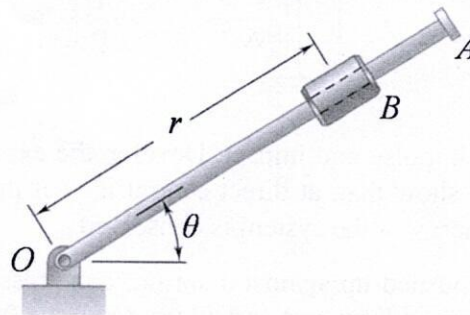


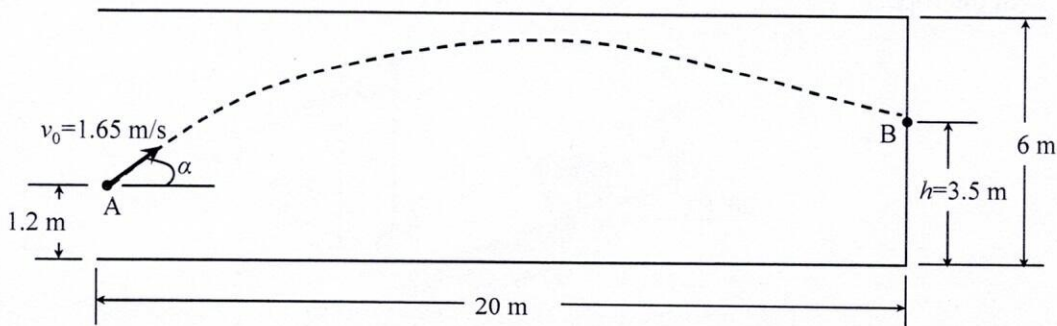
- N.B.:** i) Answer any THREE questions from each section in separate scripts.  
ii) Figures in the right margin indicate full marks.  
iii) Assume reasonable data if any are missing.

**SECTION-A**

- 1(a) A motorcycle and an automobile are both travelling at the constant speed of 64 km/hr; the motorcycle is 25 m behind the automobile. The motorcyclist wants to pass the automobile, i.e., he wishes to place his motorcycle 25 m in front of the automobile, and then resume the speed of 64 km/hr. The maximum acceleration of the motorcycles is  $1.8 \text{ m/s}^2$ , and the maximum deceleration obtained by applying the brakes is  $5.5 \text{ m/s}^2$ . What is the shortest time in which the motorcyclist can complete the passing operation if he does not at any time exceed a speed of 87 km/hr? 18
- 1(b) The rotation of rod  $OA$  about  $O$  is defined by the relation  $\theta = t^3 - 4t$ , where  $\theta$  is expressed in radians and  $t$  in seconds. Collar  $B$  slides along the rod in such a way that its distance from  $O$  is  $r = 25t^3 - 48t^2$ , where  $r$  is expressed in m and  $t$  in seconds. When  $t = 1.55 \text{ sec}$ , determine (i) the velocity of the collar; (ii) the total acceleration of the collar; and (iii) the acceleration of the collar relative to the rod. 17

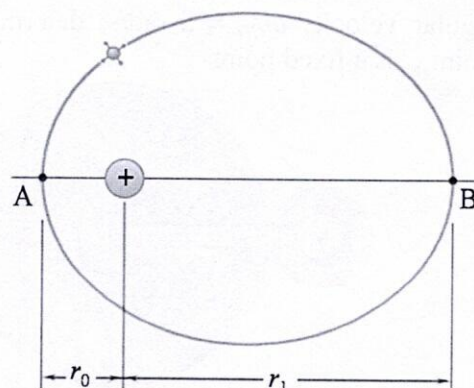


- 2(a) A player throws a ball with an initial velocity of 1.65 m/s from a point  $A$  located 1.2 m above the floor. Knowing that  $h = 3.5 \text{ m}$ , determine the angle  $\alpha$ , for which the ball will strike the wall at point  $B$ . Check whether the ball hits the ceiling or not. 18

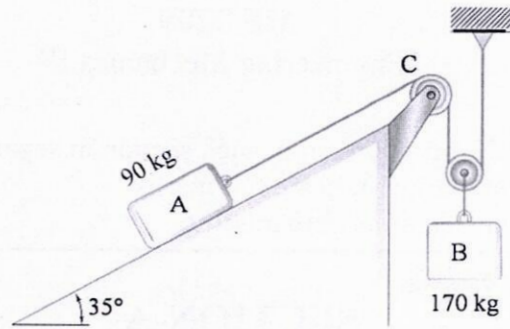


- 2(b) A satellite describes an elliptic orbit about a planet. Denoting by  $r_0$  and  $r_1$ , the distances corresponding, respectively, to the perigee and apogee of the orbit show that the curvature of the orbit at each of these two points can be expressed as 17

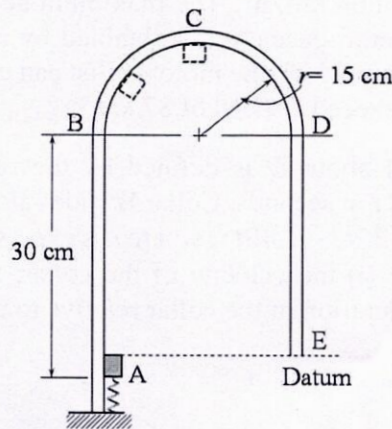
$$\frac{1}{\rho} = \frac{1}{2} \left( \frac{1}{r_0} + \frac{1}{r_1} \right).$$



