KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechanical Engineering

B. Sc. Engineering 2nd Year Backlog Examination, 2022

ME 2113

(Fluid Mechanics I)

Time: 3 Hours   Full 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 is missing.

SECTION-A

1(a) What is meant by Newtonian fluid? Draw rheological diagram to identify different types of fluids. 11

1(b) Distinguish between ideal fluid and real fluid. 08

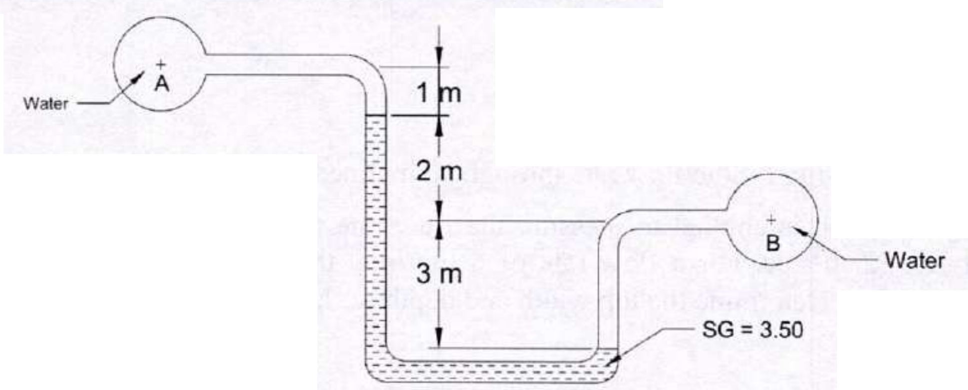
1(c) Explain how viscosity of fluid varies with temperature and pressure. 06

1(d) A rectangular plate 35 cm by 55 cm and weighing 28 N slides down 39° inclined surface at a uniform velocity of 2.3 m/sec. If the uniform gap 1.5 mm between the plate and inclined surface is filled with oil, determine the viscosity of the oil. 10

2(a) Show that the static pressure remains constant along the horizontal surface, where it varies along the vertical direction when fluid is at rest and incompressible. 10

2(b) Describe the working principle for measuring viscosity by a Saybolt viscometer with neat sketch. 15

2(c) The manometric fluid in the manometer of the following figure has a specific gravity of 3.50. Pipe A and B both contain water. If the pressure in pipe A is decreased by 187.2 Pa, determine the new differential reading of the manometer. 10



3(a) Explain the stability conditions of fully submerged object with neat schematic diagrams. 10

3(b) Derive an expression of the metacentric height of a floating object. 12

3(c) A solid cylinder of diameter 3.75 m and a height of 3.2 m. Find the metacentric height of the cylinder, if the specific gravity of the material of cylinder is 0.58 and it is floating in water with its axis vertically. State whether the equilibrium is stable or unstable. 13

4(a) Deduce the expression for pressure head of fluid in a cylindrical container subjected to constant angular rotation about its vertical axis. 18

4(b) Petrol with density of 889 kg/m^3 is transported in a level road in a 7 m long and 3.5 m diameter cylindrical tanker. The tanker is completely filled with milk and it accelerate at 2.0 m/sec^2. If minimum pressure in the tanker is 75 kPa, determine the maximum pressure and its location. 17

SECTION-B

5(a)	Distinguish between (i) uniform and non-uniform flow, and (ii) rotational and irrotational flow.	10
5(b)	State Bernoulli's theorem. What are the assumptions of Bernoulli's equation?	10
5(c)	Deduce the general form of continuity equation in Cartesian three dimensional coordinate. Also, reduce this equation for steady, two dimensional, incompressible flow.	15

6(a)	Distinguish between geometric similarity and dynamic similarity.	06
6(b)	State and explain the Buckingham's π – theorem.	10
6(c)	Write the physical significance of following non-dimensional terms: (i) Mach number (ii) Weber number (iii) Euler number	09
6(d)	The drag force F on a floating vessel in water depends on the speed v, length l, density ρ, viscosity μ and acceleration due to gravity g. Develop the dimensionless groups and check each.	10

7(a)	Write short notes on: (i) Orifice meter (ii) Anemometer (iii) Weir	09
7(b)	Classify the Orifice meter and explain two major type with neat sketch.	11
7(c)	Derive the expression to measure the flow rate by a trapezoidal notch.	15

