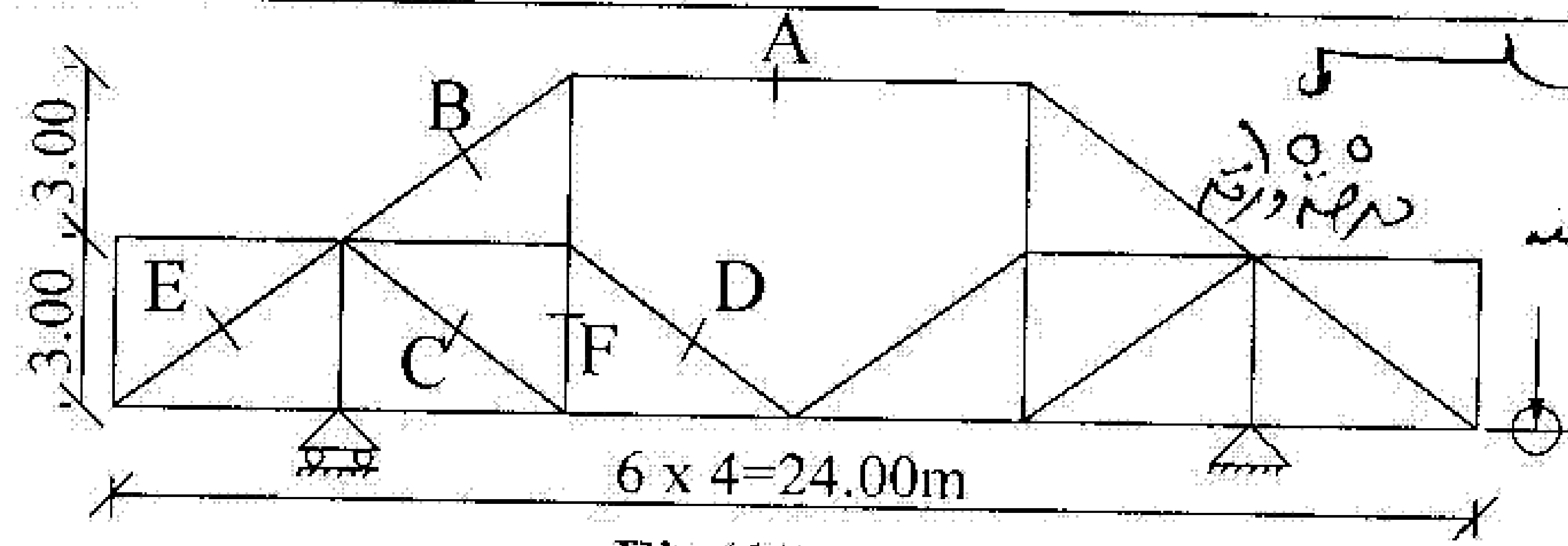
SECOND YEAR CIVIL TIME 3 hours	FAYOUM UNIVERSITY FACULTY OF ENGINEERING لائحة جديدة	STRUCTURAL ANALYSIS & MECH.

Question (1) (20%)

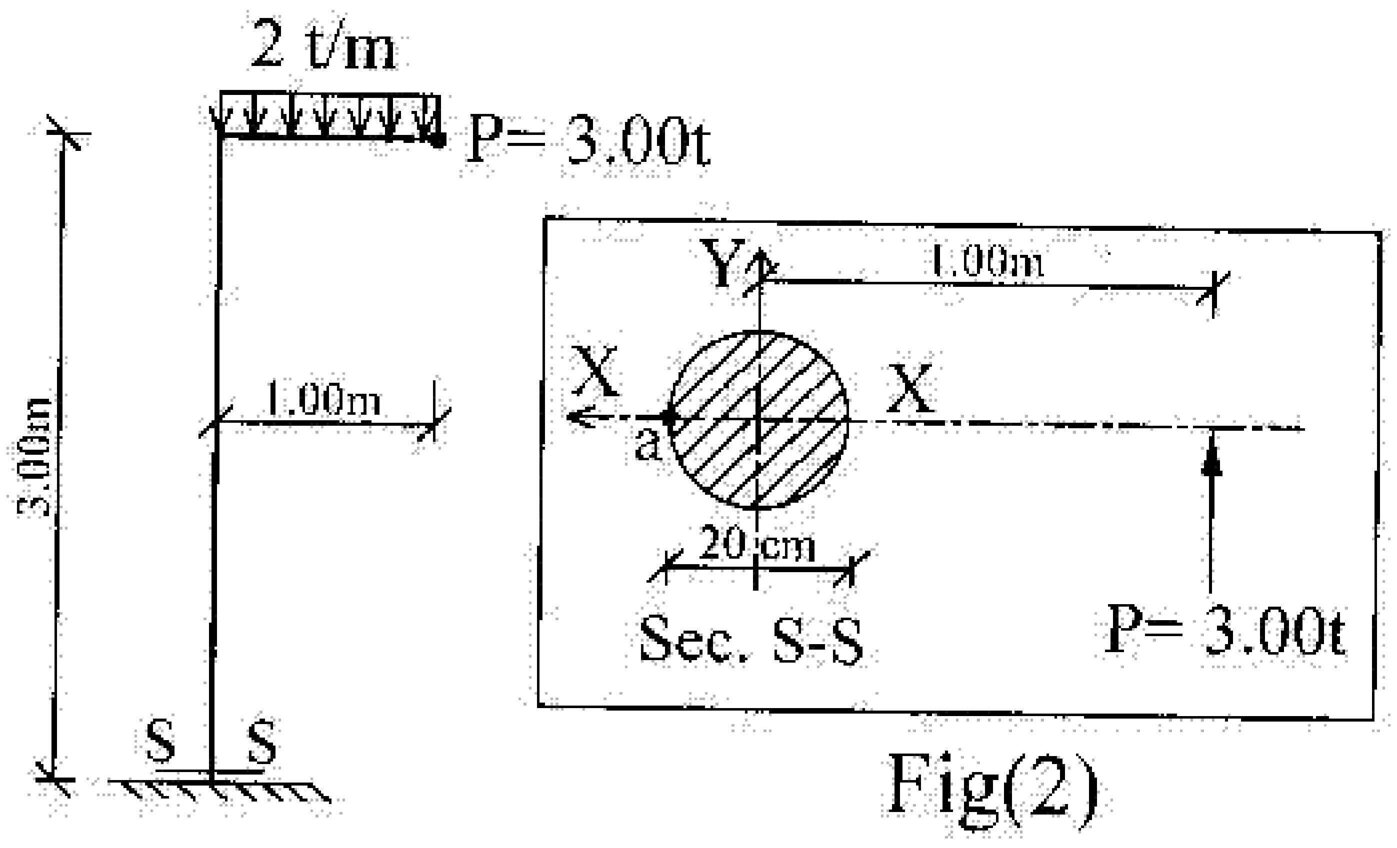
For the truss shown in Fig (1) draw influence lines for the marked members A, B,C,D,E,F



Fig(1)

Question (2) (30%)

The shown steel column carries a uniform load 2 t/m and an out-of plane lateral load P of 3t ↑. Determine analytically and check graphically the directions and stresses on the principal normal and principal shear planes at point (a) of section S-S shown in Fig. (2).

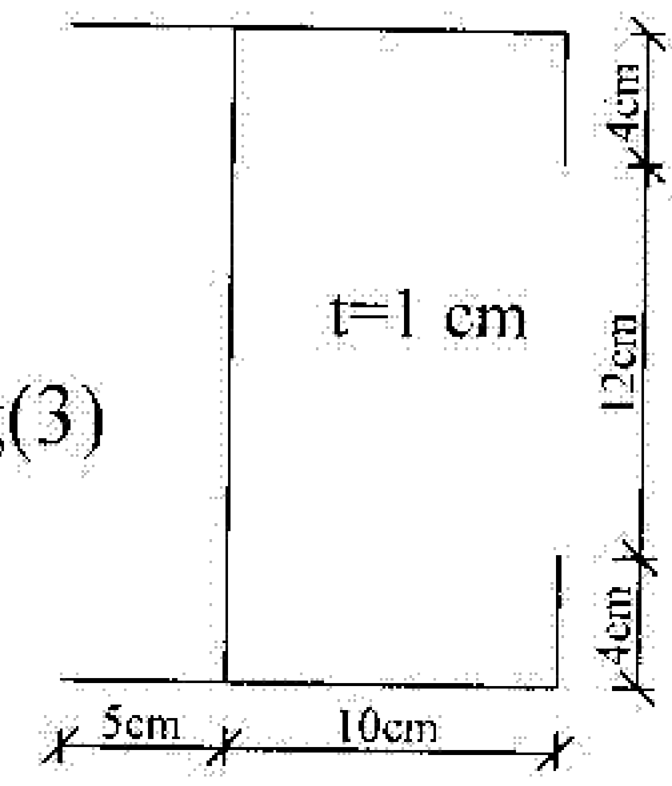


Fig(2)

Question (3) (20%)

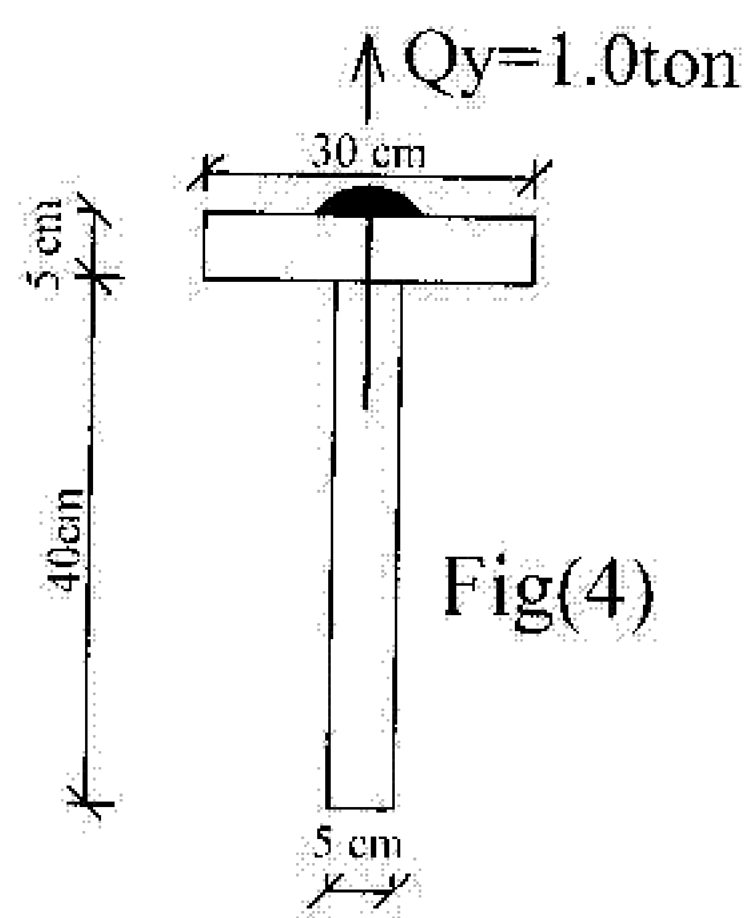
Find the shear center of the section shown in Fig. (3) by using the shear flow diagram

Fig(3)



Question (4) (20%)

Nails are used to connect the two wooden planks to make them act as one beam as shown in Fig. (4). Calculate the spacing (p) of the nails if Qy=1.00 ton and the allowable shearing force per nail is 50 Kg.



