PROBLEM 1: (20 points)

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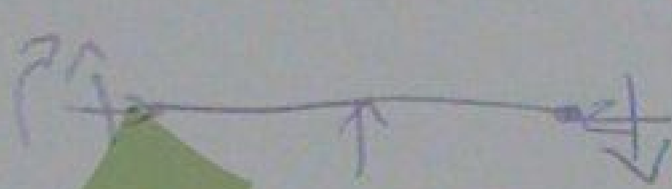
Classify each of the structures as statically determinate or statically indeterminate, stable or unstable (internal and external stability must be checked). If statically indeterminate, specify the degree of indeterminacy. Show the details of your calculation.

a)



r = 6
n = 2
→ r = 3n → Determinate Structure

Rxns neither // nor concurrent → Stable

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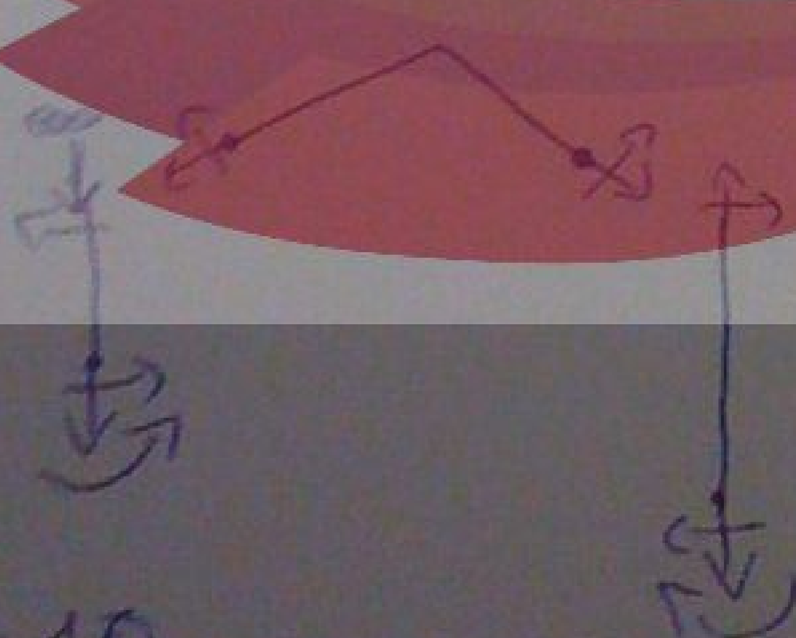
b)



r = 10
n = 3 → 3n = 9

→ r > 3n (10 > 9) →

Statically Inderminate Structure to ~~[illegible]~~ the 1st degree.

Structure Stable

5/5

c)

b = 25
r = 4
j = 14 ⇒ 2j = 28

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b+r = 29
b+r > 2j (29>28)
⇒ Statically Indeterminate
Structure to the 1st degree.
Structure is externally stable. And By inspection
It is internally stable.

d)

b = 20
r = 3
j = 12 ⇒ 2j = 24
b+r = 23 < 2j (23<24)
⇒ The structure is
Unstable.

