L-3/T-2/NAME **Date: 22/03/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2019-2020

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

Full Marks: 210 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

Assume reasonable value for missing data (if any)

SECTION – A

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

1. (a) The motor shaft A exerts a constant torque of 100 N-m and is geared to shaft B as shown in Fig. for Q. No. 1(a). The moments of inertia of the parts attached to the motor shaft A is 2 kg-m^2 and that of the parts attached to another shaft B is 32 kg-m^2. Find the gear ratio which gives the maximum angular acceleration of shaft B and the corresponding angular acceleration of each shaft. **(18)**

   (b) Derive the expression $I = I_A + \sum \frac{G_x^2 I_x}{\eta_x}$, where the symbols have their usual meanings. **(17)**

2. (a) State and explain the 'three centers in line' theorem with appropriate schematic representation. **(10)**

   (b) A mechanism, as shown in Fig. For Q. No. 2(b), has the following dimensions: O_1A= 60mm; AB = 180 mm; O_2B = 100 and CD = 270 mm. The crank O_1A rotates clockwise at a uniform speed of 120 r.p.m. The block D moves in vertical guides. Find, by instantaneous center method, the velocity of D and the angular velocity of CD. **(25)**

3. (a) Schematically determine the velocities in slide crank mechanism by using relative velocity method. **(10)**

   (b) The dimensions of the various links of a pneumatic riveter, as shown in Fig. for Q. No. 3(b), are as follows: AO = 175 mm; AB = 180 mm; AD = 500 mm; and BC = 325 mm. Find the velocity ratio between C and ram D when OB is vertical. What will be the efficiency of the machine if a load of 2.5 kN on the piston C causes a thrust of 4 kN at the ram D? **(25)**

4. (a) Derive an expression for magnitude and direction of coriolis component of acceleration. **(18)**

   (b) The crank of a slider crank mechanism, as shown in Fig. for. Q. No. 4 (b), rotates clockwise at a constant speed of 300 r.p.m. The crank is 150 mm, and the connecting rod is 600 mm long. Determine: **(17)**

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Contd... Q. No. 4(b)

i. linear velocity and acceleration of the midpoint of the connecting rod, and

ii. angular velocity and angular acceleration of the connecting rod, at a crank angle of 45° from inner dead center position.

SECTION – B

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

5\. (a) What are the laws of simple pendulum? Explain with necessary figures. **(20)**

(b) A point moves with simple harmonic motion. When this point is 0.75 meter from the mid path, its velocity is 11 m/s and when 2 meters from the center of its path its velocity is 3 m/s. Find its angular velocity, periodic time and maximum acceleration. **(15)**

6\. (a) Define and explain the term kinematic link. Discuss the classification of kinematic link with necessary figures. **(15)**

(b) What is a machine? Differentiate between a machine and a structure by elaborating three examples from a ship and/or boat. **(20)**

7\. (a) Discuss the following laws of friction: **(15)**

i. Laws of Static Friction

ii. Laws of Dynamic Friction

iii. Laws of Fluid Friction

(b) An effort of 1500 N is required to just move a certain body up an inclined plane of angle 12 degrees, force acting parallel to the plane. If the angle of inclination is increased to 15 degrees, the effort required is 1720 N. Find the weight of the body and the coefficient of friction. **(20)**

8\. (a) Explain different types of flat belt drives with necessary figures. **(20)**

(b) The power is transmitted from a pully 1 m diameter running at 200 RPM to a pully 2.25 m diameter by means of a belt. Find the speed loss by the driven pully as a result of creep, if the stress on the tight and slack side of the belt is 1.4 MPa and 0.5 MPa respectively. The young's modulus for the material of the belt is 100 MPa. **(15)**

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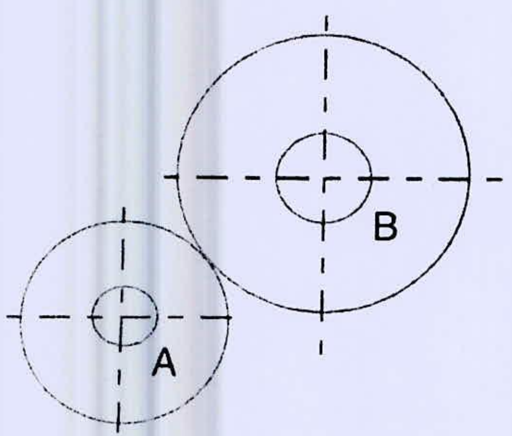
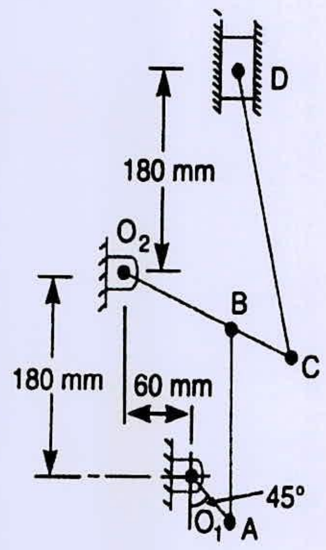


Fig. for Q. No. 1(a)



Fig, for Q. No. 2(b)

