L-3/T-2/NAME

L-3/T-2  B. Sc. Engineering Examinations 2017-2018
Sub: **NAME 319** (Theory of Machine)

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

1. (a) State and explain Grashof's Law. Why is it an important consideration for designing a mechanism? 
(b) Modify Kutzbach criterion for the mobility of a planar mechanism and hence prove that the minimum number of binary links in a constrained mechanism with simple hinges is four.
(c) Explain the limitations of Kutzbach criterion for determining mobility of mechanism. Determine the number of degrees of freedom of the mechanism shown in figure for Q. No.1(c).

2. (a) The mechanism of a wrapping machine, as shown in figure Q. No. 2(a) has the following dimensions:
   \[ Q_1A = 100 \text{ mm}; AC = 700 \text{ mm}; BC = 200 \text{ mm} \]
   \[ Q_2C = 200 \text{ mm}; O_2E = 400 \text{ mm}; O_2D = 200 \text{ mm} \]
   and \[ BD = 150 \text{ mm} \].
   The crank \( Q_1A \) rotates at a uniform speed of 120 rad/s. Find the velocity of the point \( E \) of the bell crank lever by instantaneous centre method.
   
   (b) A crank and slotted lever mechanism used in a shaper machine has a centre distance of 300 mm between the centre of oscillation of the slotted lever and the centre of rotation of the crank. The radius of the crank is 120 mm. Find the ratio of the time of cutting stroke to the time of return stroke.

3. (a) Write short note on:
   (i) Inversion of mechanism
   (ii) Coriolis Component of Acceleration
   (b) The dimensions of the various links of a mechanism as shown in Figure for Q. No. 3(b), are as follows: \( AB = 30 \text{ mm}; BC = 80 \text{ mm}; CD = 45 \text{ mm} \) and CE 120 mm.
   The crank AB rotates uniformly in the clockwise direction at 120 rpm. Draw the velocity diagram for the given configuration of the mechanism and determine the velocity of the slider E and angular velocity of the link CE.

Contd. ........... P/2
4. Determine the acceleration of the slider D and the angular acceleration of link CD for the mechanism shown in figure for Q. No. 4.

Given that \( OA = 150 \text{ mm}; \ AB = 450 \text{ mm}; \ PB = 240 \text{ mm}; \ BC = 210 \text{ mm}; \ CD = 660 \text{ mm} \)
and the crank OA rotates uniformly at 200 rpm in clockwise direction.

SECTION – B

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

Symbols have their usual meanings. Assume reasonable values in case of missing data.

5. (a) A wagon of mass 14 tonnes is hauled up an incline of 1 in 20 by a rope which is parallel to the incline and is being wound round a drum of 1m diameter as shown in Figure for Q. No. 5(a). The drum, in turn, is driven through a 40 to 1 reduction gear by an electric motor. The frictional resistance to the movement of the wagon is 1.2 kN, and the efficiency of the gear drive is 85 percent. The bearing friction at the drum and motor shafts may be neglected. The rotating parts of the drum have a mass of 1.25 tonnes with a radius of gyration of 450 mm and the rotating parts on the armature shaft have a mass of 110 kg with a radius of gyration of 125 mm. At a certain instant the wagon is moving up the slope with a velocity of 1.8 m/s and an acceleration of 0.1 m/s². Find the torque on the motor shaft and the power being developed.

(b) What is a torsional pendulum? Show that

\[ t_p \propto \frac{2\pi KG}{r} \sqrt{\frac{l}{g}} \]

6. (a) Prove that the minimum periodic time of a compound pendulum is

\[ t_p (min) = 2\pi \sqrt{\frac{2KG}{g}} \]

(b) The pendulum of an Izod impact testing machine has a mass of 30 kg. Its centre of gravity is 1.05 m from the axis of suspension and the striking knife is 150 mm below the centre of gravity. The time for 20 small free oscillation is 43.5 seconds. In making a test the pendulum is released from an angle of 60° to the vertical.

Determine,

(i) the position of the centre of percussion relative to the striking knife and the striking velocity of the pendulum, and
(ii) the impulse on the pendulum and the sudden change of axis reaction when a specimen giving an impact value of 55 N-m is broken.

