THE INSTITUTION OF ENGINEERS SRI LANKA, SRI LA
PART I EXAMINATION-MARCH/APRIL 2008

105- THERMODYNAMICS

Answer any Five (5) questions **Time allowed: Three (3) Hou**
ALL questions carry equal Marks
Thermodynamics Property Tables of Steam, Air and Ammonia are provided.

Q 1.

A Piston-cylinder device contains 0.1 m3 of a gas initially at 500 kPa. A spring exerts a force on the piston, which is proportional to the displacement of the piston. Heat is transferred to the gas, causing the piston to rise and compress the spring until the volume inside the cylinder doubles and pressure becomes 1MPa. If the cross-sectional area of the piston is 0.2 m^2, determine the spring constant.

Q 2.

a) Write the steady flow energy equation and apply it to a turbine.(State any assumption you make)

b) In a gas turbine unit, the gas flow rate (through the turbine) is 15 kg/s and the power developed by the turbine is 12000 kW. The enthalpies of gases at the inlet and outlet are 1260 kJ/kg and 400 kJ/kg respectively, and the velocity of gases at the inlet and outlet are 50 m/s and 110 m/s respectively. Calculate:

(i) The rate of heat rejection from the turbine? (State any assumptions you make)
(ii) The inlet area of the duct, if the specific volume of the gas at the inlet is 0.45m^3/kg

Q 3.

a) Discuss the interpretation of the Second Law of Thermodynamics with reference to a heat engine and heat pump.

b) The surroundings of a freezer are at a temperature of 27^{0}C. To maintain the freezer component at –40^{0}C, it is necessary to remove energy by heat transfer at the rate of 1.25 kW. Determine.

(i) The maximum coefficient of performance.
(ii) The minimum theoretical power input required, in kW, for any refrigeration cycle operating under these conditions.

Q 4.

Consider a steam power plant working between the limits of 30 bar, 400 ^{0}C, and 0.1 bar. Assuming isentropic efficiency of the turbine expansion to be 80%, determine the cycle efficiency, the work done and quality of the steam entering the condenser for following cases.(You may neglect the feed pump work)

(i) A simple Rankine cycle
(ii) A reheat Rankine cycle with the steam reheated to 400^{0}C at the pressure of 6 bar

Q 5.

a) State the air standard assumptions?

b) An ideal diesel cycle using air as the working fluid has volume compression ratio [illegible] fuel cutoff ratio 2.The intake conditions are 1 bar, 27 ^{0}C and 3200 cm^3.Using cold standard assumptions, determine:

(Take: C_P = 1.0045 kJ/kgK and C_V = 0.7175 kJ/kgK)

(iii)The temperature and pressure at end the of each process
(iv)The net work output
(v) The thermal efficiency
(vi)The mean effective pressure

Q 6.

a) State five important characteristics expected from a refrigerant

b) State the important parameters to be considered in selection of a refrigerant?

c) In a heat pump, refrigerant "Ammonia" leaves the evaporator as dry saturated State at **-6^0 C**. Then, compressed to a pressure of **12.37 bar** and cooled and condensed to a saturated liquid at the condenser. Then, it passes through a throttle valve and returns to the evaporator.

(i) Sketch the cycle on **T-s** and **p-h** diagrams
(ii) Calculate COP assuming that the isentropic efficiency of compression process is 85%.

Q 7.

a) State the characteristics of steady flow process.

b) An insulated rigid tank having 6 kg of air at 30 kPa and 27^{0}C is connected to an air supply at 90KPa and 47^{0}C through a valve. The valve is now slowly opened to allow the air from the supply line to flow in to the tank until the tank pressure reaches 90 kPa and then the valve is closed. Determine the final temperature of the air in the tank. Also, find the amount of air added to the tank.(Take γ =1.4)

Q 8.

A certain quantity of air initially at a pressure of 8 bar and 287^{0}C has a volume of 0.035m^3. It undergoes the following processes in the following sequence in a cycle:

a. Expands at constant pressure to 0.1m^3
b. Follows polytropic process with n=1.4, and
c. A constant temperature process (Which complete the cycle)

Draw a schematic p-v diagram for the cycle and evaluate the followings:

(i) The heat received in the cycle
(ii) The heat rejected in the cycle
(iii) Thermodynamic Efficiency of the cycle