8(a)	Derive an expression for the flow rate through an inclined Venturimeter.	18
8(b)	A triangular notch is applied to measure the flow rate through a canal whose maximum capacity is 1.2 m^3/sec. For a flow rate of 6 liter/sec, the depth of water over the notch becomes 0.15 m. Determine the top width and depth of the notch assuming $c_d = 0.05$.	17

≈ *end* ≈

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechanical Engineering

B. Sc. Engineering 2nd Year Backlog Examination, 2022

ME 2213

(Fluid Mechanics II)

Time: 3 Hours | Full Marks: 210

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

SECTION-A

1(a) State laws of fluid friction for both laminar and turbulent flows on the basis of experimental observations. 08

1(b) Explain major and minor losses for fluid flows through a pipe. Also, show that the head loss in pipes due to friction may be expressed in terms of velocity head for a given pipe geometry. 14

1(c) A pipe of 50 mm diameter is 6 m long and the velocity of flow water in the pipe is 2.4 m/s. What loss of head and the corresponding power would be saved if the central 2 m length of pipe was replaced by 75 mm diameter pipe, the change of section being sudden? Take $f = 0.04$ for the pipes of both diameters. 13

2(a) Derive the expressions of wall shear stress for incompressible laminar flow between two co-axial cylinders. 17

2(b) Oil of viscosity 0.15 Pa.s and specific gravity 0.90, flows through a horizontal pipe of 25 mm diameter. If the pressure drop per meter length of pipe is 15 kPa, determine– 18

(i) the rate of flow in m^3/min,
(ii) the shear stress at the pipe wall,
(iii) the Reynold's number of the flow, and
(iv) the power required per 50 m length of pipe to maintain the flow.

3(a) Prove that the maximum velocity of a laminar flow between two parallel stationary flat plates is equal to 1.5 times the average velocity of the flow. 20

3(b) Two parallel plates kept at 0.15 m apart have laminar flow of oil between them with a maximum velocity of 2.5 m/s. Calculate the discharge per unit width, the shear stress at the plates and the pressure difference between two points 25 m apart. Take $\mu = 2.45$ N.s/m^2. 15

4(a) What are favorable and adverse pressure gradients? Illustrate the effect of pressure gradient on boundary layer velocity profile with neat sketch. 10

4(b) Explain the fundamental causes of existence for boundary layer. 07

4(c) A laminar boundary layer at zero pressure gradient over a flat plate is described by the velocity profile 18

$$\frac{u}{U_\infty} = \frac{3}{2}\eta - \frac{1}{2}\eta^3 \quad \text{where} \quad \eta = \frac{y}{\delta}$$

Derive the expression of boundary layer thickness in terms of local length of the plate and local Reynolds number.

SECTION-B

5(a) Prove that the exerted force of a jet on a semi-circular cup is the same whether striking at the center of the cup or striking tangentially at one tip. Explain the reason. 18

5(b) A jet of water having a velocity of 45 m/s impinges without shock on a series of vanes moving at 15 m/s, the direction of motion of the vanes being inclined at 20° to that of jet. The relative velocity of outlet is 0.9 of that at the inlet and absolute velocity of water at exit is to be normal to motion of the vanes. Determine– 17

(i) the vane angles at entrance and exit,
(ii) the work done on the vanes per unit weight of water supplied by the jet,
(iii) the hydraulic efficiency.

6(a) Discuss lift and drag with their general mathematical expressions. 05

6(b) Discuss the phenomena of flow separation in a diverging flow. 08

6(c) Explain the methods of controlling the separation of boundary layer. 12

6(d) A thin plate is installed in a water tunnel as splitter. The plate is 0.4 m long and 1.2 m wide. The freestream speed is 1.8 m/s. Assume laminar boundary layers form on both sides of the plate and the velocity profile approximated as parabolic. Determine the total drag on the plate. Take $\rho = 998$ kg/m^3 and $\mu = 1.2 \times 10^{-3}$ Pa.s. 10

7(a) Show that $\frac{dA}{A} = \frac{dV}{V}(M^2 - 1)$ for compressible fluid flow with negligible friction through a pipe of varying cross-section. Discuss the relationship between area variation with the velocity for subsonic and supersonic flows. 15

7(b) For an adiabatic flow through a constant area duct of diameter 24 mm, the Mach number at the inlet is 1.47. Find the length of pipe to develop the flow at Mach number 1. Assume $f = 0.0038$. 12

7(c) What are Fanno line and Rayleigh line? Draw them and explain. 08

8(a) Differentiate between normal shock wave and oblique shock wave. 08

8(b) Derive the Rankine-Hugoniot equation for a normal shock of compressible flow. 14

