Name: **Enrolment No:**	

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2018

Course: Thermodynamics and Heat Transfer Systems **Semester: I**

Program: M.Tech Energy Systems(EPEC7028)

Time: 03 hrs. **Max. Marks: 100**

Instructions:

SECTION A

S. No.		Marks	CO
Q 1	The temperature t on a thermometric scale is defined in terms of a property K by the relation t = a ln K + b. Where a and b are constants. The values of K are found to be 1.83 and 6.78 at the ice point and the steam point, the temperatures of which are assigned the numbers 0 and 100 respectively. Determine the temperature corresponding to a reading of K equal to 2.42 on the thermometer.	**4**	**CO1**
Q 2	The thermal conductivity of an insulating material used over a hot pipe varies as $k = 0.0545x(1+28.4\times10^{-4}T)$ where T is in °C and k is in W/mK. Insulation used for a thickness of 12 cm over a pipe of diameter 0.6 m. The pipe surface is at 300°C and the outside insulation temperature is 60°C. Determine the heat flow for a length of 5 m. Also find the mid layer temperature.	**4**	**CO1**
Q 3	The properties of a certain fluid are related as follows: u = 196 + 0.718t; pv = 0.287 (t + 273). Where u is the specific internal energy (kJ/kg), t is in °C, p is pressure (kN/ m^2), and v is specific volume (m^3/kg). For this fluid, Determine C_V and C_P.	**4**	**CO2**
Q 4	Heat is conducted through a material with a temperature gradient of – 9000 °C/m. The conductivity of the material is 25 W/mK. If this heat is convected to surroundings at 30°C with a convection coefficient of 345 W/m^2K, Determine the surface temperature. If the heat is radiated to the surroundings at 30°C determine the surface temperature.	**4**	**CO3**
Q 5	A single-cylinder, double-acting, reciprocating water pump has an indicator diagram which is a rectangle 0.075 m long and 0.05 m high. The indicator spring constant is 147 MPa per m. The pump runs at 50 rpm. The pump cylinder diameter is 0.15 m and the piston stroke is 0.20 m. Determine the rate in kW at which the piston does work on the water.	**4**	**CO2**

SECTION B

Q 6	A spherical container holding a cryogenic fluid at – 140°C and having an outer diameter of 0.4 m is insulated with three layers each of 50 mm thick insulations of $k_1 = 0.02$, $k_2 = 0.06$ and $k_3 = 0.16$ W/mK (starting from inside). The outside is exposed to air at 30°C with h = 15 W/m^2K. Determine the heat gain and the various surface temperatures.	**10**	**CO3**

Q 7	A mass of 8 kg gas expands within a flexible container so that the p–v relationship is of the from $pv^{1.2}$ = constant. The initial pressure is 1000 kPa and the initial volume is 1 m3. The final pressure is 5 kPa. If specific internal energy of the gas decreases by 40 kJ/kg, Determine the heat transfer in magnitude and direction.	**10**	**CO4**
Q 8	Discuss the classification of heat exchangers with diagram.	**10**	**CO3**
Q9	A single-cylinder, single-acting, 4 stroke engine of 0.15 m bore develops an indicated power of 4 kW when running at 216 rpm. Calculate the area of the indicator diagram that would be obtained with an indicator having a spring constant of 25×10^6 N/m^3. The length of the indicator diagram is 0.1 times the length of the stroke of the engine. (or) A six-cylinder, 4-stroke gasoline engine is run at a speed of 2520 RPM. The area of the indicator card of one cylinder is 2.45×10^3 mm^2 and its length is 58.5 mm. The spring constant is 20×10^6 N/m^3. The bore of the cylinders is 140 mm and the piston stroke is 150 mm. Determine the indicated power, assuming that each cylinder contributes an equal power.	**10**	**CO4**
SECTION-C			
Q 10	Determine the area required in parallel flow heat exchanger to cool oil from 60°C to 30°C using water available at 20°C. The outlet temperature of the water is 26°C. The rate of flow of oil is 10 kg/s. The specific heat of the oil is 2200 J/kg K. The overall heat transfer coefficient U = 300 W/m2 K. Compare the area required for a counter flow exchanger.	**20**	**CO5**
	(or)		
Q 10	A composite cylinder is made of 6 mm thick layers each of two materials of thermal conductivities of 30 W/m°C and 45 W/m°C. The inside is exposed to a fluid at 500°C with a convection coefficient of 40 W/m^2 °C and the outside is exposed to air at 35°C with a convection coefficient of 25 W/m^{2}K. There is a contact resistance of 1×10^{-3} m^2 °C/W between the layers. Determine the heat loss for a length of 2 m and the surface temperatures. Inside dia = 20 mm.	**20**	**CO5**
Q 11	A nozzle is a device for increasing the velocity of a steadily flowing stream. At the inlet to a certain nozzle, the enthalpy of the fluid passing is 3000 kJ/kg and the velocity is 60 m/s. At the discharge end, the enthalpy is 2762 kJ/kg. The nozzle is horizontal and there is negligible heat loss from it. (a) Determine the velocity at exists from the nozzle. (b) If the inlet area is 0.1 m^2 and the specific volume at inlet is 0.187 m^3/kg, Determine the mass flow rate. (c) If the specific volume at the nozzle exit is 0.498 m^3/kg, Determine the exit area of the nozzle.	**20**	**CO5**

Name: Enrolment No:	UPES

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End Semester Examination, December 2018

