L-3/T-2/NAME Date: 29/03/2023

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2020-2021

Sub: **NAME 319** (Theory of Machines)

Full Marks: 210 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

Symbols have their usual meanings. Assume reasonable values for any missing data.

The figures in the margin indicate full marks

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE** questions.

1. (a) Explain the procedure of determining degrees of freedom for plane mechanisms by the application of Kutzbach criterion. **(10)**

(b) Fig. for Q. No. 1(b) shows the layout of a quick return mechanism of the oscillating link type, for a special purpose machine. The driving crank BC is 30 mm long and time ratio of the working stroke to the return stroke is to be 1.7. If the length of the working stroke of R is 120 mm, determine the dimensions of AC and AP. **(10)**

(c) What do you mean by inversion of mechanism? Schematically explain the inversion of single slider crank chain mechanism. **(15)**

2. (a) Define instantaneous centre. Schematically explain the location of instantaneous centres in case of a mechanism. **(10)**

(b) The crank OA of a mechanism, as shown in Fig. for Q. No. 2(b), rotates clockwise at 120 r.p.m. The lengths of various links are: **(25)**

OA = 100 mm; AB = 500 mmi AC = 100 mm and CD = 750 mm

Find, by instantaneous centre method :

i) velocity of point C

ii) velocity of slider D, and

iii) angular velocities of the links AB and CD.

3. (a) What do you understand by coriolis component of acceleration? Schematically determine the acceleration at the mid-point of a connecting rod in case of slider crank mechanism. **(12)**

(b) In the mechanism shown in Fig. for Q. No. 3(b), the slider C is moving to the right with a velocity of 1m/s and an acceleration of 2.5 m/s^2.

The dimensions of various links are AB = 3 m inclined at 45° with the vertical and BC = 1.5 m inclined at 45° with the horizontal. **(23)**

Determine:

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Contd... Q. No. 3(b)

i) the magnitude of vertical and horizontal component of the acceleration of the point B, and

ii) the angular acceleration of the links AB and BC.

4. (a) Write short notes on – **(4×2=8)**

i) slip of belt

ii) creep of belt

(b) A shaft which rotates at a constant speed of 160 r.p.m. is connected by belting to a parallel shaft 720 mm apart, which has to run at 60, 80 and 100 r.p.m. The smallest pulley on the driving shaft is 40 mm in radius. Determine the remaining radii of the two stepped pulleys for **(17)**

i) a crossed belt, and

ii) an open belt.

Neglect belt thickness and slip. The mechanism is shown in Fig. for Q. No. 4(b).

(c) Define centrifugal tension in case of a flat belt drive. Derive the expression, **(10)**

$$2.3\log\left(\frac{T_{t1}-T_c}{T_{t2}-T_c}\right)=\mu\theta,$$

where the Symbols have their usual meanings.

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) The motion of a particle is given by $a = t^3-3t^2+5$, where "a" is the acceleration in ms^{-2} and "t" is the time in seconds. The velocity of the particle at t = 1 second is 6.25 ms^{-1} and the displacement is 8.30 meter. Calculate the displacement and velocity at t = 2 seconds. **(12)**

(b) From the acceleration vs time graph given in Fig. for Q. no. 5(b), find the initial velocity of a body if its final velocity is 55 ms^{-1}. **(08)**

(c) Investigate the nature of acceleration for a particle traveling along a circular path and demonstrate how it can be analyzed as the combination of two distinct components. Develop the equations that characterize there components and identify the circumstances under which each component would have a null value. **(15)**

6. (a) A mass M of 75 Kg is hung from a rope wrapped round a drum of effective radius of 0.3 meter, which is keyed to shaft A. The shaft A is geared to shaft B which runs at 6 times the speed of shaft A. The total mass moment of inertia of the masses attached to shaft A is 100 Kg-m and that of shaft B is 5 $kg\text{-}m^2$. **(17)**

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Contd... Q. No. 6(a)

Find the acceleration of mass M if it is allowed to fall freely and when the efficiency of the gearing system is 90%. The configuration of the system is shown in Fig. for. Q. No. 6(a).

(b) A container ship and a tanker ship are moving in the same direction, with the tanker moving at a faster speed. As the tanker approaches from behind, it collides with the rear of the container ship. During the collision, the kinetic energy and momentum of the system are conserved. Formulate an equation to determine the kinetic energy lost during the collision. **(18)**

If the mass of the container ship is 50,000 Kg and the mass of the tanker is 80,000 Kg, and the initial velocity of the container ship is 10 ms^{-1} and that of tanker is 20 ms^{-1}, determine the kinetic energy lost during the impact (e=0.8)

7. (a) A cargo ship is sailing in rough seas when it is struck by a large wave. As a result the ship experiences a strong rotational force, causing it to pitch and roll. Some time later the same ship is struck by another wave but this time the ship displaces without experiencing any pitch or roll. What is this difference between the two instances? Discuss. **(5)**

(b) A small connecting rod of mass 1.5 Kg is suspended in a horizontal plane by two wires 1.25 m long. The wires are attached to the rod at points 120 mm on either side of the center of gravity. If the rod makes 20 oscillations in 40 seconds, find the radius of gyration and the mass moment of inertia of the rod about a vertical axis through the center of gravity. **(10)**

(c) Fig. for Q. no. 7(c) shows a mechanism in which OA = QC = 100 mm, AB = QB = 300 mm and CD = 250 mm. The crank rotates at 150 rpm in the clockwise direction. Determine the velocity of the slider at D, angular velocity of link QB and AB and rubbing velocity at the pin B which is 40 mm in diameter. **(20)**

8. (a) A conical pivot supports a load of 20 kN, the cane angle is 120° and the intensity of normal pressure is not to exceed 0.3 Nmm^{-2}. The external diameter is twice the internal diameter. Find the outer and inner radii of the bearing surface. If the shaft rotates at 200 r.p.m and the coefficient of friction is 0.1, find the power absorbed in friction. (Assume uniform pressure) **(17)**

(b) The pitch of 50 mm mean diameter threaded screw of a screw jack is 12.5 mm. The co-efficient of friction between the screw and the nut is 0.13. Determine the torque required on the screw to raise a load of 25 kN, assuming the load to rotate with the screw. Determine the ratio of the torque required to raise the local and torque required to lower the load. Also determine the efficiency of the machine. **(18)**

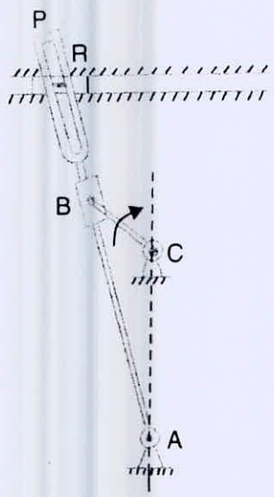

Fig. for Q. No. 1(b)