Fig(4)

Question (5) (20%)

Using the method of virtual work, calculate the vertical deflection of point d for the frame shown in Fig. (5)

EI (part abcd)=50,000 m2.t
EA (tie)=40,000 t

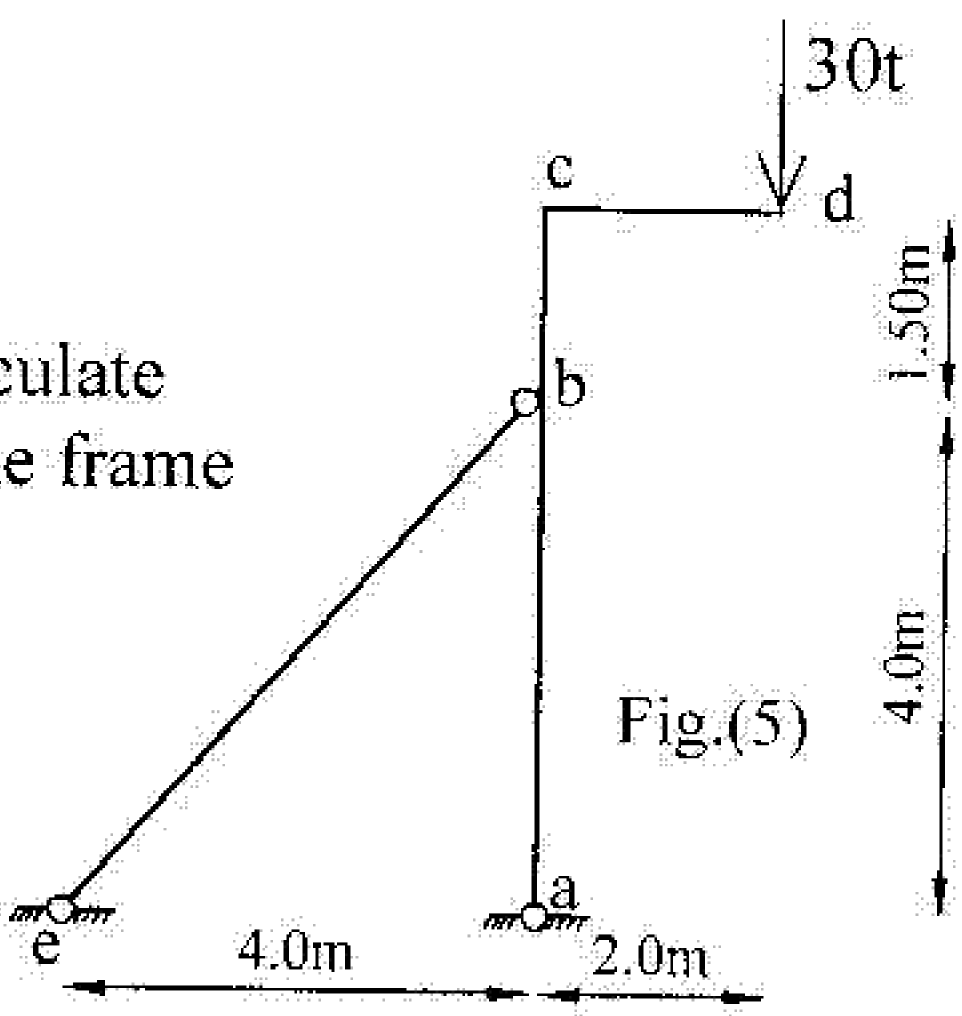
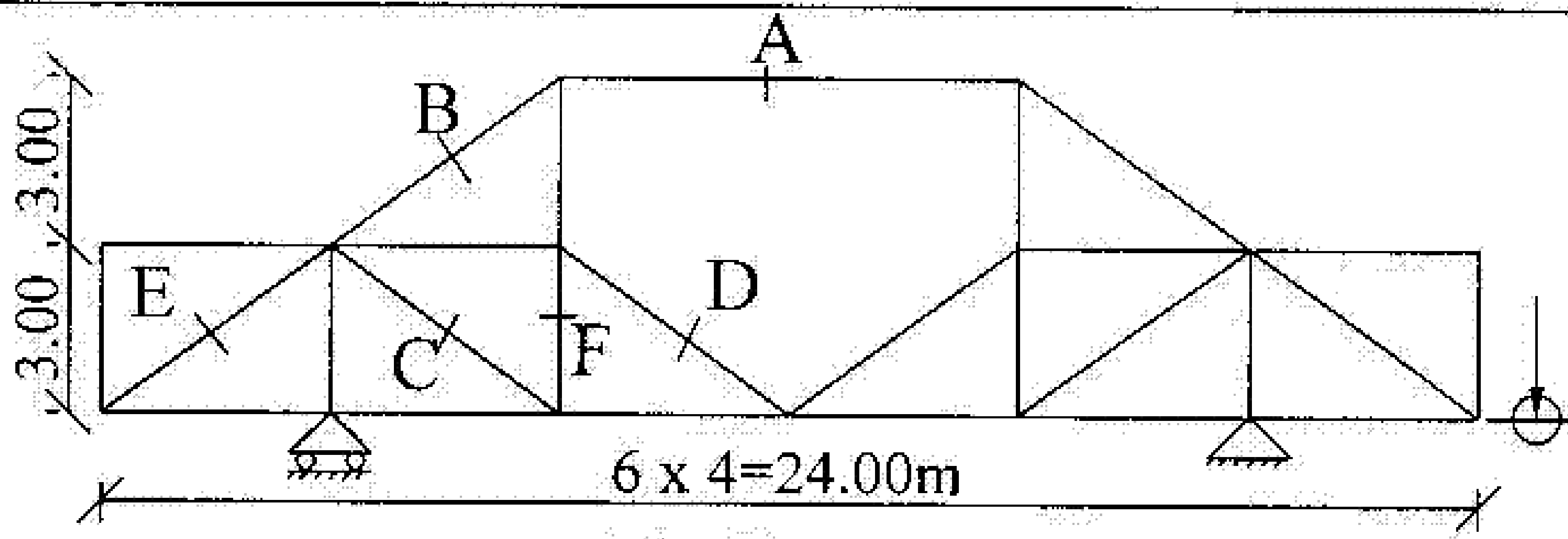


Fig.(5)

SECOND YEAR CIVIL TIME 3 hours	FAYOUM UNIVERSITY FACULTY OF ENGINEERING لائحة قديمة	STRUCTURAL ANALYSIS & MECH.

Question (1) (20%)

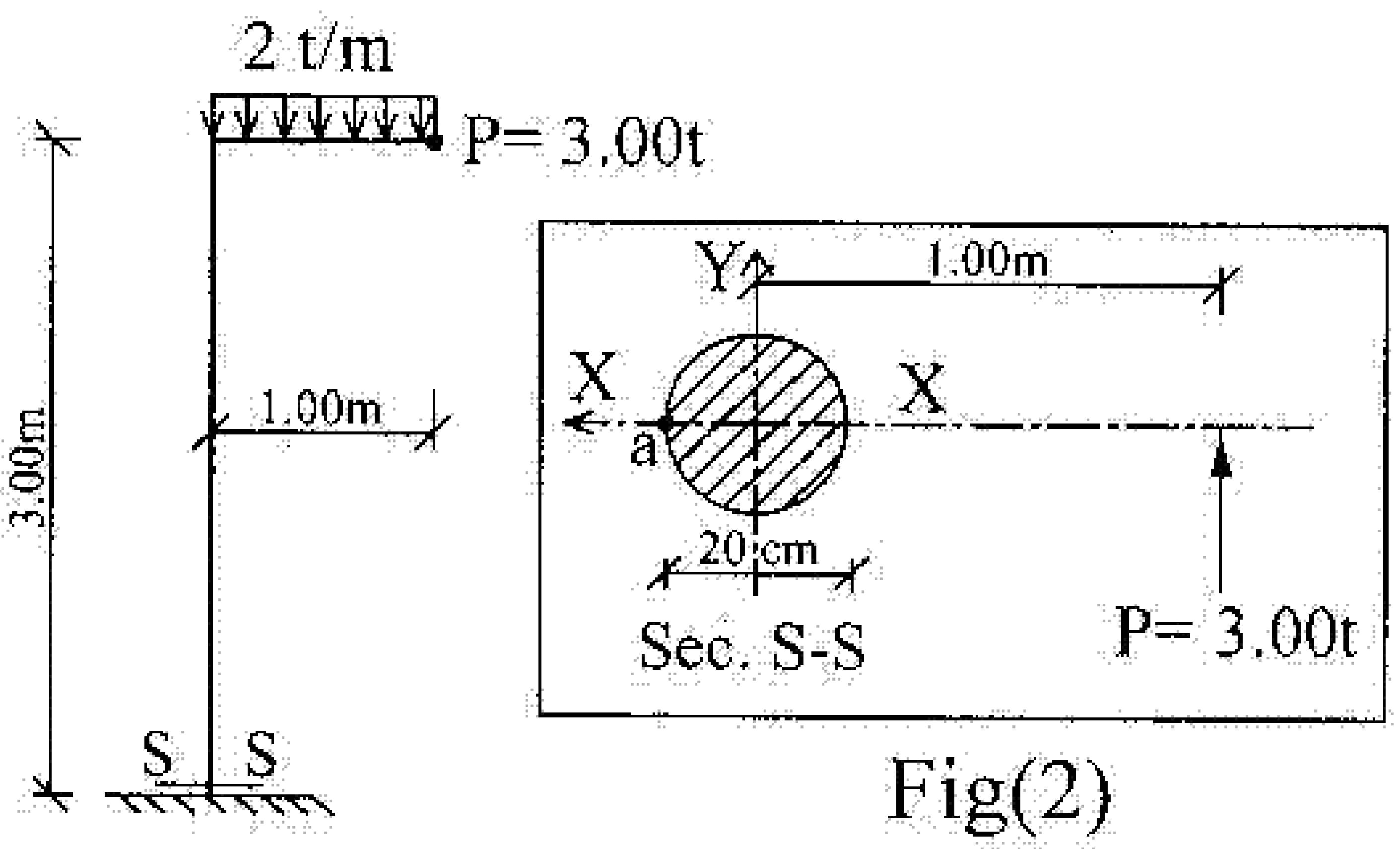
For the truss shown in Fig (1) draw influence lines for the marked members A, B,C,D,E,F



Fig(1)

Question (2) (30%)

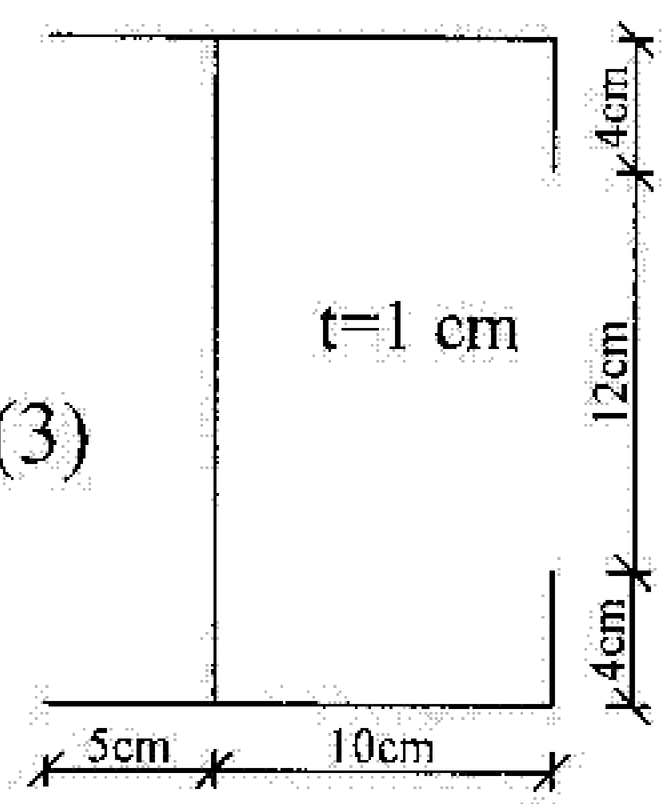
The shown steel column carries a uniform load 2 t/m and an out-of plane lateral load P of 3t↑. Determine analytically and check graphically the directions and stresses on the principal normal and principal shear planes at point (a) of section S-S shown in Fig. (2).



Fig(2)

Question (3) (20%)

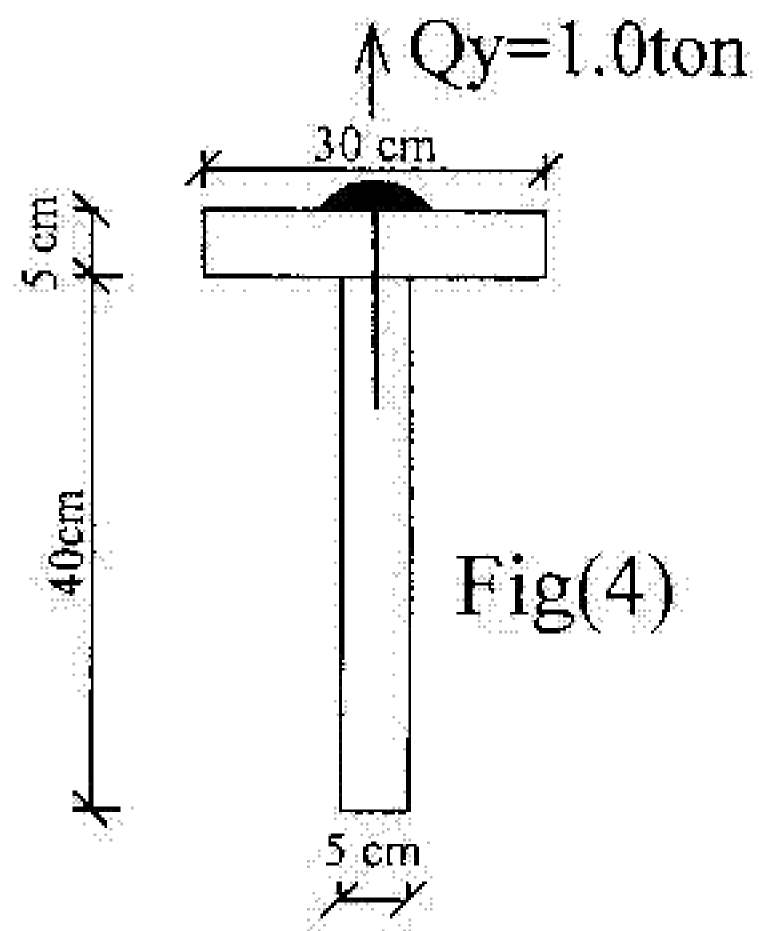
Find the shear center of the section shown in Fig. (3) by using the shear flow diagram



Fig(3)

Question (4) (20%)

Nails are used to connect the two wooden planks to make them act as one beam as shown in Fig. (4). Calculate the spacing (p) of the nails if Qy=1.00 ton and the allowable shearing force per nail is 50 Kg.



