



## TECHNICAL UNIVERSITY OF MOMBASA

---

Faculty of Engineering and Technology  
Department of Mechanical & Automotive Engineering  
UNIVERSITY EXAMINATION FOR:  
BSc. Mechanical Engineering  
EMG 2510 : REFRIGERATION AND AIRCONDITIONING  
END OF SEMESTER EXAMINATION  
SERIES: DECEMBER 2016  
TIME: 2 HOURS

DATE: Pick Date Supplementary Examination for December 2016 Main  
Examination

### INSTRUCTIONS TO CANDIDATES

1. You are required to have the following for this examination:
  - Answer Booklet
  - A Non-Programmable Scientific Calculator
  - Thermodynamic and Transport Properties of Fluids (SI Edition) by Y.R Mayhew and G.F.C Rogers
  - p-h diagram for R-134a (A3 size)
  - Chart for friction pressure drop for circular ducts
2. This paper consists of **FIVE** Questions.
3. Answer **ANY THREE** Questions.
4. All questions carry equal marks.
5. **This paper consists of FOUR printed pages.**

**Question 1 (40 Marks)**

- a) Give brief definitions of the following terms used in the study of solar energy:
- i. Direct solar radiation (3 Marks)
  - ii. Diffuse solar radiation (3 Marks)
  - iii. Reflected solar radiation (3 Marks)
  - iv. Refraction (3 Marks)
- b) A room has one masonry wall exposed to solar radiation. This wall is provided with a glass window. Give full accounts of what happens to:
- i. Solar radiation incident on the masonry wall (16 Marks)
  - ii. Solar radiation incident on the glass window (7 Marks)
- c) Give two (2) methods of reducing heat transfer to the room through the above masonry wall. (2 Marks)
- d) Give three (3) methods of reducing heat transfer to the room through the above glass window. (3 Marks)

**Question 2 (40 Marks)**

- a) The following terms are used in the study of airconditioning:
- i. Comfort airconditioning
  - ii. Industrial airconditioning
  - iii. Inside design conditions
  - iv. Shading
  - v. Sensible heating/cooling
  - vi. Latent heat load
  - vii. Thermal insulation

Write brief explanations of the meaning of each term.

**(16 Marks)**

- b) List five (5) important components of internal heat load for a space used for processing or manufacturing goods. **(5 Marks)**
- c) List three (3) important components of external heat load for a residential building. **(3 Marks)**
- d) Explain how each of the following affect the temperature of the indoor air:
- i. Solar radiation incident on an exterior wall **(3 Marks)**
  - ii. Solar radiation transmitted through window glass **(3 Marks)**

**Question 3 (40 Marks)**

- a) With the aid of a labeled T-s diagram and suitable explanations of the processes shown thereon, give the definitions of the following terms:  
**3 + 4 = 7 Marks for T-s diagram and explanations**
- i. Dry bulb temperature (2 Marks)
  - ii. Dew point temperature (2 Marks)
  - iii. Wet bulb temperature (2 Marks)
  - iv. Saturation vapor pressure (3 Marks)
  - v. Adiabatic saturation temperature (4 Marks)
- b) The barometric air pressure reading in a room is 1.00 bar, while the dry bulb and the relative humidity 30°C and 30%, respectively

Determine:

- i. the partial pressure of each component (4 Marks)
- ii. the specific volume of each component (based on total pressure) (9 Marks)
- iii. the dew point temperature (7 Marks)

**Question 4 (40 Marks)**

- a) Give 7 desirable properties of a refrigerant (7 Marks)
- b) A vapor compression refrigeration plant using R-134a is required to operate as follows:
- i) State 1 is inlet to the compressor.  $P_1 = 0.4 \text{ bar}$  and  $t_1$  is  $5^\circ \text{C}$  above saturation temperature.
  - ii) Heat water from  $20^\circ \text{C}$  to  $45^\circ \text{C}$  at the rate of  $0.2 \text{ kg / sec}$ .
  - iii) Condenser pressure of  $10 \text{ bar}$  with  $10^\circ \text{C}$  superheating at the entry to the condenser and  $5^\circ \text{C}$  of under cooling at the entry to the throttling valve.
- Show the arrangement of the components of this cycle and also show the cycle on T-s and p-h diagrams. (4 + 2 + 2 = 8 Marks)