8(c) A normal shock occurs in a compressible flow through a duct. The conditions before the shock are $p = 35$ kPa, $T = 2$°C and $V = 900$ m/s. Determine the Mach number and pressure, temperature, and density after the shock. 13

– End –

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechanical Engineering

B. Sc. Engineering 2nd Year Backlog Examination, 2022

ME 2211

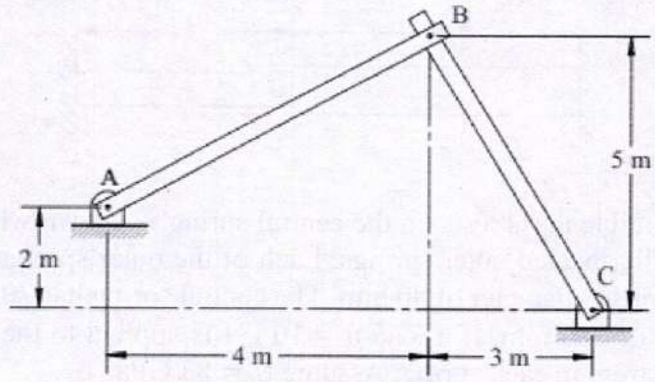
(Mechanics of Solid)

Time: 3 Hours | Full Marks: 210

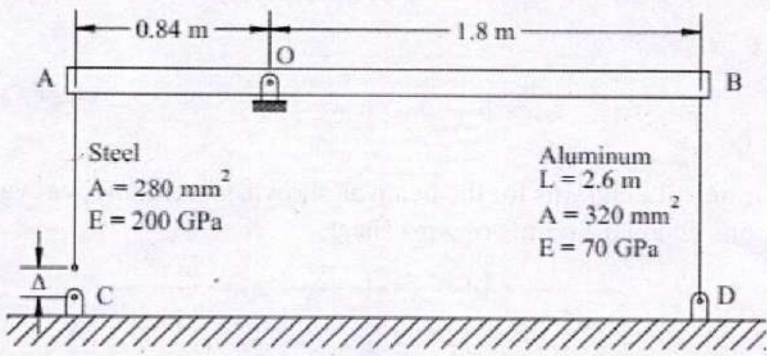
N.B.: i) Answer any THREE questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.
iii) Assume reasonable data if any missing.
iv) Table B2 may be supplied on request.

SECTION-A

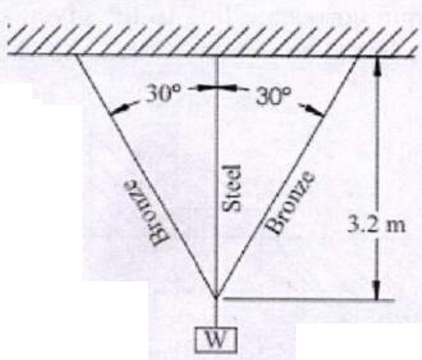
1(a) The members of the structure in the figure weigh 3 kN/m. Determine the smallest diameter pin that can be used at A if the shearing stress is limited to 20 MPa, Assume single shear. 17



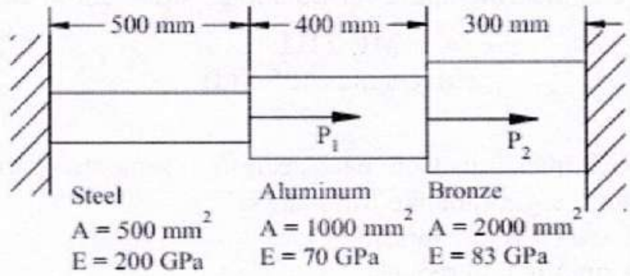
1(b) The assembly in the figure consists of a light rigid bar AB, pinned at O, that is attached to the steel and aluminum rods. In the position shown, bar AB is horizontal and there is a gap, $\Delta = 6$ mm, between the lower end of the steel rod and its pin support at C. Compute the stress in the aluminum rod when the lower end of the steed rod is attached to its support. 18



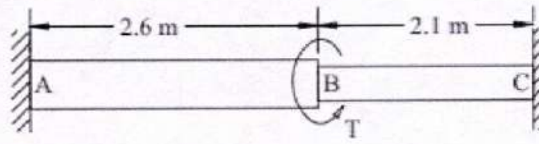
2(a) Three rods, each of area 280 mm^2, jointly support a 9.6 kN load as shown. Assuming that there was no slack or stress in the rods before the load was applied, find the stress in each rod. Use $E_{st} = 200$ GPa and $E_{br} = 83$ GPa. 18