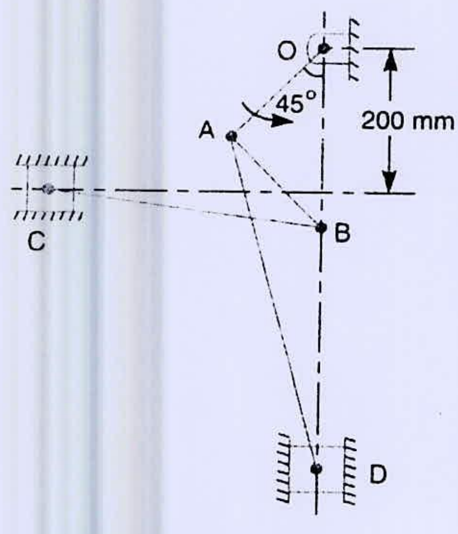


Fig. for Q. No. 3(b)

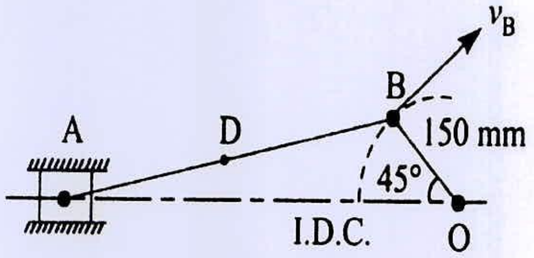


Fig. for Q. No. 4(b)

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BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2019-2020

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.

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

SECTION – A

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

1. (a) What do you understand by fouling factor? Explain. A double-pipe (shall-and-tube) heat exchanger is constructed of a stainless steel (k = 15.1 W/m · °C) inner tube of inner diameter D_i = 1.5 cm and outer diameter D_0 = 1.9 cm and an outer shell of inner diameter 3.2 cm. The convection heat transfer coefficient is given to be h_i = 800 W/m^2· °C on the inner surface of the tube and h_0 = 1200 W/m^2· °C on the outer surface. For a fouling factor of $R_{f,}i$ = 0.0004 m^2· °C/W on the tube side and $R_{f,\,0}$ = 0.0001 m^2· °C/W on the shell side, determine (a) the thermal resistance of the heat exchanger per unit length and (b) the overall heat transfer coefficients, U_i and U_o based on the inner and outer surface areas of the tube, respectively. **(15)**

(b) A 2-shell passes and 4-tube passes heat exchanger is used to heat glycerin from 20°C to 50°C by hot water, which enters the thin-walled 2-cm-diameter tubes at 80°C and leaves at 40°C (see Fig. for Question No. 1(b)). The total length of the tubes in the heat exchanger is 60 m. The convection heat transfer coefficient is 25 W/m^2· °C on the glycerin (shell) side and 160 W/m^2· °C on the water (tube) side. Determine the rate of heat transfer in the heat exchanger (i) before any fouling occurs and (ii) after fouling with a fouling factor of 0.0006 m^2· °C/W occurs on the outer surfaces of the tubes. **(20)**

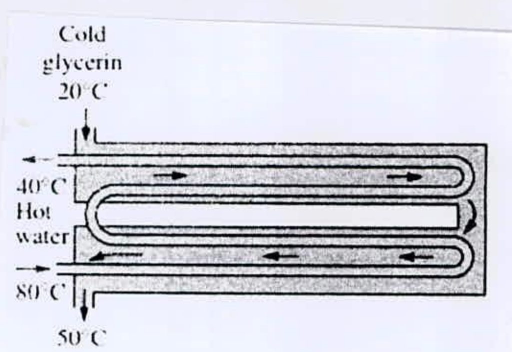

Fig. for Question No. 1(b)

2. (a) Determine the view factors associated with an enclosure formed by two spheres, shown in Fig. for Question No. 2(a). **(17)**

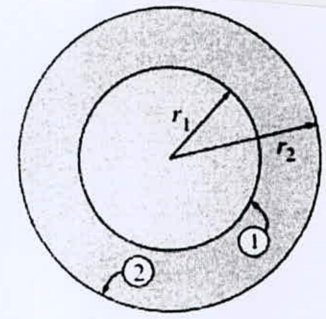

Fig. for Question No. 2(a)

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Contd ... Q. No. 2

(b) Two rectangles 50 by 50 cm as shown in Figure for question No. 2(b) are placed perpendicularly with a common edge. One surface has T_1 = 1000 K, ϵ_1 = 0.6. While the other surface is insulated and in radiant balance with a large surrounding room at 300 K. Determine the temperature of the insulated surface and the heat lost by the surface at 1000 K. Assume $F_{12} = F_{21} = 0.2$ **(18)**

Where symbols have their usual meaning.

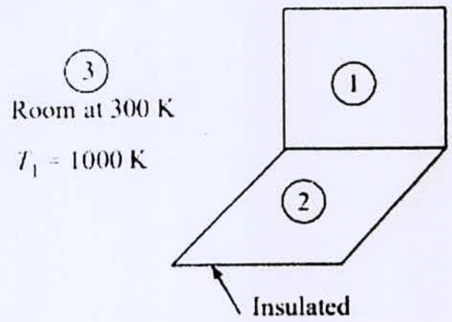

Fig. for Question No. 2(b)

3. (a) Write short notes on the following: **(15)**
   (i) Nusselt number and Pranditl number
   (ii) Intensity of emitted radiation
   (iii) Wien's displacement law

   (b) The local atmospheric pressure in Denver, Colorado (elevation) 1610 m), is 83.4 kPa. Air at this pressure and 20°C flows with a velocity of 8 m/s over a 1.5 m × 6 m flat plate whose temperature is 140°C. Determine the rate of heat transfer from the plate if the air flows parallel to the (i) 6-m-long side and (ii) the 1.5-m side. The properties of air at the film temperature and 83.4 kPa pressure are, k = 0.02953 W/m· °C, Pr = 0.7154 and $\nu = 2.548 \times 10^{-5}$ m²/s. **(20)**

