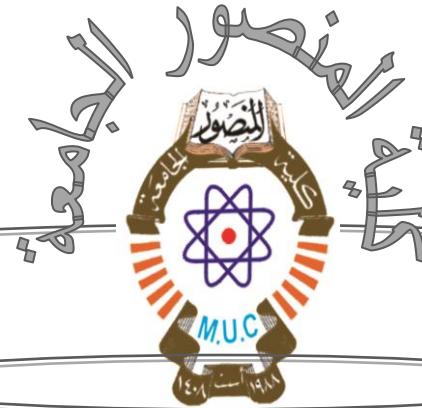


قسم الهندسة المدنية

المرحلة الاولى

Al-Mansour University College



Civil Eng. Dept.

1st. Stage

Engineering Mechanics

2022-2023

1

الميكانيك
الهندسية

د. عبد الله سنان

Force Systems

Quantities

الكميات

1) Scalar Quantities

١) القيميات القياسية

A scalar is any positive or negative physical quantity that has magnitude only

هي القيميات التي يكفي لتصنيفها معرفة قيمتها فقط

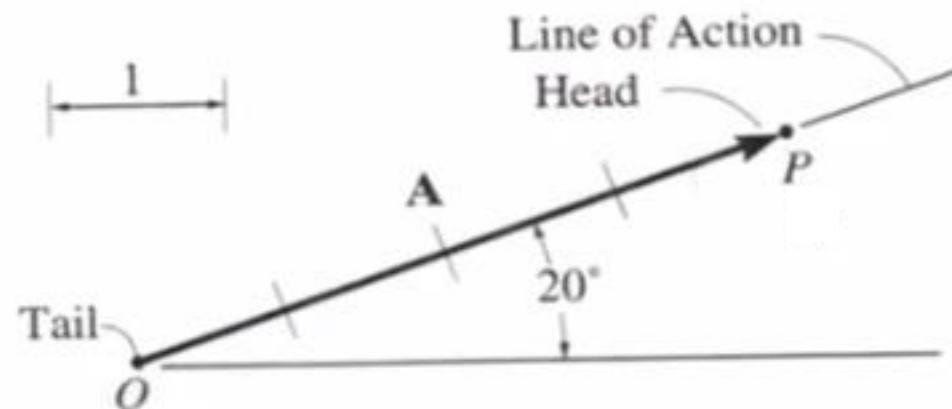
Examples :- length, mass, and time

مثال : الطول ، الكتلة ، الزمن

2) Vector Quantities

A vector is a quantity that possesses magnitude and direction

٢) الكميات المتجهة



هي الکمیات التي یلزم لتصویفها معرفة قیمتها واتجاهها

Examples :- force , displacement , and acceleration

مثال : القوة ، الإزاحة ، العجلة

Vector Addition of Forces جمع القوى إتجاهياً

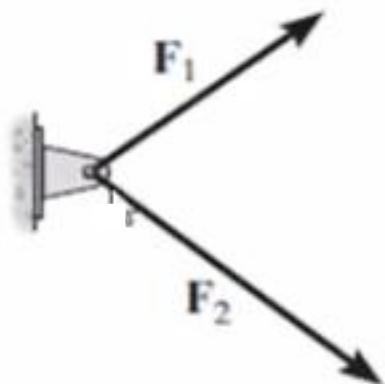
- ▶ Finding a Resultant Force إيجاد محصلة القوى
- ▶ Finding the Components of a Force إيجاد مركبات القوى
- ▶ Addition of Several Forces جمع عدة قوى

Vector Addition of Forces جمع القوى إتجاهيا

► Finding a Resultant Force

◀ إيجاد محصلة القوى

$$\mathbf{F}_R = \mathbf{F}_1 + \mathbf{F}_2$$

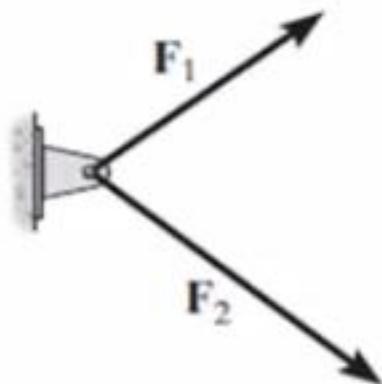


(a)

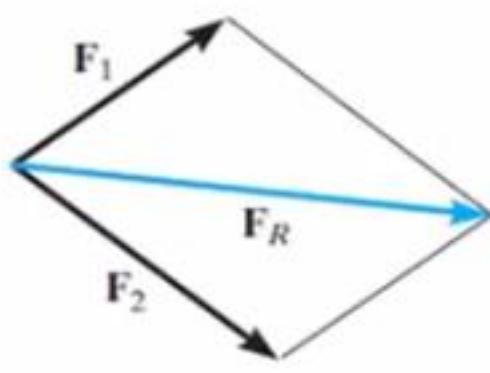
Vector Addition of Forces جمع القوى إتجاهيا

Finding a Resultant Force ◀ ايجاد محصلة القوى

$$\mathbf{F}_R = \mathbf{F}_1 + \mathbf{F}_2$$

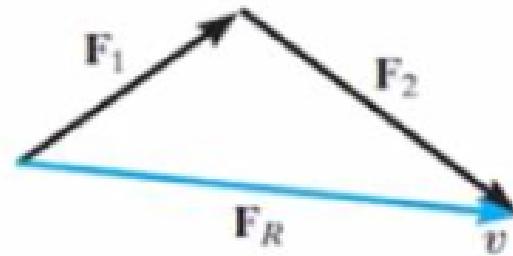


(a)



(b)

Parallelogram law

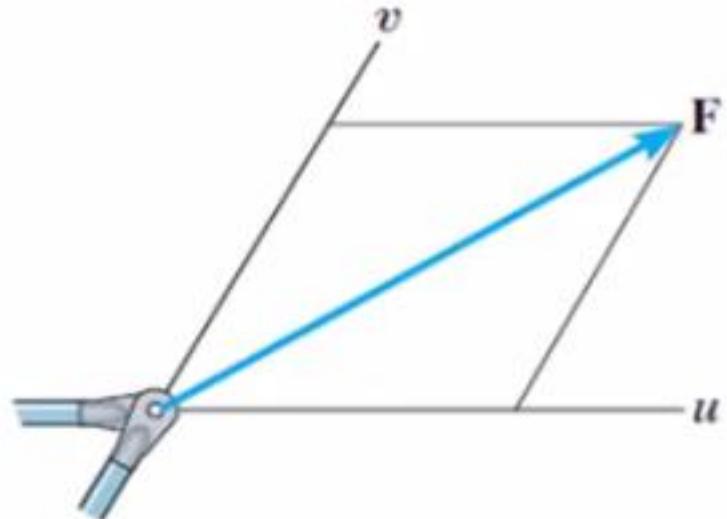


$$\mathbf{F}_R = \mathbf{F}_1 + \mathbf{F}_2$$

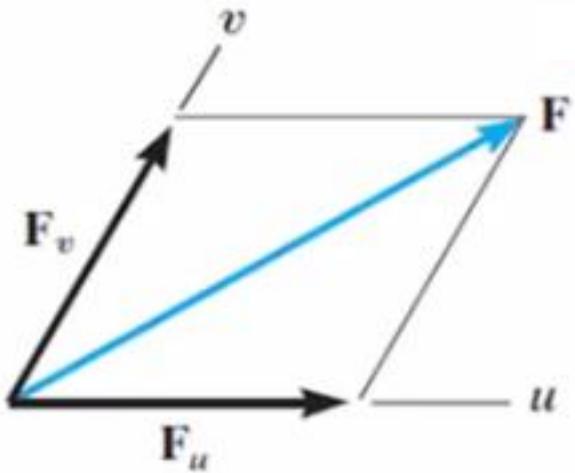
Triangle law

Vector Addition of Forces جمع القوى إتجاهيا

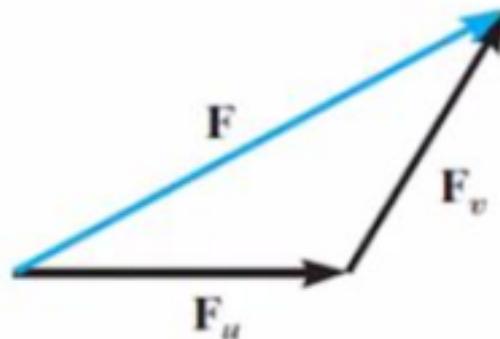
Finding the Components of a Force ◀ إيجاد مركبات القوى



(a)



(b)



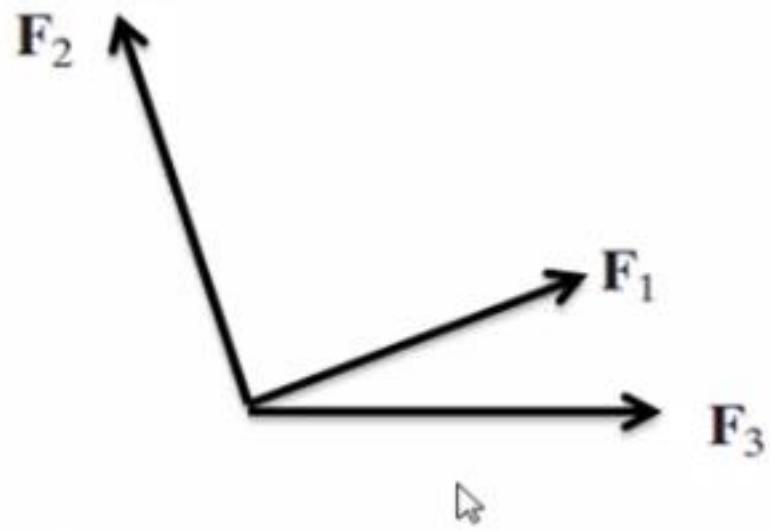
(c)

Vector Addition of Forces جمع القوى إتجاهيا

Addition of Several Forces

جمع عدة قوى

$$\mathbf{F}_R = (\mathbf{F}_1 + \mathbf{F}_2) + \mathbf{F}_3$$

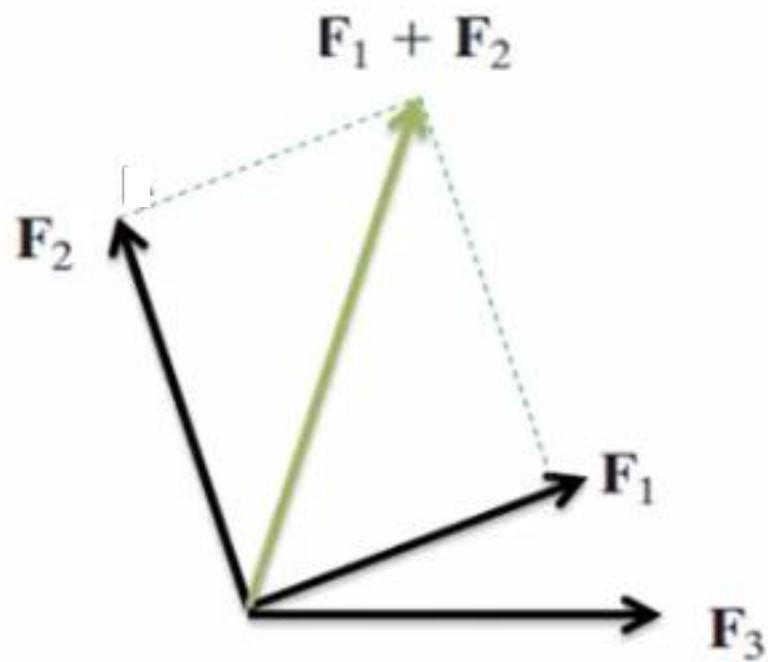


Vector Addition of Forces جمع القوى إتجاهيا

Addition of Several Forces

جمع عدة قوى

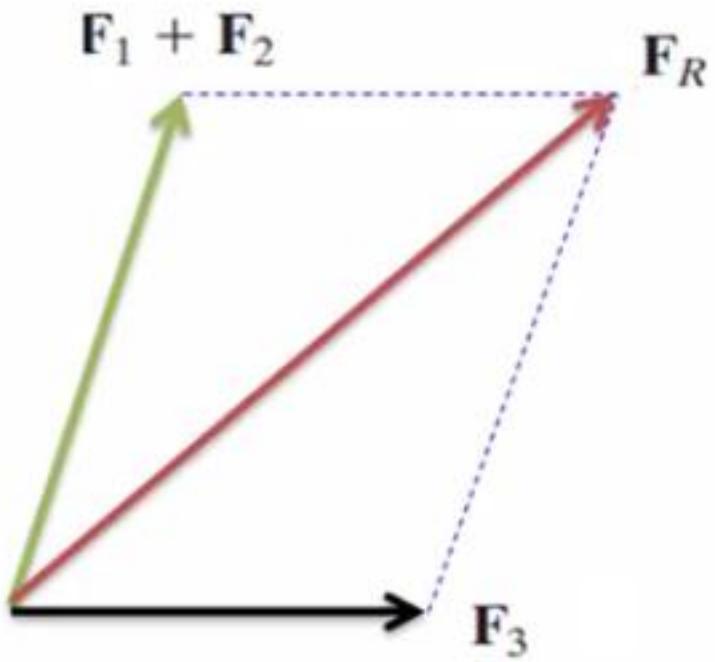
$$\mathbf{F}_R = (\mathbf{F}_1 + \mathbf{F}_2) + \mathbf{F}_3$$