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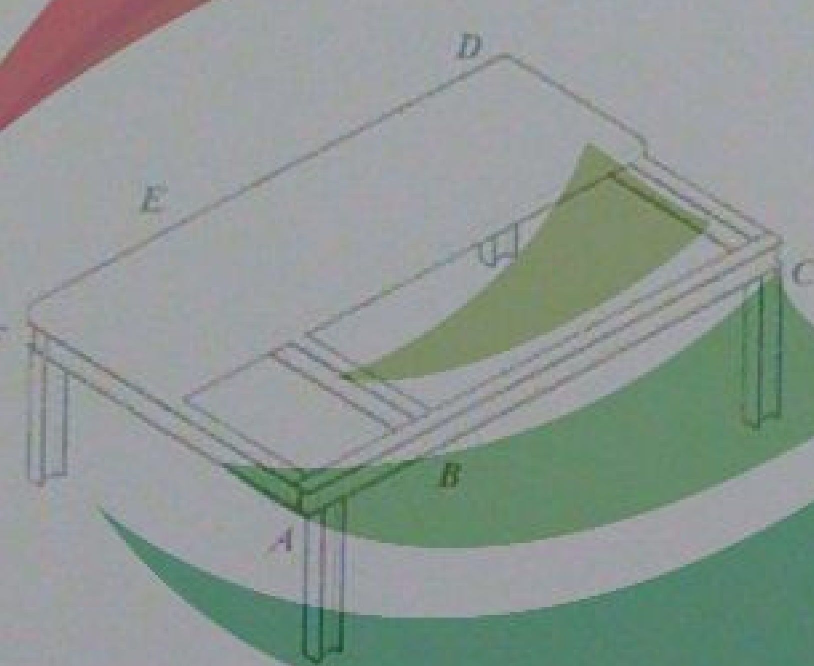
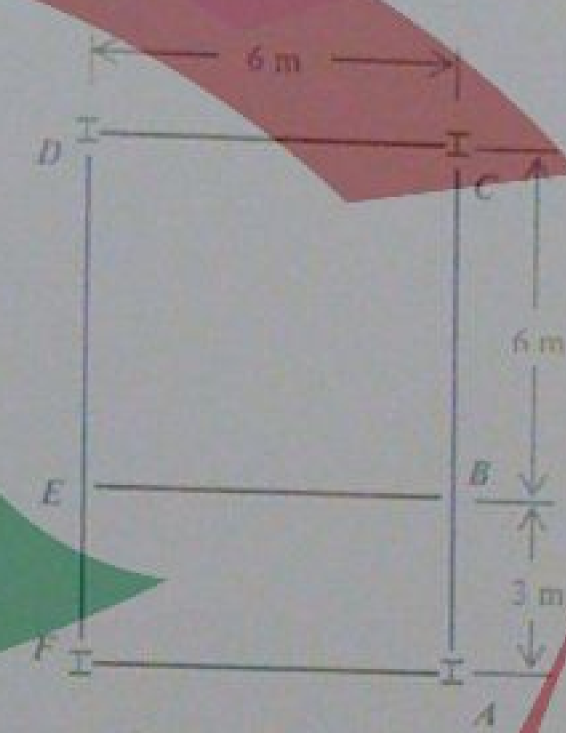
PROBLEM 2: (25 points)

The steel framework is used to support the 250-mm reinforce concrete slab (γ = 24 kN/m^3), that carries a uniform live loading of 5 kN/m^2.
Assuming that all members are pin connected Sketch the loading that acts along:

1. Beams *AF*, *BE*, and *CD*
2. Girder *ABC*





Idealized framing plan

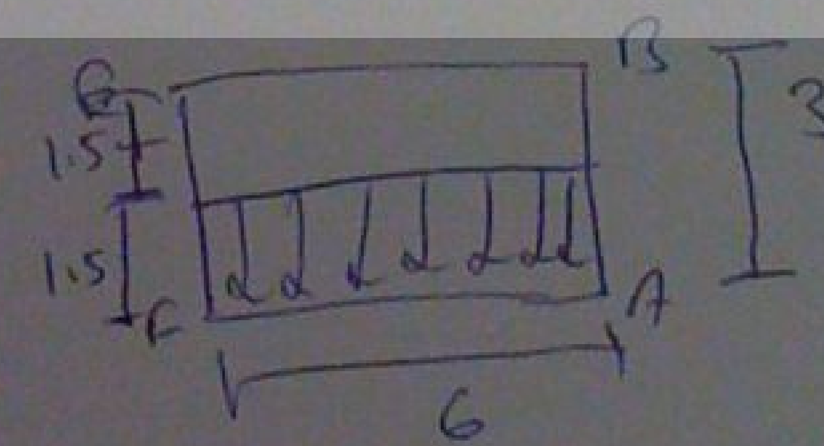
1) ~~load~~ L.L. = 5 kN/m^2

D.L. = 24 kN/m^3 = 24 × 0.25 = 6 kN/m^2

T.L. = D.L. + L.L. = 5 + 6 = 11 kN/m^2

T.L. = 11 kN/m^2 4/4

Consider Beam:



