KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechanical Engineering

B. Sc. Engineering 3rd year 2nd Term Examination, 2018

ME 3205

(Heat Transfer II)

Time: 3 Hours. Total Marks: 210

N.B. i) Answer any THREE questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.
iii) Necessary Charts may be supplied on request.
iv) Assume reasonable data if any missing.

SECTION - A

1(a) Discuss the physical mechanism of convection heat transfer briefly. Also, on what factor does the convection heat transfer coefficient depend? 08

1(b) Write the energy balance in mathematical form of an elemental control volume within a laminar boundary layer with necessary assumptions. 09

1(c) Air at 21°C and 1 atmosphere pressure flows over a flat plate at a velocity of 2.1 m/sec. Consider that the plate is heated over its entire length to a temperature of 55°C. Calculate the heat transferred in the first 37 cm of the plate. 18

2(a) Show that the relation between fluid friction and heat transfer for laminar flow on a flat plate is given by, $St_x Pr^{2/3} = \frac{C_{fx}}{2}$; where the symbols have their usual meanings. 15

2(b) A vertical plate of length 0.8m and width 0.16m has one of its surfaces insulated. The other surface is maintained at a uniform temperature of 421K. The plate is exposed to quiescent atmospheric air at 310K. Calculate the total rate of heat loss from the plate. 20

3(a) A lubricating oil of viscosity μ and thermal conductivity k is contained in the clearance L between the journal and the bearing, which can be regarded as two parallel plates. Let u_1 be the velocity of the upper plate while the lower plate is considered stationary. Heat is generated in the oil layer during rotation as a result of viscous-energy dissipation. Develop expressions for the temperature distribution in the fluid for the lower plate is maintained at a temperature T_o and the upper plate at a temperature T_l with $T_l > T_o$. 20

3(b) Engine oil flows with a mean velocity of 2 m/s inside a 1.5 cm diameter tube which is electrically heated at the wall at a uniform rate of 2500 W/m^2. Heat transfer is taking place in the thermally developed region. Calculate the temperature difference between the tube wall surface and the mean flow temperatures. 15

4(a) Show that the local heat transfer coefficient can be calculated from the correlation $Nu_x = 0.53 Pe_x{}^{1/2}$, when a liquid metal flows over the horizontal plate at laminar flow condition. Symbols have their usual meanings. 17

4(b) A circular tube of radius r maintains a laminar forced convection with a uniform heat flux at the tube wall. In the region where the velocity and temperature profile are fully developed, the temperature distribution may be expressed as – 18

$$\theta(r) = \frac{96}{11}\left[\frac{3}{16} - \frac{1}{4}\left(\frac{r}{R}\right)^2 + \frac{1}{16}\left(\frac{r}{R}\right)^4\right].$$

Derive an expression for the convective heat transfer coefficient of the same.

SECTION – B

5(a) What are the disadvantages of dropwise condensation? 05

5(b) Derive an expression for the thickness of condensate layer when steam will condense on a vertical plate. 15

5(c) Pure saturated steam at a temperature of 98°C and pressure of 60 Pa condenses on the outer surface of 400 horizontal tubes of 2.6 cm OD in a 20×20 array. Tube surfaces are maintained at a uniform temperature of 75°C. Calculate the total mass of condensation if the tube (each) length is 5m. 15

6(a) Distinguish between nucleate and film boiling. Why does radiation play a significant role in the film boiling heat transfer? 10

6(b) What is the condition of collapsing a bubble in boiling phenomena? 08

6(c) Water at atmospheric pressure and saturation temperature is boiled by using an electrically heated, circular disk of diameter 15 cm with the heated surface facing up. The surface of the element is maintained at a uniform temperature of 95°C. Calculate the rate of evaporation and the peak heat flux. 17

7(a) What is meant by capacity factor? 05

7(b) Derive an expression for effectiveness of counter flow heat exchanger in NTU method. 15

7(c) A counter flow heat exchanger of heat transfer area 14 m^2 is to cool oil with water. The oil enters at 105°C with mass flow rate of 2.5 kg/sec, while the water enters at 20°C with mass flow rate of 0.5 kg/sec. The overall heat transfer coefficient is U = 450 W/m°C. Calculate the exit temperature of water and the total heat transfer rate. 15