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

   (b) Derive the expression of Nusselt number for flow over a flat plate within laminar region. **(15)**

SECTION – B

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

5. (a) Derive the one-dimensional heat conduction equation in a long cylinder. **(17)**

   (b) A 3-m-high and 5-m-wide wall consists of long 16-cm × 22-cm cross section horizontal bricks (k = 0.72 W/m· °C) separated by 3-cm-thick plaster layers (k = 0.22 W/m· °C). There are also 2-cm –thick plaster layers on each side of the brick and a 3-cm-thick rigid foam (k = 0.026 W/m· °C) on the inner side of the wall, as shown in Fig. for Q. No. 5(b). The indoor and the outdoor temperatures are 20°C and −10°C, and the convection heat transfer coefficients on the inner and the outer sides are h_1 = 10 W/m²· °C) and h_2 = 25 W/m²· °C), respectively. Assuming one-dimensional heat transfer and disregarding radiation, determine the rate of heat transfer through the wall (State necessary assumptions). **(18)**

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6. (a) Derive the equation of temperature distribution and heat transfer rate of an infinitely long fin. Consider that the temperature at the fin tip approaches that of surrounding fluid. (State necessary assumptions and draw necessary figures). **(15)**

(b) Why critical thickness of insulation concept is applicable for cylindrical and spherical object rather than plane wall? Explain. **(5)**

(c) The cylinder barrel of a motorcycle is constructed of aluminum alloy (k = 186 W/m· K) 0.15 m high and 50 mm in diameter as shown in Fig. for Q. No. 6(c). Under typical operating conditions, the outer surface of the cylinder is at a temperature of 500 K and is exposed to the ambient air at 300 K with convection coefficient of 50 W/m^2. K. Annular fins of rectangular profiles are typically added to increase the heat transfer rate to the surroundings. Assume that five such fins; 6 mm thick, 20 mm long and equally' spaced – are added. What is the increase in the rate of heat transfer due to the addition of the fins? Take fin efficiency as 0.95. **(15)**

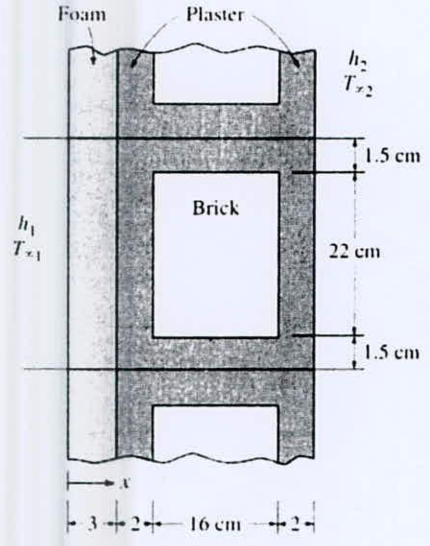

Figure for Q. No. 5(b)

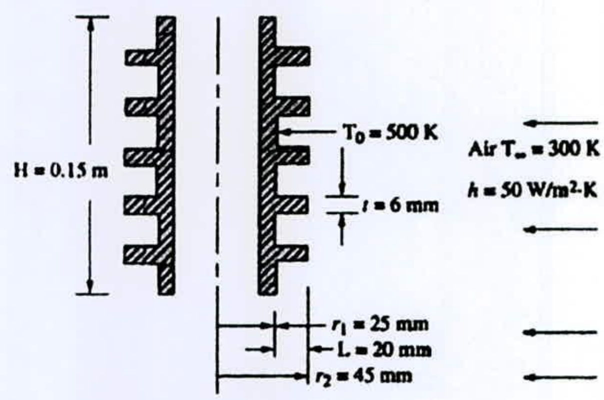

Figure for Q. No. 6(c)

7. (a) Deduce an expression for heat transfer using lumped system analysis. **(12)**

(b) Discuss the important criteria for lumped system analysis. **(8)**

(c) The temperature of a gas stream is to be measured by a thermocouple whose junction can be approximated as a 1-mm-diameter sphere, as shown in Fig. for Q. No. 7(c). The properties of the junction are k = 35 W/m·°C, ρ = 8500 kg/m^3, and Cp = 320 J/kg·°C, and the convection heat transfer coefficient between the junction and the gas is h = 210 W/m^2·°C. Determine how long it will take for thermocouple to read 99 percent of the initial temperature difference. (Assume the thermal properties of the junction and the heat transfer coefficients are constant. Also, radiation effects are negligible). **(15)**

8. (a) Define Grashof Number and Rayleigh Number. Use order for magnitude estimates to find an expression for Grashof Number and hence Rayleigh Number. **(10)**

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(b) Consider a 0.6-m × 0.6-m thin square plate in a room at 30°C. One side of the plate is maintained at a temperature of 90°C, while the other side is insulated, as shown in Fig. for Q. No. 8(b). Determine the rate of heat transfer from the plate by natural convection if the plate is (i) vertical, (ii) horizontal with hot surface facing up, and (iii) horizontal with hot surface facing down. **(25)**

The properties of air at the film temperature of 60°C and 1 atm are: $k = 0.02808$ W/m·°C, $\nu = 1.896 \times 10^{-5}$ m^2/s, Pr = 0.7202, $\beta = \frac{1}{T_f} = \frac{1}{333k}$.