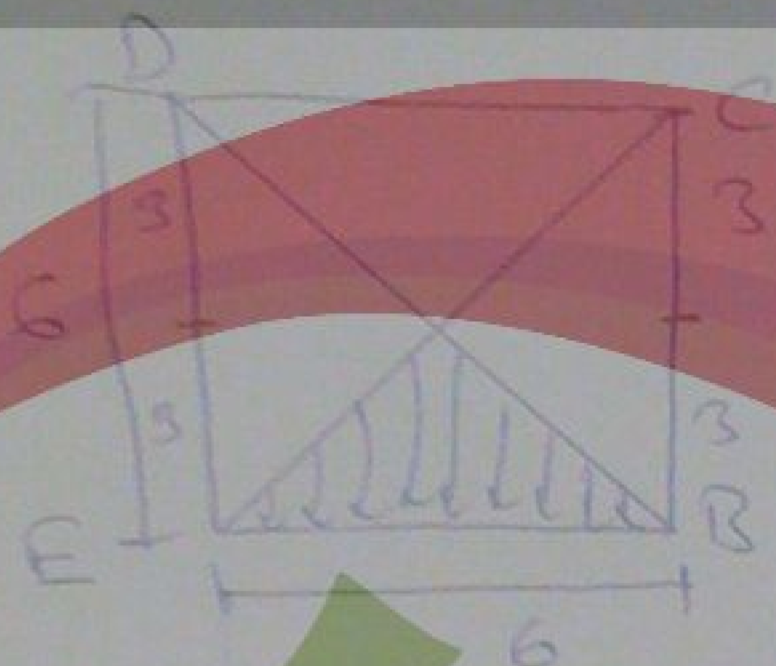
$\frac{L}{W} = \frac{6}{3} = 2$

⇒ It is a one way slab

⇒ The loading that acts on Beam AF:

11 × 1.5 = 16.5 kN/m. 3/3

Consider Beam:



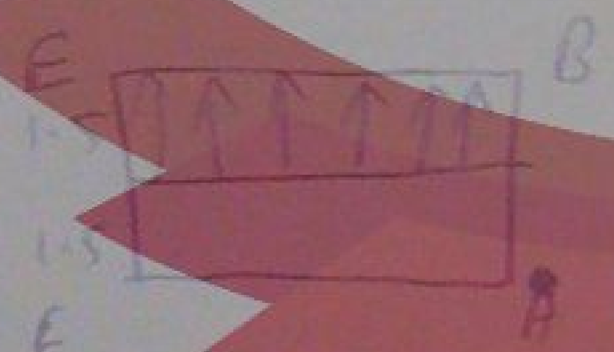
$\frac{L}{W} = \frac{6}{6} = 1 < 2$

=> It acts as a two way slab (square slab)

The ~~Beam~~ Load acting on Beam BE from DCEB:

$11 \times 3 =$ **33 kN/m**

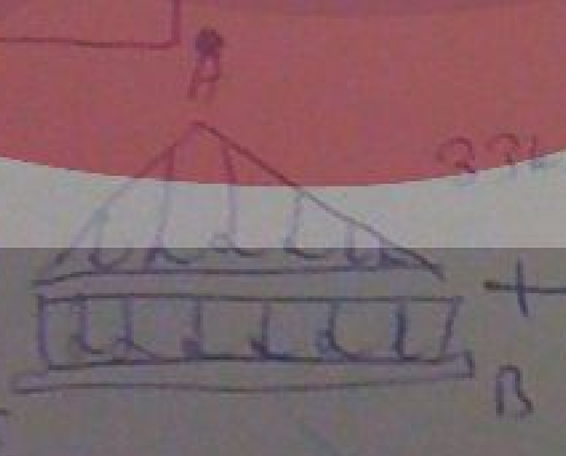
But also there is a load on BE from structure ABEF



