الكورس الاول
السعـر/

محاضرة / -2-
التاريخ /

Engineering Mechanics

الميكانيك الهندسي

لطلبة الدراسات الاولية

المرحلة الاولى

قسم الهندسة الموارد المائية

Dr. Khitam Abdulhussein

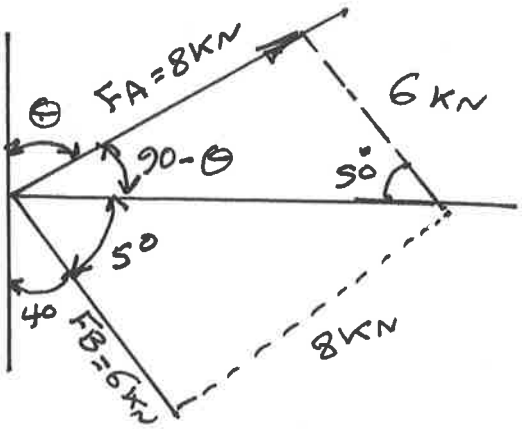
النسخة الأصلية
في مكتب الغدير داخل كلية الهندسة / الفرع الاول
مكتب الغدير 2 مقابل كلية الهندسة / الفرع الثاني
بأدارة / عادل الكناني

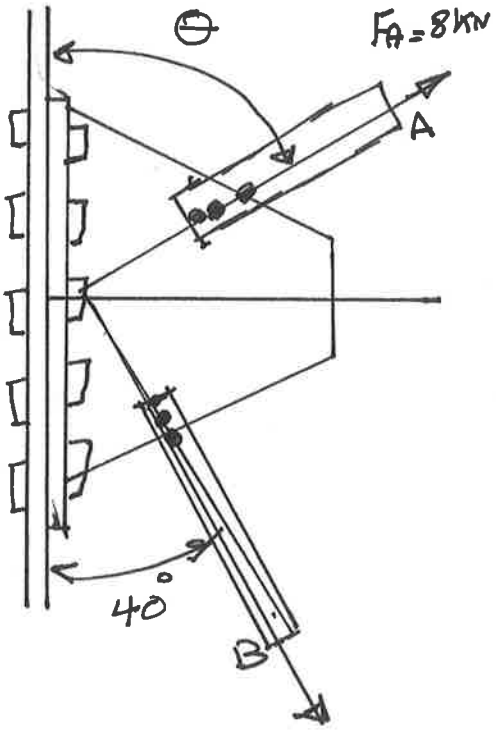
2018 - 2019

Ex.1 Determine the angle θ so that the resultant force directed horizontally to the right. Also find magnitude of the resultant

Solution

Parallelegram Law: as shown in fig. below:



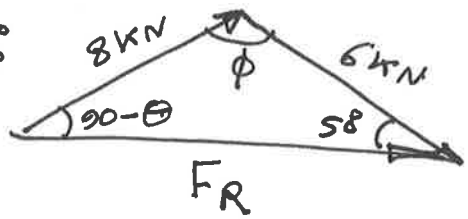


by using law of sines

$$\frac{\sin(90^\circ-\theta)}{6} = \frac{\sin 50^\circ}{8} \Longrightarrow \theta = 54.93^\circ = 54.9^\circ$$

From the triangle, $\Longrightarrow$

$$\phi = 180^\circ-(90^\circ-54.9)-50 = 94.93^\circ$$

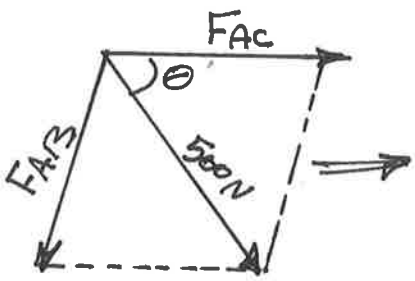


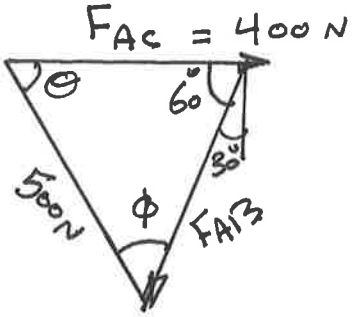
by law of cosines, it can be fined the magnitude of F_R as

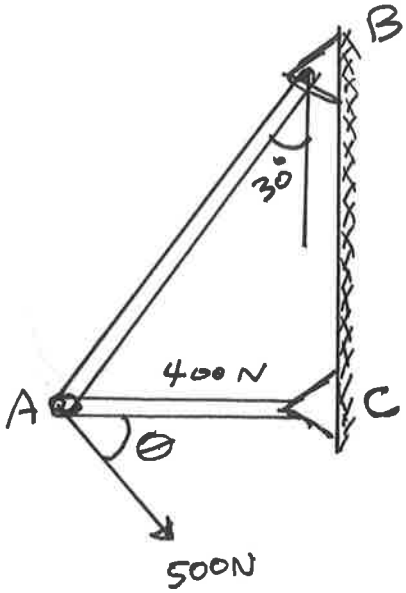
$$F_R = \sqrt{8^2+6^2-2(8)(6)\cos 94.93^\circ} = 10.4 \text{ KN}$$

Ex:2 For the frame shown, determine the angle Θ so that the horizontal component FAC has a magnitude of 400 N, also find F_{AB}

Solution :-







$$\frac{400}{\sin\phi} = \frac{500}{\sin 60^\circ}$$

$$\sin\phi = 0.6928$$

$$\phi = 43.85^\circ$$

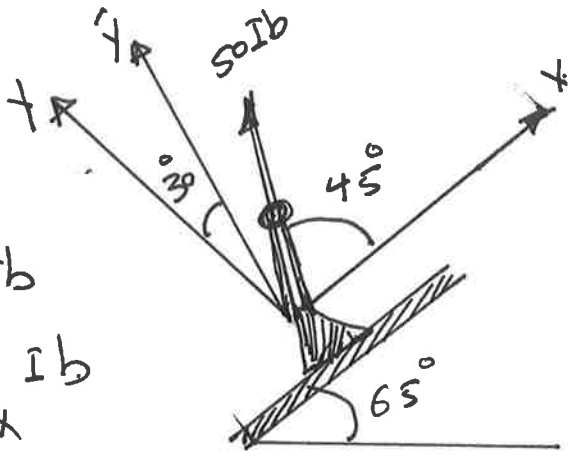
$$\Theta = 180 - (60 + 43.85) = 76.15^\circ$$

$$\therefore \frac{F_{AB}}{\sin 76.15} = \frac{500}{\sin 60} \longrightarrow F_{AB} = 560.56\ N$$

OR $$F_{AB} = \sqrt{500^2 + 400^2 - 2(500)(400)\cos 76.15}$$

$$F_{AB} = 560.56\ N$$

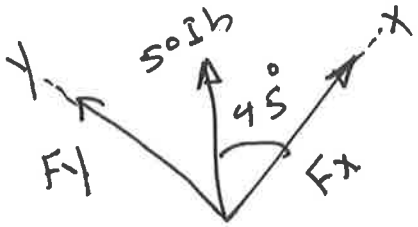
Ex:3 Resolve the 50 lb force into components acting along (a) the x and y axes, and (b) the x and ý axes.



Solution :-

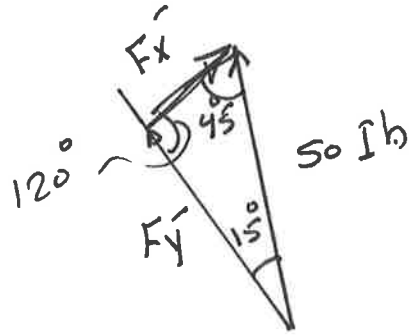
(a) $F_x = 50 \cos 45^\circ = 35.4$ lb

$F_y = 50 \sin 45^\circ = 35.4$ lb

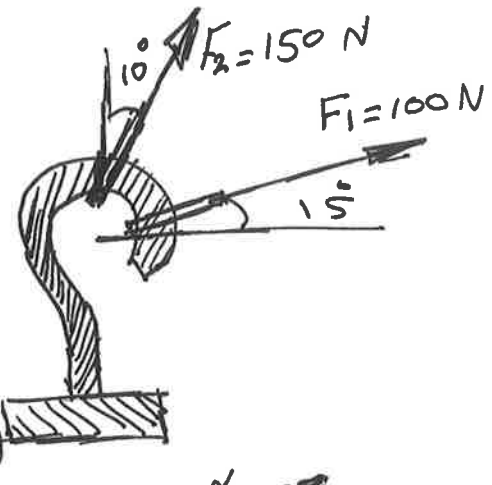


(b) $\frac{F_{\acute{x}}}{\sin 15^\circ} = \frac{50}{\sin 120^\circ} \longrightarrow F_{\acute{x}} = 14.9$ lb

$\frac{F_{\acute{y}}}{\sin 45^\circ} = \frac{50}{\sin 120^\circ} \longrightarrow F_{\acute{y}} = 40.8$ lb



Ex:4 The screw eye shown is subjected to two forces F_1 and F_2. Determine the magnitude and direction of the resultant force.

