DEPARTMENT OF CIVIL ENGINEERING

CE-221 SOLID MECHANICS

Quiz-1 22/08/17 PAPER CODE: A

Note: Write your name & roll no. on answerbook and on summary answer sheet provided on the reverse.
You must submit the question-paper-cum-summary-answer-sheet along with the answerbook.
Closed book, closed notes test. No formula sheet allowed. No mobile phones allowed in the exam hall.
Both questions carry equal marks. Assume suitable data if required and state the same clearly

Problem 1

A frame is made of a **2 m** long vertical pipe ***CD*** and a brace ***AB*** formed from two flat bars (see **Fig. 1**). The frame is supported by bolted connections at points ***A*** and ***C***. The brace is fastened to the pipe at point ***B*** by a bolted connection. If the diameter of the bolts used in all the connections is **20 mm** and the allowable shear stress in each bolt is **40 MPa**, calculate the maximum value of the load P that can be applied on the frame.

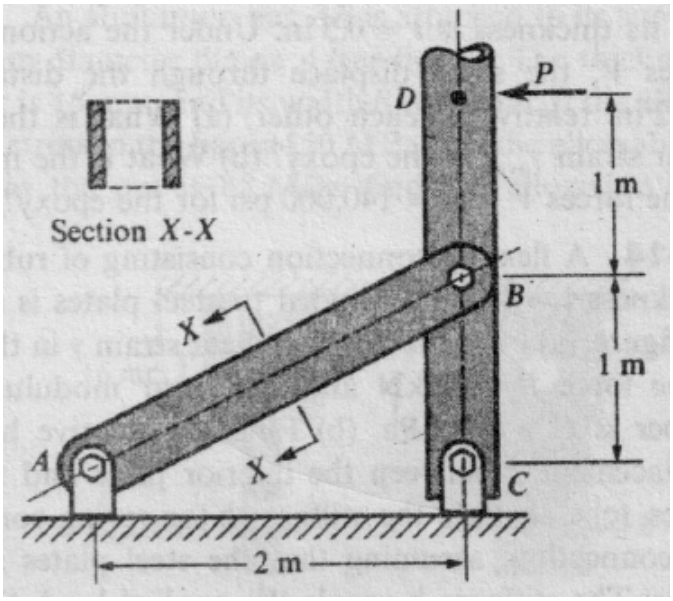

Fig. 1

Problem 2

Determine the vertical displacement δ of the **800 N** block due to its self-weight after it is put in place as shown in **Fig. 2**. Both members ***AB*** and ***CD*** have same axial rigidity. Neglect friction.
E **= 2 x 10^{11} Pa,** ***A*** **= 50 mm^2.**

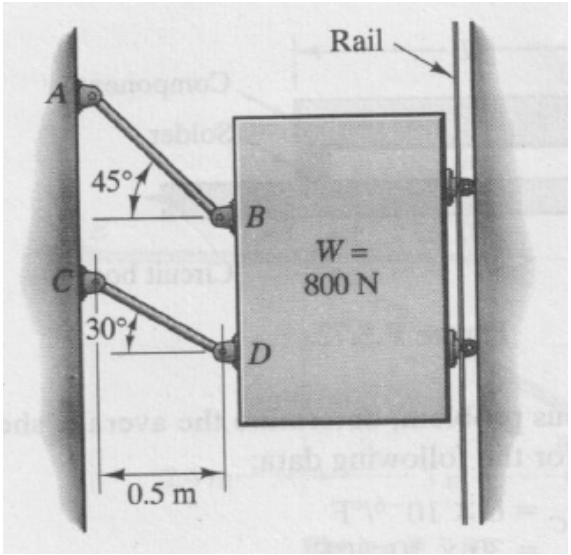

Fig. 2

DEPARTMENT OF CIVIL ENGINEERING

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Quiz-1 20/08/16 PAPER CODE: B

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Problem 1

A frame is made of a **1 m** long vertical pipe ***CD*** and a brace ***AB*** formed from two flat bars (see **Fig. 1**). The frame is supported by bolted connections at points ***A*** and ***C***. The brace is fastened to the pipe at point ***B*** by a bolted connection. If the diameter of the bolts used in all the connections is **25 mm** and the allowable shear stress in each bolt is **50 MPa**, calculate the maximum value of the load P that can be applied on the frame.