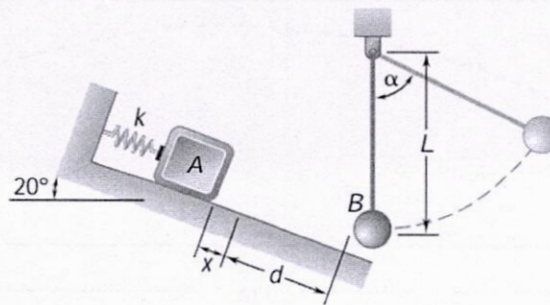
- 3(a) The two blocks, as shown, are originally at rest. Neglecting the masses of the pulleys and considering the effect of friction in pulley  $C$  and the incline, determine (i) the acceleration of each block, (ii) the tension in the cable. Assume that the coefficient of friction between block  $A$  and the incline, and at pulley  $C$  are  $\mu_s = 0.25$  and  $\mu_k = 0.15$ . 17



- 3(b) A 200-gm pellet is released from rest at  $A$  when the spring is compressed 7.5 cm and travels around the loop  $ABCDE$ . Determine the smallest value of the spring constant for which the pellet will travel around the loop and will at all times remain in contact with the loop. 18

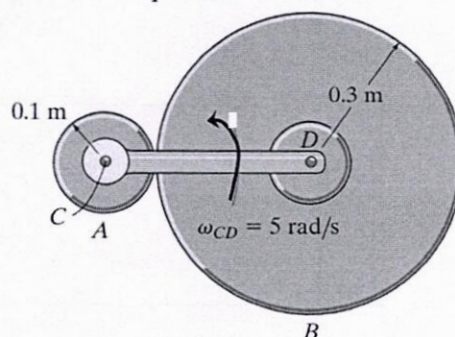


- 4(a) Distinguish between impulse and impact. Develop the expression for the coefficient of restitution and hence show that, at direct central impact in the case of perfectly elastic impact, the kinetic energy of the system is conserved. 15
- 4(b) A 2.5-kg block  $A$  is pushed up against a spring, compressing it a distance  $x = 12$  cm. The block is then released from rest and slides down the  $20^\circ$  incline until it strikes a 1-kg sphere  $B$ , which is suspended from a 110 cm inextensible cord. The spring constant  $k = 850$  N/m, the coefficient of friction between  $A$  and the incline is 0.20, the distance  $A$  slides from the unstretched length of the spring  $d = 150$  cm, and the coefficient of restitution between  $A$  and  $B$  is 0.85. When  $\alpha = 45^\circ$ , find (i) the speed of  $B$ , (b) the tension in the rope. 20



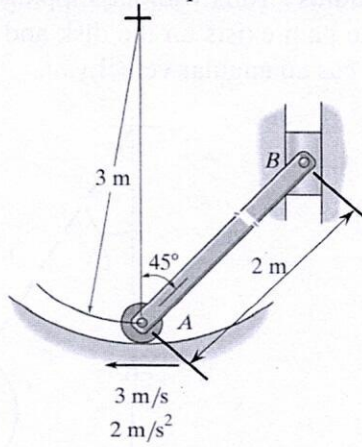
## SECTION-B

- 5(a) Show that a rigid body has only one angular velocity and angular acceleration. 06
- 5(b) The cylinder  $B$  rolls on the fixed cylinder  $A$  without slipping. If the connected bar  $CD$  is rotating with an angular velocity  $\omega_{CD} = 5$  rad/s, determine the angular velocity of cylinders  $A$  and  $B$ . Point  $C$  is a fixed point. 14

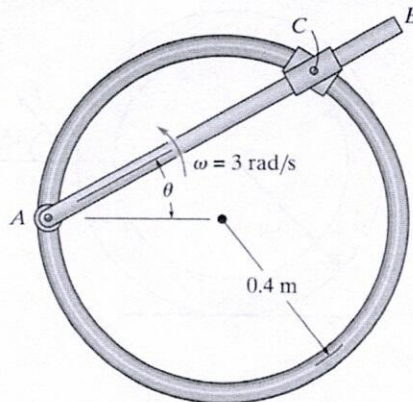


5(c) Determine the velocity and acceleration of point  $B$  of the following figure.

