BANGLADESH UNIVERSITY OF PROFESSIONALS
Military Institute of Science and Technology
B.Sc. in Environmental, Water Resources, and Coastal Engineering,
Supplementary-I Examination 2022: March 2023

Subject: EWCE 211, Mechanics of Solids (OBE)

Time: 3.00 hours **Full Marks: 240**

INSTRUCTIONS:

a. Use **SEPARATE** answer scripts for each section.
b. **Question-1** in **Section-A** and **Question-5** in **Section-B** are compulsory
c. Answer any other **TWO** questions out of **THREE** from each section.
d. Figures in the margin indicate full **marks**.
e. Assume reasonable data if necessary.
f. **Symbols** and **abbreviations** used have their usual meanings.

SECTION-A

Question 1 (Compulsory)

a. Sufficient amount of liquefied gas need to be stored. A closed cylindrical steel vessel (figure 1) has linear diameter of 1m and length of 5m. Compute- **20**

(i) The thickness of the vessel, if the maximum allowable stress is 60 Mpa and internal pressure is 0.7 Mpa.

(ii) The maximum internal pressure it can sustain so that neither its circumferential nor its longitudinal stress component exceeds 80 Mpa, while the thickness of the vessel is chosen 20mm.

(iii) The maximum internal pressure that a smaller size spherical vessel can sustain [under the same conditions of (ii)]

(iv) The change in diameter in the sphere caused by pressurization employing the same as (iii).

Assume, E = 200 Gpa and $\upsilon = 0.25$.



Figure 1 [for Question 1(a)]

b. A cantilever beam is loaded as shown in figure 2. Given that, E = 2 ksi and I = 12000 in^4. **20**

(i) Apply moment area theorem, find the deflection at point B and rotation at point A.

(ii) For the given load, compute the strain energy stored in the beam.

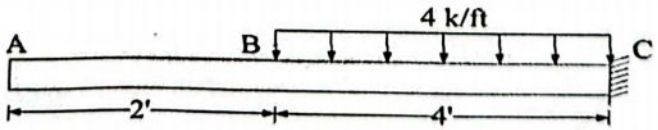


Figure 2 [for Question 1(b)]

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Question 2

a. Segments AB and CD of the assembly (figure 3) are solid circular rods with diameter of 20 mm. Segment BC is a tube, in which inner diameter is 20 mm and outer diameter is 30 mm, if E = 20 Mpa. 2

(i) Draw the internal axial force diagram along the length of the member.

(ii) Compute the displacement at the end D.

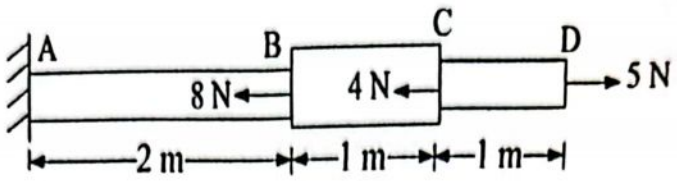


Figure 3 [for Question 2(a)]

b. The control arm is subjected to the loading shown in figure 4. Determine to the nearest $\frac{1}{4}$ inch the required diameter of the steel pins at A and C if the allowable shear stress for the steel is τ_{allow} = 8 ksi. 2

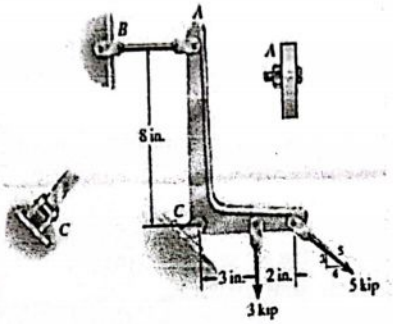


Figure 4 [for Question 2(b)]

Question 3

a. The device is used to measure a change in temperature. Bars AB and CD are made of steel and aluminum alloy respectively (figure 5). When the temperature is at 75° F, ACE is in the horizontal position. Determine the vertical displacement of the pointer at E when the temperature rises to 150°F. Assume the coefficient of thermal expansion for aluminum and steel to be 23.2×10^{-6} /°C and 12×10^{-6}/°C, respectively. 2

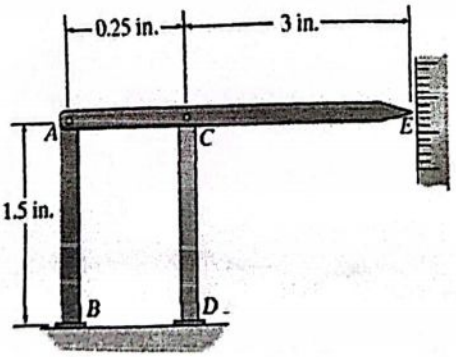


Figure 5 [for Question 3(a)]

b. The steel block as shown in figure 6 is subjected to uniform pressure on all of its faces. Given that the change in length of edge AB is -1.2×10^{-3} in, determine- 20

(i) the change in length in other two edges

(ii) the pressure applied to the faces of the block

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(iii) the change in volume Δv of the block, when it is subjected to the hydrostatic pressure, $P = 42 \times 10^3$ ksi. Assume $E = 29 \times 10^6$ psi and $\upsilon = 0.29$.

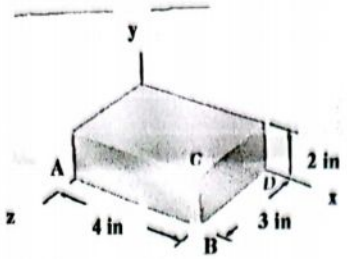


Figure 6 [for Question 3(b)]

Question 4

a. Determine the bending stress developed at the four corners. What is the orientation of the neutral axis? Use figure 7. **20**

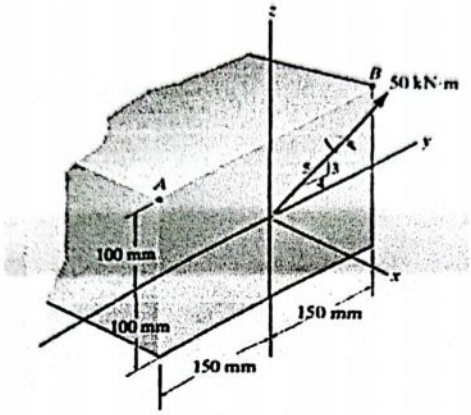


Figure 7 [for Question 4(a)]

b. Compute the largest weight 'W' that can be supported safety by the structure (figure 8). The working stresses are 16 ksi for the steel cable AB and 0.72 ksi for the wood strut BC. Neglect the weight of the structure. If W = 20 kips, also find the permissible area of AB and BC. **20**

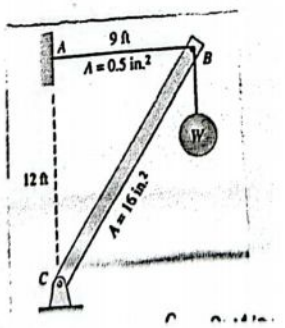


Figure 8 [for Question 4(b)]

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SECTION-B

Question 5 (Compulsory)

a. Calculate the value of deflection at free end and at mid span, assuming that the beam is a W18 × 50 rolled slope and ω_o = 2.5 kip/ft, L = 18 ft, and E = 29 × 10^3 ksi. Moment of inertia of a W18 × 50 section is 800 in^4. The beam is shown in figure 9.

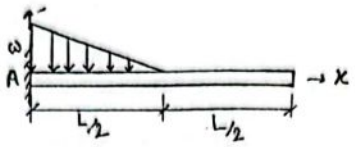


Figure 9 [for Question 5(a)]

b. Select a 18 ft long pin ended column to carry a concentric load of 165 kips, using the AISC LRFD column formulas. The structural steel is to be A572, σ_{yp} = 50 ksi. 1

Question 6

a. Draw shear force and bending moment diagram of the structure shown in figure 10. 2

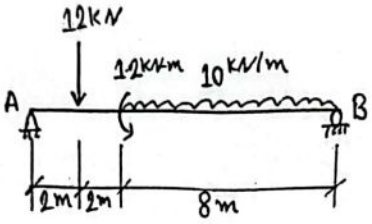


Figure 10 [for Question 6(a)]

b. Determine the maximum value of W_o that will not exceed a flexural stress of 2000 psi. The structure is shown in figure 11. 2

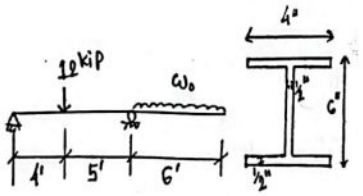


Figure 11 [for Question 6(b)]

Question 7

a. Compute the support reactions of the structure shown in figure 12. Also draw shear force and bending moment diagram. 2

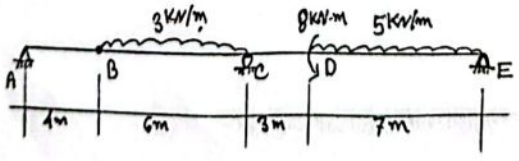


Figure 12 [for Question 7(a)]

b. A structure is shown in figure 13. Based on that, 20

(i) compute the maximum bending stress in the beam.

(ii) Sketch the bending stress distribution over the cross section on which the maximum bending occurs.

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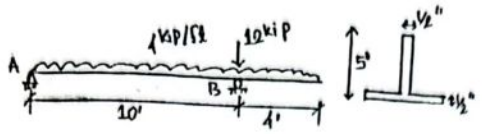


Figure 13 [for Question 7(b)]

Question 8

a. Compute the support reactions of the structure shown in figure 14. Draw axial force diagram, shear force diagram, and bending moment diagram of the structure. **20**

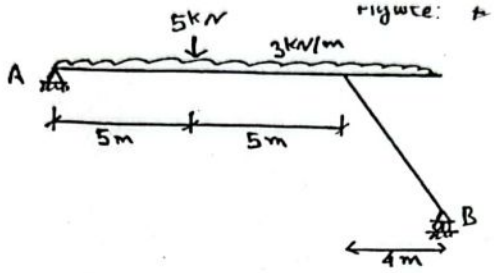


Figure 14 [for Question 8(a)]

b. Given the state of stress shown in figure 15. Using Mohr Circle, transform it **20**

(i) into the principal stresses

(ii) into the maximum shear stresses and the associated normal stresses.

Show the results for both cases on properly oriented elements.

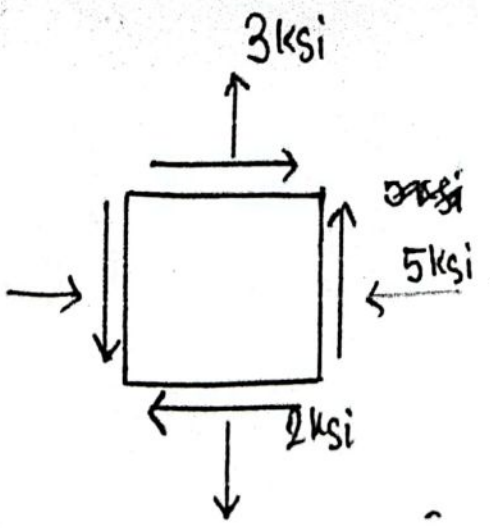


Figure 15 [for Question 8(b)]

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AISC LRFD,

$$\lambda_c = \frac{L_e}{r\pi}\sqrt{\frac{\sigma_{yp}}{E}}$$

$\lambda_c > 1.5$,

$$\sigma_{cr} = \left[\frac{0.877}{\lambda_c^2}\right]\sigma_{yp}$$

$\lambda_c \leq 1.5$,

$$\sigma_{cr} = (0.658^{\lambda_c^2})\,\sigma_{yp}$$

Stress strain transformation formulas,

$$\sigma_x' = \frac{\sigma_x+\sigma_y}{2} + \frac{\sigma_x-\sigma_y}{2}\cos 2\theta + \tau_{xy}\sin 2\theta$$

$$\tau_{xy}' = -\frac{\sigma_x-\sigma_y}{2}\sin 2\theta + \tau_{xy}\cos 2\theta$$

$$\tan 2\theta_p = \frac{\tau_{xy}}{(\sigma_x-\sigma_y)/2}, \quad \tan 2\theta_s = -\frac{(\sigma_x-\sigma_y)/2}{\tau_{xy}}$$

$$\sigma_{max/min} = \frac{\sigma_x+\sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x-\sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$\tau_{max/min} = \pm\sqrt{\left(\frac{\sigma_x-\sigma_y}{2}\right)^2 + \tau_{xy}^2}, \quad \sigma' = \frac{\sigma_x+\sigma_y}{2}$$

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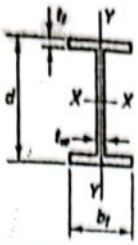


TABLE 4A. AMERICAN STANDARD STEEL W SHAPES DIMENSIONS AND PROPERTIES U.S. CUSTOMARY UNITS (ABRIDGED LIST)

Designation*	Area	Depth	Web Thickness	Flange Width	Flange Thickness	Axis X-X		Axis Y-Y	
	A	d	t_w	b_f	t_f	I_x	r_x	I_y	r_y
in × lb/ft	in²	in	in	in	in	in⁴	in	in⁴	in
W36 × 245	72.1	36.08	0.800	16.510	1.350	16100	15.0	1010	3.75
230	67.6	35.90	0.760	16.470	1.260	15000	14.9	940	3.73
150	44.2	35.85	0.625	11.975	0.940	9040	14.3	270	2.47
135	39.7	35.55	0.600	11.950	0.790	7800	14.0	225	2.38
W33 × 201	59.1	33.68	0.715	15.745	1.150	11500	14.0	749	3.56
130	38.3	33.09	0.580	11.510	0.855	6710	13.2	218	2.39
118	34.7	32.86	0.550	11.480	0.740	5900	13.0	187	2.32
W30 × 173	50.1	30.65	0.710	15.040	1.185	9170	12.8	673	3.66
173	50.8	30.44	0.655	14.985	1.065	8200	12.7	598	3.43
W27 × 102	47.4	27.59	0.680	14.020	1.080	6280	11.5	497	3.24
146	42.9	27.38	0.605	13.965	0.975	5630	11.4	443	3.21
94	27.7	26.92	0.490	9.990	0.745	3270	10.9	124	2.12
84	24.8	26.71	0.460	9.960	0.640	2850	10.7	106	2.07
W18 × 60	17.6	18.24	0.415	7.555	0.695	984	7.47	50.1	1.69
50	14.7	17.99	0.355	7.495	0.570	800	7.38	40.1	1.65
46	13.5	18.06	0.360	6.060	0.605	712	7.25	22.5	1.29
35	10.3	17.70	0.300	6.000	0.425	510	7.04	15.3	1.22

Designation*	Area	Depth	Web Thickness	Flange Width	Flange Thickness	Axis X-X		Axis Y-Y	
	A	d	t_w	b_f	t_f	I_x	r_x	I_y	r_y
in × lb/ft	in²	in	in	in	in	in⁴	in	in⁴	in
W16 × 26	7.68	15.69	0.250	5.500	0.345	301	6.26	9.59	1.12
W14 × 193	56.8	15.48	0.890	15.710	1.440	2400	6.50	931	4.05
159	46.7	14.98	0.745	15.565	1.190	1900	6.38	748	4.00
99	29.1	14.16	0.485	14.565	0.780	1110	6.17	402	3.71
90	26.5	14.02	0.440	14.520	0.710	999	6.14	362	3.70
W12 × 72	21.1	12.25	0.430	12.040	0.670	597	5.31	195	3.04
65	19.1	12.12	0.390	12.000	0.605	533	5.28	174	3.02
50	14.7	12.19	0.370	8.080	0.640	394	5.18	56.3	1.96
45	13.2	12.06	0.335	8.045	0.575	350	5.15	50.0	1.94
40	11.8	11.94	0.295	8.005	0.515	310	5.13	44.1	1.93
W10 × 112	32.9	11.36	0.755	10.415	1.250	716	4.66	236	2.68
60	17.6	10.22	0.420	10.080	0.680	341	4.39	116	2.57
49	14.4	9.98	0.340	10.000	0.560	272	4.35	93.4	2.54
45	13.3	10.10	0.350	8.020	0.620	248	4.33	53.4	2.01
39	11.5	9.92	0.315	7.985	0.530	209	4.27	45.0	1.98
33	9.71	9.73	0.290	7.960	0.435	170	4.19	36.6	1.94
W8 × 67	19.7	9.00	0.570	8.280	0.935	272	3.72	88.6	2.12
58	17.1	8.75	0.510	8.220	0.810	228	3.65	75.1	2.10
40	11.7	8.25	0.360	8.070	0.560	146	3.53	49.1	2.04
31	9.13	8.00	0.285	7.995	0.435	110	3.47	37.1	2.02
28	8.25	8.06	0.285	6.535	0.465	98.0	3.45	21.7	1.62
24	7.08	7.93	0.245	6.495	0.400	82.8	3.42	18.3	1.61
21	6.16	8.28	0.250	5.270	0.400	75.3	3.49	9.77	1.26
18	5.26	8.14	0.230	5.250	0.330	61.9	3.43	7.97	1.23

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Student Group: 36< Earned Credit Hours ≤ 72

Subject: EWCE 211, Mechanics of Solids

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SECTION-A

Question 1 (Compulsory)

a. What is Pure Bending? Illustrate with an example. (Answer must be supported with diagrams) **10**

a. Derive the flexural formula for bending stress of a simply supported beam in the form **15**

$$\sigma_{max} = \frac{M_{max}}{S}$$

where S is called the section modulus of the beam

b. A rectangular beam of breadth 150mm and depth 300mm is simply supported over a span of 5m. The beam is loaded with an uniformly distributed load of 6kN/m over the entire span. Find the maximum bending stresses developed in the beam. **15**

Question 2

a. Draw the Shear Force and Bending Moment Diagram for the Cantilever (overhanging) beam subjected to loading as shown in Figure 01. Find out the point of contra flexure and maximum moment developed in the beam. **40**

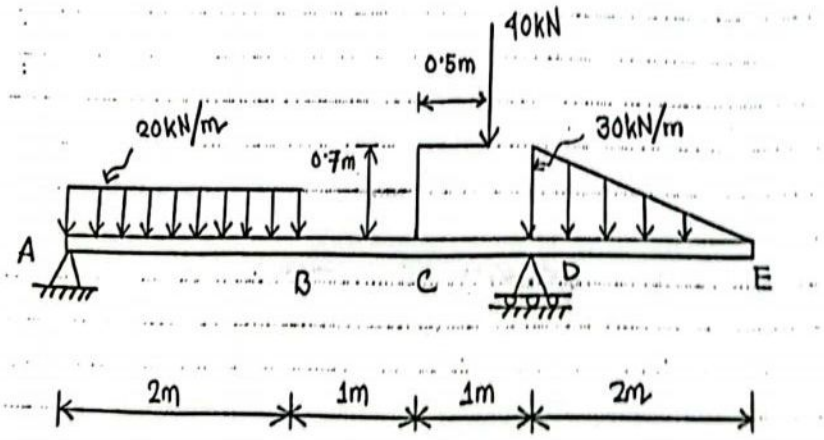


Figure 01

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Question 3

a. Find the stress distribution at section ABCD for the block shown in Figure 02, where P = 64 KN. Locate the line of zero stress. Neglect the weight of the block. The unit is in mm.

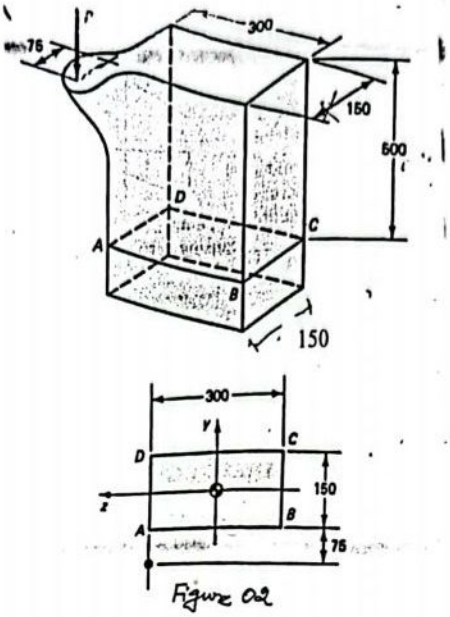


Figure 02

b. Determine (i) the principal stresses (ii) the orientation of the principal plane (iii) maximum shear stresses for the state of plane stress shown in Figure 03.

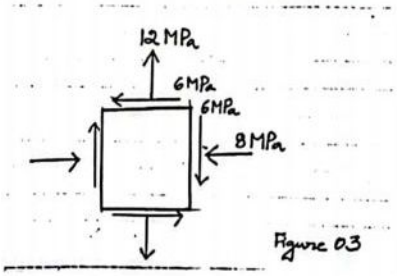


Figure 03

Question 4

a. Draw axial, shear force and bending moment diagram of each member of the frame shown in Figure 04. (Show detail calculation with diagram).

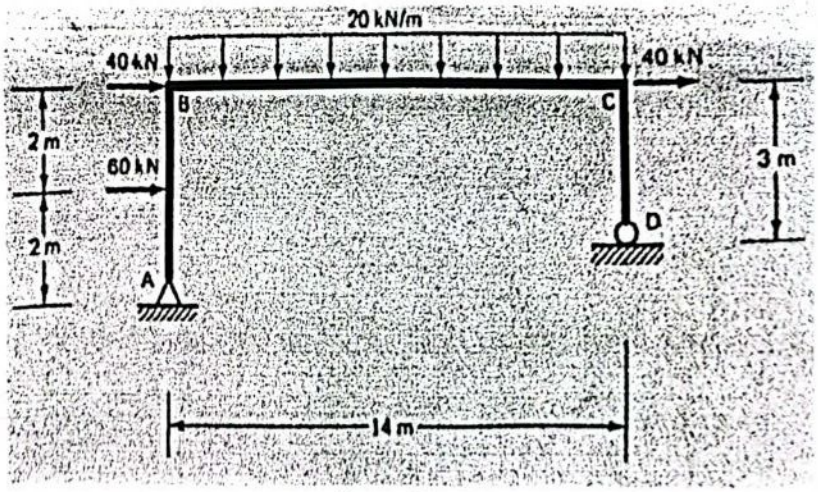


Figure-04

b. Find the shortest length 'L' for a steel column with pinned ends having a cross-sectional area of 60mm × 100mm, for which the elastic Euler formula applies. E = 200 GPa and the proportional limit to be 250 MPa.

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SECTION-B

Question 5 (Compulsory)

a. Calculate the value of deflection at free end and at mid span of beam shown in Figure 5(a), assuming that the beam is a W14×30 rolled shape and W_0=3.5kip/ft, L=25ft, E=29000ksi. Moment of Inertia of a W14×30 section is 600in^4. **20**

b. The bell crank is in equilibrium under the forces shown in the Figure 5(b). If allowable shear stress is 100MPa, determine the diameter required for pin B. Use a Factor of safety is 3. **20**

Question 6

a. Determine the relative displacement of point D from O for the elastic steel bar of variable cross section shown in Figure 6(a). Concentrated forces P_1=90kN and P_3=150kN are acting to the left and P_2=220kN and P_4=20kN are acting to the right as shown in Figure 6(a).
The respective areas for bar segments OB, BC and CD are 800mm^2, 1100mm^2 and 1600mm^2. Let, E=200GPa.
Draw the Axial Force and Axial Strain diagram of the bar. **20**

b. A bracket of negligible weight shown in Figure 6(b) is loaded with a vertical force P of 4kips. For interconnection purposes, the bar ends are clevised (Forked). Pertinent dimensions are shown in the figure. Find the axial stresses in members AB and BC and the bearing and shearing stresses for pin C. All pins are 0.375inch in diameter. **20**

Question 7

a. Two wires are connected to a rigid bar as shown in Figure 7(a). The wire AB is of steel having A_{AB}=0.12in^2, E_s=30×10^{6}psi and coefficient of thermal expansion α_s=12.2×10^{-6}/°C.
The aluminium alloy wire CD has A_{CD}=0.25in^2, E_a=10×10^{6}psi and α_a=22.5×10^{-6}/°C. The load W is negligible, **20**

(i) Compute the deflection at point E due to 30°C temperature rise.