▶ Addition of Several Forces

◀ جمع عدة قوى

$$\mathbf{F}_R = (\mathbf{F}_1 + \mathbf{F}_2) + \mathbf{F}_3$$

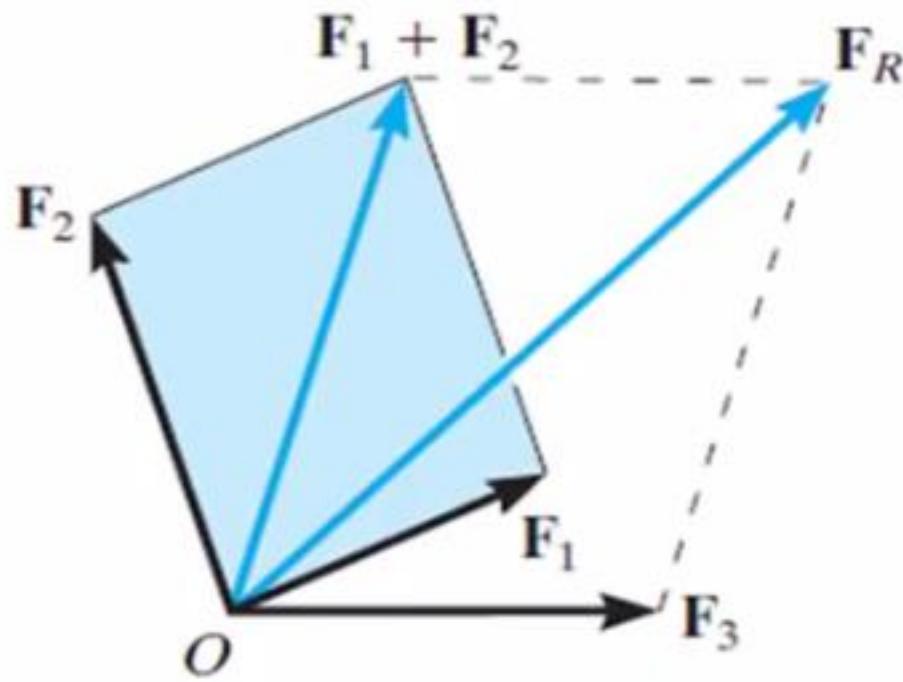
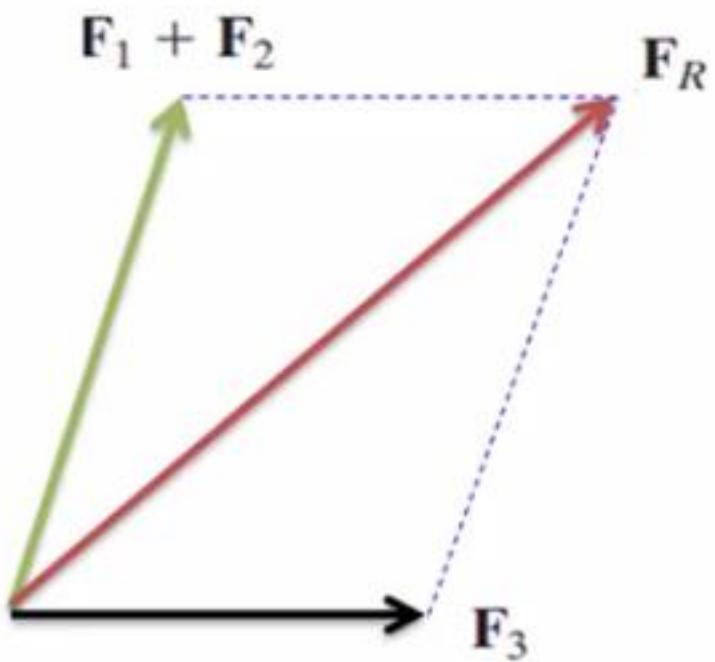


Vector Addition of Forces جمع القوى إتجاهيا

Addition of Several Forces

جمع عدة قوى

$$\mathbf{F}_R = (\mathbf{F}_1 + \mathbf{F}_2) + \mathbf{F}_3$$



Remember

تذكرة

$$F_x = F \cos \theta$$

$$F_y = F \sin \theta$$

Law of sines

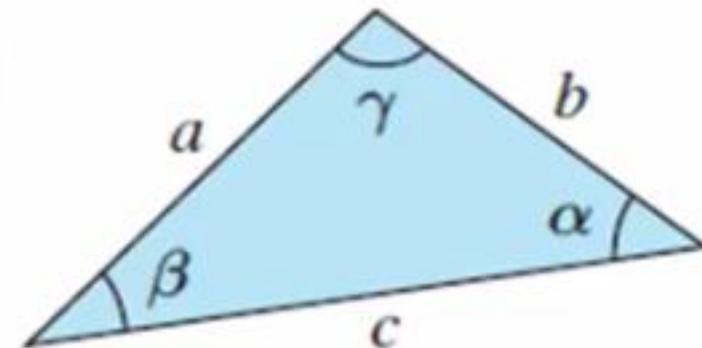
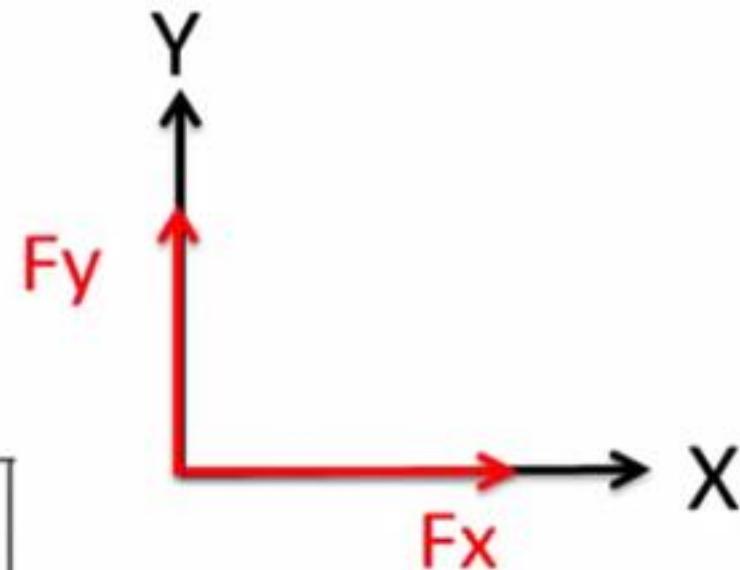
$$\frac{a}{\sin \alpha} = \frac{b}{\sin \beta} = \frac{c}{\sin \gamma}$$

Law of cosines

$$a^2 = b^2 + c^2 - 2bc \cos \alpha$$

$$b^2 = c^2 + a^2 - 2ca \cos \beta$$

$$c^2 = a^2 + b^2 - 2ab \cos \gamma$$



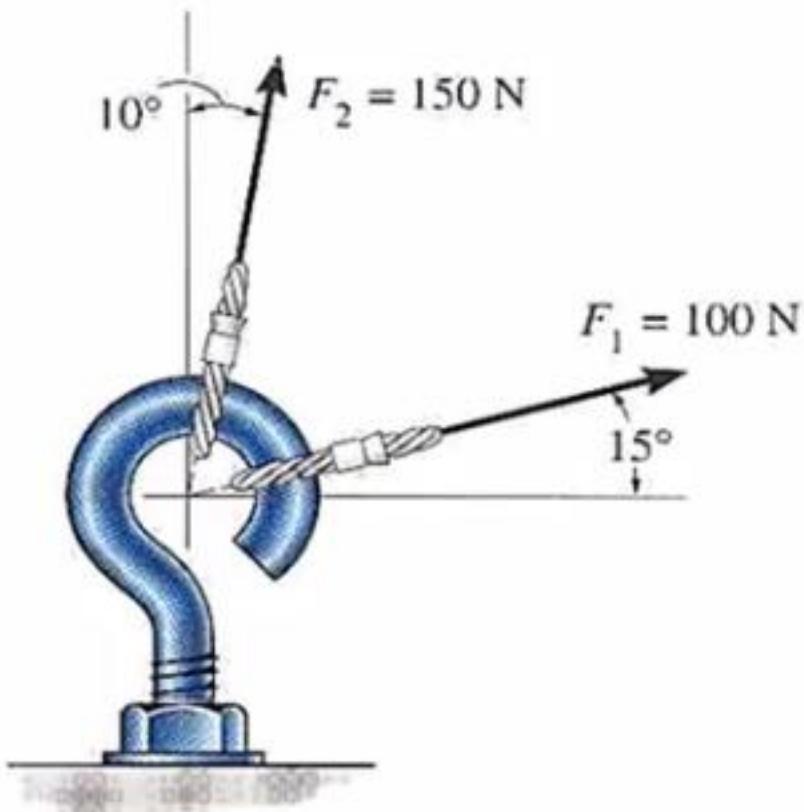
Examples

Example (1) :

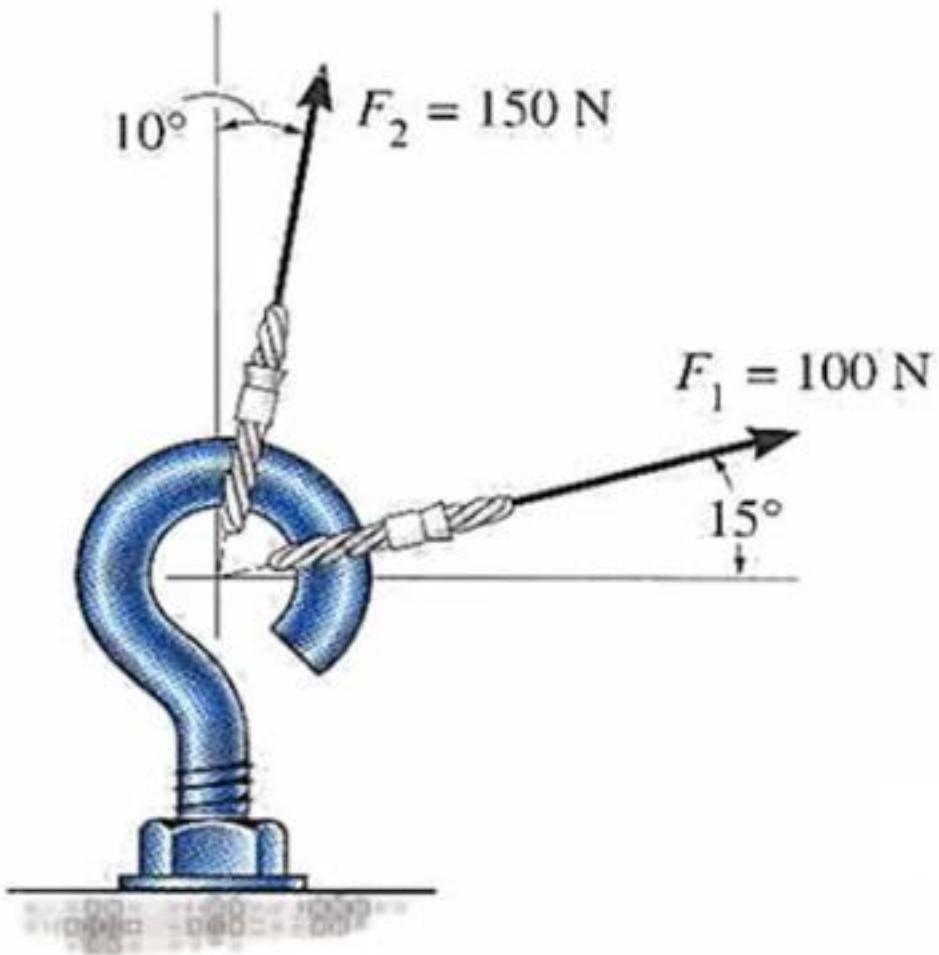
The screw eye in Figure is subjected to two forces, F_1 and F_2 . Determine the magnitude and direction of the resultant force.

مثال (١) :

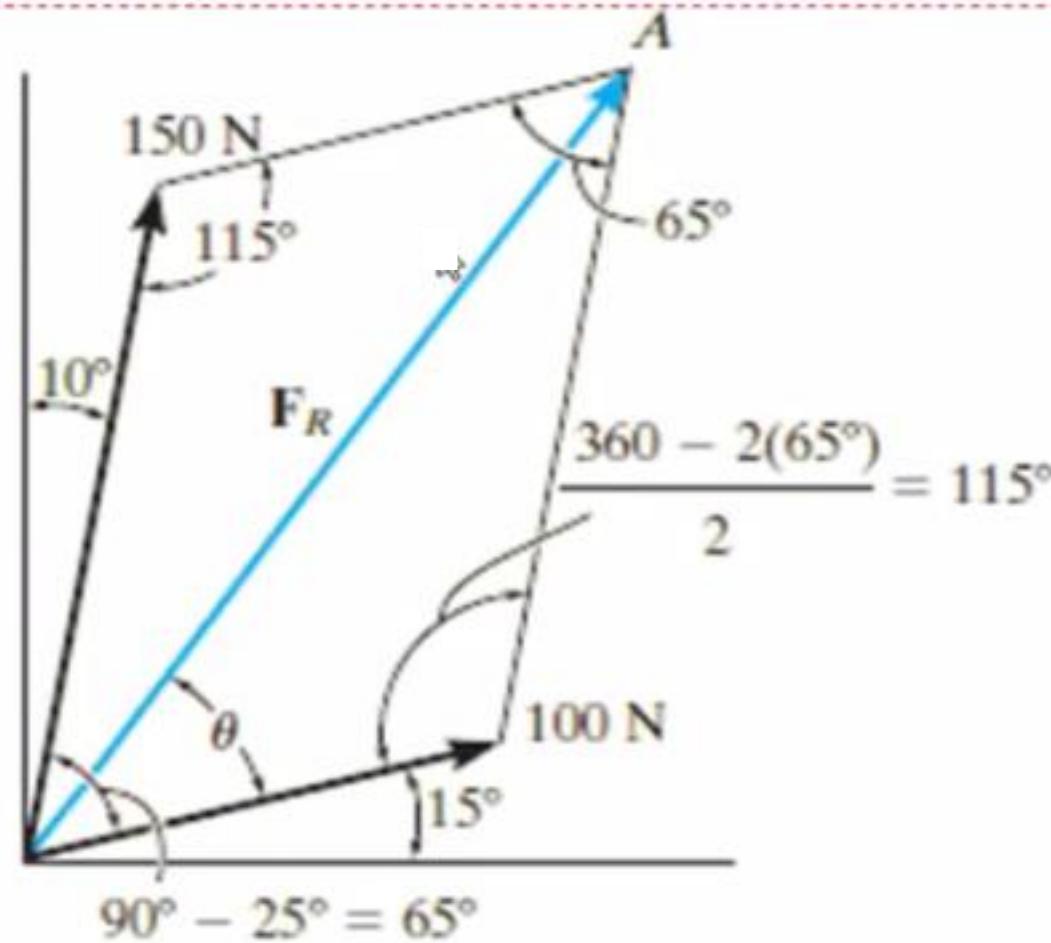
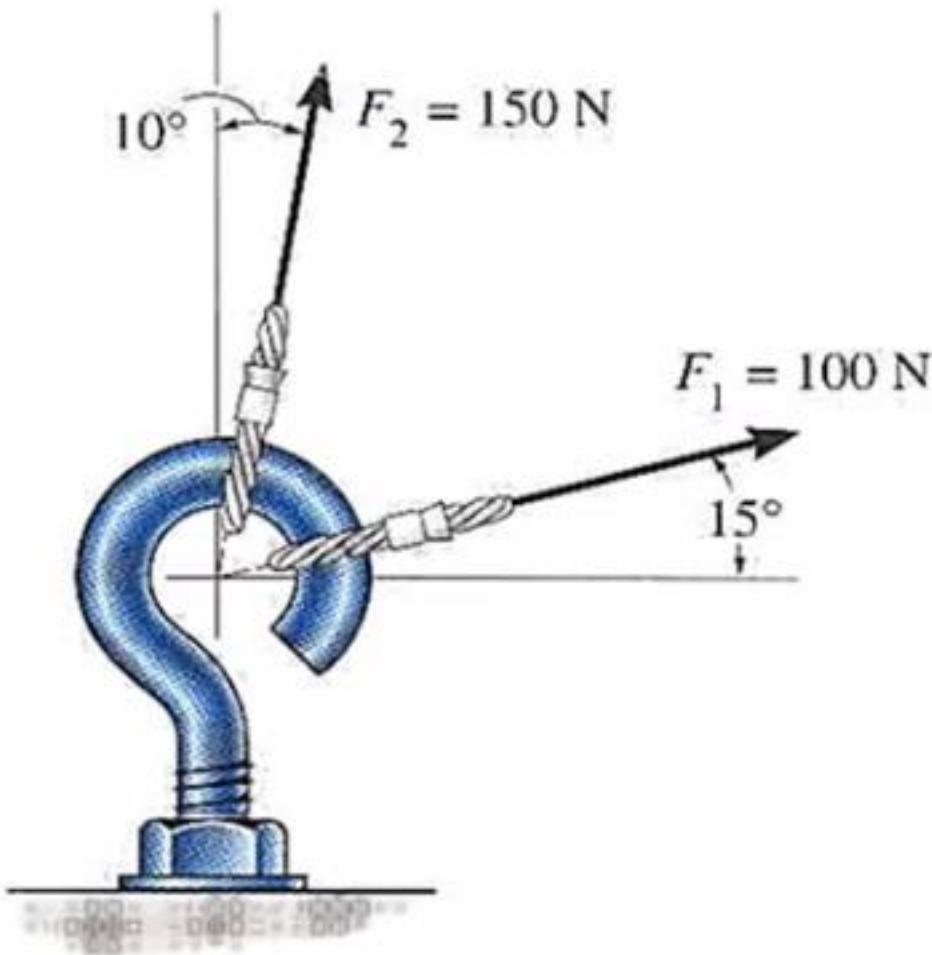
قم بحساب محاصلة القوتين اللتين تؤثران على رأس المسamar المبين بالشكل ؟