$11 \times 1.5 =$ **16.5 kN/m**

Summation

Load on EB =

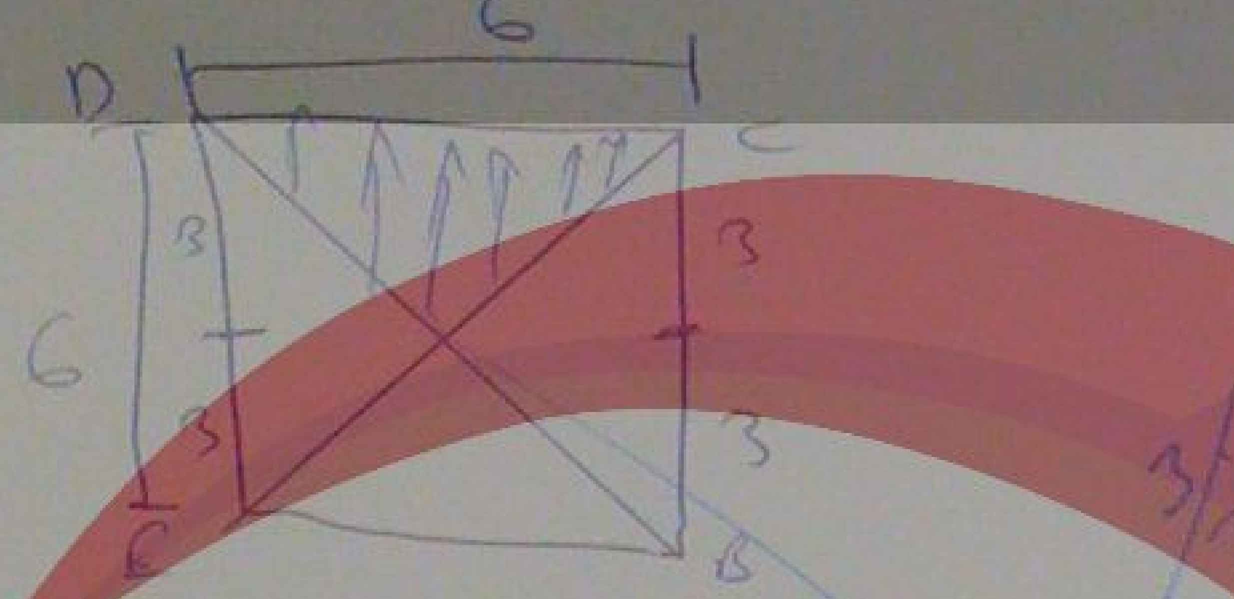


5/5

=> Total Load on EB = 33 + 16.5 = **49.5 kN/m.**

→

→ For CD:



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Load on CD = $11 \times 3 = 33\ kN/m$

2) For Girder ABC:

0/5

Along Girder ABC:

From DCEB: $11 \times 3 + \left(\frac{11 \times 3}{2}\right) + \left(\frac{11 \times 3}{2}\right) = 66\ kN/m$

From EBAF: $\left(\frac{11 \times 1.5}{2}\right) + \left(\frac{11 \times 1.5}{2}\right) = 16.5\ kN/m$

⇒ Loads on Girder ABC $= 66 + 16.5 = 82.5\ kN/m$

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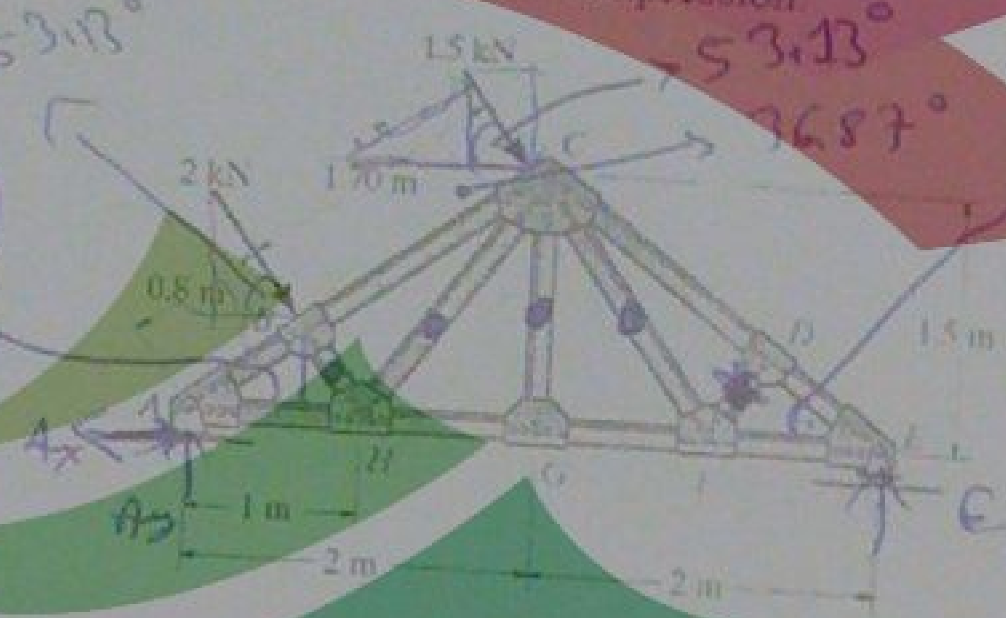
PROBLEM 3: **(25 points)**

For the roof truss shown in figure:

1. Find the reactions at **pin** *A* and **roller** *E*.
2. Indicate all the zero-force members.
3. Determine the force in members *GH* and *CD*. Indicate if the members are in tension or compression.