7. (a) A shaft rotating at 200 rpm drives another shaft at 300 rpm and transmits 6 kN through a belt. The belt is 100 mm wide and 10 mm thick. The distance between the shafts is 4 m. The smaller pulley is 0.5 m in diameter. Calculate the stress in the belt, if it is

(i) an open belt driver, and
(ii) a cross belt drive.

Take $h = 0.3$

(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 as shown in Figure for Q. No. 7(b). The parallel shaft has to run at 60, 80 and 100 rpm. The smallest pulley on the driving shaft is 40 mm in radius. Determine the remaining radii of pulleys for

(i) cross belt and (ii) open belt.

8. (a) Two involute gears of 20° pressure angle are in mesh. The number of teeth on pinion is 20 and the gear ratio is 2. If the pitch expressed in module is 5 mm and the pitch line speed is 1.2 m/s, assuming addendum as standard and equal to one module find

(i) the angle turned through by pinion when one pair of teeth is in mesh and
(ii) the maximum velocity of sliding..

(b) Derive the expressions of minimum number of teeth on pinion and wheel to avoid interference.
SECTION - A

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

Symbols have their usual meaning. Assume reasonable value for any missing data.

1. (a) Using dimensional analysis, derive an expression for heat transfer coefficient in forced convection in terms of Nusselt number, Reynolds number and Prandtl number.

(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 plates are maintained at 20°C.

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

(ii) Determine the maximum temperature in the oil.

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

Is the extent of viscous dissipation significant? Suggest how the answers you found could be improved.

The properties of oil at 20°C are,

\[ K = 0.145 \frac{W}{mK}, \quad \mu = 0.8374 \, \text{kg/ms} \]

2. (a) Write short notes on the following:

(i) Prandtl number

(ii) Nusselt number

(b) Engine oil at 60°C flows over the upper surface of a 5-m-long flat plate whose temperature is 20°C with a velocity of 2 m/s. Determine the total drag force and rate of heat transfer per unit width of the entire plate. The properties of engine oil at the film temperature \( \rho = 876 \, \text{kg/m}^3, P_f = 2870, K = 0.144 \frac{W}{m^2K}, \nu = 242 \times 10^{-6} \, \text{m}^2/\text{s}. \]

(c) For two black surfaces \( A_1 \) and \( A_2 \) arbitrarily located in space prove that the fraction of radiation leaving \( A_1 \) that strikes \( A_2 \) is

\[ F_{A_1 \rightarrow A_2} = \frac{1}{A_1} \int_{A_2} \frac{\cos \theta_1 \cos \theta_2}{\pi r^2} dA_1 dA_2 \]

where symbols have their usual meaning.

Contd .......... P/2
3. (a) Show that the net rate of radiation heat transfer between two non black bodies is given by:

\[ Q_{\text{net}} = \frac{\delta T_1^4 - \delta T_2^4}{\frac{1}{A_1 e_1} + \frac{1}{A_1 F_1} + \frac{1}{A_2 e_2}} \]

where symbols have their usual meaning.

Hence for two large parallel plates maintained at uniform temperatures of 800 K and 500 K, with emissivities 0.2 and 0.7, determine the net rate of radiation heat transfer per unit area of the plates.

(b) Derive the ratio of radiation heat transfer with \(N\) shields present and without any shield present between two infinite parallel planes with all the surfaces having equal emissivity.

4. (a) For a double pipe parallel flow heat exchanger, derive the expression of the log-mean temperature difference. State any assumption you made in the derivation.

(b) Hot oil is to be cooled by water in a 1-shell-pass and 8-tube-passes heat exchanger. The tubes are thin-walled and are made of copper with an internal diameter of 1.4 cm. The length of each tube pass in the heat exchanger is 5 m, and the overall heat transfer coefficient is 310 W/(m\(^2\)°C). Water flows through the tubes at a rate of 0.2 kg/s and the oil through the shell at a rate of 0.3 kg/s. The water and the oil enter at temperature of 20°C and 150°C, respectively. Determine the rate of heat transfer in the heat exchanger and the outlet temperatures of the water and the oil.

SECTION - B

There are FOUR questions in this section. Answer any THREE. Assume reasonable value for any missing data.