Examples



Examples

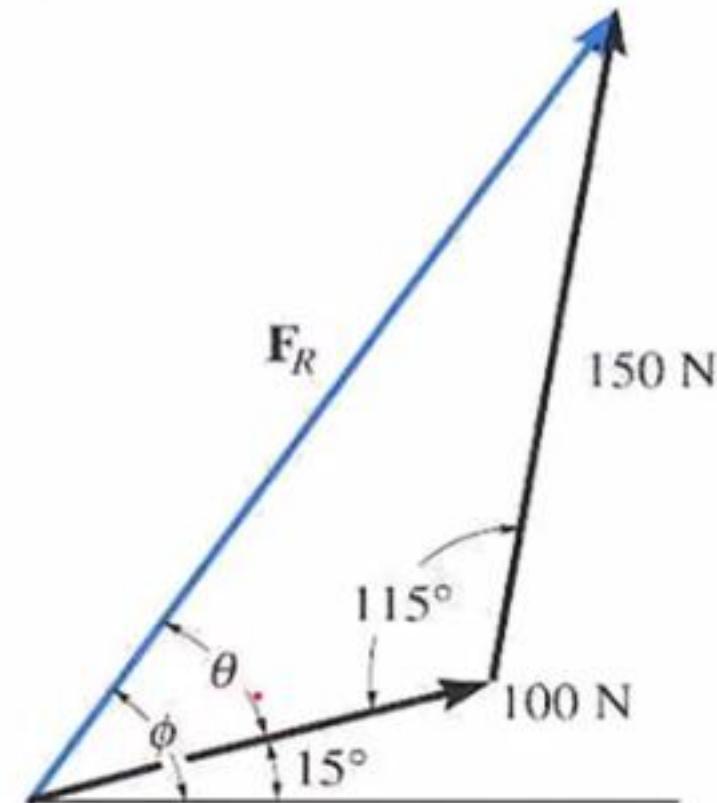


Examples

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

$$\begin{aligned} &= \sqrt{10\,000 + 22\,500 - 30\,000(-0.4226)} = 212.6 \text{ N} \\ &= 213 \text{ N} \end{aligned}$$

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



Examples

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

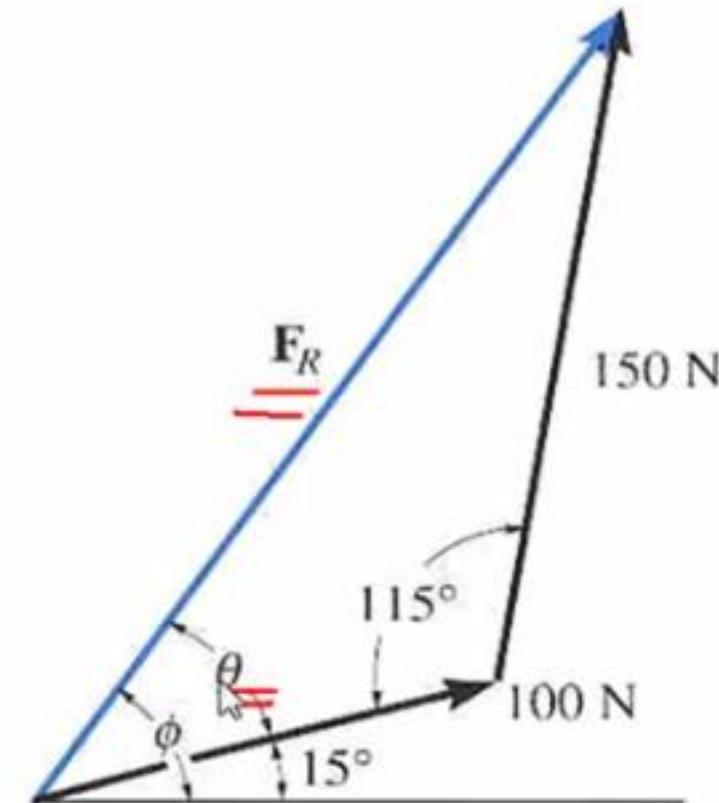
$$\begin{aligned} &= \sqrt{10\,000 + 22\,500 - 30\,000(-0.4226)} = 212.6 \text{ N} \\ &= 213 \text{ N} \end{aligned}$$

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

$$\sin \theta = \frac{150 \text{ N}}{212.6 \text{ N}} (0.9063)$$

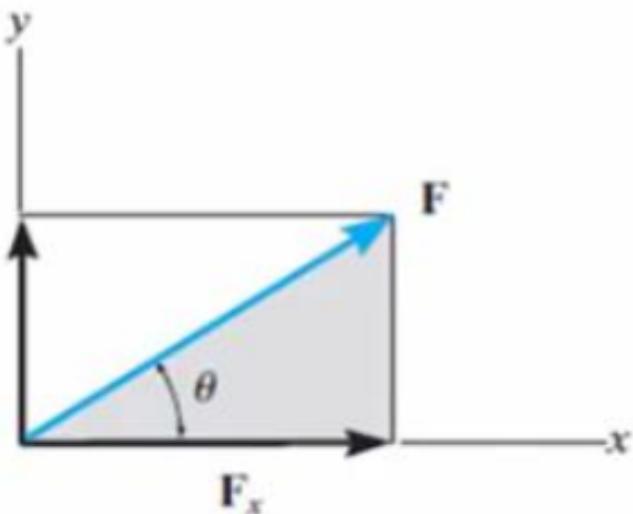
$$\theta = 39.8^\circ$$

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



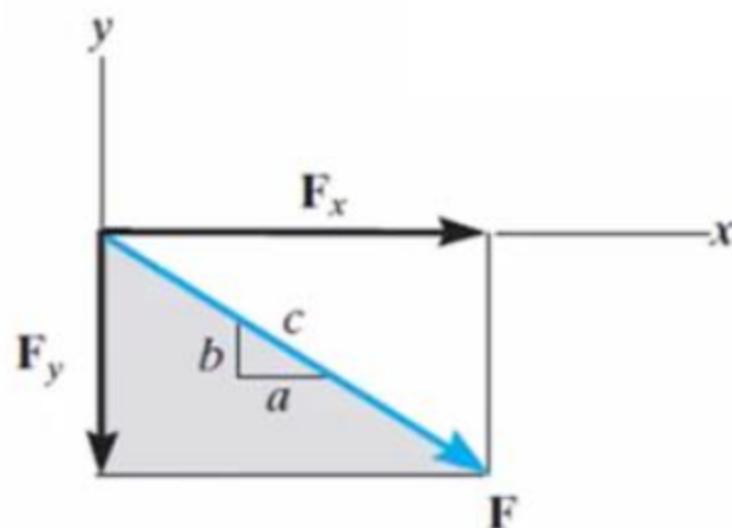
Addition of a System of Coplanar Forces

جمع مجموعة قوى مستوية



$$F_x = F \cos \theta$$

$$F_y = F \sin \theta$$



$$\frac{F_x}{F} = \frac{a}{c}$$

or

$$F_x = F \left(\frac{a}{c} \right)$$

$$\frac{F_y}{F} = \frac{b}{c}$$

or

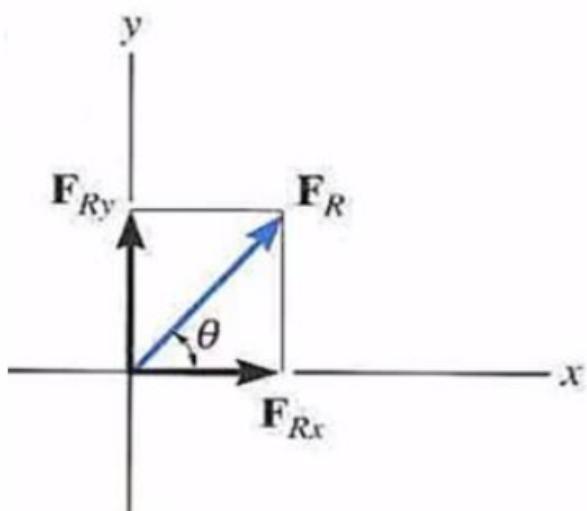
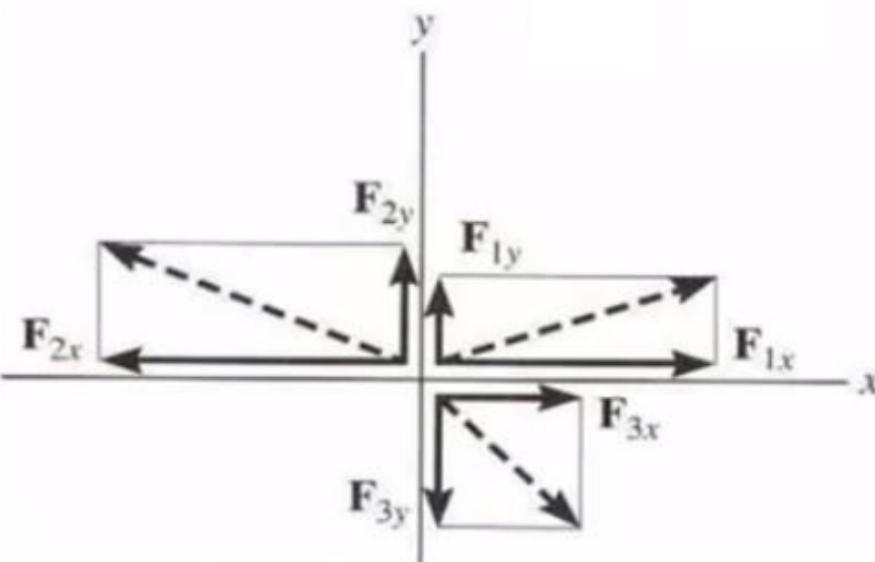
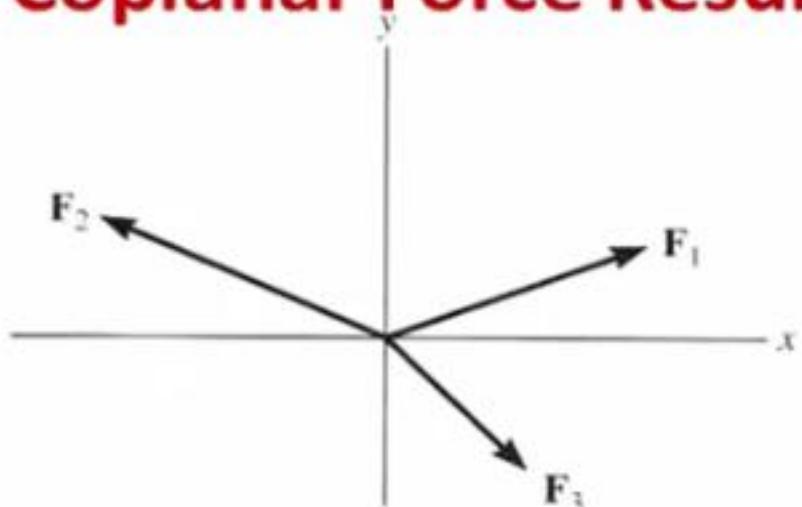
$$F_y = -F \left(\frac{b}{c} \right)$$

Addition of a System of Coplanar Forces

جمع مجموعة قوى مستوية

Coplanar Force Resultants.

