobaric (b) polytropic (c) isothermal (d) adiabatic
- iv. For an isochoric process; (a) there occurs no transfer of mass and energy across the system boundary (b) the product of pressure and volume remains essentially constant (c) free expansion takes place (d) work output from the system is zero.
- v. The efficiency of a Carnot heat engine will be 100% if; (a) it operates at an infinitely high speed (b) it operates with a perfect gas as the working fluid (c) its working fluid is a pure substance (d) if its sink temperature is 0 K while the source is at any finite temperature (e) if its sink is at 0°C and the source at 1000 K
- vi. The change in entropy for any natural process would be; (a) zero (b) negative (c) positive (d) infinite
- vii. Identify the correct option. (a) Work is entropy free (b) No entropy is transferred by work (c) Energy is transferred by both heat and work (d) Entropy is transferred only by heat (e) All are true.
- viii. Tick the correct option; (a) The loss of available energy is less at 1500 K than at 300 K (b) The loss of available energy is more at 1500 K than at 300 K (c) The loss of available energy at 1500 K is five times that at 300 K (d) None of the above
- ix. In a throttling calorimeter, throttling of wet steam is carried out to convert the steam into a; (a) sub-cooled liquid (b) dry saturated vapour (c) condensate (d) superheated steam
- x. The work done by steam in a steam turbine is the change of; (a) enthalpy of the steam at the inlet and outlet conditions (b) entropy of the steam at the inlet and

outlet conditions (c) internal energy of the steam at the inlet and outlet conditions (d) none of the above

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| Q.2 | Short answer type questions (4 questions @ 2.5 marks) | 10 |
| i. | What do you mean by a steady-flow process? | |
| ii. | Define specific heat at constant volume and specific heat at constant pressure. | |
| iii. | Can you describe an imaginary process that satisfies the first law but violates the second law? | |
| iv. | What do you understand by the terms "degree of superheat" and "degree of subcooling"? | |
| Q.3A | Discuss the salient features of a free expansion process. | 05 |
| Q.3B | 0.5 kg of an ideal gas expands adiabatically until its pressure is halved. During expansion, the gas does 30 kJ of external work and its temperature falls from 500 K to 400 K. Make calculations for the adiabatic exponent and the characteristic gas constant. | 05 |
| Q.4A | Explain the perpetual motion machine of first kind. | 05 |
| Q.4B | A centrifugal pump delivers 2750 kg of water per minute from initial pressure of 0.8 bar absolute to a final pressure of 2.8 bar absolute. The suction is 2 m below and the delivery is 5 m above the center of pump. If the suction and delivery pipes are of 15 cm and 10 cm diameter respectively, make calculations for the power required to run the pump. | 05 |
| Q.5A | What is a throttling process? Point out its salient aspects. | 05 |
| Q.5B | An inventor claims to have developed an engine that operates between a source at 450 K and a sink at 280 K, and is capable of delivering 0.15 kWh of work for every 1200 kJ of heat received. As a patent officer, would you issue a patent for such an engine? | 05 |
| Q.6A | What are Helmholtz function and Gibb's function? | 05 |
| Q.6B | In the absence of any friction and other irreversibilities, can a heat engine have an efficiency of 100 percent? Explain. | 05 |
| | OR | |
| Q.6B | Derive the expression for the "availability of a non-flow or closed system". | 05 |
| Q.7A | Derive an expression for the efficiency of a Carnot cycle. | 05 |
| Q.7B | 0.2 kg of air initially at 575 K temperature receives 300 kJ of heat reversibly at constant pressure. Determine the available and unavailable energies of the heat added. Take C_p for air = 1.005 kJ/kg K and temperature of surroundings 300 K. | 05 |
| | OR | |
| Q.7B | Establish the inequality of Clausius. | 05 |
| Q.8 | Determine the enthalpy, volume, internal energy and entropy of superheated steam at 15 bar pressure and 220° C. The volume of water may be neglected and take specific heat of superheat equal to 2.2 kJ/kg K. | 10 |

Steam at an absolute pressure of 10 bar and 250°C expands isentropically in a steam turbine till the pressure drops to 1 bar. Estimate the quality of steam leaving the turbine and work developed by turbine per kg of steam. If the actual drop is 90% of isentropic drop and steam flow rate through the turbine is 500 kg/min, determine the power developed by the turbine. Use Mollier chart.

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- Q.10 A gas initially at 1.5 bar pressure, 0.15 m^3 volume and 300 K was compressed polytropically ($p v^{1.25} = \text{constant}$) to 15 bar pressure. Determine the change in entropy. Also calculate the work done on the gas during this compression process. Take $C_p = 1.04\text{ kJ/kg K}$ and $C_v = 0.745\text{ kJ/kg K}$.

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OR

- Q.10 A steam turbine operates under steady flow conditions receiving steam at the following state: pressure 15 bar; internal energy 2700 kJ/kg ; specific volume $0.17\text{ m}^3/\text{kg}$ and velocity 100 m/s . The exhaust of steam from the turbine is at 0.1 bar with internal energy 2175 kJ/kg , specific volume $15\text{ m}^3/\text{kg}$ and velocity 300 m/s . The intake is 2.5 meters above the exhaust. The turbine develops 30 kW and heat loss over the surface of turbine is 25 kJ/kg . Determine the steam flow rate through the turbine.

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