5. (a) Briefly explain thermal diffusivity. Also derive one dimensional heat conduction equation for a long cylinder.

(b) A 3 m internal diameter spherical tank made of 2 cm thick stainless steel \(K=15\frac{w}{m^\circ C}\) is used to store iced water at \(T_{a1} = 0^\circ C\). The tank is located in a room whose temperature \(T_{a2} = 22^\circ C\). The walls of the room are also at 22°C. The outer surface of the tank is black and heat transfer between the outer surface of the tank and the surroundings is by natural convection and radiation. The convection heat transfer coefficient at inner and outer surfaces of the tank are \(h_1 = 80\frac{w}{m^2\circ C}\) and \(h_2 = 10\frac{w}{m^2\circ C}\), respectively. Determine the rate of heat transfer to the iced water in the tank and the amount of ice at 0°C that melts during a 24 hours period. (State necessary assumptions).
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 the surrounding fluid. (State necessary assumptions and draw necessary figures).

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

(c) Consider a cylindrical pipe of outer radius \( r_1 \) whose outer surface temperature \( T_1 \) is maintained constant. The pipe is now insulated with a material whose thermal conductivity is \('K'\) and outer radius is \('r_2'\). Heat is lost from the pipe to the surrounding medium at temperature \( T_m \), with a convection heat transfer co-efficient \('h'\).

(i) Obtain the expression of critical radius insulation.

(ii) What will happen to heat transfer rate if the radius of insulation is greater or lower than critical radius of insulation?

(iii) Give some practical examples where you can apply critical radius of insulation concept.

7. (a) Briefly explain fourier number.

A steel ball \( \left[ C = 0.46 \frac{kJ}{kg^{\circ}K}, K = 35 \frac{w}{m.K}, \rho = 7800 \frac{kg}{m^3} \right] \) 5.0 cm in diameter and initially at a uniform temperature of 450°C is suddenly placed in a controlled environment in which the temperature is maintained at 100°C. The convection heat transfer co-efficient is \( 10 \frac{w}{m^2.K} \). Calculate the time required for the ball to attain a temperature of 150°C.

(b) A long 20-cm diameter cylindrical shaft made of stainless steel 304 comes out of an oven at a uniform temperature of 600°C. The shaft is then allowed to cool slowly in an environment chamber at 200°C with an average heat transfer co-efficient of \( h = 80 \frac{w}{m^2.\circ C} \). Determine the temperature at the centre of the shaft 45 minutes after the start of cooling process. Also determine the heat transfer per unit length of the shaft during this time period.

[At room temperature, the properties of 304 steel are \( k = 14.9 \frac{w}{m^\circ C}, \rho = 7900 \frac{kg}{m^3}, C_p = 477 \frac{J}{kg.\circ C} \) and \( \alpha = 3.95 \times 10^{-6} \frac{m^2/s}{s} \)]

Contd ......... P/4
8. (a) Draw typical velocity and temperature profiles for natural convection flow over both a hot and a cold vertical plate. (6)

(b) Derive the equation of motion for natural convection flow over a vertical flat plate. (14)

(c) A 6 m long section of an 8 cm diameter horizontal hot water pipe shown in Fig. for Q. No. 8(c) passes through a 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 convection. (15)

Figure for 8. no. 4(b)

Fig. for Q. No. 5(b)
Transient temperature and heat transfer chart for a long cylinder of radius $r$, initially at a uniform temperature $T_i$, subjected to convection from all sides to an environment at temperature $T_w$ with a convection coefficient of $h$.

Fig 8: No 3(e) 7(b)
Empirical correlations for the average Nusselt number for natural convection over surfaces