محصلة قوى مستوية



$$\begin{array}{l} (\rightarrow) \\ (+ \uparrow) \end{array}$$

$$F_{Rx} = F_{1x} - F_{2x} + F_{3x}$$
$$F_{Ry} = F_{1y} + F_{2y} - F_{3y}$$

$$F_R = \sqrt{F_{Rx}^2 + F_{Ry}^2}$$

$$F_{Rx} = \sum F_x$$
$$F_{Ry} = \sum F_y$$

$$\theta = \tan^{-1} \left| \frac{F_{Ry}}{F_{Rx}} \right|$$

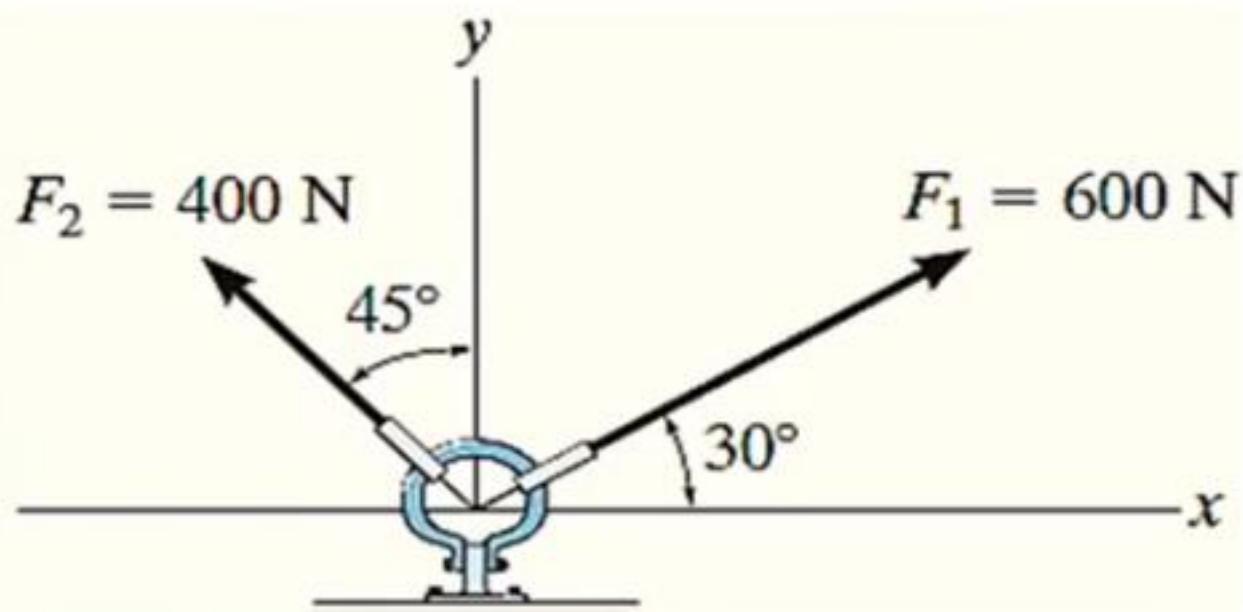
Examples

Example (6) :

The shown screw eye in Figure is subjected to two forces, F_1 and F_2 . Determine the magnitude and direction of the resultant force.

مثال (٦) :

قم بحساب محصلة القوتين اللتين تؤثران على رأس المسamar المبين بالشكل ؟



Examples

SOLUTION I

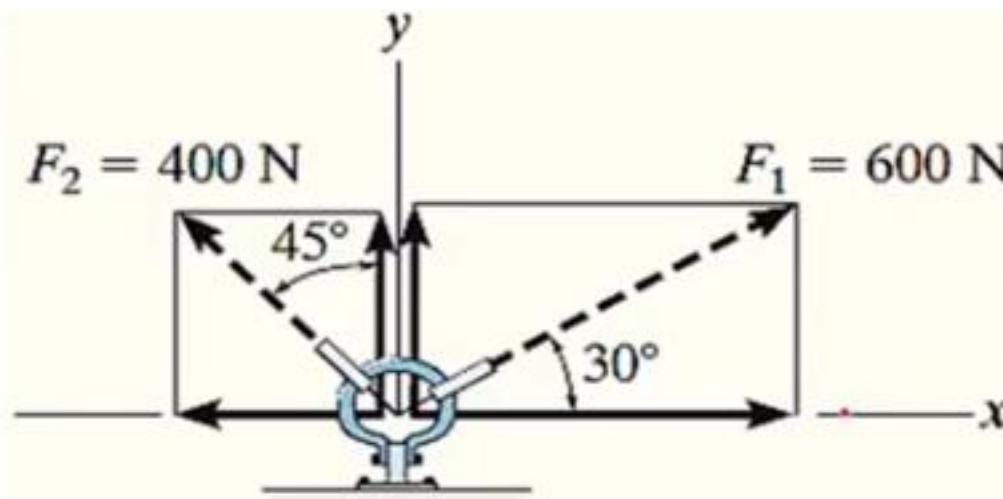
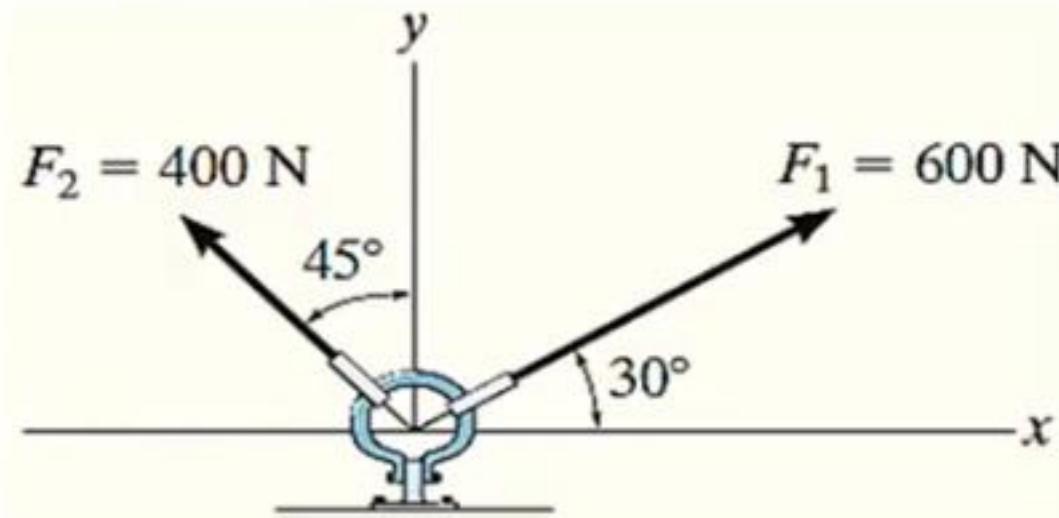
Scalar Notation.

$$\stackrel{+}{\rightarrow} F_{Rx} = \sum F_x$$

$$F_{Rx} = 600 \cos 30^\circ \text{ N} - 400 \sin 45^\circ \text{ N} = 236.8 \text{ N} \rightarrow$$

$$+\uparrow F_{Ry} = \sum F_y$$

$$F_{Ry} = 600 \sin 30^\circ \text{ N} + 400 \cos 45^\circ \text{ N} = 582.8 \text{ N} \uparrow$$



Examples

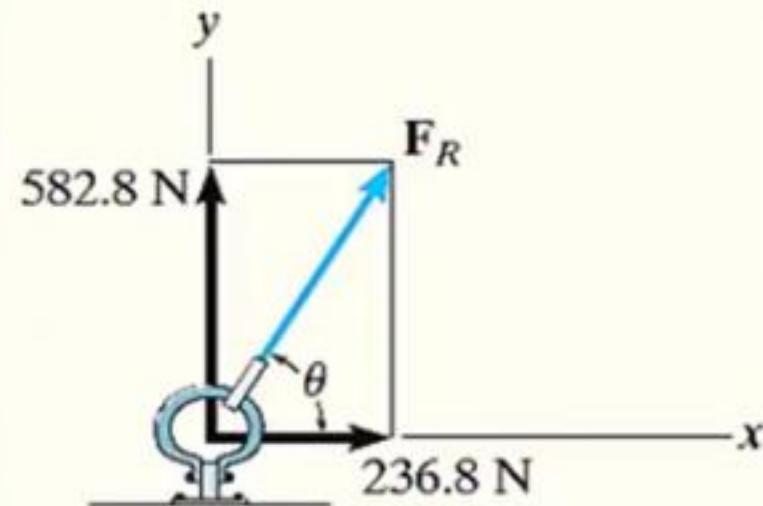
SOLUTION I

$$F_{Rx} = 600 \cos 30^\circ \text{ N} - 400 \sin 45^\circ \text{ N} = 236.8 \text{ N} \rightarrow$$

$$F_{Ry} = 600 \sin 30^\circ \text{ N} + 400 \cos 45^\circ \text{ N} = 582.8 \text{ N} \uparrow$$

$$F_R = \sqrt{(236.8 \text{ N})^2 + (582.8 \text{ N})^2} = 629 \text{ N}$$

$$\theta = \tan^{-1} \left(\frac{582.8 \text{ N}}{236.8 \text{ N}} \right) = 67.9^\circ$$



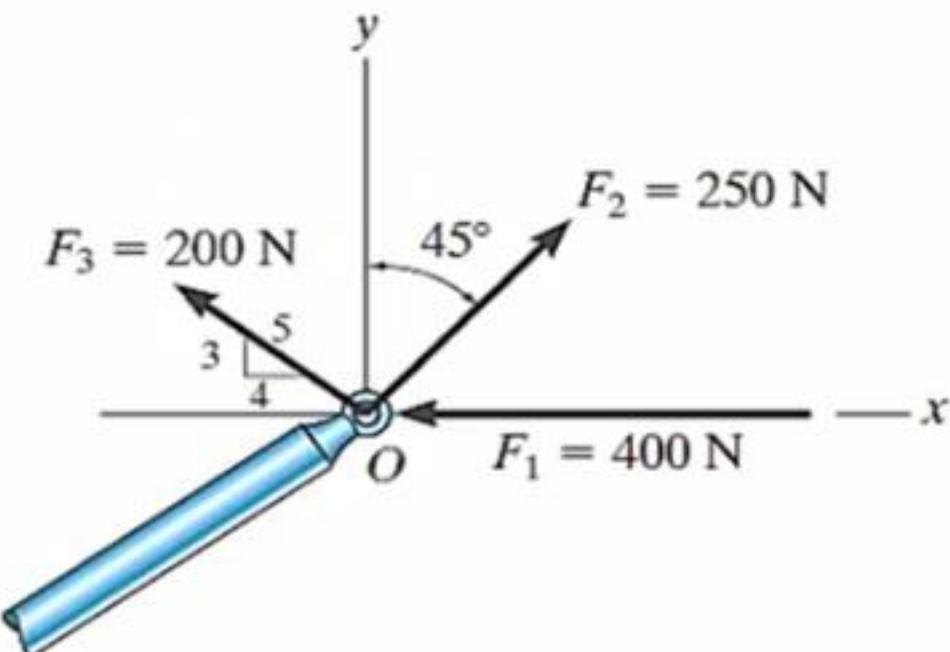
Examples

Example (7) :

The end of the shown boom O is subjected to three concurrent and coplanar forces. Determine the magnitude and direction of the resultant force.

مثال (٧) :

نقطة نهاية ذراع التطويل المبين بالشكل معرض لثلاث قوى متلاقيّة ومستوّية. قم بحساب المحصلة قيمة واتجاهها؟



Examples

$$\rightarrow F_{Rx} = \sum F_x$$

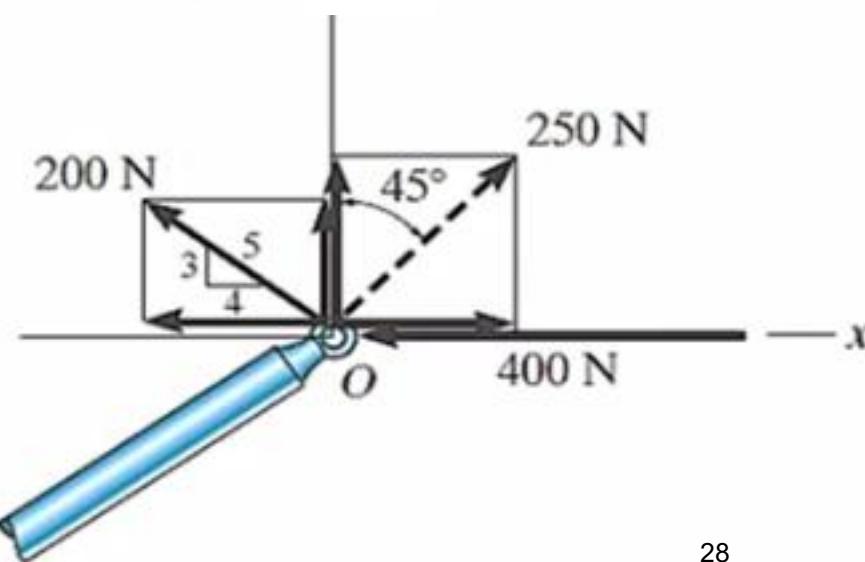
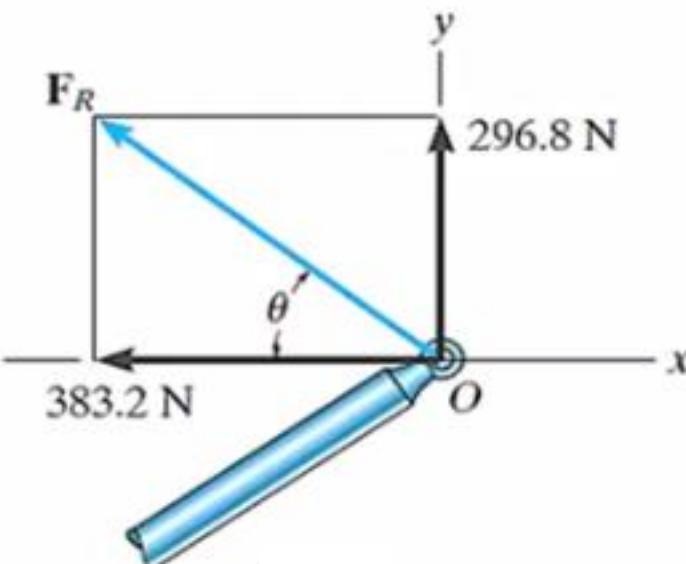
$$\begin{aligned} F_{Rx} &= -400 \text{ N} + 250 \sin 45^\circ \text{ N} - 200\left(\frac{4}{5}\right) \text{ N} \\ &= -383.2 \text{ N} = 383.2 \text{ N} \leftarrow \end{aligned}$$

$$+ \uparrow F_{Ry} = \sum F_y$$

$$F_{Ry} = 250 \cos 45^\circ \text{ N} + 200\left(\frac{3}{5}\right) \text{ N} = 296.8 \text{ N} \uparrow$$

$$F_R = \sqrt{(-383.2 \text{ N})^2 + (296.8 \text{ N})^2} = 485 \text{ N}$$

$$\theta = \tan^{-1}\left(\frac{296.8}{383.2}\right) = 37.8^\circ$$



قسم الهندسة المدنية

المرحلة الاولى

Al-Mansour University College

Civil Eng. Dept.