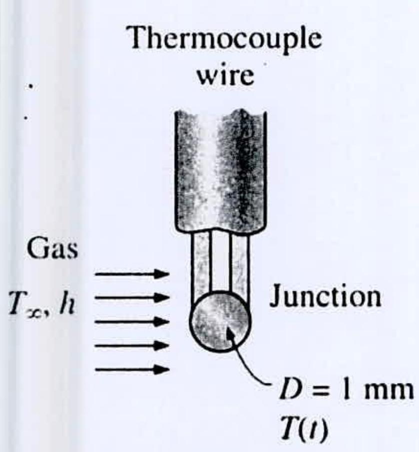

Figure for Q, No. 7(c)

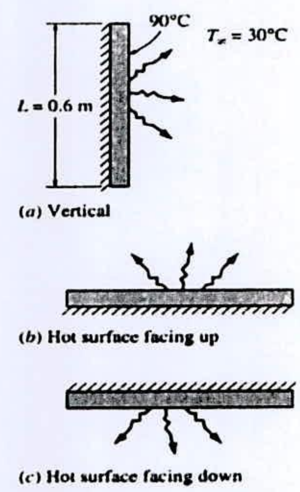

Figure for Q, No. 8(b)

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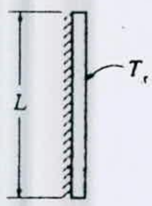
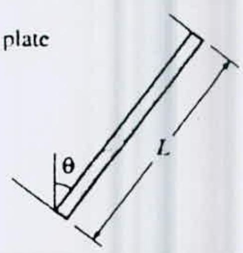
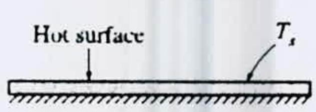
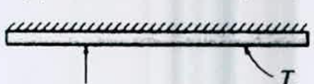
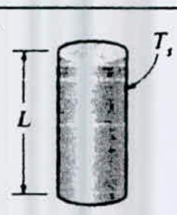
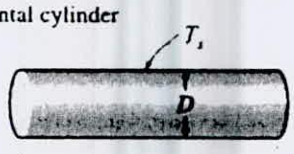
Table for Q. No. 8(b)

Empirical correlations for the average Nusselt number for natural convection over surfaces

Geometry	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)

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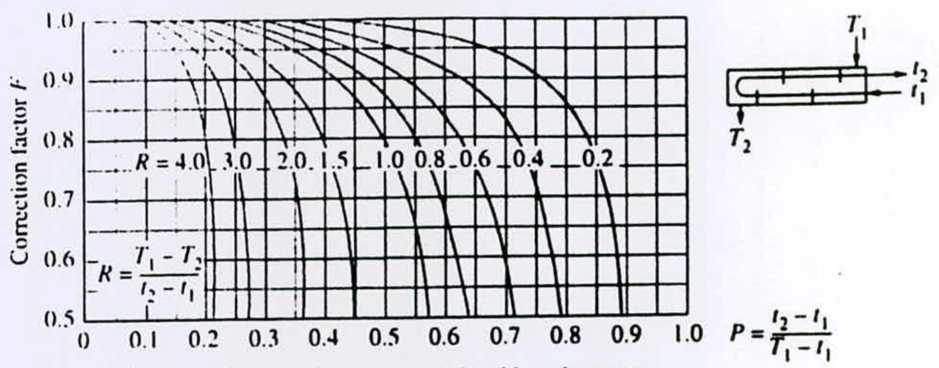
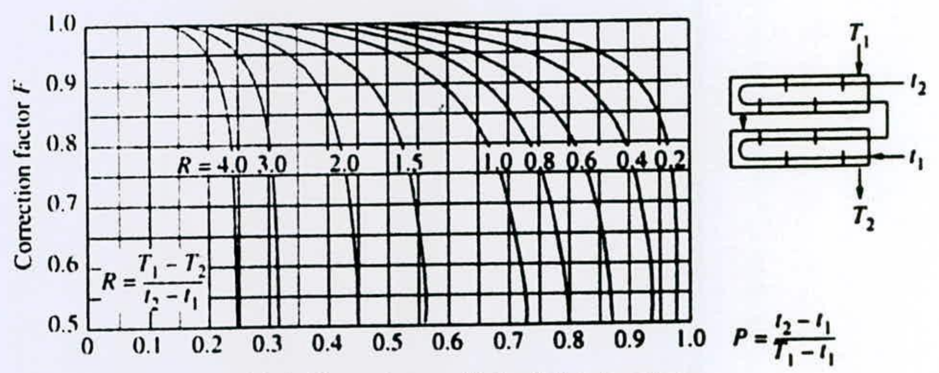
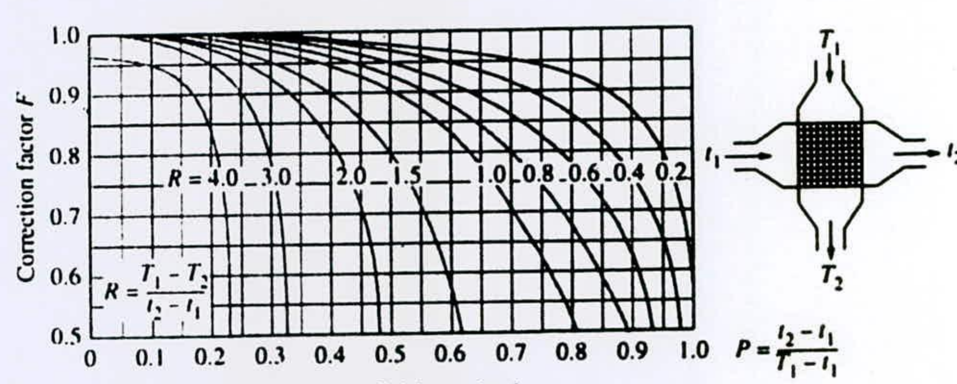
Graph for Q. No. 1(b)