<table>
<thead>
<tr>
<th>Geometry</th>
<th>Characteristic length $L$</th>
<th>Range of $Ra$ $^{10^6}$</th>
<th>Nu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical plate</td>
<td>$L$</td>
<td>$10^5-10^9$</td>
<td>$Nu = 0.59Ra^{1/3}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$10^6-10^7$</td>
<td>$Nu = 0.14Ra^{1/3}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$Nu = 0.025 + 0.387Ra^{1/3}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$(0-19)$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$(19-20)$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$(0-21)$ (complex but more accurate)</td>
</tr>
<tr>
<td>Inclined plate</td>
<td>$L$</td>
<td></td>
<td>$Nu$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Use vertical plate equations for the upper surface of a hot plate and the lower surface of a cold plate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Replace $g$ by $g$ cos $\theta$ for $Ra &lt; 10^9$</td>
</tr>
<tr>
<td>Horizontal plate</td>
<td>$L$</td>
<td>$10^4-10^9$</td>
<td>$Nu = 0.56Ra^{1/3}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$10^5-10^7$</td>
<td>$Nu = 0.10Ra^{1/3}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$Nu = 0.27Ra^{1/3}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$(0-22)$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$(0-23)$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$(0-24)$</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>$(0-25)$</td>
</tr>
<tr>
<td>Vertical cylinder</td>
<td>$L$</td>
<td>$10^4$</td>
<td>$Nu = 0.387Ra^{1/3}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$10^5-10^7$</td>
<td>$Nu = 0.2 + 0.387Ra^{1/3}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$(0-26)$</td>
</tr>
<tr>
<td>Horizontal cylinder</td>
<td>$D$</td>
<td>$Ra &lt; 10^9$</td>
<td>$Nu = 0.589Ra^{1/3}$</td>
</tr>
<tr>
<td>Sphere</td>
<td>$D$</td>
<td>$Ra &lt; 10^9$</td>
<td>$Nu = 0.589Ra^{1/3}$</td>
</tr>
</tbody>
</table>

Fig for Q. No 8(c)
SECTION – A
There are FOUR questions in this section. Answer any THREE.

1. (a) Discuss different ship design stages with design spiral. (20)
   (b) Discuss ship contract in details. (15)

2. (a) Discuss the role of stockyard in shipyards. (5)
   (b) Which decisions are required for planning an effective shipyard layout? Provide such a layout. (12)
   (c) What is double bottom? Why is it required? Discuss its different types with figures. Provide CS rules for depth and thickness regarding double bottom. (18)

3. (a) Discuss the ABS or any other international CS rule for centre girder design. (10)
   (b) Show with figure how to maintain continuity of the longitudinal stiffeners through the transverse watertight bulkhead. (10)
   (c) What are the design criteria of engine room construction? Show with figure a typical machinery seat section. (15)

4. (a) An unequal angle bracket is welded to a column by 10mm fillet welds as shown in figure for Q. No. 4(a). Determine the maximum eccentricity, at which a load of 120 kN can be placed on the bracket, if the stress in the weld is limited to 80 MPa. (20)
   (b) A hollow circular steel column with its ends fixed in position has unsupported span of 2m, an outside diameter of 100 mm and an inside diameter of 80 mm. Determine the permissible load according to the ABS or any other international CS rule. (15)

SECTION – A
There are FOUR questions in this section. Answer any THREE.

5. (a) With neat sketches, describe different types of rudders. How can you construct a rudder? (15)
   (b) Discuss different type of stern construction. (10)
   (c) What can you say about marine propeller from the construction/assembly point of view. (10)
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6. (a) With neat sketches, explain elaborately plimsoll marks used in ships. (12)

(b) How would you describe Admiralty pattern, stockless, Admiralty cast, CQR and Danforth anchors? (13)

(c) How could you discuss manhole cover details? (10)

7. (a) How would you protect ships by means of paints? (5)

(b) List different surface preparation techniques for successful painting and describe them. (10)

(c) How can you prevent corrosion by a good design? (10)

(d) Which cathodic protection system is the best you think? Justify your answer. (10)

8. (a) Can you make a distinction between thermal insulation and accounting insulation? (10)

(b) How would you explain the principle of operation of a sounding pipe? (10)

(c) Write short notes on:
   (i) Bilge system
   (ii) Anti-fouling paint
   (iii) Scuppers
   (iv) Sampson posts
   (v) Bulwark (15)

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Figure for Q. No. 4(a)
SECTION – A

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

1. (a) State the advantages of staggered and collocated grid arrangement. (5)
   
   (b) Derive the discretized form of equations for steady laminar flow with respect to staggered grid arrangement for SIMPLE algorithm. (30)