1st. Stage

2022– 2023

2

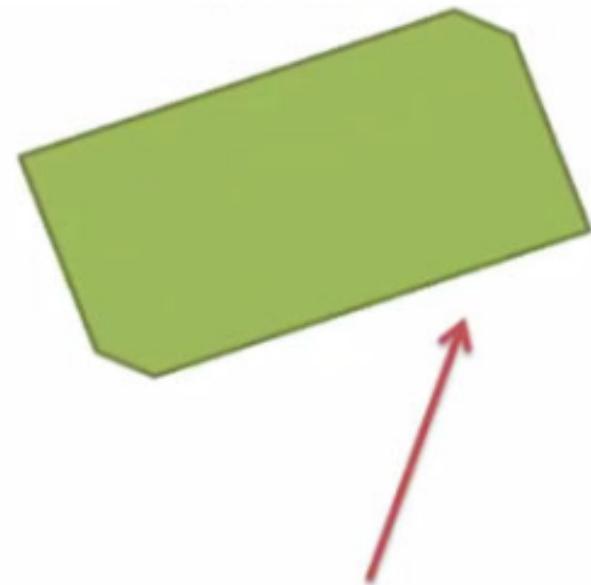
الميكانيك الهندسية

د. عبد الله سنان

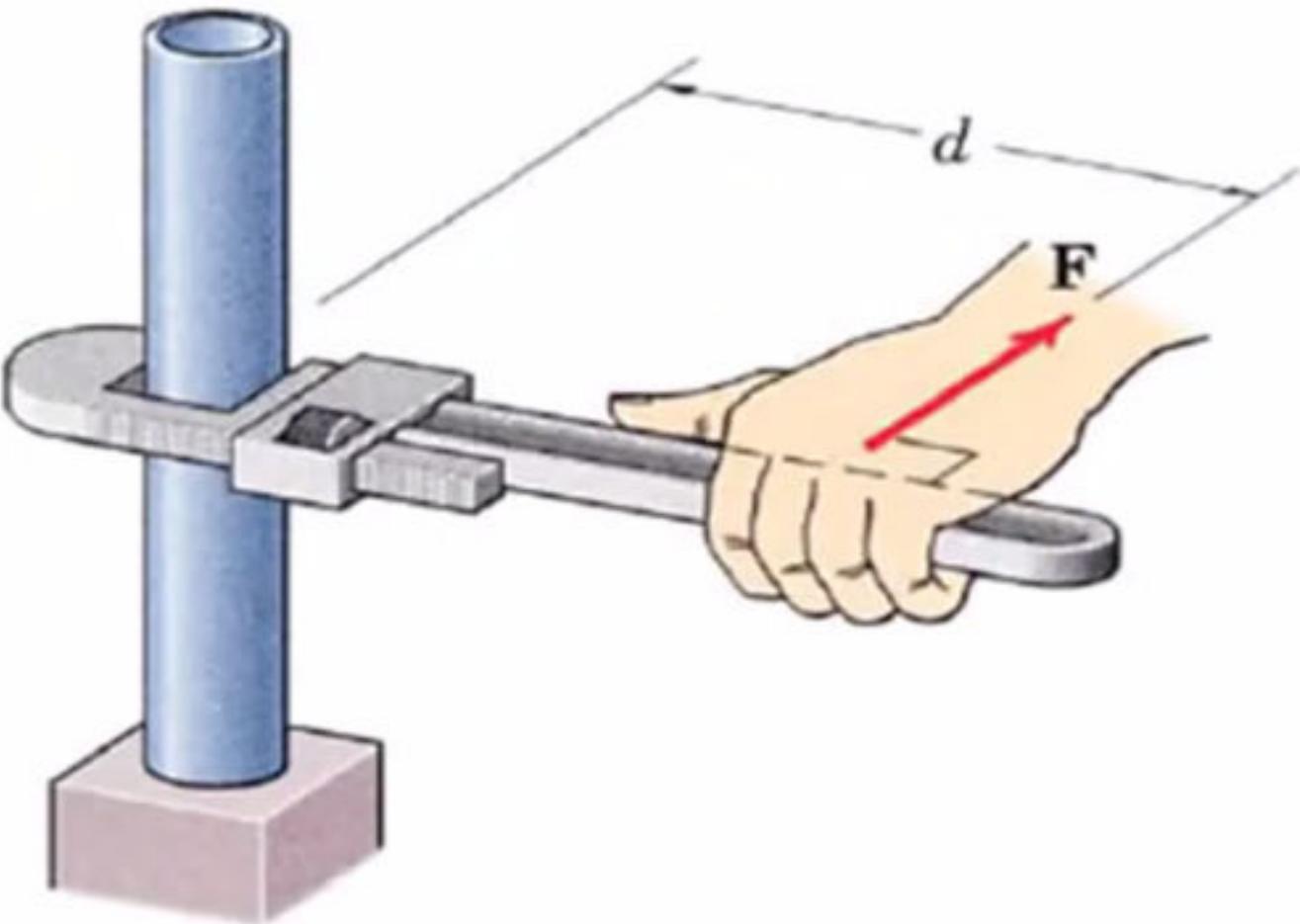
Moment of a Force

When a force is applied to a body it will produce a tendency for the body to rotate about a point that is not on the line of action of the force. This tendency to rotate is called the moment of a force.

عندما يتم تطبيق قوة على جسم فإنه سوف ينتج نزعة للجسم تجعله يدور حول نقطة ولكنها ليست على خط عمل القوة. ويسمى هذا الميل للتدوير "عزم القوة"



Moment of a Force

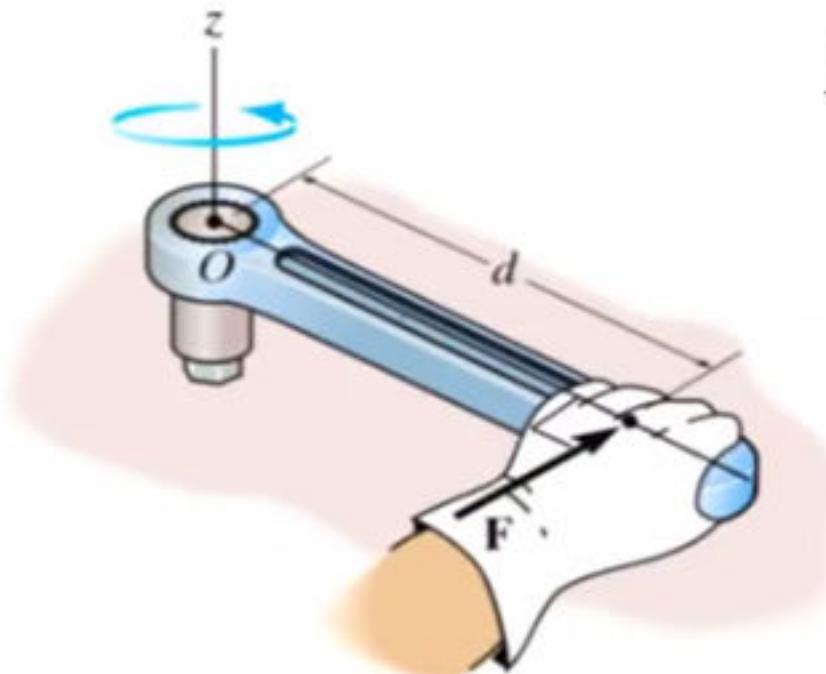


عزم قوة

Moment of a Force

القيمة :

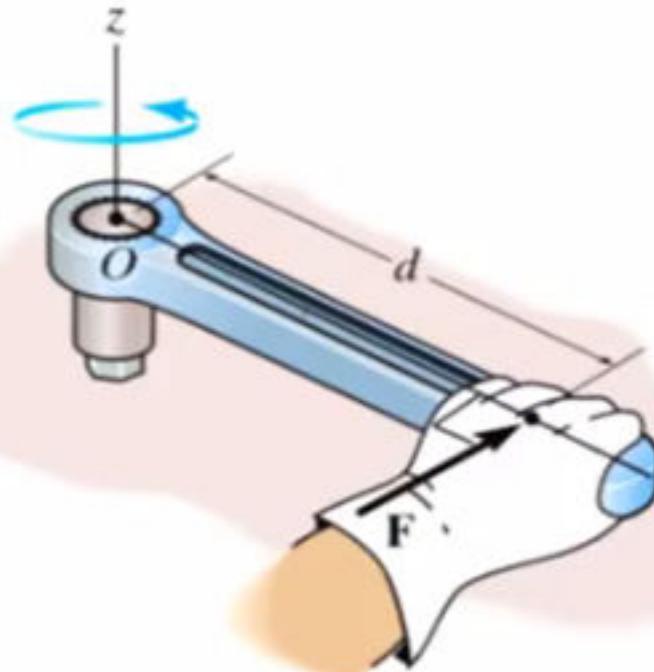
$$M_O = Fd$$



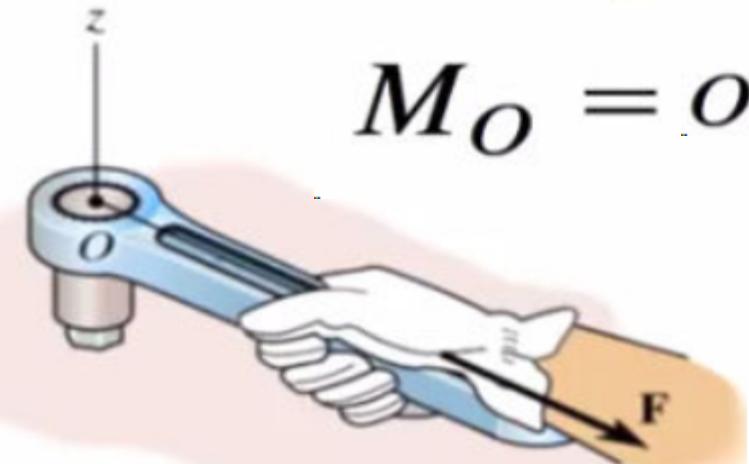
Moment of a Force

القيمة :

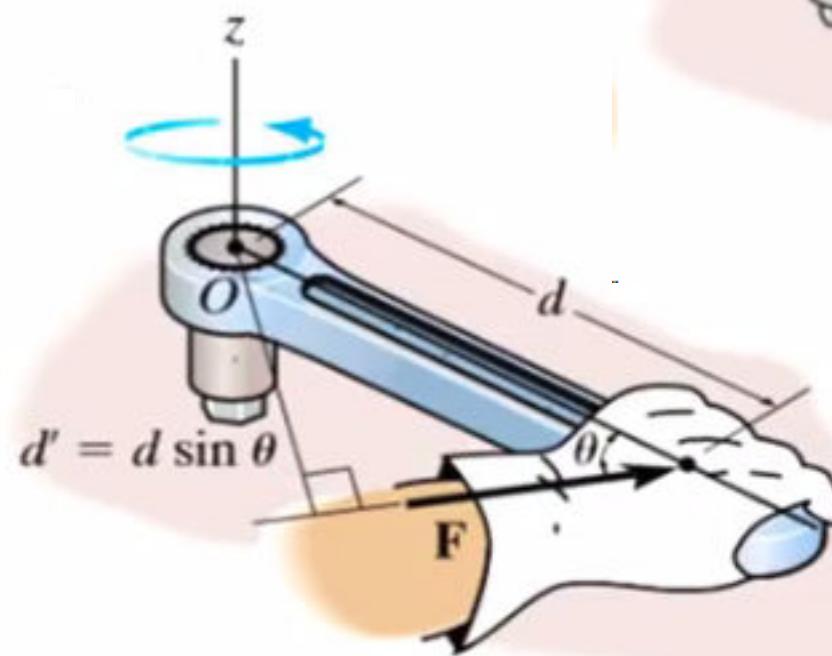
Magnitude :