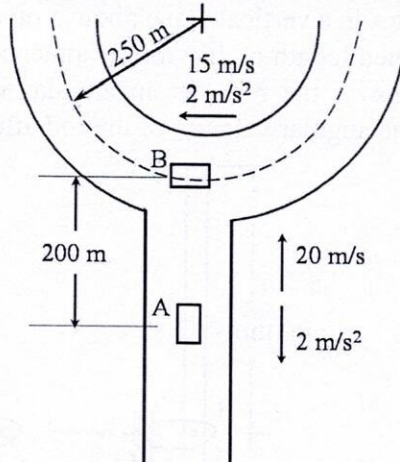
15



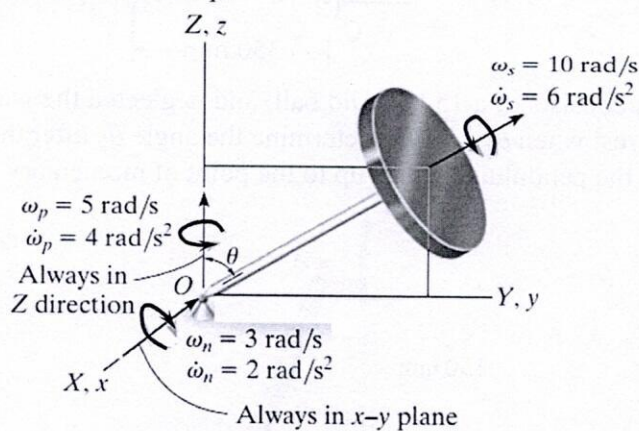
6(a) Rod  $AB$  rotates counterclockwise with a constant angular velocity  $\omega = 3 \text{ rad/s}$ . Determine the velocity and acceleration of point  $C$  located on the double collar when  $\theta = 45^\circ$ . The collar consists of two pin-connected slider blocks, which are constrained to move along the circular path and the rod  $AB$ .



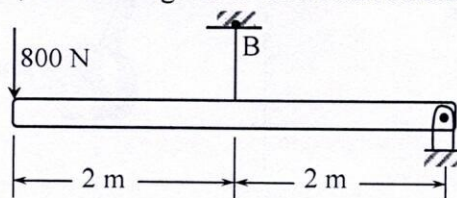
6(b) At the instant shown in the figure, car  $B$  is travelling in a circular path and car  $A$  in a straight path. Determine the velocity and acceleration of car  $A$  with respect to car  $B$ .



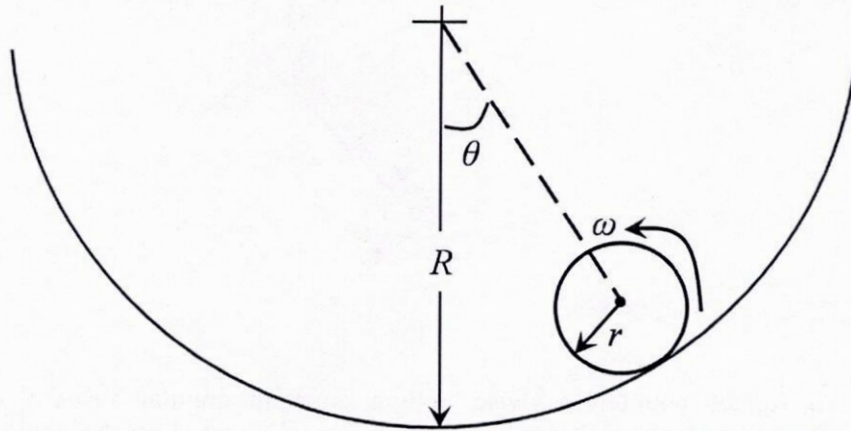
6(c) At the instant  $\theta = 60^\circ$ , the gyro top in the figure has three components of angular motion directed as shown and having magnitudes shown in the figure. Determine the angular velocity and acceleration of the top.



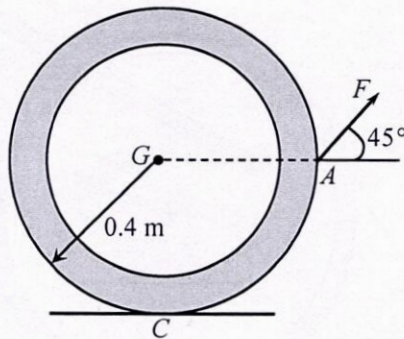
7(a) If the cord at  $B$  suddenly fails, determine the horizontal and vertical components of the initial reaction at the pin  $A$ , and the angular acceleration of the 120 kg beam.



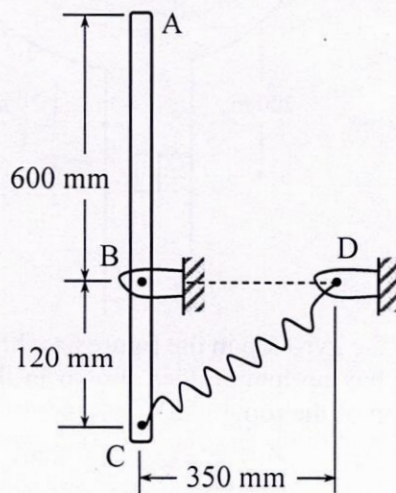
- 7(b) The disk of mass  $m$  and radius  $r$  rolls without slipping on the circular path. Determine the normal force which the path exerts on the disk and disk's angular acceleration if at the instant shown the disk has an angular velocity  $\omega$ . 15



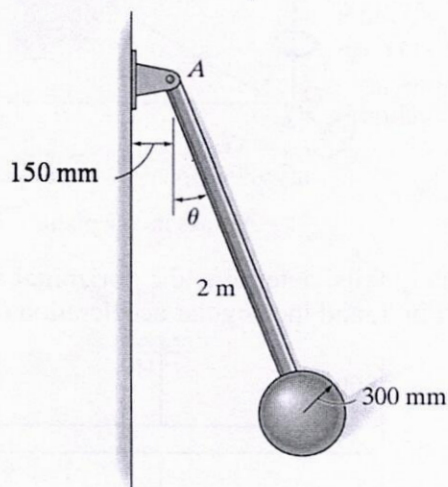
- 7(c) Determine the largest force  $F$  that can be applied to the 5 kg ring, without causing it to slip. Assume  $\mu_s = 0.3$  and  $\mu_k = 0.2$ . 10