Fig(4)

Question (5) (20%)

Find the minimum permissible diameter d for the circular shaft shown in Fig. (5) if the allowable shearing stress = 500 kg/cm2.

Hence, find the maximum angle of twist.

G= 500 t/cm2

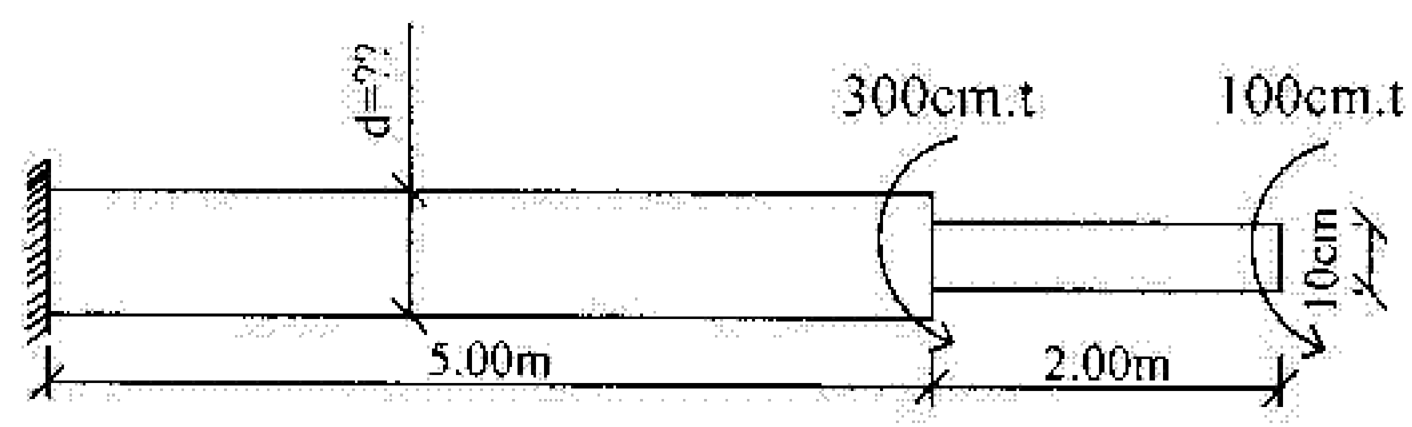
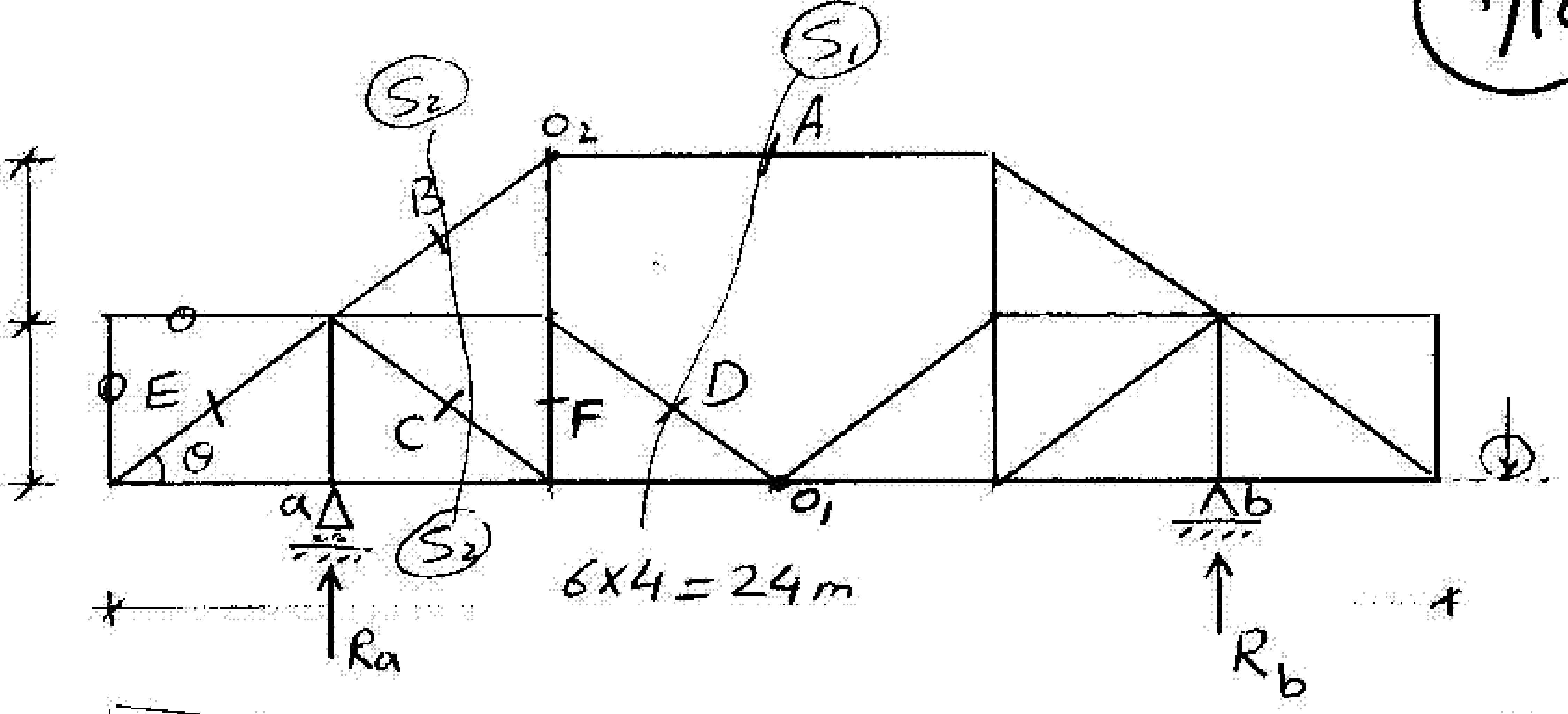


Fig.(5)

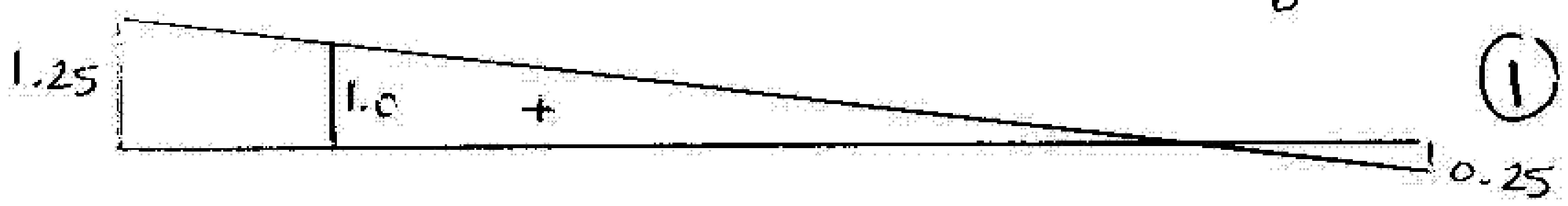
1

20

1/10

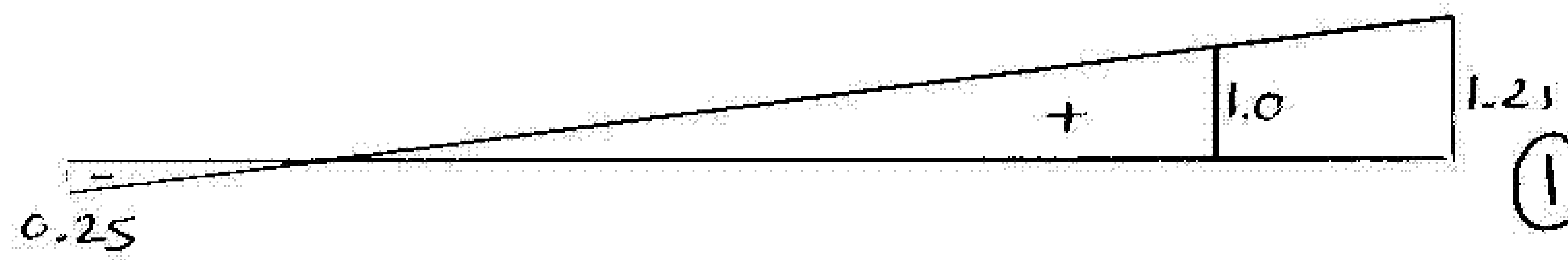


I.L. R_a



(1)

I.L. R_b



(1)

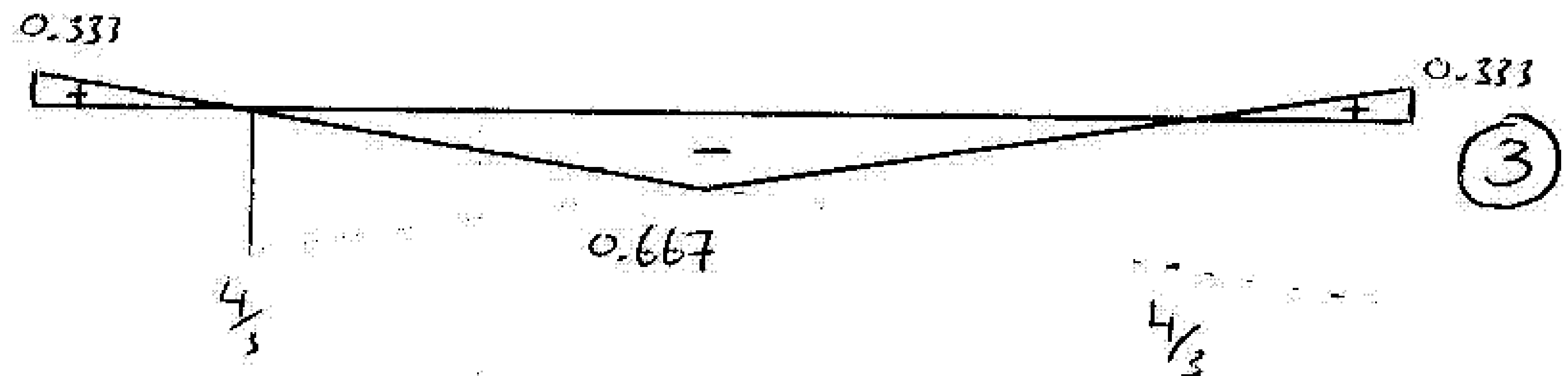
I.L. R_a, I.L. R_b

I.L. F_A

Sec(S_1-S_1)