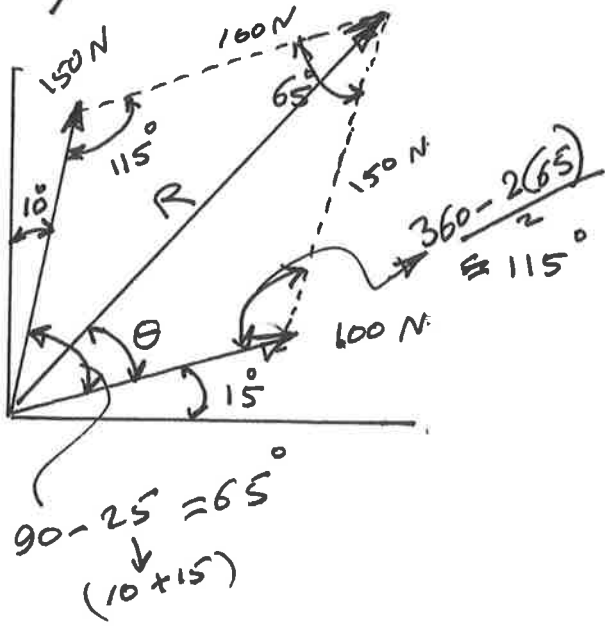


Solution:-

$$R = \sqrt{(100N)^2 + (150N)^2 - 2(100N)(150N)\cos 115^\circ}$$

$$R = \sqrt{10000 + 22500 - 30000(-0.4226)}$$

$$R = 213\ N$$

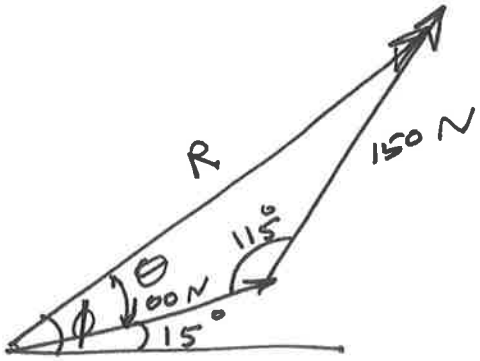


Applying the law of sines to determine θ

$$\frac{150\ N}{\sin\theta} = \frac{212.6N}{\sin 115^\circ}$$

$$\sin\theta = \frac{150\ N}{212.6N}(\sin 115^\circ)$$

$$\theta = 39.8^\circ$$



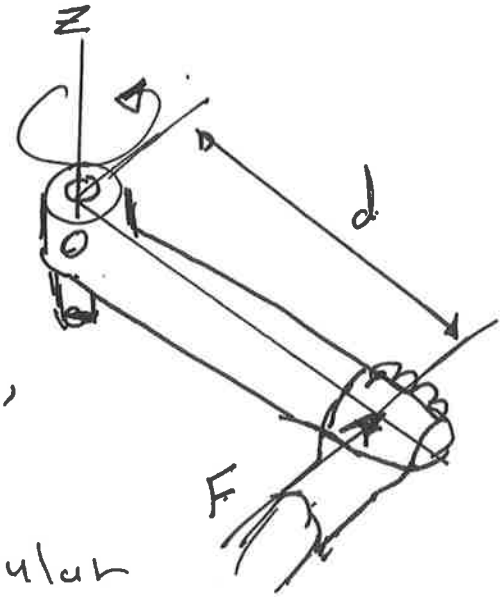
Thus, the direction (ϕ) of R measured from the horizontal is

$$\phi = 39.8^\circ + 15.0^\circ = 54.8^\circ$$

Moment and Couples

1- Moment of a force

- The moment of a force about a point or axis provides a measure of the tendency of the force to cause a body to rotate about the point or axis.

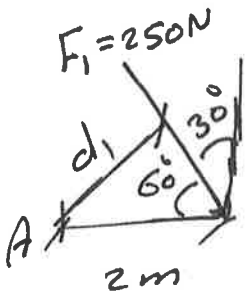


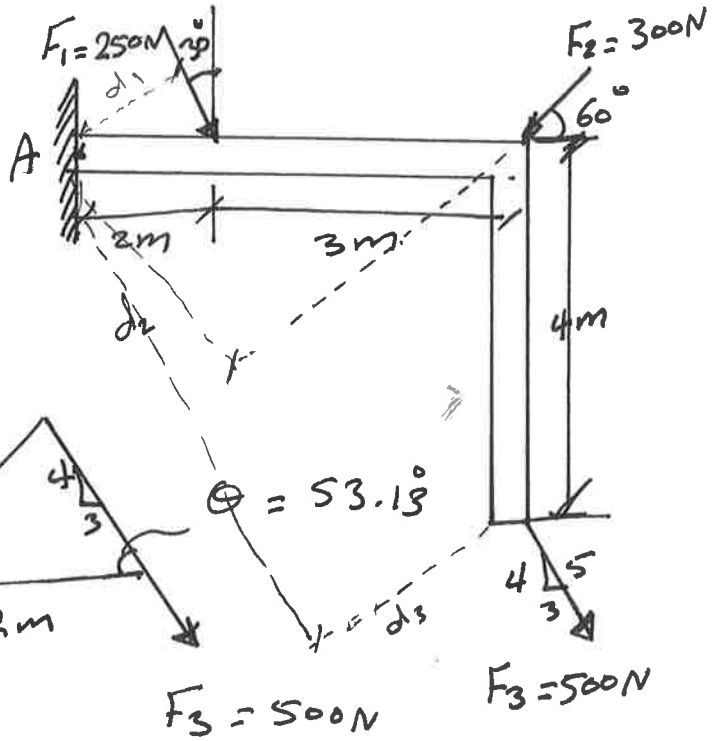
- The force F and the point O lie in a plane. The moment about the point O, or about an axis passing through O and perpendicular to the plane is a vector quantity.

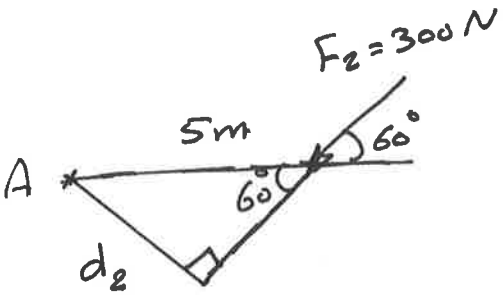
The magnitude of M is : $M = F \cdot d$

where d is the moment arm or perpendicular distance from point O to the line of action of the force F. Units of moment consist of force times distance, e.g. N.m or lb.ft.

Ex:- Determine the moment of each of the three forces about point A







The moment arm measured perpendicular to each force from point A is

$d_1 = 2 \sin 60 = 1.732\,m$ $\rightarrow \sin 60 = \frac{d_1}{2}$

$d_2 = 5 \sin 60^\circ = 4.330\,m$ $\rightarrow \sin 60 = \frac{d_2}{5}$

$d_3 = 2 \sin 53.13^\circ = 1.60\,m$ $\rightarrow \sin \frac{53.13}{} = \frac{d_3}{2}$

Using each force where $M_A = Fd$ we have

$(+\circlearrowright)(M_{F_1})_A = -250\,(1.732)$

$= -433\,N.m = 433\,N.m$ (clockwise)

$$\overset{+}{\circlearrowright}(M_{F_2})_A = -300(4.33) = -1299\ N.m = 1.3\ kN.m \quad \text{(clockwise)}$$

$$\overset{+}{\circlearrowright}(M_{F_3})_A = -500(1.60) = -800\ N.m = 800\ N.m \quad \text{(clockwise)}$$

2- Resultant moment of a system of Coplanar Forces:

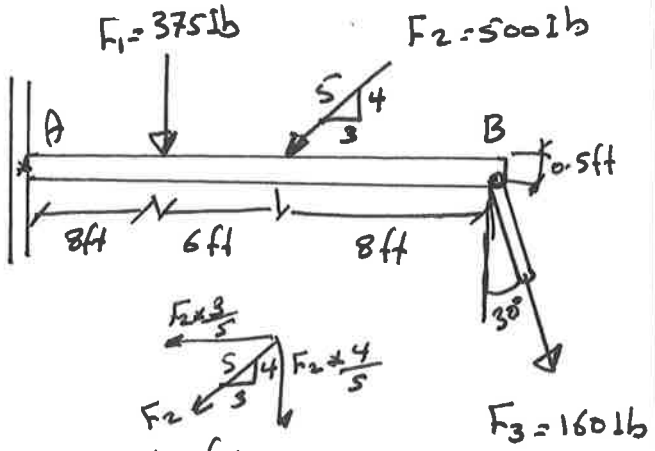
Resultant moment M_R of the system can be determined by adding the moments of all forces algebraically.

or $\overset{+}{\circlearrowright} M_R = \sum Fd$

The moment of any force will be positive if is rotate the body clockwise, whereas a negative moment rotate the body counterclockwise.

