KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechanical Engineering

B.Sc. Engineering 3rd year Backlog Examination, 2022

ME 3105

(Heat Transfer I)

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) Derive the three dimensional general heat conduction equation in rectangular coordinates. 17

1(b) The rectangular wall of a house having size 3 m × 4 m is made of brick [k = 0.8 W/(m^{0}C)] having thick 0.2 m which is followed by a 0.1 m layer of gypsum plaster [k = 0.55 W/(m^{0}C)] on both side. Both side of the wall is exposed to air having inner and outer surface convective heat transfer coefficient of 20 W/(m^2 ^{0}C) and 25 W/(m^2 ^{0}C), respectively. If the temperatures of air of inner and outer side of the wall are 25^{0}C and 40^{0}C, respectively. Calculate the total heat transfer from the wall. 18

2(a) What is the effect of contact resistance on heat transfer? 05

2(b) Derive an expression for the critical radius of insulation of small hollow cylinder. 15

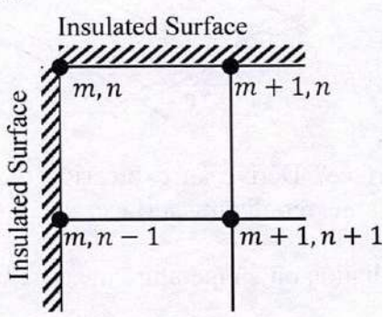
2(c) A 0.6 m thick furnace wall [k = 2 W/(m^{0}C)] is to be insulated with a material [k = 0.05 W/(m^{0}C)]. The temperature inside the furnace is 1100^{0}C. If the heat loss should not exceed 500 W/m^2 for the outer surface temperature of 60^{0}C, what thickness of insulation is required? 15

3(a) What are the conditions for which the use of fin is justified? 05

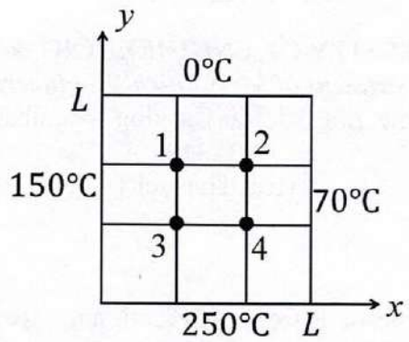
3(b) Derive an expression for heat flow rate through a long circular fin of uniform cross section when the temperature at the fin tip approaches the surrounding fluid temperature. 15

3(c) A very long 1 cm diameter copper rod [k = 377 W/(m K)] is exposed to an environment at 22^{0}C. The base temperature of the rod is maintained at 160^{0}C. The convection heat transfer coefficient between the rod and the surrounding air is 12 W/(m^2 K). Determine the heat transfer rate from the rod to the surrounding air. 15

4(a) Derive an expression for the nodal equation of node (m,n) for the insulated corner under steady state condition. 17



4(b) Compute the temperature of nodes 1, 2, 3 and 4 for a square region of side L by a mesh size $\Delta x = \Delta y = \frac{1}{3}L$ for the boundary condition shown in figure below. 18



SECTION – B

5(a) What is Heisler chart? How this chart can be used to determine heat transfer in two dimensional problem? 17

5(b) A 50 cm thick concrete slab [$\alpha = 7 \times 10^{-7}$ m^2/sec and k = 1.4 W/(m^{0}C)] is initially at a uniform temperature $T_i = 340°C$. Suddenly its surface is subjected to convective cooling with a heat transfer coefficient h = 100 W/(m^2 ^{0}C) into an ambient $T_\infty = 38°C$. Calculate the temperature 15 cm from the surface 1 hour after the start of cooling. 18

6(a) Define the following terms:
i) Emissivity; ii) Gray body and iii) Solar constant. 09

6(b) State and explain Wien's displacement law. 10

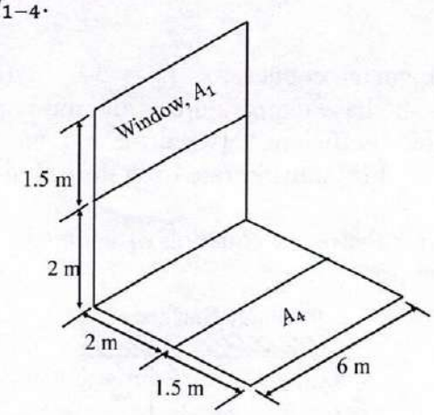
6(c) Derive the Kirchhoff's law of radiation. 10