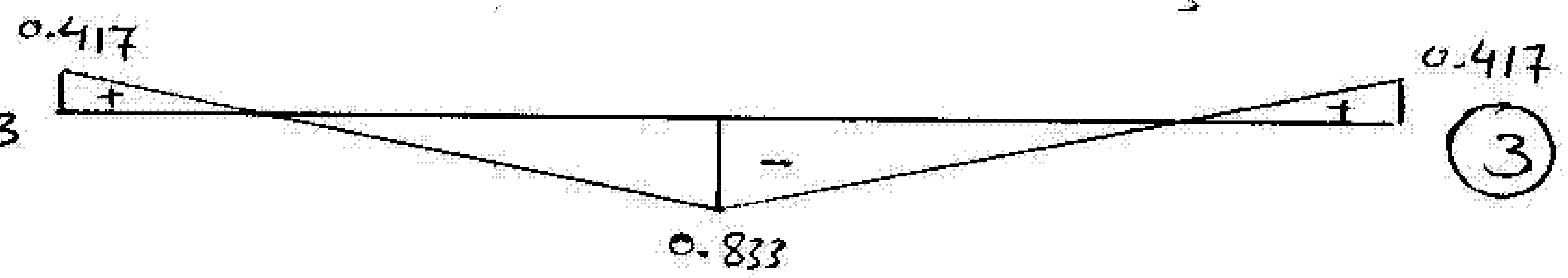
$\Sigma M @ O_1 = 0$

I.L. F_A



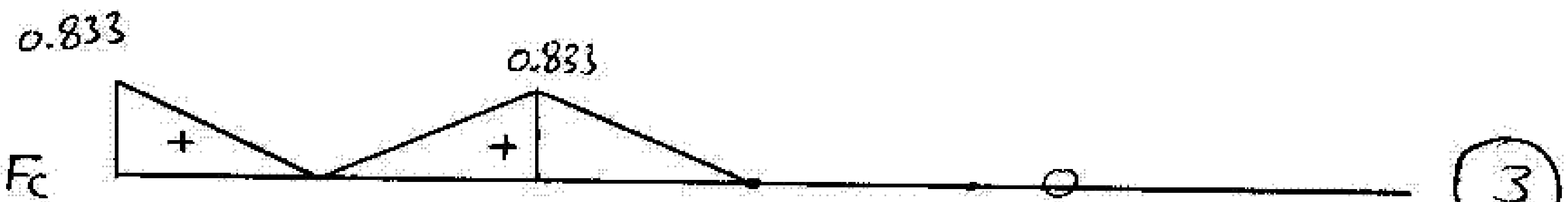
(3)

I.L. F_B



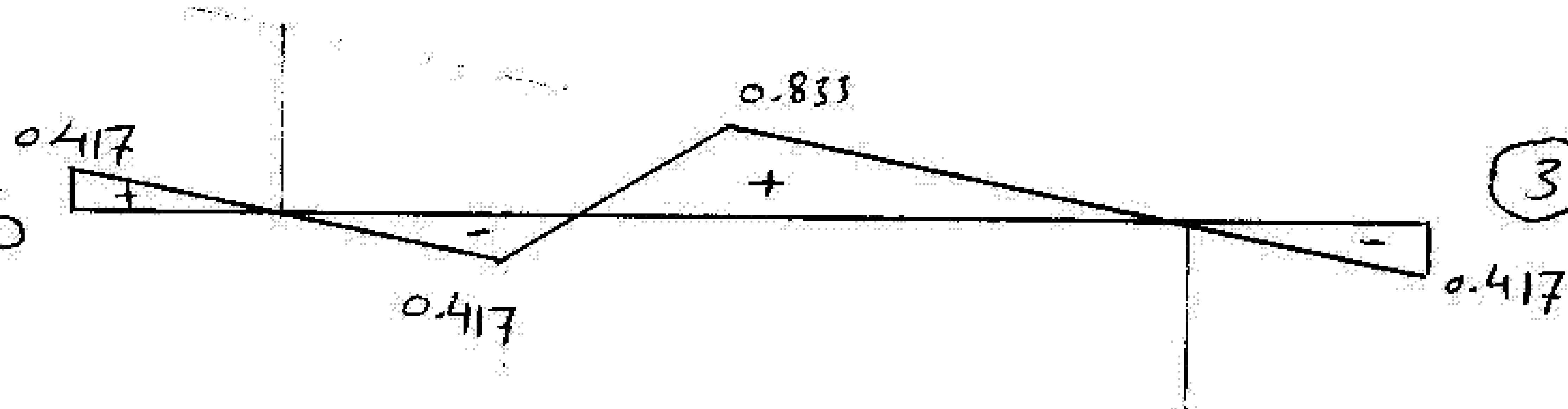
(3)

I.L. F_C



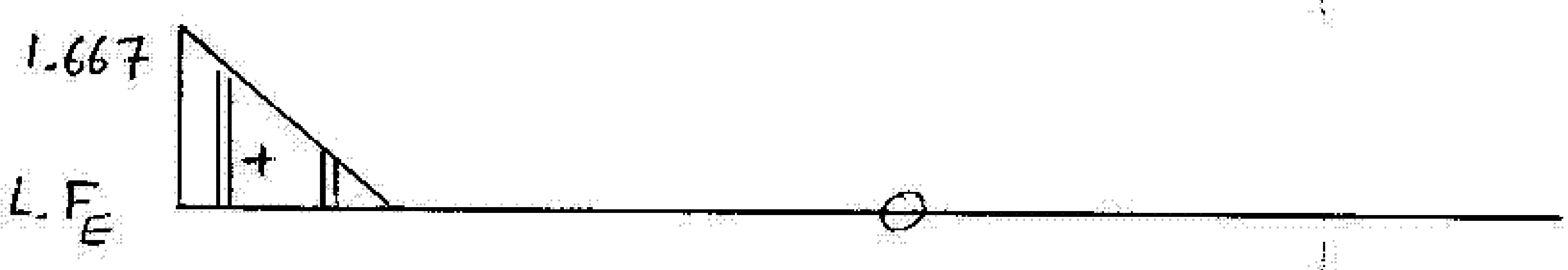
(3)

I.L. F_D



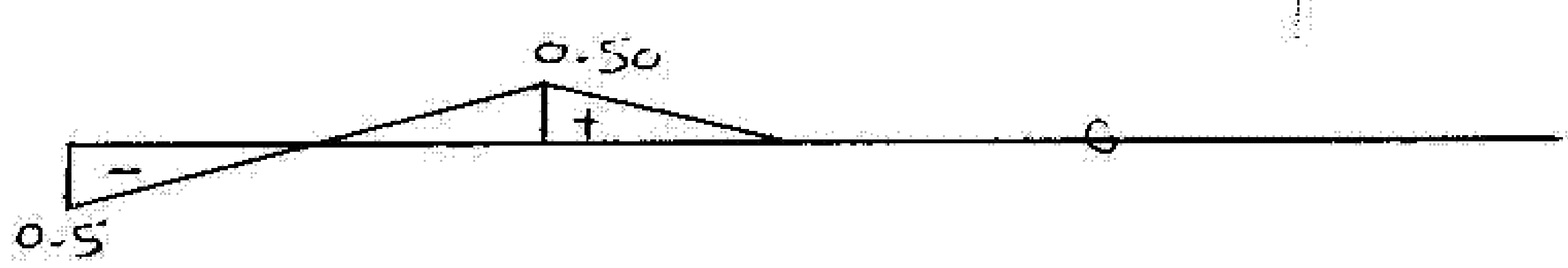
(3)

I.L. F_E



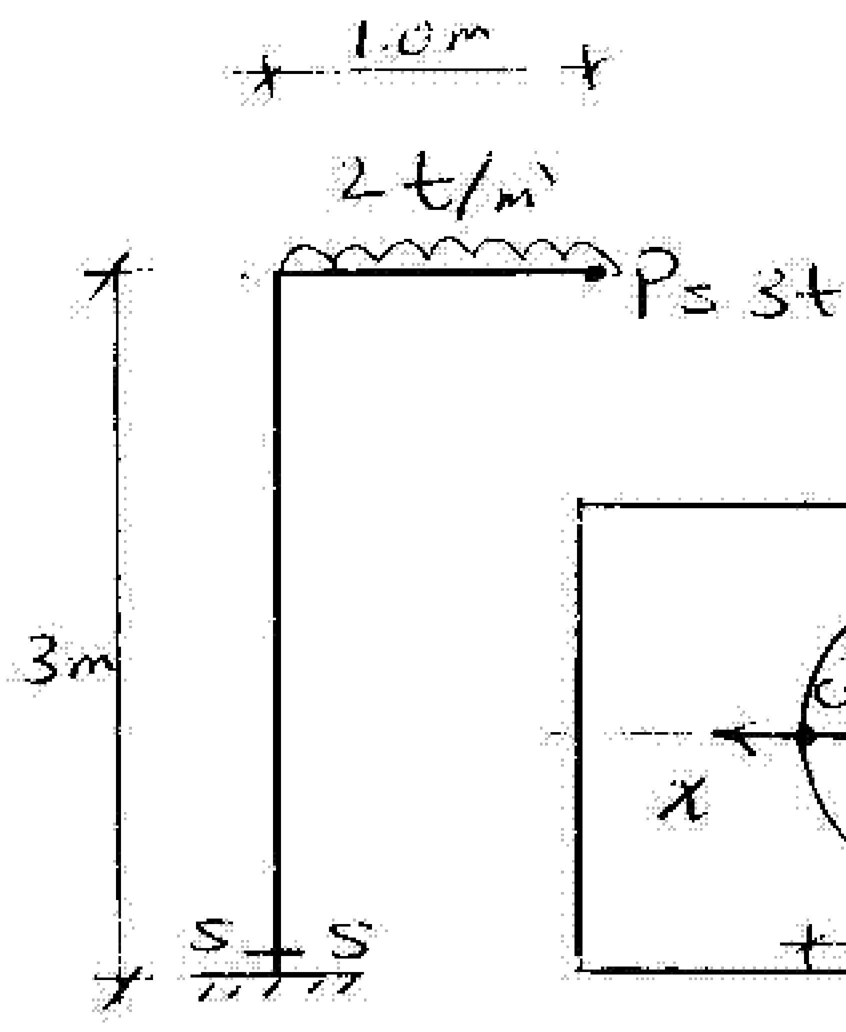
(3)

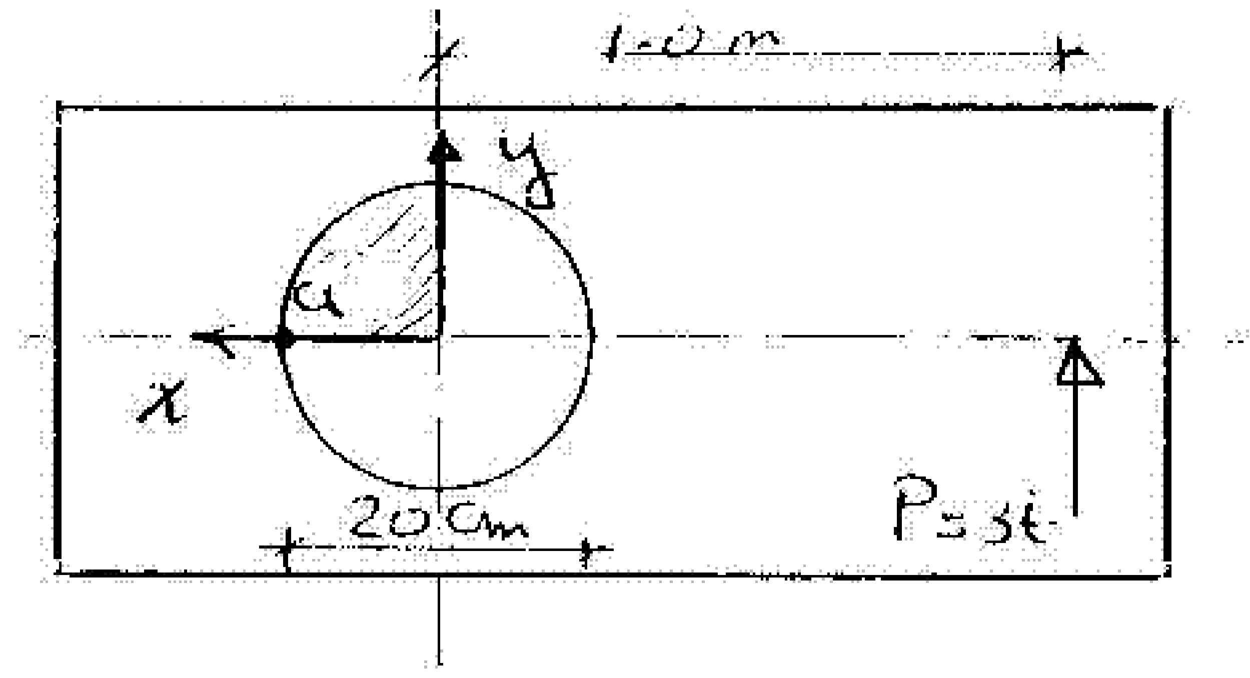
I.L. F_F



(3)

2





$N = -2 * 1 = -2\,t$

$Q_x = 0$

$Q_y = 3t$

$M_x = -3 * 3 = -9 \text{ t.m.}$

$M_y = +2 * 1 * 0.5 = +1.0 \text{ t.m.}$

$M_t = 3 * 1 = 3 \text{ t.m.}$

at point a ($x = -10$ cm, $y = 0$)

$$\sigma = \frac{N}{A} + \frac{M_x}{I_x} y + \frac{M_y}{I_y} x$$

$A = \pi(10)^2 = 314.16 \text{ cm}^2$

$$I_x = I_y = \frac{\pi (10)^4}{4} = 7853.98 \text{ cm}^4$$

$$\sigma_a = \frac{\overset{t}{-2}}{\underset{cm^2}{314.16}} + \frac{M_x}{I_x} \underset{0}{\cancel{y}} + \frac{\overset{t.m.}{1.0 * 100}}{\underset{cm^4}{7853.98}} * \overset{cm}{(+10)}$$

