**BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI (RAJ)**

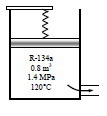
**Second Semester (2015-2016)**

**BITS F111 Thermodynamics**

**Comprehensive Examination Make up (close book)**

**Max Mark 90 Thursday, 28 th July 2016 Duration 120 min**

1. The performance of a heat pump degrades (i.e. its COP decreases) as the temperature of the heat source decreases. This makes using heat pumps at locations with severe weather conditions unattractive. Consider a house that is heated and maintained at 20°C by a heat pump during the winter. What is the maximum COP for this heat pump if heat is extracted from the outdoor air at (*a*) 10°C, (*b*) 25°C, and (*c*) 230°C? [5M]
2. A tank having a volume of 0.85 m3 initially contains water as a two-phase liquid–vapor mixture at 260°C and a quality of 0.7. Saturated water vapor at 260°C is slowly withdrawn through a pressure-regulating valve at the top of the tank as energy is transferred by heat to maintain the pressure constant in the tank. This continues until the tank is filled with saturated vapor at 260°C. Determine the amount of heat transfer, in kJ and draw T-v diagram. Neglect all kinetic and potential energy effects. [10M]



1. An insulated vertical piston–cylinder device initially contains 0.8 m3 of refrigerant-134a at 1.4 MPa and 120°C. A linear spring at this point applies full force to the piston. A valve connected to the cylinder is now opened, and refrigerant is allowed to escape. The spring unwinds as the piston moves down, and the pressure and volume drop to 0.7 MPa and 0.5 m3 at the end of the process. Determine (*a*) the amount of refrigerant that has escaped and (*b*) the final temperature of the refrigerant. [15M]
2. The radiator of a steam heating system has a volume of 20 L and is filled with superheated water vapor at 200 kPa and 200°C. At this moment, both the inlet and the exit valves to the radiator are closed. After a while, it is observed that the temperature of the steam drops to 80°C as a result of heat transfer to the room air, which is at 21°C. Assuming the surroundings to be at 0°C, determine (*a*) the amount of heat transfer to the room and (*b*) the maximum amount of heat that can be supplied to the room if this heat from the radiator is supplied to a heat engine that is driving a heat pump. Assume the heat engine operates between the radiator and the surroundings. [20M]
3. Steam at 7 MPa and 400°C enters a two-stage adiabatic turbine at a rate of 15 kg/s. Ten percent of the steam is extracted at the end of the first stage at a pressure of 1.8 MPa for other use. The remainder of the steam is further expanded in the second stage and leaves the turbine at 10 kPa. If the turbine has an isentropic efficiency of 88 percent, determine the wasted power potential during this process because of irreversibilities. Assume the surroundings to be at 25°C. [20M]
4. A certain industrial process requires a steady 0.5 kg/s of air at 200 m/s at the condition of 150 kPa, 300 K. This air is to be the exhaust from a specially designed turbine whose inlet pressure is 400 kPa. The turbine process may be assumed to be reversible and polytropic, with polytropic exponent *n* = 1.20. (*a*) What is the turbine inlet temperature? (*b*) What are the power output and heat transfer rate for the turbine? (c) Calculate the rate of net entropy increase if the heat transfer comes from a source at a temperature 100°C higher than the turbine inlet temperature. [20M]