2. (a) Derive an expression for Crank-Nicolson scheme from one-dimensional unsteady heat conduction equation. (15)
   
   (b) The problem for one-dimensional heat conduction for a thin plate is governed by
   
   \[ \rho C_a \frac{\partial T}{\partial t} = \frac{\partial}{\partial x} \left( k \frac{\partial T}{\partial x} \right) \]
   
   With \( T = 200 \) at \( t = 0 \)
   
   \( \frac{\partial T}{\partial x} = 0 \) at \( x = 0, t > 0 \)
   
   \( T = 0 \) at \( x = L, t > 0 \)
   
   The thin plate is initially at a uniform temperature of 200°C and at a certain time \( t = 0 \), the temperature of the east side of the plate is suddenly reduced to 0°C. The other side is insulated. Calculate the transient temperature distribution of slab using Explicit scheme with a time step size \( t = 40 \) sec. Given: \( L = 3 \) cm, \( k = 10 \) w/m-k, \( c_c = 10 \times 10^6 \) J/m^3-K. To generate the grid, divide the domain width \( L \) into three equal control volumes with \( \Delta x = 1 \) cm. (20)

3. (a) Referring to Fig. for Q.No. 3(a) show that for unstructured grid the diffusion flow through each control volume can be expressed as (15)

   \[ n \cdot \nabla \Phi \Delta A_i = \frac{n_n \Delta A_i}{n C_i} \Phi_i + \Phi_r - \frac{C_i}{n C_i} \Phi_b - \frac{C_i}{n C_i} \Phi_n \Delta A_i \]
   
   (b) The governing equation for heat conduction through a 2-D hexagonal ring is given by
   
   \[ \text{div} (k \text{ grad } T) = 0 \]
   
   The geometry and the boundary conditions are specified as shown in Fig. for Q. No. 3(b). Determine the discretized equations for nodes \( i = 1, 2, 3 \) and \( 5 \). \( K = 50 \) w/m-k (20)
4. Consider the steady two-dimensional flow of a frictionless and constant density fluid through a nozzle as shown in Fig. for Q. No. 4. Calculate the pressures at the nodes B, C and D and velocities at nodes at 1, 2, 3 and 4 using SIMPLE algorithm of backward staggered grid arrangement. The stagnation point is given in the inlet and the static pressure is specified at the exit.

Given: The density of the fluid $\rho = 1 \text{ kg/m}^3$

Nozzle length $L = 2\text{ m}$ and grid spacings $\Delta x = \frac{L}{4}$

Cross sectional area at the inlet $A_A = 0.5 \text{ m}^2$

and at the exit $A_E = 0.1\text{ m}^2$

Boundary conditions: 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 the inlet $P_0 = 10\text{ Pa}$. The static pressure at the exit is $P_E = 0 \text{ Pa}$. Initial velocity field: To generate the initial velocity field guess a mass flow rate $\dot{m} = 1.0 \text{ kg/s}$ and $u = \dot{m} / \rho A \text{ m/s}$. Initial pressure field: To generate a starting field of guessed pressure assume a linear pressure variation between nodes A and E.

**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) Using source panel method prove that

$$\frac{\lambda_t}{2} + \sum_{j=1}^{n} \frac{\lambda_j}{2\pi} \int_{j\neq i} \left( \ln r_{ij} \right) ds_j + V_{x_i} \cos \beta_i = 0$$

(b) Derive the general expression of influence coefficient ($l_{ij}$) for two arbitrarily oriented panels.

6. (a) According to conservation laws of fluid flow show that:

$$\frac{\partial (\rho \phi)}{\partial t} + \text{div}(\rho u \phi) = \rho \frac{D\phi}{Dt}$$

(b) Consider a large vertical plate of thickness $L = 2.5 \text{ cm}$

With constant thermal conductivity $k = 0.5 \text{ W/m/K}$ and uniform heat generation $q = 1000 \text{ kW/m}^3$. The sides A and B are at temperatures of $100^\circ\text{C}$ and $220^\circ\text{C}$ respectively. Considering one-dimensional steady state diffusion, calculate the temperature distribution dividing the domain into four control volumes.
7. (a) How can you assess different discretisation schemes?