$\sigma_a = 0.121 \text{ t/cm}^2$

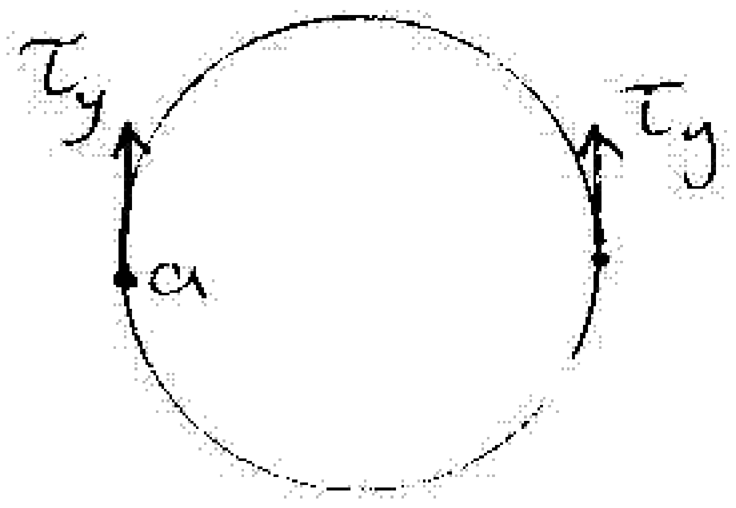
$\sigma = +121 \text{ kg/cm}^2$

due to Shear

$Q_y = 3t$

$$\tau_y = \frac{Q_y S_x}{I_x b} = \frac{\overset{t}{3} * \left[\frac{\pi(10)^2}{2} * \frac{4(10)}{3\pi} \right]^{cm^3}}{\underset{cm^4}{7853.98} * \underset{cm}{20}} = 0.01273 \ t/cm^2$$

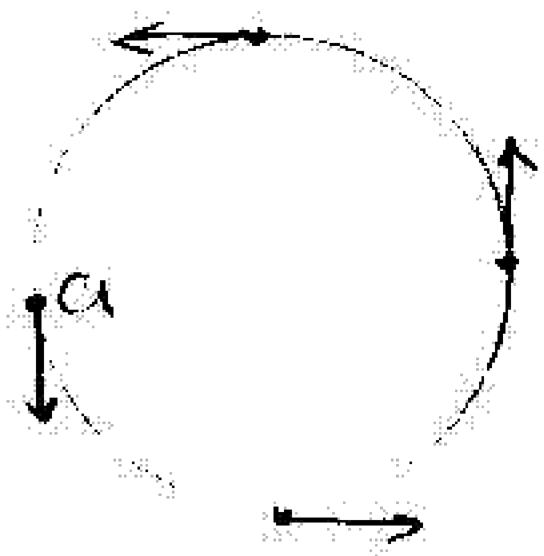
$\tau_y = 12.73 \ Kg/cm^2$



due to torsion

$$\tau_t = \frac{M_t * R}{I_p} = \frac{\overset{t.m.}{3} * 10 * 100}{\frac{\pi(10)^4}{2}} = 0.19098 \ t/cm^2$$

$\tau_t = 190.98 \ Kg/cm^2$



$\tau_{total\,(a)} = 12.73 - 190.98 = -178.25$ Kg/cm²

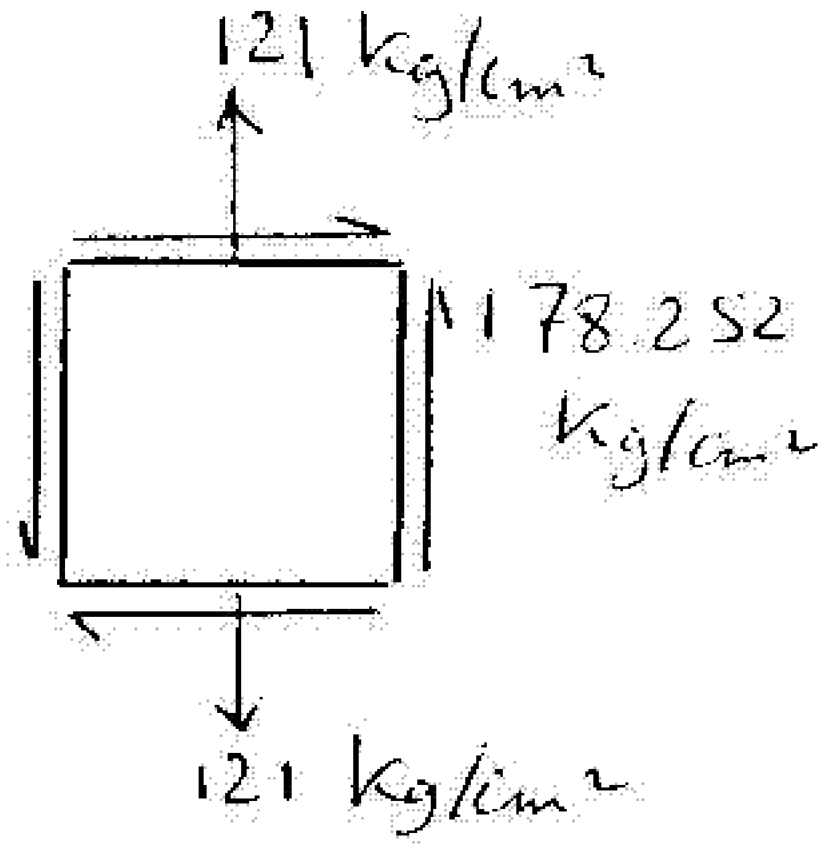
τ_t

at point a

$\sigma_x = 0$

$\sigma_y = +121 \ Kg/cm^2$

$\tau_x = -\tau_y = 178.252 \ Kg/cm^2$



Analytical Method

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

$$= \left(\frac{0+121}{2}\right) \pm \sqrt{\left(\frac{0-121}{2}\right)^2 + (178.252)^2}$$

$$\sigma_{max} = 248.74 \quad kg/cm^2$$

$$\sigma_{min} = -127.74 \quad kg/cm^2$$

$$\tan 2\alpha = \frac{-\tau_x}{\left(\frac{\sigma_x - \sigma_y}{2}\right)} = \frac{-178.252}{\left(\frac{0-121}{2}\right)}$$

$$2\alpha = 180 + 71.252$$

$$\alpha = 125.63^\circ$$

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

$$= \pm \sqrt{\left(\frac{0-121}{2}\right)^2 + (178.252)^2}$$

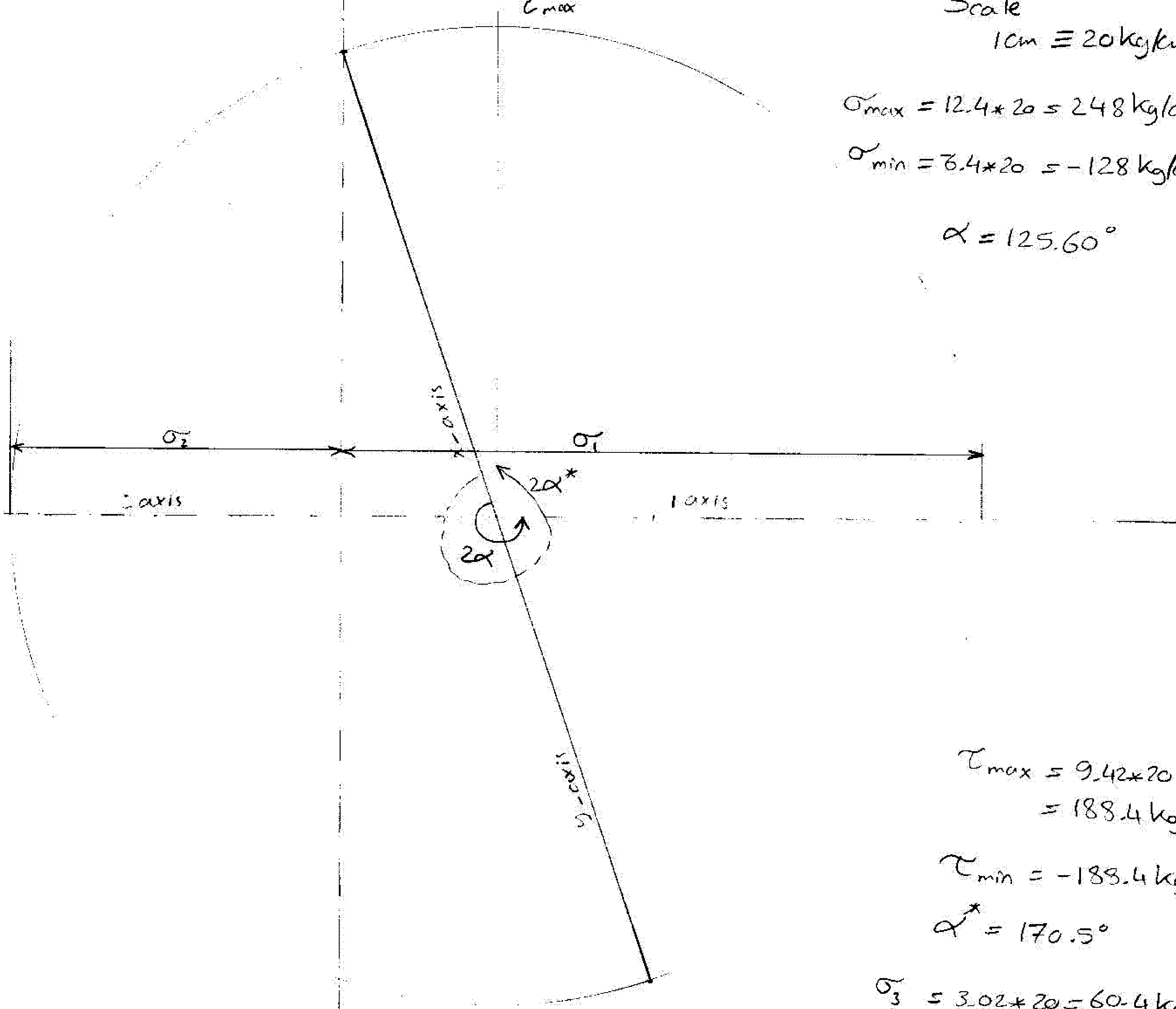
$$\tau_{max} = +188.24 \quad kg/cm^2$$

$$\tau_{min} = -188.24 \quad kg/cm^2$$

$$\alpha^* = \alpha + 45 = 170.63^\circ$$

$$\sigma_{\substack{3 \\ 4}} = \frac{\sigma_x + \sigma_y}{2} = \frac{0+121}{2} = 60.5 \quad kg/cm^2$$

Graphical Method



Scale
1cm ≡ 20 kg/cm²

$\sigma_{max} = 12.4 * 20 = 248\ kg/cm^2$

$\sigma_{min} = 6.4 * 20 = -128\ kg/cm^2$

$\alpha = 125.60°$

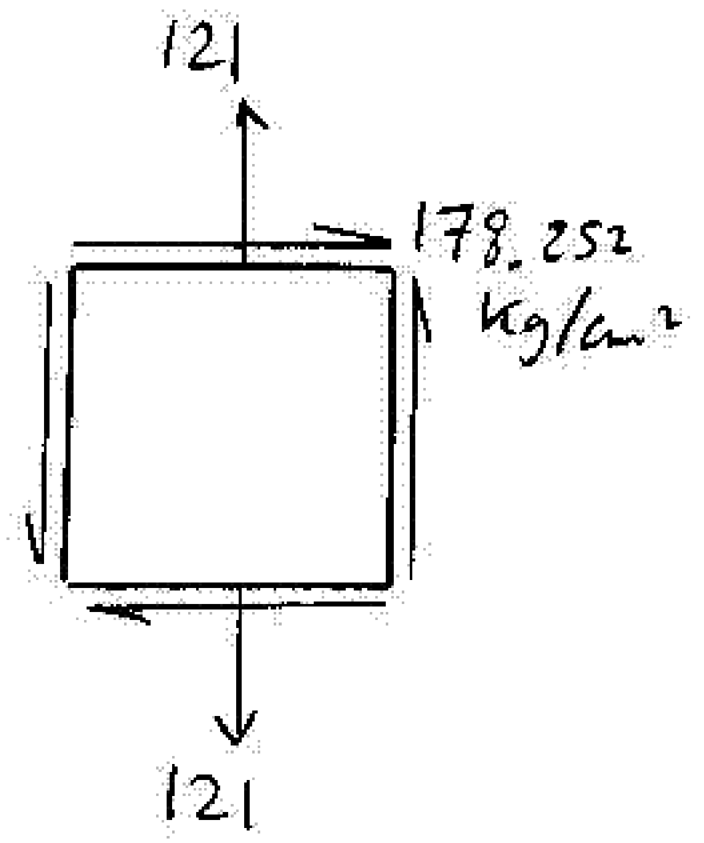
$\tau_{max} = 9.42 * 20$
$= 188.4\ kg/cm^2$