6(d) Distinguish between beam radiation and diffuse radiation. 06

7(a) What is meant by view factor? State the reciprocity rule and summation rule of view factor. 09

7(b) What is radiation shield? Show that the radiation heat flow reduces to one half when a radiation shield is placed between two infinite parallel plates. 13

7(c) Suppose an architect wants to evaluate the percentage of daylight entering through a window A_1 that impinges on the floor A_4 located relative to A_1 as shows in figure. Evaluate shape factor F_{1-4}. 13



8(a) What is reradiating surface? Derive an expression of net heat flow in a 3-zones enclosure of which one zone reradiating surface. 12

8(b) Explain the effect of radiation on temperature measurement. 08

8(c) Two coaxial cylinders of radii $r_1 = 6$ cm and $r_2 = 20$ cm are maintained at $T_1 =$ 1200 K and $T_2 = 450$ K, respectively. The emissivity for the surfaces are $\varepsilon_1 =$ 0.7 and $\varepsilon_2 = 0.9$, respectively. 15
i) Calculate the radiation exchange between them per meter length of the cylinder.
ii) Calculate the heat transfer rate if a radiation shield of $r_3 = 10$ cm having emissivity $\varepsilon_3 = 0.1$ is placed between them.

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY
Department of Mechanical Engineering
B.Sc. Engineering 3rd year Backlog Examination, 2022
ME 3217
(Machine Design II)

Time: 3 Hours | Total Marks: 210

N.B.: i) Answer any THREE questions from each section in separate scripts.
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iii) Assume reasonable data if any missing.

SECTION – A

1(a) An angular contact ball bearing with the inner ring rotating is to be selected for an application with a design life of 25 kh at a speed 350 rev/min. The radial load is 3.5 kN and an application factor of 1.2 is required. The reliability goal is 0.90. Find the multiple of rating life X_p required and the catalog rating C_{10} with which to enter a bearing table. Choose a 02 - series bearing and estimate the reliability in use. The Weibull parameters are $X_0 = 0.02, (\theta - X_0) = 4.439$ and $b = 1.483$. 20

1(b) A 02-series single row deep-groove ball bearing with a 30 mm bore is loaded with a 2 kN axial load and a 5 kN radial load. The inner ring rotates at 400 rev/min.
i) Determine the equivalent radial load that will be experienced by particular bearing.
ii) Determine whether this bearing should be expected to carry this load with 95 percent reliability for 10 kN. 15

2 A milled teeth steel pinion and gear pair have $S_{ut} = 113$ kpsi; $S_y = 86$ kpsi and a hardness at the involute surface of 262 Brinell. The diametral pitch is 3 teeth/in., the face width is 2.5 in., and the pinion speed is 870 rev/min. The tooth counts are 20 and 100. Use the Gerber criteria to compensate for one way bending. For a design factor of 1.5, rate the gear set for power considering both bending and wear. 35

3 A 55 × 55 mm ring-oiled full sleeve bearing is lubricated with SAE 40 oil at an inlet temperature of 40^0 C and supports a radial load of 5 kN. The bearing has a journal speed of 1500 rev/min and a radial clearance of 50 μm. The bearing is medium construction ($A = 20\ dl$) and operating in still air. Determine: 35
i) Oil average temperature
ii) Co-efficient of friction
iii) Magnitude of minimum film thickness
iv) Total flow and side flow
v) Maximum oil film pressure
vi) Frictional loss in bearing and
vii) Heat dissipation to the surroundings.

4 A commercial enclosed gear drive consists of helical gears with a 20^0 normal pitch angle and a helix angle of 30^0. A normal diametral pitch of 6 tooth/in. to be considered. The pinion with 16 teeth is driving a 48 tooth gear. The pinion speed is 300 rev/min and the face width is 2 in. The gear are grade 1 steel, through hardened at 200 Brinell, made to No. 6 quality standards, uncrowned, and are to be accurately and rigidly mounted. Assume a pinion life of 10^8 cycles and a reliability of 0.90. Determine the AGMA bending and contact stress and the corresponding factor of safety if 5 hp is to be transmitted. 35