(b) A property $\phi$ is transported by means of convection and diffusion through the one-dimensional domain as shown in Fig. for q. N. 7(b). The boundary conditions are $\phi_0 = 1$ at $x = 0$ and $\phi_L = 0$ at $x = L$. Using five equally spaced cells and the hybrid differencing scheme for convection and diffusion, calculate the distribution of $\phi$ for $u = 2.5$ m/s.

[ $\rho = 1.0$ kg/m$^3$, $\Gamma = 0.15$ kg/m/s, $L = 1.0$ m]

8. (a) How can you approximate partial derivatives with finite difference expressions with equal and variable step sizes?

(b) Using Taylor's series expansion, find approximate expressions for mixed partial derivatives, $\partial^2 f/\partial x \partial y$.

(c) Derive the expressions of metrics and the Jacobian of transformation of Governing PDEs for fluid motion.
Fig. for Q. No. 3(a)

Fig. for Q. No. 3(b)

Fig. for Q. No. 4
L-3/T-2/NAME Date: 25/03/2019
BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA
L-3/T-2  B. Sc. Engineering Examinations 2017-2018
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
Assume reasonable values for missing data (if any). Symbols have their usual meaning

SECTION -A
There are FOUR questions in this section. Answer any THREE.

1. (a) What is MBT? Draw a transverse section of MBT and explain how it makes a submarine dive and surface. (10)
   (b) Discuss the stability of a submarine in submerged condition. (10)
   (c) Describe, why "submerged endurance" and "stealth" is considered as a design driver of submarine. (8)
   (d) A submarine is 260 ft long, has a maximum diameter of 32 ft, and a submerged displacement of 3400 ton. Determine the wetted surface of the bare hull. (7)

2. (a) What is a Ro-Ro vessel? Mention some of the types of Ro-Ro vessel. (5)
   (b) From a Naval Architect's perspective mention the dangers of a Ro-Ro vessel design. (15)
   (c) Mention some of the advantages and disadvantages of a Ro-Ro vessel. (15)

3. (a) As a Naval Architect, if you are approached by an owner who is asking you to build a Passenger vessel, what should be your questions to her/him, the answers to which will be helpful for you to determine the principal dimensions of the vessels. Also mention the reasons behind the questions. (12)
   (b) "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 its minimum permissible value." Why? Also, mention the measures to counter this difficulty. (10)
   (c) Draw the midship section of a general cargo carrier. (13)

4. (a) Draw the midship section of a double hull tanker and comment on the arrangement. (15)
   (b) Estimate the dimensions for a VLCC of total deadweight 150,000 tonnes with a speed of 15 knots at a maximum draught 17m. (20)

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SECTION – B

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

5. (a) How does the voyage profile of a fishing vessel affect the design of the vessel? (12)
(b) For a deep-sea trawler having length of 220 ft calculate the probable displacement using Posdunine expression. Calculate $C_b$ and $C_w$. Assume reasonable free running speed. (15)
(c) Explain the meaning of 'By Catch'. How can it be minimized? (8)

6. (a) What are the characteristic elements of a catamaran vessel? Explain. (7)
(b) Draw a typical general arrangement (only elevation) of a container vessel. Use proper notations to mark different parts of the vessel. (8)
(c) Calculate the dimensions of a container vessel to meet the following requirements: (20)
   i. 1600 containers $(6.05 \times 2.43 \times 2.43m)$
   ii. 1200 containers in holds
   iii. 400 containers on deck.
   iv. Loaded draft of 10.0 m
   v. Service speed of 24 knots.
   vi. Containers are 7 high in each cell with 9 cells across the ship.

7. (a) A reputed shipbuilding company intends to win a government tender for design and construction of a Dock Tug having engine power of 1200 kW. You are appointed in this company to design the tug. Calculate the length, displacement, depth, breadth, prismatic coefficient and block coefficient of the tug. Provide explanation of the formulae and methods that you are going to use for the calculations. (35)

8. Write short notes on the following: (35)
   i. Aircraft catapult
   ii. Purse seining
   iii. Box girder
   iv. Gob-rope
   v. IMDG classification of dangerous goods
   vi. Girthing
   vii. Scissor lift
SECTION-A