$\alpha = \tan^{-1}\left(\frac{1.5}{2}\right)$

$\alpha = 36.87°$

$\cos 36.87° = \frac{x}{0.8}$

$\sin 36.87° = \frac{y}{0.8}$

1) $\circlearrowleft + \sum M_A = 0$

$E_y(4) - 1.5\sin(53.13°)(2) - 1.5\cos(53.13°)(1.5) - 2\sin(53.13°)(0.8 \times \cos 36.87°) - 2\cos(53.13°)(0.8 \times \sin 36.87°)$

$\Rightarrow 4E_y = 5.35$

$\Rightarrow E_y = 1.3375\ kN$

$+\uparrow \sum F_y = 0 \quad A_y + E_y - 1.5\sin(53.13°) - 2\sin(53.13°) = 0$

$\Rightarrow A_y = 1.4625\ kN$

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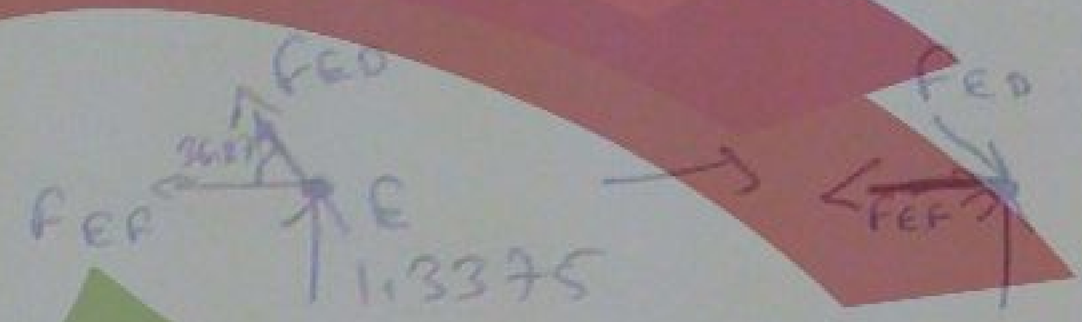
$\xrightarrow{+} \sum F_x = 0$

$A_x + 2\cos(53.13°) + 1.5\cos(53.13°) = 0$

$A_x = -2.1$

2) Zero force members are dotted on the figure
They are : HB, HG, CG, DF, FC .

3) For member $\underline{CD}$:



$+\uparrow \sum F_y = 0$

$F_{ED} \sin(36.87^\circ) + 1.3375 = 0$

$\Rightarrow F_{ED} = -2.23$

$\Rightarrow \boxed{F_{ED} = 2.23\ kN\ (C)}$

$\xrightarrow{+} \sum F_x = 0$

$-F_{ED} \cos(36.87^\circ) - F_{EF} = 0$

$F_{EF} = +1.78$

$\Rightarrow \boxed{F_{EF} = 1.78\ kN\ (T)}$

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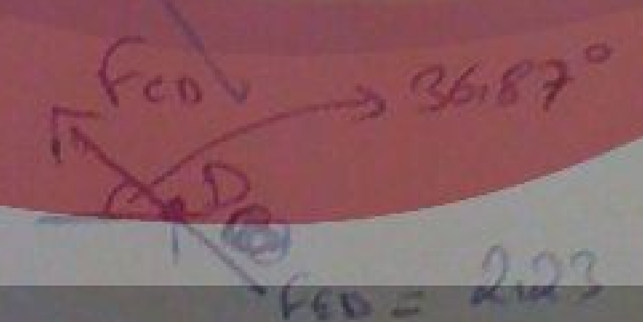

$+\uparrow \sum F_y = 0$

$F_{CD} \sin(36.87^\circ) + F_{ED} \sin(36.87^\circ) = 0$

$F_{CD} = -2.23$

$\Rightarrow \boxed{F_{CD} = 2.23\ kN\ (C)}$

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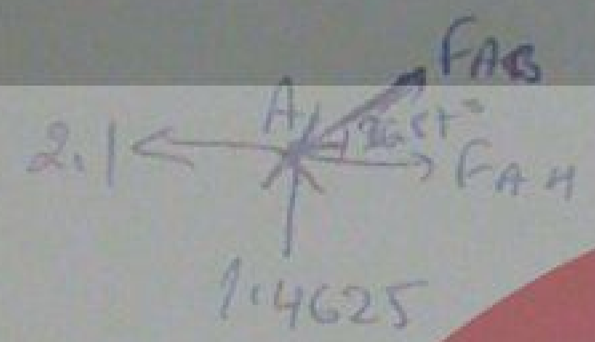
Member GH:



$\overset{+}{\rightarrow} \Sigma F_x = 0 \qquad -2.1 + F_{AH} + F_{AB}\cos(36.87°) = 0$