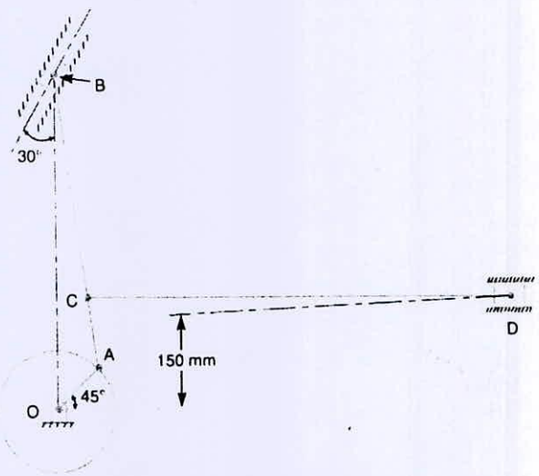

Fig. for Q. No. 2(b)

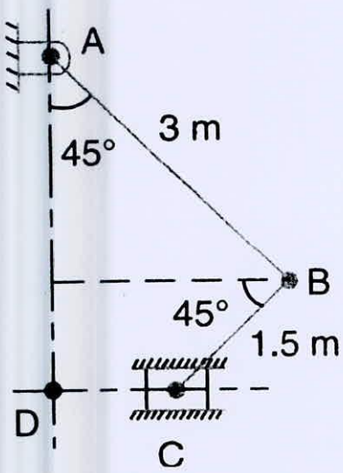

Fig. for Q. No. 3(b)

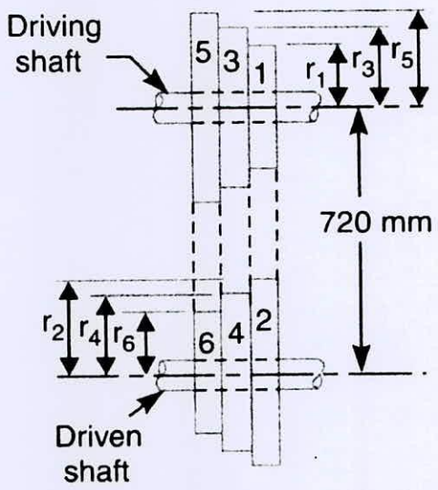

Fig. for Q. No. 4(b)

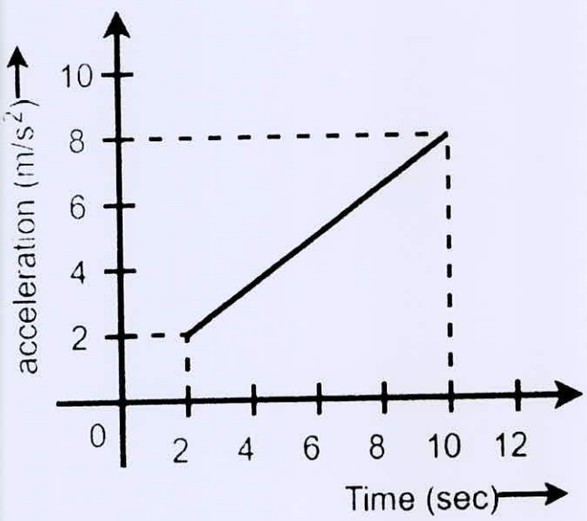

Fig. for Q.no-5(b)

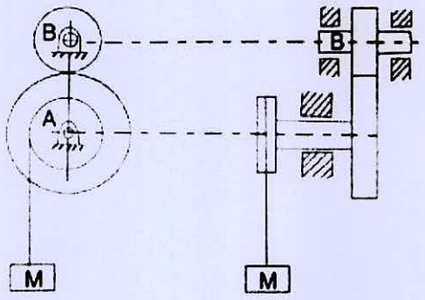

Fig for. Q.no 6(a)

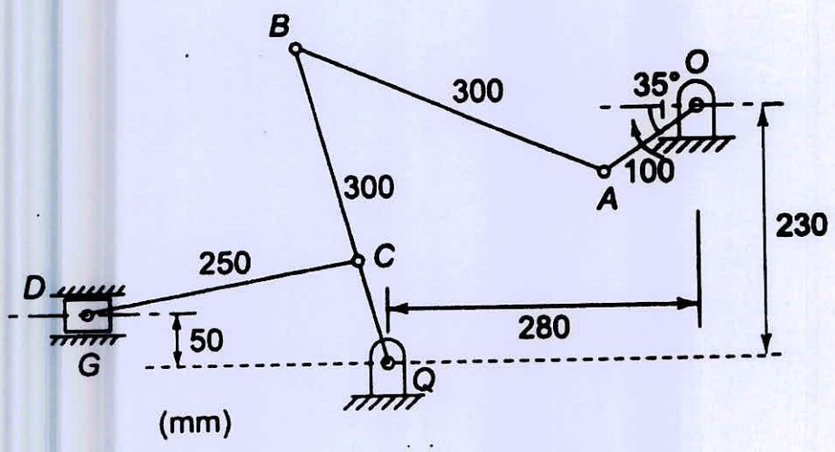

Fig. for. Q.no 7(c)

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2020-2021

Sub: **NAME 329** (Heat Transfer)

Full Marks: 210 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE** questions.

1. (a) Prove that for flow over a flat plate, pressure remains constant over the entire plate. **(10)**

(b) The flow of oil in a Journal bearing can be approximated as parallel flow between two large plates with one plate moving and the other stationary. Such flows are known as couette flow. Consider two large isothermal plates separated by 2 mm thick oil film. The upper plate moves at a constant velocity of 12 m/s, while the lower plate is stationary. Both the plates are maintained at 20°C. **(25)**

Obtain the followings:

i) the relations for the velocity and temperature distributions in the oil.

ii) the maximum temperature in the oil.

iii) the heat flux from the oil to each plate.

The properties of oil at 20°C are K = 0.145 w/m.k and $\mu = 0.800$ Ns/m^2.

2. (a) Derive the expression of velocity boundary layer thickness for flow over a flat plate within laminar region. **(20)**

(b) Engine oil at 60°C flows over the upper surface of a 5m long flat plate whose temperature is 20°C with a velocity of 2 m/s as shown in Figure for Question No. 2(b). Determine the total drag force and the rate of heat transfer per unit width of the entire plate. **(15)**

The properties of engine oil at the film temperature are:

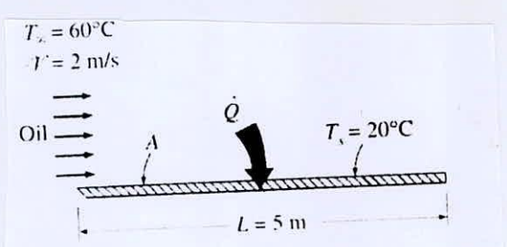

Figure for Question No. 2(b)

Contd …… P/2

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3. (a) Consider an inclined cold plate as shown in Figure for Question No. 3(a). How will the buoyancy driven flow take place on the upper and lower surface of the cold plate? Justify your answer with necessary figure(s). **(10)**