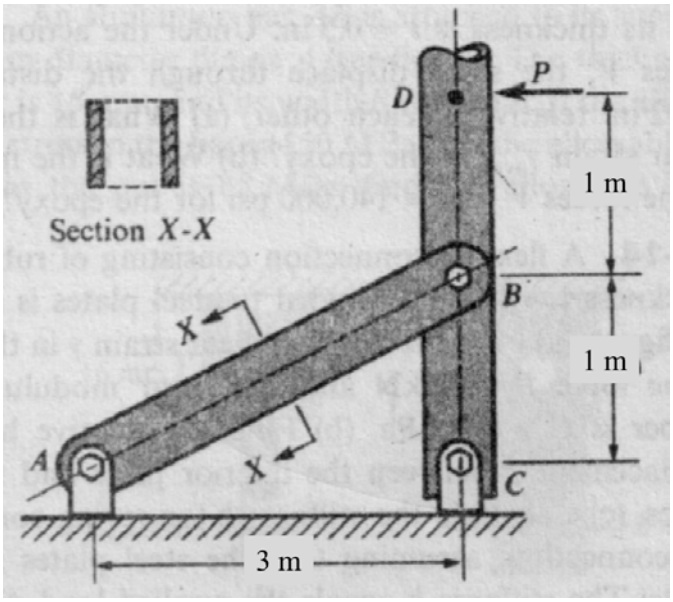

Fig. 1

Problem 2

Determine the vertical displacement δ of the **700 N** block due to its self-weight after it is put in place as shown in **Fig. 2**. Both members ***AB*** and ***CD*** have same axial rigidity. Neglect friction.
***E* = 1.75 x 10^{11} Pa, *A* = 40 mm^2.**

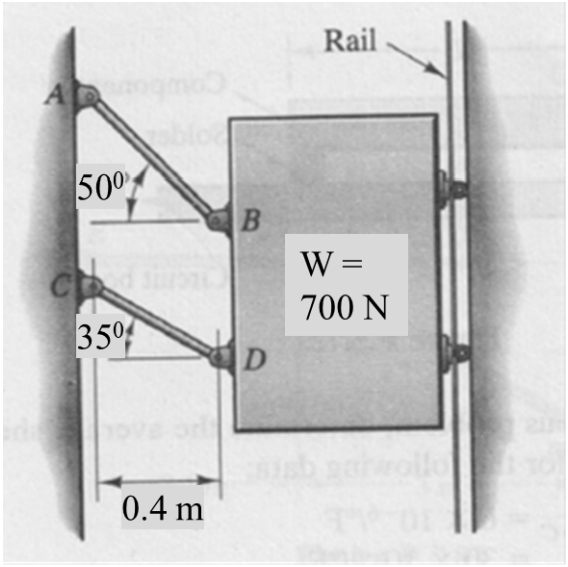

Fig. 2

DEPARTMENT OF CIVIL ENGINEERING

CE-221 SOLID MECHANICS

Quiz-1 20/08/16 PAPER CODE: C

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Both questions carry equal marks. Assume suitable data if required and state the same clearly

Problem 1

A frame is made of a **1 m** long vertical pipe ***CD*** and a brace ***AB*** formed from two flat bars (see **Fig. 1**). The frame is supported by bolted connections at points ***A*** and ***C***. The brace is fastened to the pipe at point ***B*** by a bolted connection. If the diameter of the bolts used in all the connections is **15 mm** and the allowable shear stress in each bolt is **60 MPa**, calculate the maximum value of the load P that can be applied on the frame.

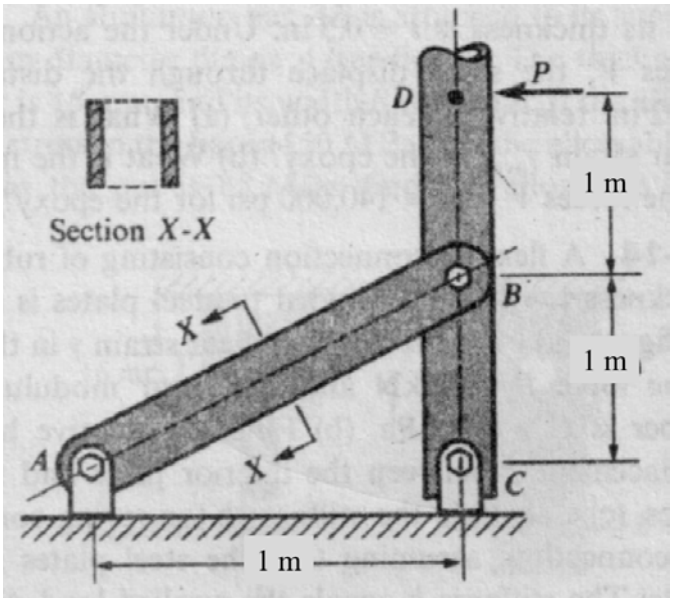

Fig. 1

Problem 2

Determine the vertical displacement δ of the **900 N** block due to its self-weight after it is put in place as shown in **Fig. 2**. Both members ***AB*** and ***CD*** have same axial rigidity. Neglect friction.
***E* = 2.25 x 10^{11} Pa, *A* = 60 mm^2.**