$$M_O = Fd$$



$$M_O = 0$$

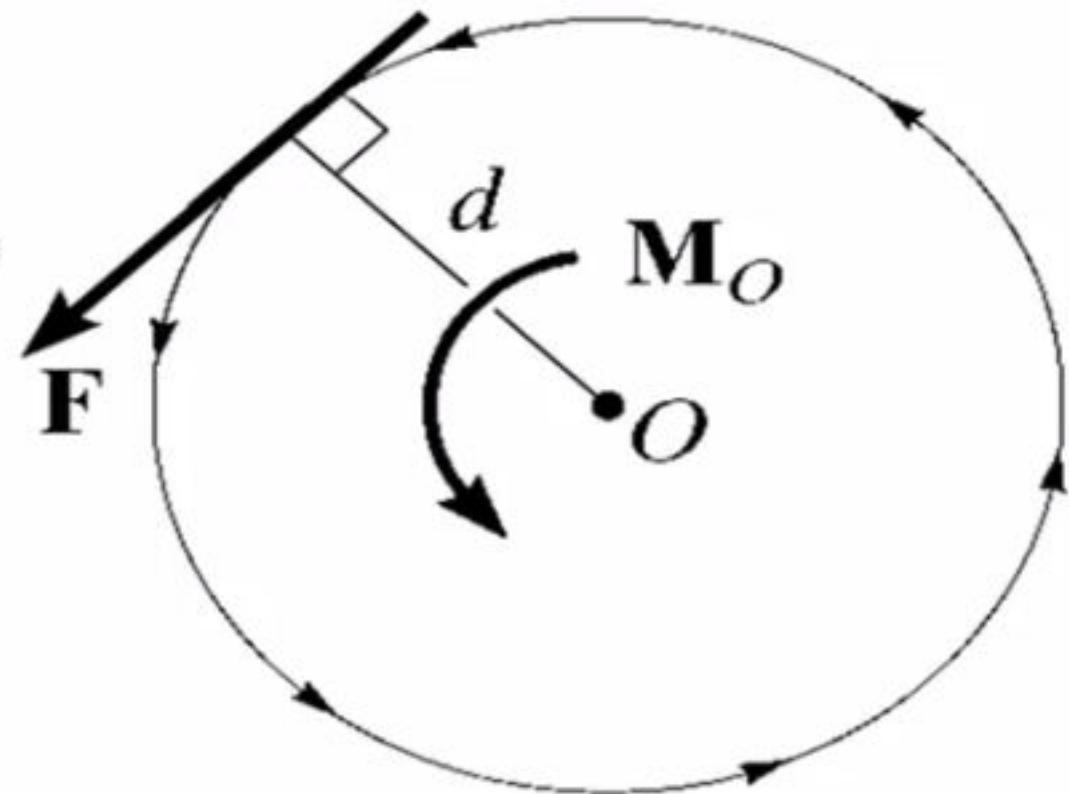


$$M_O = Fd'$$

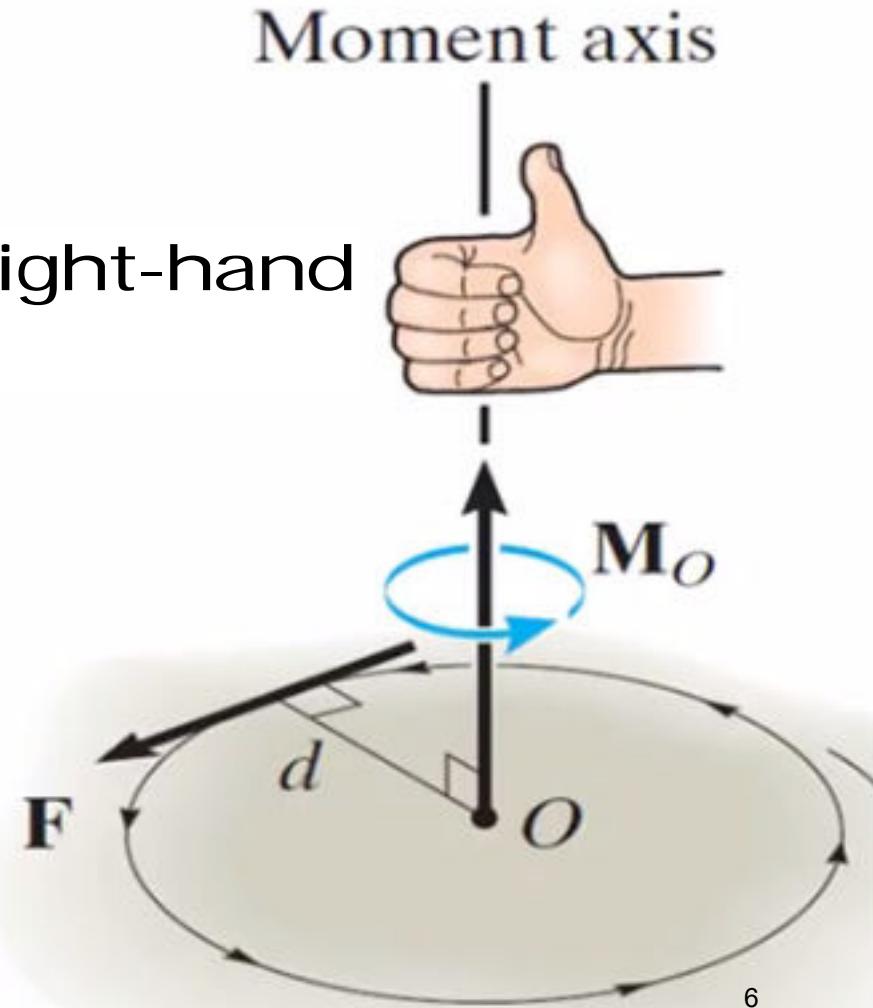
Moment of a Force

Direction :

The direction of M_o is defined by its *moment axis*.



The right-hand rule

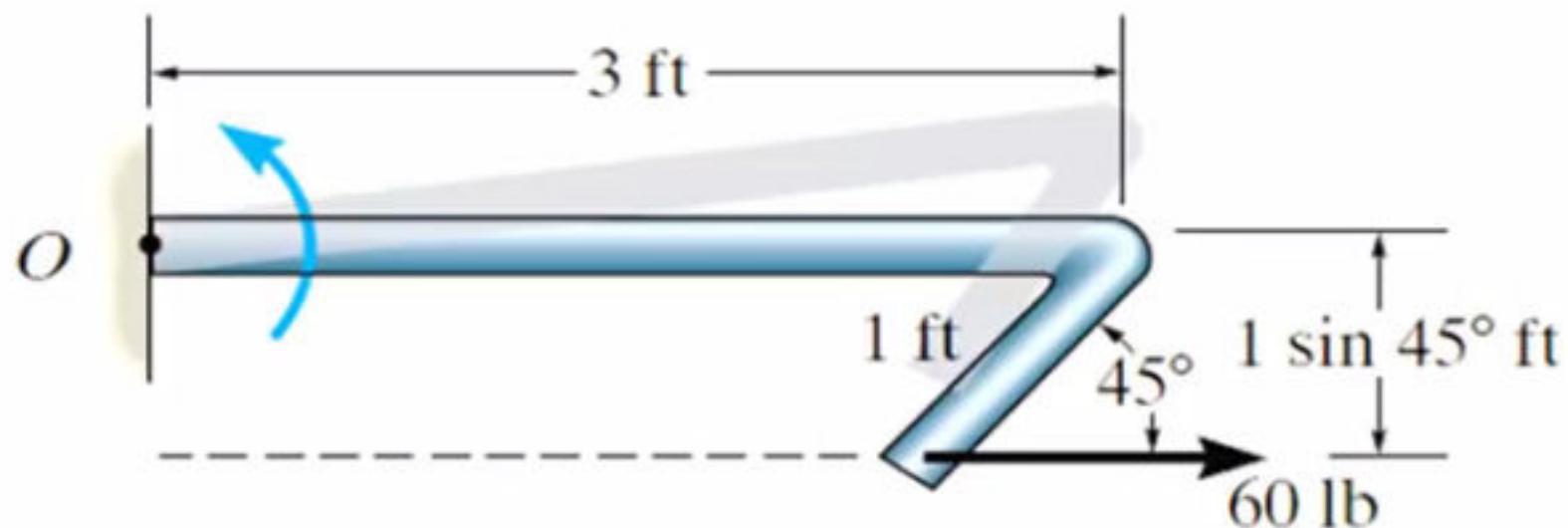


Examples

Example (1) :

Determine the moment of the force about point O.

أحسب عزم القوة المبينة حول النقطة (O).



$$M_O = (60 \text{ lb})(1 \sin 45^\circ \text{ ft}) = 42.4 \text{ lb} \cdot \text{ft}$$

Examples

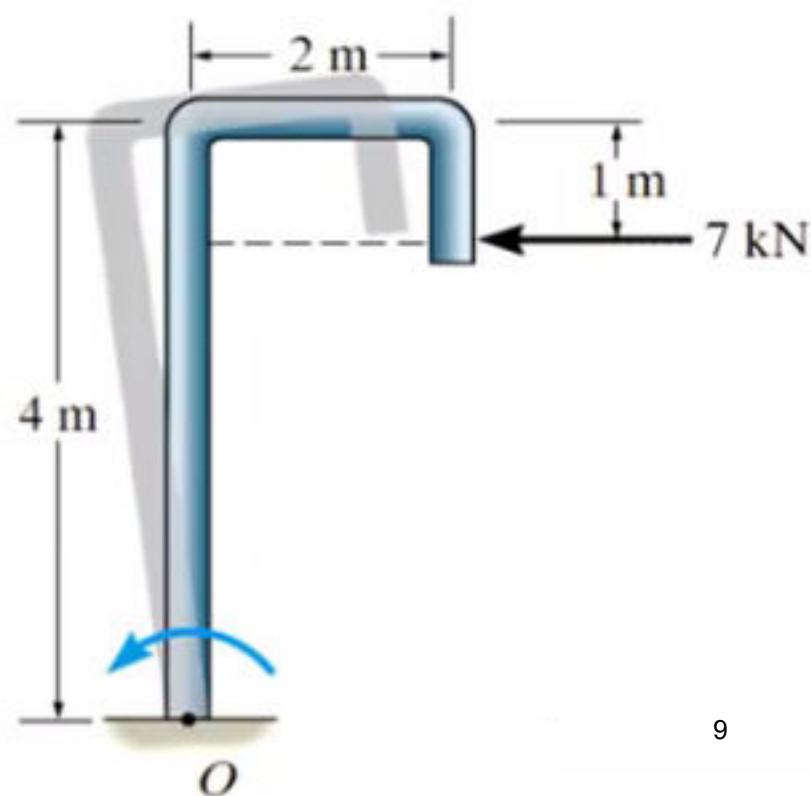
Example (2) :

Determine the moment of the force about point O.

مثال (٢) :
أحسب عزم القوة المبينة حول النقطة (O).

Solution :

$$\begin{aligned}M_O &= (7 \text{ kN})(4 \text{ m} - 1 \text{ m}) \\&= 21.0 \text{ kN} \cdot \text{m}\end{aligned}$$

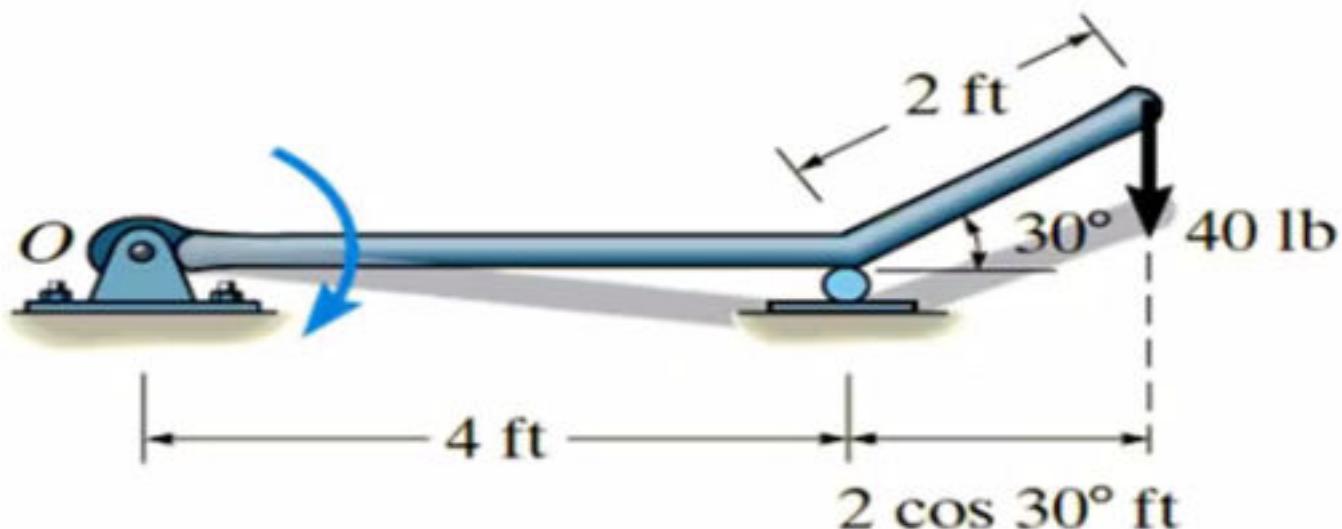


Examples

Example (3) :

Determine the moment of the force about point O.

أحسب عزم القوة المبينة حول النقطة (O).

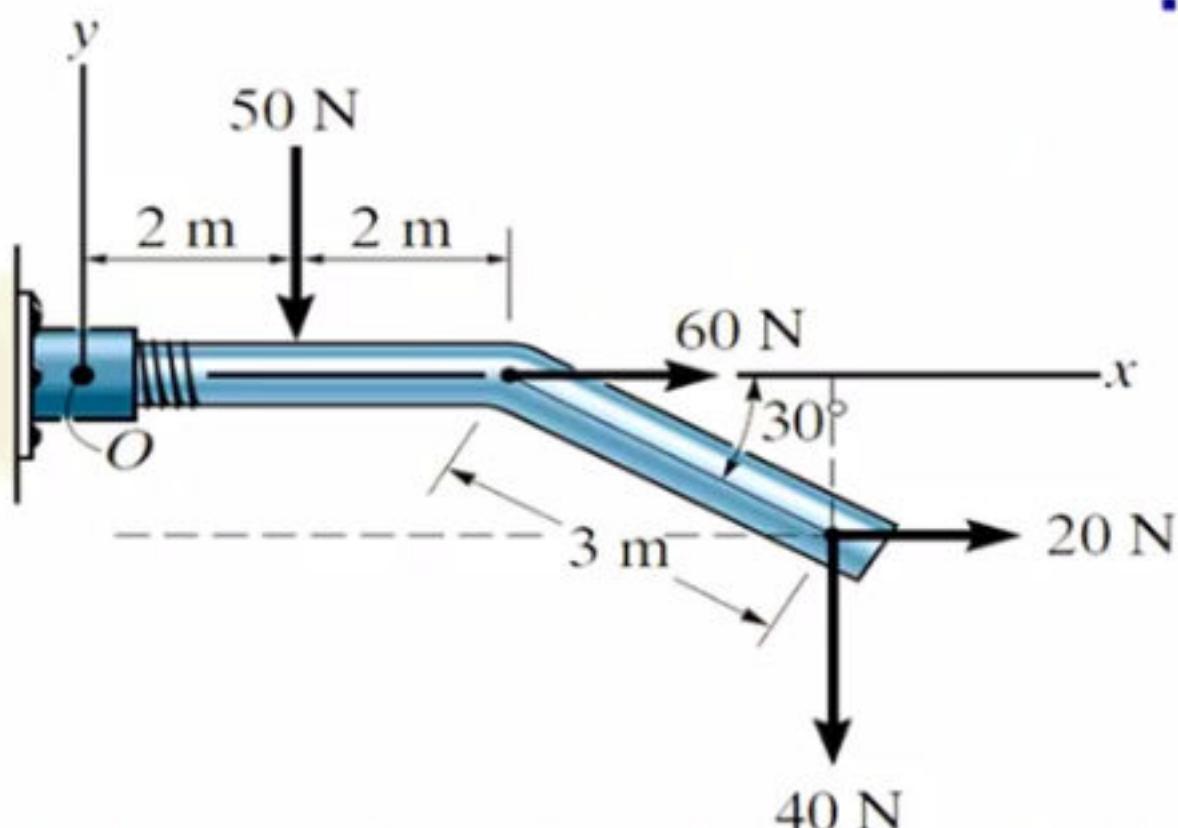


Examples

Example (4) :

Determine the resultant moment of the four forces acting on the rod about point O.