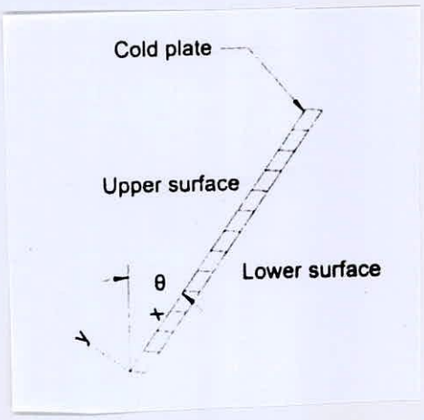

Figure for Question No. 3(a)

(b) Explain the natural convection flow on the upper and lower surface of a horizontal hot plate with necessary figure (s). **(5)**

(c) Explain the boundary layer flow over a cold horizontal cylinder due to natural convection. **(5)**

(d) A 6m long section of an 8 cm diameter horizontal hot water pipe passes through large room whose temperature is 20°C. If the outer surface temperature of the pipe is 70°C, determine the rate of heat loss from the pipe by natural convention. Also, discuss the effect of radiation heat transfer in this case. The properties of air at the film temperature are: **(15)**

$$k = 0.02699 \quad W/m.^{\circ}C \qquad \Pr = 0.7241$$
$$\nu = 1.749 \times 10^{-5} \quad m^2/s \qquad \beta = \frac{1}{T_f} = \frac{1}{318} k$$

4. (a) State and explain the observations made from the graph of spectral blackbody emissive power vs. wavelength for different temperatures. **(10)**

(b) Show that the net rate of radiation heat transfer between two non-black bodies is given by: **(10)**

$$\dot{Q}net = \frac{\sigma\left(T_1^4 - T_2^4\right)}{\frac{1-\varepsilon_1}{A_1\varepsilon_1} + \frac{1}{A_1 F_{12}} + \frac{1-\varepsilon_2}{A_2\varepsilon_2}}$$

where symbols have their usual meanings.

Contd P/3

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Contd... Q. No. 4

(c) A furnace is shaped like a long equilateral triangular duct, as shown in Figure for Question No. 4(c). The width of each side is 1 m. The base surface has an emissivity of 0.7 and is maintained at a uniform temperature of 600k. The heated left side surface closely approximates a blackbody at 1000k. The right side surface is well insulated. Determine the rate at which heat must be supplied to the heated side externally per unit length of the duct in order to maintain these operating conditions. **(15)**

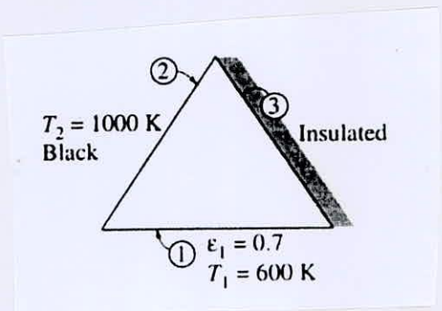

Figure for Question No. 4(c)

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) A test conducted to determine the overall heat transfer coefficient in an automotive radiator that is a compact cross-flow water-to-air heat exchanger with both fluids (air and water) unmixed as shown in Fig. for Q. No. 5(a). The radiator has 40 tubes of internal diameter 0.5 cm and length 65 cm in a closely spaced plate-finned matrix. Hot water enters the tubes at 90°C at a rate of 0.6 kg/s and leaves at 65°C. Air flows across the radiator through the interfin spaces and is heated from 20°C to 40°C. Determine the overall heat transfer coefficient U_i of this radiator based on the inner surface area of tubes. **(15)**

(b) What are the common causes of fouling in a heat exchanger? How does fouling affect heat transfer and pressure drop? **(10)**

(c) A heat exchanger is to be selected to cool a hot liquid chemical at a specified rate to a specified temperature. Explain the steps involved in the selection process. **(10)**

6. (a) In a production facility, large brass plates of 4 cm thickness that are initially at a uniform temperature of 20°C are heated by passing them through an oven that is maintained at 500°C as shown in Fig. for Q. No. 6(a). The plates remain in the oven for a period of 7 min. Taking the combined convection and radiation heat transfer coefficient to be h = 120 W/m^2, °C, determine the surface temperature of the plates when they come out of the oven. **(15)**

Contd P/4

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Contd... Q. No. 6

(b) What is lumped system analysis? Discuss the criteria for lumped system analysis. **(12)**

(c) What is an infinitely long cylinder? When is it proper to treat an actual cylinder as being infinitely long, and when is it not? **(8)**

7. (a) Steam in a heating system flows through tubes whose outer diameter is D_1 = 3 cm and whose walls are maintained at a temperature of 120°C. Circular aluminum fins (k = 180 W/m. °C) of outer diameter D_2 = 6 cm and constant thickness t = 2 mm are attached to the tube, as shown in Fig. for Q. No. 7(a). The space between the fins is 3 mm, and thus there are 200 fins per meter length of the tube. Heat is transferred to the surrounding air at T_∞ = 25 °C, with a combined heat transfer coefficient of h = 60 W/m2. °C. Determine the increase in heat transfer from the tube per meter of its length as a result of adding fins. **(15)**

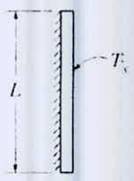
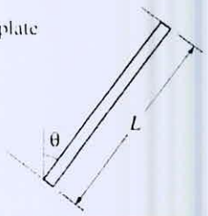
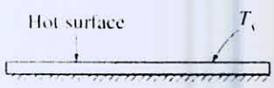
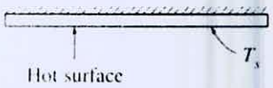
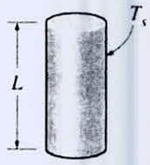
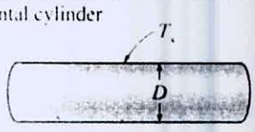
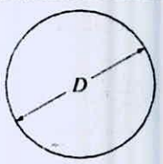
(b) With the help of necessary figure and assumptions, derive the equation of temperature distribution and heat transfer rate of an infinitely long fin. **(12)**

(c) Define the logarithmic mean temperature difference ΔT_{lm} of a heat exchanger. Can it be a negative quantity? Explain. **(8)**

8. (a) Consider a 1.2-m-high and 2-m-wide double-pane window as shown in Fig. for Q. No. 8(a) consisting of two 3-mm-thick layers of glass (k = 0.78 W/m. °C) separated by a 12-mm-wide stagnant air space (k = 0.026 W/m. °C). Determine the steady rate of heat transfer through this double-pane window and the temperature of its inner surface for a day during which the room is maintained at 24°C while the temperature of the outdoors is – 5°C. Take the convection heat transfer coefficients on the inner and outer surface of the window to be h_1 = 10 W/m^2. °C and h_2 = 25 W/m^2. °C, and disregard any heat transfer by radiation. **(20)**

(b) How does transient heat transfer differ from steady heat transfer? Discuss briefly. **(7)**