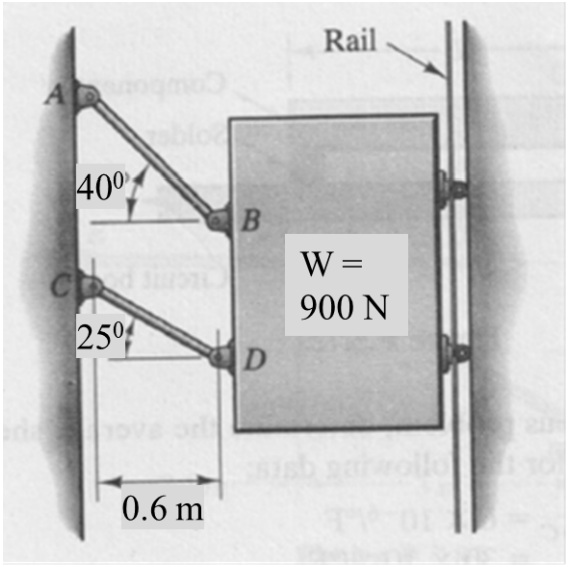

Fig. 2

DEPARTMENT OF CIVIL ENGINEERING

CE-221 SOLID MECHANICS

Quiz-1 20/08/16 PAPER CODE: D

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Problem 1

A frame is made of a **4 m** long vertical pipe ***CD*** and a brace ***AB*** formed from two flat bars (see **Fig. 1**). The frame is supported by bolted connections at points ***A*** and ***C***. The brace is fastened to the pipe at point ***B*** by a bolted connection. If the diameter of the bolts used in all the connections is **30 mm** and the allowable shear stress in each bolt is **70 MPa**, calculate the maximum value of the load P that can be applied on the frame.

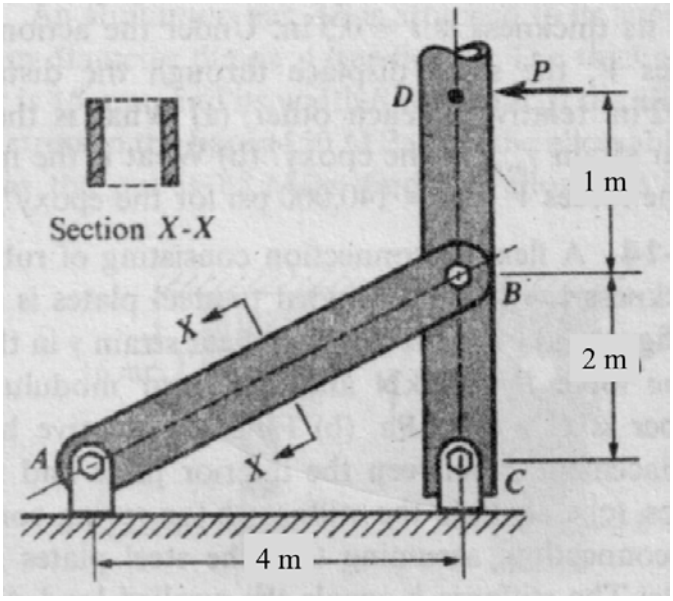

Fig. 1

Problem 2

Determine the vertical displacement δ of the **600 N** block due to its self-weight after it is put in place as shown in **Fig. 2**. Both members ***AB*** and ***CD*** have same axial rigidity. Neglect friction. ***E* = 1.5 x 10^{11} Pa, *A* = 30 mm^2.**