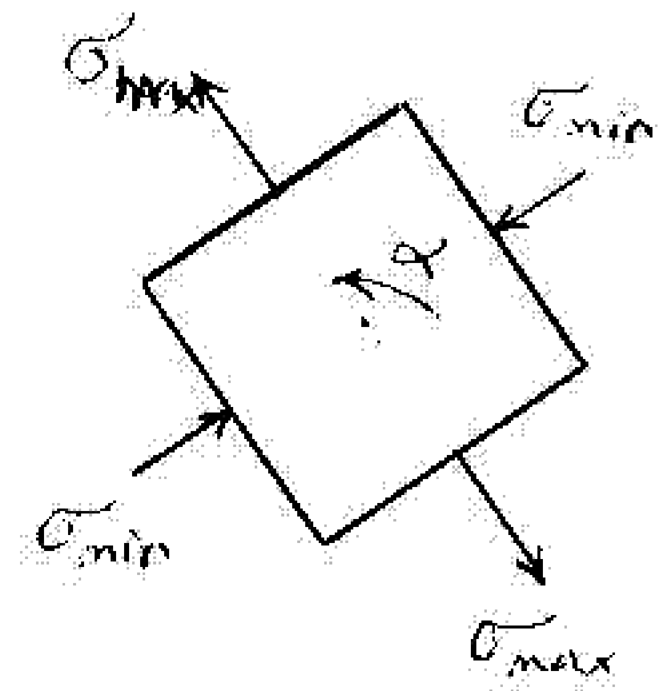
$\tau_{min} = -188.4\ kg/cm^2$

$\alpha^* = 170.5°$

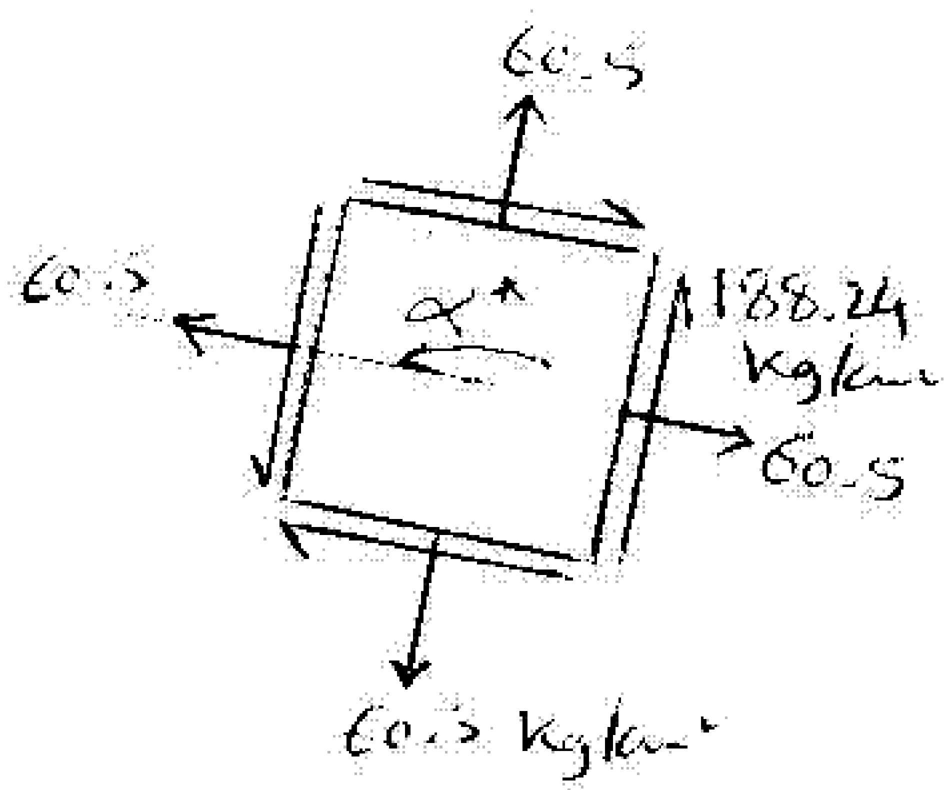
$\sigma_{3/4} = 3.02 * 20 = 60.4\ kg/cm^2$

6/10





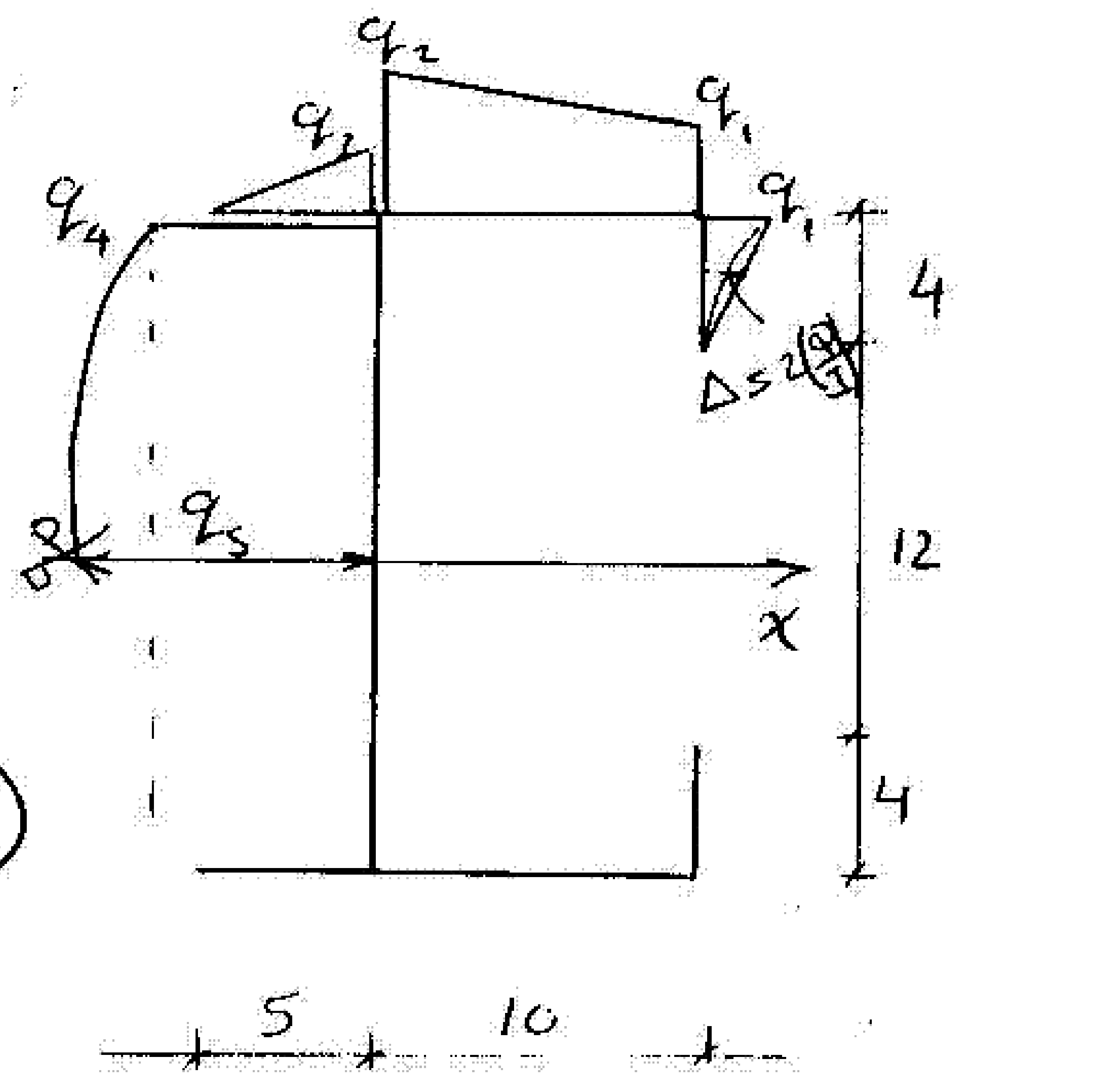
principal Normal Stresses



principal Shear Stresses

$\boxed{3}$ $\boxed{20}$ 7/10

$$q = \frac{Q_y}{I_x} S_x$$



$$I_x = \left[\frac{10(1)^3}{12} + 10(1)(10)^2 + \frac{5(1)^3}{12} + 5(1)(10)^2 + \frac{1(4)^3}{12} + 1(4)(8)^2\right] * 2 + \left[\frac{1(20)^3}{12}\right]$$

5

$$I_x = 4191.833\ cm^4$$

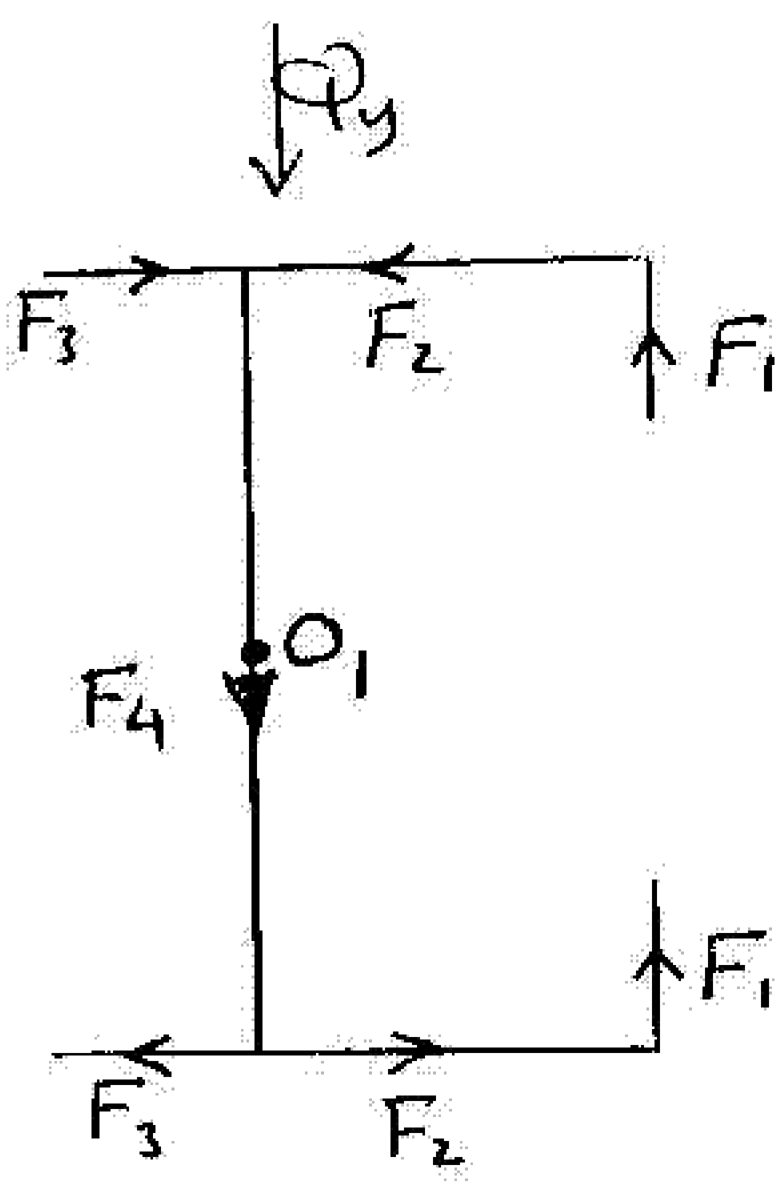
$$q = \left(\frac{Q_y}{I_x}\right) * S_x$$

$$q_1' = (1)(2)(7) = 14$$

$$q_1 = 1(4)(8)\left[\frac{Q_y}{I_x}\right] = 32\left(\frac{Q_y}{I_x}\right)$$

$$\Delta = 2\left(\frac{Q_y}{I_x}\right)$$

$$q_2 = [32 + (1)(10)(10)]\left(\frac{Q_y}{I_x}\right) = 132\left(\frac{Q_y}{I_x}\right)$$



$$q_3 = (1)(5)(10)\left(\frac{Q_y}{I_x}\right) = 50\left(\frac{Q_y}{I_x}\right)$$ 5

$$q_4 = q_2 + q_3 = 182\left(\frac{Q_y}{I_x}\right)$$

$$q_5 = [182 + (1)(10)(5)]\left(\frac{Q_y}{I_x}\right) = 232\left(\frac{Q_y}{I_x}\right)$$

$$F_1 = \left(\frac{1}{2}\right) q_1 (4) - \frac{2}{3}\left(2\frac{Q_y}{I_x}\right)(4) = 64\left(\frac{Q_y}{I_x}\right) - \frac{2}{3}\left(2\frac{Q_y}{I_x}\right)(4) = 58.667\left(\frac{Q_y}{I_x}\right)$$

$$F_2 = \left(\frac{q_1 + q_2}{2}\right)(10) = 820\left(\frac{Q_y}{I_x}\right)$$ 5

$$\boxed{e = 3.894\ cm}$$ 5

$$F_3 = q_3 * \tfrac{1}{2} * 5 = 125\left(\frac{Q_y}{I_x}\right)$$

$$F_4 = \left[(182 * 20) + \left(\frac{2}{3} * 50 * 20\right)\right]\frac{Q_y}{I_x} = 4306.667\left(\frac{Q_y}{I_x}\right)$$