(c) What is the critical radius of insulation? How is it defined for a cylindrical layer? **(8)**

	Characteristic length L_c	Range of Ra	Nu
Vertical plate 	L	10^4–10^9 10^9–10^{13} Entire range	$Nu = 0.59Ra_L^{1/4}$ (9-19) $Nu = 0.1Ra_L^{1/3}$ (9-20) $Nu = \left\{0.825 + \frac{0.387Ra_L^{1/6}}{[1 + (0.492/Pr)^{9/16}]^{8/27}}\right\}^2$ (9-21) (complex but more accurate)
Inclined plate 	L		Use vertical plate equations for the upper surface of a cold plate and the lower surface of a hot plate Replace g by $g\cos\theta$ for $Ra < 10^9$
Horiontal plate (Surface area A and perimeter p) (*a*) Upper surface of a hot plate (or lower surface of a cold plate)  (*b*) Lower surface of a hot plate (or upper surface of a cold plate) 	A_s/p	10^4–10^7 10^7–10^{11} 10^5–10^{11}	$Nu = 0.54Ra_L^{1/4}$ (9-22) $Nu = 0.15Ra_L^{1/3}$ (9-23) $Nu = 0.27Ra_L^{1/4}$ (9-24)
Vertical cylinder 	L		A vertical cylinder can be treated as a vertical plate when $D \geq \frac{35L}{Gr_L^{1/4}}$
Horizontal cylinder 	D	$Ra_D \leq 10^{12}$	$Nu = \left\{0.6 + \frac{0.387Ra_D^{1/6}}{[1 + (0.559/Pr)^{9/16}]^{8/27}}\right\}^2$ (9-25)
Sphere 	D	$Ra_D \leq 10^{11}$ ($Pr \geq 0.7$)	$Nu = 2 + \frac{0.589Ra_D^{1/4}}{[1 + (0.469/Pr)^{9/16}]^{4/9}}$ (9-26)

NAME 329: Table for question No. 3(d)

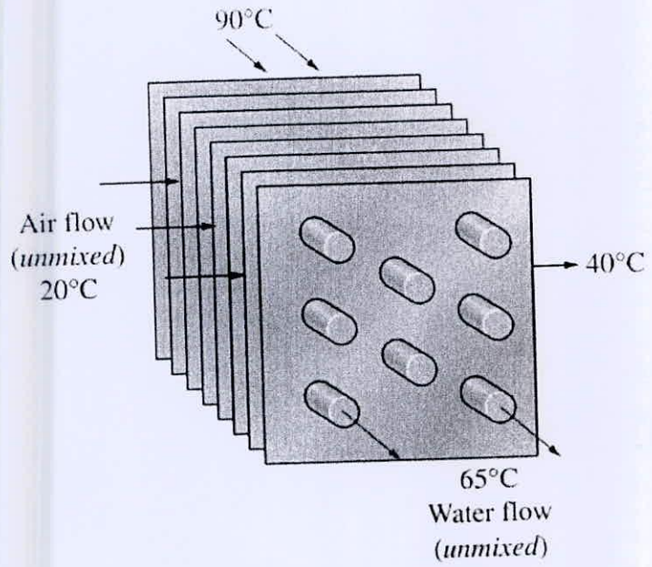
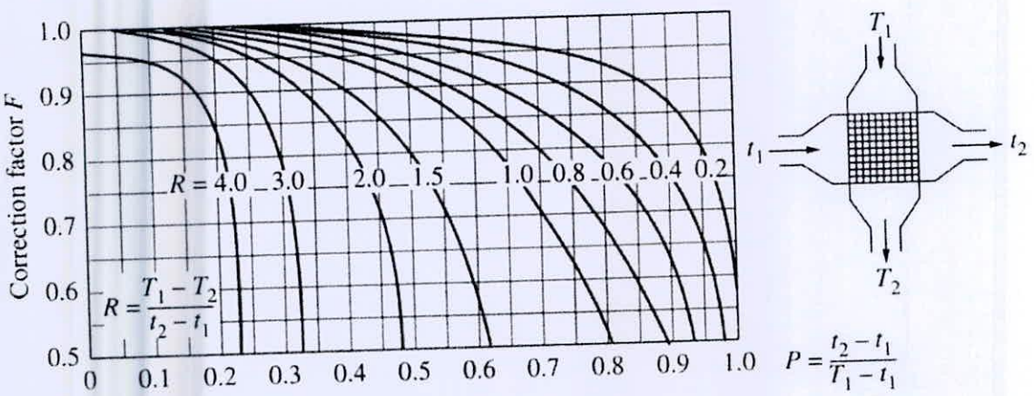


Fig. for Q. No. 5(a)



(c) Single-pass cross-flow with both fluids *unmixed*

Correction factor F chart for Q. No. 5(a)

$T_\infty = 500°C$

$h = 120\ W/m^2.°C$

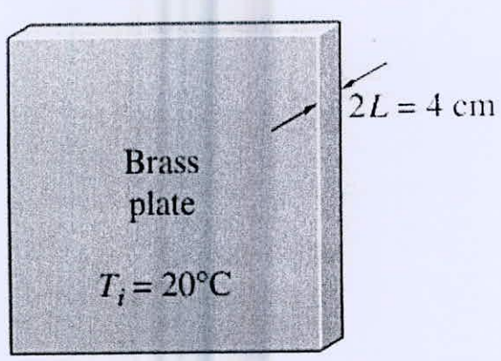


Fig. for Q. No. 6(a)