Ex:- Determine the moment about point B of each of the three forces acting on the beam.

Solution:



$$+\circlearrowright (M_{F_1})_B = 375 * 14$$

$$= 5250 \text{ lb.ft}$$

(Counterclockwise)

$$+\circlearrowright (M_{F_2})_B = 500\left(\frac{4}{5}\right) * 8 = 3200 \text{ lb.ft}$$

(Counter clockwise)

$$+\circlearrowright (M_{F_3})_B = 160 \sin 30^\circ (0.5) - 160 \cos 30^\circ (0)$$

$$= 40 \text{ lb.ft} \quad \text{(Counter clockwise)}$$

Ex:- For the power pole shown, determine the resultant moment about base O. Then determine the resultant moment if line A removed.

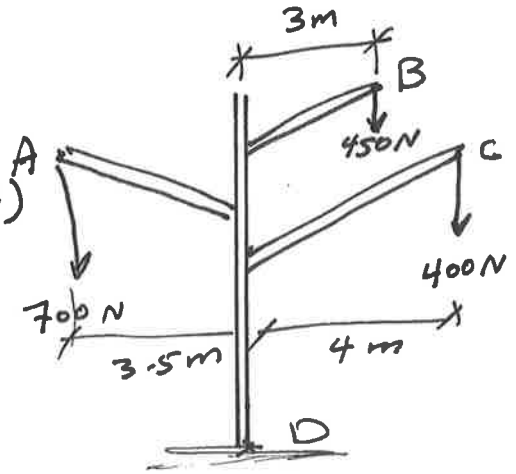
Solution

$$\circlearrowright M_{R_O} = \Sigma Fd$$

$$M_{R_O} = 700(3.5) - 450(3) - 400(4)$$

$$= -500 \text{ N.m} = 500 \text{ N.m}$$

(clockwise)



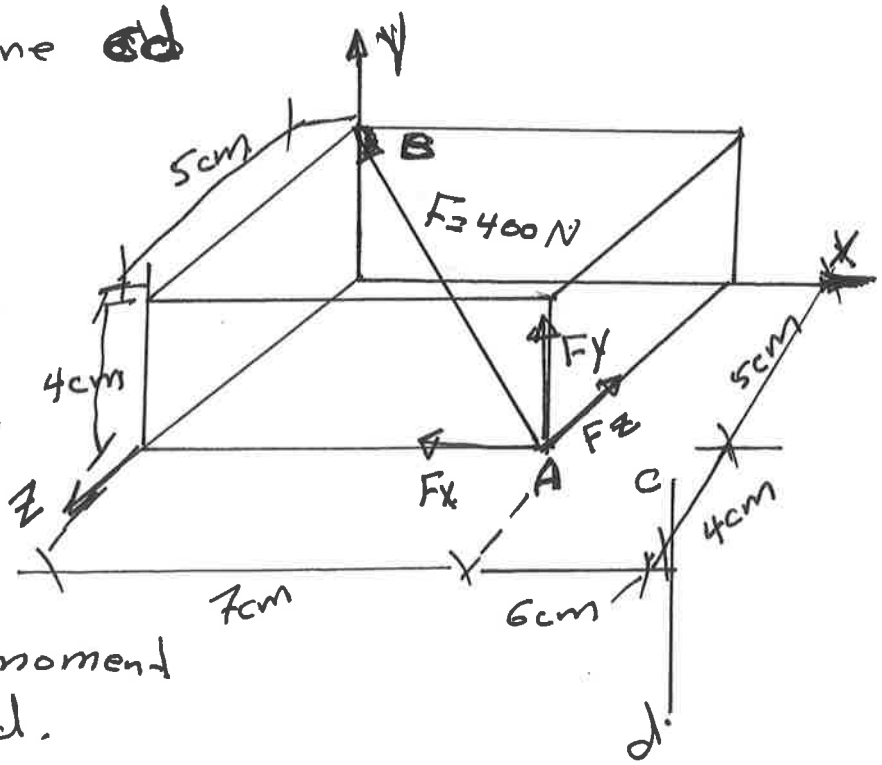
when the cable A is removed it will create the greatest moment at point D

$$\circlearrowright (M_{R_D}) = \Sigma F_d$$

$$= -450(3) - 400(4)$$

$$= -2950 \text{ N.m} \quad \text{(clockwise)}.$$

Ex:- Determine the moment of force F with respect to the vertical line cd



Solution

the length of AB is

$\sqrt{4^2+5^2+7^2} = 9.49$ cm

$\therefore$ the scale for $F = \frac{400}{9.49}$

$F = 42.2$ N/cm

since Fy // cd,

therfore it has no moment with respect to cd.

$F_x = 42.2(7) = 295$ N ←

$F_x = F\cos\theta_x \Rightarrow 400 * \frac{7}{9.49}$

$F_z = 42.2(5) = 211$ ↗

$$\Sigma M_{cd} = -295(4) + 211(6)$$

$$= +86$$

$\therefore M_{cd} = 86$ N.C

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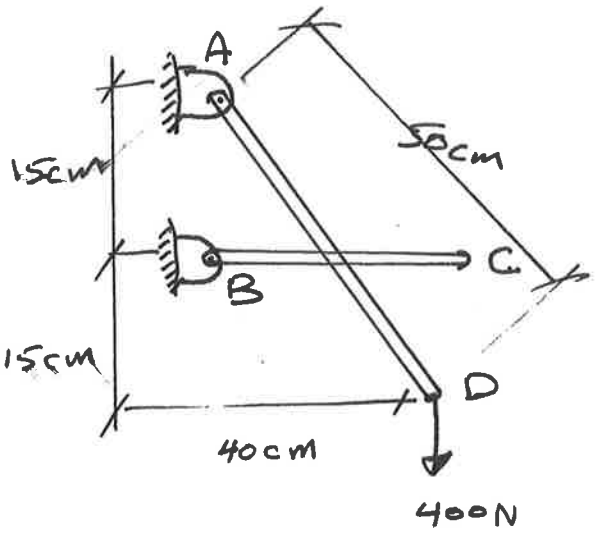
Problems

1-25 Determin the moment of the force with respect to the point A for each system shown in fig.

Solution

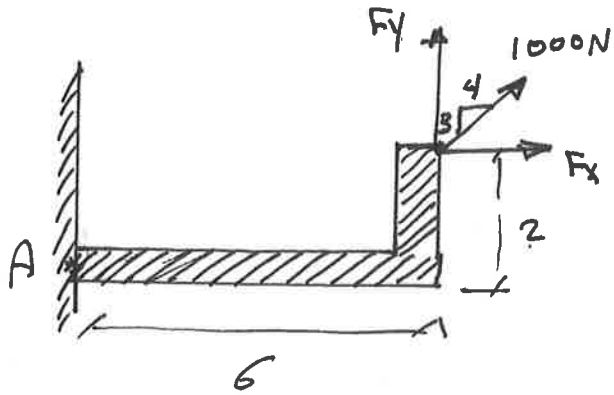


(a)

$$+\circlearrowright \quad M_A = 400 \times 40$$

$$= 16000 \text{ N.cm} \circlearrowright$$

(b)



$$F_x = 1000 \times \frac{4}{5} = 800\,N \rightarrow$$

$$F_y = 1000 \times \frac{3}{5} = 600\,N \uparrow$$

$$+\circlearrowright$$

$$\Sigma M_A = 800 \times 2 - 600 \times 6$$

$$= 1600 - 36000$$

$$= -2000 \circlearrowright$$

$$= +\,2000 \text{ N.cm} \circlearrowleft$$

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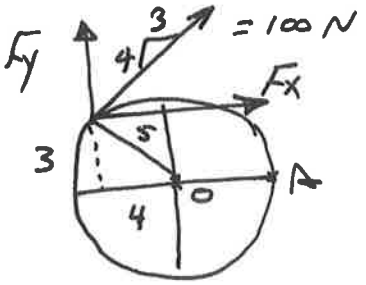
(c) $F_x = 100 \times \frac{3}{5} = 60\ N \rightarrow$

