Code No RT21033 **R13** SET - 1

II B. Tech I Semester Supplementary Examinations, June - 2015
THERMODYNAMICS
(Com. to ME, AE, AME)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B)**
2. Answer **ALL** the question in **Part-A**
3. Answer any **THREE** Questions from **Part-B**

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PART-A

1. a) What do you understand by macroscopic and microscopic viewpoints?
   b) Define the specific heats at constant volume and constant pressure.
   c) State Kelvin-Planck and Clausius' statement of second law.
   d) What is pure substance? Draw PV diagram for a pure substance.
   e) Explain the terms Dry bulb temperature and Wet bulb temperature.
   f) State the four processes of Diesel Cycle? (4M+4M+4M+4M+3M+3M)

PART-B

2. a) The following data refer to 12-cylinder, single-acting, two-stroke marine diesel engine:
   Speed= 150 rpm, Cylinder diameter = 0.8 m, Stroke of piston = 1.2 m
   Area of indicator diagram = 5.5 x 10^{-4} m^2, Length of diagram=0.06m
   Spring value= 147 Mpa per m
   Find the net rate of work transfer from the gas to the pistons in kW.
   b) With the help of neat sketch explain the working of constant pressure gas thermometer. (8M+8M)

3. a) A stationary mass of gas is compressed without friction from an initial state of 0.3 m^3 and 0.105 MPa to a final state of 0.15 m^3 and 0.105 MPa, the pressure remaining constant during the process. There is a transfer of 37.6 kJ of heat from the gas during the process. How much does the internal energy of the gas change?
   b) Derive the steady flow energy equation of an open system (8M+8M)
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4. a) A cyclic heat engine operates between a source temperature of 800 ^oC and a sink temperature of 30^oC. What is the least rate of heat rejection per kW net output of the engine?
   b) Establish the equivalence of Kelvin Planck and Clausius Statements (8M+8M)

5. a) A vessel of volume 0.04 m^3 contains a mixture of saturated water and saturated steam at a temperature of 250^oC. The mass of the liquid present is 9 kg. Find the pressure, mass, specific volume, enthalpy, the entropy and the internal energy.
   b) Steam initially at 1.5 MPa, 300 ^oC expands reversibly and adiabatically in a steam turbine to 40 ^oC. Determine the ideal work output of turbine per kg of steam. (8M+8M)

6. a) Derive the expression for an entropy change of an Ideal gas
   b) Explain the Psychrometric process
   i) Sensible heating and Cooling
   ii) Cooling and dehumidification (8M+8M)

7. a) An engine working on the Otto cycle is supplied with air at 0.1 MPa, 35 ^oC. The compression ratio is 8. Heat supplied is 2100 kJ/kg. Calculate the maximum pressure and temperature of the cycle, the cycle efficiency, and the mean effective pressure. (For air, $C_p = 1.005$, $C_v = 0.718$, and $R = 0.287$ kJ/kg K).
   b) With a neat sketch explain the working of simple vapour compressing refrigeration cycle and derive the expression for cop (8M+8M)

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2. Answer **ALL** the question in **Part-A**
3. Answer any **THREE** Questions from **Part-B**

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PART-A

1. a) What is the difference between closed system and open system? Give example
   b) State the first law for a closed system undergoing a cycle.
   c) Define what is refrigerator and heat pump?
   d) What do you understand by triple point?
   e) Explain the terms Specific humidity and relative humidity.
   f) What is an air standard cycle? Explain any one cycle

(4M+4M+4M+4M+3M+3M)

PART-B

2. a) A cooling tower nozzle disperses water into a stream of droplets. If the average diameter of the droplets is 60 microns, estimate the work required for atomizing 1 kg of water isothermally at the ambient conditions. Given; surface tension of water in contact with air = 0.07 N/m, density of water = 1000 kg/m^3. Water is assumed to enter the nozzle through a pipe of 15 mm diameter.
   b) Why does free expansion have zero work transfer? Explain (8M+8M)

3. a) 1.5 kg of liquid having a constant specific heat of 2.5 kJ/kg K is stirred in a well-insulated chamber causing the temperature to rise by 15°C. Find ΔE and W for the process.
   b) In a steam power station, steam flows steadily through a 0.2 m diameter pipeline from the boiler to the turbine. At the boiler end, the steam conditions are found to be: p = 4 MPa, t = 400°C, h = 3213.6 kJ/kg, and v = 0.073 m^3/kg. At the turbine end, the conditions are found to be: p = 3.5 MPa, t = 392°C, h = 3202.6 kJ/kg, and v = 0.084 m^3/kg. There is a heat loss of 8.5 kJ/kg from the pipeline. Calculate the steam flow rate. (8M+8M)
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4. a) Explain about absolute thermodynamic temperature scales.
   b) A reversible power cycle R and an irreversible power cycle I operate between the same two reservoirs. Each receives Q_H from the hot reservoir. The reversible cycle develops work W_R while the irreversible cycle develops work W_I. i) Evaluate the rate of entropy generation σ for cycle I in terms of W_I, W_R and the temperature T_C of the cold reservoir. ii) Demonstrate that σ must be positive. (8M+8M)