أحسب محصلة عزم القوى الأربع المبينة حول النقطة .(O)

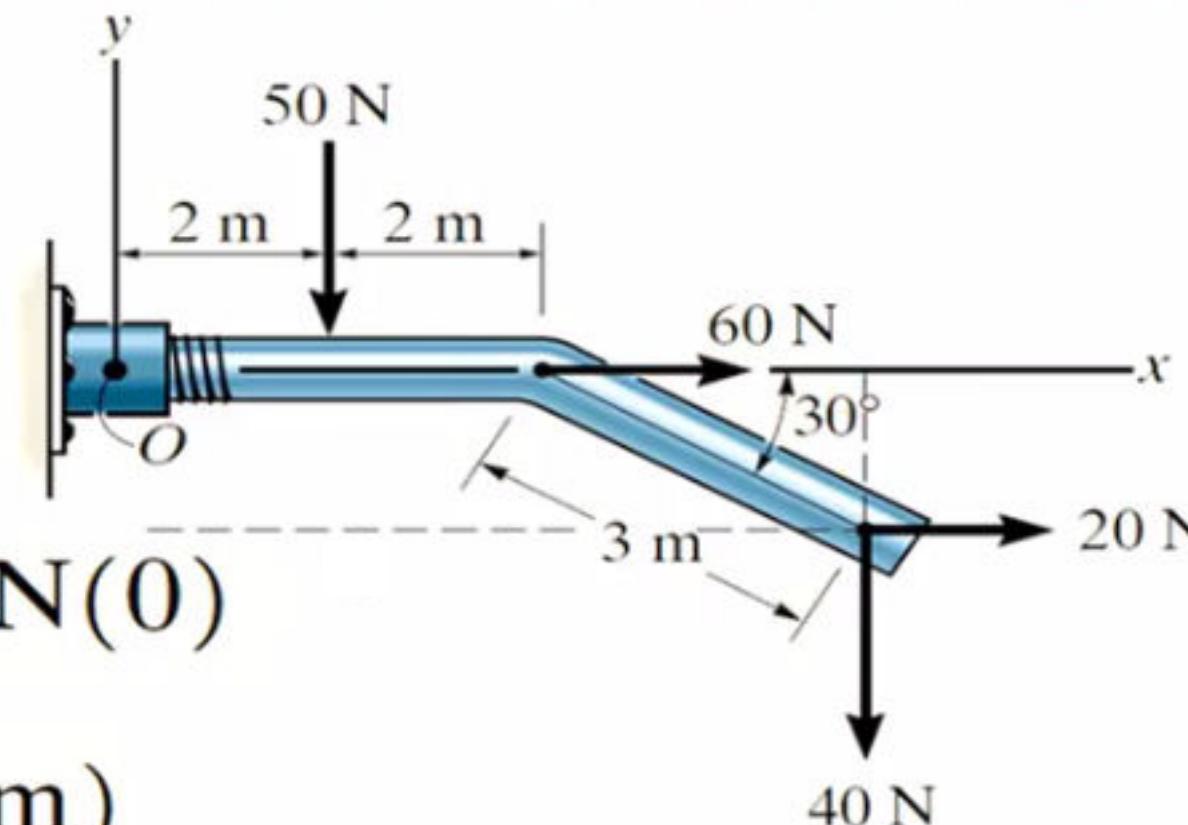


Examples

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

$$\begin{aligned}
 M_{R_O} &= -50 \text{ N}(2 \text{ m}) + 60 \text{ N}(0) \\
 &\quad + 20 \text{ N}(3 \sin 30^\circ \text{ m}) \\
 &\quad - 40 \text{ N}(4 \text{ m} + 3 \cos 30^\circ \text{ m})
 \end{aligned}$$

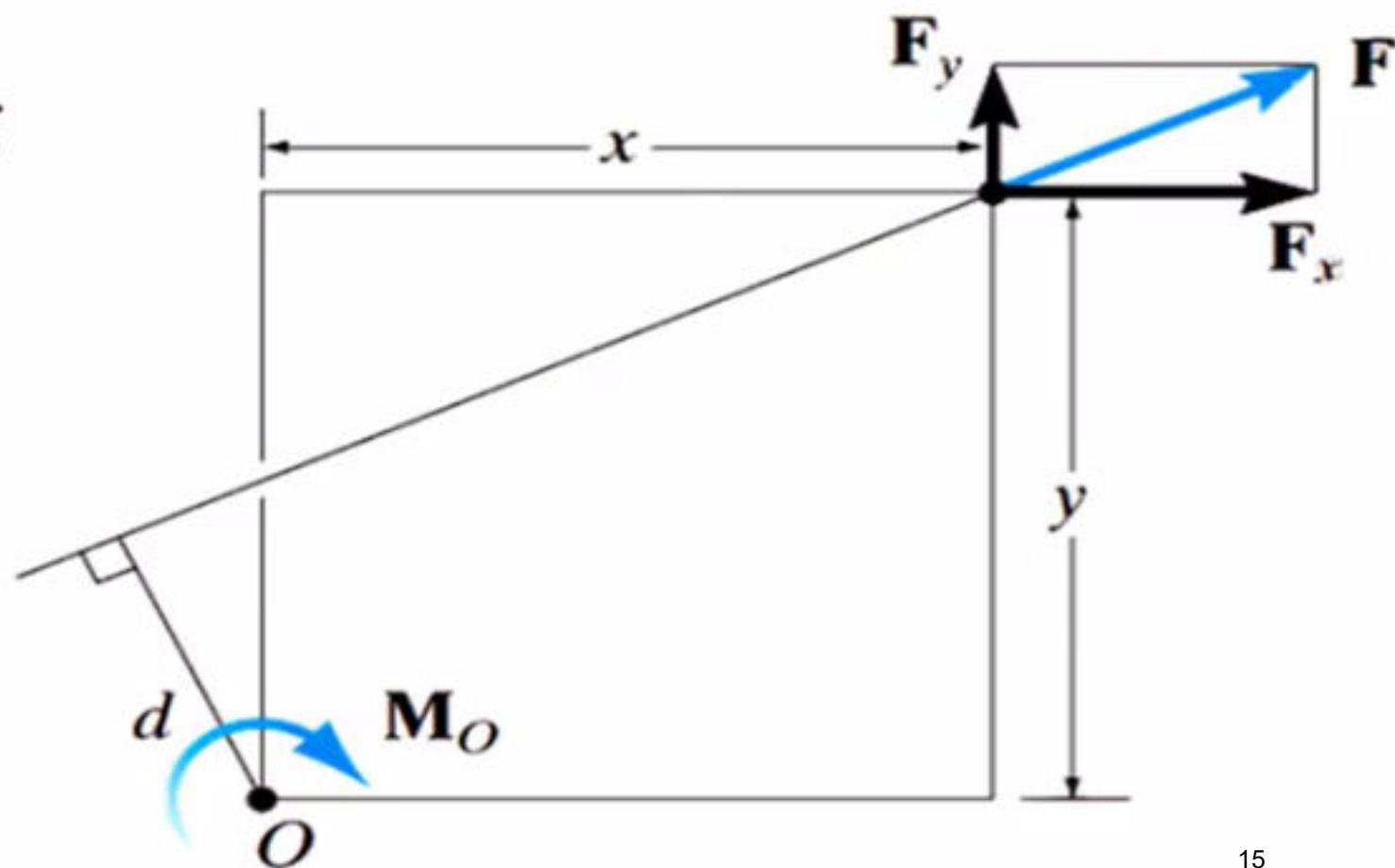
$$M_{R_O} = -334 \text{ N}\cdot\text{m} = 334 \text{ N}\cdot\text{m}$$



For two-dimensional problems :

$$M_O = F_x y - F_y x$$

This method is generally easier than finding the same moment using $M_o = Fd$.

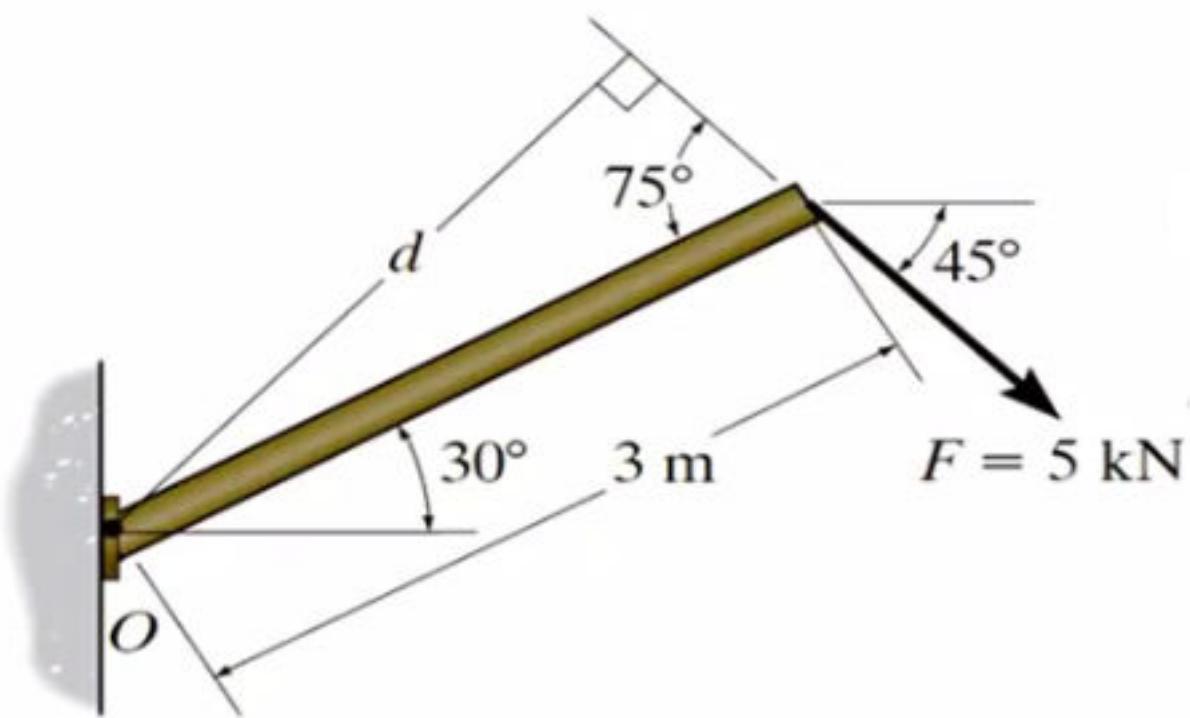


Examples

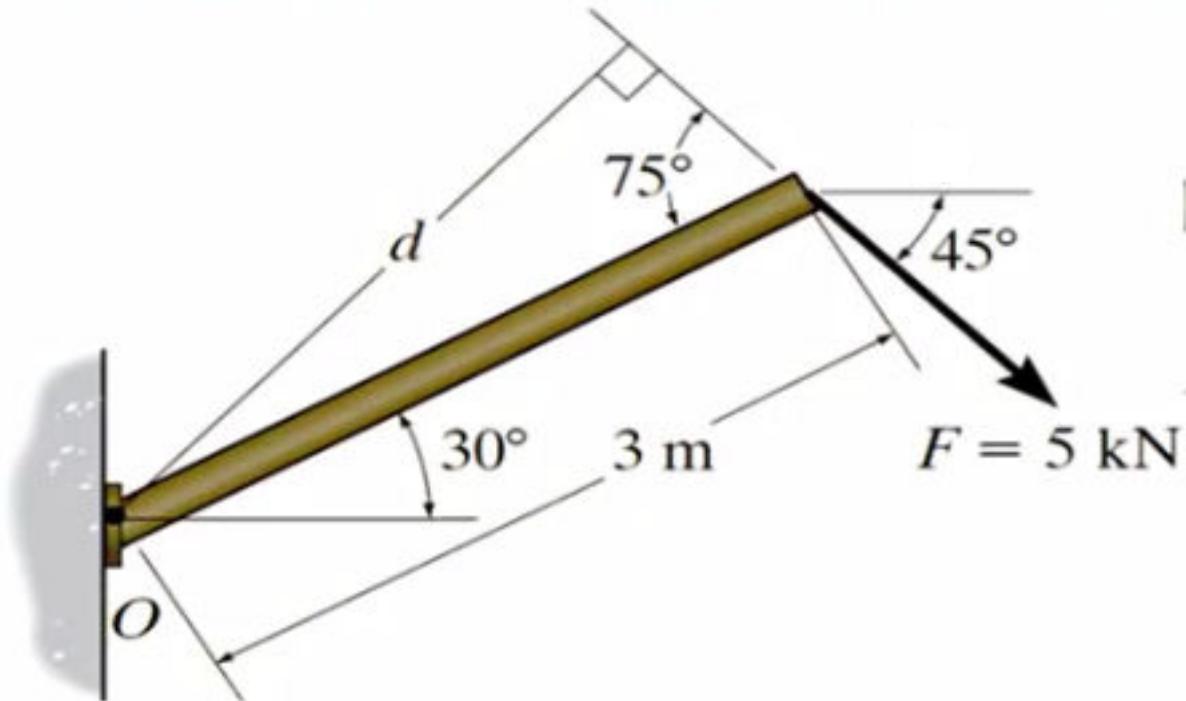
Example (5) :

Determine the moment of the force about point O.

أحسب عزم القوة المبينة حول النقطة (O).



Examples

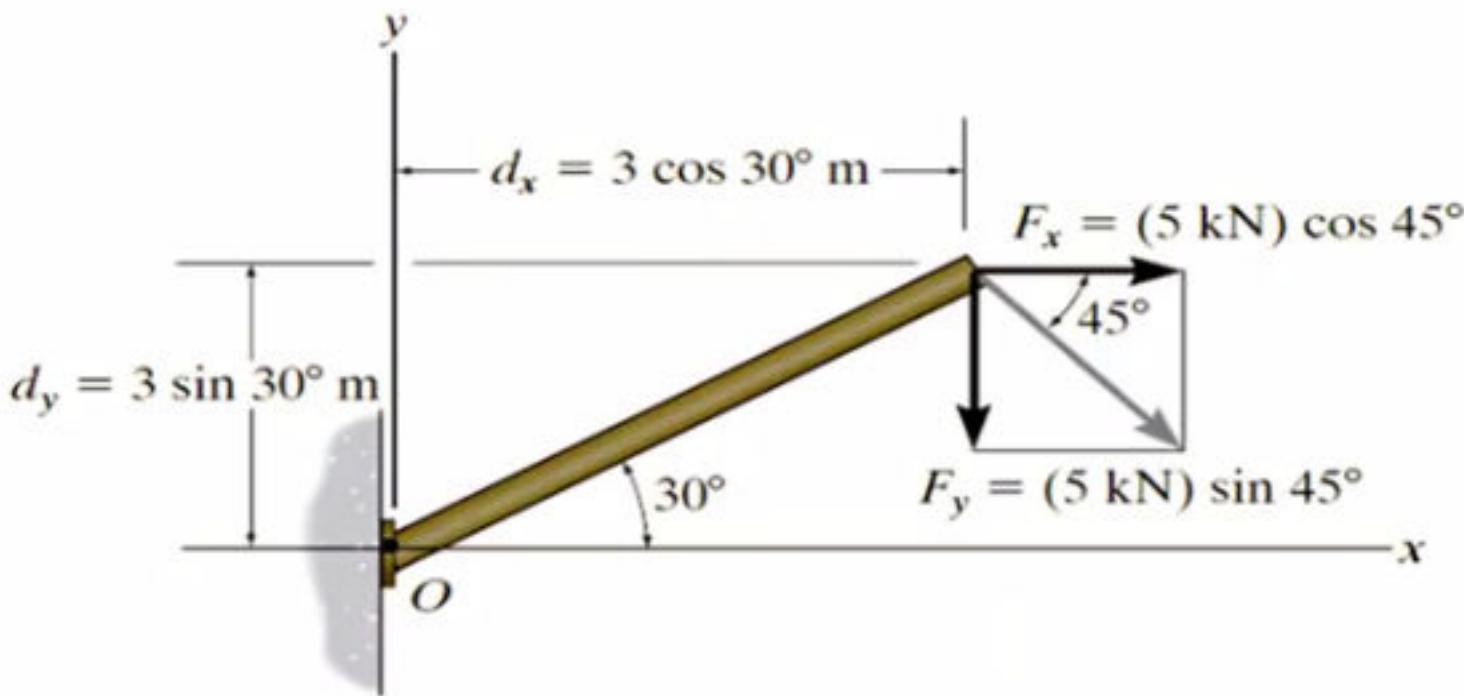


Solution 1:

$$d = (3 \text{ m}) \sin 75^\circ = 2.898 \text{ m}$$

$$Mo = Fd = (5\text{kN})(2.898 \text{ m}) = 14.5 \text{ kN.m}$$

Examples



Solution 2:

$$Mo = -F_x dy - F_y dx$$

$$\begin{aligned}
 &= -(5 \cos 45^\circ \text{ kN})(3 \sin 30^\circ \text{ m}) - (5 \sin 45^\circ \text{ kN}) \\
 &\quad (3 \cos 30^\circ \text{ m}) \\
 &= -14.5 \text{ kN.m}
 \end{aligned}$$