$F_y = 100 \times \frac{4}{5} = 80\ N \uparrow$



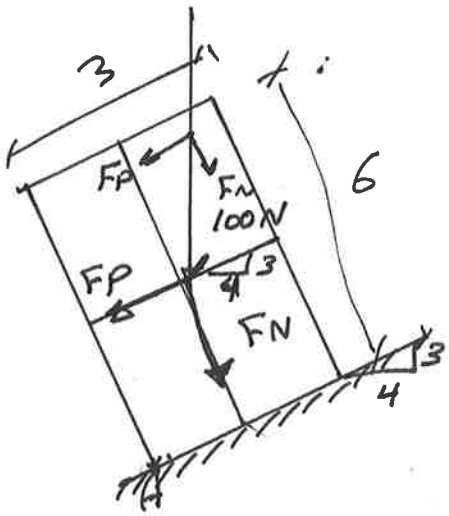
$+\circlearrowright \Sigma M_A = 60 \times 3 + 80(4+5)$

$= 180 + 720 = 900\ N.cm \circlearrowright$

1-26 Determine the moment of the force with respect to point A

(a) $F_P = 100 \times \frac{3}{5} = 60\ N$

$F_N = 100 \times \frac{4}{5} = 80\ N$



$+\circlearrowright \Sigma M_A = 80(1.5) - 60(3)$

$= 120 - 180 = -60$

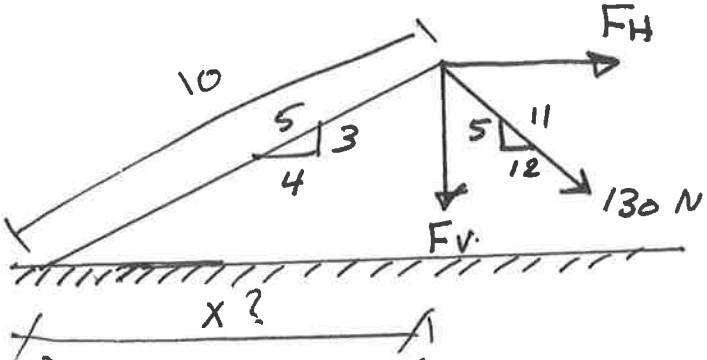
$= 60\ N.cm. \circlearrowleft$

(b) $F_H = 130 \times \frac{12}{13}$

$= 120\ N \rightarrow$

$F_V = 130 \times \frac{5}{13}$

$= 50\ N \downarrow$



$+\circlearrowright \Sigma M_A = 50(8) + 120(6)$

$= 1120\ N.cm \circlearrowright$

$\frac{4}{5} = \frac{X}{10} \Rightarrow X = 8$

1-28 (a) Determine the moment of the 260 N force at point-A - (1) if resolved at B (2) if resolved at C

(b) Determine the ⊥ distance from (A) to point A By using the principle of moments.

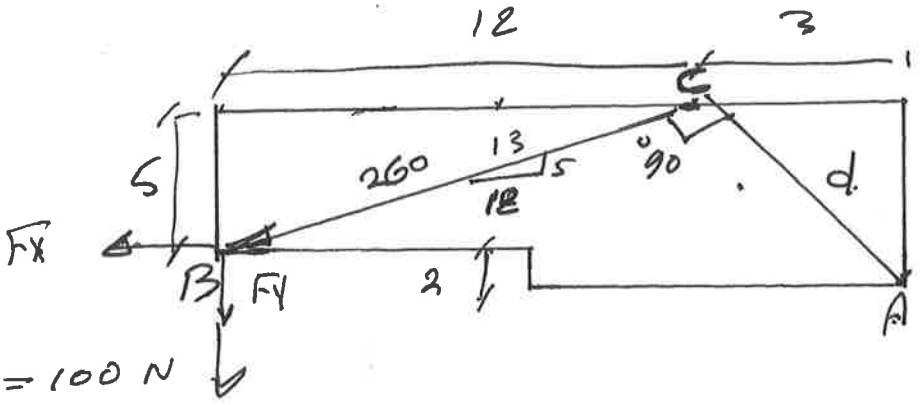
(a)

↓

(1) $F_x = 260 * \frac{12}{13}$

$= 240\ N \leftarrow$

$F_y = 200 * \frac{5}{13} = 100\ N$



$(+\circlearrowleft)_{(1)}\ \Sigma M_A = 240(2) + 100(15)$

$= 480 + 1500 = 1980\ N.cm$ ↺

(2) $(+\circlearrowleft)\ \Sigma M_A = 240(7) + 100(3)$

$= 1680 + 300 = 1980$ ↺

(b) The moment of force = Σ Moment of its components

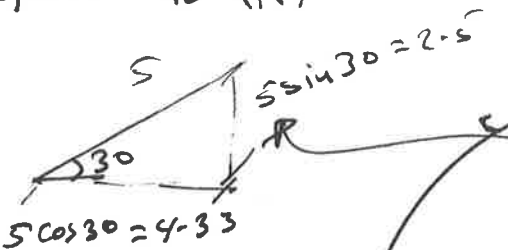
$260(d) = 1980$

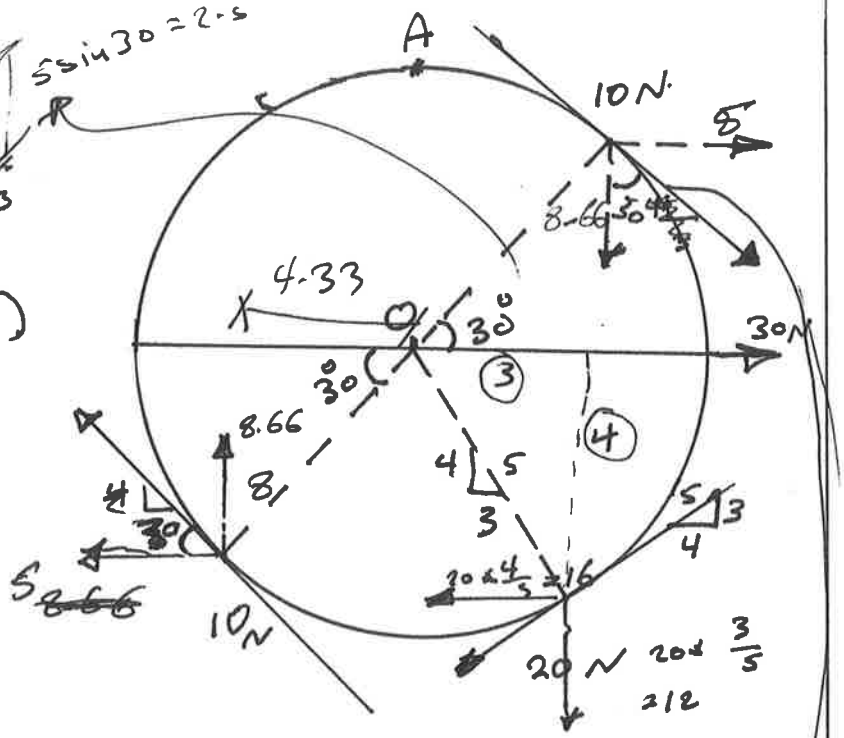
$\therefore d = \frac{1980}{260} = 7.61\ cm$

1-30 Determine the moment of the force system

(a) with respect to (O)
(b) with respect to (A)

Solution :-





(a)

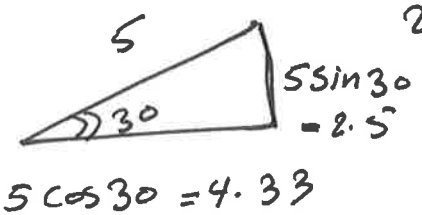
$$\sum M_O = 10(5) + 10(5) + 20(5)$$

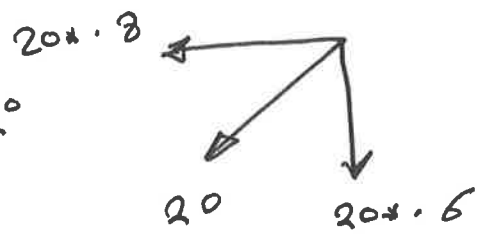
$$= 200 \text{ N.cm} \circlearrowright$$

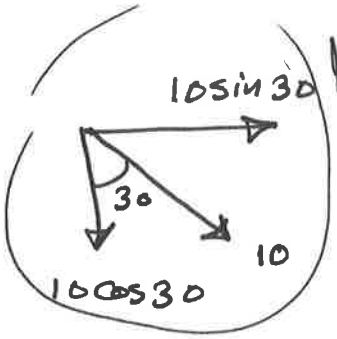
(b)

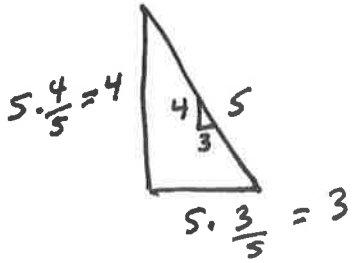
$$\sum M_A = 8.66(4.33) - 5(5-2.5) + 8.66(4.33) + 5(5+2.5) - 30(5) + 16(5+4) + 12(3)$$

$$= 130 \text{ N.cm} \circlearrowright$$









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1-34 (a) Determine the moment of the forces with respect to a-axis.