- 8(a) Show that the velocity of two spheres, with different masses and the same radius, is mass independent when they travel the same height in an inclined plane without slipping. 09
- 8(b) A 4 kg slender rod rotates in a vertical plane about a pivot at  $B$ . A spring of constant  $k = 210$  N/m and unscratched length of 160 mm is attached to the rod as shown. Knowing that in the position shown, the rod has an angular velocity of 3.5 rad/sec counter clockwise, determine the angular velocity of the rod after it has rotated through  $90^\circ$ . 10



- 8(c) The pendulum consists of a 15 kg solid ball, and neglected the weight of the rod. If it is released from rest when  $\theta_1 = 90^\circ$ , determine the angle  $\theta_2$  after the ball strikes the wall, rebounds, and the pendulum swings up to the point of momentary rest. Take  $e = 0.6$ . 16



# KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechanical Engineering  
B. Sc. Engineering 2nd Year 2nd Term Examination, 2024

ME 2211  
(Mechanics of Solid)

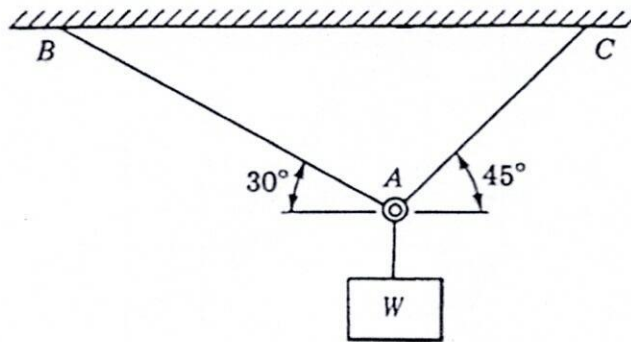
Time: 3 Hours

Total Marks: 210

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

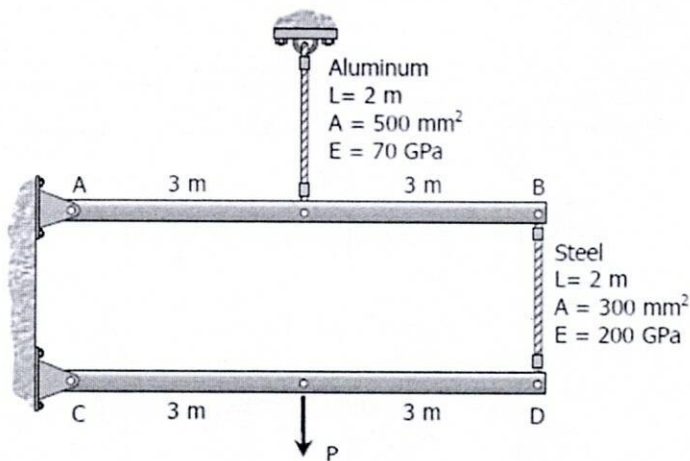
## SECTION-A

- 1(a) Determine the largest weight  $W$  that can be supported by the two wires shown in the figure. The stress in either wire is not to exceed 200 MPa. The cross-sectional areas of wires AB and AC are  $260 \text{ mm}^2$  and  $320 \text{ mm}^2$ , respectively. 18

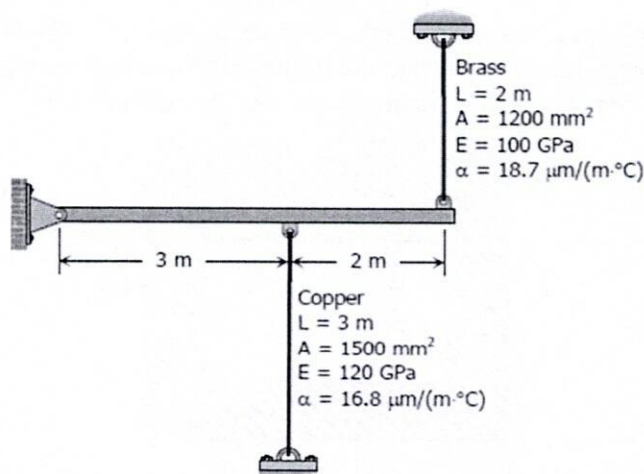


- 1(b) A cylindrical pressure vessel is fabricated from steel plating that has a thickness of 20 mm. The diameter of the pressure vessel is 450 mm, and its length is 2.0 m. Determine the maximum internal pressure that can be applied if the longitudinal stress is limited to 140 MPa, and the circumferential stress is limited to 60 MPa. 17

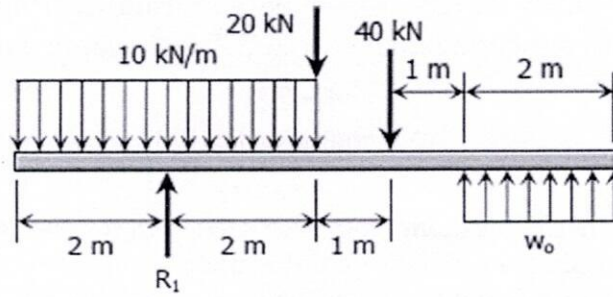
- 2(a) The rigid bars AB and CD shown in the figure are supported by pins at A and C and the two rods. Determine the maximum force  $P$  that can be applied as shown if its vertical movement is limited to 5 mm. Neglect the weights of all members. 18



