Mansoura University — *1th Year-Production & Design Eng. Dept.*
Faculty of Engineering — *Final Exam, Jan., 2009*
Mech. Power Eng. Dept — *Allowed Time: 3 hour*

Thermal Engineering (MPE 5116)

Steam tables and Charts are allowed to be used.
Answer the following questions:

Question No.1

a) Derive the relation for the work done during an isothermal process (**pv= c**).

b)A volume **0.15 m^3** of gas initially at **25°C** and **101 kPa** is compressed to **1/5** of its initial volume ($v_1 = 5v_2$) according to the law **$pv^{1.3} = c$**, find:

i) the mass of the gas in kg,
ii) the temperature and pressure at the end of compression
iii) the work done on the gas during the process, and
iv) the amount of heat during the process

Assume **C_p= 1005 J/kg K, C_v = 718 J/kg K**

Question No.2

a) Discuss the Kelvin-Planck statement of the second law of thermodynamics with simple sketch showing the two thermal reservoirs that the thermodynamic cycle working between them.

b) A heat pump operating between two reservoirs receives energy at **Q'_c** from a cold reservoir at a temperature; **t_c = 10°C** and rejects heat energy at a rate of **Q'_H = 4000** J/s to the hot one at **t_H = 25°C.** The rate of input work **W' = 600 J/s**. Determine the **C.O.P** of this heat pump. What would be the needed rate of work if the heat pump works on a reversed cycle?

Question No.3

a) Classify the I.C.E according to the type of fuel used. Explain with simple sketch the main components of an I.C. engine, the function of each component and from what material each is manufactured..

b) In an ideal Diesel cycle has compression ratio (r) of **18** and uses air as a working fluid. The pressure and temperature at the beginning of compression are **100 kPa** and **30°C,** respectively. If the heat added during the cycle is **500 kJ/kg** of the air, Sketch the cycle on p-v and T- s diagrams and find:

i) the temperature and pressure at other points of the cycle.
ii) the amount of heat rejected in kJ/kg. ii) the net work done in kJ/kg.
iii) the thermal efficiency, **η** and iv) the mean effective pressure.

(for air take **C_p= 1.005 kJ/kg K, C_v= 0.717 kJ/kg K**).

Question No.4

a) Classify the steam boilers according to the contents in the tube. With simple sketch, show the main components of a simple vertical boiler and mention its main properties.

b) In a steam power plant (based on Rankine cycle), the steam leaves the boiler at a rate of **20 kg/s** and enters the turbine at **4 MPa** and **300°C**, respectively and exhausts to the condenser at **0.01 MPa.** Assuming adiabatic expansion **(s=c)** through the turbine, draw the cycle on Mollier chart (h-s). Use both the chart and steam tables to determine:

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i) the state of the steam after leaving the turbine **(x, t)**.
ii) The net rate of work output from the plant
iii) What would be the net efficiency (η_{th}), taking the pump work into consideration.
iv) the back work ratio (bwr)
v).The rate of heat rejected in the condenser.

Question No.5

a) Draw a layout of the vapor compression refrigeration system and describe the function of each of its components. Represent the simple cycle processes, on T-s and p-H diagrams.

b) A superheated steam at **250°C** flows in a stainless steel pipe of **40 m** long, **100 mm** internal diameter and **180 mm** outer diameter is covered by an insulating material of **30 mm** thick. The coefficient of thermal conductivities for the steel and the insulation are **54 W/m^{2}K** and **0.03 W/m^{2}K**, respectively. If the convective heat transfer coefficient of the flowing steam and surrounding atmosphere are 10000 W/m^{2}K and 25 W/m^{2}K, respectively. **Determine the following**;

i) the total thermal resistance
ii) the rate of heat loss from the pipe
iii) the temperature of outer surface of the pipe beneath the insulation
iv) the rate of heat loss from the pipe if insulation has been removed (without insulation)

GOOD LUCK

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