Course: Thermodynamics and Heat Transfer Systems **Semester: I**
Program: M.Tech ES(EPEC7028)
Time: 03 hrs. **Max. Marks: 100**
Instructions:

SECTION A

S. No.		Marks	CO
Q 1	Determine the heat flow across a plane wall of 10 cm thickness with a constant thermal conductivity of 8.5 W/mK when the surface temperatures are steady at 100°C and 30°C. The wall area is 3m^2. Also determine the temperature gradient in the flow direction.	**4**	**CO1**
Q 2	A new scale N of temperature is divided in such a way that the freezing point of ice is 100°N and the boiling point is 400°N. Determine the temperature reading on this new scale when the temperature is 150°C. Calculate the temperature where both the Celsius and the new temperature scale would be the same.	**4**	**CO1**
Q 3	An insulating wall 16 cm thick has one face at 600°C while the other is at 100°C. The thermal conductivity of the material is given by k = 0.078x(1 + 17.95 × 10–4 T) W/mK and T is in °C. Determine the heat loss per unit area and the mid plane temperature.	**4**	**CO2**
Q 4	A mass of 1.5 kg of air is compressed in a quasi-static process from 0.1 MPa to 0.7 MPa for which pv = constant. The initial density of air is 1.16 kg/m^3. Determine the work done by the piston to compress the air.	**4**	**CO2**
Q 5	Discuss and provide equations (1) Overall Heat Transfer Coefficient (2) effectiveness of fins and efficiency of fins (3) Critical thickness of insulation (4) Steady State Heat Conduction with Variable Heat Conductivity	**4**	**CO3**
	SECTION B		
Q 6	A steam turbine drives a ship's propeller through an 8:1 reduction gear. The average resisting torque imposed by the water on the propeller is 750 × 10^3 mN and the shaft power delivered by the turbine to the reduction gear is 15 MW. The turbine speed is 1450 rpm. Determine (a) the torque developed by the turbine, (b) the power delivered to the propeller shaft, and (c) the net rate of working of the reduction gear.	**10**	**CO4**
Q 7	Derive an expression for Logarithmic Mean Temperature Difference (LMTD) for counter flow heat exchanger stating the assumption made. (or) Define critical radius of insulation. Derive critical radius of insulation for cylinders and spheres.	**10**	**CO3**
Q 8	A gas flows steadily through a rotary compressor. The gas enters the compressor at a temperature of 16°C, a pressure of 100 kPa, and an enthalpy of 391.2 kJ/kg. The gas leaves the compressor at a temperature of 245°C, a pressure of 0.6 MPa, and an	**10**	**CO3**

	enthalpy of 534.5 kJ/kg. There is no heat transfer to or from the gas as it flows through the compressor. (a) Evaluate the external work done per unit mass of gas assuming the gas velocities at entry and exit to be negligible. (b) Evaluate the external work done per unit mass of gas when the gas velocity at entry is 80 m/s and that at exit is 160 m/s.		
Q 9	In a refinery fuel oil is to be cooled from 100°C to 40°C by water at 25°C flowing on the outside of the tube. The inner diameter is 25 mm and the oil flow rate is 1 kg/s. Water is heated to 45°C. The tube is made of 0.5 % carbon steel of thickness 3 mm. The inner diameter of the outer pipe is 62.5 mm. The outside may be considered as insulated. The properties of oil at 70°C are: density = 858 kg/m3, kinematic viscosity v = 60×10^{-6} m/s. k = 0.140 W/mK, specific heat = 2100 J/kg K. Determine the overall heat transfer coefficient. Consider good performance even after fairly long usage. Tube material k = 53.6 W/mK.	**10**	**CO4**
SECTION-C			
Q 10	A spherical vessel of ID 0.3 m and thickness of 20 mm is made of steel with conductivity of 40 W/mK. The vessel is insulated with two layers of 60 mm thickness of conductivity 0.05 and 0.15 W/mK. The inside surface is at – 196°C. The outside is exposed to air at 30°C with convection coefficient of 35 W/m2K. There is a contact resistance of 1 × 10–3 m2°C/W between the two insulations. Determine the heat gain and also the surface temperatures and the overall heat transfer coefficient based on the outside surface area of the metallic vessel. (or) A furnace wall is of three layers, first layer of insulation brick of 12 cm thickness of conductivity 0.6 W/mK. The face is exposed to gases at 870°C with a convection coefficient of 110 W/m^2K. This layer is backed by a 10 cm layer of firebrick of conductivity 0.8 W/mK. There is a contact resistance between the layers of 2.6×10^{-4} m^2°C/W. The third layer is the plate backing of 10 mm thickness of conductivity 49 W/ mK. The contact resistance between the second and third layers is 1.5×10^{-4} m^2°C/W. The plate is exposed to air at 30°C with a convection coefficient of 15 W/m^2K. Determine the heat flow, the surface temperatures and the overall heat transfer coefficient.	**20**	**CO5**
Q 11	Air flows steadily at the rate of 0.4 kg/s through an air compressor, entering at 6 m/s with a pressure of 1 bar and a specific volume of 0.85 m^3/kg, and leaving at 4.5 m/s with a pressure of 6.9 bar and a specific volume of 0.16 m^3/kg. The internal energy of the air leaving is 88 kJ/kg greater than that of the air entering. Cooling water in a jacket surrounding the cylinder absorbs heat from the air at the rate of 59 W. Calculate the power required to drive the compressor and the inlet and outlet cross-sectional areas.	**20**	**CO5**