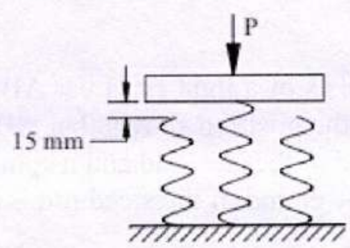
2(b) A bar is composed of three segments as shown and carries the axial loads $p_1 = 100$ kN and $p_2 = 40$ kN. Determine the stress in each material, if the wall are rigid. 17



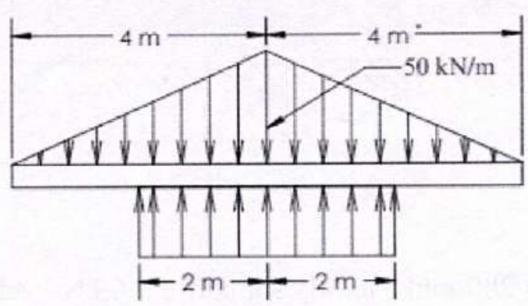
3(a) The compound shaft is attached to rigid supports as shown. For the bronze segment AB, the diameter is 80 mm, $\tau \leq 65$ MPa, and $G = 40$ GPa. For the steel segment BC, the diameter is 56 mm, $\tau \leq 84$ MPa, and $G = 86$ GPa. Compute the maximum torque T that can be applied. 17



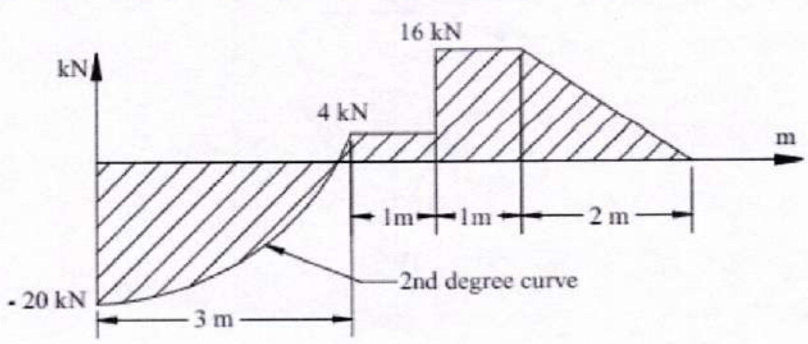
3(b) A rigid plate of negligible mass rests on the central spring as shown which is 15 mm higher than the symmetrically located outer springs. Each of the outer springs consists of 15 turns of 12 mm wire on a mean diameter of 80 mm. The central spring has 20 turns of 25 mm wire on a mean diameter of 120 mm. If a load $p = 10$ kN is applied to the plate, determine the maximum shearing stress in each spring. Assume $G = 83$ GPa. 18



4(a) Draw shear and moment diagrams for the beam as shown. Give numerical values at all change of loading positions and at all points of zero shear. 18

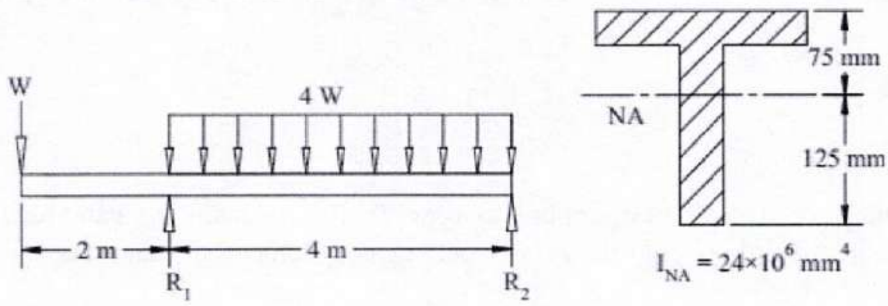


4(b) Draw moment and load diagram corresponding to the given shear diagrams. Specify values at all change of load positions and at all points of zero shear. 17

