# B.Tech/ME/3rd Sem/MECH-2101/2015

## 2015

## APPLIED THERMODYNAMICS

## (MECH 2101)

*Time Alloted : 3 Hours* *Full Marks : 70*

***Figures out of the right margin indicate full marks.***

***Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.***

***Candidates are required to give answer in their own words as far as practicable***

### GROUP - A

**(Multiple Choice Type Questions)**

1. Choose the correct alternatives for the following : **[10×1=10]**

   i) For a control mass surrounded by an adiabatic wall
   (a) entropy change > entropy generation
   (b) entropy change < entropy generation
   (c) entropy change = entropy generation
   (d) none of these

   ii) In the Ideal Rankine cycle, the steam that enters the condenser leaves as a
   (a) liquid vapour mixture (b) saturated liquid
   (c) sub cooled liquid (d) superheated vapour





   iii) The infinitesimal and reversible work interaction in a steady flow process with no change in KE and PE is equal to
   (a) pdv (b) –pdv
   (c) vdp (d) –vdp

   iv) The value of Joule Thomson co-efficient for an ideal gas is
   (a) positive
   (b) negative
   (c) zero
   (d) can be positive or negative

   v) For the same compression ratio ($r_k$) & same heat rejection ($Q_2$)
   (a) $\eta_{Diesel} > \eta_{Dual} > \eta_{Otto}$ (b) $\eta_{Diesel} < \eta_{Dual} < \eta_{Otto}$
   (c) $\eta_{Diesel} = \eta_{Dual} = \eta_{Otto}$ (d) none of the above

   vi) The efficiency of a reversible cycle depends on
   (a) nature of the working substance
   (b) amount of the working substance
   (c) type of the cycle followed
   (d) temperatures of the two reservoirs between which the cycle is operated

   vii) Reheat cycles are used in vapour power plants mainly
   (a) for increasing the efficiency
   (b) for increasing the dryness fraction at the turbine exit
   (c) both (a) and (b)
   (d) none of these

viii) In comparison with the slopes of constant pressure lines in T-s plot of an ideal gas, the slopes of constant volume lines are

(a) more (b) less
(c) equal (d) unpredictable

ix) _____ is not an extensive property

(a) Volume (b) Energy
(c) Entropy (d) Pressure

x) In a vapour compression refrigeration system, the working fluid is superheated vapour at the entrance to

(a) evaporator (b) condenser
(c) compressor (d) expansion valve

## GROUP - B

2. (a) An engine cylinder has a piston area 0.15 $m^2$ and contains gas at a pressure of 1.5 MPa. The gas expands according to a process which is represented by a straight line on a pressure volume diagram. The final pressure is 0.15 MPa. Calculate the work done by the gas on the piston if the stroke is 0.30 m.

(b) A blower handles 1 kg/s of air at 20°C and consumes a power of 15 kW. The inlet and outlet velocities of air are 100 m/s and 150 m/s respectively. Find the exit air temperature assuming adiabatic conditions. Take $c_p$ of air 1.005 kJ/kg-K. **6+6 = 12**

3. (a) A domestic refrigerator is loaded with food and the door closed. During a certain period, the machine consumes 1 kWh of energy and the internal energy of the system drops by 5000 kJ. Find the net heat transfer for the system.

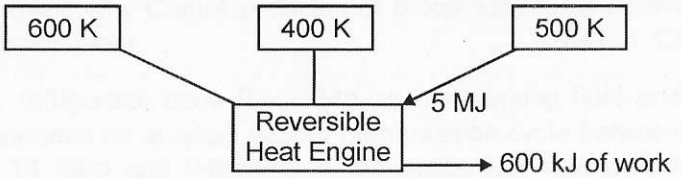




(b) A 750-L rigid tank initially contains water at 250°C, which is 50% saturated liquid and 50% saturated vapour, by volume. A small pipe connected at the top has a valve which is opened and saturated vapour is slowly withdrawn. Heat transfer takes place such that the temperature inside the tank remains constant at 250°C. Find the amount of heat transfer required to reach a stage where half the original mass is withdrawn. **4+8 = 12**

## GROUP - C

4. (a) A reversible heat engine, as shown in the figure draws 5 MJ heat from the 500 K reservoir and does 600 kJ of work, in a cyclic operation. Find the quantity and direction of heat interactions from the other two reservoirs.