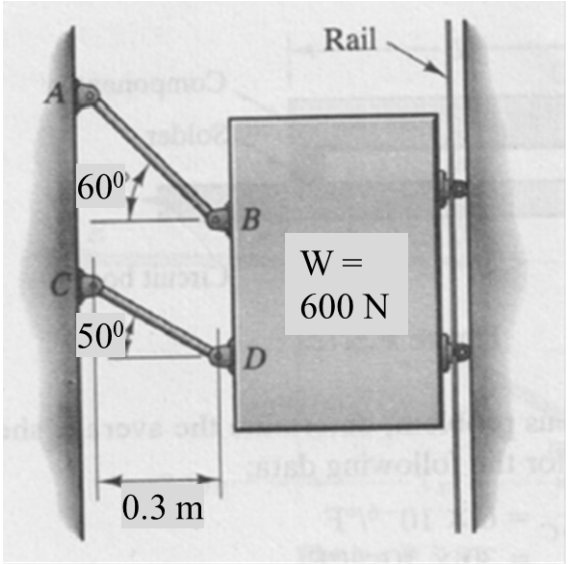

Fig. 2

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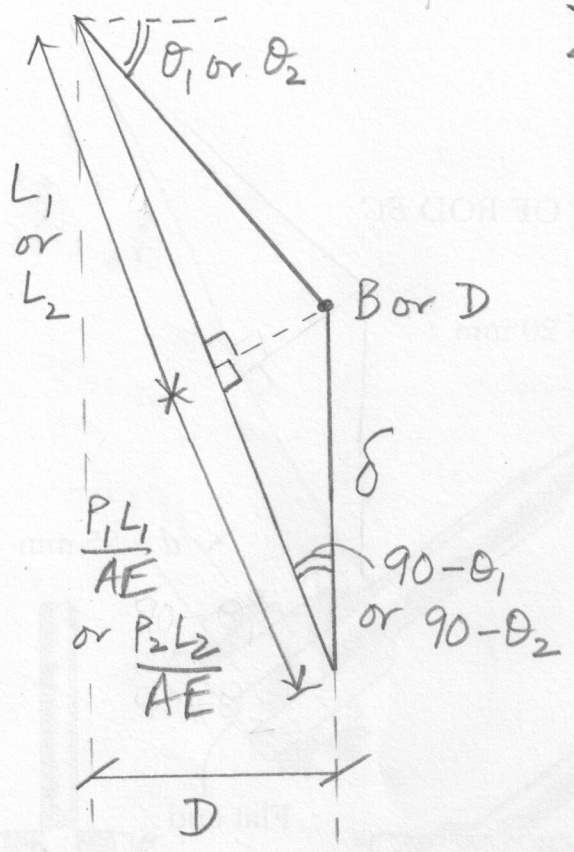
P2



Equil:

$$\sum F_y = 0 = P_1 \sin\theta_1 + P_2 \sin\theta_2 - W \quad \rightarrow (1)$$

Compat:

$$\delta = \frac{P_1 D/\cos\theta_1}{AE}\frac{1}{\sin\theta_1} = \frac{P_2 D/\cos\theta_2}{AE}\frac{1}{\sin\theta_2} \quad \rightarrow (2)$$

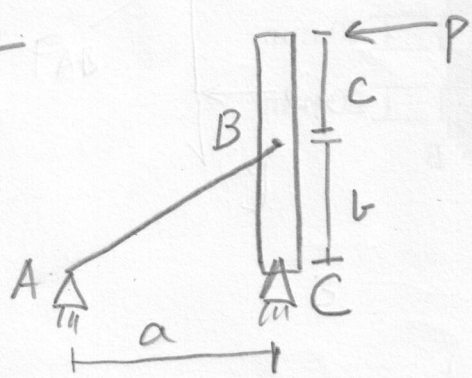
$$\Rightarrow P_2 = \frac{\sin 2\theta_2}{\sin 2\theta_1} P_1$$

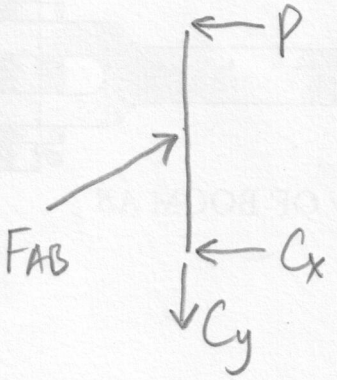
$$P_1 = \frac{W}{\left(\sin\theta_1 + \sin\theta_2 \frac{\sin 2\theta_2}{\sin 2\theta_1}\right)}$$

$$\delta = \frac{W}{\left(\sin^2\theta_1 \cos\theta_1 + \sin^2\theta_2 \cos\theta_2\right)} \cdot \frac{D}{AE}$$

Code A → δ = 7.02E-5 m, B → 6.19E-5, C → 8.36E-5
D → 5.32E-5,

P1





$$P(b+c) = F_{AB}\frac{a}{\sqrt{a^2+b^2}}\, b$$

$$C_y = F_{AB}\frac{b}{\sqrt{a^2+b^2}}$$

$$C_x = -P + F_{AB}\frac{a}{\sqrt{a^2+b^2}}$$

failure at A, B: $\tau_{all} = \dfrac{F_{AB}/2}{\frac{\pi}{4}d^2} \Rightarrow P_{all} = \dfrac{\pi d^2}{2}\tau_{all}\dfrac{a}{\sqrt{a^2+b^2}}\dfrac{b}{(b+c)}$

failure at C: $\tau_{all} = \dfrac{\sqrt{C_x^2+C_y^2}/2}{\frac{\pi}{4}d^2} \Rightarrow P_{all} = \dfrac{\pi d^2}{2}\tau_{all}\left[(a^2+b^2)\left(\dfrac{b+c}{ab}\right)^2 + 1 - 2\left(\dfrac{b+c}{b}\right)\right]^{-1/2}$

In all paper codes, failure at A, B occurs for lower P_{all}

Ans: Code A → P_{all} = 11239 N, B → 23284 N, C → 7497 N, D → 59008 N