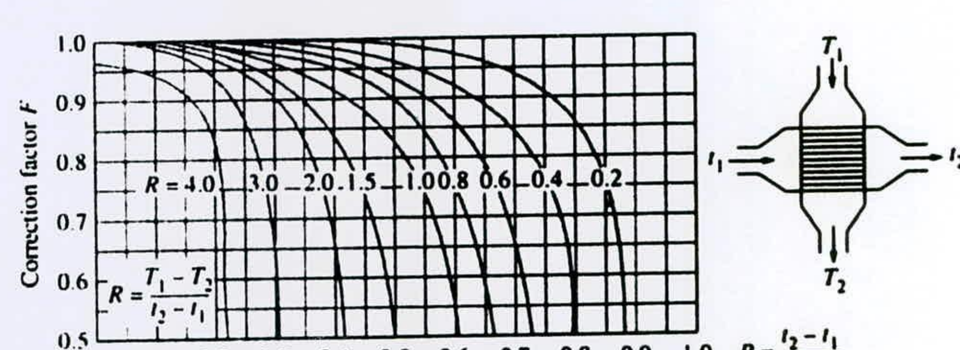
(*a*) One-shell pass and 2, 4, 6, etc. (any multiple of 2), tube passes



(*b*) Two-shell passes and 4, 8, 12, etc. (any multiple of 4), tube passes



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



(*d*) Single-pass cross-flow with one fluid *mixed* and the other *unmixed*

FIGURE [redacted]
Correction factor F charts for common shell-and-tube and cross-flow heat exchangers (from Bowman, Mueller, and Nagle, Ref. 2).

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L-3/T-2/NAME **Date: 10/04/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2019-2020

Sub: **NAME 347** (Design of Special Ships)

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** questions.

Assume reasonable data for missing values, if any.

1. (a) With a neat sketch discuss some common features of the Midship section of a container vessel. **(15)**

(b) Estimate the (i) Length (ii) Breadth (iii) Depth (iv) Block coefficient and (v) Displacement for a container vessel to meet the following requirements: **(20)**

2000 containers of size 6.05 m × 2.43 m × 2.43 m (1300 containers in holds and 700 on deck)

Service draught of 12.5 m

Service speed of 21 knots

Assume the containers are 8 high in each cell with 14 cells across the ship. Also assume, engine room length = 0.2 L – 10.75 m, where L is the ship length in meter.

2. (a) Using practical examples discuss the validity of the statement, "The mission and function of a passenger vessel dictates the design of the vessel". **(20)**

(b) Discuss the design process of a passenger vessel using system-based design process. **(15)**

3. (a) Draw a neat sketch of the Midship section of a Ro-Ro vessel. **(18)**

(b) Why is the design of a Ro-Ro vessel a challenge for a naval architect from a stability perspective? **(17)**

4. (a) For the case of submarine, we need to understand two types of stability. Briefly discuss these two types of stability. **(8)**

(b) Why does the maintenance of a static position for a submerged submarine requires dynamic calibration of various provisions and factors? **(7)**

(c) A submarine is 250 ft. long, has a maximum diameter of 32 ft. and submerged displacement of 3500 ton. Estimate the shaft power of the submarine when traveling at 30 knots. Given: **(20)**

$$\frac{\text{Total wetted surface of the appendage}}{\text{Total wetted surface of the bare hull}} = 0.2$$

$$\frac{\text{Average viscous} - \text{drag coefficient of the appendage}}{\text{Viscous} - \text{drag coefficient of the smooth bare hull}} = 0.2$$

Roughness (correlation) allowance, CA = 0.0002, Propulsive coefficient = 0.80

Density of sea water = 35 ft^3/ton, kinematic viscosity of sea water = 1.28×10^{-5} ft^2/sec

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SECTION – B

There are **FOUR** questions in this section. Answer any **THREE** questions.
Symbols have their usual meaning.

5. (a) Discuss the structural features of single hull tanker and double hull tanker with necessary figures **(20)**

   (b) Oil tankers have a number of systems that are unique compared to other types of ships. Briefly discuss these unique features. **(15)**

6. (a) Discuss the operation of a War Ship during war time and during peace time. Focus your answer on the distinct features of the warships that enable these operations. **(18)**

   (b) What do you understand by S^5 of warship design? Explain this term in your own language. **(17)**

7. (a) Explain the factors that influence the design of a fishing trawler. **(20)**

   (b) Design a deep-sea trawler of length 210 ft. Calculate the probable displacement of the vessel assuming reasonable free running speed. State proper justifications for necessary assumptions. **(15)**

8. Calculate the following design parameters for a dock tug having an engine power of 1,000 KW: **(35)**

   (i) L_{BP} by Greig's formula (consider kg = 42).

   (ii) Displacement of the vessel using Posdunine's expression $\left(V / \sqrt{L_{BP}} = 1.2 \right)$.

   (iii) Depth moulded by Barnaby's formula taking bollard pull 25 tons and $C_{dm} = 185$.

   (iv) Breadth, draft, Cp and Cm of the vessel.

   (v) Metacentric height (KG = 22.55 ft) of the vessel. Comment on the stability criteria.