(ii) Now if we consider the load W=1500lb, where should the weight be located so that the bar would remain horizontal?

b. Derive the formula of deflection (Δ) using Elastic strain energy for the beam of Figure 7(b). Also, determine vertical deflection at loading point. Moment of Inertia, I=300in^4, E=29×10^{6}psi. **20**

Question 8

a. Shaft BC is hollow with inner and outer diameter of 90mm and 120mm respectively. Shaft AB and CD are solid of diameter d. For the loading shown in Figure 8(a). Determine, **20**
(i) The minimum and maximum shearing stress in shaft BC.
(ii) The required diameter d of shafts AB and CD if the allowable shearing stress in these shafts is 75MPa.

b. For an industrial laboratory a pilot unit is to employ a pressure vessel of the dimensions shown in Figure 8(b). The vessel will operate at an internal pressure of 0.62MPa. If the bolt diameter of 20mm needs to be used, predict the number of bolts required to resist the stress of 110MPa. Assume, stress concentration factor as 2.5. **20**

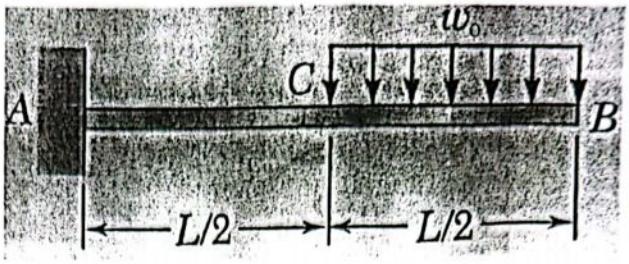


Figure: 5(a) of Question No. 5(a)

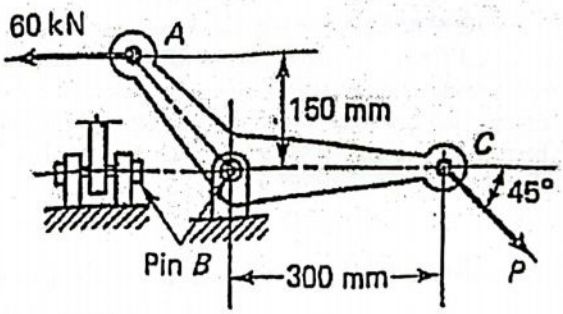


Figure: 5(b) of Question No. 5(b)

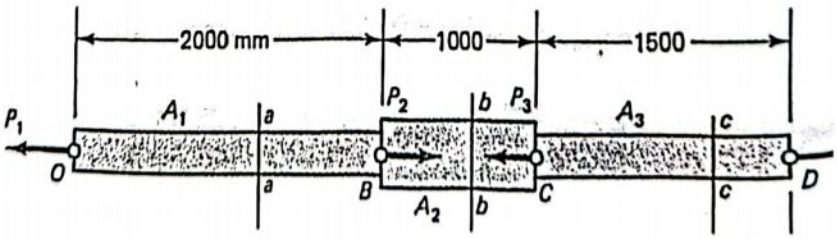


Figure: 6(a) of Question No. 6(a)

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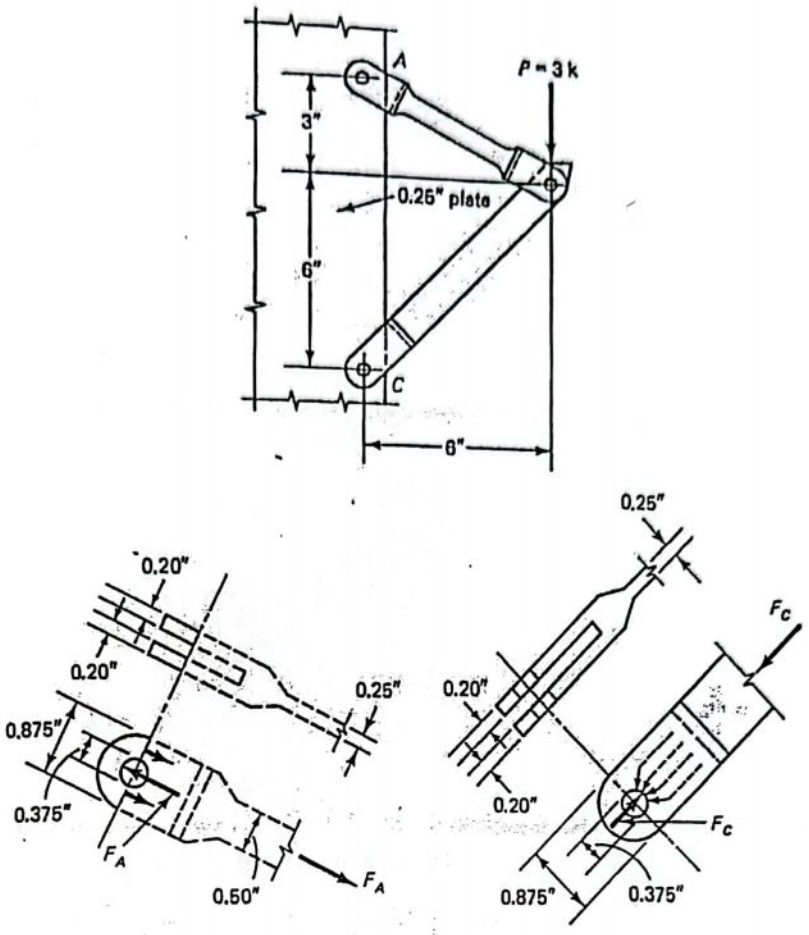


Figure: 6(b) of Question No. 6(b)

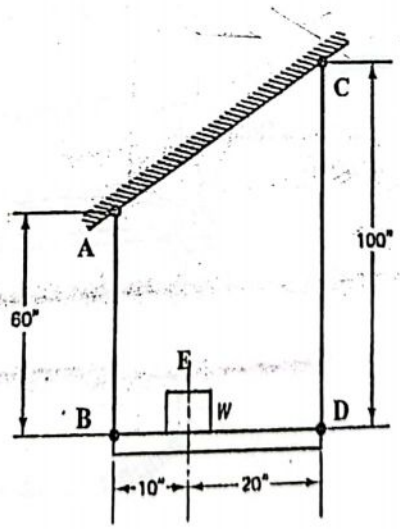


Figure: 7(a) of Question No. 7(a)

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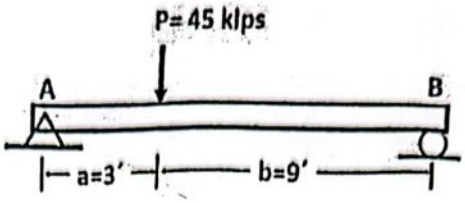


Figure: 7(b) of Question No. 7(b)

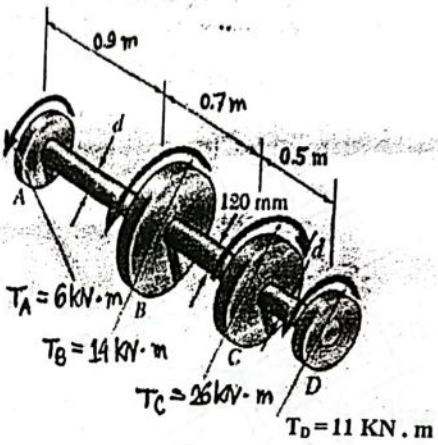


Figure: 8(a) of Question No. 8(a)

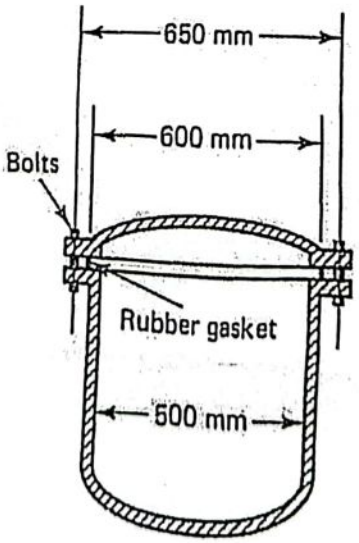


Figure: 8(b) of Question No. 8(b)

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BANGLADESH UNIVERSITY OF PROFESSIONALS
Military Institute of Science and Technology
B.Sc. in Environmental, Water Resources and Coastal Engineering
Student Group: 36 < Earned Credit Hour <= 72, Final Examination (Spring) : Feb 2021

Subject: EWC-211, Mechanics of Solids I

Total: 2.00 hours **Full Marks: 180**
Section A: 1.00 hour **Section A : 90**

INSTRUCTIONS:

a. Use **SEPARATE** answer scripts for each section.
b. **Question – 1 and Question – 4 (Viva Voce)** in **Section A** are compulsory.
c. Answer any **OTHER ONE** question from this section **(From Q - 2 & Q - 3)**.
d. Figures in the margin indicate full **marks**.
e. Assume reasonable data if necessary.
f. **Symbols** used have their usual meanings.

SECTION-A

Question – 1 **(Compulsory)**

Construct shear force and bending moment diagrams for the overhanging beam loaded with forces shown in figure-1. Use any method for calculating shear force and bending moment. Mark salient points on the shear force and bending moment diagrams (location of maximum moment, point of contra flexure must be included in BMD). **30**

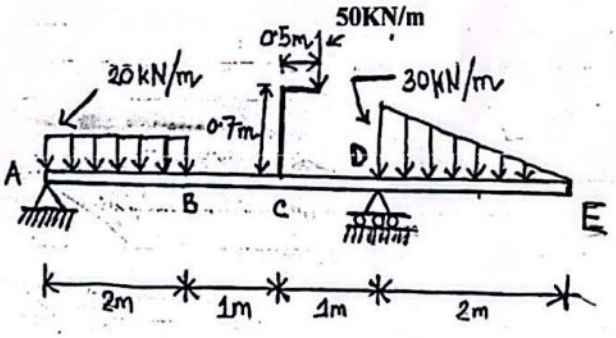


Figure 1

Question – 2

a. Construct shear force and bending moment diagrams for beam loaded with forces shown in figure-2. Use method of sections for calculating shear force and bending moment. **20**

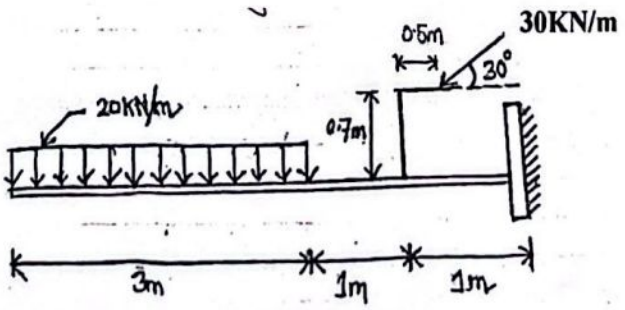


Figure 2

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b. Derive the flexural stress formula, $\sigma_{max} = \frac{MC}{I}$ (Notations denote their usual meaning). Your derivation must include assumptions and must be supported by diagrams.

Question – 3

a. A composite beam with cross sectional dimensions is shown in figure-3. The upper part 200 by 300 mm wood, E_w=10 GPa; the lower part 20 by 200 mm strap is steel, Es= 200 GPa. If this beam is subjected to a bending moment of 40 KN-m around a horizontal axis, what are the maximum stresses in the steel and wood?

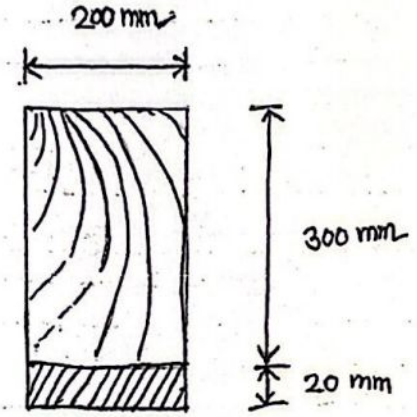


Figure 3

b. Construct shear force and bending moment diagrams for the beam loaded with forces shown in figure-4. Use any method for calculating shear force and bending moment. Mark salient points on the shear force and bending moment diagrams.

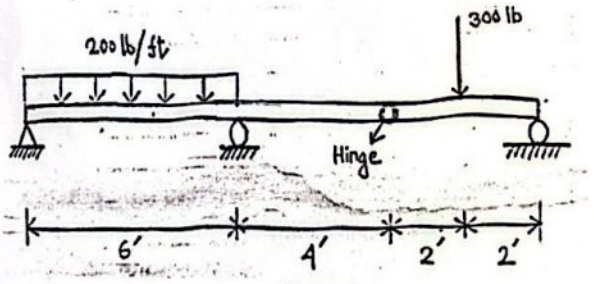


Figure 4

Question – 4 Viva Voce (Compulsory)

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Military Institute of Science and Technology
B.Sc. in Environmental, Water Resources and Coastal Engineering
Student Group: 36 < Earned Credit Hour <= 72, Final Examination (Spring) : Feb 2021

Subject: EWC-211, Mechanics of Solids I

Total: 2.00 hours **Full Marks: 180**
Section B: 1.00 hour **Section B : 90**

INSTRUCTIONS:

a. Use **SEPARATE** answer scripts for each section.
b. **Question – 5 and Question – 8 (Viva Voce)** in **Section B** are compulsory.
c. Answer any **OTHER ONE** question from this section **(From Q - 6 & Q - 7)**.
d. Figures in the margin indicate full **marks**.
e. Assume reasonable data if necessary.
f. **Symbols** used have their usual meanings.

SECTION-B

Question – 5 (Compulsory)

a. Define engineering stress and true stress. Draw Engineering stress-strain diagram and true stress-strain diagram. How we can calculate true stress from engineering stress? **10**

b. A force P KN is applied to a rigid bar suspended by three identical wires, as shown in figure-5. For each wire, A= 80 mm^2, E= 200 GPa and L=4 m. If initially there were no slack in the wires, what stress will develop in these wires? **20**

P=Last two digits of your student ID

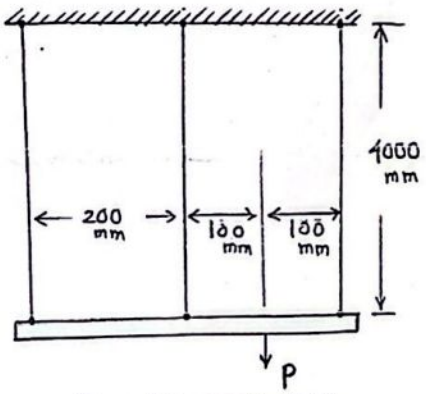


Figure 5 for question 5(b)

Question – 6

a. Show that, for a cylindrical pressure vessel transverse stress is twice of longitudinal stress. **10**

b. A cylindrical steel pressure vessel of length 5 m has outside diameter 1650 mm and wall thickness 25 mm. Considering a factor of safety 2, calculate maximum internal pressure that may be applied to the vessel if the hoop stress and longitudinal stress are limited to 80 MPa and 50 MPa, respectively. What will be the change of length and radius if the vessel is subjected to maximum internal pressure? Given, E=200GPa and Poisson's ratio=0.25 **20**

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Question – 7

a. Derive the elastic torsion formula for computing torsional shear stress in a solid circular shaft.

b. Two solid shafts of different materials are rigidly fastened together and attached to rigid supports as shown in figure-6. Calculate the maximum shear stress developed in each segment when the torque, T Kip-inch is applied at the junction of the two segments. Use $G=4x10^6$ psi for aluminum and $G= 12 \times 10^6$ psi for steel.

T= Last two digits of your student ID

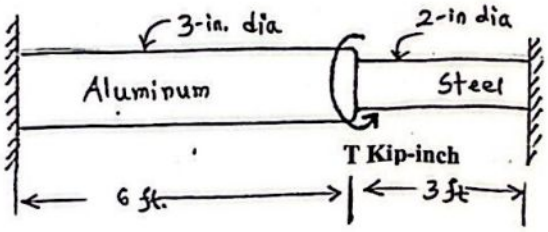


Figure 6 for question 7(b)

Question – 8 Viva Voce(Compulsory)

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BANGLADESH UNIVERSITY OF PROFESSIONALS
Military Institute of Science and Technology
B.Sc. in Environmental, Water Resources, and Coastal Engineering, Term Final (Spring) Examination 2023: Jul-Sep2023

Student Group: 36<Earned Credit Hours ≤ 72

Subject: EWCE 211, Mechanics of Solids

Time: 3.00 hours **Full Marks: 240**

INSTRUCTIONS:

a. Use **SEPARATE** answer scripts for each section.
b. **Question-1in Section-A** and **Question-5** in **Section-B** are compulsory
c. Answer any other **TWO** questions out of **THREE** from each section.
d. Figures in the margin indicate full **marks**.
e. Assume reasonable data if necessary.
f. **Symbols** and **abbreviations** used have their usual meanings.

SECTION-A

Question 1 (Compulsory)

a. What is Pure Bending? Illustrate with an example. (Answer must be supported with diagrams) **10**

a. Derive the flexural formula for bending stress of a simply supported beam in the form **15**

$$\sigma_{max}=\frac{M_{max}}{S}$$

where S is called the section modulus of the beam

b. A rectangular beam of breadth 150mm and depth 300mm is simply supported over a span of 5m. The beam is loaded with an uniformly distributed load of 6kN/m over the entire span. Find the maximum bending stresses developed in the beam. **15**

Question 2

a. Draw the Shear Force and Bending Moment Diagram for the Cantilever (overhanging) beam subjected to loading as shown in Figure 01. Find out the point of contra flexure and maximum moment developed in the beam. **40**

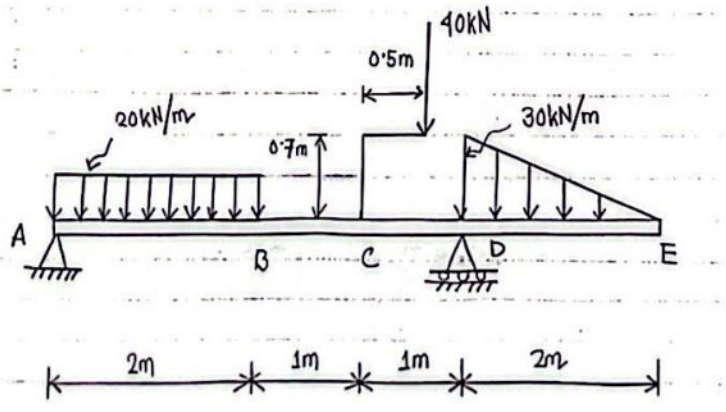


Figure 01

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Question 3

a. Find the stress distribution at section ABCD for the block shown in Figure 02, where P = 64 KN. Locate the line of zero stress. Neglect the weight of the block. The unit is in mm.

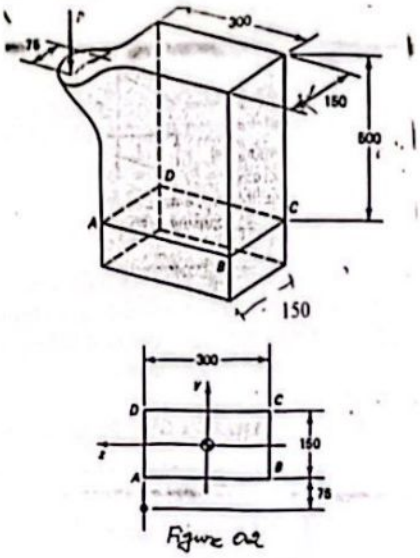


Figure 02

b. Determine (i) the principal stresses (ii) the orientation of the principal plane (iii) maximum shear stresses for the state of plane stress shown in Figure 03.

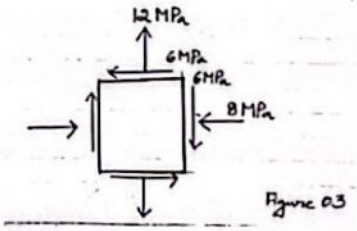


Figure 03

Question 4

a. Draw axial, shear force and bending moment diagram of each member of the frame shown in Figure 04. (Show detail calculation with diagram).

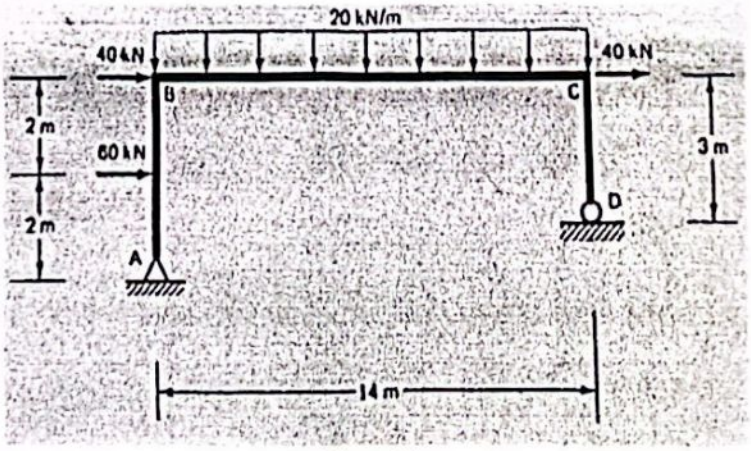


Figure-04

b. Find the shortest length 'L' for a steel column with pinned ends having a cross-sectional area of 60mm × 100mm, for which the elastic Euler formula applies. E = 200 GPa and the proportional limit to be 250 MPa.

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SECTION-B

Question 5 (Compulsory)

a. Calculate the value of deflection at free end and at mid span of beam shown in Figure 5(a), assuming that the beam is a W14×30 rolled shape and W_0=3.5kip/ft, L=25ft, E=29000ksi. Moment of Inertia of a W14×30 section is 600in^4. **20**

b. The bell crank is in equilibrium under the forces shown in the Figure 5(b). If allowable shear stress is 100MPa, determine the diameter required for pin B. Use a Factor of safety is 3. **20**

Question 6

a. Determine the relative displacement of point D from O for the elastic steel bar of variable cross section shown in Figure 6(a). Concentrated forces P_1=90kN and P_3=150kN are acting to the left and P_2=220kN and P_4=20kN are acting to the right as shown in Figure 6(a).
The respective areas for bar segments OB, BC and CD are 800mm^2, 1100mm^2 and 1600mm^2. Let, E=200GPa.
Draw the Axial Force and Axial Strain diagram of the bar. **20**

b. A bracket of negligible weight shown in Figure 6(b) is loaded with a vertical force P of 4kips. For interconnection purposes, the bar ends are clevised (Forked). Pertinent dimensions are shown in the figure. Find the axial stresses in members AB and BC and the bearing and shearing stresses for pin C. All pins are 0.375inch in diameter. **20**

Question 7

a. Two wires are connected to a rigid bar as shown in Figure 7(a). The wire AB is of steel having A_{AB}=0.12in^2, E_s=30×10^{6}psi and coefficient of thermal expansion α_s=12.2×10^{-6}/°C.
The aluminium alloy wire CD has A_{CD}=0.25in^2, E_a=10×10^{6}psi and α_a=22.5×10^{-6}/°C. The load W is negligible, **20**

(i) Compute the deflection at point E due to 30°C temperature rise.

(ii) Now if we consider the load W=1500lb, where should the weight be located so that the bar would remain horizontal?

b. Derive the formula of deflection (Δ) using Elastic strain energy for the beam of Figure 7(b). Also, determine vertical deflection at loading point. Moment of Inertia, I=300in^4, E=29×10^{6}psi. **20**

Question 8

a. Shaft BC is hollow with inner and outer diameter of 90mm and 120mm respectively. Shaft AB and CD are solid of diameter d. For the loading shown in Figure 8(a). Determine, **20**
(i) The minimum and maximum shearing stress in shaft BC.
(ii) The required diameter d of shafts AB and CD if the allowable shearing stress in these shafts is 75MPa.

b. For an industrial laboratory a pilot unit is to employ a pressure vessel of the dimensions shown in Figure 8(b). The vessel will operate at an internal pressure of 0.62MPa. If the bolt diameter of 20mm needs to be used, predict the number of bolts required to resist the stress of 110MPa. Assume, stress concentration factor as 2.5. **20**

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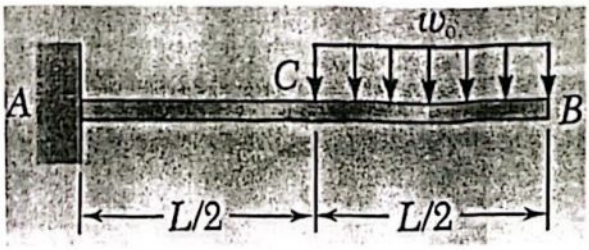


Figure: 5(a) of Question No. 5(a)

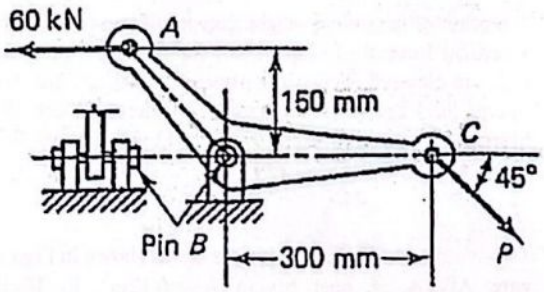


Figure: 5(b) of Question No. 5(b)

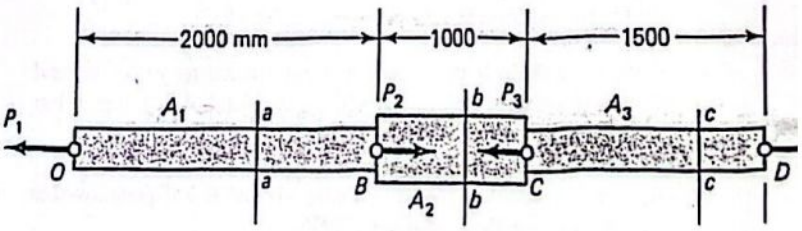


Figure: 6(a) of Question No. 6(a)

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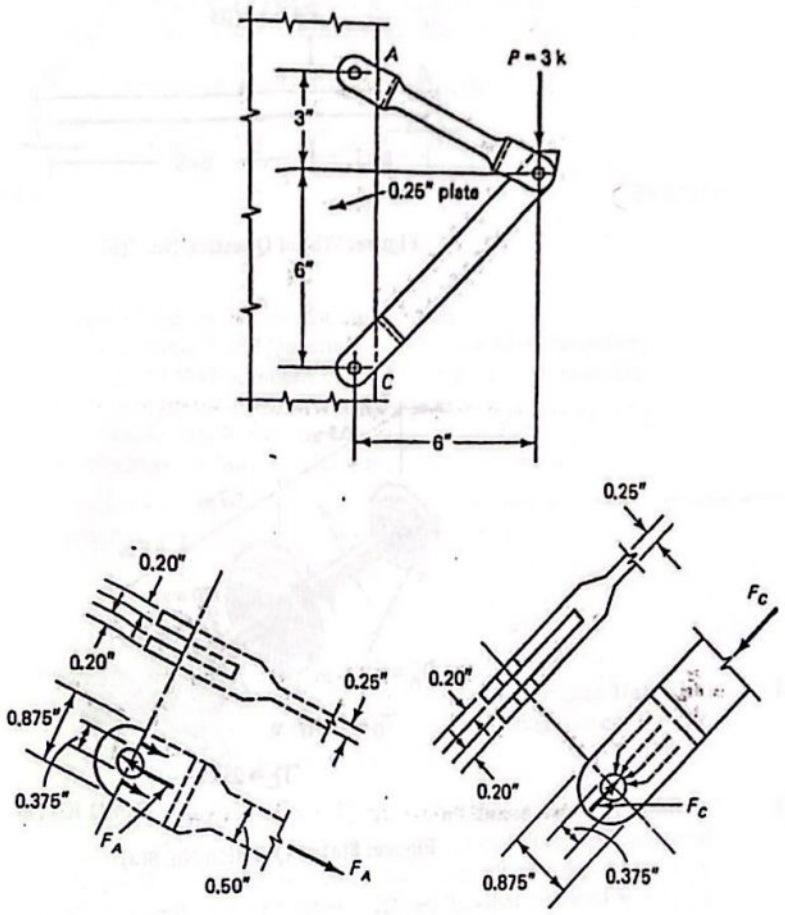


Figure: 6(b) of Question No. 6(b)

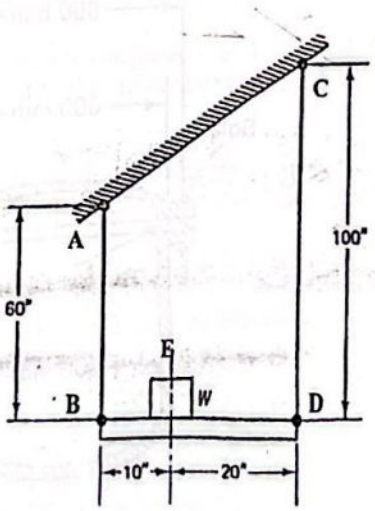


Figure: 7(a) of Question No. 7(a)

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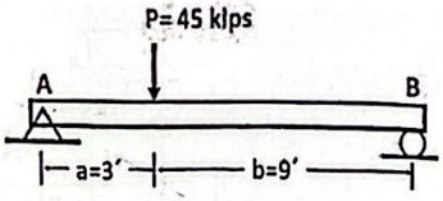


Figure: 7(b) of Question No. 7(b)

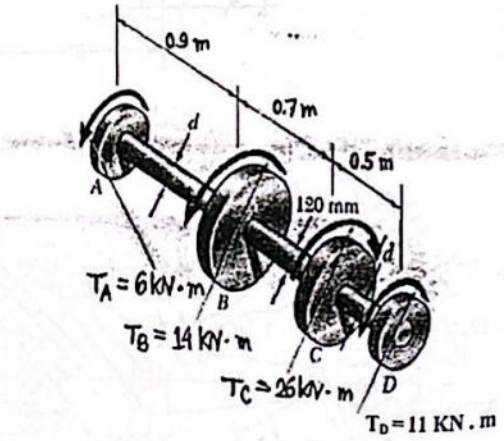


Figure: 8(a) of Question No. 8(a)

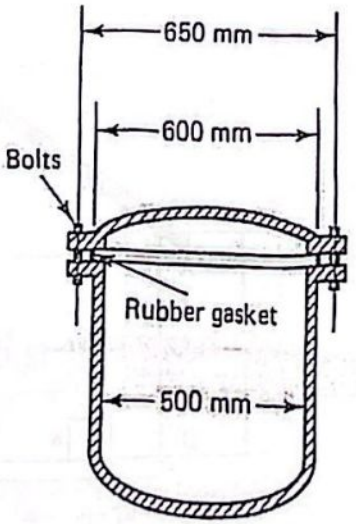


Figure: 8(b) of Question No. 8(b)

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BANGLADESH UNIVERSITY OF PROFESSIONALS

Military Institute of Science and Technology

B.Sc. in Environmental, Water Resources and Coastal Engineering,

Term Final (Spring) Examination 2021: July-Aug 2021

Student Group: 36 < Earned Credit Hours ≤ 72

Subject: EWCE-211, Mechanics of Solids

Total : **2.00 hours (Online Examination for Section-A + Section-B)** — **Full Marks : 240**

Section A : **1.00 hour (Online Examination)** — **Section A : 120**

INSTRUCTIONS - ONLINE EXAMINATION (IF PHYSICAL EXAMINATION IS NOT HELD)

a. **Question - 1** and **Question – 4 (Viva Voce)** in **Section A** are compulsory.
b. Answer any **OTHER ONE** question from **Q-2 & Q-3** of **Section-A**.
c. Figures in the margin indicate full **marks.**
d. Assume reasonable data if necessary.
e. **Symbols** and **abbreviations** used have their usual meanings.