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

1. (a) Determine whether the following functions are differentiable
   (i) $f(z) = z^3$. (ii) $g(z) = z \ln(z)$.
   Hence discuss the analyticity of these functions.
   (b) Write down Cauchy-Riemann equations in polar form. If $f(z) = u(r, \theta) + iv(r, \theta)$, then using this equation show that $f'(z_0) = \frac{-i}{z_0} (u_\theta + iv_\theta)$.
   (c) Describe mathematically and graphically the region represented by $|z - 2| - |z + 2| > 3$.
   (d) Determine the region $R'$ in the $w$-plane into which the region $R$ in the $z$-plane bounded by the line $x = 0$, $y = 0$, $x = 1$, $y = 2$ is mapped under the transformation $w = \sqrt{2e^{-\pi}z + (2-i)}$.

2. (a) Show that $u(x, y) = e^x \cos y$ is harmonic. Find an analytic function $f(z)$ in which $u(x, y)$ is the real part. Also express $f(z)$ in terms of $z$.
   (b) Find the principle value of $\left[\frac{e}{2} (-1 - \sqrt{3}i) \right]^{3\pi i}$.
   (c) Evaluate $\int_C z^2 dx$ where $C$ is the part of the unit circle going anticlockwise from the point $z = 1$ to the point $z = i$.

3. (a) Use Cauchy integral formula to evaluate $\int_C \frac{z}{(\theta - z^2)(z + i)} dz$, where $C$ is the circle $|\theta| = 2$.
   (b) Express $f(z) = \frac{1}{(z + 1)(z + 3)}$ in a Laurent series valid in the region $0 < |z + 1| < 1$.
   (c) Evaluate the integral $\int_C \frac{e^{iz}}{(z + 3)(z - i)^3} dz$ by Cauchy residue theorem, where $C = \{z: z = 1 + 2\cos \theta, 0 \leq \theta \leq 2\pi\}$.

4. Evaluate the following integral by contour integration:
   (i) $\int_0^{2\pi} \frac{\cos 2\theta}{5 - 3\cos \theta} d\theta$.
   (ii) $\int_0^\infty \frac{\sin x}{x} dx$.

Contd .......... P/2
There are FOUR questions in this section. Answer any THREE.

5. (a) Expand \( f(x) \) in a half-range Fourier cosine series, where

\[
f(x) = \begin{cases} 
x, & 0 \leq x < \frac{\pi}{2} \\
\pi - x, & \frac{\pi}{2} \leq x \leq \pi
\end{cases}
\]

(b) Find the Fourier sine integral formula of \( e^{-x} \sin x \) for \( x \geq 0 \).

(c) Define Fourier transform. Find the Fourier transform of \( f(x) = \begin{cases} x, & |x| < 1 \\
0, & |x| > 1
\end{cases} \).

6. (a) Write down Laplace's equation in spherical coordinates \((\rho, \theta, \phi)\) and solve this equation by considering various cases.

(b) Find the steady-state temperature inside a solid sphere of unit radius if the temperature of its surface is (given by) \( u_0 \cos \theta \).

7. (a) Find \( L\{J_1(t)\} \), where \( J_1(t) \) is the Bessel's function of order one.

(b) Find the Laplace transform of \( S(t) \).

(c) If \( F(t) \) has period \( T > 0 \), then prove that

\[
L\{F(t)\} = (1 - e^{-sT})^{-1} \int_0^T e^{-st} F(t) \, dt.
\]

Hence find \( L\{G(t)\} \), where \( G(t) = \begin{cases} \sin t, & 0 < t < \pi \\
0, & \pi < t < 2\pi
\end{cases} \).

8. (a) Use Laplace transform to evaluate the integral \( \int_0^\infty \sin x^2 \, dx \).

(b) State convolution theorem. Using convolution property find

\[
L^{-1}\left\{ \frac{s}{(s^2 + 4)^{1/2}} \right\}.
\]

(c) Use Laplace Transform to solve the system of simultaneous differential equations

\[
\begin{align*}
2x'(t) + y'(t) - 2x(t) &= 1 \\
x'(t) + y'(t) - 3x(t) - 3y(t) &= 2
\end{align*}
\]
subject to \( x(0) = 0, y(0) = 0 \).