(b) Determine the ⊥ distance from the 130 N force to the a-axis

$L = \sqrt{5^2+12^2+4^2}$

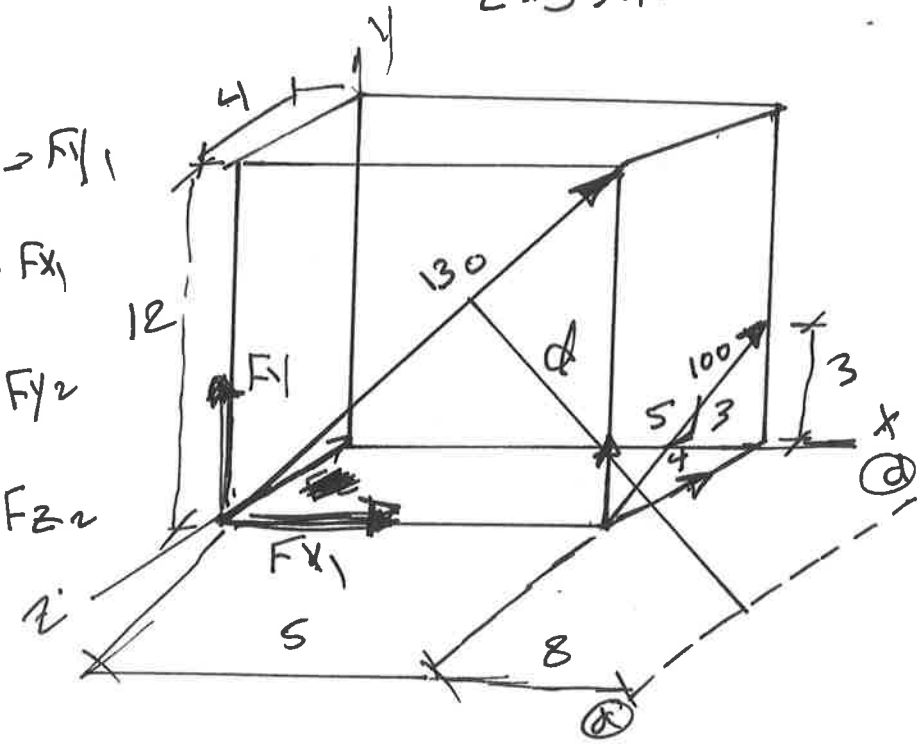
(a)

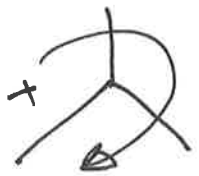
$130 \times \frac{12}{13} = 120\ N \Rightarrow F_{y1}$

$130 \times \frac{5}{13} = 50\ N = F_{x1}$

$100 \times \frac{3}{5} = 60\ N = F_{y2}$

$100 \times \frac{4}{5} = 80\ N = F_{z2}$

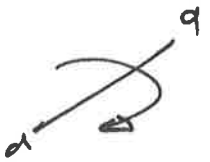




$\Sigma M_{a-a} = 120(13) + 60(8)$

$= 1560 + 480$

$= 2040\ N.cm$



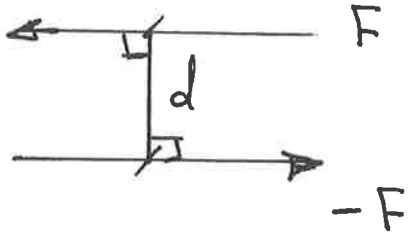
(b) mom. of a force = ΣM of it compon.

$130(d) = 1560$

$\therefore d = \frac{1560}{130} = 12\ cm$

Couples

A couple is defined as two parallel forces that may have the same magnitude, and opposite directions, and are separated by a perpendicular distance



- since the resultant of the two forces is zero, the only effect of a couple is to produce a rotation.
- The moment produced by a couple ~~moment~~ called a couple moment and is

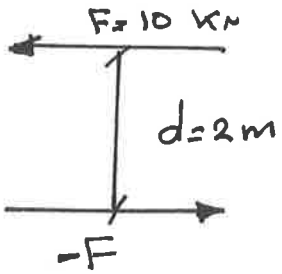
$$M_c = F \cdot d$$

where F is a magnitude of one of the forces and, d is the perpendicular distance between the two forces.

Ex:1 Determine the magnitude of the couple

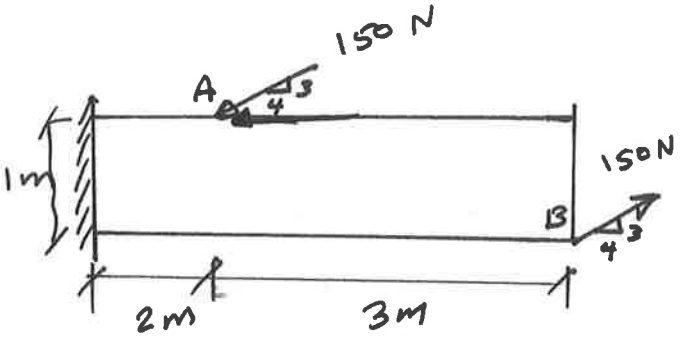
Solu:

$$\curvearrowright M_c = F \cdot d$$
$$= 10 * 2 = 20 \text{ KN.m} \curvearrowright$$

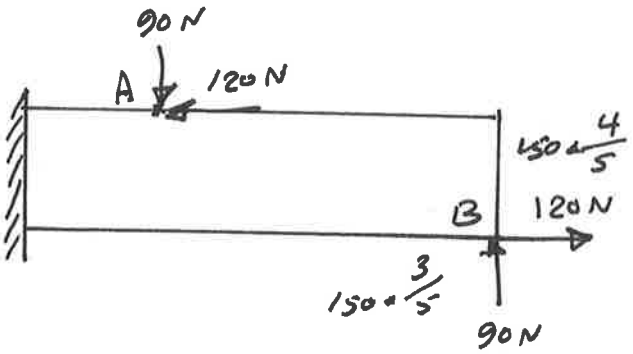


Ex: 2 Determine the magnitude of the couple.

Solu:
It is difficult to find the perpendicular distance between the forces.



Thus, we can resolve each force into components.



$F_x = 150\left(\frac{4}{5}\right) = 120\ N$

$F_y = 150\left(\frac{3}{5}\right) = 90\ N$

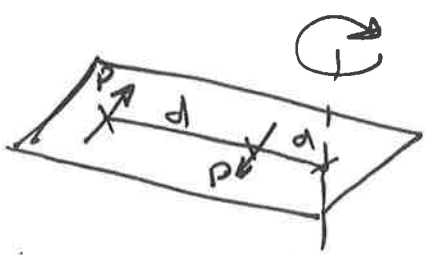
There are two couples,

$M_1 = 120\,(1) = 120\ N.m$ ↻

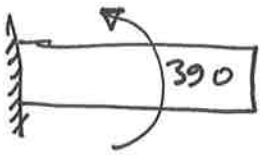
$M_2 = 90\,(3) = 270\ N.m$ ↻

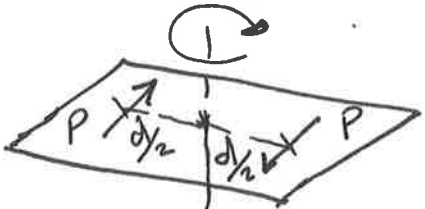
$M_C = 120 + 270 = 390\ N.m$ ↻

- Notice that the couple moment can be act at any point of the member since the Mc is free vector