(b) A system maintained at constant volume is initially at temperature $T_1$, and a constant temperature heat reservoir at the lower temperature $T_0$ is available. Show that the maximum work recoverable as the system is cooled to $T_0$ is $W = C_v [(T_1 - T_0) - T_0 \ln (T_1/T_0)]$; $C_v$ is the specific heat capacity at constant volume. **6+6 = 12**

5. (a) Show that if two bodies of heat capacities $C_1$ and $C_2$ at temperatures $T_1$ and $T_2$ are brought to a temperature T by means of a reversible heat engine, then
$\ln T = (C_1 \ln T_1 + C_2 \ln T_2) (C_1 + C_2)$

(b) A block of iron weighing 200 kg and having a tempeature of 100°C is immersed in 100 kg of water at a temperature of 20°C. What will be the change of entropy of the combined system of iron and water? Specific heats of iron and water are 0.45 kJ/kg-K and 4.18 kJ/kg-K respectively. **6+6 = 12**

## Group - D

6. (a) Derive the expressions for the reversible work of compression with appropriate parameters if the compression process is
   (i) adiabatic
   (ii) polytropic
   (iii) isothermal

   (b) In an air standard diesel cycle, the compression ratio is 15. Compression begins at 0.1 MPa, 40°C. The heat added is 1.675 MJ/kg. Find
   (i) the maximum temperature of the cycle
   (ii) cut off ratio
   (iii) cycle efficiency
   (iv) the work done per kg of air.
   Given, $\gamma$ = 1.4, $c_p$ = 1.005 kJ/kg-K. **(2+1+2)+7 = 12**

7. (a) Show that the compression ratio for the maximum specific work output for an Otto cycle is given by $r_k = \left(\frac{T_{max}}{T_{min}}\right)^{\frac{1}{2(1-\gamma)}}$.
   Hence, show that the maximum specific work output is $c_v\left[\sqrt{T_{max}} - \sqrt{T_{min}}\right]^2$.

   (b) In an air standard Otto cycle, the compression ratio is 7, and compression begins at 33°C, 0.1 MPa. The maximum temperature of the cycle is 1127°C. Find





   (i) the cycle efficiency the temperature and pressure at the cardinal points
   (ii) the work done per kg of air.
   Use, $\gamma$ = 1.4, $c_v$ = 0.718 kJ/kg-K. **(4+3)+5 = 12**

## GROUP - E

8. (a) In a reheat cycle, the initial steam pressure and the maximum temperature are 150 bar and 550°C respectively. If the condenser pressure is 0.1 bar and the moisture in the condenser inlet is 5%, determine, assuming ideal process
   (i) the reheat pressure
   (ii) the cycle efficiency
   (iii) the steam rate

   (b) Explain why Carnot cycle is not practicable for a steam power plant. **8+4 = 12**

9. (a) A refrigerator uses R – 134a as the working fluid and operates on an ideal vapour compression cycle between 0.14 MPa and 0.8 MPa. If the mass flow rate of the refrigerant is 0.1 kg/s, determine
   (i) the rate of heat removal from the refrigerated space
   (ii) the power input
   (iii) COP.
   Given, at 0.14 MPa: $h_g$ = 236.04 kJ/kg, $s_g$ = 0.9322 kJ/kg-K; at 0.8 MPa: $h_f$ = 93.42 kJ/kg, enthalpy with s = 0.9322 kJ/kg-K is 272.05 kJ/kg;

   (b) Briefly explain the components of a vapour compression refrigeration plant. What is meant by one tonne of refrigeration? **6+4+2 = 12**

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