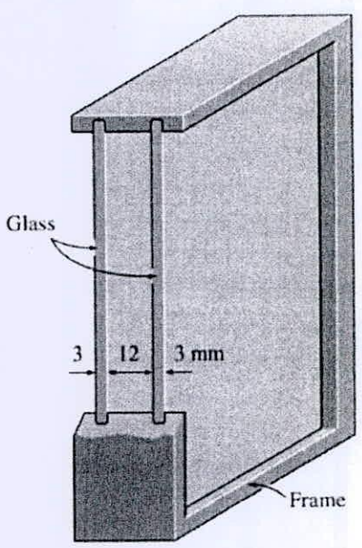
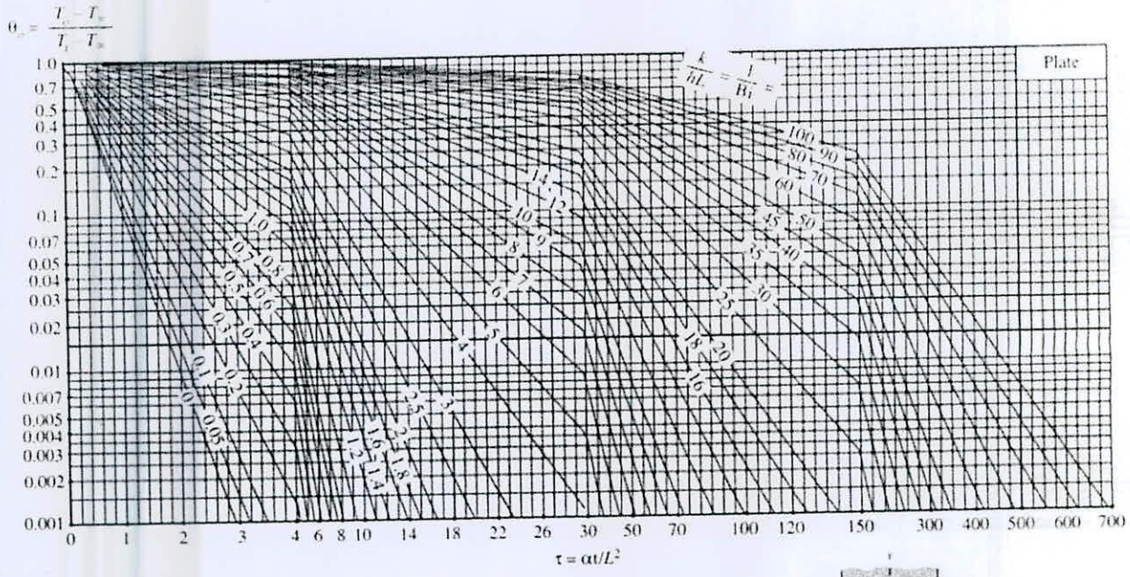
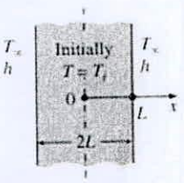
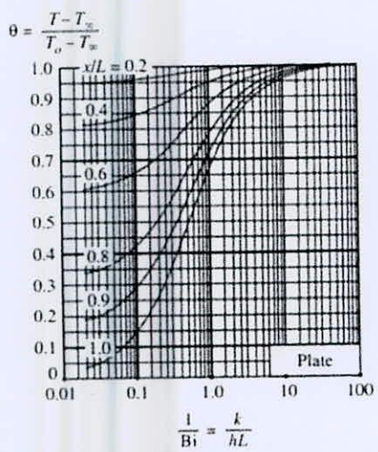


Fig. for Q. No. 8(a)

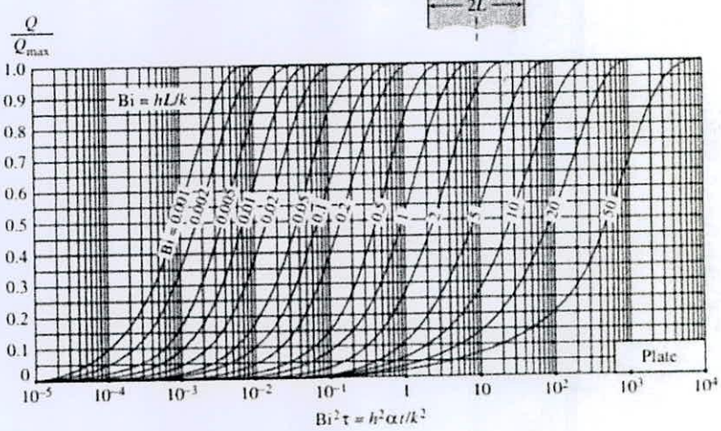


(*a*) Midplane temperature (from M. P. Heisler)





(*b*) Temperature distribution (from M. P. Heisler)



(*c*) Heat transfer (from H. Gröber et al.)

FIGURE 4–18

Transient temperature and heat transfer charts for a plane wall of thickness $2L$ initially at a uniform temperature T_i subjected to convection from both sides to an environment at temperature T_∞ with a convection coefficient of h.

Chart for Q. No. 6(a)

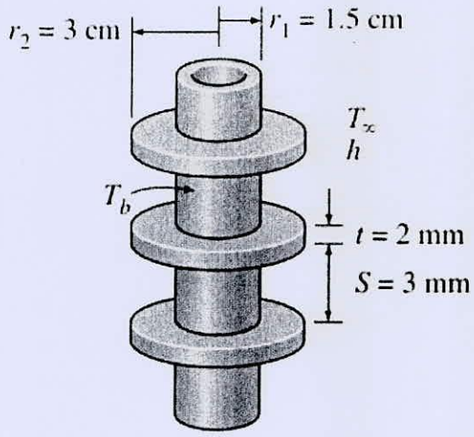


Fig. for Q. No. 7(a)

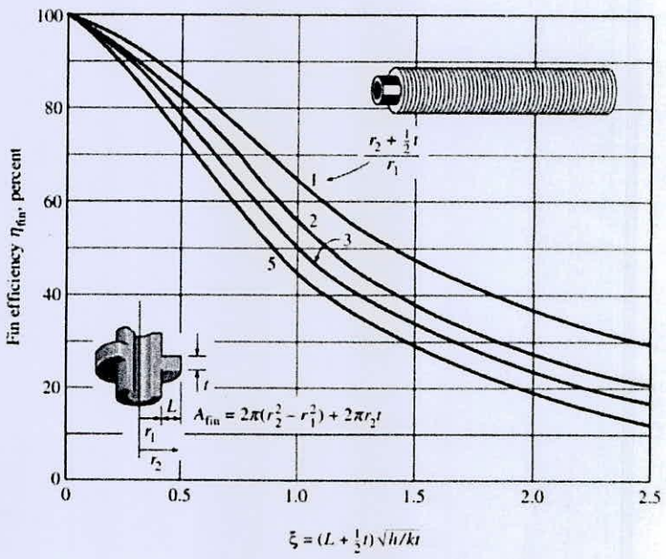


FIGURE 3-19C
Efficiency of circular fins of length L and constant thickness t (from Gardner, Ref. 6).

Chart for Q. No. 7(a)

L-3/T-2/NAME **Date: 12/04/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2020-2021

Sub: (Design of Special ships)

Full Marks: 210 **NAME 347** Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE** questions.

Assume reasonable data for missing values, if any

1. (a) The piping system is the lifetime of an oil tanker. Explain the vital pipes that make up an oil tanker piping system and also classify the three fundamental types of piping system, found in an oil taker, with brief description. **(15)**

   (b) If you were to visually compare the midship sections of a single hull tanker and double hull tanker, what would you observe? Demonstrate these differences with the help of clear illustrations. **(20)**

2. (a) To what extent does the itinerary and intended usage of a fishing boat impact its functional design. **(18)**

   (b) For a deep-sea traveler having length of 220 ft, calculate the probable displacement using Posdunine expression, also calculate C_b and C_w. Assume reasonable free running speed. **(17)**

3. (a) How can the broad range of tanks performed by warships, including peacetime, patrols, disaster relief, heightened tension scenarios and full blown conflict, be demonstrate through examples of joint operations? Also, how does the design of a warship reflect its ability to carry out various missions effectively? **(18)**

   (b) Estimate the principle particulars of a container vessel that neets the following requirement. **(17)**

   i) 1500 containers (6.05m × 2.43m × 2.43m) of which 1100 containers will be in hold and the rest on deck ii) Service speed 15 knots iii) Service draught 8.0m.