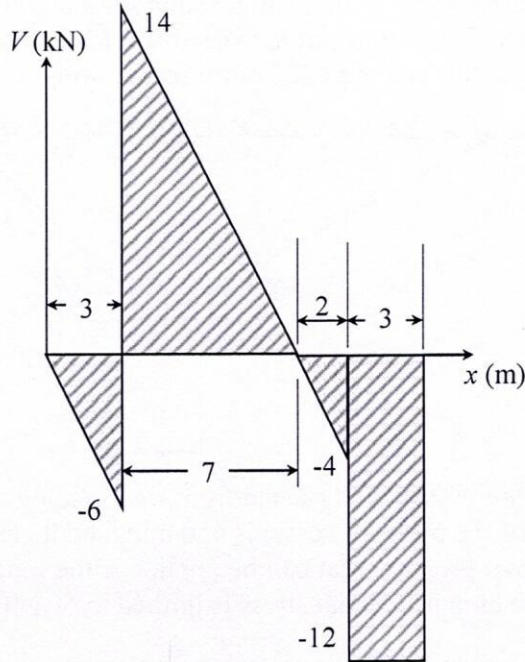
- 2(b) A rigid horizontal bar of negligible mass is connected to two rods as shown in the figure. If the system is initially stress-free, calculate the temperature change that will cause a tensile stress of 90 MPa in the brass rod. Assume that both rods are subjected to a change in temperature. 17



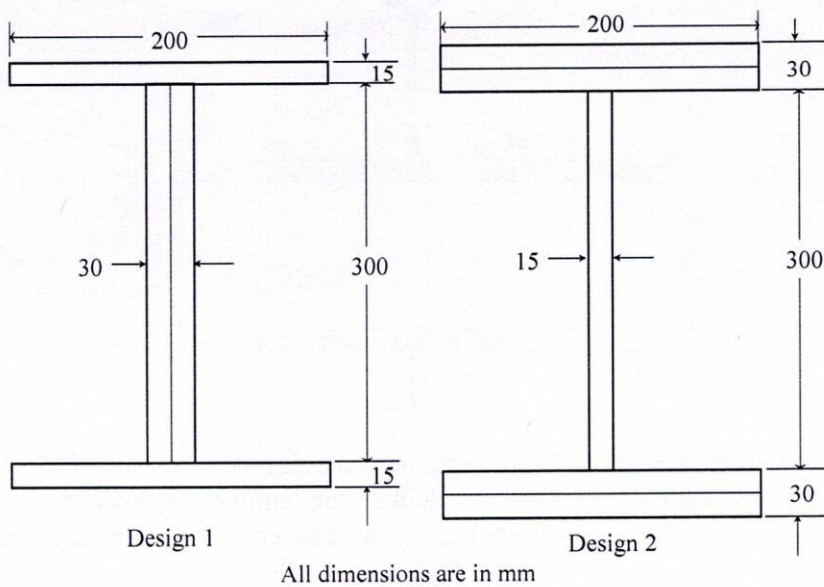
- 3(a) Draw shear and moment diagrams for the beam loaded as shown in the figure. Give numerical values at all changes of loading positions and at all points of zero shear. 18



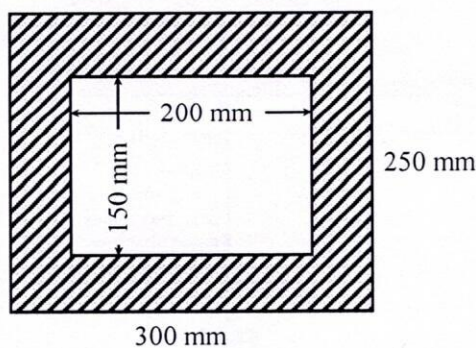
- 3(b) Draw the load diagram and bending moment diagrams for the shear diagram shown in the figure. Also, specify values at all changes of loading positions and at all points of zero shear. 17



- 4(a) Two designs for a beam are to be considered, as shown in the figure. Determine which one will support a moment of  $M = 150 \text{ kN}\cdot\text{m}$  with the least amount of flexural stress. What is that stress? 20

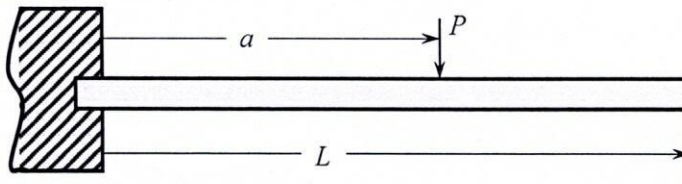


- 4(b) A simply supported beam of length  $L$  carries a uniformly distributed load of  $6 \text{ kN/m}$  and has the cross-section shown in the figure. Find  $L$  to cause a maximum flexural stress of  $16 \text{ MPa}$ . What maximum shearing stress is then developed? 15