8/10

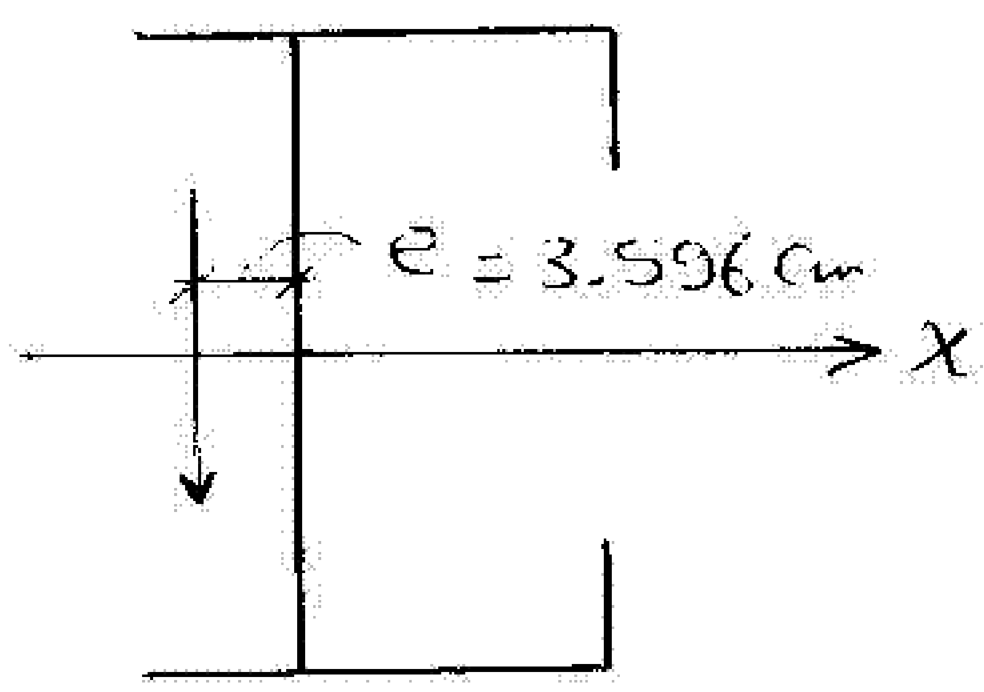
$$\Sigma M_{@ o_1} = 0$$

$$2 * F_1 * 10 + 2 * F_2 * 10 + 0 - F_3 * 2 * 10 = P_y * e$$

$$2(58.667)\frac{P_y}{I_x} * 10 + 2(820)\frac{P_y}{I_x} * 10 - 2(125)\frac{P_y}{I_x} * 10$$

$$= P_y * e$$

$$e = 3596 \text{ cm}$$



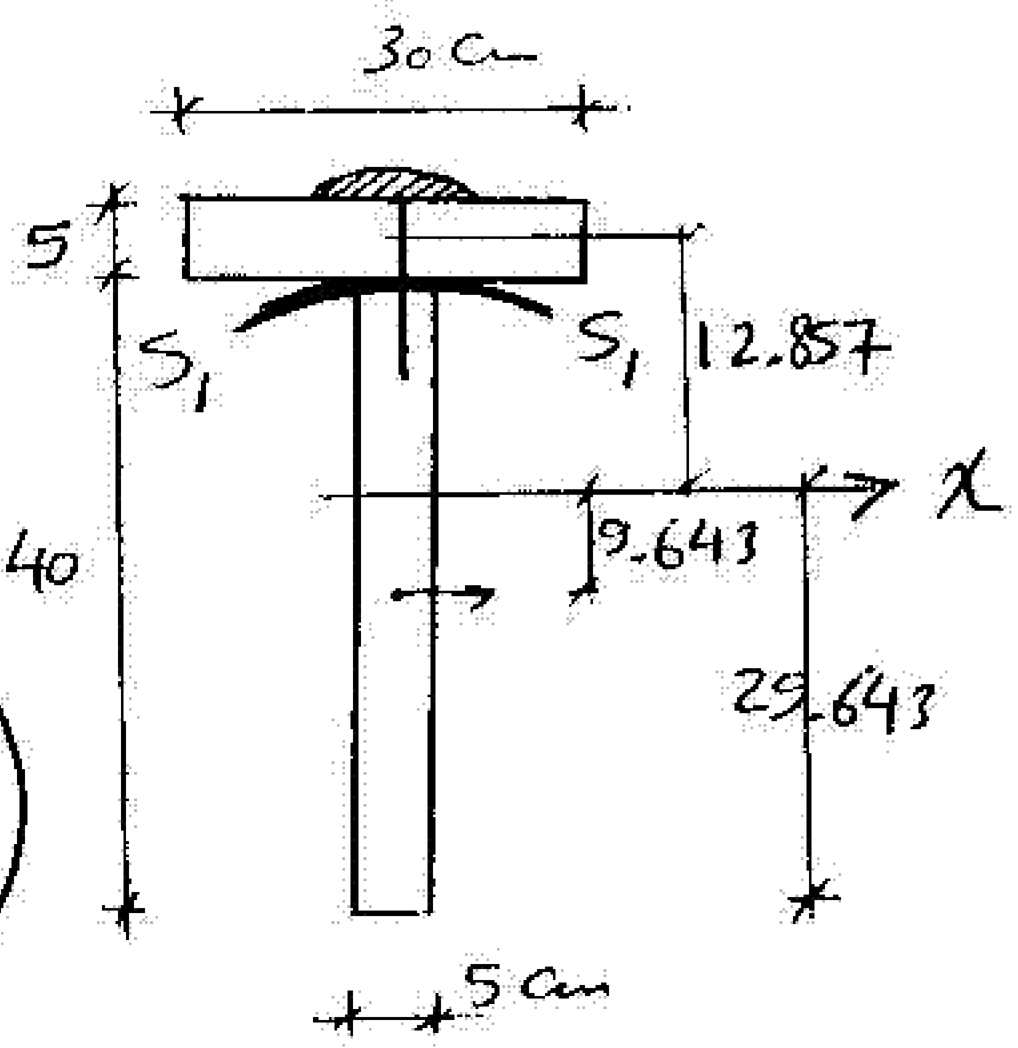
4

20

9/10

Spacing $(P) = ?$

$Q_y = 1\ t,$



allowable shearing force per nail = 50 kg

$A = (40)(5) + (30)(5) = 350\ cm^2$

$\bar{y} = \Sigma AY / \Sigma A$

$$\bar{y} = \frac{40 \times 5 \times 20 + 30 \times 5 \times 42.5}{350} = 29.643\ cm$$

$\bar{y}$ 5

$$I_x = \frac{30(5)^3}{12} + 30(5)(12.857)^2 + \frac{5(40)^3}{12} + 5(40)(9.643)^2$$

$I_x = 70372.024\ cm^4$ 5

at sec $(S_1 - S_1)$

$S_x = 5 \times 30 \times 12.857 = 1928.55\ cm^3$

$$q = \frac{Q_y * S_x}{I_x} = \frac{1 * 1928.55}{70372.024} = 0.0274\ t/cm$$

q 5

allowable shearing force per nail = 50 kg

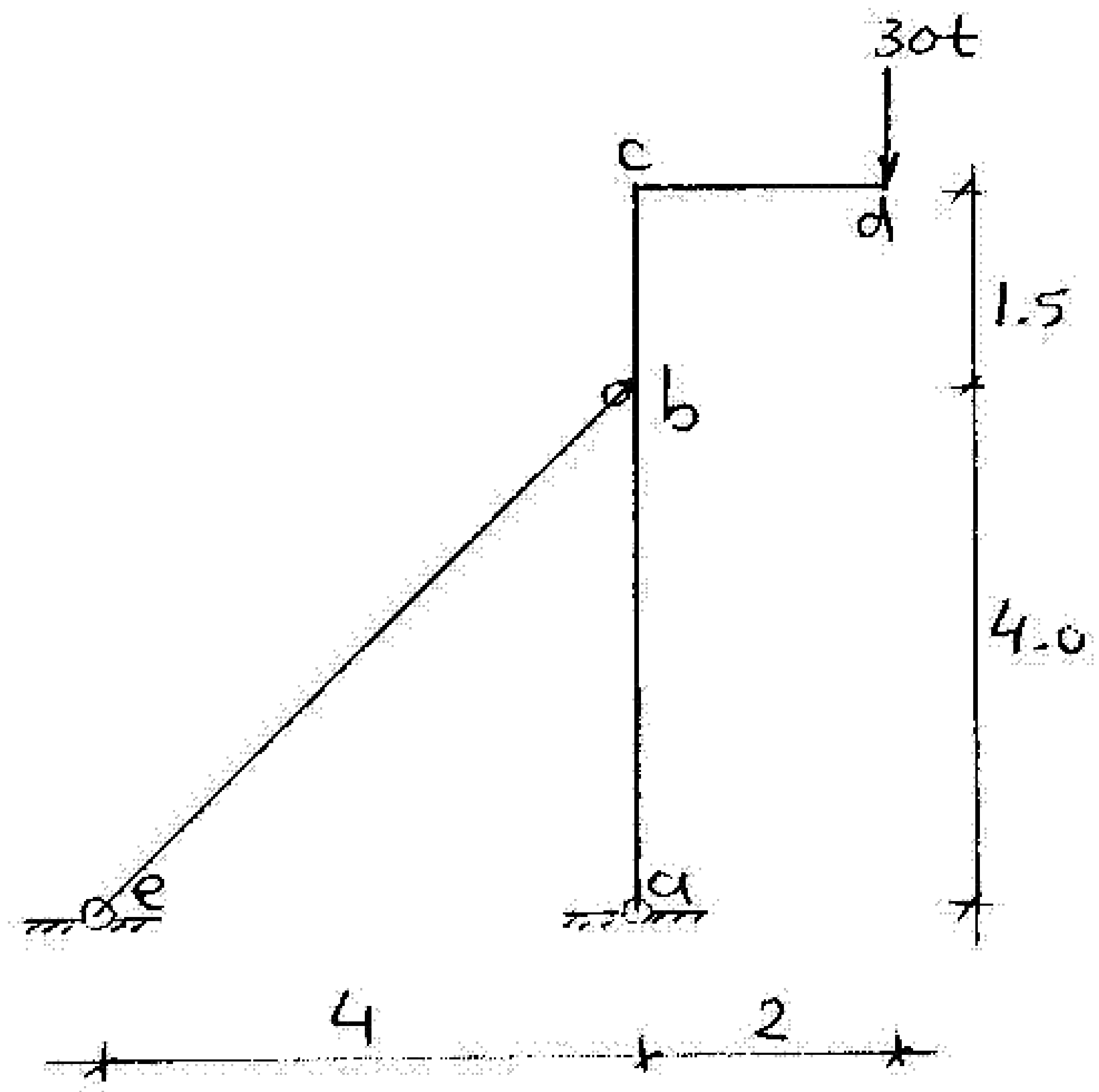
$F = q * p = (0.0274 * 1000) * \overset{cm}{p} = 50$ 5

$p = 1.82\ cm$

5 vertical deflection at point (d) 20 10/10

EI (part abcd) $= 50\,000$ m^2.t

EA (tie) $= 40\,000$ t



we will Draw the B.M.D.