   Assume the containers are 7 high in each cell with 10 cells across the ship. For the engine room length make appropriate assumption.

4. (a) As a Naval Architect, if you are approached to design a passenger vessel, what questions should you ask the owners which will help you to determine the principal dimensions of the vessel? Mention your justifications behind the questions. **(15)**

   (b) Briefly discuss some of the unique features of a passenger vessel. **(10)**

Contd P/2

NAME 347

Contd... Q. No. 4

(c) "Keeping in view the safety aspect as well as the comfort level, it is a challenging task for the designer to keep the GM at it's minimum possible value, " Why? How can you counter this difficulty? **(10)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Classify different types of tug boats and outline the fundamental prerequisites that are common to all types of tugs. **(15)**

(b) A dock tug has the following characteristics: **(20)**

Length = 97.23 ft

Breadth = 24.31 ft

Draft = 14.83 ft

Free Board = 2.43 ft

Block Coefficient = 0.49

Water plane area Coefficient = 0.7

Calculate the Metacentric height GM for the vessel if KG = 22.55 ft. Explain your observations on the tugs stability.

6. (a) Draw and explain the midship section of a R_0R_0 ferry. What are the key features that makes a R_0R_0 ferry different from conventional ships? **(20)**

(b) In your own words, explain the safety issues of R_0R_0 ferries operating in the inland waterways of Bangladesh. **(15)**

7. (a) Describe the contrasting features of a conventional submarine and a surface ship. Draw necessary schematic diagrams to support your arguments. **(18)**

(b) Explain the factors that affect the stability of a submarine. Draw necessary figures in this regard. **(17)**

8. (a) Make a comparison of hull forms of container ships, bulk carriers and oil tankers. **(15)**

(b) What is the significance of torsion box in a container vessel? How does it serve to provide strength of the ship? Explain with necessary figures. **(20)**

L-3/T-II/NAME **Date : 06/05/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-II B. Sc. Engineering Examinations 2020-2021

Sub : **NAME 355** (Ship Construction)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

The symbols have their usual meanings. Assume reasonable value for missing data.

1. (a) What are the technical specifications for ship contracts? **(5)**

   (b) Describe the surveys conducted by Classification societies? **(8)**

   (c) Which decisions are required for planning an effective shipyard layout? Provide such a layout. **(12)**

   (d) Discuss the advantages and disadvantages of aluminium as shipbuilding material. **(10)**

2. (a) Explain cargo pumping and piping arrangements in Tankers with neat sketch. **(15)**

   (b) What is inert gas system and why is it required in Tankers? Explain its procedure and arrangements. **(12)**

   (c) Write short notes on following: **(8)**

   (i) Admiralty pattern anchor

   (ii) Stress corrosion

3. (a) Why surface preparation is required before painting? Describe the common methods to prepare steel surfaces. **(13)**

   (b) Describe the paint systems on ships dictated by the environment. **(12)**

   (c) "The attachment between aluminium superstructures to steel hull requires special attention" –Explain this with necessary figures. **(10)**

4. (a) Explain an erection sequence for a dry cargo bulk carrier. **(7)**

   (b) Describe the traditional heated frame bending for a ship with figure. **(8)**

   (c) What is stress concentration factor? Explain the effect of the following on stress concentration factor- **(20)**

   (i) Corner radius for rectangular openings

   (ii) Shape and orientation of rectangular openings.

Contd P/2

NAME 355

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Mention the functions of bulkhead. What are the advantages of corrugated bulkhead over plain bulkhead? **(15)**

   (b) Explain the function of pillars. With neat sketches describe different types of pillar construction. **(12)**

   (c) Why fore end structure is important for a ship? Explain. **(8)**

6. (a) Differentiate between single bottom structure and double bottom structure, with appropriate schematic representation. **(11)**

   (b) Discuss the procedure of ensuring local strengthening of shell plating in case of a ship structure. **(12)**

   (c) Using suitable sketch (if necessary), distinguish the following terms: **(2×6=12)**

   (i) Duct keel and bilge keel

   (ii) Longitudinal framing system and transverse framing system.

7. (a) Schematically describe different types of rudders. How can you construct a rudder? **(15)**

   (b) Discuss different types of stern construction. **(10)**

   (c) Make a comparison between hatch coamings and hatch covers. **(10)**

8. (a) Discuss the importance of incorporating bulbous bows in a ship structure. **(10)**

   (b) Mention the location of chain locker in a ship. Briefly describe the construction of a chain locker. **(13)**

   (c) With appropriate sketches, distinguish between superstructures and deckhouses. **(12)**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2020-2021

Sub: **NAME 363** (Computational Fluid Dynamics)

Full Marks: 210 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE** questions.

1. (a) Define CFD? What are the possible sources of error involved in CFD? **(10)**

(b) Determine the forward difference approximation formulae for $\frac{\partial t}{\partial x}$ and $\frac{\partial^2 t}{\partial x^2}$ by fitting a third degree polynomial $f(x) = Ax^3 + Bx^2 + Cx + D$ through the four equally spaced points at x_{i+3}' x_{i+2}' x_{i+1}' and x_i **(15)**

(c)Compute the first derivative of the function $f(x) = tan\left(\frac{\pi x}{4}\right)$ at x = 1.5 using first order forward and backward approximations using step sizes of 0.01 and 0.1. **(10)**

2. (a) Derive the shape functions for two-dimensional quadrilateral element with respect to natural co-ordinate. **(15)**

(b) Derive the Euler-Lagrange equation for the necessary condition of a functional to have an extreme value. **(20)**

3. (a) What are the differences between structured and unstructured grid? Transform the physical domain as given in Fig. for Q. No. 3(a) defined by L = 4, H_1 = 2 and H_2 = 4 into computational domain using algebraic grid generation technique. **(15)**

(b) Show that the integration of the polynomial terms in the area co-ordinate of triangular element can be expressed as **(20)**

$$I = \int_A L_1^m L_2^n L_3^p \, dA = \frac{m!\, n!\, p!}{(m+n+p+2)!} 2A$$

4. Solve the two-dimensional boundary value problem $\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{dy^2} = -2$ with v =0 on the boundary of the square $0 < \lambda \leq 1$. o<y≤1 by finite element method. The domain is to be discretized as given in Fig. for Q. No. 4. **(35)**

Contd P/2

NAME 363

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Derive the integral form of the transport equation for unsteady fluid motion. **(17)**

(b) Describe different steps of finite volume method for two and three dimensional steady diffusion problems. **(18)**

6.

