THE MOMBASA POLYTECHNIC UNIVERSITY COLLEGE

(A Constituent College of JKUAT)

Faculty of Engineering & Technology

DEPARTMENT OF MECHANICAL & AUTOMOTIVE ENGINEERING

DIPLOMA IN MECHANICAL ENGINEERING (PRODUCTION OPTION)
DIPLOMA IN MECHANICAL ENGINEERING (PLANT OPTION)
DIPLOMA IN MECHANICAL ENGINEERING (AUTOMOTIVE OPTION)
[Institutional Based Programmes)

EME 2303: THERMODYNAMICS III

END OF SEMESTER EXAMIANTION
SERIES: AUGUST 2012
TIME: 2 HOURS

Instructions to Candidates:
You should have the following for this examination
- *Answer Booklet*
- *Steam Tables*
- *Scientific Calculator*

This paper consists of **FIVE** questions. Answer any **THREE** questions
Maximum marks for each part of a question are as shown
This paper consists of **THREE** printed pages

Question One (20 marks)

a) Define the following terms as applied in psychrometry:
- **i)** Saturated air
- **ii)** Wet bulb temperature
- **iii)** Dew point temperature
- **iv)** Sensible heat
- **v)** Enthalpy. **(5 marks)**

b) The atmospheric conditions are 20°C and specific humidity of 0.0095kg/kg dry air. If the barometric pressure is 1.0132: Determine:
- **i)** Partial pressure of vapour
- **ii)** Relative humidity
- **iii)** Dew point temperature. **(7 marks)**

c) A gas turbine unit has a pressure ratio of 6:1 and maximum cycle temperature of 610°C. The isentropic efficiencies of the compressor and the turbine are 0.80 and 0.82 respectively. If air enters the turbine at 15°C at the rate of 16kg/s, determine:
- **i)** Power output
- **ii)** Thermal efficiency

(Take Cpa = 1.005 KJ/Kg K, $\gamma_a = 1.4$, $CP_g = 1.11$KJ/Kg K and $\gamma_g = 1.333$) **(12 marks)**

d) Explain the **THREE** ways in which heat can be transferred. **(6 marks)**

Question Two (20 marks)

a) State Fourier's Law of Heat Conduction. **(3 marks)**

b) Define the following terms:
- **i)** Thermal conductivity
- **ii)** Coefficient of convective heat transfer. **(4 marks)**

c) A flat wall is exposed to an environment temperature of 38°C. The wall is covered with a layer of insulation 2.5cm thick whose thermal conductivity is 1.4W/m°C and the temperature of the wall on the inside of the insulation is 315°C. The wall loses heat to the environment by convection. If the outer surface temperature does not exceed 41°C, determine the value of the convection heat transfer coefficient. **(13 marks)**

Question Three (20 marks)

In an open gas turbine plant, the air from the compressor passes through a heat exchanger where it is heated by the exhaust gases from the law pressure turbine. The high pressure turbine drives the compressor only. The exhaust gases from the high pressure turbine passes through the low pressure combustion chamber, then into the low pressure turbine, which drives an external load.

Given the following data:

Overall pressure ratio	9:1
Compressor Isentropic efficiency	0.88

H.P turbine isentropic efficiency	0.86
L.P turbine isentropic efficiency	0.9
Heat exchanger effectiveness	0.75

Temperature of gases entering H.P turbine 700°C
Temperature of gases entering L.P turbine 650°C
Atmospheric pressure and temperature 1.01325 bar and 25°C respectively.

C_P for both air and gases are 1.005 KJ/KgK.
If the compression and expansion index is 1.4

a) Sketch the plant layout and T-S diagram.
b) Determine
   i) Pressure of gas entering the low pressure turbine
   ii) Overall thermal efficiency **(20 marks)**

Question Four (20 marks)

Air at 40°C and 45% percentage saturation enters a central air conditioning system supplying a lecture hall. The air in the hall is to be maintained at 23°C and 50% saturation. The sensible heat level is 14.4KW and latent heat load is 9.6KW. The condition air is supplied through ducts from a system consisting of a cooler battery, a heater battery, a fan and a mixing unit. Fresh air is mixed with recirculated air in the ratio of 1:3. The temperature rise in the fan and duct work is neglible and the apparatus dew point of the cooler is 5°C. If temperature of air entering the room is 12.5°C.

a) Sketch the plant layout
b) Determine:
   i) The cooler battery load
   ii) The heater battery load
   iii) Cooler coil bypass factor. **(20 marks)**

Question Five (20 marks)

a) Show that the logarithmic mean radius, τ_m, for heat flow through a cylinder is given by:

$$r_m = \frac{r_2 - r_1}{In\left(\frac{r_2}{r_1}\right)}$$

Where r_1 and r_2 are internal and external radii respectively. **(9 marks)**

b) A steam main of 160mm outside diameter containing wet steam at 28bar is insulated with an inner layer of asbestos, 35mm thick and an outer layer of magnesium 300mm thick. The inside surface of the pipe is at the steam temperature, and the heat transfer coefficient for the outside surface of the lagging is 15W/m^{2}K. The thermal conductivities of asbestos and magnesia are 0.07 and 0.06W/mk respectively.

If the thermal resistance of the pipe wall is neglible and the room temperature is 22°C, determine:

i) The rate of heat loss per unit length of pipe.

ii) The temperature of the outside surface of the lagging. **(11 marks)**