



Study Programme : Bachelor of Science Honours in Engineering
Name of the Examination : Final Examination
Course Code and Title : **DMX5205 Applied Thermodynamics II**
Academic Year : 2024/25
Date : 6th February 2026
Time : 0930 - 1230hrs
Duration : **3 hours**

General instructions

1. This question paper consists of Five **(5)** questions.
2. Answer all Five **(5) questions**. All questions carry **equal marks**.
3. Answer for each question should commence from a new page.
4. This is a Closed Book Test **(CBT)**.
5. Answers should be in clear handwriting.
6. Do not use red colour pen.
7. A psychrometric chart is provided.

Question 01

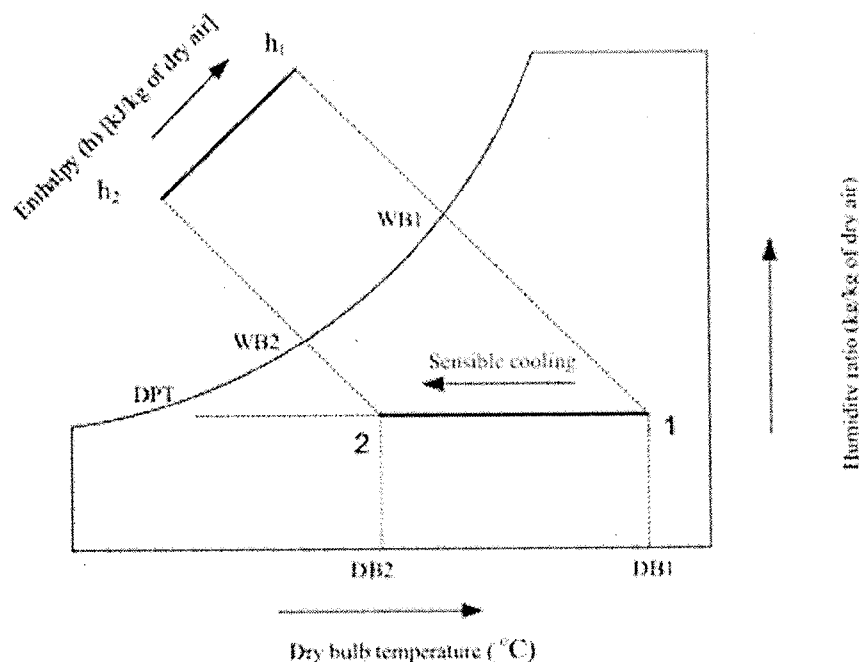
- (i) What is the main function of a compressor in a refrigeration system? 03 marks
- (ii) What factors affect the COP of a vapor compression refrigeration system? 03 marks
- (iii) A vapour-compression refrigeration system using R-12 operates between the evaporator pressure of 2.2 bar and the condenser pressure of 9.2 bar. The refrigerant enters the compressor as dry saturated vapour at 2.2 bar. Compression is isentropic. There is no subcooling at the condenser outlet (i.e., condenser exit is saturated liquid at 9.2 bar). The actual COP = 0.6 × theoretical COP. Refrigerant mass flow rate is 6 kg/min. C_p of R-12 vapour = 0.68 kJ/kg K. Properties of refrigerant are given in Table Q1.
- a) Sketch the cycle on a T-S or p-h axes. 03 marks
- b) Find the temperature at the end of compression. 06 marks
- c) Estimate the theoretical COP. 02 marks
- d) Calculate the theoretical and actual compressor power. 03 marks

Pressure (bar)	Saturation temperature(°C)	Enthalpy kJ/kg		Entropy of saturated vapour, kJ/kg K
		liquid	vapour	
9.2	38	72.56	202.51	0.6830
2.2	-10	26.87	183.2	0.7019

Table Q1

Question 02

- (i) (a) What is "Human comfort"? 03 marks
- (b) List down four (04) factors affecting human comfort. 04 marks
- (ii) (a) Figure 1 shows the sensible cooling process in a Psychrometric chart. Assuming the mass transfer rate of this process as m_a , derive an equation for the heat transfer rate (Q) during this process. 04 marks