8(a) State and explain Fick's law of diffusion. 05

8(b) Derive an expression for calculating the molal flux for the case of steady state unidirectional diffusion in gases. 15

8(c) Determine the diffusion rate of water from the bottom of a flask of 5.5 cm in diameter and 30 cm high into dry atmospheric air at 34°C. Assume diffusion coefficient for water is D = 0.265 cm^2/sec. 15

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KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY
Department of Mechanical Engineering
B. Sc. Engineering 3rd year 2nd Term Examination, 2018
ME 3215
(Engineering Metallurgy)

Time: 3 Hours. Total Marks: 210

N.B. i) Answer any THREE questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.
iii) Assume reasonable data if any missing.

SECTION - A

1(a) What is the importance of calibration in temperature measurement through thermometer? Explain the working principle and calibration method for resistance thermometer. 08

1(b) Can a biological microscope be used to investigate metallurgical properties? Compare and contrast between Electron and Light microscope with neat sketch. 10

1(c) What are the limitations of ultrasonic inspection? Explain and illustrate the principle of eddy current inspection. 17

2(a) What are the various types of atomic bonds? Explain the formation of metallic bond. Also, mention the significance of it. 08

2(b) What is polymorphism? Explain the mechanism of crystallization using cooling curve and necessary sketches. 15

2(c) What is solid solution? Explain the different types of solid solution. 12

3(a) Draw a iron-iron carbide equilibrium diagram and label it completely. 10

3(b) Bismuth (melting point 520°F) and cadmium (melting point 610°F) are assumed to be completely soluble in the liquid state and completely insoluble in the solid state. They form a eutectic at 290°F containing 40% cadmium. 25

(i) Draw the equilibrium diagram to scale on a piece of graph paper labeling all points, lines and areas;

(ii) For any alloy containing 70% cadmium (a) determine the temperature of initial solidification; (b) determine the temperature of final solidification; (c) determine the chemical composition and the relative amounts of the phase present at a temperature of 100°F below the initial solidification temperature.

4(a) What is spherodizing? How is it done on steel? When spherodized structure is desirable? 08

4(b) What is the significance of T-T-T diagram in heat treatment industries? Draw a T-T-T diagram of eutectoid steel and explain the method of obtaining pearlite, bainite and martensite structures together in steel. 15

4(c) Explain the following heat treatment process: 12
(i) Carburizing; (ii) Nitriding; (iii) Induction hardening

SECTION – B

5(a) Name various types of cast iron. Write down the composition, properties and applications of gray cast iron. 08

5(b) Describe the manufacturing process of pig iron from ore using blast furnace with neat sketch. 14

5(c) Explain the limitations of carbon steel. 05

5(d) Why surface treatment is needed? What are the basic methods of surface treatments of metals? 08

6(a) What are the effects of alloying element Cr and Mo in steel? Why Ni is typically used in combination with Cr and Mo? 08

6(b) What are the drawbacks that limit the use of Bassemer process? How these can be solved by Open-Hearth process? 07

6(c) Suppose that you have to design a steel making plant in Bangladesh, which steel making process would you suggest to build and why? 06

6(d) Explain the steel manufacturing process using Electric arc furnace (EAF) with neat sketch. 14

7(a) What is the major application of each of the following materials – 05
(i) Copper, (ii) Nickel, (iii) Tin, (iv) Lead, (v) Aluminum

7(b) Explain the production of Aluminum from ores with block diagram. 12

7(c) Why metal coating or spraying is required? Describe the general working principle of flame wire metal spraying with neat sketch. 09

7(d) Write down the compositions and uses of the following non-ferrous alloys: 09
(i) Gun metals, (ii) Inconel, (iii) Duralunein

8(a) When can we suggest to make a component by powder metallurgy over the conventional production process and why? 08

8(b) Draw a flow diagram of basic processing steps of powder metallurgy. Explain the sintering steps in details. 15

8(c) What are the various methods of powder production? Explain gas atomization process with necessary sketches. 12

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