$+\uparrow \Sigma F_y = 0 \qquad 1.4625 + F_{AB}\sin(36.87°) = 0$

~~$F_{AH} + \cos(36.87°)\, F_{AB} - 2.1 = 0$~~

$\Rightarrow F_{AB} = -2.44$

$\Rightarrow F_{AB} = 2.44\ kN\ (C)$

$\Rightarrow F_{AH} = 4.05\ kN$

$\Rightarrow \boxed{F_{AH} = 4.05\ kN\ (T)}$

$\tan^{-1}\left(\frac{1.5}{1}\right) = 56.3°$

$\overset{+}{\rightarrow} \Sigma F_x = 0 \qquad -4.05 + F_{HG} + F_{HC}\cos(56.3°) = 0$

$+\uparrow \Sigma F_y = 0 \qquad F_{HC}\sin(56.3°) = 0$

$\boxed{F_{HC} = 0}$

$\Rightarrow \boxed{F_{HG} = 4.05\ kN\ (T)}$

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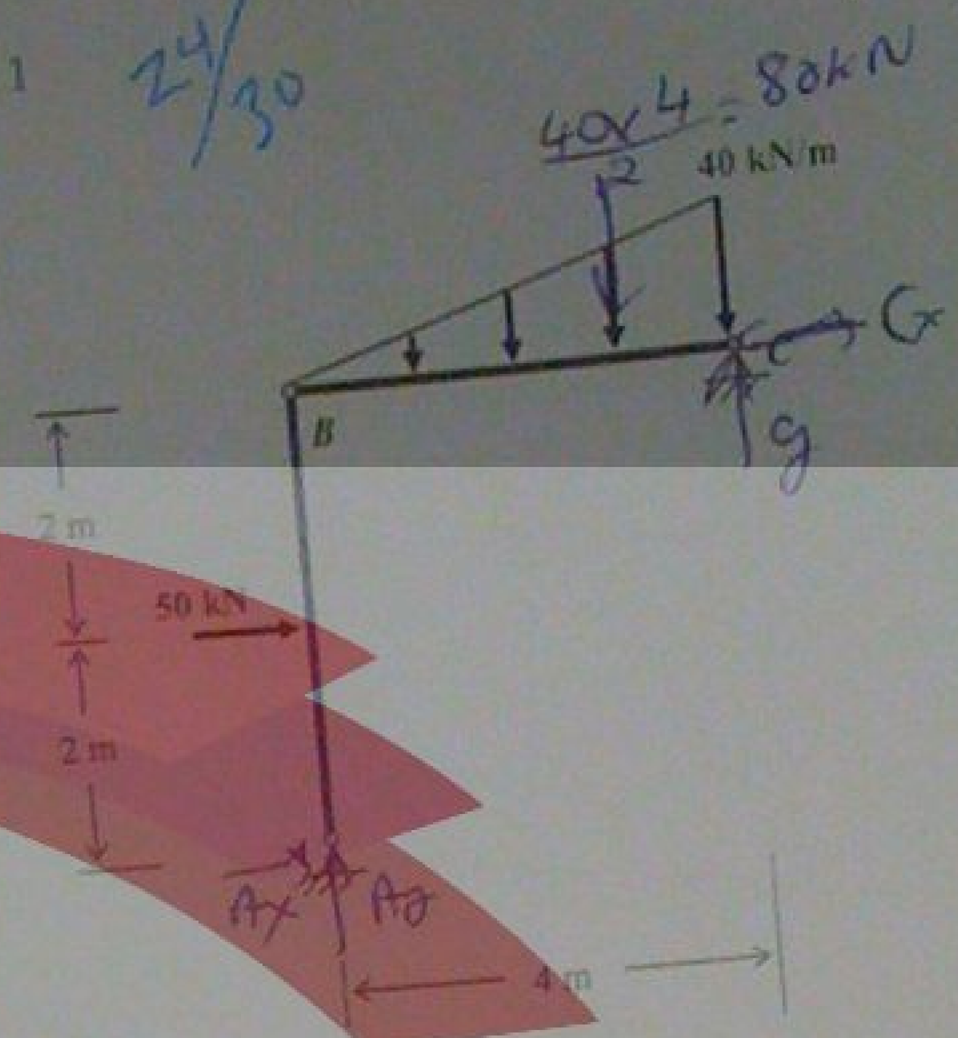
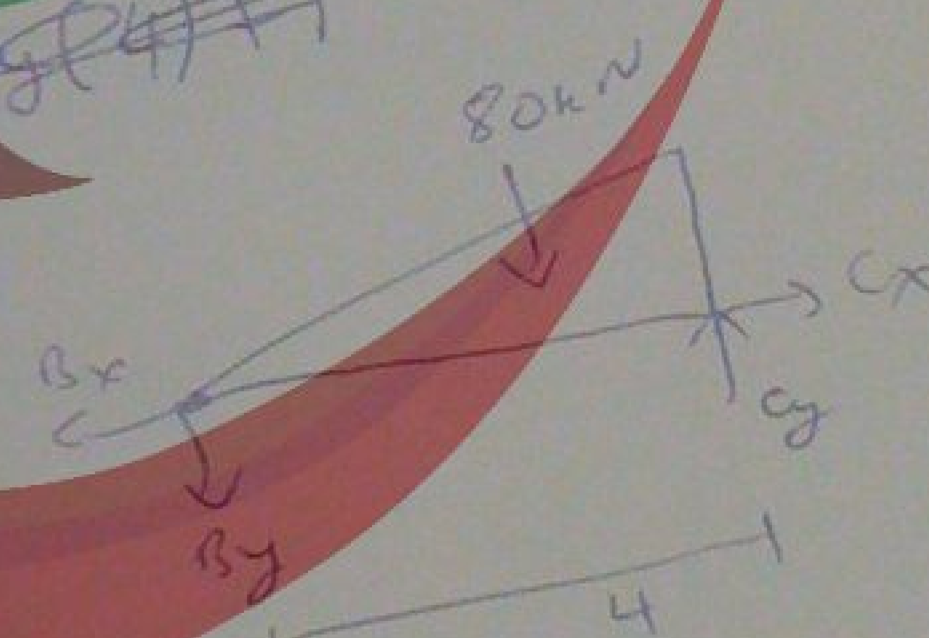
PROBLEM 6: (30 points)