DPT-Dew point temperature, WB-Wet bulb temperature, DB-Dry bulb temperature

Figure 1: Schematic Diagram of Sensible Cooling Processes

- (b) A new sensible air-cooling device cools air with a dry bulb temperature of 35°C and a relative humidity of 40% to a dry bulb temperature of 28°C. Determine the sensible heat capacity of the cooling coil for a unit mass flow rate. (Hint: use the given Psychrometric Chart for the necessary data) 04 marks
- (c) After the above cooling process, the air is passed through a wetted pad until it gets saturated and released to the atmosphere. Find temperature, specific enthalpy, specific volume, and the amount of moisture absorb by unit mass of air flow rate that is released to the ambient. (Hint: use the given Psychrometric Chart for the necessary data) 05 marks

Question 03**0048**

- (i) Define the emissive power and state the SI units of measurement. 02 marks
- (ii) What are the mechanisms of heat transfer from a hot cylindrical surface placed inside a room? 03 marks
- (iii) Grashof number is given by the following expression. Identify each parameter with the SI units of measurement.

$$Gr = \frac{g\beta\theta L^3}{\nu^2}$$

04 marks

- (iv) A cylindrical electric heater of diameter 30 mm and length 0.4 m has a uniform surface temperature of 540°C inside a room. The room air is at 20°C, and the enclosing walls are at 16°C.

Assume that

- Surroundings are black.
- Emissivity of the heater surface is 0.55

You may use following equation and air properties given at mean bulk temperature

$$Nu = 0.4(Gr)^{1/4}$$

Kinematic viscosity (ν)	$= 4.48 \times 10^{-5} \text{ m}^2/\text{s}$
Thermal conductivity (k)	$= 4.375 \times 10^{-5} \text{ kW/m K}$
Coefficient of cubic expansion (β)	$= 1/293 \text{ K}^{-1}$

04 marks

- (a) Calculate the Grashof number and Nusselt number.
- (b) Estimate the total heat loss from the heater, considering convection from the heater surface to the surrounding air, and radiation from the heater surface to the room walls. [Stefan-Boltzmann constant (σ) = $5.67 \times 10^{-8} \text{ W/m}^2\text{K}^4$] 05 marks
- (c) Calculate the total electrical power input required to maintain the heater at this temperature. 02 marks

Question 04

- (i) State four (04) advantages of insulating furnace walls. 04 marks
- (ii) A 2 m × 1.5 m section of a furnace wall is exposed to ambient air and is initially not insulated. The temperature of the outer surface of the wall is maintained at 80°C, while the surrounding air is at 30°C. The combined convective and radiative heat-transfer coefficient at the outer surface is 10 W/m²°C.

To improve energy efficiency, the wall section is insulated using glass wool ($k = 0.038 \text{ W/m}^\circ\text{C}$) with the objective of reducing the heat loss by 90%.

- (a) Determine the rate of heat transfer from the outer surface of the furnace wall section without the insulation. 06 marks
- (b) Calculate the rate of heat transfer with the insulation. 06 marks
- (c) Determine the thickness of the glass wool insulation needed to reduce the heat loss by 90 %. 04 marks

Question 05

- (i) Define the following terms in the context of combustion. 04 marks

- (a) Air-Fuel ratio
(b) Enthalpy of Combustion

- (ii) Write the stoichiometric combustion equation for Hexane (C_6H_{14}). Calculate the air-fuel ratio for the stoichiometric combustion of Hexane. 04 marks

- (iii) Determine the enthalpy of combustion of liquid octane (C_8H_{18}) at $25^\circ C$ and 1atm, using enthalpy of formation (h_f^0) data given. Assume the water in the products is in the liquid form.

Substance	$\bar{h}_f^0$ (kJ/mol)
$C_8H_{18}(l)$	-249.99
$H_2O(l)$	-285.83
CO_2	-393.52

05 marks

- (iv) (a) The mass transfer coefficient is the rate of mass transfer per unit area per unit driving force. State the two methods by which the mass transfer coefficient of a component can be expressed. 02 marks

- (b) Air at $25^\circ C$ flows over a flat plate of length 0.4 m with a velocity of 3 m/s. The mass diffusivity of the vapour (D) in air is $2.5 \times 10^{-5} \text{ m}^2/\text{s}$ and the kinematic viscosity is $\nu = 15.5 \times 10^{-6} \text{ m}^2/\text{s}$. Assume laminar flow. Calculate the mass-transfer coefficient.

05 marks

Reynolds number, Schmidt number, and Sherwood number with usual notations are:

$$\text{Reynolds number } Re = \rho LU / \mu = LU / \nu$$

$$\text{Schmidt number } Sc = \frac{\nu}{D}$$

$$\text{Sherwood number, } Sh = h_m L / D = 0.664(Re)^{0.5}(Sc)^{0.33}$$

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