SECTION-A

Question – 1 (Compulsory)

a. A beam has different types of loads as shown in figure-1-a

(1) Draw free body diagram of left portion of beam at sec D-D and find the equations of V(x). **03**
(2) From the equations of V(x), find equations of M(x) by integration, use appropriate boundary condition. **03**
(3) Find the equations of M(x) again from free body diagram and check whether it is same as found in (2) above. **04**
(4) Find equation of V(x) again by differentiating M(x). **02**
(5) Find values of V and M at 18′ and 22′ from the left support. **03**
(6) Draw SFD and BMD of the beam and check the shear force and bending moment found at 18′ and 22′ are same as found from equations. **10**

Note: While finding equations of V(x) and M(x) from the free-body diagram, you must show detailed calculation to support the equilibrium equations.

b. Derive the equation of slope and deflection of the cantilever beam with UVL as shown in figure-1-b. **10**

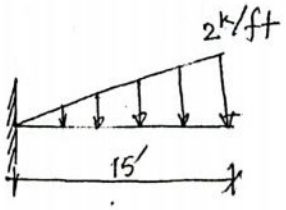


figure 1-b

c. From the above equation find the deflection of the beam at 5′ and 10′ from support. **05**

Question – 2 **3+8+4=15**

a. A frame is given with concentrated forces as shown in figure-2a.
i. Find support reactions of the frame given in figure above.
ii. Draw free body diagram and show horizontal and vertical forces and moment at each joint on free body diagram.
iii. Draw AFD, SFD and BMD of the force.

b. State of stress are given in figure-2b. Using Mohr's circle of stresses, **15**

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transform it on a plane graph paper.

i. to the principal stresses,
ii. into the maximum shear stress and associated normal stresses,
iii. Show the results for both cases on properly oriented elements,
iv. Find value of stresses at 45° (clockwise) using Mohr's circle.

[show all result in the tabular form]

c. Answer the following questions in short, form the knowledge of Transformation of stresses, 5+5=10

i. How do you define Mohr's circle of stresses? What is denoted by the locus of the circle? If $\sigma_1 + \sigma_2 = 0$, what would happen to its Mohr's circle? If $\sigma_x + \sigma_y = 0$ what will happen to its Mohr's circle?
ii. What is the angle Θ_1 and Θ_2 in transformation of stresses. What is the angular difference between them? Prove the angle by writing down the required expression with trigonometric function Θ_1 and Θ_2 and draw necessary figures to explain their orientations and angle.

Question – 3

a. Remove the extension of the beam by replacing required moment and forces, find support reactions and draw SFD and BMD of the beams given in figure 3(a). 24

b. Determine the design compressive strength for a 20ft W14×90 steel column fixed at both ends using AISC LRFD formula. Assume A-36 steel having σ_{yp}=36ksi. 16

Question – 4

VIVA VOCE (Compulsory in case of Online Examination) 40

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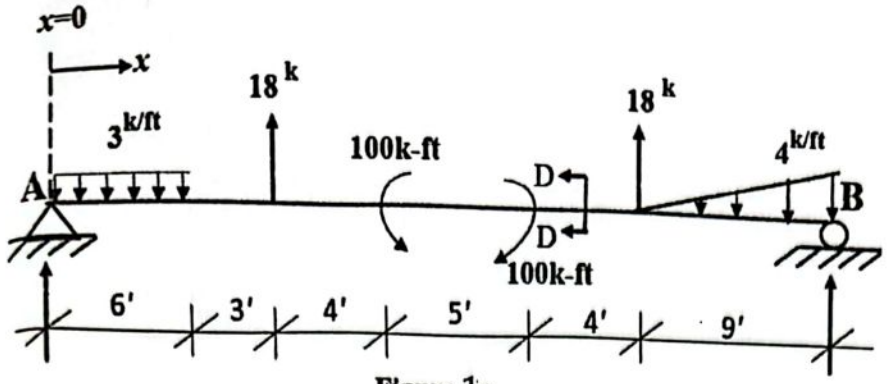


Figure-1a

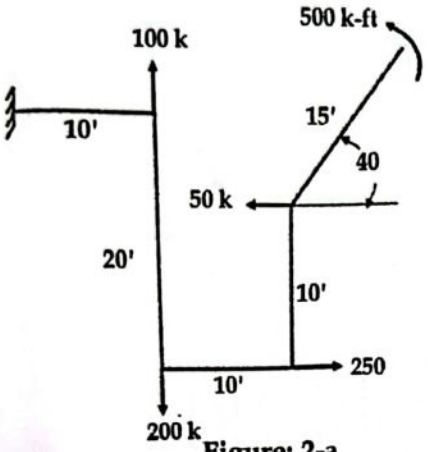


Figure: 2-a

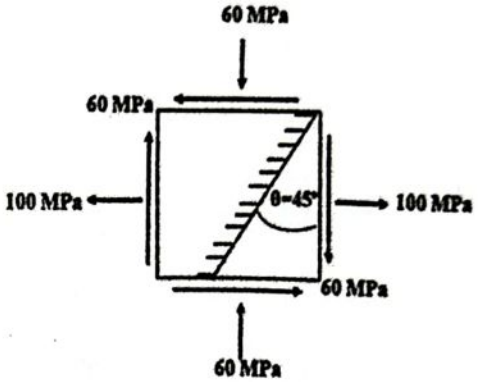


Figure: 2-b

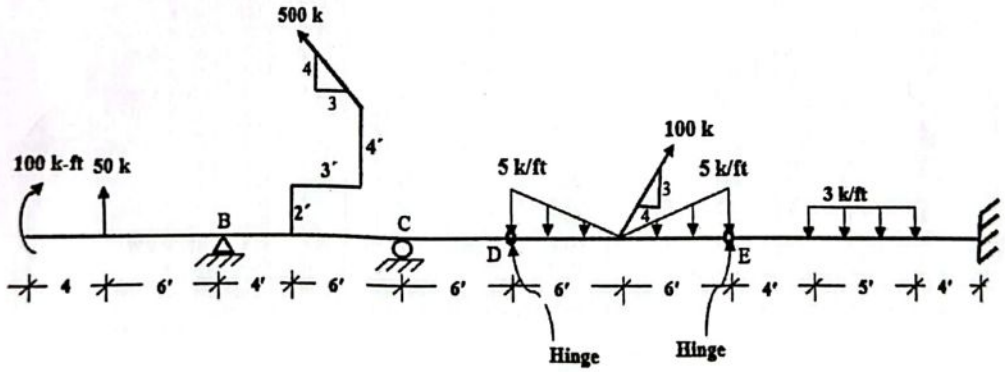


Figure: 3-a

Important Formula for AISC LRFD

$$\lambda_c = \frac{L_e}{r\pi}\sqrt{\left(\frac{\sigma_{yp}}{E}\right)}$$

For $\lambda_c > 1.5 : \sigma_{cr} = \left[\frac{0.877}{\lambda_c^{\,2}}\right]\sigma_{yp}$

For $\lambda_c \leq 1.5 : \sigma_{cr} = \left[(0.658)^{\lambda_c^{\,2}}\right]\sigma_{yp}$

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Important Formula for AISC ASD:

$C_c = \sqrt{(2\pi^2 E / \sigma_{yp})}$

If Long Column $\frac{L_e}{r} > C_c$: $\sigma_{allow} = \frac{12\pi^2 E}{23(L_e/r)^2}$

If $\frac{L_e}{r} < C_c$: $\sigma_{allow} = [(1 - (L_e/r)^2 / 2C_c^2)\sigma_{yp}] \div F.S.$

$$F.S. = \frac{5}{3} + \frac{3(L_e/r)}{8C_c} - \frac{(L_e/r)^3}{8C_c^3}$$



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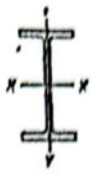


Table 4. American Wide-Flange Steel Beams, W Shapes, Properties for Designing

Designation*	Area	Depth	Flange		Web	Axis X–X			Axis Y–Y		
			Width	Thickness	Thickness	I	$S = I/c$	r	I	$S = I/c$	r
	in^2	in	in	in	in	in^4	in^3	in	in^4	in^3	in
W36 × 230	67.6	35.90	16.470	1.260	0.760	15000	837	14.9	940	114	3.73
× 150	44.2	35.85	11.975	0.940	0.625	9040	504	14.3	270	45.1	2.47
W33 × 201	59.1	33.68	15.745	1.150	0.715	11500	684	14.0	749	95.2	3.56
× 130	38.3	33.10	11.510	0.855	0.580	6710	406	13.2	218	37.9	2.38
W30 × 173	50.8	30.44	14.985	1.065	0.655	8200	539	12.7	598	79.8	3.43
× 108	31.8	29.82	10.484	0.760	0.548	4470	300	11.9	146	27.9	2.15
W27 × 146	42.9	27.78	13.965	0.975	0.605	5630	411	11.4	443	63.5	3.21
× 94	27.7	26.92	9.990	0.745	0.490	3270	243	10.9	124	24.8	2.12
W24 × 131	38.5	24.48	12.855	0.960	0.605	4020	329	10.2	340	53.0	2.97
× 76	22.4	23.92	8.990	0.680	0.440	2100	176	9.69	82.5	18.4	1.92
W21 × 111	32.7	21.51	12.340	0.875	0.550	2670	249	9.05	274	44.5	2.90
× 62	18.3	20.99	8.240	0.615	0.400	1330	127	8.54	57.5	13.9	1.77
W18 × 97	28.5	18.59	11.145	0.870	0.535	750	188	7.82	201	36.1	2.65
× 50	14.7	17.99	7.495	0.570	0.355	800	88.9	7.38	40.1	10.7	1.65
× 35	10.3	17.70	6.000	0.425	0.300	510	57.6	7.04	15.3	5.12	1.22
W16 × 100	29.4	16.97	11.425	0.985	0.585	1490	175	7.10	186	35.7	2.51
× 50	14.7	16.25	7.070	0.630	0.380	659	81.0	6.68	37.2	10.5	1.59
× 36	10.6	15.86	6.985	0.430	0.295	448	56.5	6.51	24.5	7.00	1.52
× 26	7.68	15.69	5.500	0.345	0.250	301	38.4	6.26	9.59	3.49	1.12
W14 × 730	215.0	22.42	17.890	4.910	3.070	14300	1280	8.17	4720	527	4.69
× 455	134.0	19.02	16.835	3.210	2.015	7190	756	7.33	2560	304	4.38
× 311	91.4	17.12	16.230	2.260	1.410	4330	506	6.88	1610	199	4.20
× 193	56.8	15.48	15.710	1.440	0.890	2400	310	6.50	931	119	4.05
× 159	46.7	14.98	15.565	1.190	0.745	1900	254	6.38	748	96.2	4.00
× 90	26.5	14.02	14.520	0.710	0.440	999	143	6.14	362	49.0	3.70
W14 × 74	21.8	14.17	10.070	0.785	0.450	796	112	6.04	134	26.6	2.48
× 68	20.0	14.04	10.035	0.720	0.415	723	103	6.01	121	24.2	2.46
× 61	17.9	13.89	9.995	0.645	0.375	640	92.2	5.98	107	21.5	2.45
× 53	15.6	13.92	8.060	0.658	0.370	542	77.8	5.90	57.5	14.3	1.92
× 43	12.6	13.66	7.995	0.530	0.305	428	62.7	5.82	45.2	11.3	1.89
W14 × 38	11.2	14.10	6.770	0.515	0.310	385	54.6	5.87	26.7	7.86	1.54
× 34	10.0	13.98	6.745	0.455	0.285	340	48.6	5.83	23.3	6.91	1.53
× 30	8.85	13.84	6.730	0.385	0.270	291	42.0	5.73	19.6	5.82	1.49
W12 × 87	25.6	12.53	12.125	0.810	0.515	740	118	5.38	241	3.97	3.07
× 65	19.1	12.12	12.000	0.605	0.390	533	87.9	5.28	174	29.1	3.02
× 53	15.6	12.06	9.995	0.575	0.345	425	70.6	5.23	95.8	19.2	2.48
× 40	11.8	11.94	8.005	0.515	0.295	310	51.9	5.13	44.1	11.0	1.93
W12 × 35	10.3	12.50	6.560	0.520	0.300	285	45.6	5.25	24.5	7.47	1.54
× 30	8.79	12.34	6.520	0.440	0.260	238	38.6	5.21	20.3	6.24	1.52
× 26	7.65	12.22	6.490	0.380	0.230	204	33.4	5.17	17.3	5.34	1.51
W10 × 112	32.9	11.36	10.415	1.250	0.755	716	126	4.66	238	45.3	2.68
× 100	29.4	11.10	10.340	1.120	0.680	623	112	4.60	207	40.0	2.65
× 88	25.9	10.84	10.265	0.990	0.605	534	98.5	4.54	179	34.8	2.63
× 77	22.6	10.60	10.190	0.870	0.530	455	85.9	4.49	154	30.1	2.60
× 60	17.6	10.22	10.080	0.680	0.370	341	66.7	4.39	116	23.0	2.57
× 49	14.4	9.98	10.000	0.560	0.340	272	54.6	4.35	93.4	18.7	2.54
W10 × 45	13.3	10.10	8.020	0.620	0.350	248	49.1	4.32	53.4	13.3	2.01
× 39	11.5	9.92	7.985	0.530	0.315	209	42.1	4.27	45.0	11.3	1.98
× 33	9.71	9.73	7.960	0.435	0.290	170	35.0	4.19	36.6	9.20	1.94
W10 × 30	8.84	10.47	5.810	0.510	0.300	170	32.4	4.38	16.7	5.75	1.37
× 22	6.49	10.17	5.750	0.360	0.240	118	23.2	4.27	11.4	3.97	1.33
W 8 × 67	19.7	9.00	8.280	0.935	0.570	272	60.4	3.72	88.6	21.2	2.12
× 58	17.1	8.75	8.220	0.810	0.510	228	52.0	3.65	75.1	18.3	2.10
× 48	14.1	8.50	8.110	0.685	0.400	184	43.3	3.61	60.9	15.0	2.08
× 40	11.7	8.25	8.070	0.560	0.360	146	35.5	3.53	49.1	12.2	2.04
× 35	10.3	8.12	8.020	0.495	0.310	127	31.2	3.51	42.6	10.6	2.03
× 31	9.13	8.00	8.000	0.435	0.285	110	27.5	3.47	37.1	9.27	2.02
W 8 × 28	8.25	8.06	6.535	0.465	0.285	98.0	24.3	3.45	21.7	6.63	1.62
× 24	7.08	7.93	6.495	0.400	0.245	82.8	20.9	3.42	18.3	5.63	1.61
W 8 × 21	6.16	8.28	5.270	0.400	0.250	75.3	18.2	3.49	9.77	3.71	1.26
× 18	5.26	8.14	5.250	0.330	0.230	61.9	15.2	3.43	7.97	3.04	1.23

*American wide-flange I- or H-shaped steel beams are referred to as W shapes, and are designed by the letter W followed by their *nominal* depth in inches, with their weight in pounds per linear foot given last. For example, W21 × 62 means that this W shape is 21 in deep and weighs 62 lbft. This list is abridged.

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BANGLADESH UNIVERSITY OF PROFESSIONALS

Military Institute of Science and Technology

B.Sc. in Environmental, Water Resources and Coastal Engineering,

Term Final (Spring) Examination 2021: July-Aug 2021

Student Group: 36 < Earned Credit Hours ≤ 72

Subject: EWCE-211, Mechanics of Solids

Total : **2.00 hours (Online Examination for Section-A + Section-B)** — **Full Marks : 240**

Section B : **1.00 hour (Online Examination)** — **Section B : 120**

INSTRUCTIONS - ONLINE EXAMINATION (IF PHYSICAL EXAMINATION IS NOT HELD)

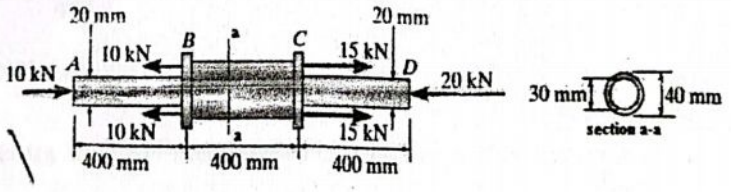
a. **Question - 5** and **Question – 8 (Viva Voce)** in **Section A** are compulsory.
b. Answer any **OTHER ONE** question from **Q-6 & Q-7** of **Section-B**.
c. Figures in the margin indicate full **marks.**
d. Assume reasonable data if necessary.
e. **Symbols** and **abbreviations** used have their usual meanings.

SECTION-B

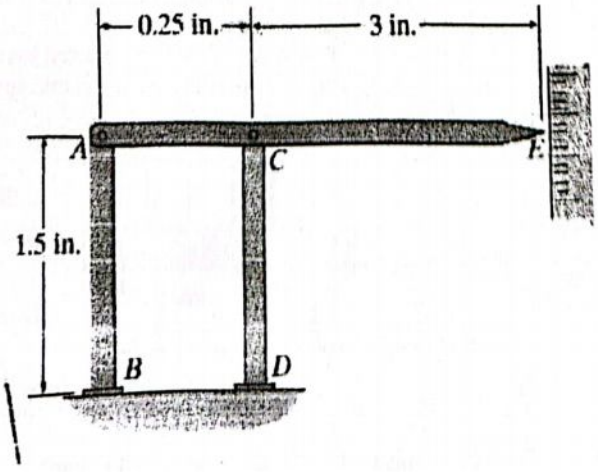
Question – 5 (Compulsory)

a. Segments AB and CD of the assembly are solid circular rods and segments BC is a tube, as shown in fig 4. If the assembly is made of aluminum, determine **24**

(i) The displacement of end D with respect to end A
(ii) The stress at section a-a
(iii) The strain energy in the region BC of the beam assembly [E = 68 GPa]



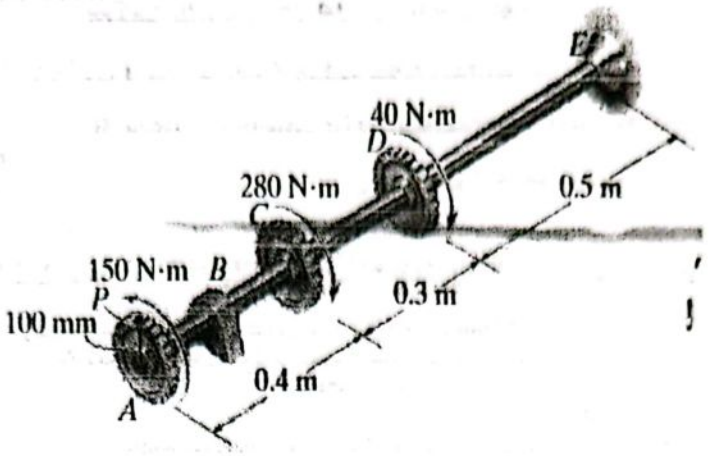
b. The device is used to measure a change in temperature. Bars AB and CD are made of steel and aluminum alloy, respectively (fig 5). When the temperature is at 75°F, ACE is in the horizontal position. Determine the vertical displacement of the pointer at E when the temperature rises to 150°F. Assume, the coefficient of thermal expansion for aluminum and steel to be 23.2×10^{-6}/°C and 12×10^{-6}/°C respectively. **16**



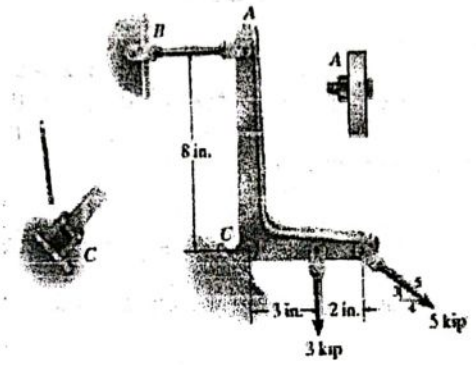
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Question – 6

a. The gears attached to the fixed-end steel shaft are subjected to the torques, shown in fig 6. If the shear modulus of elasticity is 80 GPa and the shaft has a diameter of 14 mm, determine the angle of twist and the displacement of the tooth, P on gear A. The shaft turns freely within the bearing at B. **24**



b. The control arm is subjected to the loading shown in fig 7. Determine to the nearest ¼ inch the required diameters of the steel pins at A and C if the allowable shear stress for the steel is $\tau_{allow} = 8$ ksi. **16**



Question – 7

a. A cylindrical pressure vessel has an inner diameter of 4 ft and a thickness of ½ inch. **24**

(i) Determine the maximum internal pressure it can sustain so that neither its circumferential nor its longitudinal stress component exceeds 20 ksi.

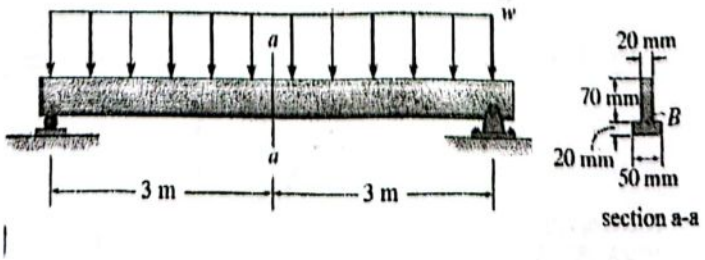
(ii) Under the same conditions, what is the maximum internal pressure that a smaller size spherical vessel can sustain?

(iii) Calculate the change in diameter in the sphere caused by pressurization. Let E = 200 GPa and $\upsilon = 0.28^{\circ}$.

b. If the beam, shown in fig 8 has an allowable bending stress of $\sigma_{allow} = 150$ MPa, determine **16**

(i) The maximum allowable uniformly distributed load, w.

(ii) The shear stress at point B for the section at mid span.



Question – 8

VIVA VOCE (Compulsory in case of Online Examination) **40**

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BANGLADESH UNIVERSITY OF PROFESSIONALS
Military Institute of Science and Technology
B.Sc. in Environmental, Water Resources and Coastal Engineering
Student Group: 36 < Earned Credit Hour <= 72, Final Examination (Spring) : Feb 2021

Subject: EWC-211, Mechanics of Solids I

Total: 2.00 hours **Full Marks: 180**
Section A: 1.00 hour **Section A : 90**

INSTRUCTIONS:

a. Use **SEPARATE** answer scripts for each section.
b. **Question – 1 and Question – 4 (Viva Voce)** in **Section A** are compulsory.
c. Answer any **OTHER ONE** question from this section **(From Q - 2 & Q - 3)**.
d. Figures in the margin indicate full **marks**.
e. Assume reasonable data if necessary.
f. **Symbols** used have their usual meanings.

SECTION-A

Question – 1 (Compulsory)

Construct shear force and bending moment diagrams for the overhanging beam loaded with forces shown in figure-1. Use any method for calculating shear force and bending moment. Mark salient points on the shear force and bending moment diagrams (location of maximum moment, point of contra flexure must be included in BMD). 30

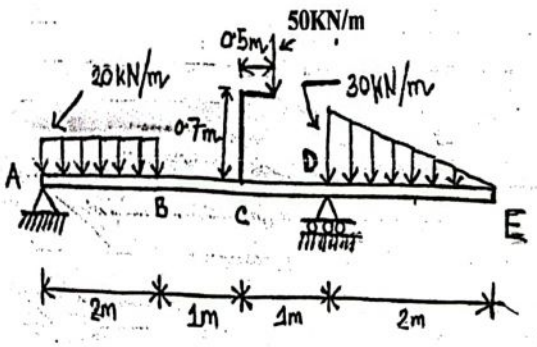


Figure 1

Question – 2

a. Construct shear force and bending moment diagrams for beam loaded with forces shown in figure-2. Use method of sections for calculating shear force and bending moment. 20

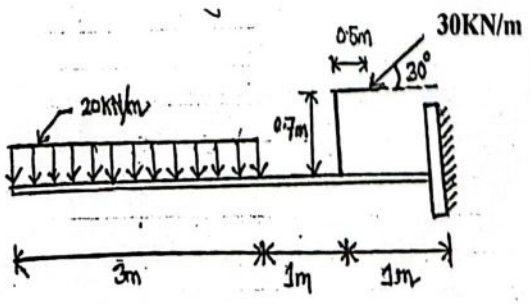


Figure 2

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b. Derive the flexural stress formula, $\sigma_{max} = \frac{MC}{I}$ (Notations denote their usual meaning). Your derivation must include assumptions and must be supported by diagrams.

Question – 3

a. A composite beam with cross sectional dimensions is shown in figure-3. The upper part 200 by 300 mm wood, E_w=10 GPa; the lower part 20 by 200 mm strap is steel, Es= 200 GPa. If this beam is subjected to a bending moment of 40 KN-m around a horizontal axis, what are the maximum stresses in the steel and wood?

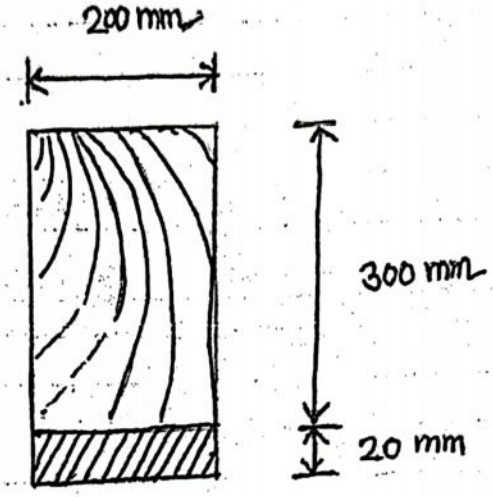


Figure 3

b. Construct shear force and bending moment diagrams for the beam loaded with forces shown in figure-4. Use any method for calculating shear force and bending moment. Mark salient points on the shear force and bending moment diagrams.

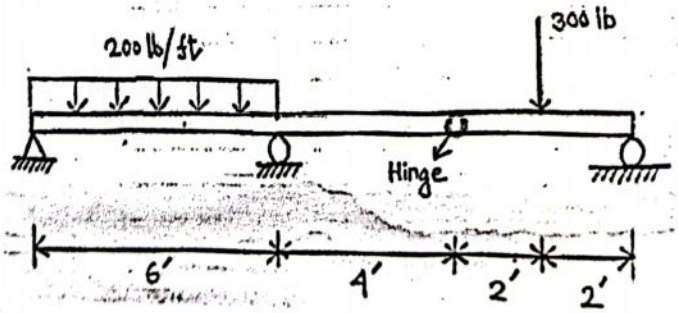


Figure 4

Question – 4 Viva Voce (Compulsory)

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BANGLADESH UNIVERSITY OF PROFESSIONALS
Military Institute of Science and Technology
B.Sc. in Environmental, Water Resources and Coastal Engineering
Student Group: 36 < Earned Credit Hour <= 72, Final Examination (Spring) : Feb 2021

Subject: EWC-211, Mechanics of Solids I

Total: 2.00 hours **Full Marks: 180**
Section B: 1.00 hour **Section B : 90**

INSTRUCTIONS:

a. Use **SEPARATE** answer scripts for each section.
b. **Question – 5 and Question – 8 (Viva Voce)** in **Section B** are compulsory.
c. Answer any **OTHER ONE** question from this section **(From Q - 6 & Q - 7)**.
d. Figures in the margin indicate full **marks**.
e. Assume reasonable data if necessary.
f. **Symbols** used have their usual meanings.