L-3/T-2/NAME **Date: 02/04/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2019-2020

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

Full Marks: 210 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

Assume reasonable value for missing data

SECTION – A

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

1. (a) Discuss the role of stockyard. What will be the ideal characteristics of a stockyard from Bangladesh point of view? **(10)**

   (b) Draw a typical midship section of an oil tanker and identify important items. **(10)**

   (c) Explain an assembly sequence of various parts of a general cargo ship. **(8)**

   (d) Explain different kinds of loading on a vessel. Give some examples of discontinuities in ship structures. **(7)**

2. (a) Draw a forecastle deck of a ship and arrange different mooring equipment. Discuss their functions. **(10)**

   (b) Distinguish between CQR and Danforth anchors with figures. **(10)**

   (c) Write short notes on "Marks on anchor's" and "Anchor Certificate". **(10)**

   (d) Write down the equipment number formula of a tug ship. How is it different from other ships? **(5)**

3. (a) Explain "Bilge and ballast pumping and piping" of a ship with neat sketch. **(15)**

   (b) What is bilge keel and why is it required? Explain with figures its safe construction mentioning errors found from previous cases. **(10)**

   (c) Discuss different hatch covers. **(5)**

   (d) What is heat line bending? **(5)**

4. (a) Discuss mill scale and shot blasting. **(8)**

   (b) Write short notes on stem, chain locker and bow thruster with figures. **(9)**

   (c) Classify fire on board. Discuss different types of fixed fire-fighting systems used in ships. **(10)**

   (d) Discuss compensation and reinforcements for openings in ships with figure. **(8)**

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NAME 355

SECTION – B

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

5. (a) Briefly describe the development stages of marine biofouling on the submerged portion of a ship hall. **(15)**

   (b) Discuss the impact of biofouling on maritime industry. **(10)**

   (c) What are the problems and remedies of corrosion in the cargo tanks and ballast tanks? **(10)**

6. (a) Briefly discuss the cathodic protection system to prevent corrosion in a ship. **(15)**

   (b) Explain bimetallic corrosion cell problems in ship hull with possible remedies. **(10)**

   (c) Write short notes on any three of the following: **(10)**

   (i) Ship contracts

   and (ii) Classification societies

7. (a) Discuss various types of framing system with necessary figures. **(15)**

   (b) Show the connection between the following members. **(10)**

   (i) Side stringer and side stiffener

   and (ii) Deck longitudinal and web deck beam

   (c) Write down the design criteria of engine room construction. **(10)**

8. With necessary Figures describe the construction of following members in a ship structure. **(35)**

   (i) Watertight bulkhead

   (ii) Hatch coamings

   (iii) Pillar

   (iv) Double bottom

   and (v) Knee bracket

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2019-2020

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

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**.

1. (a) Derive a central difference approximation for $\frac{\partial^3 f}{\partial x^3}$ which is of order $(\Delta x)^2$. **(15)**

(b) Solve the Poisson equation $\nabla^2 f = 2x^2y^2$ by finite difference method over the square domain $0 < x \leq 3$ and $0 < y \leq 3$ with $f = 0$ on the boundary. The domain is to be divided into square of unit sizes. **(20)**

2 (a) Derive the shape functions $\phi_i(x, y)$ for triangular element and hence show that $\sum_{i=1}^{3} \phi_i(x, y) = 1$. **(15)**

(b) Prove the following variational formulae **(20)**

(i) $\delta \int_a^b y(x)\,dx = \int_a^b \delta\, y(x)\,dx$

(ii) $\text{grad}(\delta F).\,\text{grad } F \frac{1}{2} \delta \mid \text{grad } F \mid^2$

3. (a) Find the functional of the following boundary value problem **(15)**

$$\frac{d^2y}{dx^2} = f(x) \text{ with } y(a) = y(b) = 0$$

(b) Solve the problem **(20)**

$$\frac{d^2y}{dx^2} + y = -x; \qquad y(0) = y(1) = 0$$

Use Galerkin method with the trial function $\phi_1(x) = x(1 - x)$ and $\phi_2(x) = x^2(1 - x)$. Also compare the results with the analytical solution.

4. (a) Transform the following governing equation from the physical space to computational space. **(15)**

$$\frac{\partial u}{\partial x} = \alpha \frac{\partial u}{\partial y} = 0$$

Contd P/2

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Contd ... Q. No. 4

(b) In case of panel method, deduce the following expression from the normal velocity at the i-th panel induced by the j-th panel. **(20)**

$$\frac{\lambda_i}{2} + \sum_{\substack{j=1 \\ j \neq i}}^{h} \frac{\lambda_j}{2\lambda} I_{ij} + V_\infty \cos\beta_i = 0$$

where $I_{ij} = \int \frac{\partial}{\partial n} \ln r_{ij} \, ds_j$ and the symbols have their usual significance.

SECTION – B

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

Symbols have their usual meaning. Reasonable value can be assumed for any missing data.

5. (a) Make a comparative study between structured and unstructured girds. **(17)**

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

6. Consider a large plate of thickness, L = 2.5 cm with constant thermal conductivity, k = 0.5 W/m/K and uniform heat generation, q = 1200 KW/m^3 (see Fig. for Q. No. 6). The faces A and B are at temperatures of 150°C and 250°C respectively. Assume that the dimensions in the y-and-z-directions are so large that temperature gradients are significant in the x-direction only and the area in they-z plane A is 1.50 m^2. Calculate the steady state temperature distribution by dividing the domain into five control volumes. **(35)**