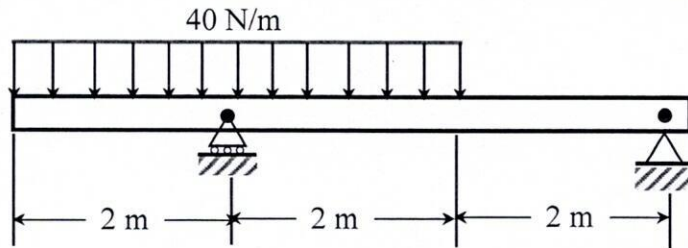


## SECTION-B

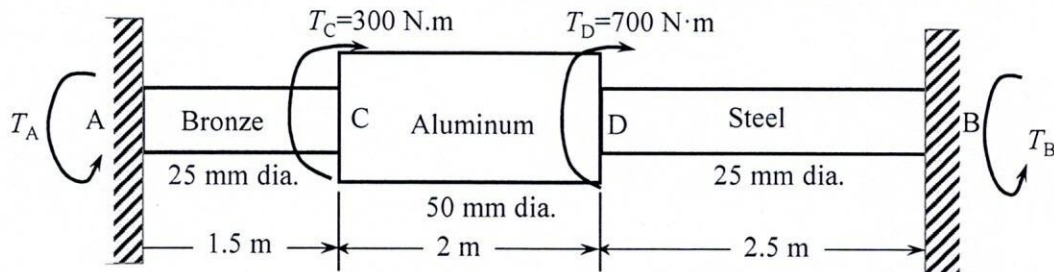
- 5(a) Determine the maximum value of  $EIy$  for the cantilever beam loaded as shown in the figure. Take the origin at the wall. 17



- 5(b) Determine the value of  $EI\delta$  at the left end of the beam shown in the figure. 18

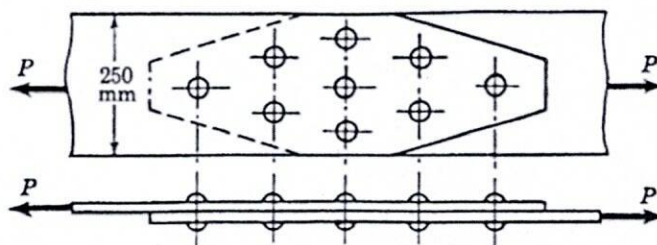


- 6(a) A shaft composed of segments AC, CD, and DB is fastened to rigid supports and loaded as shown in the figure. For bronze,  $G = 35$  GPa; for aluminum,  $G = 28$  GPa, and for steel,  $G = 83$  GPa. Determine the maximum shearing stress developed in each segment. 15



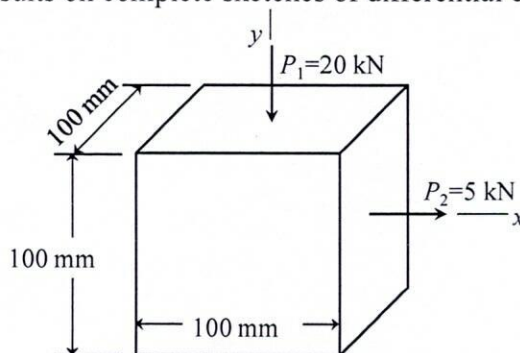
- 6(b) Select the lightest W shape that will act as a column 8 m long with hinged ends and support an axial load of 270 kN with a factor of safety of 2.5. Assume that the proportional limit is 200 MPa and  $E = 200$  GPa. 20

- 7(a) Find the safe load on the lap connection shown in the figure, if the rivets are 19 mm in diameter and the plates are 8 mm thick. Use allowable stress  $\tau = 95$  MPa,  $\sigma_t = 140$  MPa and  $\sigma_b = 220$  MPa. 18



- 7(b) A  $150 \times 100 \times 13$  mm angle is to be welded to a gusset plate with the 150 mm leg against the plate. If the angle carries a centroidal load of 400 kN, what lengths of 8 mm side fillet welds will be required along the toe and heel of the angle for a non-eccentric connection? Assume the allowable shearing stress through the throats of the welds is 145 MPa. 17

- 8 A metal block is loaded as shown in the figure. 35
- Determine the normal stress and shearing stress in plane AB.
  - Determine the plane of maximum shearing stress and its value.
  - Show all results on complete sketches of differential elements.



Plane AB is  $30^\circ$  counter-clockwise from the x-axis

# KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechanical Engineering  
B. Sc. Engineering 2nd Year 2nd Term Examination, 2024

ME 2213  
(Fluid Mechanics II)