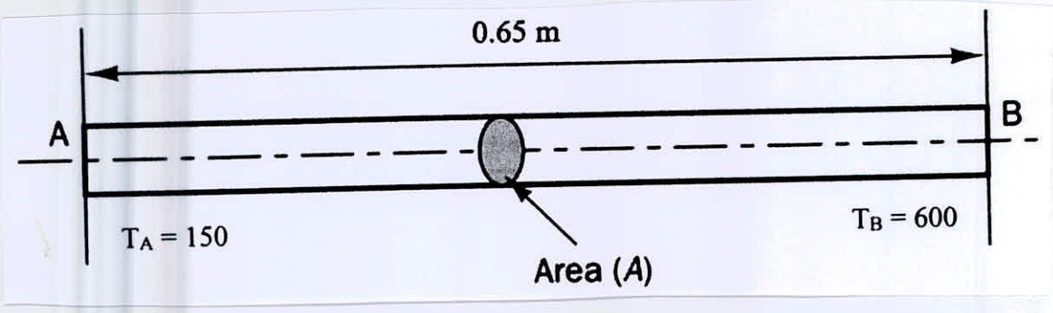


Fig. for Q. No. 6

Consider the problem of source-free heat conduction in an insulated rod whose ends are maintained at constant temperatures of 150 °C and 600 °C respectively. Calculate the steady state temperature distribution in the rod by dividing the domain into five control volumes. Thermal conductivity k equals 1050 W/m.K, cross-sectional area A is 12.5×10^{-3} m^3. **(35)**

7. Explain finite volume method for one dimensional unsteady heat conduction using Crank-Nicolson scheme. **(35)**

8. In Fig. for Q. No. 8, a two-dimensional plate of thickness 1 cm is shown. The thermal conductivity of the plate material is k = 1050 W/m.K. The west boundary receives a steady heat flux of 500 kW/m^2 and the south and east boundaries are insulated. If the north boundary is maintained at a temperature of 100 °C, using a uniform grid with $\Delta x = \Delta y = 0.1$ m, calculate the steady state temperature distribution at Nodes 1-8 after first iteration. **(35)**

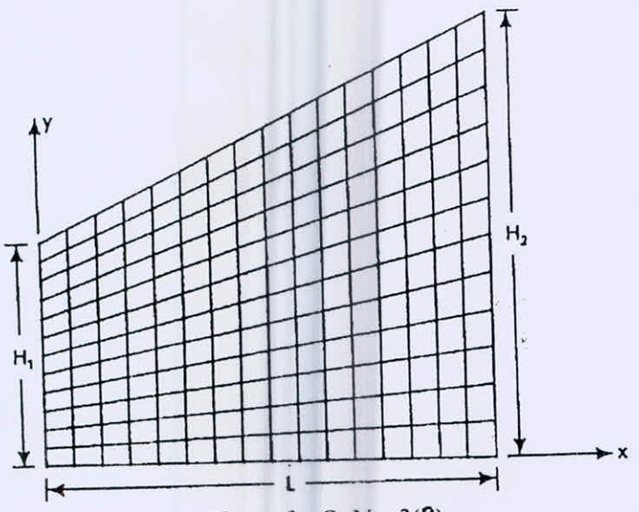


Figure for Q. No. 3(a)

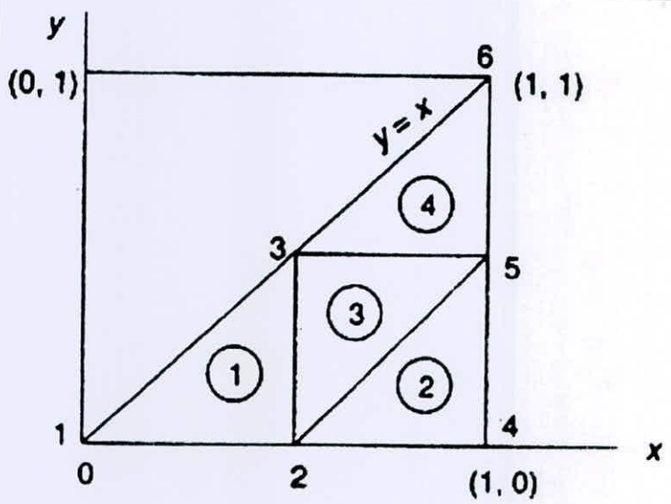


Figure for Q. No. 4

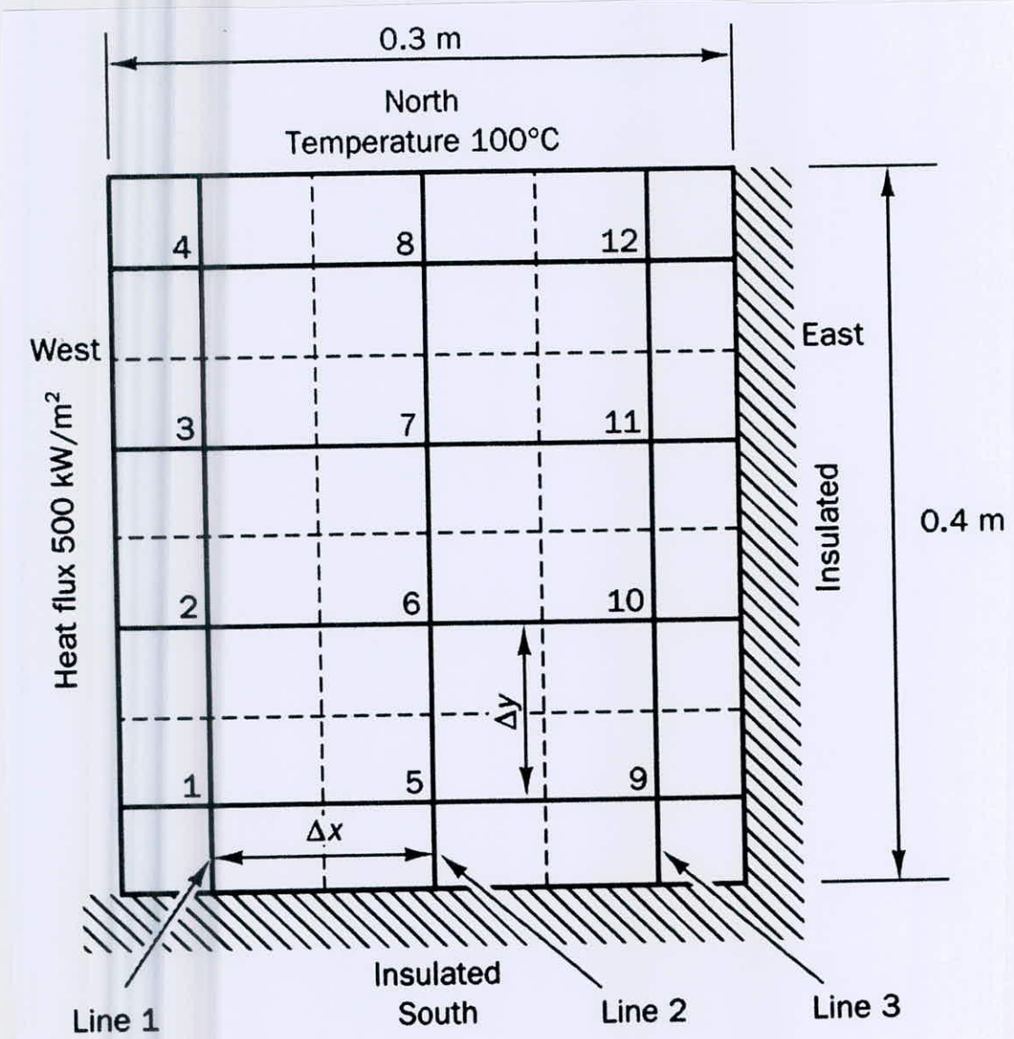


Fig. for Q. No. 8

L-3/T-2/NAME **Date: 30/04/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2020-2021

Sub: **MATH 381** (Fourier Analysis, Harmonic Function, Complex Variable and Laplace Transform)

Full Marks: 280 Time: 3 Hours

The figures in the margin indicate full marks

Symbols used have their usual meaning.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE** questions.