$M = P(d+a) - P(a)$
$= Pd + Pa - Pa$
$= Pd$



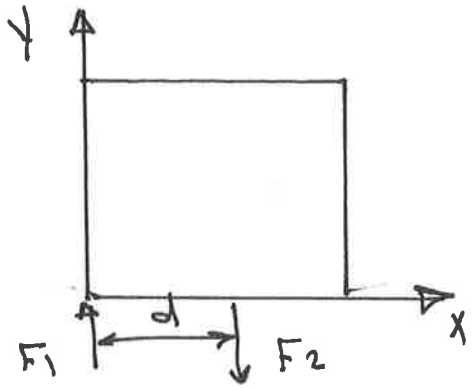


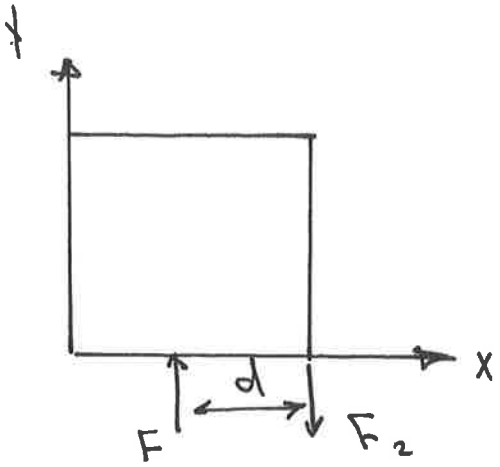
$M = P\left(\frac{d}{2}\right) + P\left(\frac{d}{2}\right)$
$= Pd$

Transformations of A couple:

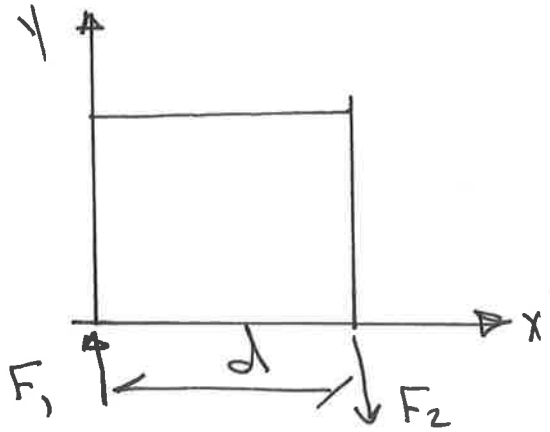
Transformations of a couple are operations on the couple that do not change any of its characteristics.

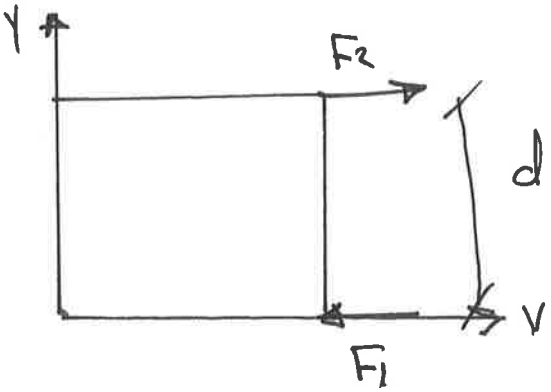
1- The couple is moved to a parallel position in its plan.



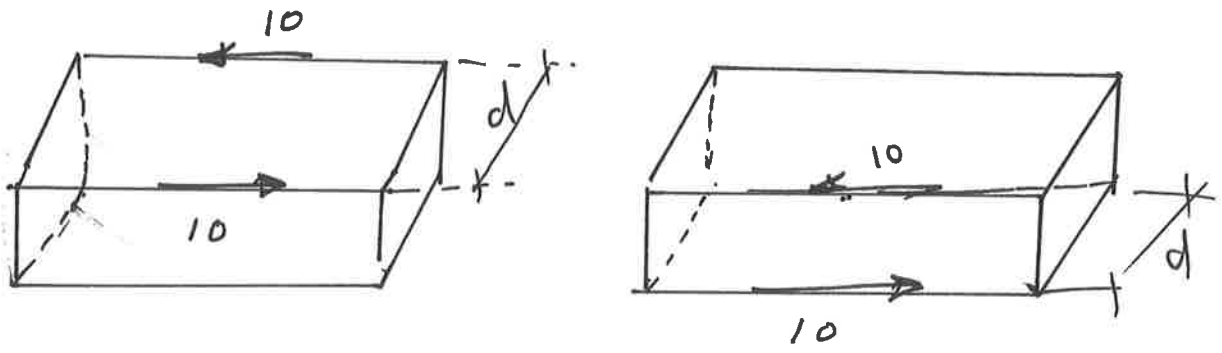


2- The couple is rotated in its plane.



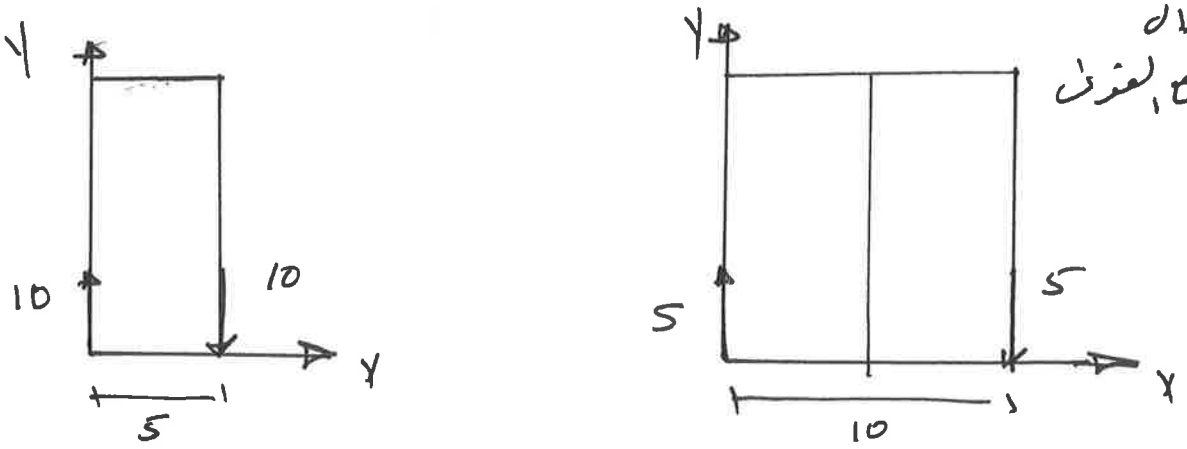


3- The couple is moved to aparellel plane.



4- The distance between the forces of the couple is the magnitude of the forces are changed, provided the moment remains the same

حيث استبدال المسافة مع العزم



Al-Mustansiriyah University
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Engineering Mechanics

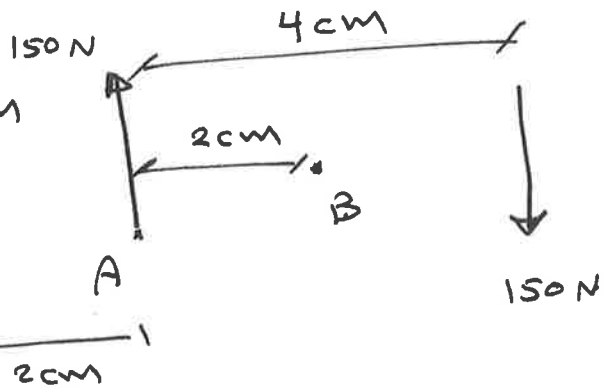
The date: 18-11-2018
Lecturer: Dr: Khitam Abdulhussein

Problems :

1-39: Determine the moment of the couple in fig. with respect to (a) point A (b) point B (c) point C

Solu:

(a) $M_A = 150 * 4 = 600$ N.cm



(b) $M_B = 150 \times 2 + 150 \times 2$

$= 600$ N.cm

(c) $M_C = 150 * 6 - 150 \times 2$

$= 600$ N.cm

1-40: By using the transformations of acouple, replace the three couple of fig. by one couple with the forces acting horizontally at A and B.