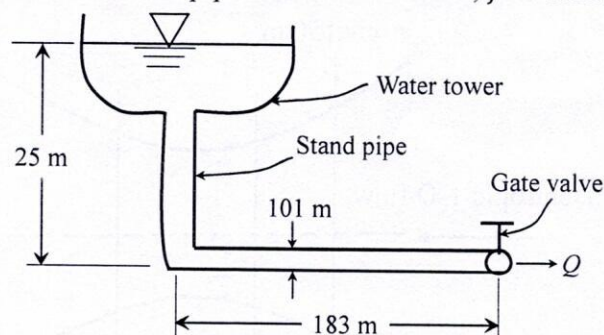
Time: 3 Hours

Total Marks: 210

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

## SECTION-A

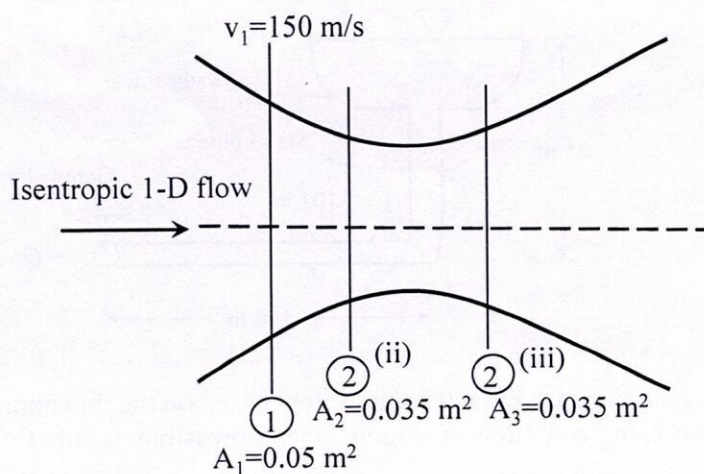
- 1(a) For fully developed laminar flow between a stationary and a constant velocity moving plate, derive the expression of average velocity of the flow. Draw and explain the non-dimensional velocity profile. 17
- 1(b) A flow of 500 liters/min of oil ( $SG = 0.89$  and velocity = 1.56 poise) is pumped through a pipeline 85 mm in diameter having a length of 80 m. Calculate the pressure drop, average shear stress at the wall of the pipe, and power required by the pump to maintain the flow (i) if the pipe is horizontal, (ii) the outlet of the pipe is 4 m higher than its inlet. The pump efficiency is 55 %. 18
- 2(a) What is the loss coefficient and equivalent length for minor head loss? Explain the fundamental causes of head loss with sketches for flow through the inlet and exit of the pipe. How can these losses be minimized? 12
- 2(b) State the rules for analyzing pipe networks. What conditions are imposed on discharge and head loss in series and parallel connections of multiple pipes? 08
- 2(c) A fire protection system is supplied from a water tower and a standpipe 25 m tall. The longest pipe in the system is 183 m and is made of cast iron. The pipe is 101 m in diameter and contains one gate valve. Neglecting other minor losses, determine the maximum rate of flow through the pipe. For a fully open gate valve, assume  $L_e/D = 8$  and take roughness,  $e = 0.26$  for cast iron pipe and friction factor,  $f = 0.03$ . 15



- 3(a) Deduce the equations for boundary layer flow based on the thin approximation of Prandtl from the governing equations of viscous, incompressible, steady flow. 08
- 3(b) Show that the boundary layer thickness for laminar flow with zero pressure gradient grows parabolically. 12
- 3(c) Water flows at 1.2 m/s past a flat plate with  $L = 0.9$  m in the flow direction. The boundary layer is tripped, so it becomes turbulent at the leading edge. Evaluate disturbance thickness, displacement thickness, and wall shear stress at the end of the plate. Compare the results with laminar flow maintained at the same position. Assume  $\nu = 1 \times 10^{-6}$  m<sup>2</sup>/s for water. 15
- 4(a) What is the velocity profile shape factor? "Shape factor is a powerful indicator of boundary layer separation and pressure gradient."—Justify the statement with sketches. 10
- 4(b) Obtain the relationship between the skin-friction coefficient and drag coefficient for a turbulent boundary layer over a flat plate. 12
- 4(c) A hydrofoil of 0.35 m long and 2 m wide is placed in a uniform seawater flow of 15 m/s, with  $\rho = 1025$  kg/m<sup>3</sup> and  $\nu = 1.05 \times 10^{-6}$  m<sup>2</sup>/s. Estimate the boundary layer thickness at the end of the plate. Also, estimate the friction drag for (i) turbulent smooth-wall flow from the leading edge, (ii) laminar turbulent flow with  $R_e = 5 \times 10^5$ , and (iii) turbulent rough wall flow with  $e = 0.12$  mm. 13

## SECTION-B

- 5(a) Prove that when a jet strikes centrally on a stationary flat plate normal to the jet, it splits into two streams with equal flowrates ( $Q_1 = Q_2$ ). But, when the plate is inclined at an angle  $\theta$ , the split is unequal flow rates ( $Q_1 \neq Q_2$ ). 10
- 5(b) Justify the statement— “The force exerted by a jet in its direction of flow on a stationary curved vane is always greater than that exerted by a flat plate”. 10
- 5(c) A jet of water moving at 25 m/s impinges on a symmetrical curved vane where the jet strikes tangentially and is deflected through  $130^\circ$ . If the vane is moving at 5 m/s, find the angle of the jet so that there is no shock at the inlet. Also, determine the absolute velocity of the exit in magnitude and direction. 15
- 6(a) Define compressibility. Explain mathematically why compressibility cannot be neglected when  $m_a \geq 0.32$ . 09
- 6(b) Explain with suitable sketches of wave propagation. Why an arbitrary car does not produce a sonic boom, whereas a jet can? 06
- 6(c) For a variable flow cross-sectional area, explain how a change in area affects the velocity variation for the subsonic and supersonic conditions. 12
- 6(d) Why does the mass flow rate stop increasing after the nozzle chokes, even if the back pressure is reduced further? 08
- 7(a) Choked flows are to be created from a large reservoir kept at high pressure. Discuss how these can be created for the following processes: 15
- (i) A duct with varying cross-sectional area. Neglect friction and heat transfer.
  - (ii) A constant area duct with friction and adiabatic flow.
  - (iii) A constant area duct with heat transfer but negligible friction.
- 7(b) Air flows isentropically through a duct as shown in the figure. At section 1, the area is  $0.05 \text{ m}^2$ , and the velocity  $v_1 = 150 \text{ m/s}$ ,  $P_1 = 550 \text{ kPa}$  and  $T_1 = 470 \text{ K}$ . Compute (i)  $T_0, P_0, M_1, \dot{m}$  and  $A^*$ . If the area of section 2 is  $0.035 \text{ m}^2$ , compute  $M_2$  and  $P_2$ , if the flow is (ii) subsonic or (iii) supersonic, assume  $k = 1.4$ . 20