SECTION-B

Question – 5 (Compulsory)

a. Define engineering stress and true stress. Draw Engineering stress-strain diagram and true stress-strain diagram. How we can calculate true stress from engineering stress? **10**

b. A force P KN is applied to a rigid bar suspended by three identical wires, as shown in figure-5. For each wire, A= 80 mm^2, E= 200 GPa and L=4 m. If initially there were no slack in the wires, what stress will develop in these wires? **20**

P=Last two digits of your student ID

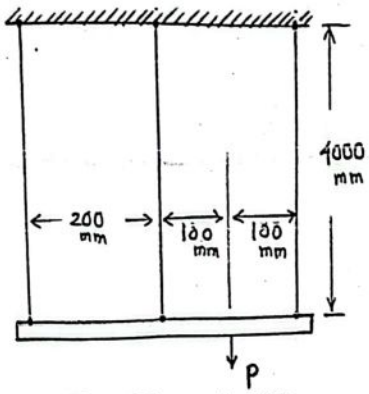


Figure 5 for question 5(b)

Question – 6

a. Show that, for a cylindrical pressure vessel transverse stress is twice of longitudinal stress. **10**

b. A cylindrical steel pressure vessel of length 5 m has outside diameter 1650 mm and wall thickness 25 mm. Considering a factor of safety 2, calculate maximum internal pressure that may be applied to the vessel if the hoop stress and longitudinal stress are limited to 80 MPa and 50 MPa, respectively. What will be the change of length and radius if the vessel is subjected to maximum internal pressure? Given, E=200GPa and Poisson's ratio=0.25 **20**

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Question – 7

a. Derive the elastic torsion formula for computing torsional shear stress in a solid circular shaft.

b. Two solid shafts of different materials are rigidly fastened together and attached to rigid supports as shown in figure-6. Calculate the maximum shear stress developed in each segment when the torque, T Kip-inch is applied at the junction of the two segments. Use $G=4x10^6$ psi for aluminum and $G= 12 \times 10^6$ psi for steel.

T= Last two digits of your student ID

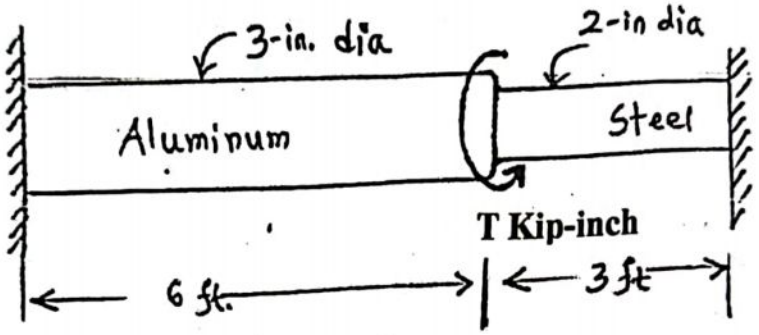


Figure 6 for question 7(b)

Question – 8 Viva Voce(Compulsory)

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BANGLADESH UNIVERSITY OF PROFESSIONALS
Military Institute of Science and Technology
B.Sc. in Environmental, Water Resources, and Coastal Engineering
Short Term Final Examination (Improvement) : Jan 2019

Subject: EWC-211, Mechanics of Solids- I

Time: 3.00 hours **Full Marks: 210**

INSTRUCTIONS:

a. Use **SEPARATE** answer scripts for each section.
b. Answer any **THREE** questions from each section out of **FOUR.**
c. Figures in the margin indicate full **marks.**
d. Assume reasonable data if necessary.
e. **Symbols** used have their usual meanings.

SECTION-A

Question – 1

a. Find reactions at supports and draw qualitative shape of S.F.D. and B.M.D of the beams shown in figure 1(a) to (f) — 20

b. Find reactions of the frame shown in figure 1(g). Draw free body diagram of all the elements and find internal forces and moments at all the joints. — 15

Question – 2

Find reactions and draw S.F.D. and B.M.D. of the symmetric beam shown in figure 2 — 35

Question – 3

a. i. Find the reactions and write an equation for moment, M(x) using singularity function of the beam given in figure 3(a). — 6

ii. Using the above singularity function equation derive on equation of shear force V(x) for the beam — 3

iii. From equation M(x) derive a general equation of moment at $20<x<25$. — 3

iv. From general equation derived as asked in question 3a (iii). Find the value of moment at $x= 22$ — 3

v. Cut the beam at $x=22'$ and draw a free body diagram of right portion. From this free body diagram find the value of moment and shear force and confirm the result found from 3a (iv). [Remember the sign conventions of V & M when preceding right to left] — 5

b. A pressure cylinder, 1.5m long is made out of 5 mm thick steel plate which has an elastic modulus of 200 GPa and Poisson's ratio of 0.25. The cylinder has a mean diameter of 0.5m and is closed at its end-by flat plates. If it is subjected to an external pressure of 4 GPa, Calculate the longitudinal and transverse stresses — 15

Question – 4

a. A stepped circular shaft is made of steel hollow section with solid cast iron and Aluminum section as shown in figure 4(a). Determine the end reaction and plot torque and angle of twist diagram. Write the data in tabular form. Necessary data are given in figure 4(a) and other properties are tabulated in table 4(a). — 20

b. A rectangular cantilever solid beam is subjected to a torque of 5 kN-m as shown in figure 4(b). All dimensions are given in figure. Required formula and necessary data are given in Table 4(b)-1 and 4(b)-2. Find the maximum shear stress, angle of twist and torsional stiffness. Table 4(b) shows necessary formula and data. — 15

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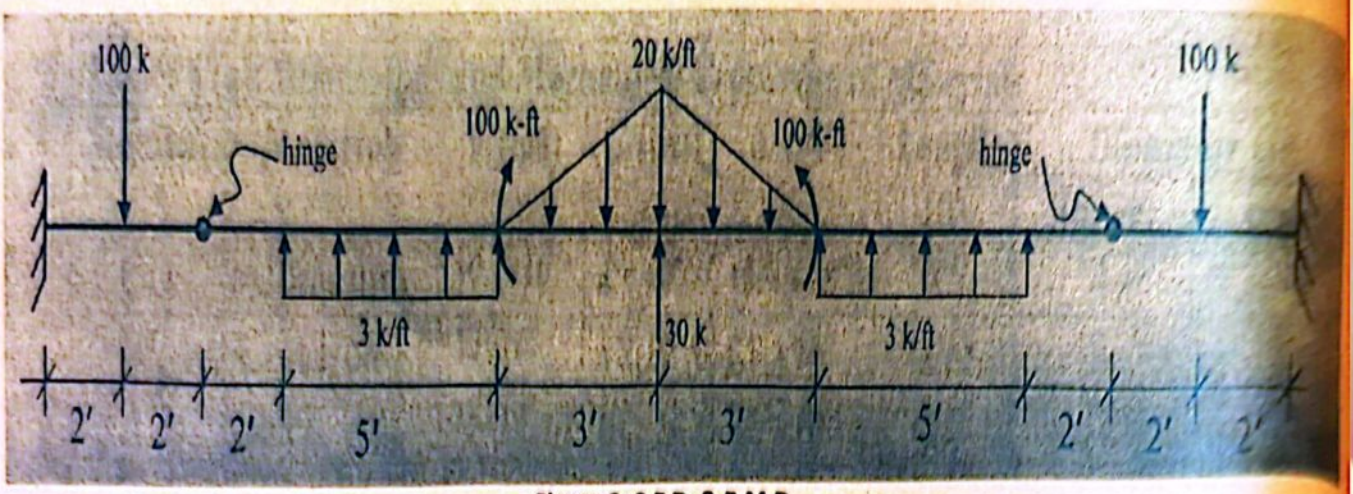


Figure-2: S.F.D. & B.M.D.

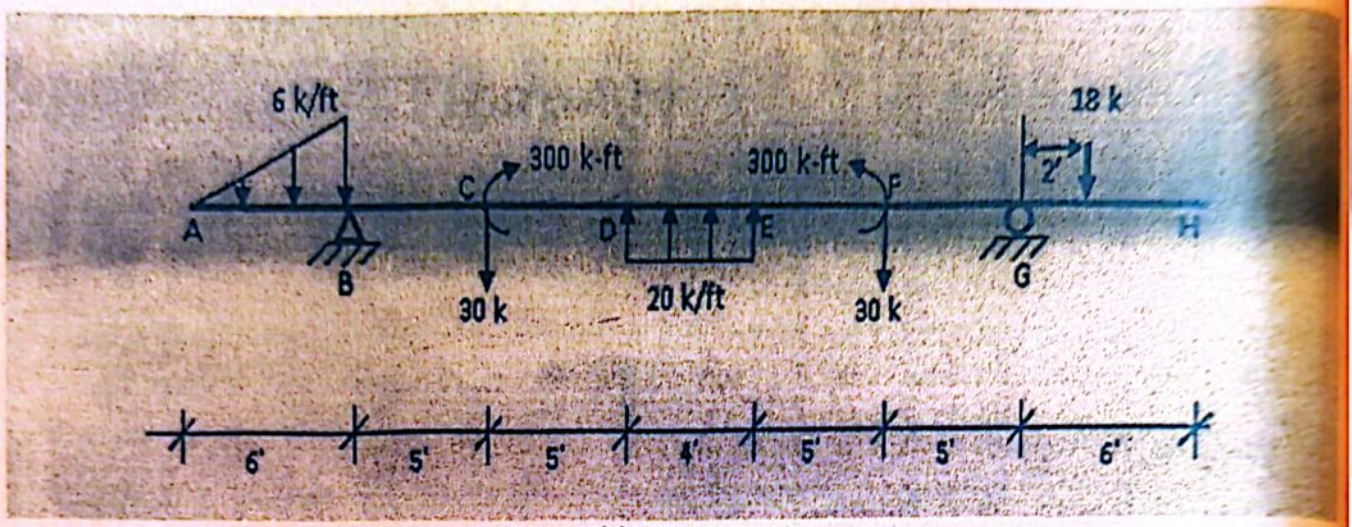
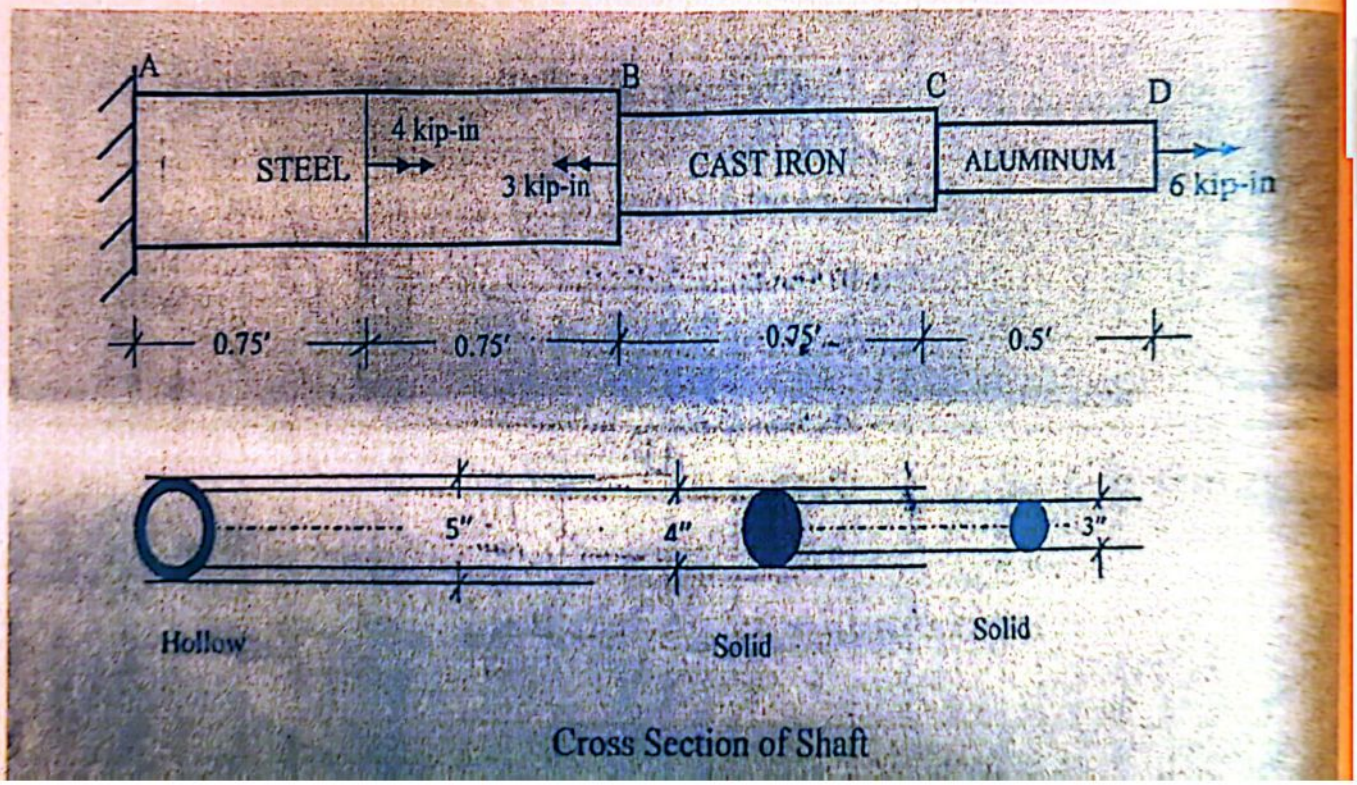


Figure-3(a) : S.F.D. & B.M.D.



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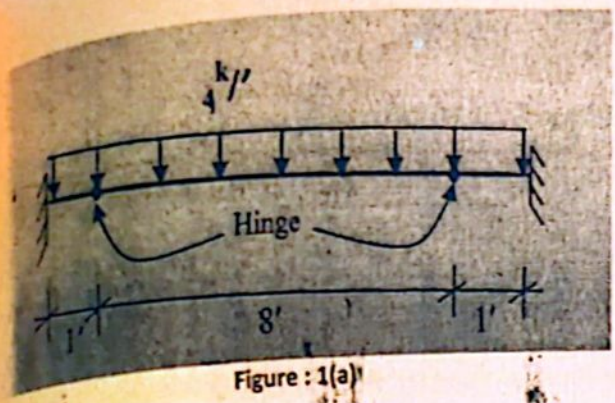


Figure : 1(a)

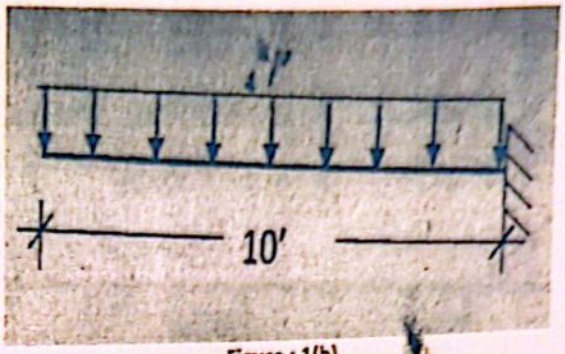


Figure : 1(b)

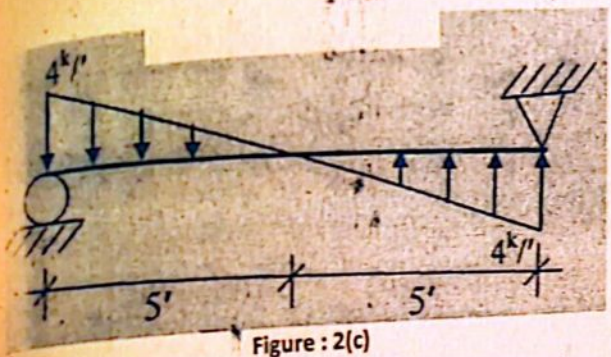


Figure : 2(c)

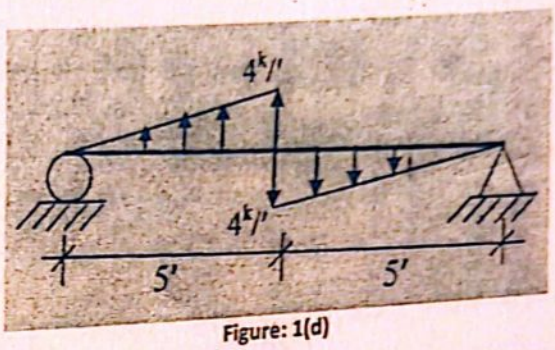


Figure: 1(d)

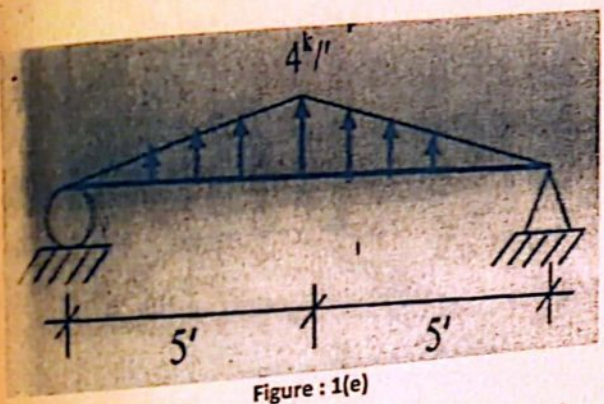


Figure : 1(e)

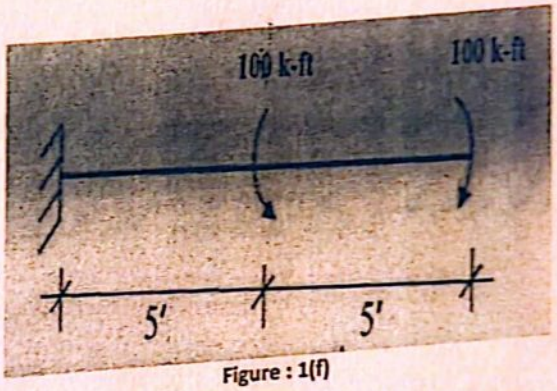


Figure : 1(f)

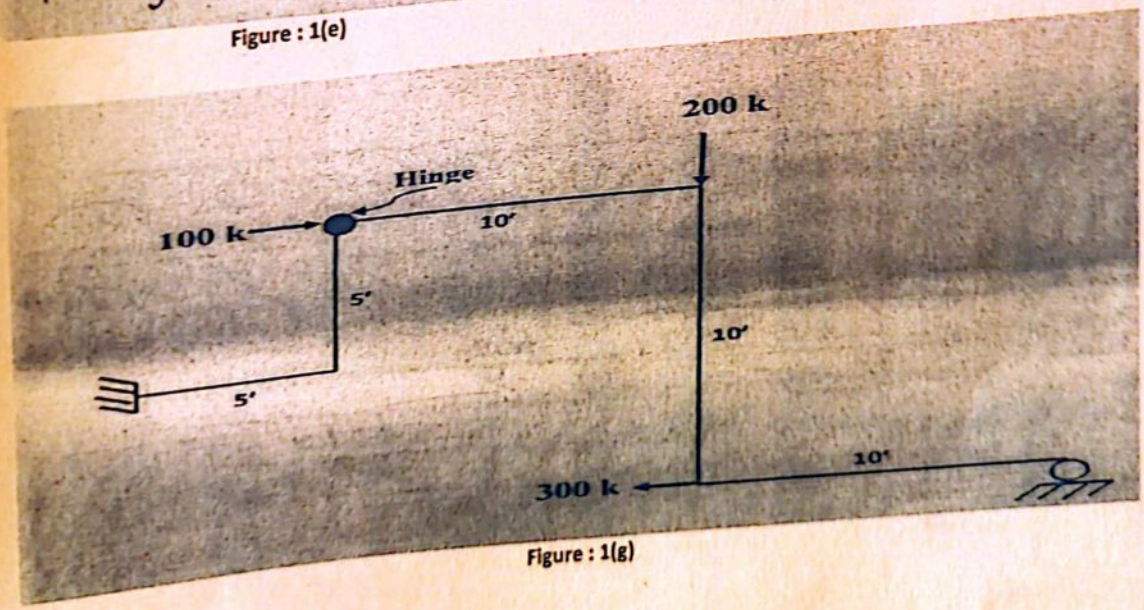


Figure : 1(g)

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Table: 4 (a): Dimensions and Mechanical Properties of Materials							
Segment	Materials	E (psi)	G (psi)	α (/°F)	Length (ft)	Diameter (in)	
						inner	outer
CD	Aluminum	10.6×10^6	4×10^6	12.9×10^{-6}	0.5	4	
BC	Cast Iron	13×10^6	6×10^6	5.8×10^{-6}	0.75	8	
AB	Steel	29×10^6	12×10^6	6.5×10^{-6}	1.0	12	

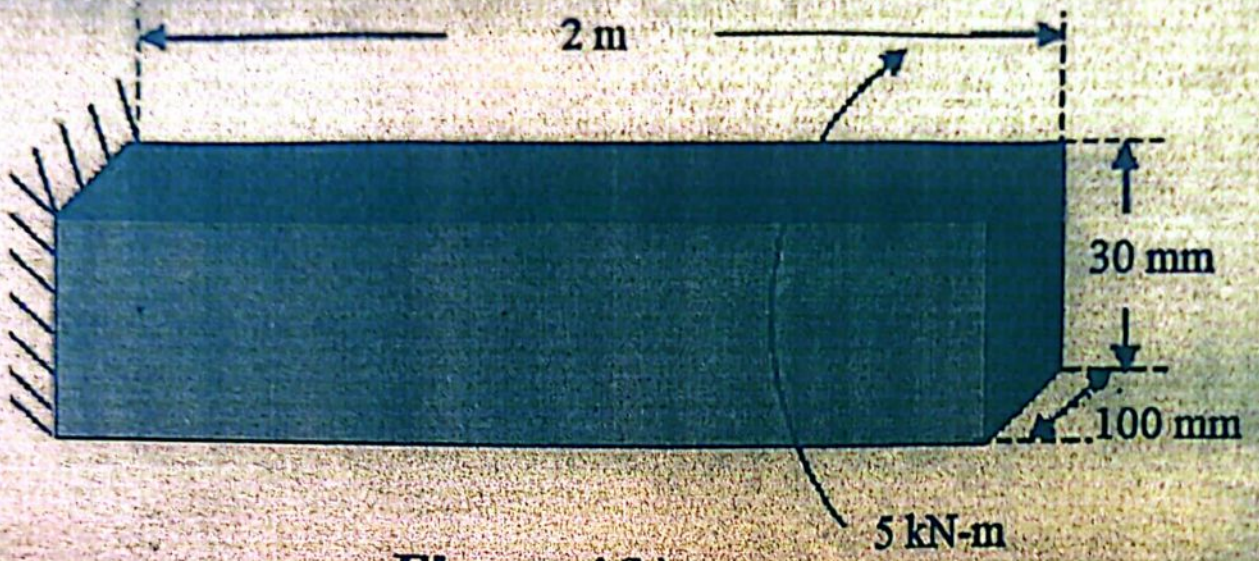


Figure-4(b)

Table 4b-1:Important Formula for Rectangular Section in Torsion		
τ_{max}	ϕ	k_t
$\frac{T}{\alpha b t^2}$	$\frac{TL}{\beta b t^3 G}$	$\frac{T}{\phi}$

Table 4b-2: Table of Coefficients for Rectangular Bar							
b/t	1.00	1.50	2.00	3.00	6.00	10.00	∞
α	0.208	0.231	0.246	0.267	0.299	0.312	0.333
β	0.141	0.196	0.229	0.263	0.299	0.312	0.333

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SECTION-B

Question –5

a. Consider a composite beam of the cross-sectional dimension shown in a figure 5(a). The upper 150 by 250 mm part is wood E_w= 10 GPa, the lower 10 by 150mm strap is steel, E_s=200 GPa. If this beam is subjected to a bending moment of 30 kN-m around horizontal axis, what are the maximum stresses in the steel and wood? 18

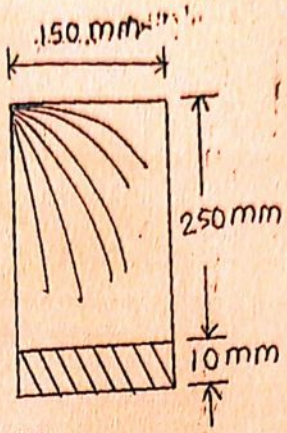


Figure : 5(a)

b. Determine the values of the stress in portions AC and CB of the steel bar shown in figure 5(b), when temperature of the bar is – 50°F, knowing that a close fit exists at both of the rigid supports when the temperature is +75°F. Use the values $E=29\times10^6$ psi and $\alpha=6.5\times10^6$/F for steel 17

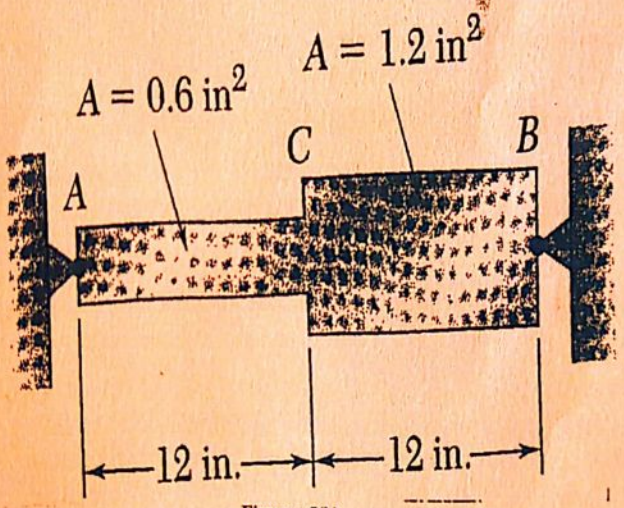


Figure : 5(b)

Question –6

a. With neat sketch, show the general state of stress acting on an infinitesimal element in Cartesian co-ordinate system. 6

b. Two solid cylindrical rods are joined at B and loaded as shown in figure 6(b). Rod AB is made of steel (E=200 GPa) and rod BC of brass (E= 105 GPa). Determine the total deformation of the composite rod ABC. 15

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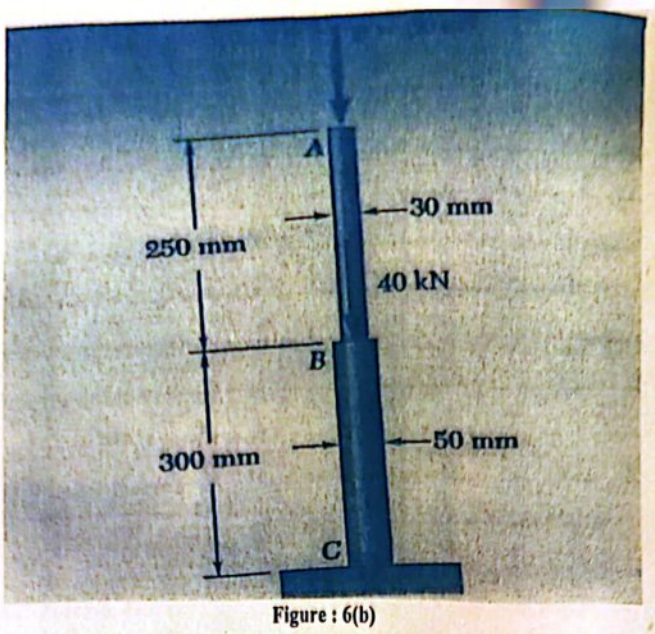


Figure : 6(b)

c. Find the approximate location of the shear center for a beam with the cross section of the channel shown in figure 6(c). Here, Given that, b=4 inch, h=6 inch, t=0.15inch. 14

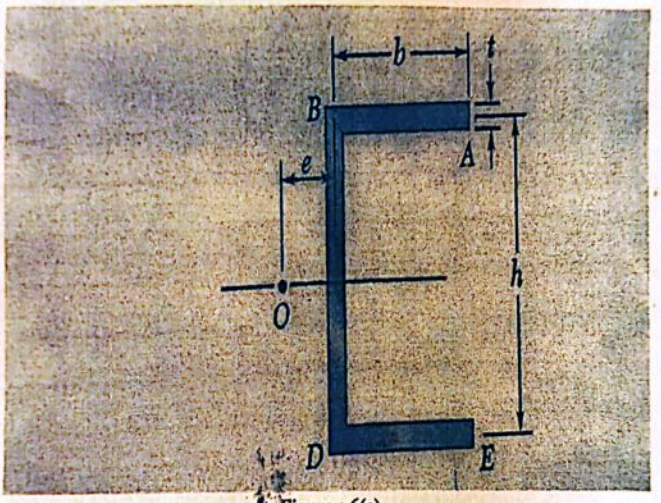


Figure : 6(c)

Question –7

a. Show that, for a horizontal prismatic beam having a cross-section with a vertical axis of symmetry, maximum bending stress at a section is given by, 15

$$\sigma_{max} = \frac{M}{S}$$

where,
M is bending moment at that section
S is the elastic sectional modulus

b. Two long wooden planks form a T section of a beam, as shown in figure 7(b) in mm. If this beam transmits a constant vertical shear of 300N; find, 20

i. The necessary spacing of the nails between the two planks to make the beam act as unit. Assume that the allowable shear force per nail is 700N.

ii. The shear stress at the Neutral Axis (NA) level.