1. (a) If z_1 and z_2 are two complex numbers with $z_1 z_2$ real and non-zero. Then show that there exists a real number α such that $z_1 = \alpha \bar{z}_2$. **(8⅔)**

(b) Test the analyticity of the following functions and determine where they are differentiable. **(9+9=18)**

(i) $f(z) = -ie^{iz}$ and (ii) $f(z) = \ln(z)$.

(c) Find all roots of the equation $\sin z = \cosh 4$ by equating the real and imaginary parts of $\sin z$ and $\cosh 4$. **(10)**

(d) Show that the transformation $w = \dfrac{2z+3}{z-4}$ transform the circle $x^2 + y^2 - 4x = 0$ into a straight line. **(10)**

2. (a) Prove that $u = x^2 - y^2$ and $v = \dfrac{y}{x^2+y^2}$ are harmonic function of (x, y), but they are not harmonic conjugate. **(15)**

(b) Write $|\exp(2z'+i)|$ and $|\exp(iz^2)|$ in terms of x and y. Then show that **(15)**

$$|\exp(2z+i)+\exp(iz^2)| \le e^{2x} + e^{-2xy}$$

(c) Evaluate the integral, $\int_i^{2-i} (3xy + iy^2)\,dz$ along the straight line joining $z = i$ and $z = 2 - i$. **(16⅔)**

3. (a) Use Cauchy's Integral formula to evaluate the integral, $\oint_C \dfrac{\cos \pi z}{z^2-1}\,dz$ where C is a rectangle with vertices at $\pm i$, $2 \pm i$. **(15)**

(b) Express $f(z) = \dfrac{z^2-1}{(z+2)(z+3)}$ in a Laurent series valid in the region $2 < |z| < 3$. **(15⅔)**

(c) Evaluate the integral $\oint_C \dfrac{z^3}{(z-1)^2(z-2)(z-4)}\,dz$ by Cauchy's residue theorem, where $C: |z| = 3$. **(16)**

Contd P/2

MATH 381/NAME

4. Evaluate the following integrals by contour integration: **(23+23⅔=46⅔)**

(a) $\int_0^{\infty} \frac{\ln(1+x^2)}{1+x^2}$

(b) $\int_0^{\pi} \frac{d\theta}{3+2\cos\theta}$.

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE** questions.

5. (a) Find the Fourier expansion of the function $f(x)=x+x^2$ defined over the interval $-\pi < x < \pi$. Hence deduce that $\frac{\pi^2}{6}=1+\frac{1}{2^2}+\frac{1}{3^2}+\frac{1}{4^2}+\cdots$. **(16⅔)**

(b) State Parseval's theorem. Find the Fourier sine transform of $\frac{e^{ax}}{x}(a>0)$ and hence establish the result $\int_0^{\infty} \frac{e^{-ax}-e^{-bx}}{x}\sin sx\,dx = \tan^{-1}\frac{b}{s}-\tan^{-1}\frac{a}{s}$. **(15)**

(c) Use the Fourier integral of $f(x)=\begin{cases}1, & |x|\le 1\\ 0, & |x|\ge 1\end{cases}$ to compute $\int_0^{\infty}\frac{\sin u}{u}\,du$. **(15)**

6. (a) Derive Fourier Transform from Fourier Series. **(15)**

(b) Find the steady temperature inside a solid sphere of unit radius if one hemisphere of its surface is kept at temperature zero and the other at temperature unity. **(16⅔)**

(c) Derive the Laplace's equation in spherical polar coordinates. **(15)**

7. (a) Define Laplace transform of a periodic function. Hence find the Laplace transform of the square wave shown in Fig. 1. **(15)**

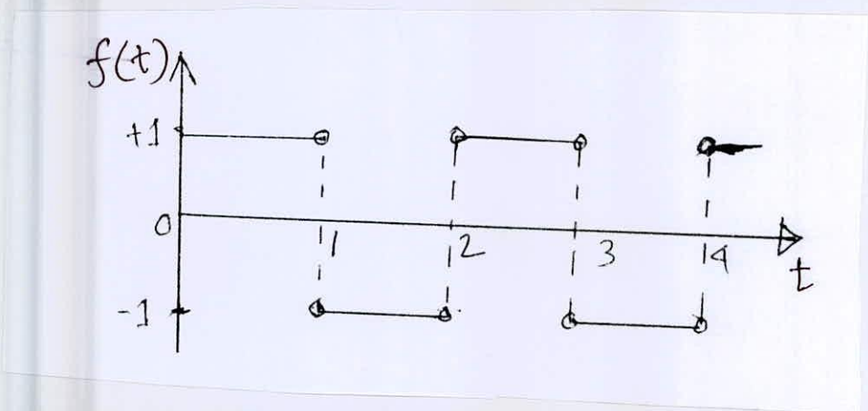


Fig. 1 A square wave

Contd P/3

MATH 381/NAME

Contd.... for Q. No. 7

(b) Apply the property $L\left\{\frac{f(t)}{t}\right\} = \int_s^\infty F(u)du$, where $L\{f(t)\} = F(s)$ to show that **(15)**

$$\int_0^\infty \frac{e^{-3t} - e^{-6t}}{t} dt = \log 2 .$$

(c) State Convolution theorem for inverse Laplace transform. Hence use the theorem to compute $L^{-1}\left\{\frac{1}{(s-1)(s^2+1)}\right\}$. **(16⅔)**

8. (a) Describe Heaviside expansion formula for inverse Laplace transform. Hence using the formula find $L^{-1}\left\{\frac{s+5}{(s+1)(s^2+1)}\right\}$. **(16⅔)**

(b) Apply Laplace transforms of derivatives to solve the initial value problem **(15)**

$$\frac{d^2x}{dt^2} + 6\frac{dx}{dt} + 9x = \sin t (t \geq 0); \quad x(0) = x'(0) = 0 .$$

(c) Using Laplace transform solve the simultaneous differential equations **(15)**

$3x' + y' + 2x = 1, x' + 4y' + 3y = 0$ subject to the conditions $x(0) = 0,\ y(0) = 0$