5. a) A large insulted vessel is divided into two chambers, one containing 5 Kg of dry saturated steam at 0.2 MPa and the other 10 kg of steam, 0.8 quality at 5 Mpa. If the partition between the chamber is removed and the steam is mixed thoroughly and allowed to settle. Find the final pressure, steam quality and entropy change in the process
   b) A steam boiler initially contains 5 m^3 of steam and 5 m^3 of water at 1 MPa. Steam is taken out at constant pressure until 4 m^3 of water is left. What is the heat transferred during the process. (8M+8M)

6. a) Explain the Psychrometric process
   i) Adiabatic mixing of two streams
   ii) Adiabatic Evaporative cooling

   b) An ideal gas of molecular weight 30 and γ =1.3 occupies a volume of 1.5 m^3 at 100kPa and 77^0C. The gas is compressed according to the law $PV^{1.25}$ =Const. to a pressure of 3 MPa. Calculate the volume and temp at the end of compression and heating, work done, heat transferred and total change of entropy (8M+8M)

7. a) In air standard Diesel cycle, the compression ratio is 16, and at the beginning of isentropic compression, the temperature is 15 °C and the pressure is 0.1 MPa. Heat is added until the temperature at the end of the constant pressure process is 1480 °C. Calculate: (i) the cut off ratio, (ii) the heat supplied per kg of air, (iii) the cycle efficiency, and (iv) the m.e.p.
   b) With a neat sketch explain the working of Belt Coleman cycle (8M+8M)

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2. Answer **ALL** the question in **Part-A**
3. Answer any **THREE** Questions from **Part-B**

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PART-A

1. a) What are intensive and extensive properties?
   b) Define enthalpy. Why the enthalpy of an ideal gas does depends only on temperature?
   c) Define what is Irreversibility? State the Causes of Irreversibility?
   d) What is pure substance? Draw PV diagram for a pure substance.
   e) Explain Gibbs and Helm holtz functions
   f) Why is air refrigeration cycle preferred in aircraft? (4M+4M+4M+4M+3M+3M)

PART-B

2. a) An electric motor drives a stirrer filted with a horizontal cylinder. The cylinder of 40 cm diameter contains a fluid restrained by a frictionless piston. During the stirring of fluid for 15 min the piston moves outward slowly by a distance of 30 cm against the atmospheric pressure of 1 bar. The current supplied to the motor is 0.5 amp. From a 24-V lead-acid accumulator. If the conversion efficiency from electrical work to mechanical work output is 90%, estimate the work done on the motor, stirrer and the atmosphere.
   b) A piston cylinder device with air at an initial temperature of 30°C undergoes an expansion process for which pressure and volume are related as below:

p (kPa)	100	37.9	14.4
V (m^3)	0.1	0.2	0.4

   Calculate the work done by the system. (8M+8M)

3. a) What is generalized compressibility chart? Explain
   b) In steady flow apparatus, 135 kJ of work is done by each kg of fluid. The specific volume of the fluid, pressure, and velocity at the inlet are 0.37 m^3/kg, 600 kPa, and 16 m/s. The inlet is 32 m above the floor, and the discharge pipe is at floor level. The discharge conditions are 0.62 m^3/kg, 100 kPa and 270 m/s. The total heat loss between the inlet and discharge is 9 kJ/kg of fluid. In flowing through the apparatus, does the specific internal energy increase or decrease, and by how much? (8M+8M)
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4. a) Show that the efficiency of all reversible engines operating between the same temperature levels is the same.
   b) Which is the more effective way to increase the efficiency of a control engine
   i) To increase T_1 keeping T_2 constant
   ii) To decrease T_2 keeping T_1 constant
   where T_1 and T_2 are source and sink temperatures (8M+8M)

5. a) Draw the phase equilibrium diagram for a pure substance h-s and T-s plots with relevant constant property line and explain the plots
   b) Steam flows in a pipeline at 1.5 Mpa. After expanding to 0.1 MPa in a throttling calorimeter, the temperature is found to be 120 ^oC. Find the quality of steam in the pipeline. What is the maximum moisture at 1.5 MPa that can determined with this setup if at least 5^oC of superheat is required after throttling for accurate readings? (8M+8M)

