Name: **Enrolment No:**	UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2018

Course: Thermodynamics & Heat Engines **Semester: III**
Programme: B.Tech GSE/GIE/APE Up
Time: 03 hrs. **Max. Marks: 100**
Instructions: Answer all the questions of a section at a place. Assume the missing data reasonably.

SECTION A (4 x 5 = 20 Marks)

S. No.		Marks	CO
Q 1	What is free expansion? Justify the fact that free expansion is associated with zero work transfer.	**5**	**CO1**
Q 2	Prove that two reversible adiabatic paths cannot intersect each other.	**5**	**CO3**
Q 3	Draw phase equilibrium diagram on h-s and T-s coordinates, along with isobars.	**5**	**CO4**
Q 4	Describe Rankine cycle in detail with plots on T-s and P-v coordinate axes.	**5**	**CO5**

SECTION B (4 x 10 = 40 Marks)

Q 5	A system of volume V contains a mass m of gas at pressure p and temperature T. The macroscopic properties of the system obey the following relationship. $\left(p+\frac{a}{V^2}\right)(V-b)=mRT$, where a, b and R are constants. Obtain an expression for the displacement work done by the system during an isothermal expansion from volume V_1 to V_2. Calculate the work done by a system which contains 10 kg of this gas expanding from 1 m^3 to 10 m^3 at a temperature of 293 K. Use the values a = 157 Nm^4, b = 0.0107 m^3 and R = 0.278 kJ/kg-K.	**10**	**CO1**
Q 6	In a gas turbine, an ideal gas enters at the rate of 5 kg/s with a velocity of 50 m/s and enthalpy of 900 kJ/kg and leaves the turbine with a velocity of 150 m/s and enthalpy of 400 kJ/kg. The loss of heat from the gas to the surroundings is 25 kJ/kg. Assume for the gas, R = 0.285 kJ/kg-K and c_p = 1.004 kJ/kg-K and the inlet conditions to be at 100 kPa and 27^0C. Determine the power output of the turbine and the diameter of the inlet pipe.	**10**	**CO2**
Q 7	A heat engine operating between two reservoirs at 1000 K and 300 K is used to drive a heat pump which extracts heat from the reservoir at 300 K at a rate twice that at which the engine rejects heat to it. If the efficiency of the engine is 40% of the maximum possible and the COP of the heat pump is 50% of the maximum possible, what is the temperature of the reservoir to which the heat pump rejects heat? What is the rate of	**10**	**CO2**

	heat rejection from the heat pump if the rate of heat supply to the engine is 50 kW?		
Q 8	Derive an expression for the maximum work obtainable from a finite body (of heat capacity Cp and at a temperature 'T') and a thermal energy reservoir at a temperature T_0. Or 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.	**10**	**CO3**
	SECTION-C (2 x 20 = 40 Marks)		
Q 9	1 kg of steam in a closed system undergoes a thermodynamic cycle composed of the following reversible processes. 1 → 2: The steam initially at 10 bar and 40% quality is heated at constant volume until the pressure rises to 35 bar. 2 → 3: It is then expanded isothermally to 10 bar. 3 →1: It is finally cooled at constant pressure back to its initial state. Sketch the cycle on T-s coordinates, calculate the work done, heat transferred and the change of entropy for each of the three processes. What is the thermal efficiency of the cycle.	**20**	**CO4**
Q 10	(i) Explain the Diesel cycle, in detail, with the help of an indicator diagram. [10M] (ii) Derive an expression for the efficiency of Diesel cycle, clearly indicating all the terms used. [10M] Or An engine working on the Otto cycle has an air standard cycle efficiency of 56% and rejects 544 kJ/kg of air. The pressure and temperature of air at the beginning of compression are 0.1 MPa and 60^0C respectively. Compute (a) the compression ratio of the engine (b) the work done per kg of air (c) the pressure and temperature at all the cardinal points of the cycle.	**20**	**CO5**