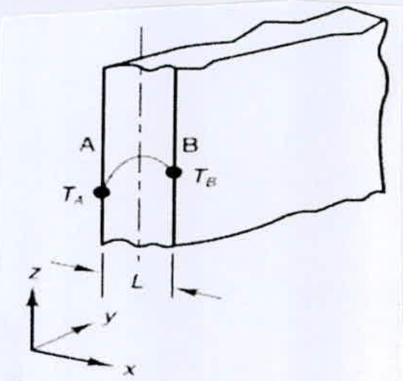

Fig. for Q. No. 6

7. Consider the steady, one-dimensional flow of a frictionless and constant density fluid through a two-dimensional nozzle as shown in Fig. for Q. No. 7. Calculate the pressures at the nodes B, C and D and velocities at nodes at 1, 2, 3 and 4 using SIMPLE algorithm of forward staggered grid arrangement given in Fig. for Q. No. 7. The stagnation point is given in the inlet and the static pressure is specified at the exit. **(35)**

The density of the fluid, $\rho = 1$ kg/m^3

Nozzle length, L = 2.10 m

Cross-sectional area at the inlet $A_A = 0.5$ m^2 and at the exit $A_E = 0.1$ m^2

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Contd … Q. No. 7

At the inlet, the flow entering the nozzle is drawn from a large plenum chamber and the fluid has zero momentum and the stagnation pressure at inlet, $\mathbf{p_0 = 10\ Pa}$. The static pressure at exit is $\mathbf{p_E = 0\ Pa}$.

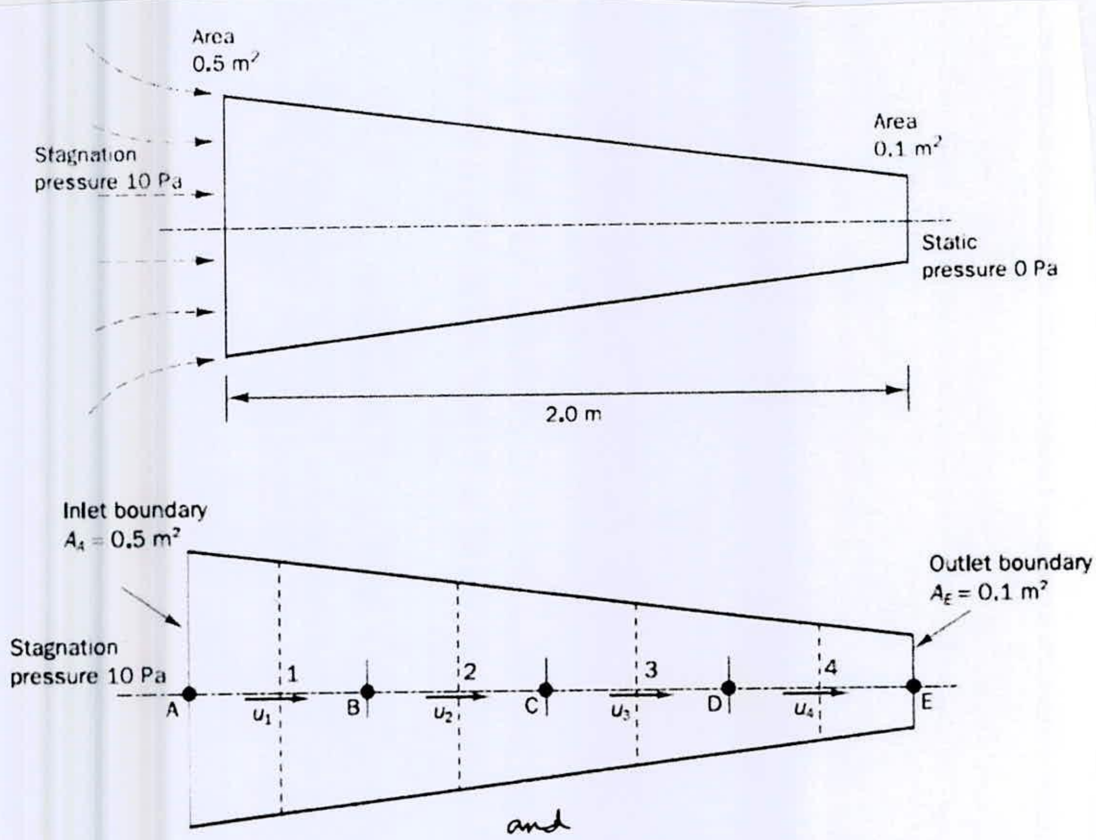

Fig. for Q. No. 7 ~~(a)~~ Nozzle and ~~(b)~~ Staggered grid arrangement

8. Consider the heat conduction through a 2-D hexagonal ring. The governing equation for the heat flow is given by *div(k grad T)* = 0 and the geometry of 2-D hexagonal ring and the boundary conditions are specified in Fig. for Q. No. 8. The problem of heat condition is governed by *div(k grad T)* = 0 with the following boundary conditions: **(35)**

TAC = 500°C	TCK = 500°C
TBE = 400°C	TEH = 200°C
TBJ = 200°C	TFG = 500°C
TGI = 500°C	

and Edges AD and DF are insulated.