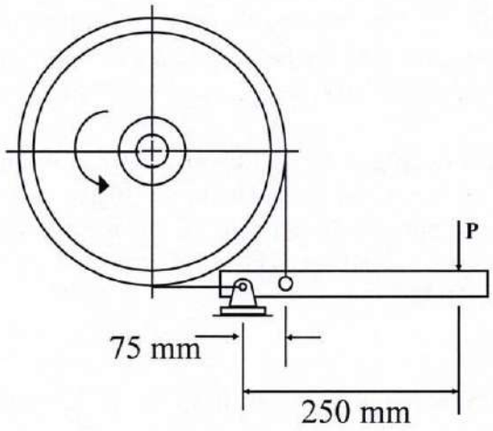
SECTION – B

5 An uncrowned straight-bevel pinion has 30 teeth, a diameteral pitch of 6.5 and a transmission accuracy number of 6.5. The driven gear has 60 teeth. Both are made of grade 80-55-06 ductile iron. The shaft angle is 90^0. The face width is 1.5 in., the pinion 35

speed is 900 rev/min and the normal pressure angle is 20^0. The pinion is mounted outboard of its bearings and the bearings of the gear straddle it. What is the power rating based on AGMA bending strength? Assume the life goal is 10^9 rev. at a reliability of 0.99 and apply factor of safety of 2.

6 Design a cylindrical worm-gear mesh to connect a squired-cage induction motor to a liquid agitator. The motor speed is 1125 rev/min, the velocity ratio to be 10:1. The output power requirement is 25 hp. The shaft axis are 90^0 to each other. An overload factor K_0 of 1.25 is appropriate. Additionally, a design factor of 1.1 is to be included to address other unquantifiable risks. Use AGMA method and worm material as steel (HRC 58) and gear material as Sand-cast bronze. 35

7 The figure depicts a band brake whose drum rotates counter clock wise at 200 rev/min. The drum diameter is 400 mm and the based lining 75 mm wide. The co-efficient of friction is 0.20. The maximum lining interface pressure is 480 kPa. 35
i) Find the brake torque, necessary force P and steady-state power.
ii) Complete the free body diagram of the drum. Find the bearing radial load that a pair of straddle mounted bearings would have to carry.
iii) What is the lining pressure P at both ends of the contact arc?



8 A 60 hp four cylinder internal combustion engine is used to drive a medium-shock brick making machine under a schedule of two shifts per day. The drive consists of two 26 in sheaves spaced about 12 ft apart, with a sheave speed of 400 rev/min. Select a Gates Rubber V-belt arrangement. Find the factor of safety, and estimate the life in passes and hours.

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Department of Mechanical Engineering
B.Sc. Engineering 3rd year Backlog Examination, 2022
ME 3215
(Engineering Metallurgy)

Time: 3 Hours | Total Marks: 210

N.B.: i) Answer any THREE questions from each section in separate scripts.
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SECTION – A

1(a) Is it necessary to calibrate the thermometer for temperature measurement? Explain the scenario. Illustrate Resistance thermometer focusing working principle and calibration method. 13

1(b) Which modification should make for a biological microscope to investigate metallurgical properties? Distinguish between electron and light microscope. 10

1(c) Write down the limitations of ultrasonic inspection. Describe briefly an inspection method which suits you. 12

2(a) Briefly discuss the relation between solid solution and cooling curve. Explain the mechanism of crystallization. 12

2(b) Describe how to draw Type I phase diagram and how to determine chemical compositions and relative amount of phases in two phase region. 15

2(c) Write down the names and general equations of five common reactions that can be found in phase diagrams. 08

3(a) Distinguish between regular tempering and austempering. 10

3(b) Explain the slow cooling of 0.6% carbon steel from molten liquid to room temperature with necessary figures and cooling curve. 25

4(a) Define heat treatment. Briefly discuss different types of defects in heat treatment. 15

4(b) What is spheroidizing? How is it done? Explain. 08

4(c) Write short note on: 12
i.) Carburizing; and ii.) Induction hardening.

SECTION – B

5(a) What is the basic difference between Iron and Steel? Draw the flow diagram for the production of iron and steel. 10

5(b) Describe the manufacturing process of cast iron with the help of Cupola furnace. 15

5(c) What is the effective method for wrought iron production? Why? 10

6(a)	Which method usually is used for higher grade steel production? Explain why?	10
6(b)	Briefly disrobe different types of high speed steel.	15
6(c)	What are the attributes for choosing steel in construction industries? Explain.	10
7(a)	Explain Bayers process for aluminum production.	12
7(b)	What are the materials usually used as spring materials? Mention their applications.	11
7(c)	Write short note on: i.) Babbitt metals; ii.) Yellow metal; iii.) Gun metal; iv.) Monel metal	12
8(a)	How many ways the surface of a material can be treated? Distinguish plating with coating.	10
8(b)	What is thermal spraying? Explain plasma arc spraying with neat sketch.	15
8(c)	What are the basic characteristics of powder material?	10