- 8(a) Show with the velocity diagram that, through a normal shock, always gives upstream  $M_1 > 1$  to downstream  $M_2 < 1$ , but for an oblique shock, the downstream Mach number may be  $M_2 > 1, M_2 = 1$  or  $M_2 < 1$ , depending on the shock angle and flow deflection. 12
- 8(b) Explain why wall friction accelerates a subsonic compressible fluid in Fanno flow. 08
- 8(c) Air enters a 27 m long 50 mm diameter adiabatic duct at  $v_1 = 90 \text{ m/s}$ ,  $T_1 = 450 \text{ K}$  and  $P_1 = 200 \text{ kPa}$ . The average friction factor of the duct is estimated to be 0.025. Determine the Mach number at the duct exit and flowrate of the air. Also, find the additional duct length,  $\Delta L$  must be added downstream of the existing duct so that the flow reaches sonic conditions at the new exit. 15

# KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechanical Engineering  
B. Sc. Engineering 2nd Year 2nd Term Examination, 2024

ME 2221  
(Computer Programming)

Time: 3 Hours

Total Marks: 210

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

## SECTION-A

- 1(a) Illustrate the structure of a C program and explain different sections of the program. 10
- 1(b) What are the data types and variables used in C programming? Briefly explain with proper examples. 10
- 1(c) Explain why and how escape sequences are used in C programs. 05
- 1(d) Write True or False for the following statements and justify your answers. 10
- (i) An array in C can store elements of different data types.
  - (ii) A function in C can return more than one value directly.
  - (iii) The conditional operator can be nested inside another conditional operator.
  - (iv) In C, the expressions ++i and i++ always produce the same results in an expression.
  - (v) The expression !(x>0) is true when x is negative.
- 2(a) Compare the while loop and do-while loop with an example. 06
- 2(b) Write a C program to determine the roots of  $ax^2 + bx + c = 0$  for any value of  $a, b, c$ ; note that for a complex root ( $b^2 < 4ac$ ), the program will tell you that the root will be complex. 15
- 2(c) Write a C program to find the prime numbers between 20 to 100. 14
- 3(a) Explain the use of 'goto', 'break', and 'continue' statements with proper examples. 09
- 3(b) Write a C program to calculate the cumulative work done by a force applied in  $n$  steps. Input the distance per step and the force at each step, then display a table showing Step | Force | Cumulative work. 11
- 3(c) Write a C program to calculate the electricity bill. Input the number of units consumed, calculate the bill using slab rate (first 100 units: 5 Tk./unit; next 100: 7 Tk./unit; above 200: 10 Tk./unit), and apply a 10% surcharge if the bill > 1000 Tk. or a 5% discount if bill < 500 Tk., and display the total bill with units. 15
- 4(a) What is meant by an array variable? What will happen if you try to access an array index out of bounds in C? 07
- 4(b) Write a C program to input 10 integers into an array. Input a number from the user and search for it in the array. If the number is found, print the positions; otherwise, print "Not Found". 12
- 4(c) Write a C program that will read a square matrix and will show the sum of the diagonal elements. 16

## SECTION-B

- 5(a) What is meant by string? Write the functions of the following string functions- 07  
(i) Strcpy() (ii) strlen() (iii) strrev() (iv) strcmp()
- 5(b) Give the names of the 120 second-year Mechanical Engineering students. Write a C 18  
program to sort them alphabetically by name.
- 5(c) Write a C program that will pass two pointer variables to a function, and the function 10  
will return the largest value between them.
- 6(a) Compare passing value as an argument by its value and by reference in C 08  
programming.
- 6(b) The combinational coefficient  $C(n, r)$  is defined as follows: 14  
$$C(n, r) = \frac{n!}{(n-r)!r!}$$
 where  $0 < r < n$  must hold and  $n, r$  are integers.  
Write a C program using a user function to compute  $C(n, r)$ .
- 6(c) Write a C program using recursion to compute temperature decay over time, following 13  
Newton's law of cooling  $T(t) = T_{env} + (T_0 - T_{env})e^{-kt}$ . Use inputs  $T_{env}, T_0, k, t$ .
- 7(a) Explain the terms static memory allocation and dynamic memory allocation. 06
- 7(b) What is meant by a structure variable? How does structure differ from union? 09  
Describe the syntax of defining the composition of a structure.
- 7(c) Write a C program where each student has a roll number, name, date of birth, and 20  
marks in three subjects. The program should input the details of each student,  
calculate the average marks, and display all the information for every student.
- 8(a) What is meant by a file in C? What are the advantages of using a data file in C 08  
programming?
- 8(b) What are global and local variables in C programming? Why are global variables used 09  
in the C programming language?
- 8(c) Write a C program to open a file to read name and CGPAs of  $n$  number of students 18  
from the user, sort them in descending order of CGPA, and store them in an output  
file.