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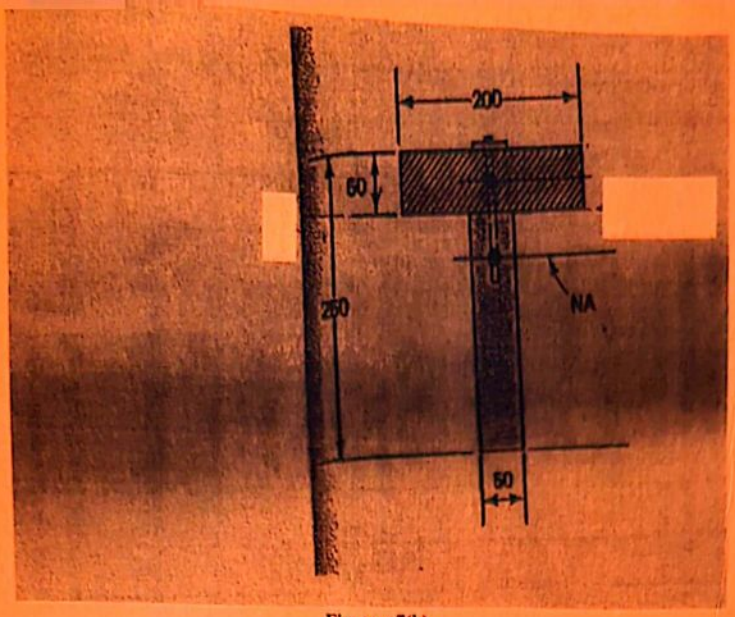


Figure : 7(b)

Question –8

a. Determine the largest load P that can be applied to the lap joint shown in figure 8(a). The bolt has a diameter of 10 mm and an allowable shear stress of 80 MPa. Each plate has an allowable tensile stress of 50 MPa, an allowable bearing stress of 80 MPa and allowable shear stress of 30 MPa. **20**

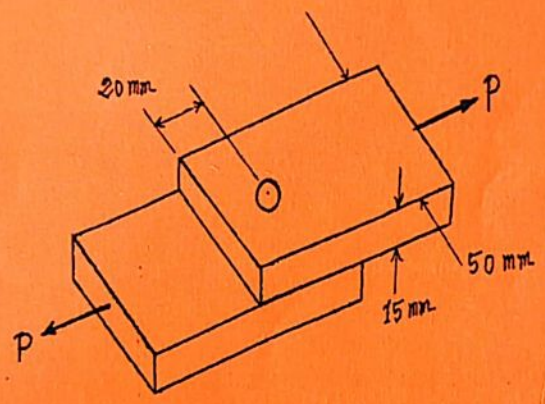


Figure : 8(a)

b. A concrete simply supported beam has a rectangular cross-section as shown in figure 8(b). Determine the allowable uniformly distributed load 'w' that the beam can carry if the allowable stress in bending is 400psi and in shear 100psi. Neglect the weight of the beam. **15**

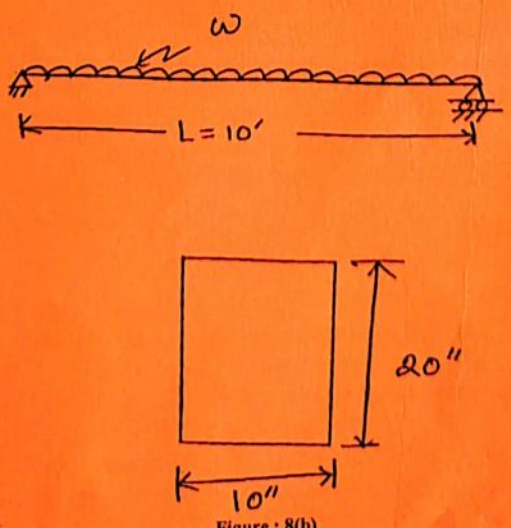


Figure : 8(b)

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BANGLADESH UNIVERSITY OF PROFESSIONALS
Military Institute of Science and Technology
B.Sc. in Environmental, Water Resources, and Coastal Engineering
Short Term Final Examination : Jan 2019

Subject: EWC-211, Mechanics of Solids- I

Time: 3.00 hours **Full Marks: 210**

INSTRUCTIONS:

a. Use **SEPARATE** answer scripts for each section.
b. Answer any **THREE** questions from each section out of **FOUR.**
c. Figures in the margin indicate full **marks.**
d. Assume reasonable data if necessary.
e. **Symbols** used have their usual meanings.

SECTION-A

Question – 1

a. Find reactions at supports and draw qualitative shape of S.F.D. and B.M.D of the beams shown in figure 1(a) to (f) **20**

b. Find reactions of the frame shown in figure 1(g). Draw free body diagram of all the elements and find internal forces and moments at all the joints. **15**

Question – 2

Find reactions and draw S.F.D. and B.M.D. of the symmetric beam shown in figure 2 **35**

Question – 3

a. i. Find the reactions and write an equation for moment, M(x) using singularity function of the beam given in figure 3(a). **6**

ii. Using the above singularity function equation derive on equation of shear force V(x) for the beam **3**

iii. From equation M(x) derive a general equation of moment at $20<x<25$. **3**

iv. From general equation derived as asked in question 3a (iii). Find the value of moment at x= 22 **3**

v. Cut the beam at x=22' and draw a free body diagram of right portion. From this free body diagram find the value of moment and shear force and confirm the result found from 3a (iv). [Remember the sign conventions of V & M when preceding right to left] **5**

b. A pressure cylinder, 1.5m long is made out of 5 mm thick steel plate which has an elastic modulus of 200 GPa and Poisson's ratio of 0.25. The cylinder has a mean diameter of 0.5m and is closed at its end-by flat plates. If it is subjected to an external pressure of 4 GPa, Calculate the longitudinal and transverse stresses **15**

Question – 4

a. A stepped circular shaft is made of steel hollow section with solid cast iron and Aluminum section as shown in figure 4(a). Determine the end reaction and plot torque and angle of twist diagram. Write the data in tabular form. Necessary data are given in figure 4(a) and other properties are tabulated in table 4(a). **20**

b. A rectangular cantilever solid beam is subjected to a torque of 5 kN-m as shown in figure 4(b). All dimensions are given in figure. Required formula and necessary data are given in Table 4(b)-1 and 4(b)-2. Find the maximum shear stress, angle of twist and torsional stiffness. Table 4(b) shows necessary formula and data. **15**

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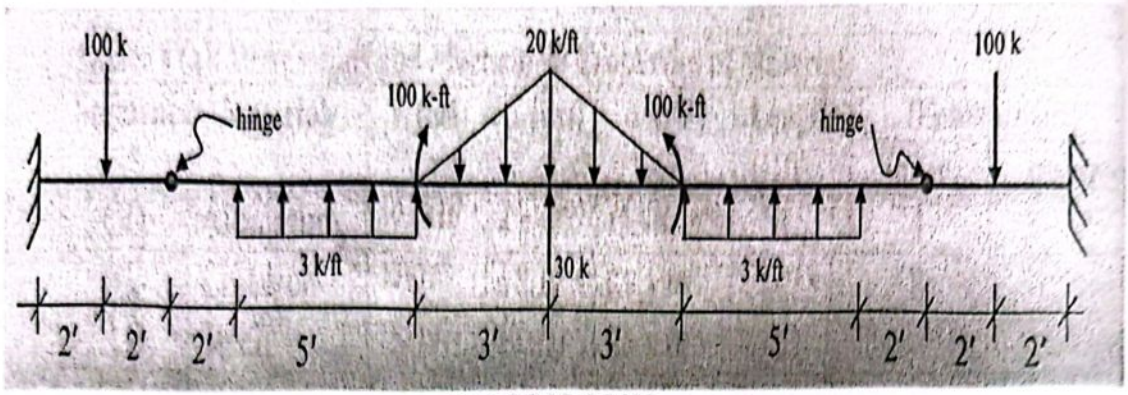


Figure-2: S.F.D. & B.M.D.

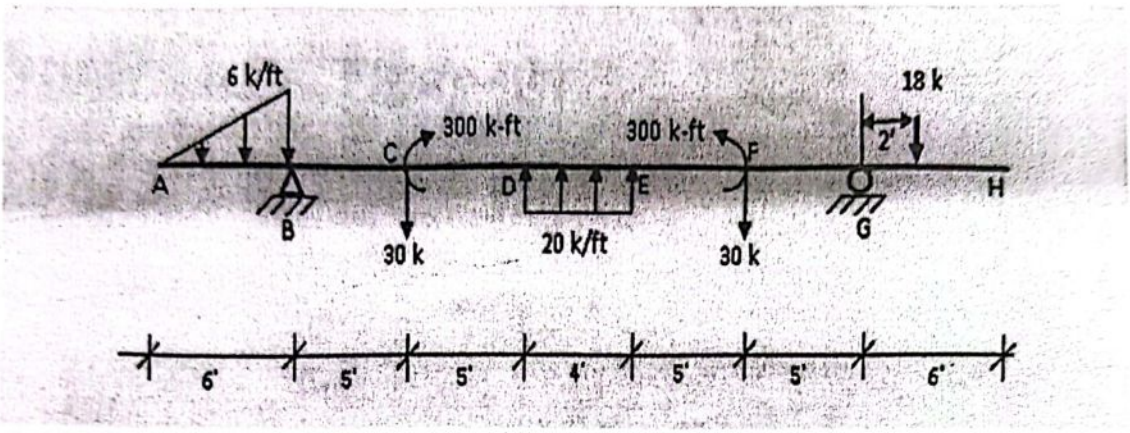


Figure-3(a) : S.F.D. & B.M.D.

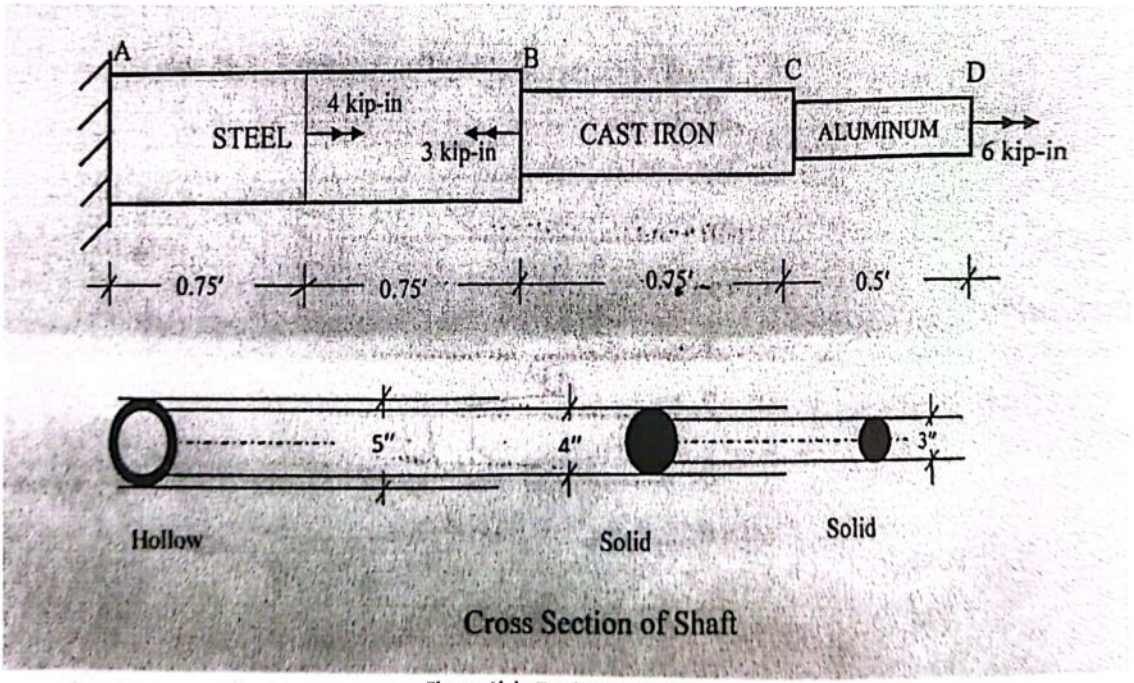


Figure-4(a) : Torsion Diagram

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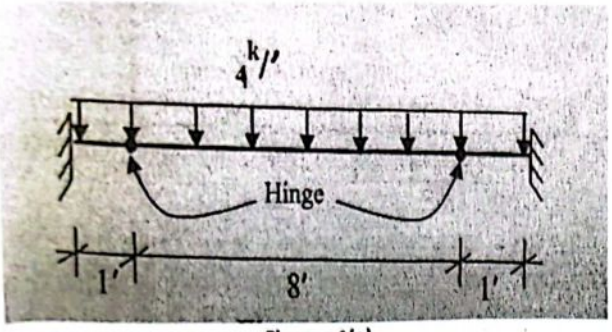


Figure : 1(a)

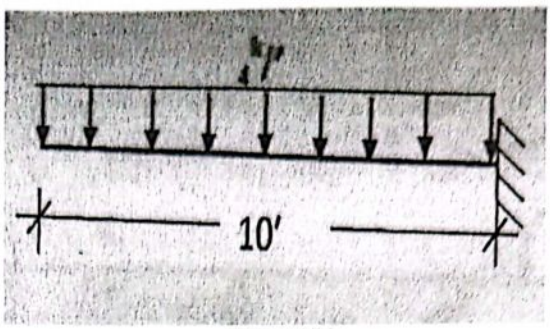


Figure : 1(b)

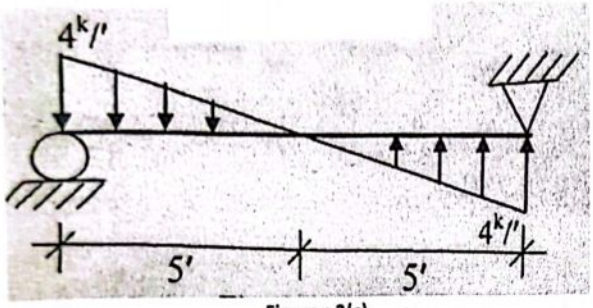


Figure : 2(c)

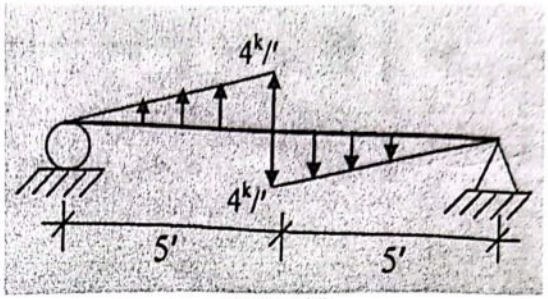


Figure: 1(d)

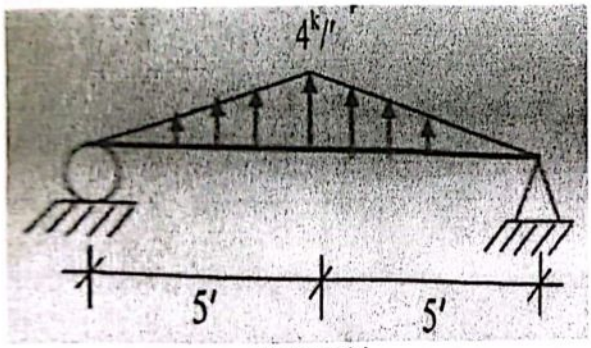


Figure : 1(e)

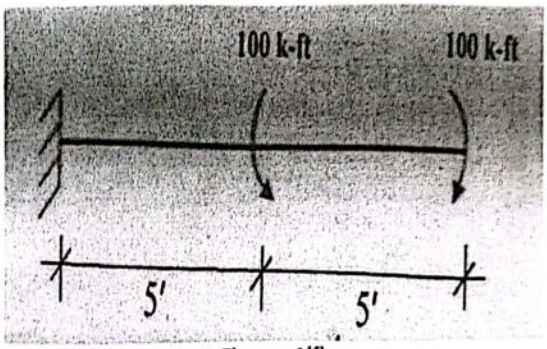


Figure : 1(f)

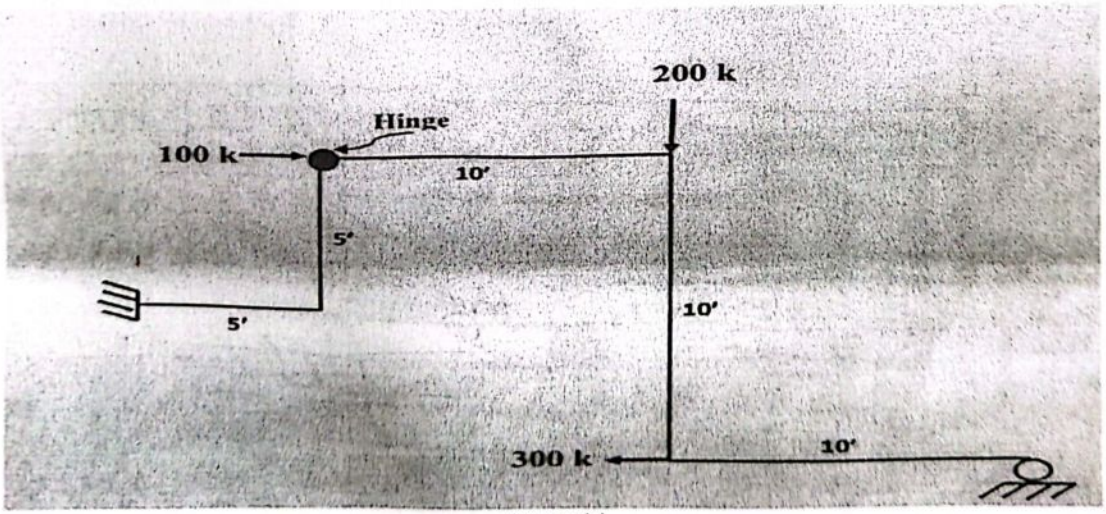


Figure : 1(g)

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Table: 4 (a): Dimensions and Mechanical Properties of Materials							
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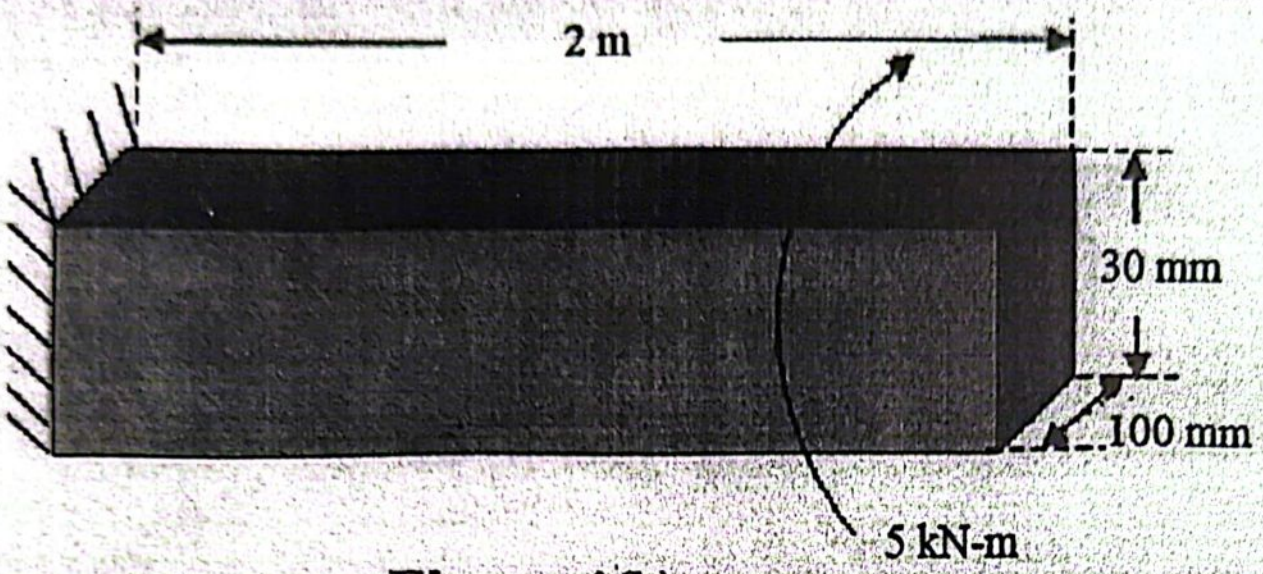


Figure-4(b)

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SECTION-B

Question –5

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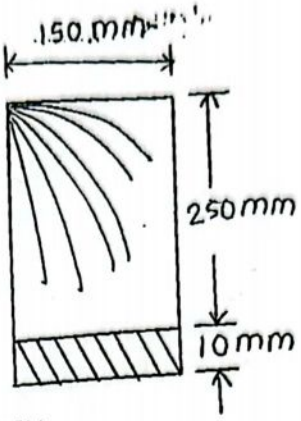


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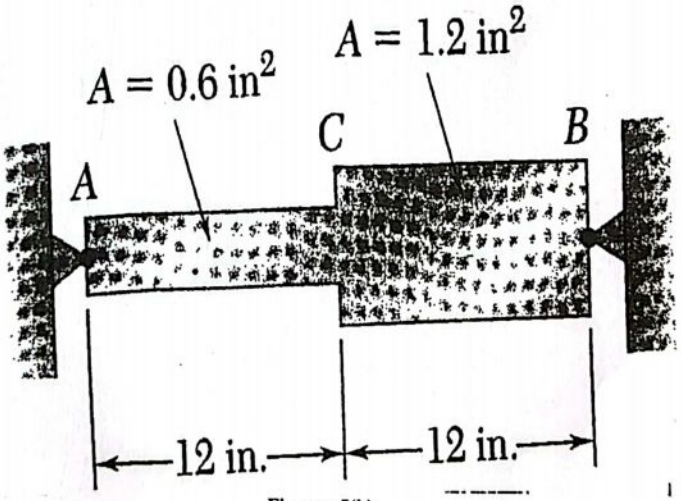


Figure : 5(b)

Question –6

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b. Two solid cylindrical rods are joined at B and loaded as shown in figure 6(b). Rod AB is made of steel (E=200 GPa) and rod BC of brass (E= 105 GPa). Determine the total deformation of the composite rod ABC. **15**

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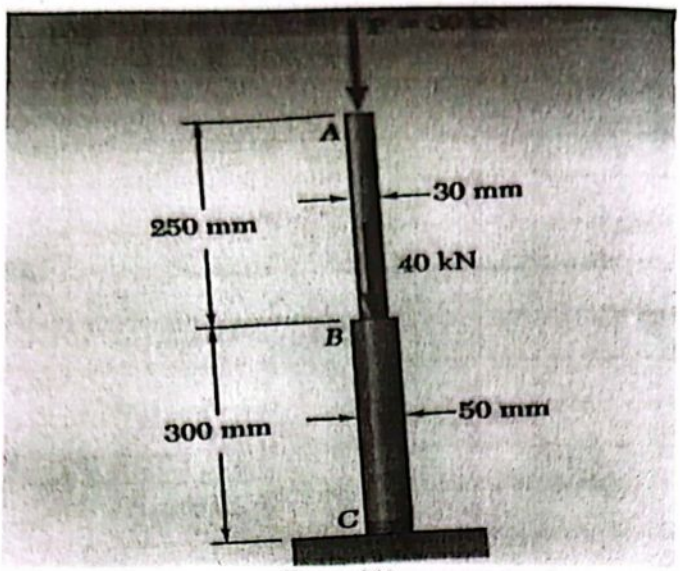


Figure : 6(b)

c. Find the approximate location of the shear center for a beam with the cross section of the channel shown in figure 6(c). Here, Given that, b=4 inch, h=6 inch, t=0.15inch. 14

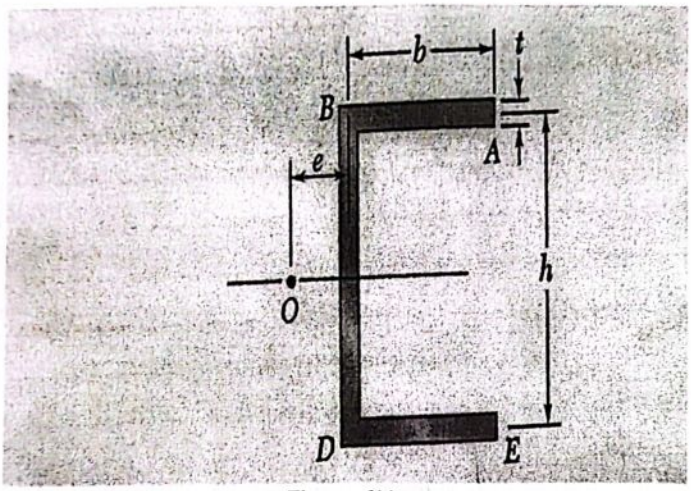


Figure : 6(c)

Question –7

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where,
M is bending moment at that section
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b. Two long wooden planks form a T section of a beam, as shown in figure 7(b) in mm. If this beam transmits a constant vertical shear of 300N; find, 20

i. The necessary spacing of the nails between the two planks to make the beam act as unit. Assume that the allowable shear force per nail is 700N.

ii. The shear stress at the Neutral Axis (NA) level.

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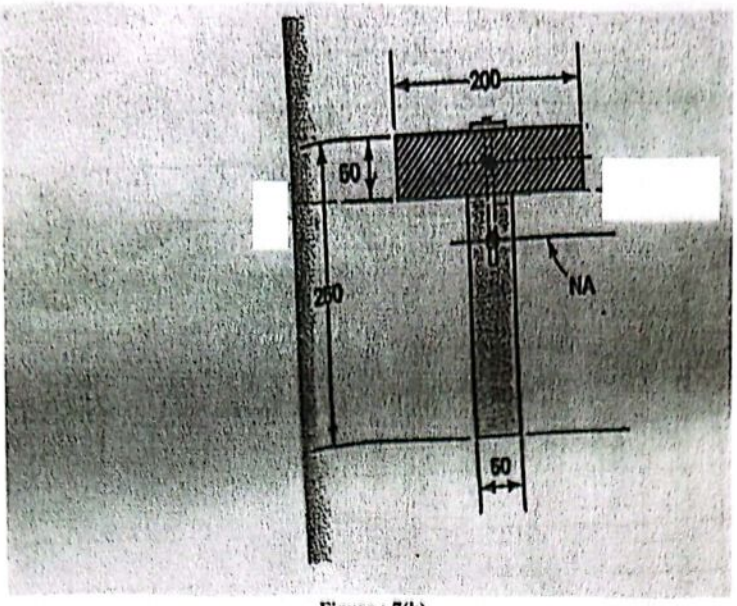


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Question –8

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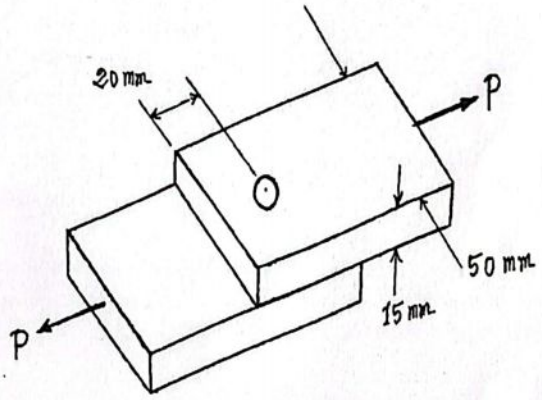
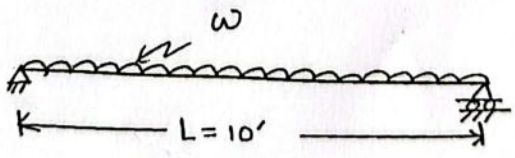
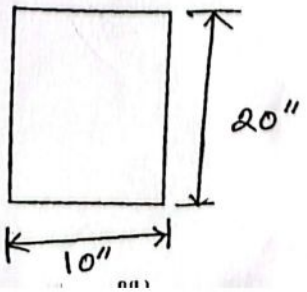


Figure : 8(a)

b. A concrete simply supported beam has a rectangular cross-section as shown in figure 8(b). Determine the allowable uniformly distributed load 'w' that the beam can carry if the allowable stress in bending is 400psi and in shear 100psi. Neglect the weight of the beam. **15**





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BANGLADESH UNIVERSITY OF PROFESSIONALS

Military Institute of Science and Technology

B.Sc. in Environmental, Water Resources and Coastal Engineering,

Term Final (Spring) Examination 2021: July-Aug 2021

Student Group: 36 < Earned Credit Hours ≤ 72

Subject: EWCE-211, Mechanics of Solids

Total : **2.00 hours (Online Examination for Section-A + Section-B)** — **Full Marks : 240**

Section A : **1.00 hour (Online Examination)** — **Section A : 120**

INSTRUCTIONS - ONLINE EXAMINATION (IF PHYSICAL EXAMINATION IS NOT HELD)

a. **Question - 1** and **Question – 4 (Viva Voce)** in **Section A** are compulsory.
b. Answer any **OTHER ONE** question from **Q-2 & Q-3** of **Section-A**.
c. Figures in the margin indicate full **marks.**
d. Assume reasonable data if necessary.
e. **Symbols** and **abbreviations** used have their usual meanings.