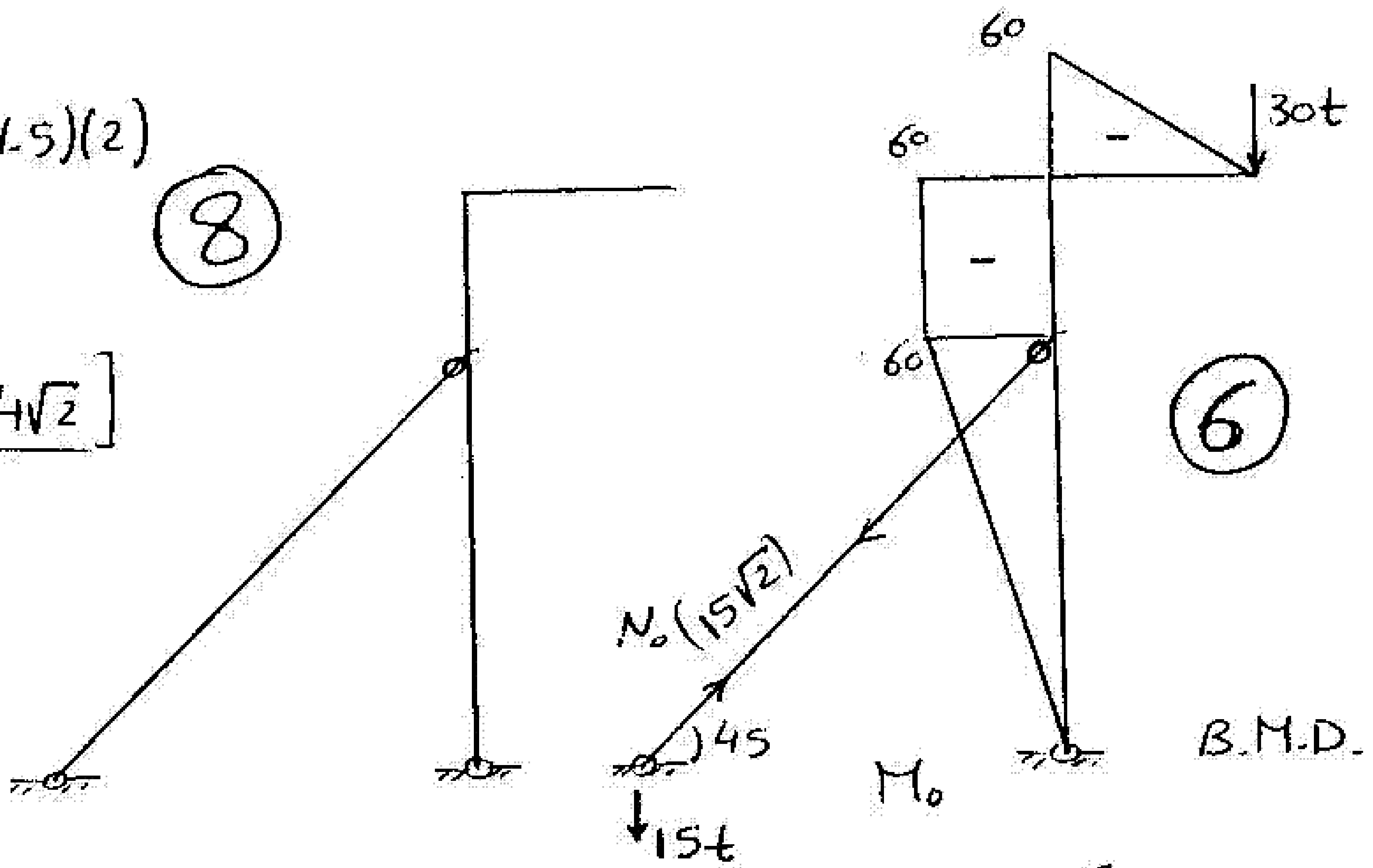
the force in the tie $= 15\sqrt{2}$ t (ten.

$$y_d = \int \frac{M_o M_1}{EI} dl + \int \frac{N_o N_1}{EA} dl$$

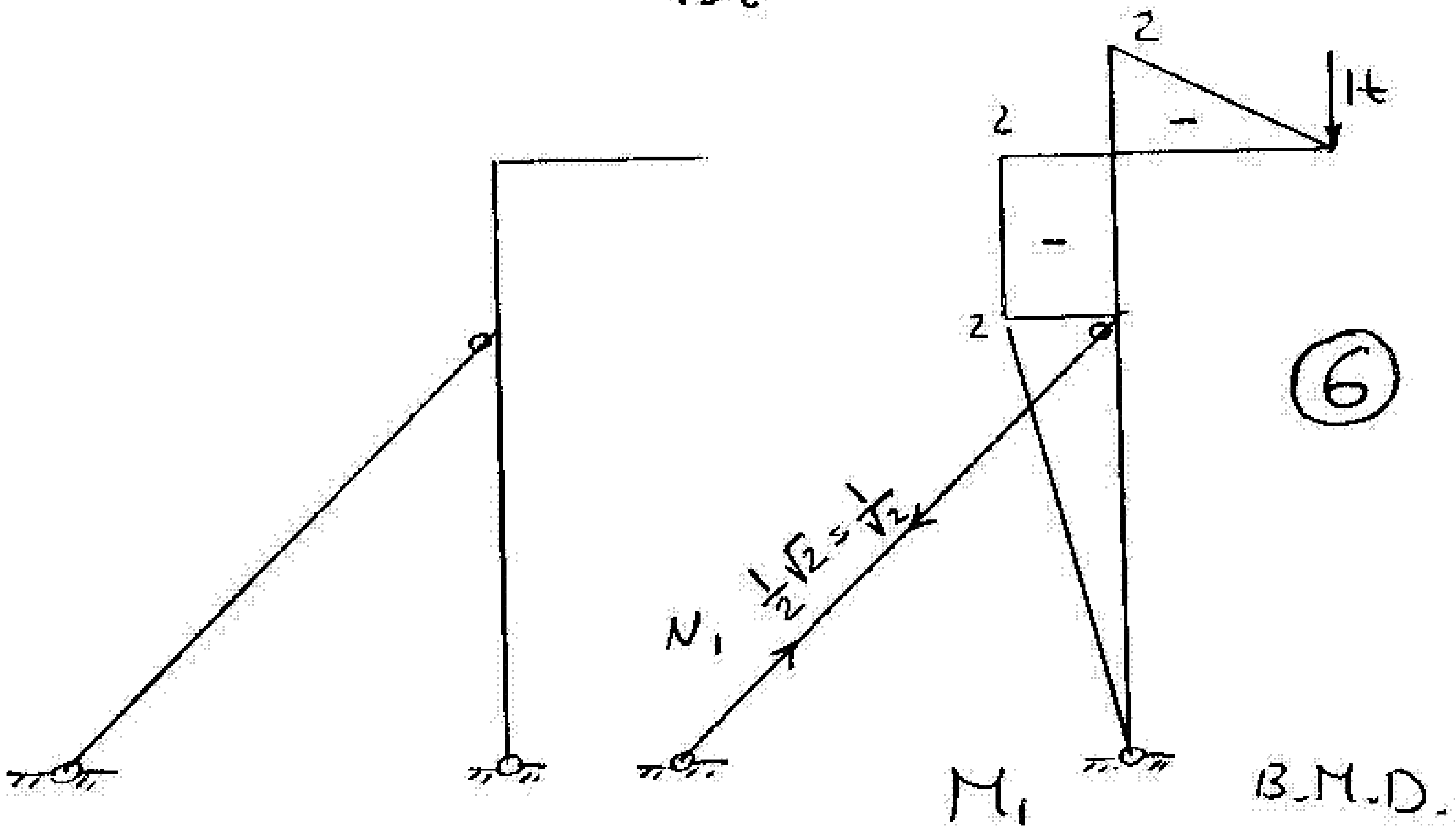
$$= \frac{1}{EI}\left[\frac{2 \times 60 \times 2}{3} + 60(1.5)(2) + \frac{60 \times 2 \times 4}{3} \right]$$

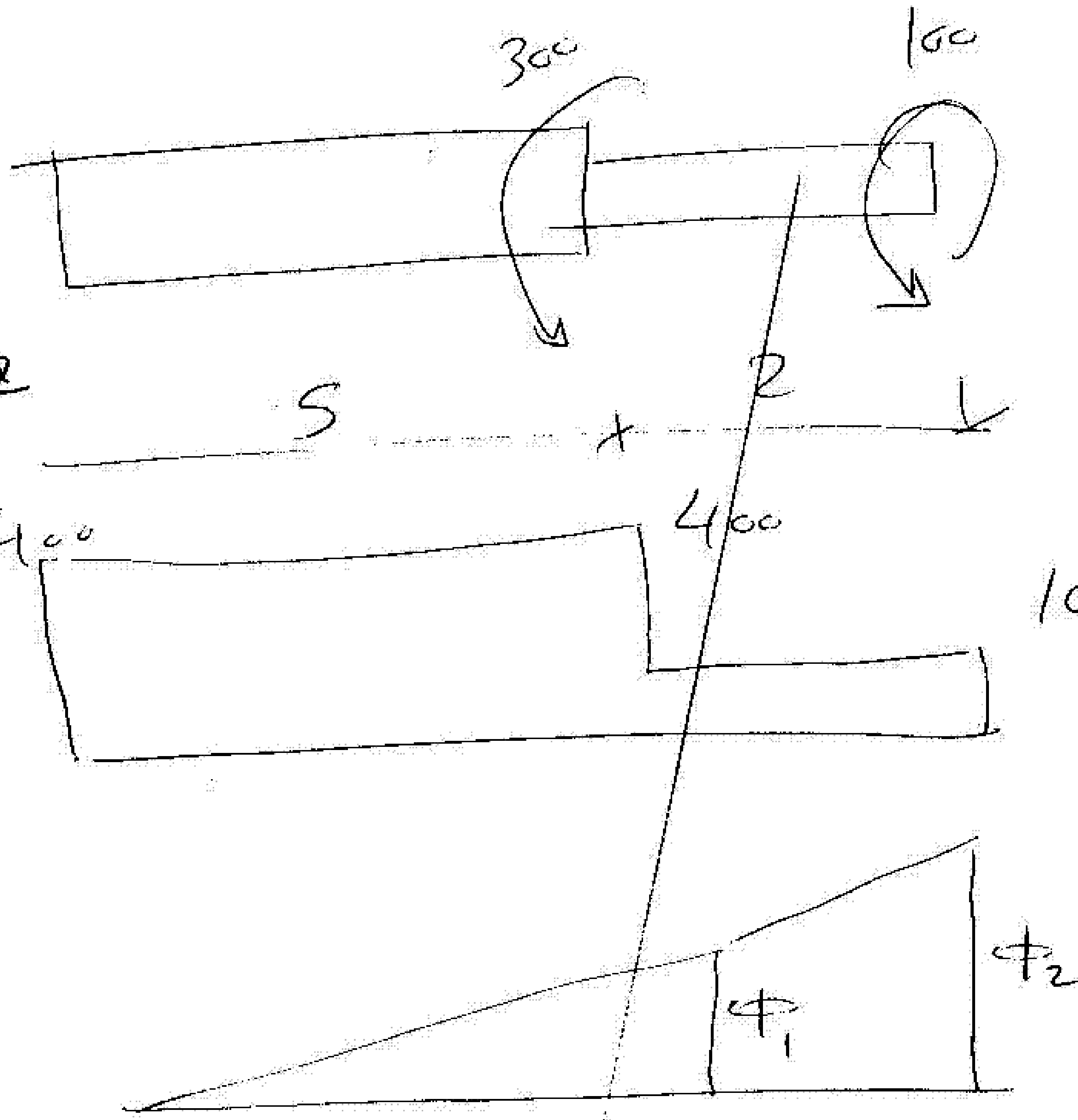
8

$$+ \frac{1}{EA}\left[\frac{1}{\sqrt{2}} * 15\sqrt{2} * 4\sqrt{2} \right]$$



$$\boxed{\begin{aligned} y_d &= 0.0105 \text{ m} \downarrow \\ &= 1.05 \text{ cm} \downarrow \end{aligned}}$$





$\tau_{all} = 500\ kg/cm^2$

$d = ?$

$\phi = ?$

$\sigma = 500\ t/cm^2$

$$\tau = \frac{M_t\, R}{I_p} = \frac{\overset{t.m}{400} \times \overset{m}{d/2}}{\pi d^4/32} \leq 500 \times \frac{10^{-3}}{10^{-4}}$$

$$= \frac{2037.18}{100 d^3} \leq 5000$$

$$d^3 \geq 0.407$$

$$d \geq 0.74\ m$$

$$\boxed{\begin{array}{c} d = 16 \\ R = 8\ cm \end{array}}$$

$$\phi = \phi_1 + \phi_2$$