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Contd ... Q. No. 8

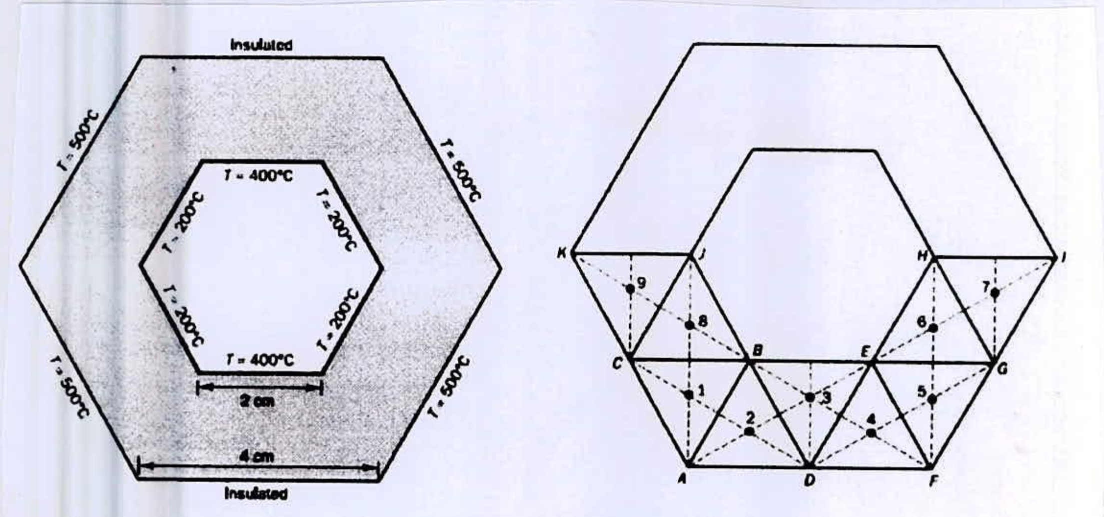

Fig. for Q. No. 8

The thermal conductivity of the material is k = 55 W/m-K. Determine the discretized equation for nodes 1, 2, 3 and 4.

L-3/T-2/NAME **Date : 18/04/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2019-2020

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

Full Marks : 280 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

Symbols have their usual meanings.

SECTION – A

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

1. (a) Prove the triangle inequalities. **(16⅔)**

(i) $|z_1 + z_2| \le |z_1| + |z_2|$ and (ii) $|z_1 - z_2| \ge ||z_1| - |z_2||$.

(b) Find the roots of the equation $z^4 + 2\sqrt{3} + 2i = 0$ in rectangular coordinates, exhibit them geometrically, and point out which is the principal root. **(15)**

(c) Find four roots of the equation $z^4 + 4 = 0$ and use them to factorize $z^4 + 4$ into quadratic factors with real coefficients. **(15)**

2. (a) Define analytic function and harmonic function. Show that the function $f(z) = |z|^2$ is differentiable only at z = 0 and nowhere else. **(16⅔)**

(b) Show that $u(x, y) = 3x^2y + 2x^2 - y^3 - 2y^2$ is harmonic in some domain and find a harmonic conjugate $v(x, y)$. Then express $f(z) = u + iv$ in terms of z. **(15)**

(c) Evaluate $\int_C \bar{z}dz$ from $z = 0$ to $z = 4 + 2i$ along the curve C given by (i) $z = t^2 + it$; (ii) the line from z = 0 to z = 2i and then from z = 2i to z = 4 + 2i. **(15)**

3. (a) Use Cauchy's Integral formula to evaluate the integral $\int_C \frac{z+1}{z^2 - 2z} dz$, where C is the circle $|z| = 3$ described in the positive sense. **(15)**

(b) Expand $f(z) = \frac{1}{z(z-2)}$ in a Laurent series valid for (i) $1 < |z| < 3$, (ii) $|z| > 3$. **(16⅔)**

(c) Using residue theorem find the value of the integral $\int_C \frac{3z^3 + 2}{(z-1)(z^2+9)} dz$, taken counterclockwise around the circle C with equation $|z| = 4$ described in the positive sense. **(15)**

4. (a) Evaluate the integral $\int_0^\infty \frac{dx}{x^6 + 1}$ using residues and contours. **(23)**

(b) Workout the integral using residues and contours: $\int_0^{2\pi} \frac{\sin 3\theta}{3\cos\theta} d\theta$. **(23⅔)**

Contd P/2

MATH 381

SECTION – B

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

5. (a) Find the Fourier series of $f(x)$ defined by $f(x)=\begin{cases}-\pi, & -\pi\le x<0\\ x, & 0<x\le\pi\end{cases}$ and hence evaluate $\sum_{n-1}^{\infty}\frac{1}{(2n-1)^2}$. **(26⅔)**

(b) Find the Fourier cosine integral formula of the function $f(x)=(1-x)e^{-2x}$ for $x\ge 0$. **(20)**

6. (a) Use Finite Fourier transform to solve the heat equation $\frac{\partial u}{\partial t}=3\frac{\partial^2 u}{\partial x^2}$; $0<x<\pi, t>0$ where $u(0,t)=0, u(\pi,t)=0, t\ge 0$ and $u(x,0)=2(t-\cos(\pi x))$ for $0\le x\le\pi$. **(26⅔)**

(b) Laplace equation in polar form is $\frac{\partial^2 u}{\partial r^2}+\frac{1}{r}\frac{\partial u}{\partial r}+\frac{1}{r^2}\frac{\partial^2 u}{\partial\theta^2}=0$. Solve this equation by the method of separation of variables. **(20)**

7. (a) Determine the steady state temperature inside a homogeneous solid sphere of radius ρ if the hemisphere above the *xy*-plane is maintained at temperature $F(\theta)=\sin^3\theta\, cos^3\theta$ and the remaining part of the sphere is maintained at zero temperature. **(26⅔)**

(b) Use Laplace transform to evaluate $\int_0^\infty \frac{\sin^2 t}{t^2}dt$. **(20)**

8. (a) Find the inverse Laplace transform of $\frac{1}{s^3(s^2+1)}$. **(10⅔)**

(b) Using Laplace transform solve

(i) $X''+4X=9t$ subjected to $X(0)=0$ and $X'(0)=7$. **(18)**

(ii) $tX''+X'+4tX=0$ subjected to $X(0)=3$ and $X'(0)=0$. **(18)**