SECTION-A

Question – 1 (Compulsory)

a. A beam has different types of loads as shown in figure-1-a

(1) Draw free body diagram of left portion of beam at sec D-D and find the equations of V(x). **03**
(2) From the equations of V(x), find equations of M(x) by integration, use appropriate boundary condition. **03**
(3) Find the equations of M(x) again from free body diagram and check whether it is same as found in (2) above. **04**
(4) Find equation of V(x) again by differentiating M(x). **02**
(5) Find values of V and M at 18′ and 22′ from the left support. **03**
(6) Draw SFD and BMD of the beam and check the shear force and bending moment found at 18′ and 22′ are same as found from equations. **10**

Note: While finding equations of V(x) and M(x) from the free-body diagram, you must show detailed calculation to support the equilibrium equations.

b. Derive the equation of slope and deflection of the cantilever beam with UVL as shown in figure-1-b. **10**

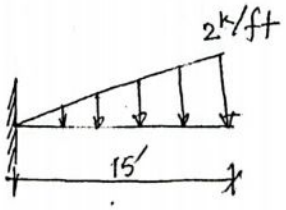


figure 1-b

c. From the above equation find the deflection of the beam at 5′ and 10′ from support. **05**

Question – 2 **3+8+4=15**

a. A frame is given with concentrated forces as shown in figure-2a.
i. Find support reactions of the frame given in figure above.
ii. Draw free body diagram and show horizontal and vertical forces and moment at each joint on free body diagram.
iii. Draw AFD, SFD and BMD of the force.

b. State of stress are given in figure-2b. Using Mohr's circle of stresses, **15**

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transform it on a plane graph paper.

i. to the principal stresses,
ii. into the maximum shear stress and associated normal stresses,
iii. Show the results for both cases on properly oriented elements,
iv. Find value of stresses at 45° (clockwise) using Mohr's circle.

[show all result in the tabular form]

c. Answer the following questions in short, form the knowledge of Transformation of stresses, 5+5=10

i. How do you define Mohr's circle of stresses? What is denoted by the locus of the circle? If $\sigma_1 + \sigma_2 = 0$, what would happen to its Mohr's circle? If $\sigma_x + \sigma_y = 0$ what will happen to its Mohr's circle?
ii. What is the angle Θ_1 and Θ_2 in transformation of stresses. What is the angular difference between them? Prove the angle by writing down the required expression with trigonometric function Θ_1 and Θ_2 and draw necessary figures to explain their orientations and angle.

Question – 3

a. Remove the extension of the beam by replacing required moment and forces, find support reactions and draw SFD and BMD of the beams given in figure 3(a). 24

b. Determine the design compressive strength for a 20ft W14×90 steel column fixed at both ends using AISC LRFD formula. Assume A-36 steel having σ_{yp}=36ksi. 16

Question – 4

VIVA VOCE (Compulsory in case of Online Examination) 40

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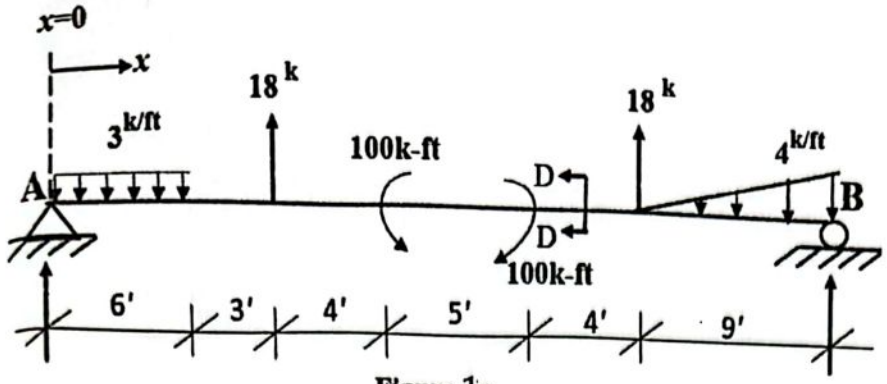


Figure-1a

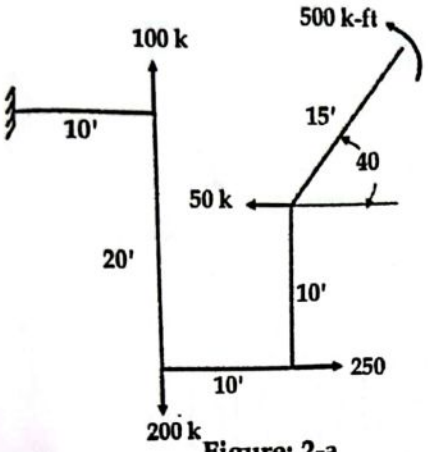


Figure: 2-a

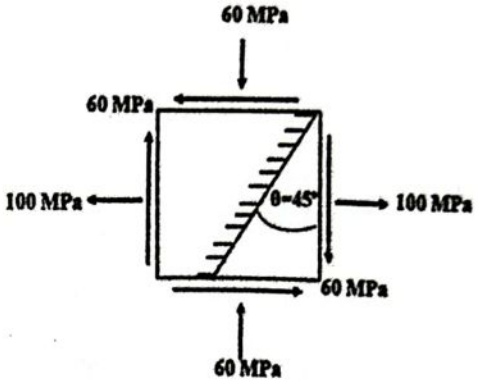


Figure: 2-b

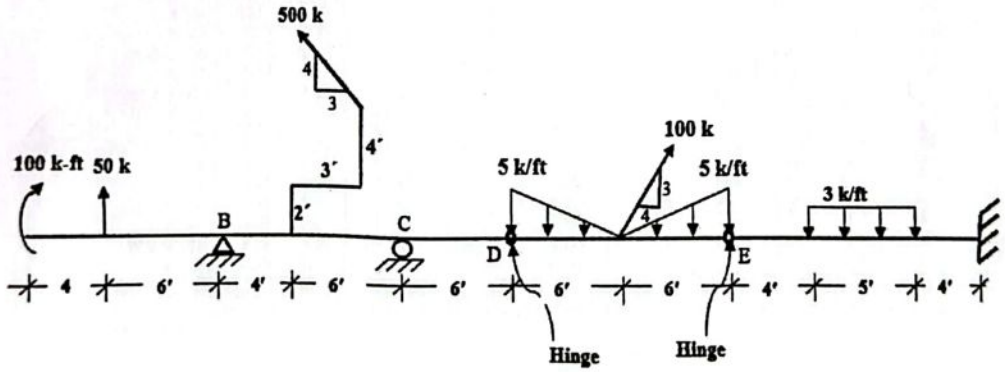


Figure: 3-a

Important Formula for AISC LRFD

$$\lambda_c = \frac{L_e}{r\pi}\sqrt{\left(\frac{\sigma_{yp}}{E}\right)}$$

For $\lambda_c > 1.5 : \sigma_{cr} = \left[\frac{0.877}{\lambda_c^{\,2}}\right]\sigma_{yp}$

For $\lambda_c \leq 1.5 : \sigma_{cr} = \left[(0.658)^{\lambda_c^{\,2}}\right]\sigma_{yp}$

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Important Formula for AISC ASD:

$C_c = \sqrt{(2\pi^2 E / \sigma_{yp})}$

If Long Column $\frac{L_e}{r} > C_c$: $\sigma_{allow} = \frac{12\pi^2 E}{23(L_e/r)^2}$

If $\frac{L_e}{r} < C_c$: $\sigma_{allow} = [(1 - (L_e/r)^2 / 2C_c^2)\sigma_{yp}] \div F.S.$

$$F.S. = \frac{5}{3} + \frac{3(L_e/r)}{8C_c} - \frac{(L_e/r)^3}{8C_c^3}$$



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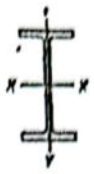


Table 4. American Wide-Flange Steel Beams, W Shapes, Properties for Designing

Designation*	Area	Depth	Flange		Web	Axis X–X			Axis Y–Y		
			Width	Thickness	Thickness	I	$S = I/c$	r	I	$S = I/c$	r
	in^2	in	in	in	in	in^4	in^3	in	in^4	in^3	in
W36 × 230	67.6	35.90	16.470	1.260	0.760	15000	837	14.9	940	114	3.73
× 150	44.2	35.85	11.975	0.940	0.625	9040	504	14.3	270	45.1	2.47
W33 × 201	59.1	33.68	15.745	1.150	0.715	11500	684	14.0	749	95.2	3.56
× 130	38.3	33.10	11.510	0.855	0.580	6710	406	13.2	218	37.9	2.38
W30 × 173	50.8	30.44	14.985	1.065	0.655	8200	539	12.7	598	79.8	3.43
× 108	31.8	29.82	10.484	0.760	0.548	4470	300	11.9	146	27.9	2.15
W27 × 146	42.9	27.78	13.965	0.975	0.605	5630	411	11.4	443	63.5	3.21
× 94	27.7	26.92	9.990	0.745	0.490	3270	243	10.9	124	24.8	2.12
W24 × 131	38.5	24.48	12.855	0.960	0.605	4020	329	10.2	340	53.0	2.97
× 76	22.4	23.92	8.990	0.680	0.440	2100	176	9.69	82.5	18.4	1.92
W21 × 111	32.7	21.51	12.340	0.875	0.550	2670	249	9.05	274	44.5	2.90
× 62	18.3	20.99	8.240	0.615	0.400	1330	127	8.54	57.5	13.9	1.77
W18 × 97	28.5	18.59	11.145	0.870	0.535	750	188	7.82	201	36.1	2.65
× 50	14.7	17.99	7.495	0.570	0.355	800	88.9	7.38	40.1	10.7	1.65
× 35	10.3	17.70	6.000	0.425	0.300	510	57.6	7.04	15.3	5.12	1.22
W16 × 100	29.4	16.97	11.425	0.985	0.585	1490	175	7.10	186	35.7	2.51
× 50	14.7	16.25	7.070	0.630	0.380	659	81.0	6.68	37.2	10.5	1.59
× 36	10.6	15.86	6.985	0.430	0.295	448	56.5	6.51	24.5	7.00	1.52
× 26	7.68	15.69	5.500	0.345	0.250	301	38.4	6.26	9.59	3.49	1.12
W14 × 730	215.0	22.42	17.890	4.910	3.070	14300	1280	8.17	4720	527	4.69
× 455	134.0	19.02	16.835	3.210	2.015	7190	756	7.33	2560	304	4.38
× 311	91.4	17.12	16.230	2.260	1.410	4330	506	6.88	1610	199	4.20
× 193	56.8	15.48	15.710	1.440	0.890	2400	310	6.50	931	119	4.05
× 159	46.7	14.98	15.565	1.190	0.745	1900	254	6.38	748	96.2	4.00
× 90	26.5	14.02	14.520	0.710	0.440	999	143	6.14	362	49.0	3.70
W14 × 74	21.8	14.17	10.070	0.785	0.450	796	112	6.04	134	26.6	2.48
× 68	20.0	14.04	10.035	0.720	0.415	723	103	6.01	121	24.2	2.46
× 61	17.9	13.89	9.995	0.645	0.375	640	92.2	5.98	107	21.5	2.45
× 53	15.6	13.92	8.060	0.658	0.370	542	77.8	5.90	57.5	14.3	1.92
× 43	12.6	13.66	7.995	0.530	0.305	428	62.7	5.82	45.2	11.3	1.89
W14 × 38	11.2	14.10	6.770	0.515	0.310	385	54.6	5.87	26.7	7.86	1.54
× 34	10.0	13.98	6.745	0.455	0.285	340	48.6	5.83	23.3	6.91	1.53
× 30	8.85	13.84	6.730	0.385	0.270	291	42.0	5.73	19.6	5.82	1.49
W12 × 87	25.6	12.53	12.125	0.810	0.515	740	118	5.38	241	3.97	3.07
× 65	19.1	12.12	12.000	0.605	0.390	533	87.9	5.28	174	29.1	3.02
× 53	15.6	12.06	9.995	0.575	0.345	425	70.6	5.23	95.8	19.2	2.48
× 40	11.8	11.94	8.005	0.515	0.295	310	51.9	5.13	44.1	11.0	1.93
W12 × 35	10.3	12.50	6.560	0.520	0.300	285	45.6	5.25	24.5	7.47	1.54
× 30	8.79	12.34	6.520	0.440	0.260	238	38.6	5.21	20.3	6.24	1.52
× 26	7.65	12.22	6.490	0.380	0.230	204	33.4	5.17	17.3	5.34	1.51
W10 × 112	32.9	11.36	10.415	1.250	0.755	716	126	4.66	238	45.3	2.68
× 100	29.4	11.10	10.340	1.120	0.680	623	112	4.60	207	40.0	2.65
× 88	25.9	10.84	10.265	0.990	0.605	534	98.5	4.54	179	34.8	2.63
× 77	22.6	10.60	10.190	0.870	0.530	455	85.9	4.49	154	30.1	2.60
× 60	17.6	10.22	10.080	0.680	0.370	341	66.7	4.39	116	23.0	2.57
× 49	14.4	9.98	10.000	0.560	0.340	272	54.6	4.35	93.4	18.7	2.54
W10 × 45	13.3	10.10	8.020	0.620	0.350	248	49.1	4.32	53.4	13.3	2.01
× 39	11.5	9.92	7.985	0.530	0.315	209	42.1	4.27	45.0	11.3	1.98
× 33	9.71	9.73	7.960	0.435	0.290	170	35.0	4.19	36.6	9.20	1.94
W10 × 30	8.84	10.47	5.810	0.510	0.300	170	32.4	4.38	16.7	5.75	1.37
× 22	6.49	10.17	5.750	0.360	0.240	118	23.2	4.27	11.4	3.97	1.33
W 8 × 67	19.7	9.00	8.280	0.935	0.570	272	60.4	3.72	88.6	21.2	2.12
× 58	17.1	8.75	8.220	0.810	0.510	228	52.0	3.65	75.1	18.3	2.10
× 48	14.1	8.50	8.110	0.685	0.400	184	43.3	3.61	60.9	15.0	2.08
× 40	11.7	8.25	8.070	0.560	0.360	146	35.5	3.53	49.1	12.2	2.04
× 35	10.3	8.12	8.020	0.495	0.310	127	31.2	3.51	42.6	10.6	2.03
× 31	9.13	8.00	8.000	0.435	0.285	110	27.5	3.47	37.1	9.27	2.02
W 8 × 28	8.25	8.06	6.535	0.465	0.285	98.0	24.3	3.45	21.7	6.63	1.62
× 24	7.08	7.93	6.495	0.400	0.245	82.8	20.9	3.42	18.3	5.63	1.61
W 8 × 21	6.16	8.28	5.270	0.400	0.250	75.3	18.2	3.49	9.77	3.71	1.26
× 18	5.26	8.14	5.250	0.330	0.230	61.9	15.2	3.43	7.97	3.04	1.23

*American wide-flange I- or H-shaped steel beams are referred to as W shapes, and are designed by the letter W followed by their *nominal* depth in inches, with their weight in pounds per linear foot given last. For example, W21 × 62 means that this W shape is 21 in deep and weighs 62 lbft. This list is abridged.

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BANGLADESH UNIVERSITY OF PROFESSIONALS

Military Institute of Science and Technology

B.Sc. in Environmental, Water Resources and Coastal Engineering,

Term Final (Spring) Examination 2021: July-Aug 2021

Student Group: 36 < Earned Credit Hours ≤ 72

Subject: EWCE-211, Mechanics of Solids

Total : **2.00 hours (Online Examination for Section-A + Section-B)** — **Full Marks : 240**

Section B : **1.00 hour (Online Examination)** — **Section B : 120**

INSTRUCTIONS - ONLINE EXAMINATION (IF PHYSICAL EXAMINATION IS NOT HELD)

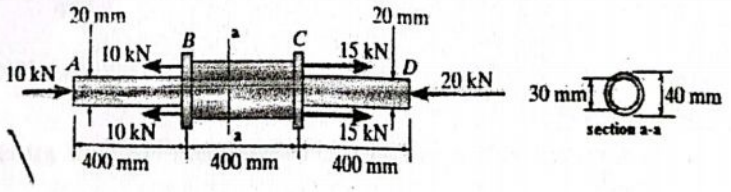
a. **Question - 5** and **Question – 8 (Viva Voce)** in **Section A** are compulsory.
b. Answer any **OTHER ONE** question from **Q-6 & Q-7** of **Section-B**.
c. Figures in the margin indicate full **marks.**
d. Assume reasonable data if necessary.
e. **Symbols** and **abbreviations** used have their usual meanings.

SECTION-B

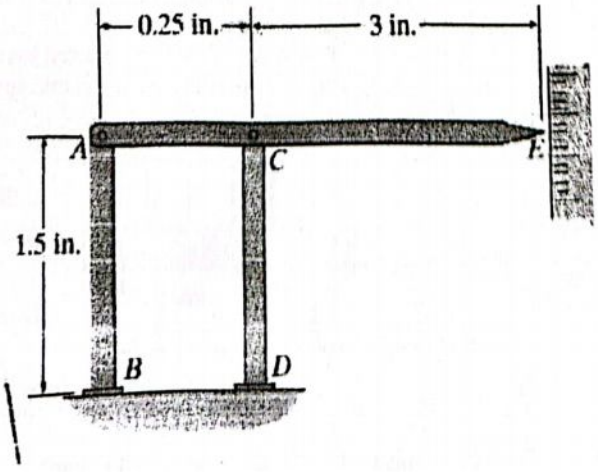
Question – 5 (Compulsory)

a. Segments AB and CD of the assembly are solid circular rods and segments BC is a tube, as shown in fig 4. If the assembly is made of aluminum, determine **24**

(i) The displacement of end D with respect to end A
(ii) The stress at section a-a
(iii) The strain energy in the region BC of the beam assembly [E = 68 GPa]



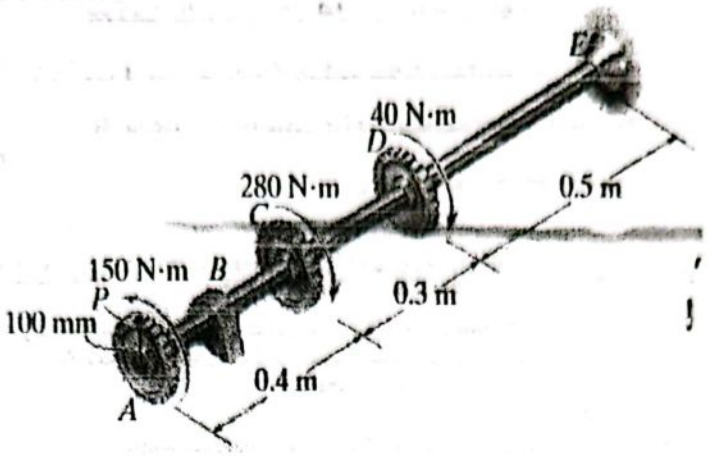
b. The device is used to measure a change in temperature. Bars AB and CD are made of steel and aluminum alloy, respectively (fig 5). When the temperature is at 75°F, ACE is in the horizontal position. Determine the vertical displacement of the pointer at E when the temperature rises to 150°F. Assume, the coefficient of thermal expansion for aluminum and steel to be 23.2×10^{-6}/°C and 12×10^{-6}/°C respectively. **16**



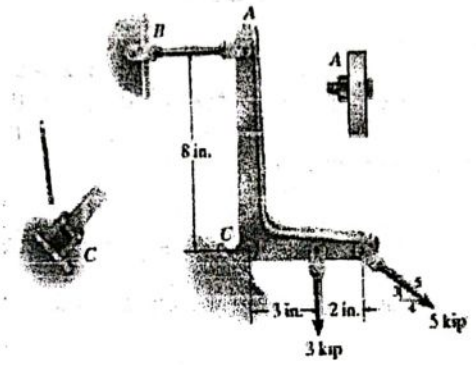
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Question – 6

a. The gears attached to the fixed-end steel shaft are subjected to the torques, shown in fig 6. If the shear modulus of elasticity is 80 GPa and the shaft has a diameter of 14 mm, determine the angle of twist and the displacement of the tooth, P on gear A. The shaft turns freely within the bearing at B. **24**



b. The control arm is subjected to the loading shown in fig 7. Determine to the nearest ¼ inch the required diameters of the steel pins at A and C if the allowable shear stress for the steel is $\tau_{allow} = 8$ ksi. **16**



Question – 7

a. A cylindrical pressure vessel has an inner diameter of 4 ft and a thickness of ½ inch. **24**

(i) Determine the maximum internal pressure it can sustain so that neither its circumferential nor its longitudinal stress component exceeds 20 ksi.

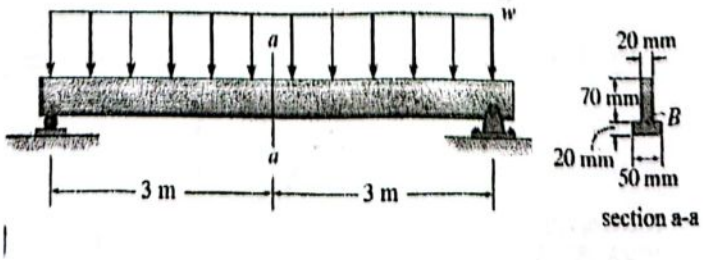
(ii) Under the same conditions, what is the maximum internal pressure that a smaller size spherical vessel can sustain?

(iii) Calculate the change in diameter in the sphere caused by pressurization. Let E = 200 GPa and $\upsilon = 0.28^{\circ}$.

b. If the beam, shown in fig 8 has an allowable bending stress of $\sigma_{allow} = 150$ MPa, determine **16**

(i) The maximum allowable uniformly distributed load, w.

(ii) The shear stress at point B for the section at mid span.



Question – 8

VIVA VOCE (Compulsory in case of Online Examination) **40**

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BANGLADESH UNIVERSITY OF PROFESSIONALS

Military Institute of Science and Technology

B.Sc. in Environmental, Water Resources and Coastal Engineering, Term Final (Spring) Examination 2021: July-Aug 2021

Student Group: 36 < Earned Credit Hours ≤ 72

Subject: EWCE-205, umerical Methods

Total : **2.00 hours (Online Examination for Section-A + Section-B)** — **Full Marks : 120**

Section A : **1.00 hour (Online Examination)** — **Section A : 60**

INSTRUCTIONS - ONLINE EXAMINATION (IF PHYSICAL EXAMINATION IS NOT HELD)

a. **Question - 1** and **Question – 4 (Viva Voce)** in **Section A** are compulsory.
b. Answer any **OTHER ONE** question from **Q-2 & Q-3** of **Section-A**.
c. Figures in the margin indicate full **marks.**
d. Assume reasonable data if necessary.
e. **Symbols** and **abbreviations** used have their usual meanings.

SECTION-A

Question – 1 (Compulsory)

a. What are the applications of Numerical Methods in Environmental and Water Resources Engineering? **06**

b. From the following table of values of x and y, calculate the first and second derivatives of the function at the point x = 2.2 and also $\frac{dy}{dx}$ at x = 2.0. **14**

x	1.0	1.2	1.4	1.6	1.8	2.0	2.2
y	2.7183	3.3201	4.0552	4.9530	6.0496	7.3891	9.0250

Question = 2

a. Use iteration method to find the real root of the equation, **10**

$$\sin^2 x = x^2 - 1$$

Correct to six decimal places.

b. Find the positive root of x = cos x, using Newton-Raphson method. Correct up to 5 decimal places. **10**

Question – 3

a. Use the Newton-Gregory's interpolation formula to obtain the polynomial f(x) and f(7.5) from the following table.

x	1	2	3	4	5	6	7	8
f(x)	1	8	27	64	125	216	343	512

b. Find $\sqrt{12}$ to four decimal places by Newton-Raphson method. **08**

Question – 4

VIVA VOCE (Compulsory in case of Online Examination) **20**

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BANGLADESH UNIVERSITY OF PROFESSIONALS

Military Institute of Science and Technology

B.Sc. in Environmental, Water Resources and Coastal Engineering, Term Final (Spring) Examination 2021: July-Aug 2021

Student Group: 36 < Earned Credit Hours ≤ 72

Subject: EWCE-205, Numerical Methods

Total : **2.00 hours (Online Examination for Section-A + Section-B)** — **Full Marks : 120**

Section B : **1.00 hour (Online Examination)** — **Section B : 60**

INSTRUCTIONS - ONLINE EXAMINATION (IF PHYSICAL EXAMINATION IS NOT HELD)

a. **Question - 5** and **Question – 8 (Viva Voce)** in **Section A** are compulsory.
b. Answer any **OTHER ONE** question from **Q-6 & Q-7** of **Section-B**.
c. Figures in the margin indicate full **marks.**
d. Assume reasonable data if necessary.
e. **Symbols** and **abbreviations** used have their usual meanings.

SECTION-B

Question – 5 (Compulsory)

a. What are the methods of solving a linear system of algebraic equations. **04**

b. Solve the following system of equations using Gauss-Jordan method. **08**

$$2x_1 + 4x_2 + 6x_3 = -8$$
$$x_1 + 3x_2 - x_3 = 10$$
$$2x_1 - 4x_2 - 2x_3 = -12$$

c. Find the value of f ′(8) and f ″(8) from the table given below: **08**

x	6	7	9	12	16
f(x)	1.556	1.690	1.908	2.158	3.797

Question – 6

a. Derive the 5-point difference formula. **04**

b. In a certain machine, a slider moves along a fixed straight rod. Its distance x cm along the rod is given below for various values of the time t seconds: **10**

t	0	0.1	0.2	0.3	0.4	0.5	0.6
x	30.13	31.62	32.87	33.64	33.95	33.81	33.24

Find (i) the velocity of the slider and
(ii) its acceleration at t = 0.3

c. A series of offsets were taken at 10 m intervals in the following order from a chain line to a curved boundary: 0, 7.2 m, 5.4 m, 6.0m, 6.8m, 7.4m, 8.2m, and 0 m. Using Simpsons rule, find the area enclosed between the chain line and the curved boundary. **06**

Question – 7

a. Use Romberg integration to evaluate $\int_0^{\pi/2} \frac{\cos x}{\sqrt{1+\sin x}} dx$ **14**
Use the 1, 2, 4 and 8 segment Trapezoidal results.

b. Obtain the solution of the following system using Gauss-Seidel iteration method. Carry the computations to 3 decimal places and proceed upto 4 iterations: **06**

$$2x_1 + x_2 + x_3 = 5$$
$$3x_1 + 5x_2 + 2x_3 = 15$$
$$2x_1 + x_2 + 4x_3 = 8$$

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BANGLADESH UNIVERSITY OF PROFESSIONALS
Military Institute of Science and Technology
B.Sc. in Environmental, Water Resources and Coastal Engineering
Short Term Final Examination: Jan 2020

Subject: EWC 211, Mechanics of Solids I

Time: 3.00 hours **Full Marks: 180**

INSTRUCTIONS:

a. Use **SEPARATE** answer scripts for each section.
b. **Question - 1** in **Section A** and **Question - 5** in **Section B** are compulsory.
c. Answer any **OTHER TWO** questions from **EACH** section.
d. Figures in the margin indicate **full marks**.
e. Assume reasonable data if necessary.
f. **Symbols** used have their usual meanings.