Solu:

$M = 200 \times 2 = 400$ ↷

$M = F.d$

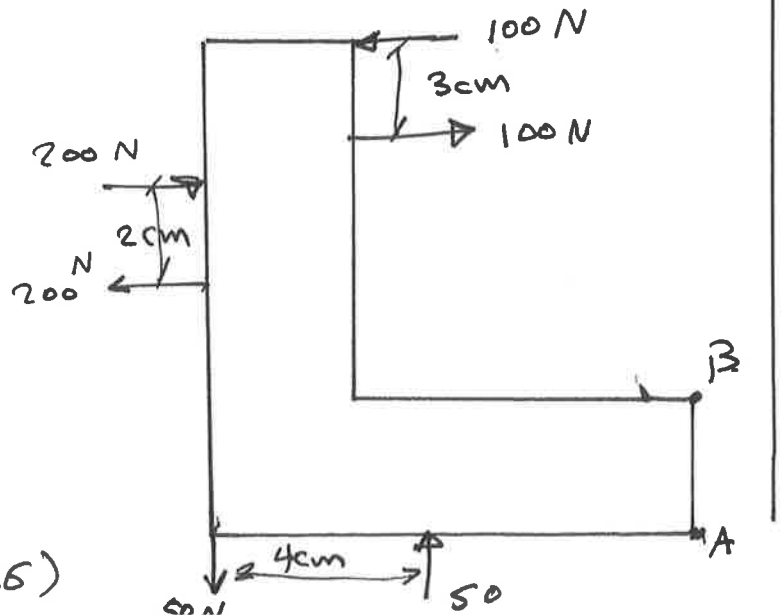
$100 \times 3 = 300$ ↷

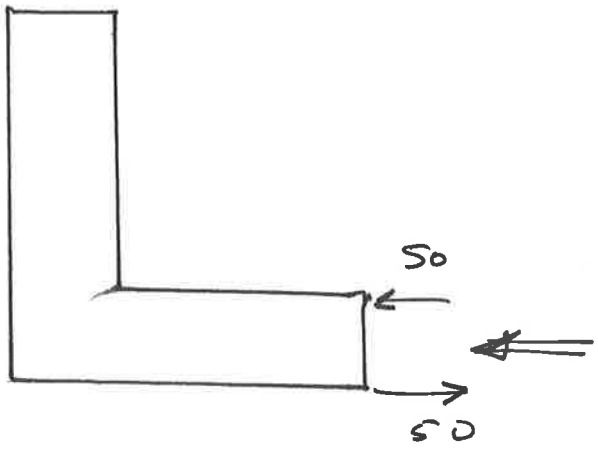
$\frac{300}{2} = 150$

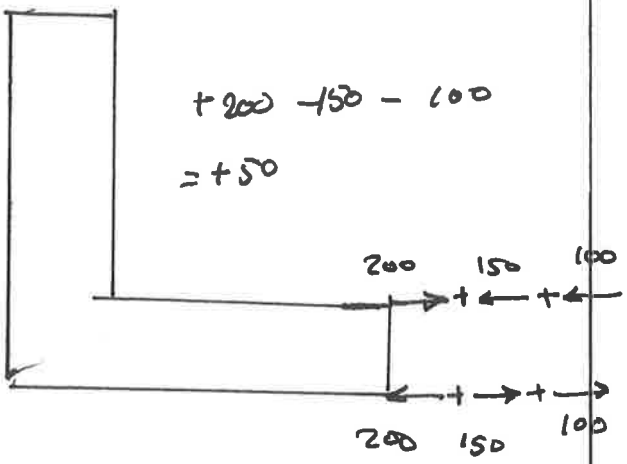
$50 * 4 = 200$ ↶

$\frac{200}{2} = 100$

$\frac{400}{2} = 200$



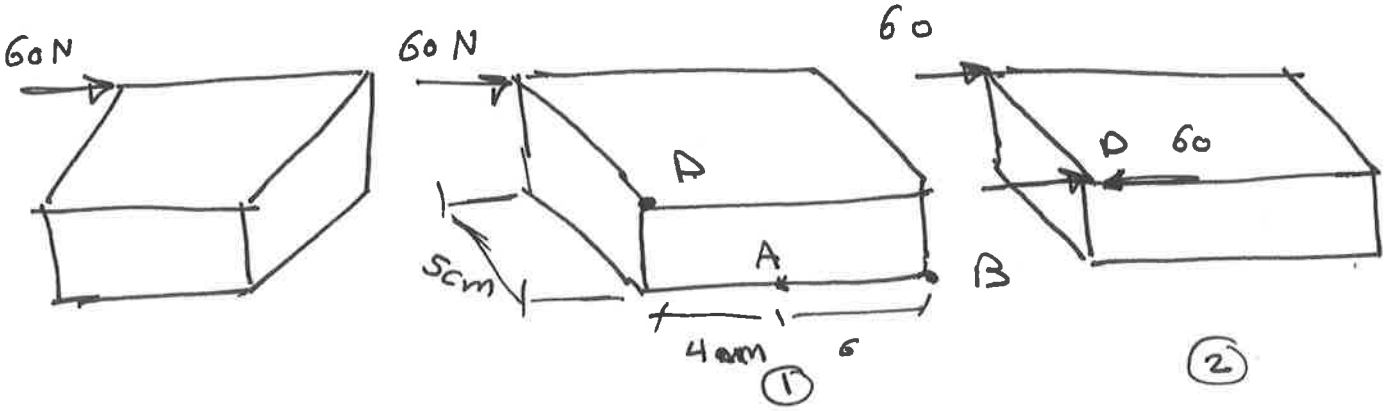


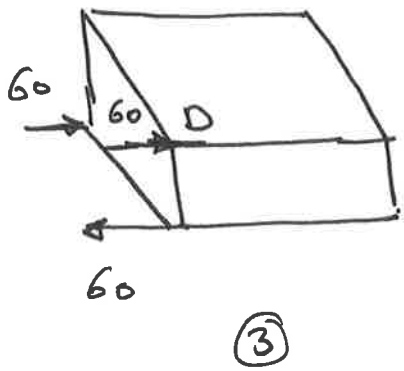


Resolution of a force into a force and couple:

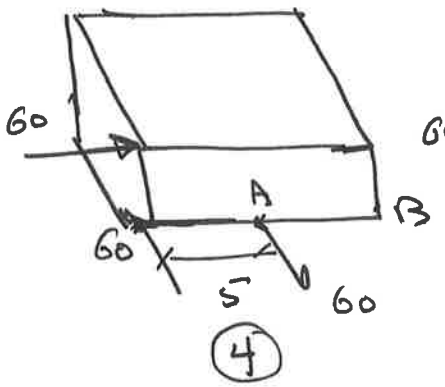
A force may be replaced by an equal parallel force through any other point of the body and a couple. This can be done by adding two equal collinear forces of opposite sense to a force system on a rigid body.

Ex:- Replace the 60 N force shown in the fig. by a force through D and a couple where forces act horizontally through A and B

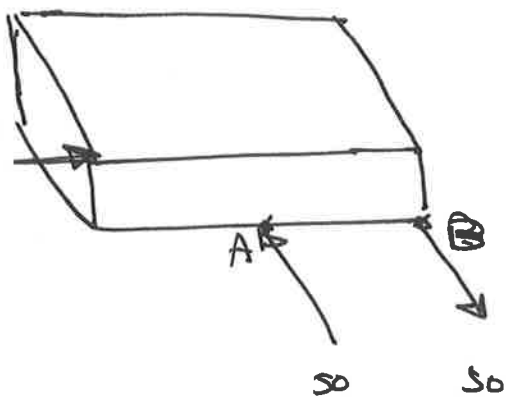




③

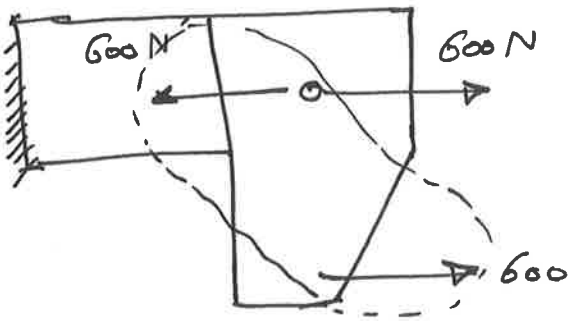


④

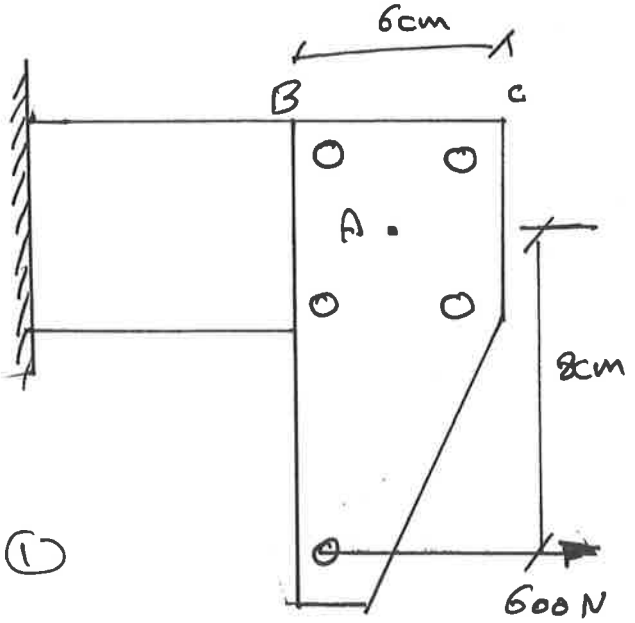


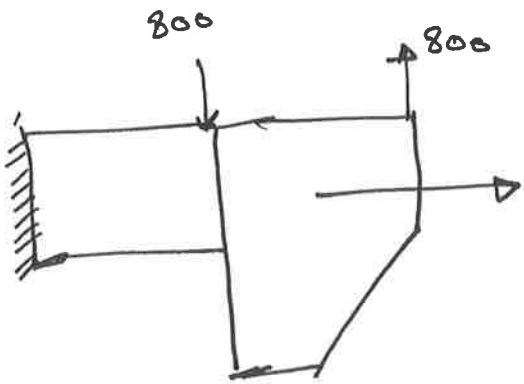
1.44 Replace the 600 N force by a force through A and a couple whose forces act vertically through points B and C.