For the frame illustrated in the figure below:

1. Find the reactions at **pin** *A* and **pin** *C*. At point *B* there is a hinge.
2. Draw the shear and moment diagrams and specify the maximum and minimum moments in the frame.





1) F.B.D-1

$\circlearrowleft \Sigma M_B = 0$

$C_y(4) - 80(2.\bar{6}) = 0$

$\Rightarrow 4C_y = 213.\bar{3}$

$C_y = 53.\bar{3}$ kN

$+\uparrow \Sigma F_y = 0$ $-B_y + C_y - 80 = 0$

$B_y = -26.\bar{6}$ kN

$\Rightarrow B_y = 26.\bar{6}$ kN $\downarrow$

Shear Diagram:

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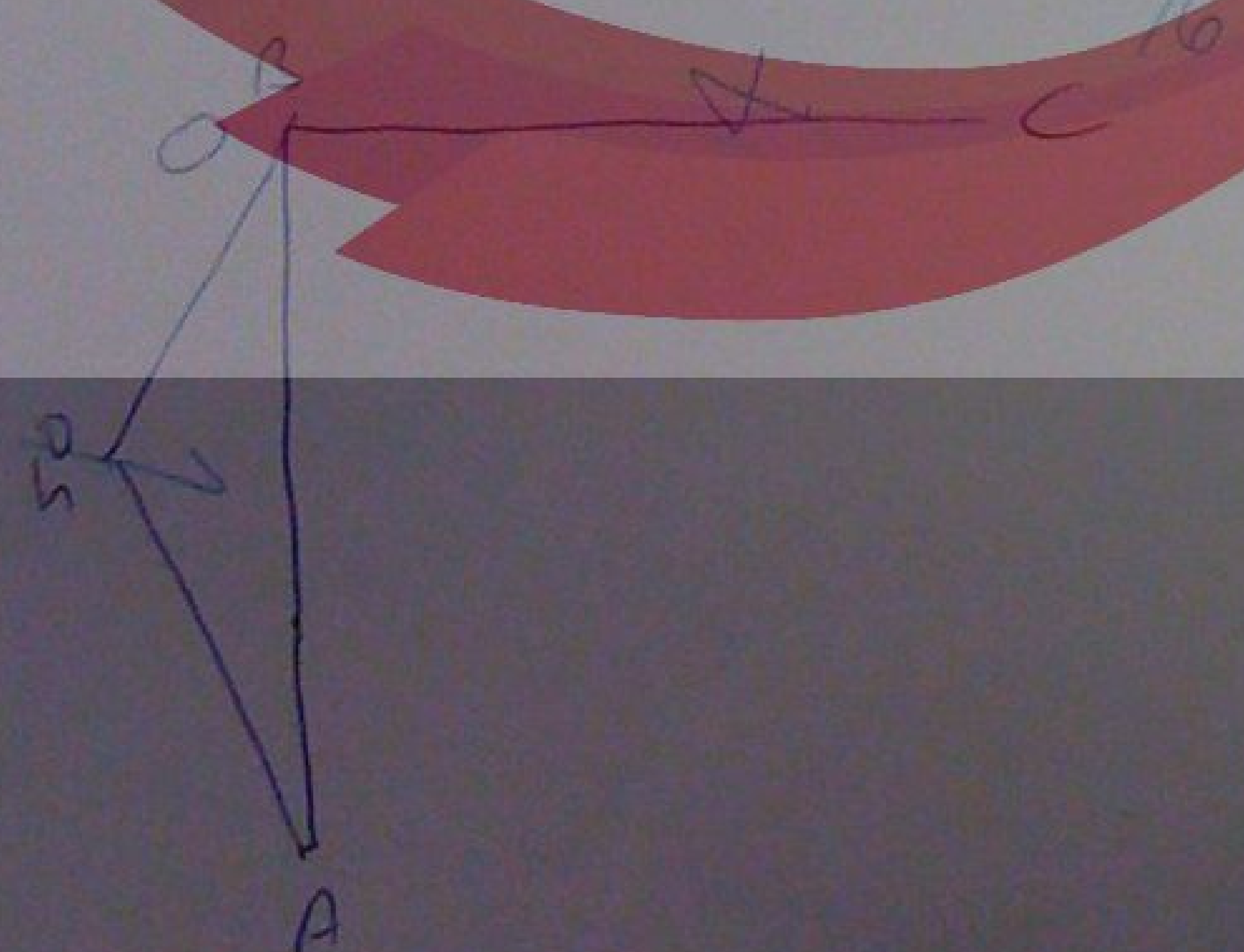
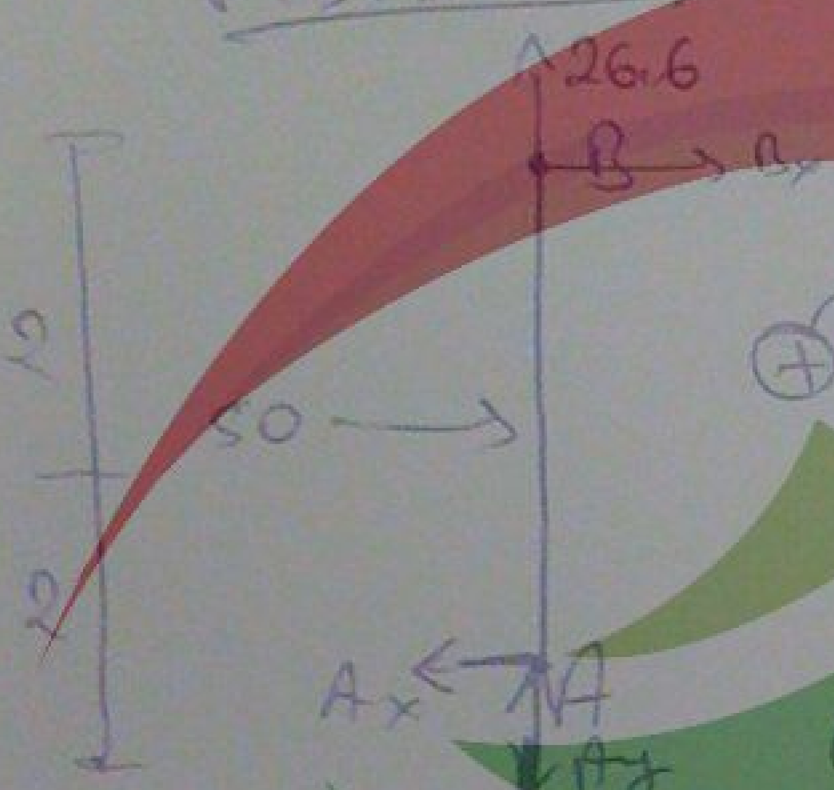
Moment Diagram:

6/6



F.B.D. 2



(+↑) $\Sigma F_y = 0$

$26.6 - A_y = 0$

$\Rightarrow A_y = 26.6\ kN$

(+↺) $\Sigma M_B = 0$

$-A_x(4) + 50(2) = 0$

$4A_x = 100$

$A_x = 25\ kN$

(+→) $\Sigma F_x = 0$ → $-25 + 50 + B_x = 0$

~~$-25 + B_x = 0$~~

~~$B_x = 25\ kN$~~

$B_x = -25\ kN$

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Returning To F.B.D. 1:

(+→) $\Sigma F_x = 0$

$-25 + C_x = 0$

$C_x = 25\ kN$

2) → On the Next Page