SECTION-A

Question – 1

a. Find reactions and draw SFD and BMD of the four beams given in figure 1(a) to 1(d) **22**

b. A simply supported beam with varying distributed (triangle) load is shown in figure 1(e) **14**
   i) Find support reactions of the beam
   ii) Find also the equations of bending moment, M(x) and shear force, V(x) using free body diagram at a point $0<x<21$
   iii) Use appropriate calculus to find M(x) from V(x). Use boundary condition as needed.
   iv) Use appropriate calculus to find V(x) from M(x).
   v) Find the magnitude and location (distance from left support) of maximum moment using the derived equations.
   vi) Draw BMD of the beam. Check whether the location and magnitude of maximum bending moment are same as found from the equation.

Question – 2

a. Find the missing reaction and draw SFD and BMD of the beams given in Figure 2(a). **9**

b. A frame is given in Figure 2(b) **11**
   i) Find support reactions.
   ii) Draw the free body diagram of the frame separating all the elements and show all internal forces at each joint of the free body diagrams.

c. Draw AFD, SFD and BMD of the frame. **7**

Question – 3

a. Find support reactions and draw SFD and BMD of the beam [Figure 3(a)]. **17**

b. Select a solid shaft for a 15hp motor operating at 50hz. The maximum shear stress of the materials is limited to 60 MPa. **10**

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Question – 4

a. A stepped circular shaft is made of steel hollow and solid section with different materials. Determine the end reactions and plot torque and angle of twist diagram. Write the data in tabular form and show necessary calculation in table. Required data are given in Figure 4(a) and few other properties are tabulated in Table 4(a).

b. A pressure cylinder, 1.0 m long is made out of 6mm thick steel plate which has an elastic modulus of 200 GPa and a Poisson's ratio of 0.3. The cylinder has a mean diameter of 0.5m and is closed at its ends by flat plates. If it is subjected to an internal pressure of 4MPa, calculate its increase in volume.

SECTION-B

Question – 5

a. A concrete slab is reinforced with 16mm diameter steel rods placed 25mm above the lower face of the slab. The center to center spacing of the rods is 100 mm. Given that, modulus of elasticity of concrete is E_c=25GPa and that of steel is E_s=200GPa
Compute the maximum stress occurring
(i) in the concrete and
(ii) in the steel reinforcements.
when a bending moment of 5kN-m acts at each 0.305m width of the slab [see Figure 5a for reference].

b. Two long wooden planks form a T-section of beam. A constant vertical shear can be determined from the Figure 5b(i). Find the necessary spacing of the nails used to make the T-section [shown in Figure 5b(ii)] in order to allow the beam to act as a unit. Assume the allowable shear force per nail to be 700N.

Question –6

a. Bending stress in the beam shown in Figure 6a should not exceed 50MPa. Determine the minimum thickness denoted as "t" in the figure.

b. An I-beam is loaded in such a way that there is a vertical shear of 50 kips at all sections. The cross-section is shown in Figure 6b where its weight is to be neglected. Compute and draw the corresponding shear stress distribution at the levels indicated in the figure.

Question –7

a. The steel frame shown in Figure 7a has a diagonal member BD with an area of 1920 mm^2. Determine the largest allowable load P if the change in length of the member is not to exceed 1.6mm. Take the modulus of elasticity of steel to be E_s=200GPa.

b. The same member BD from the problem described in Figure 7a is now detached from the frame and fixed between two rigid supports as shown in Figure 7b. Determine the value of the stress in member BD when the temperature drops to -45°C knowing that a close fit exists at both the supports when the temperature is +24°C. Assume $\alpha=11.7X10^{-6}$/°C for steel.

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Question–8

a. Determine the location of the shear center for the beam having a cross section as shown in Figure 8a. **12**

b. Two steel plates have been welded together to form a T and strengthened further by bolting two wooden blocks on the sides as shown. Given, the modulus of elasticity of wood E_w =12.5GPa and that for steel E_s =200GPa. Determine **18**

(i) the maximum stress in wood

(ii) the stress in steel along the top fiber

When a bending moment of 50kN-m is applied on the composite beam [see Figure 8b].

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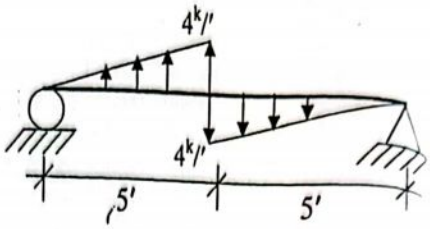


Figure 1(a)

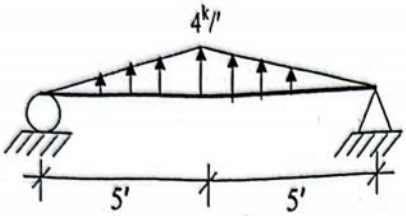


Figure 1(b)

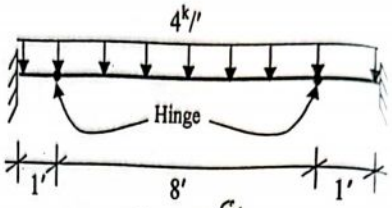


Figure 1(c)

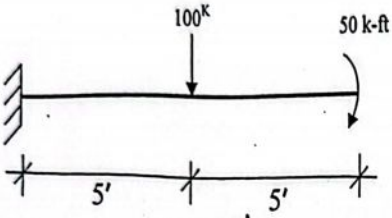


Figure 1(d)

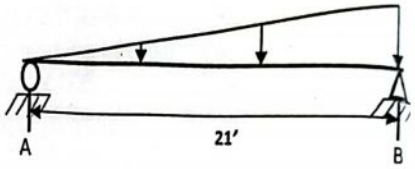


Figure-1(e): Equation of SFD & B

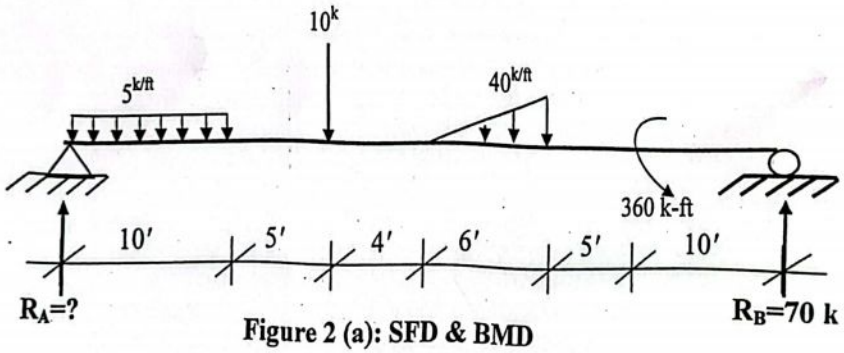
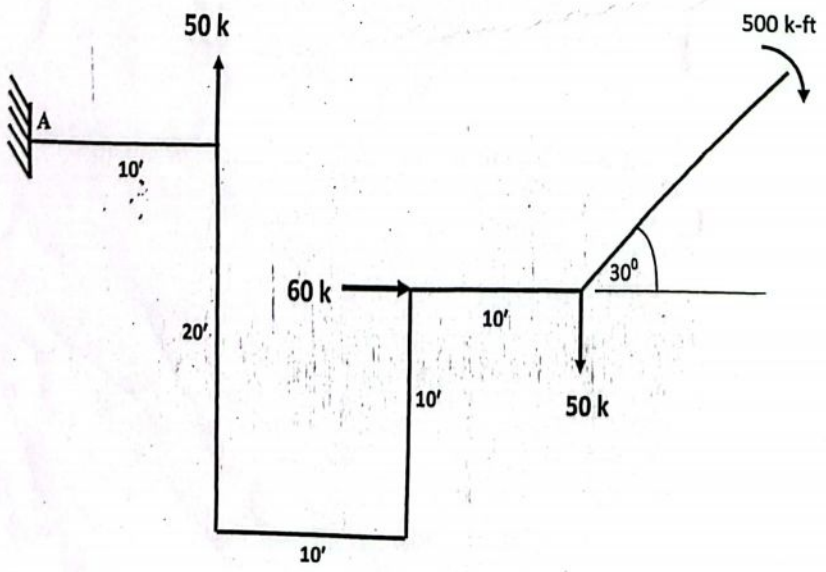


Figure 2 (a): SFD & BMD



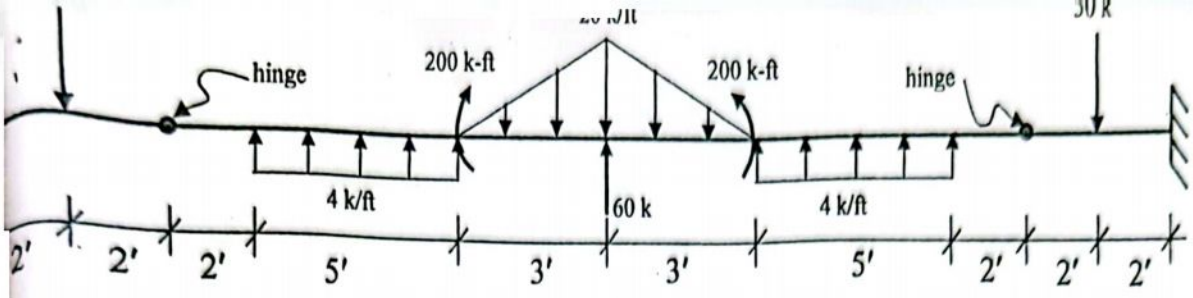
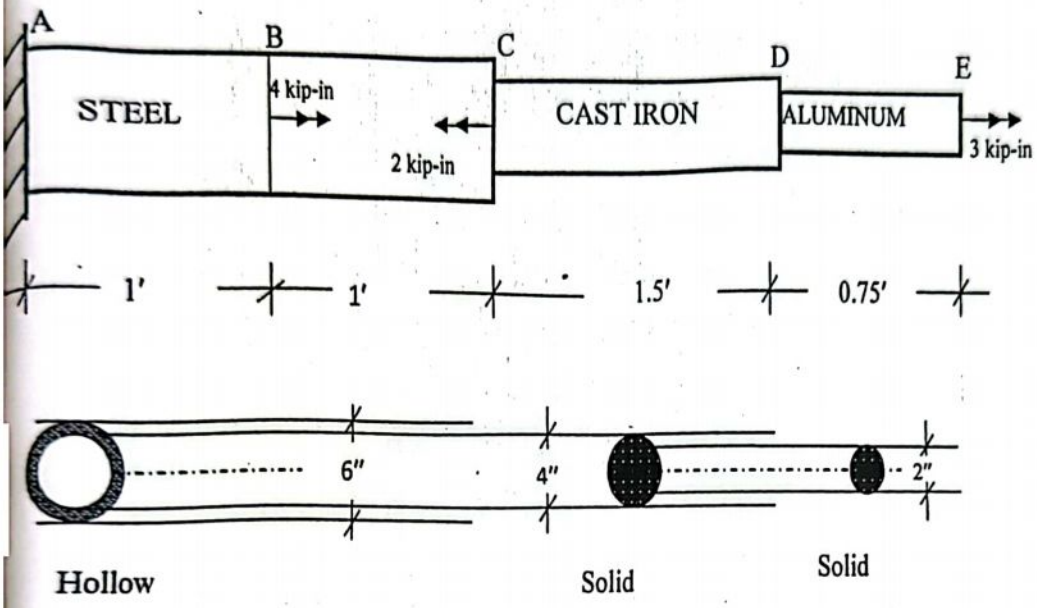


Figure 3(a)



Cross Section of Shaft

Figure-4(a):

Table-4(a): Properties and Dimension

Segment	Materials	E (psi)	G (psi)	α (/°F)	Length (ft)	Diameter (in)
DE	Aluminum	$10.6X10^6$	4×10^6	12.9×10^{-6}	0.75	2.0
CD	Cast Iron	$13X10^6$	6×10^6	5.8×10^{-6}	1.5	4.0
AC	Steel	$29X10^6$	12×10^6	6.5×10^{-6}	2.0	6.0 & 4.0

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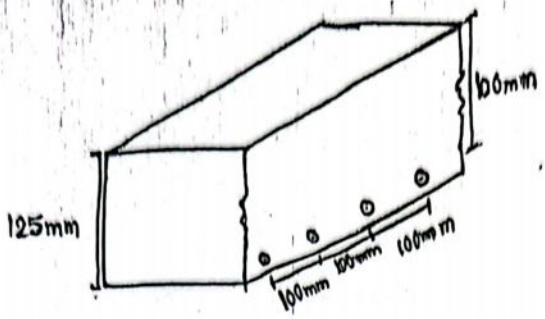


Figure 5a.

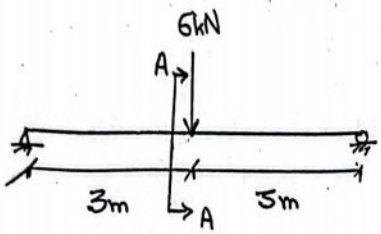
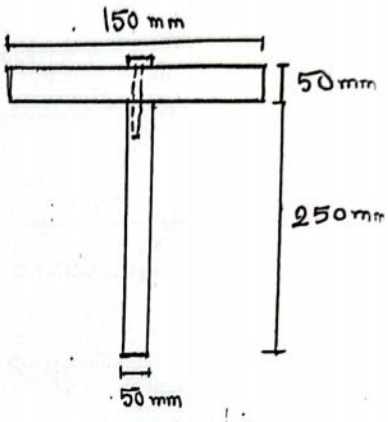
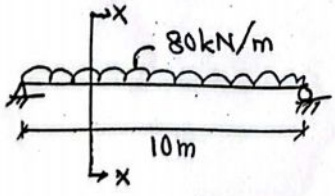


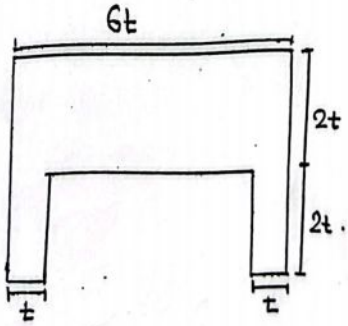
Figure 5b(i)



Section A-A.

Figure 5b(ii).





Section X-X.

Figure 6a

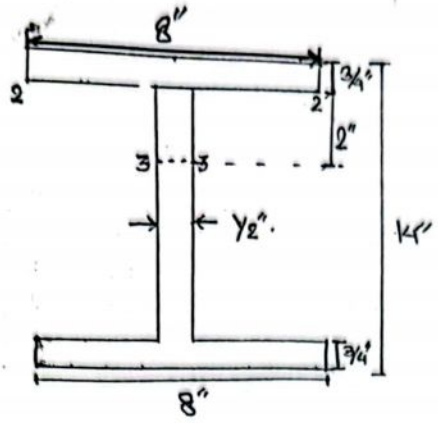


Figure 6b

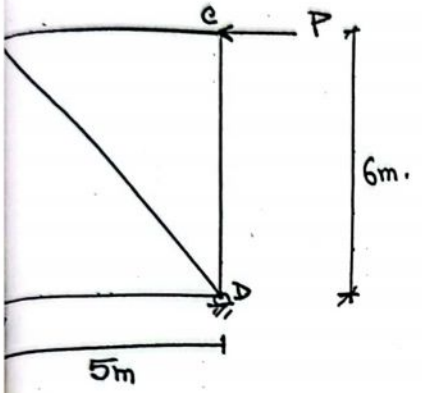


Figure 7a.



Figure 7b.

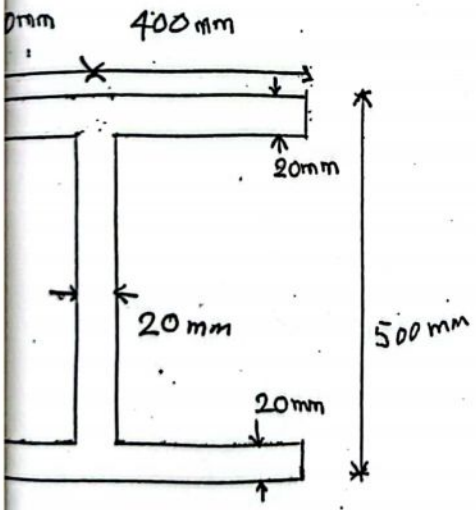


Figure 8a.

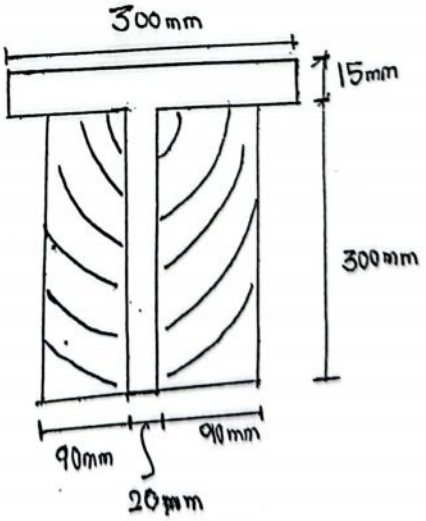


Figure 8b.

Military Institute of Science and Technology
B.Sc. in Environmental, Water Resources and Coastal Engineering
Short Term Final Examination (Improvement): Jan 2020

Subject: EWC 211, Mechanics of Solids I

Time: 3.00 hours **Full Marks: 180**

INSTRUCTIONS:

a. Use **SEPARATE** answer scripts for each section.
b. **Question - 1** in **Section A** and **Question - 5** in **Section B** are compulsory.
c. Answer any **OTHER TWO** questions from **EACH** section.
d. Figures in the margin indicate **full marks**.
e. Assume reasonable data if necessary.
f. **Symbols** used have their usual meanings.

SECTION-A

Question – 1

a. Find reactions and draw SFD and BMD of the four beams given in figure 1(a) to 1(d) — 22

b. A simply supported beam with varying distributed (triangle) load is shown in figure 1(e) — 14
   i) Find support reactions of the beam
   ii) Find also the equations of bending moment, M(x) and shear force, V(x) using free body diagram at a point $0<x<21$
   iii) Use appropriate calculus to find M(x) from V(x). Use boundary condition as needed.
   iv) Use appropriate calculus to find V(x) from M(x).
   v) Find the magnitude and location (distance from left support) of maximum moment using the derived equations.
   vi) Draw BMD of the beam. Check whether the location and magnitude of maximum bending moment are same as found from the equation.

Question – 2

a. Find the missing reaction and draw SFD and BMD of the beams given in Figure 2(a). — 9

b. A frame is given in Figure 2(b) — 11
   i) Find support reactions.
   ii) Draw the free body diagram of the frame separating all the elements and show all internal forces at each joint of the free body diagrams.

c. Draw AFD, SFD and BMD of the frame. — 7

Question – 3

a. Find support reactions and draw SFD and BMD of the beam [Figure 3(a)]. — 17

b. Select a solid shaft for a 15hp motor operating at 50hz. The maximum shear stress of the materials is limited to 60 MPa. — 10

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Question – 4

a. A stepped circular shaft is made of steel hollow and solid section with different materials. Determine the end reactions and plot torque and angle of twist diagram. Write the data in tabular form and show necessary calculation in table. Required data are given in Figure 4(a) and few other properties are tabulated in Table 4(a). 17

b. A pressure cylinder, 1.0 m long is made out of 6mm thick steel plate which has an elastic modulus of 200 GPa and a Poisson's ratio of 0.3. The cylinder has a mean diameter of 0.5m and is closed at its ends by flat plates. If it is subjected to an internal pressure of 4MPa, calculate its increase in volume. 10

SECTION-B

Question – 5

a. A concrete slab is reinforced with 16mm diameter steel rods placed 25mm above the lower face of the slab. The center to center spacing of the rods is 100 mm. Given that, modulus of elasticity of concrete is E_c=25GPa and that of steel is E_s=200GPa
Compute the maximum stress occurring
(i) in the concrete and
(ii) in the steel reinforcements.
when a bending moment of 5kN-m acts at each 0.305m width of the slab [see Figure 5a for reference]. 18

b. Two long wooden planks form a T-section of beam. A constant vertical shear can be determined from the Figure 5b(i). Find the necessary spacing of the nails used to make the T-section [shown in Figure 5b(ii)] in order to allow the beam to act as a unit. Assume the allowable shear force per nail to be 700N. 12

Question –6

a. Bending stress in the beam shown in Figure 6a should not exceed 50MPa. Determine the minimum thickness denoted as "t" in the figure. 12

b. An I-beam is loaded in such a way that there is a vertical shear of 50 kips at all sections. The cross-section is shown in Figure 6b where its weight is to be neglected. Compute and draw the corresponding shear stress distribution at the levels indicated in the figure. 18

Question –7

a. The steel frame shown in Figure 7a has a diagonal member BD with an area of 1920 mm^2. Determine the largest allowable load P if the change in length of the member is not to exceed 1.6mm. Take the modulus of elasticity of steel to be E_s=200GPa. 18

b. The same member BD from the problem described in Figure 7a is now detached from the frame and fixed between two rigid supports as shown in Figure 7b. Determine the value of the stress in member BD when the temperature drops to -45°C knowing that a close fit exists at both the supports when the temperature is +24°C. Assume $\alpha=11.7X10^{-6}$/°C for steel. 12

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Question–8

a. Determine the location of the shear center for the beam having a cross section as shown in Figure 8a. 12

b. Two steel plates have been welded together to form a T and strengthened further by bolting two wooden blocks on the sides as shown. Given, the modulus of elasticity of wood E_w =12.5GPa and that for steel E_s =200GPa. Determine 18

(i) the maximum stress in wood

(ii) the stress in steel along the top fiber

When a bending moment of 50kN-m is applied on the composite beam [see Figure 8b].

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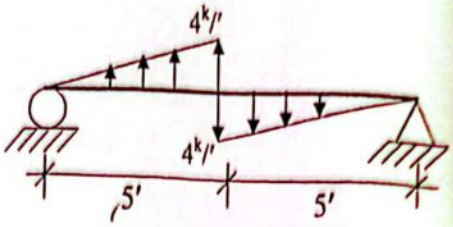


Figure 1(a)

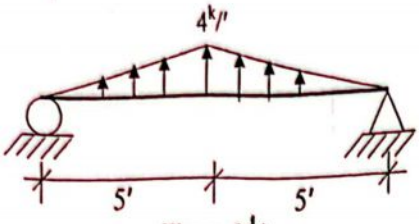


Figure 1(b)

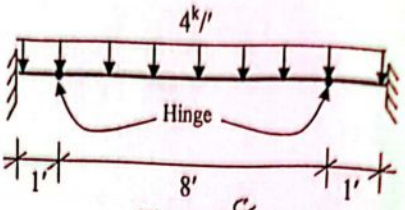


Figure 1(c)

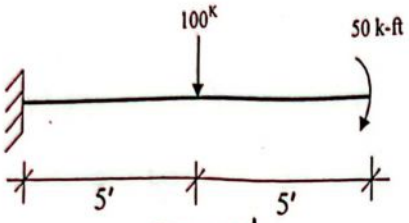


Figure 1(d)

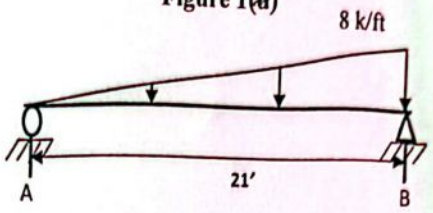


Figure-1(e): Equation of SFD & BMD

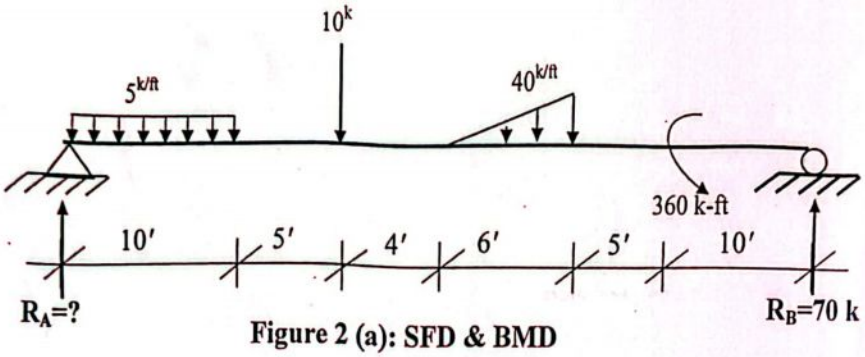
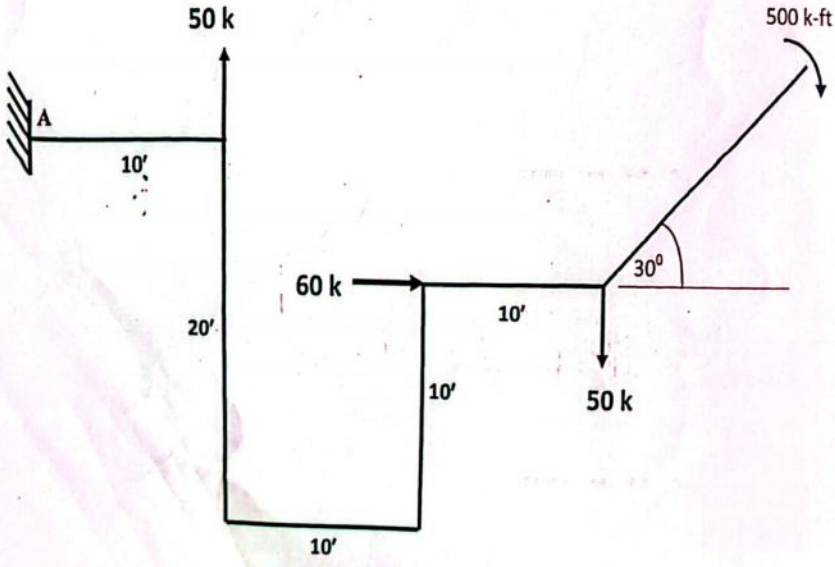


Figure 2 (a): SFD & BMD



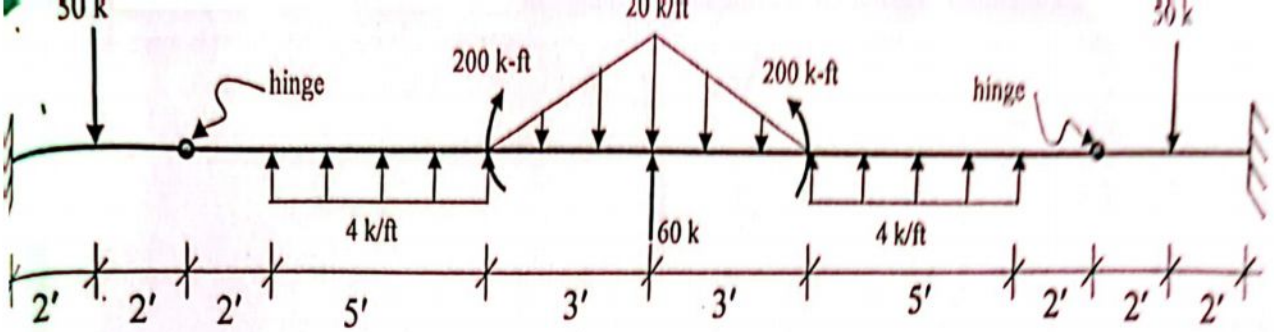
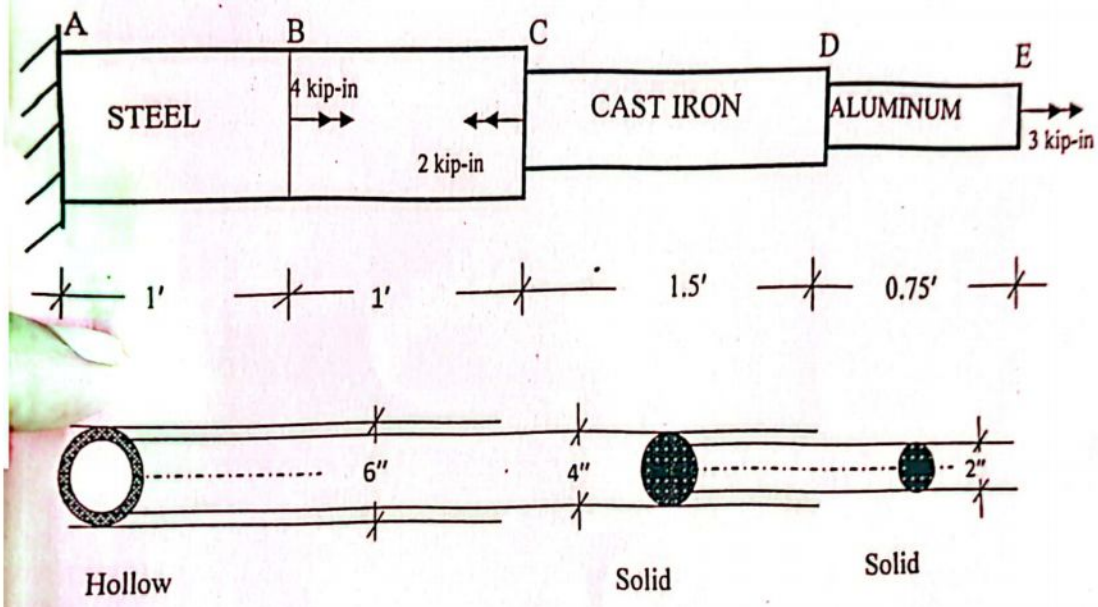


Figure 3(a)



Cross Section of Shaft

Figure-4(a):

Table-4(a): Properties and Dimension

Segment	Materials	E (psi)	G (psi)	α (/°F)	Length (ft)	Diameter (in)
DE	Aluminum	$10.6X10^6$	4×10^6	12.9×10^{-6}	0.75	2.0
CD	Cast Iron	$13X10^6$	6×10^6	5.8×10^{-6}	1.5	4.0
AC	Steel	$29X10^6$	12×10^6	6.5×10^{-6}	2.0	6.0 & 4.0

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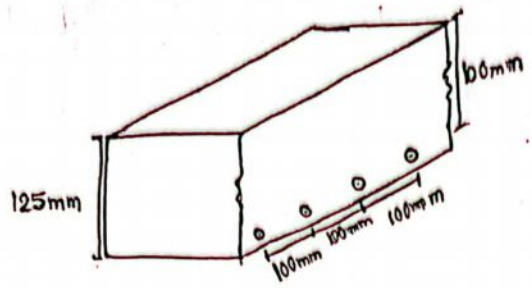


Figure 5a.