Solu:



$600 * 8 = 4800$ ↻ ... (1)

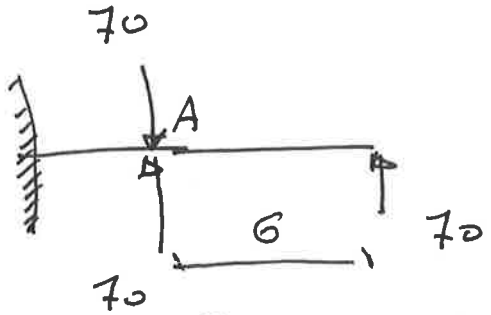


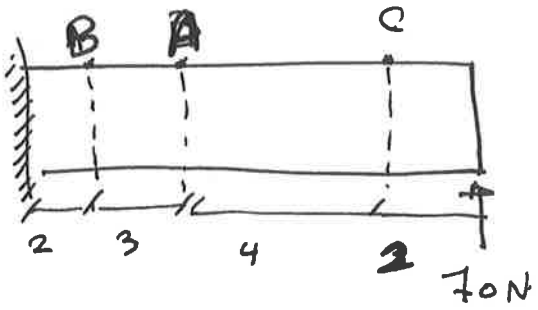


— — (2)

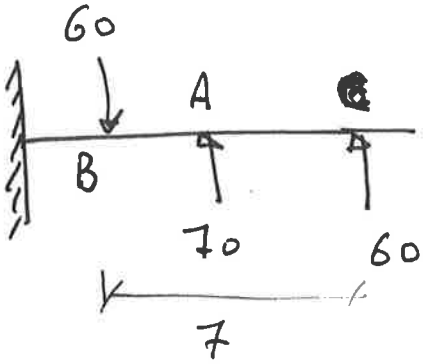
$\frac{4800}{6} = 800\ N$

1.45 By transformation of a couple replace the 70 N force by a force through A and a couple whose forces act vertically through B and C.



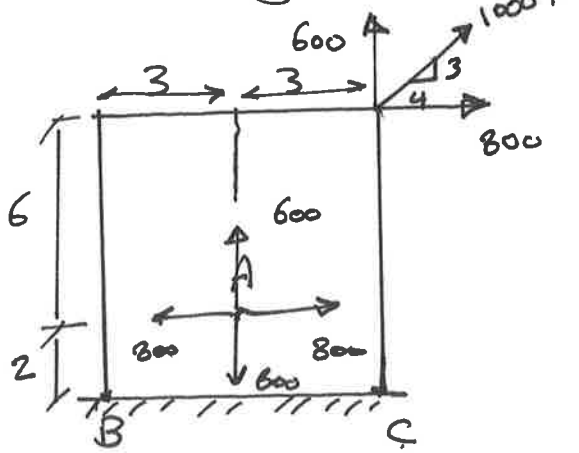


① $70 \times 6 = 420$



$\frac{420}{7} = 60$

1.48 Replace the 1000 N force by a force through A and couple whose forces and vertically through B and C.



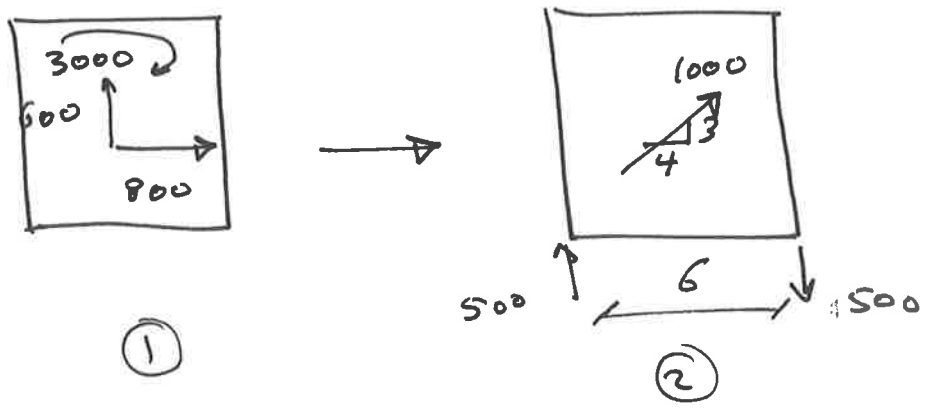
Solu

Σ couples $= 800 * 6 - 600 \times 3$

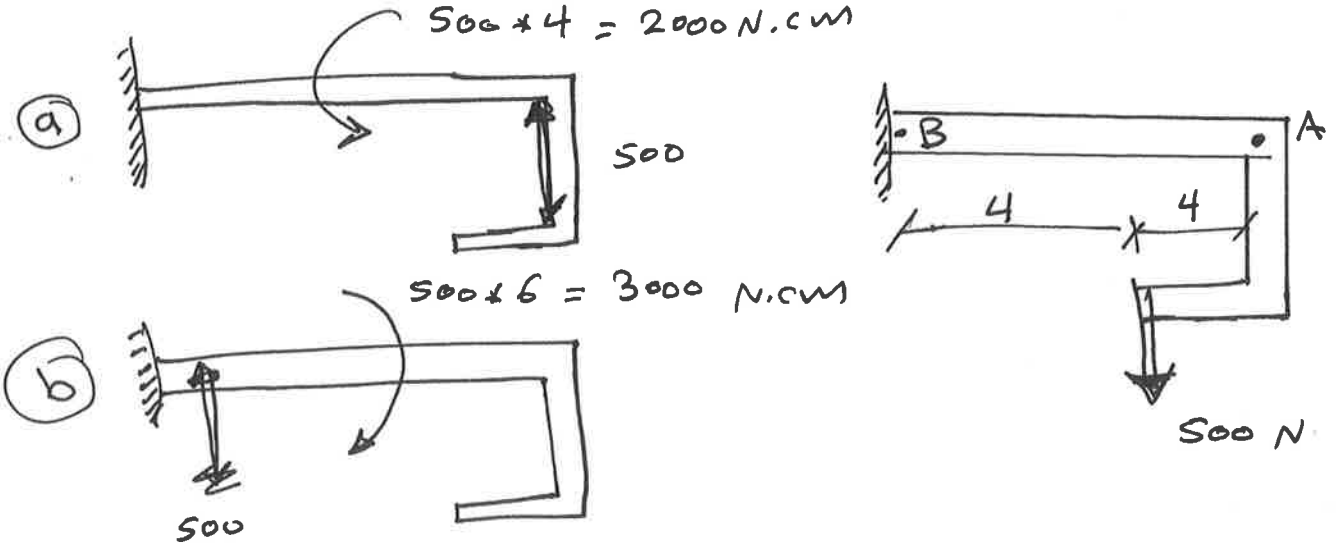
$= 4800 - 1800 =$

$= 3000$ N. cm

$\frac{3000}{6} = 500$



1-51 Replace the 500 N force by (a) a force through A and a couple (b) a force through B and a couple.



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1.53 Replace the two 100 N forces with a single force acting through G and a couple whose forces act vertically at A and B

Solu:

$L = \sqrt{1^2 + 1^2}$

$= \sqrt{2}$

$100 = R * \frac{1}{\sqrt{2}}$

$R = \frac{100}{1/\sqrt{2}}$

$= 141.42\ N$

$141.42 * 3 = 424.26$

$424.26/2 = 212.13$