Using the p – h chart for R – 134a provided and assuming ideal processes, calculate:

- i) the temperature at the beginning of each process (6 Marks)
- ii) the refrigerant flow rate in kg/sec (7 Marks)
- iii) the refrigeration effect in kW (3 Marks)
- iv) the compressor work in kW (3 Marks)
- v) the coefficient of performance of the refrigeration (3 Marks)
- vi) the coefficient of performance of the heat pump (3 Marks)

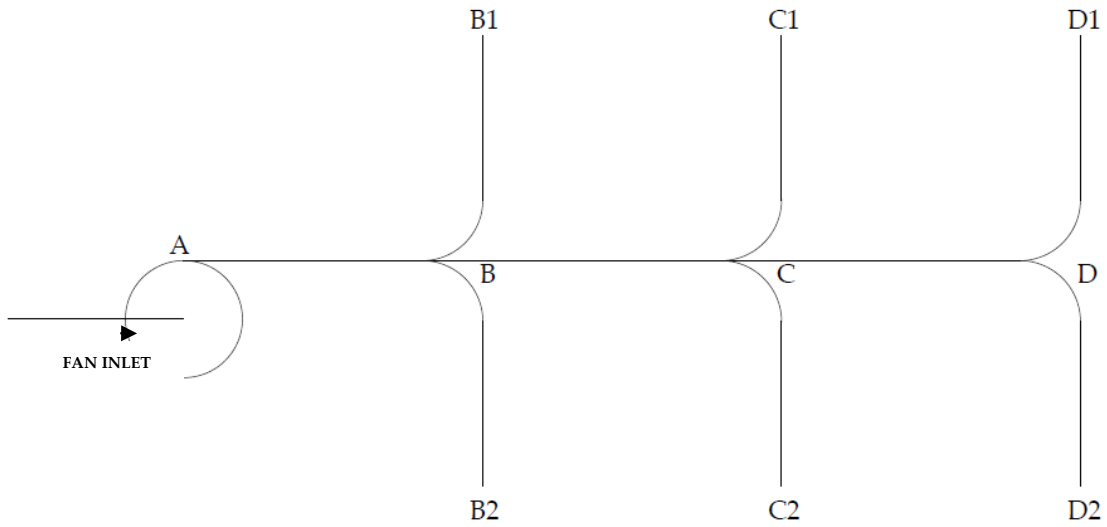
### Question 5

- a) Give brief descriptions of the meaning and application of the following terms used in the study of ventilation systems in airconditioning:
- i. Fan power (2 Marks)
  - ii. Air power (2 Marks)
  - iii. Coefficient of resistance for duct fittings (2 Marks)
  - iv. Grills (1 Mark)
  - v. Diffusers (1 Mark)
  - vi. Volume dampers (1 Marks)
  - vii. Filters (1 Mark)
- b) The circular duct system shown on Figure Q5 is to be used to distribute air in a building. The length of the ducts and some of the flow rates and allowable velocity in each run is indicated on the figure. Calculate:
- i) the flow rate in each duct run (3 Marks)
  - ii) the cross-sectional area of each section of duct system (9 Marks)
  - iii) the diameter of each section of duct system (4.5 Marks)
  - iv) friction coefficient for each sector of the duct (9 Marks)
  - v) the pressure drop in each sector of duct (assume minor losses are negligible) (4.5 Marks)

The frictional pressure drop can be calculated from the following equation and values of  $f$  taken from the charts provided:

$$h = (fC^2 L) / (2 g m) \quad (\text{mm of Aqua})$$

**Figure Q5**



Sector	Length m	Flow Rate m <sup>3</sup> /s	Allowable Velocity m/s	A m <sup>2</sup>	d m	f	h mm Aqua
A-B	5.00		7.5				
B-B1	3.00	0.5	3.5				
B-B2	3.00	0.5	3.5				
B-C	5.00		5.0				
C-C1	3.00	0.5	3.5				
C-C2	3.00	0.5	3.5				
C-D	5.00		5.0				
D-D1	3.00	0.5	3.5				
D-D2	3.00	0.5	3.5				