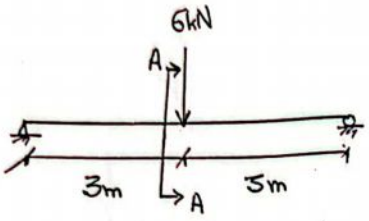
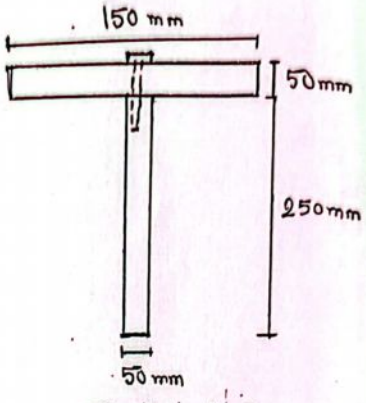
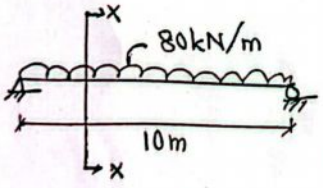


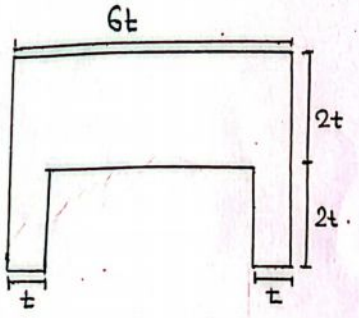
Figure 5b(i)



Section A-A.

Figure 5b(ii).





Section X-X.

Figure 6a

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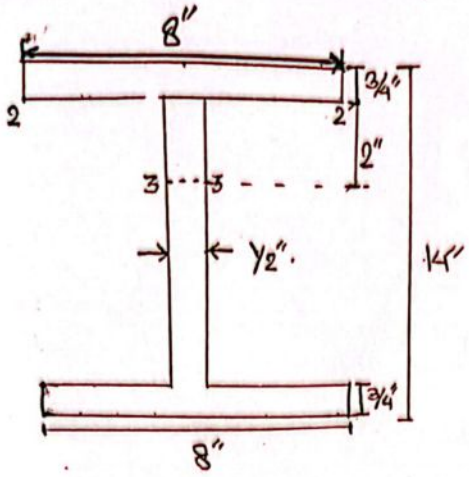


Figure 6b

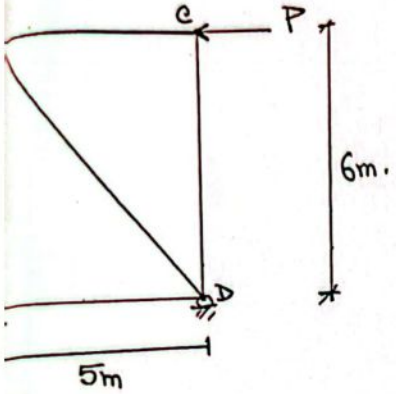


Figure 7a.

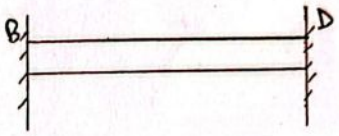


Figure 7b.

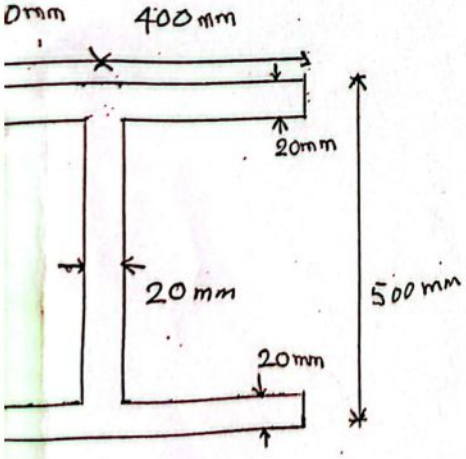


Figure 8a.

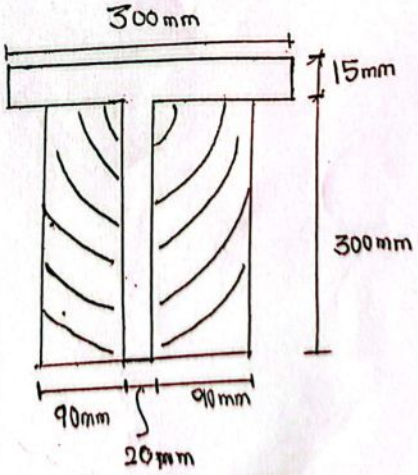


Figure 8b.

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BANGLADESH UNIVERSITY OF PROFESSIONALS
Military Institute of Science and Technology
B.Sc. in Environmental, Water Resources, and Coastal Engineering
Supplementary Examination: July 2019

Subject: EWC 211, Mechanics of Solids I

Time: 3.00 hours **Full Marks: 210**

INSTRUCTIONS:

a. Use **SEPARATE** answer scripts for each section.
b. Answer any **THREE** questions from each section out of **FOUR.**
c. Figures in the margin indicate full **marks.**
d. Assume reasonable data if necessary.
e. **Symbols** used have their usual meanings.

SECTION-A

Question – 1

a. Derive an expression for the shear stress distribution in a beam of solid rectangular cross-section transmitting a vertical shear V. Hence, show that, for such section. **10**

$$\tau_{max} = \frac{3}{2}\tau_{avg}$$

b. Draw qualitative shear force and bending moment diagram for the beams loaded as shown in figure 1 (b). **10**

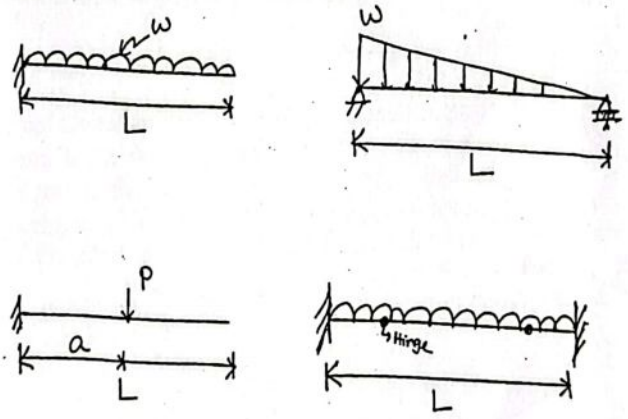


Figure: 1 (b)

c. A T beam supports three concentration loads shown in figure 1(c), Determine the maximum value of P so that, **15**

$$f_{bt} \leq 4 \text{ Ksi and } f_{bc} \leq 10 \text{ Ksi}$$

where,
f_{bt} = Allowable tensile bending stress.
f_{bc} = Allowable compressive bending stress.

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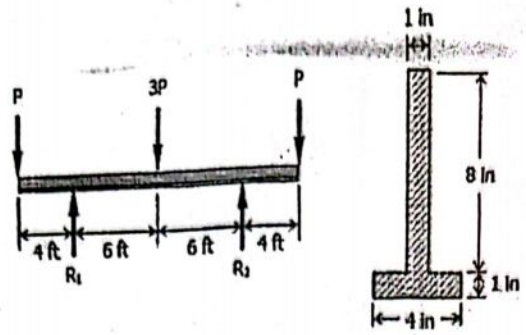


Figure: 1(c)

Question – 2

a. A frame ABCD, with rigid corners at B and C, supports the concentrated load as shown in figure 2 (a). Draw shear and moment diagrams for each of the three parts of the frame.

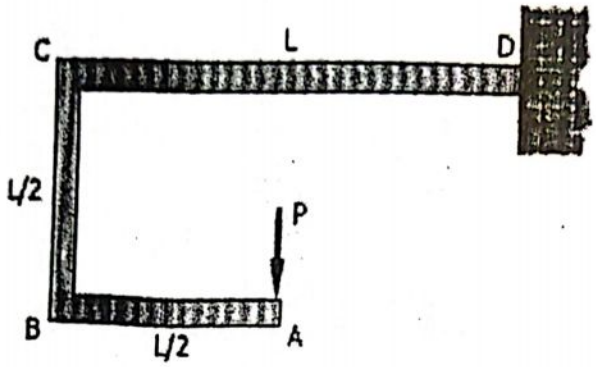


Figure: 2(a)

b. A composite beam of two different materials has the cross-section shown in figure 2 (b). For upper 50 x 80 mm bar, the elastic modulus $E_1 = 15$ GPa and lower 50 x 20 mm bar, $E_2 = 40$ GPa. Find the maximum bending stresses in both materials caused by an applied positive moment of 12 kN-m acting around the z – axis.

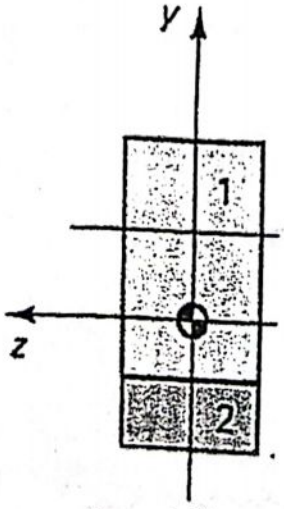


Figure : 2 (b)

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Question – 3

a. Find the external reactions and draw AFD, SFD and BMD of the beam loaded as shown in figure 3 (a). **20**

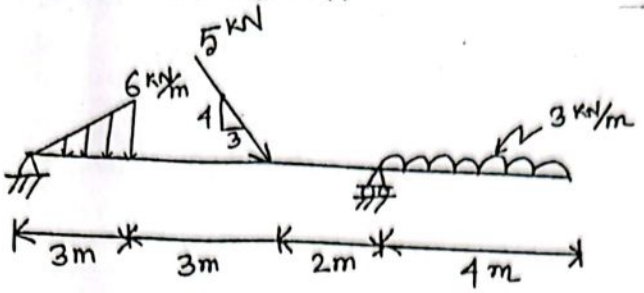


Figure: 3 (a)

b. Determine the location of the shear center for the beam having the cross-sectional dimensions as shown in figure 3 (b). All members are to be considered thin walled, and calculations should be based on the center line dimensions. **15**

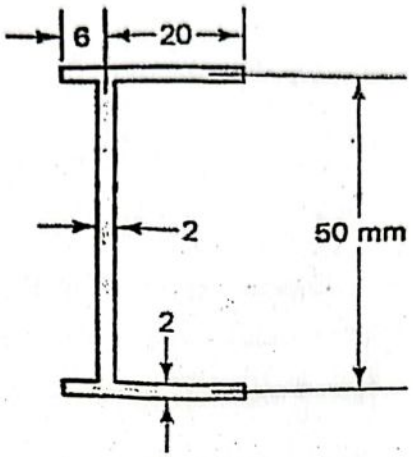


Figure: 3 (b)

Question – 4

a. For the beam loaded as shown in figure 4 (a), find out the fixed end moment and reaction at roller support. Also calculate the shear force and bending moment at section a---a at distance 5 m from fixed support. **15**

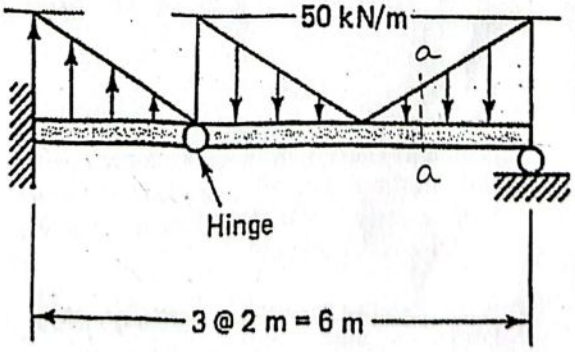


Figure: 4 (a)

b. A beam of T cross-section is formed by nailing together two boards having the dimensions shown in figure 4 (b). If the total shear force V acting on the cross section is 1600 N and each nail carry 750 N in shear, **20**

(i) What is the maximum allowable nail spacing?

(ii) Calculate the shear stress at levels 1---1 and 2---2 as indicated in the cross-section.

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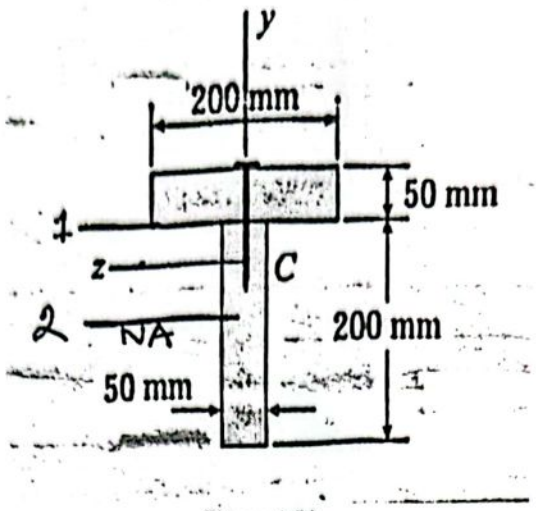


Figure: 4 (b)

SECTION-B

Question – 5

a. In the hanger shown in figure 5(a), the upper portion of link ABC is $\frac{3}{8}$ inch thick and the lower portions are each $\frac{1}{4}$ inch thick. The pin at 'A' has a $\frac{3}{8}$ inch diameter, while a $\frac{1}{4}$ inch diameter pin is used at C.

Determine –
(i) The shearing stress in pin A,
(ii) The shearing stress in pin C,
(iii) The largest normal stress in link ABC,
(iv) The average shearing stress on the bonded surfaces at B, and
(v) The bearing stress in the link at C.

b. What do you understand by the term "True Stress" and "True Strain"?

Question – 6

a. Determine the values of the stress in portions AC and CB of the bar (shown in figure 6(a)), when the temperature of the bar is – 50°F, knowing that a close fit exists at both of the rigid supports when the temperature is + 75°F. Use values, $E = 29 \times 10^6$ psi, $\alpha = 6.5 \times 10^{-6}$/°F for steel.

b. Briefly describe Saint Venant's Principle of Stress and Strain Distribution under Axial Loading.

Question – 7

a. Determine the deformation of the steel rod shown in figure 7(a) under given loads. Given, $E = 29 \times 10^6$ psi.

b. The rigid bar BDE is supported by two links AB and CD. Link AB is made of aluminum (E = 70 GPA) and has a cross sectional area of 500 mm^2, Link CD is made of steel (E = 200 GPA) and has a cross sectional area of 600 mm^2. For the 30 KN force shown, determine the deflection of point (a) B, (b) D, and (c) E (figure 7 (b)).

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Question – 8

a. A hollow cylindrical steel shaft is 1.5 m long and has inner and outer diameter respectively 40 mm and 60 mm. (Figure 8(a)). **15**
(i) What is the largest torque that can be applied to the shaft if the shearing stress is not to exceed 120 MPa?
(ii) What is the corresponding minimum value of the shearing stress in the shaft?

b. In figure 8(b); shaft BC is hollow with inner and outer diameters of 90 mm and 120 mm respectively. Shafts AB and CD are solid and of diameter, d. For the loading shown, determine – **20**
(i) Maximum and minimum shearing stress in shaft BC.
(ii)The required diameter d of shafts AB and CD if allowable shearing stress in these shafts is 65 MPa.

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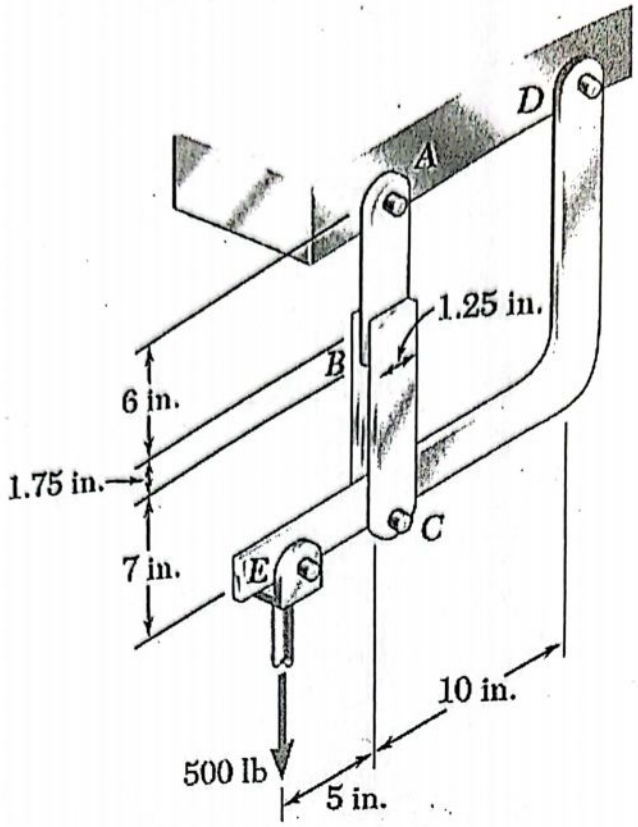


Figure 5(a): For the Que 5(a)

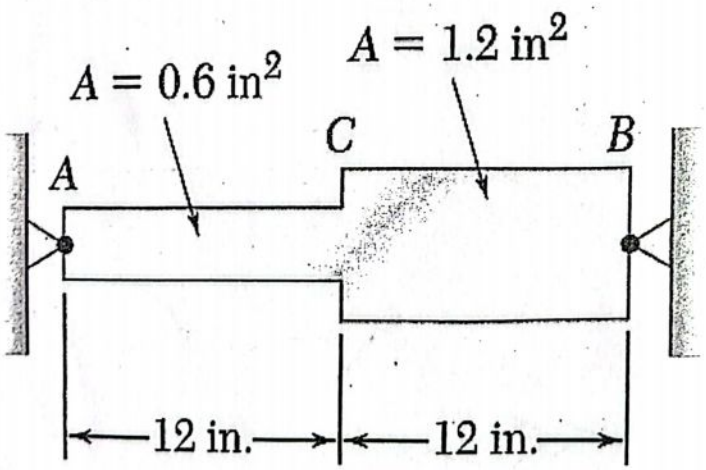


Figure 6(a): For the Que 6(a)

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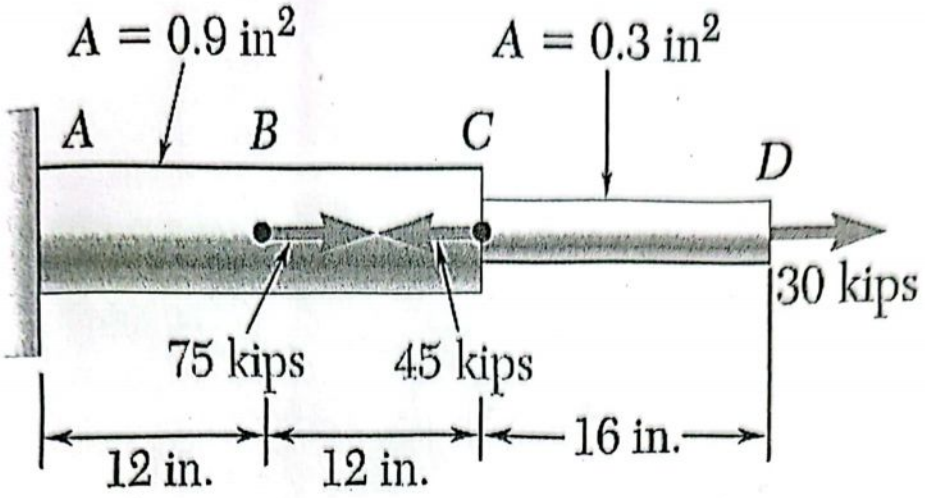


Figure 7(a): For the Que 7(a)

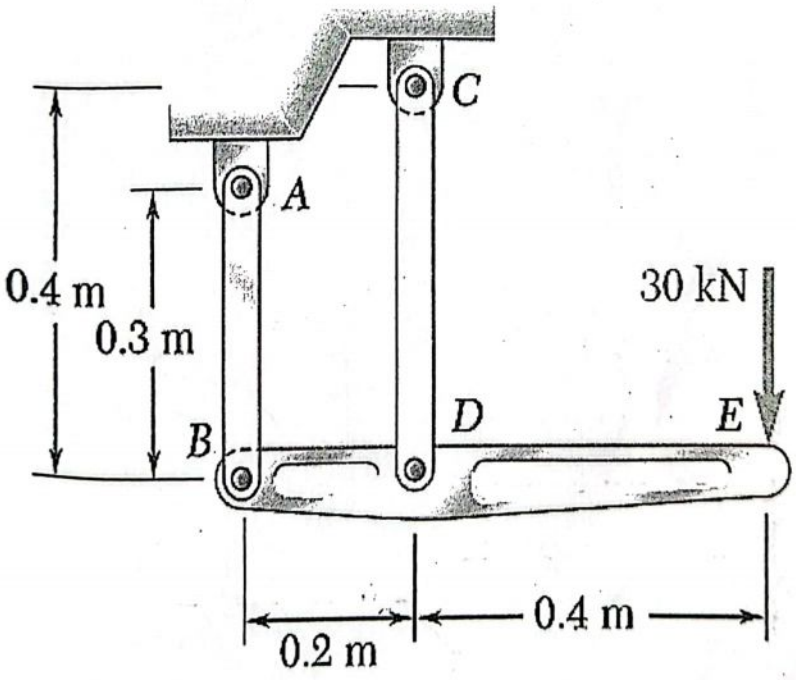


Figure 7(b: For the Que 7(b)

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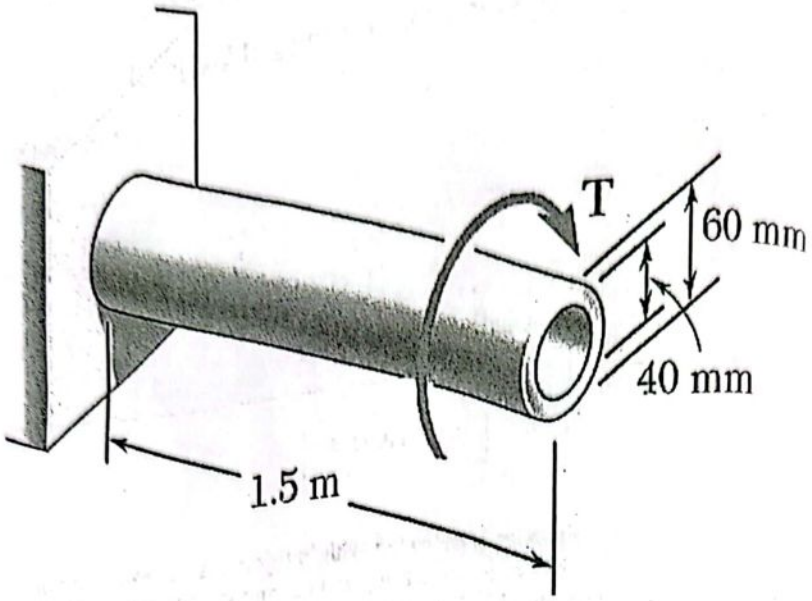


Figure 8(a): For the Que 8(a)

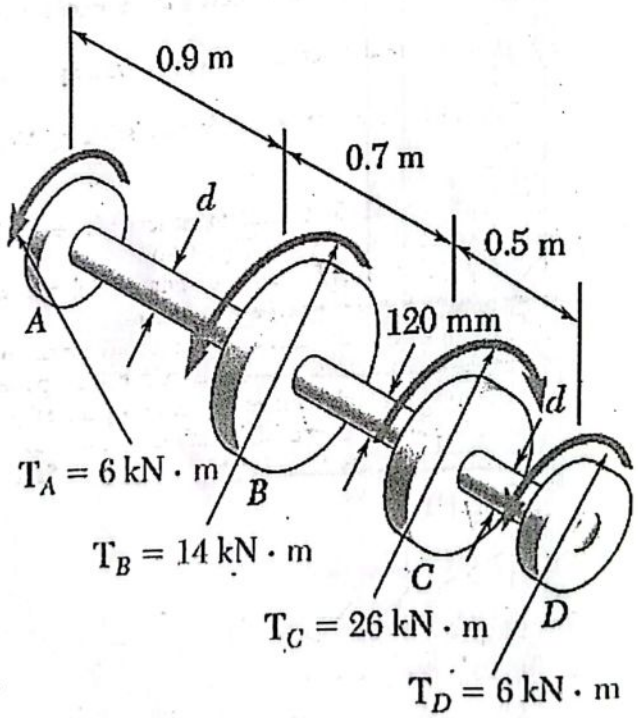


Figure 8(b): For the Que 8(b)

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