6. a) An air conditioning system is designed under following conditions.
   Outdoor conditions : 30^{0}C dbt,75% RH
   Requried indoor conditions: 22^{0}C dbt,70% RH
   8/
   Amount of free air circulated : 3.33 m^3/s
   Coil dew point temperature : 14^{0}C
   The requried condition is achieved first by cooling and dehumidification and then by heating. Estimate a) the capacity of cooling coil in tones. b) capacity of heating coil in kW. c) amount of water vapour removed in kg/s.
   b) A mass of 0.25 kg of an ideal gas has a pressure of 300 kPa, a temperature of 80 ^oC, and a volume of 0.07 m^3. The gas undergoes an irreversible adiabatic process to a final pressure of 300 kPa and final volume of 0.10 m^3, during which the work done on the gas is 25 kJ. Evaluate the C_p and C_v of the gas and the increase in entropy of the gas. (8M+8M)

7. a) An air standard dual cycle has a compression ratio of 16, and compression begins at 1 bar, 50 ^oC. The maximum pressure is 70 bar. The heat transferred to air constant pressure is equal to that at constant volume. Estimate (i) the pressures and temperature at the cardinal points of the cycle, (ii) the cycle efficiency, and (iii) the m.e.p. of the cycle,
   C_v = 0.718 kJ/kg K, C_p = 1.005 kJ/kg K.
   b) with a neat sketch explain working of sterling cycle and derive the expression for its thermal efficiency (8M+8M)

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2. Answer **ALL** the question in **Part-A**
3. Answer any **THREE** Questions from **Part-B**

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PART-A

1. a) Distinguish between terms Change of 'state', 'path', and 'process'?
   b) Define the following terms:
      i) Throttling process ii) Heat Exchangers
   c) Define what is Reversibility? State the conditions for Reversibility?
   d) What do you understand by triple point?
   e) Define an ideal gas. What is universal gas constant?
   f) Under what conditions does steady flow energy equation reduce to Euler's equation?

(4M+4M+4M+4M+3M+3M)

PART-B

2. a) What do you understand by Ideal gas temperature scale?
   b) It is required to melt 5 tonnes/h of iron from a charge at 15 °C to molten metal at 1650 °C. The melting point is 1535 °C, and the latent heat is 270 kJ/kg. The specific heat in solid state is 0.502 and in liquid state (29.93/atomic weight) kJ/kg K. If an electric furnace has 70% efficiency, find the kW rating needed. If the density in molten state is 6900 kg/m^3 and the bath volume is three times the hourly melting rate, find the dimensions of the cylindrical furnace if the length to diameter ratio is 2. The atomic weight of iron is 56. (8M+8M)

3. a) A fluid contained in a cylinder receives 150 kJ of mechanical energy by means of paddlewheel, together with 50 kJ in the form of heat. At the same time, a piston in the cylinder moves in such a way that the pressure remains constant at 200 kN/m^2 during the fluid expansion from 2 m^3 to 5 m^3. What is the change in internal energy, and in enthalpy?
   b)Write the steady flow energy equation for an open system, explain all the terms and apply the equation to i) turbine ii) Heat exchanger ii) Nozzle

(8M+8M)
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4. a) Derive the expression for maximum work obtainable from two finite bodies at temperature T_1 and T_2
   b) A fluid undergoes a reversible adiabatic compression from 0.5 MPa, 0.2 m^3 to 0.05 m^3 according to the law, $pv^{1.3}$ = constant. Determine the change in enthalpy, internal energy and entropy, and the heat transfer and work transfer during the process. (8M+8M)

5. a) Steam initially at 0.3MPa, 250 ^oC is cooled at constant volume. At what temperature will the steam become saturated vapour? What is the quality at 80 ^oC? What is the heat transferred per kg of steam in cooling from 250 ^oC to 80 ^oC.
   b) With a neat sketch explain the working of Throttling Calorimeter (8M+8M)

6. a) Draw the Psychrometric chart and indicate all the property line. Explain the importance of Psychrometric chart
   b) State and prove Daltons law of partial pressures and Avogadro’s law of additive volumes (8M+8M)

7. a) Explain the working of an Otto cycle and derive the expression for thermal efficiency
   b) In an ideal Brayton cycle, air from the atmosphere at 1 atm, 300 K is compressed to 6 atm and the maximum cycle temperature is limited 1100 K by using a large air fuel ratio. If the heat supply is 100 MW, find (i) the thermal efficiency of the cycle (ii) work ratio, (iii) power output, (iv) energy flow rate of the exhaust gas leaving the turbine. (8M+8M)