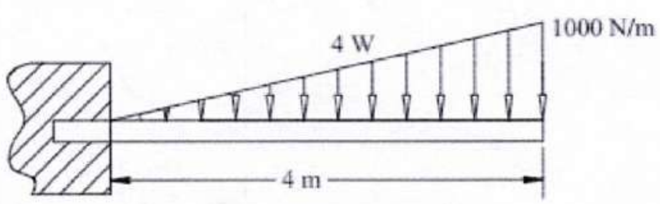


SECTION-B

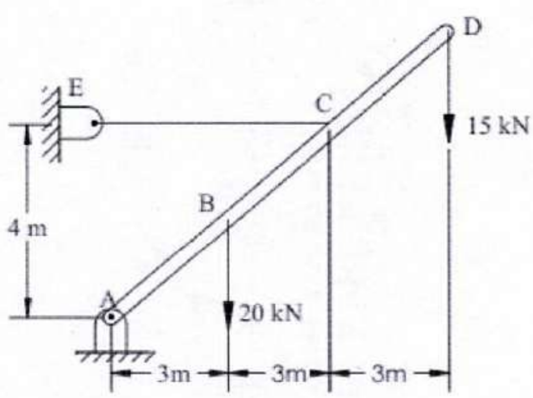
5(a) A beam carries a concentrated load W and a total uniformly distributed load 4W as shown. What safe value of W can be applied if $\sigma_c \leq 120$ MPa and $\sigma_t \leq 75$ MPa? Can a greater load be applied if the section is inverted? Explain. 18



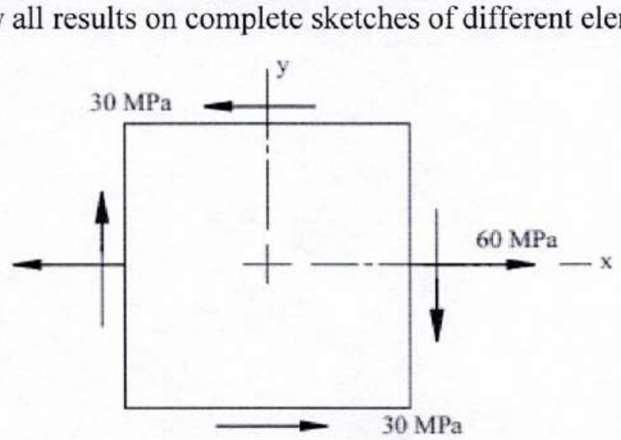
5(b) Compute the deflection and slope at a section 2.5 m from the wall for the beam as shown. Assume $E = 10$ GPa and $I = 30\times10^6$ mm^4. 17



6(a) A timber beam AD, 120 mm thick by 340 mm high and loaded as shown is pinned at its lower end and supported by a horizontal cable CE. Determine the maximum compressive stress in the beam. 17



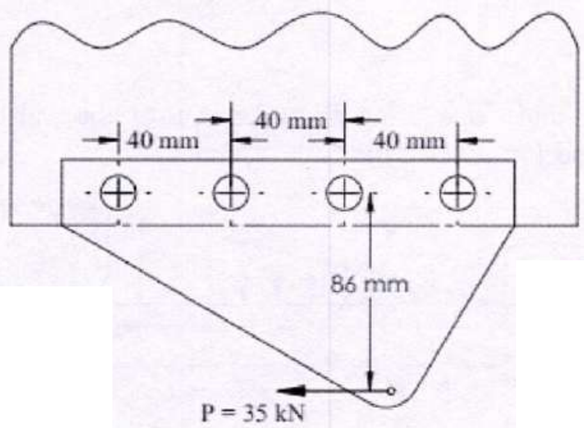
6(b) For the state of stress as shown in figure, determine the principal stress and the minimum shearing stress. Show all results on complete sketches of different elements. 18



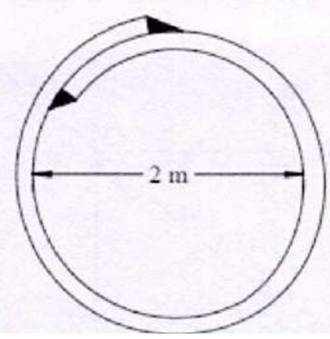
7(a) Select the lightest W shape that will act as a column 8-m long with hinged ends and support an axial load of 270 kN with a factor of safety of 3.0. Assume that the proportional limit is 200 MPa and $E = 200$ GPa. 18

7(b) Derive the critical load of a hinged long column, hence show that critical load of a long column with one end fixed and other hinged is twice the critical load of a hinged column. 17

8(a) A gusset plate is riveted to a larger plate by four 20 mm rivets arranged and loaded as shown. Determine the maximum and minimum shear stress developed in the rivets. 17



8(b) A 18 mm plate is lapped over and secured as shown by transverse fillet welds on the inside and outside to form a penstock 2.0 m in diameter. Determine the safe internal pressure, assuming allowable stresses of $\sigma_t = 150$ MPa for the plate and $\tau = 130$ MPa through the throats of the welds. Use the maximum size of welds permitted. 18



– End –