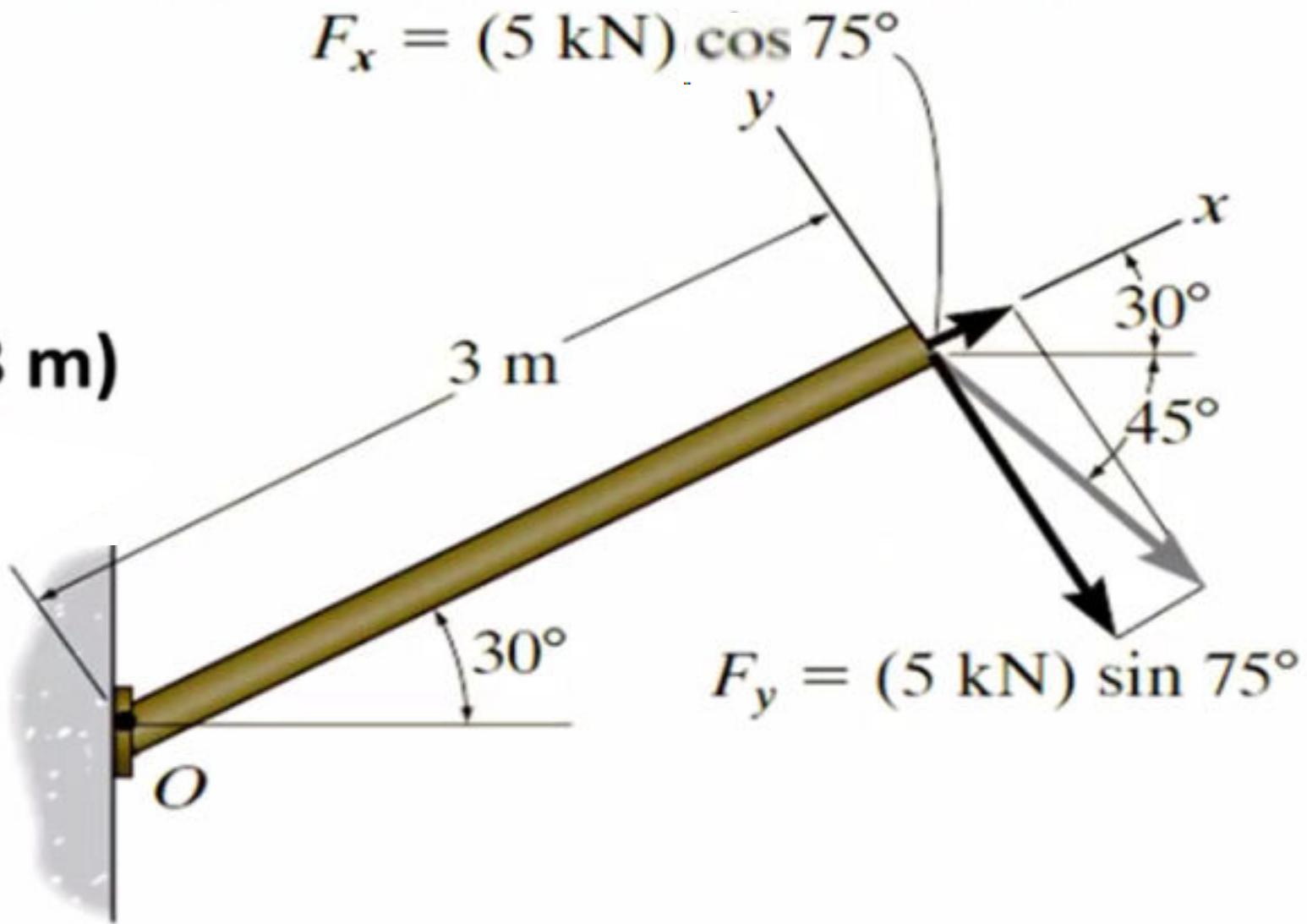
Examples

Solution 3:

$$M_O = - F_y dx$$

$$= - (5 \sin 75^\circ \text{ kN})(3 \text{ m})$$

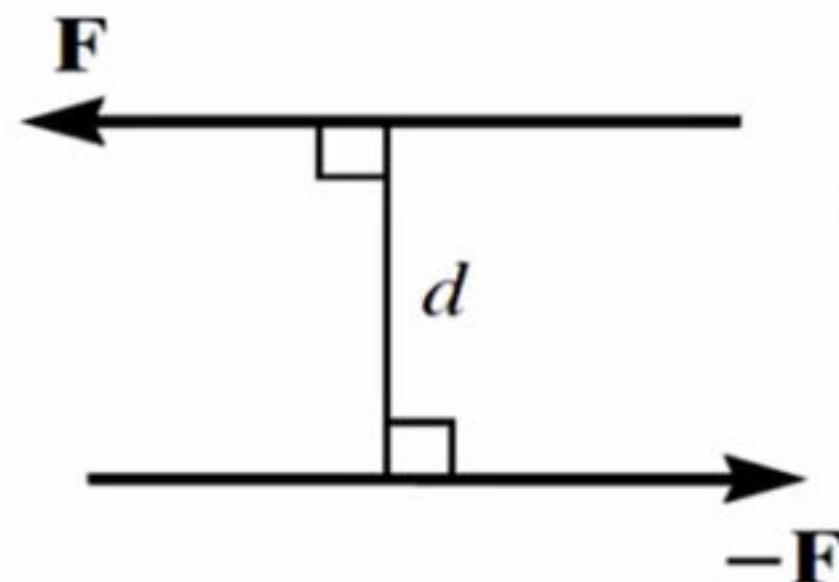
$$= -14.5 \text{ kN.m}$$



تعريف :

Definition :

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

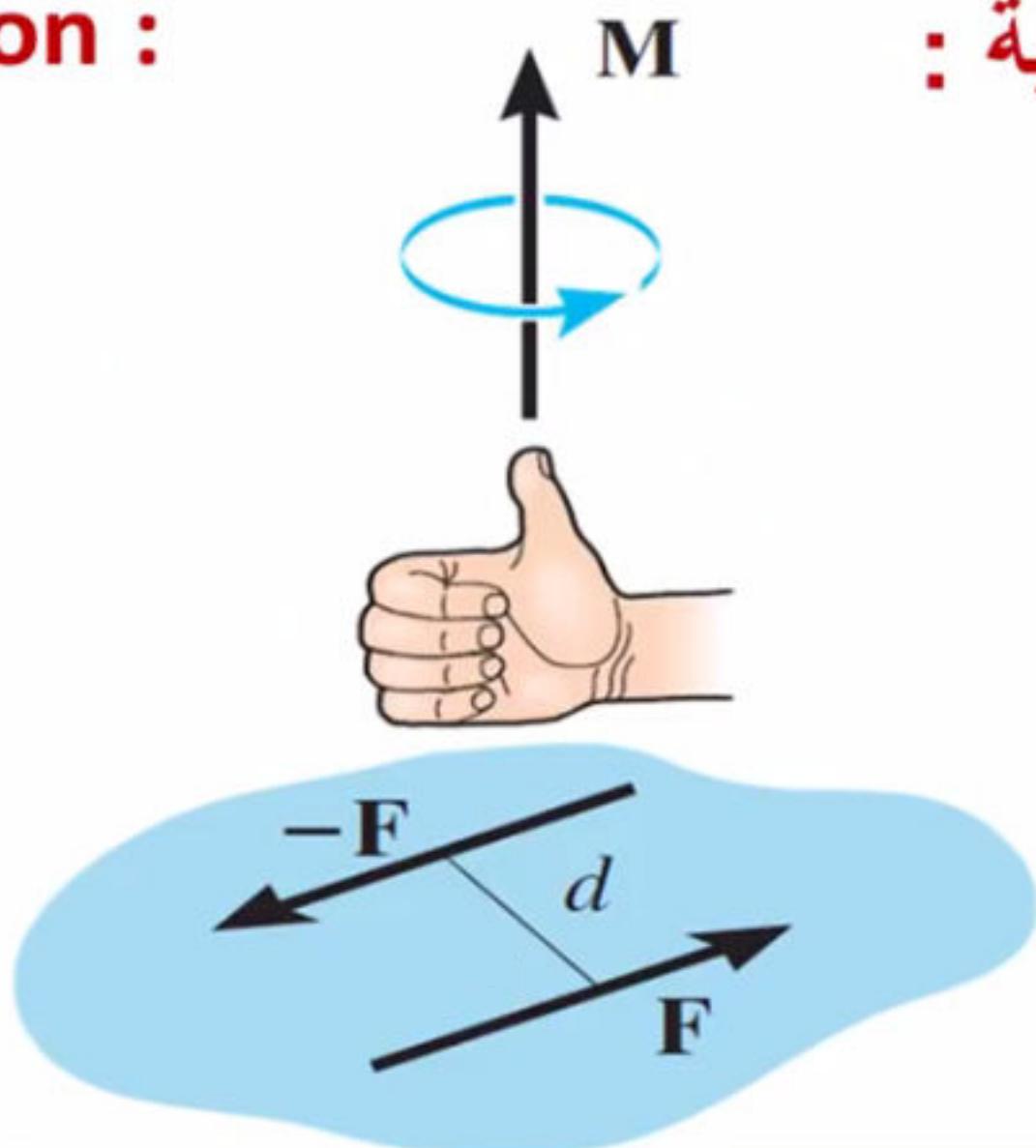


يتم تعريف الأزدواج على أنه قوتان متوازيتان لها نفس القيمة ، ولكن باتجاهين متعاكسيين ، و تكون بينهما مسافة عمودية d .

Moment of a Couple

Scalar Formulation :

$$M = Fd$$



الصياغة القياسية :

عزم الأزدواج

Moment of a Couple

عزم الأزدواج المحصل :

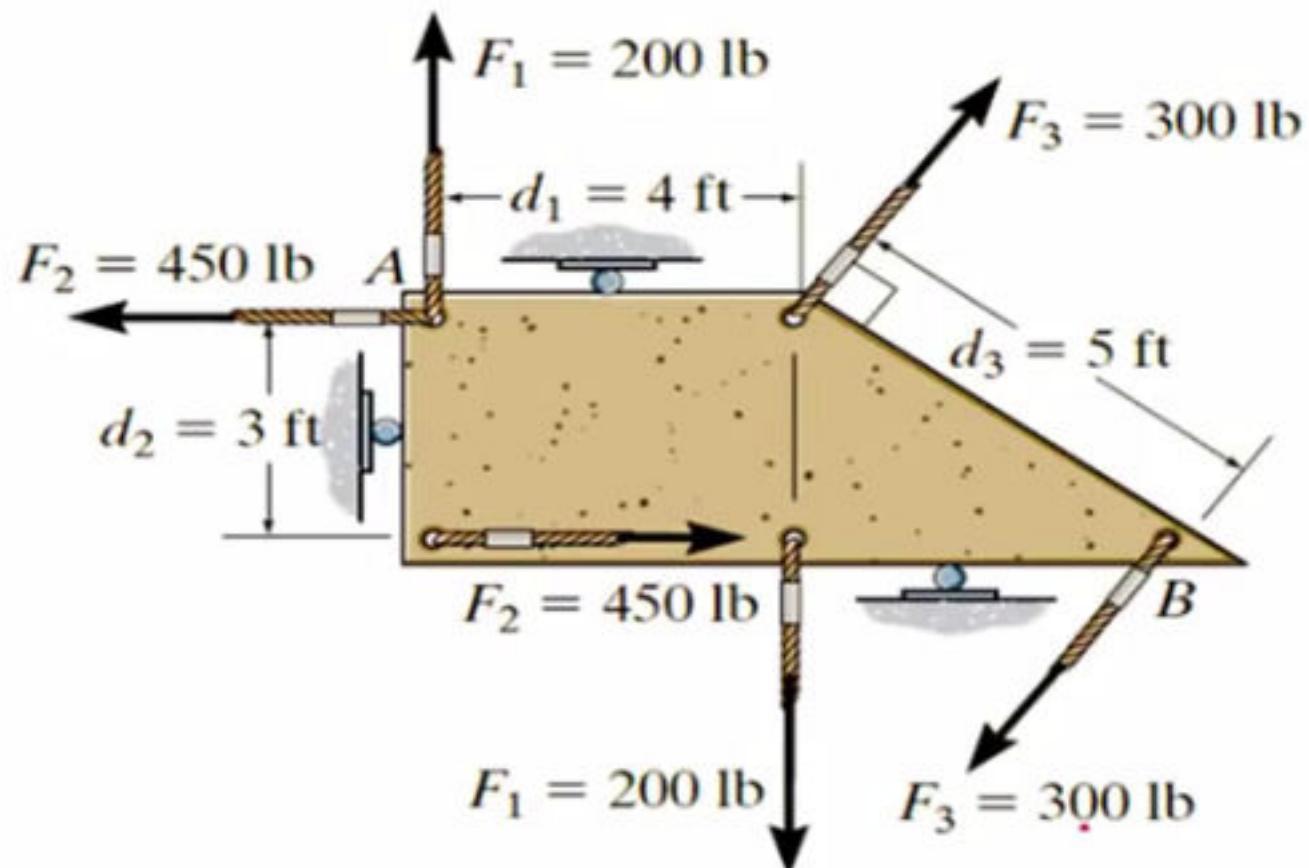
Resultant Couple Moment :

Examples

Example (6) :

Determine the resultant couple moment of the three couples acting on the plate

أحسب عزم الأزدواج المحصل للأزدواجات الثلاث المؤثرة على اللوحة المبينة.

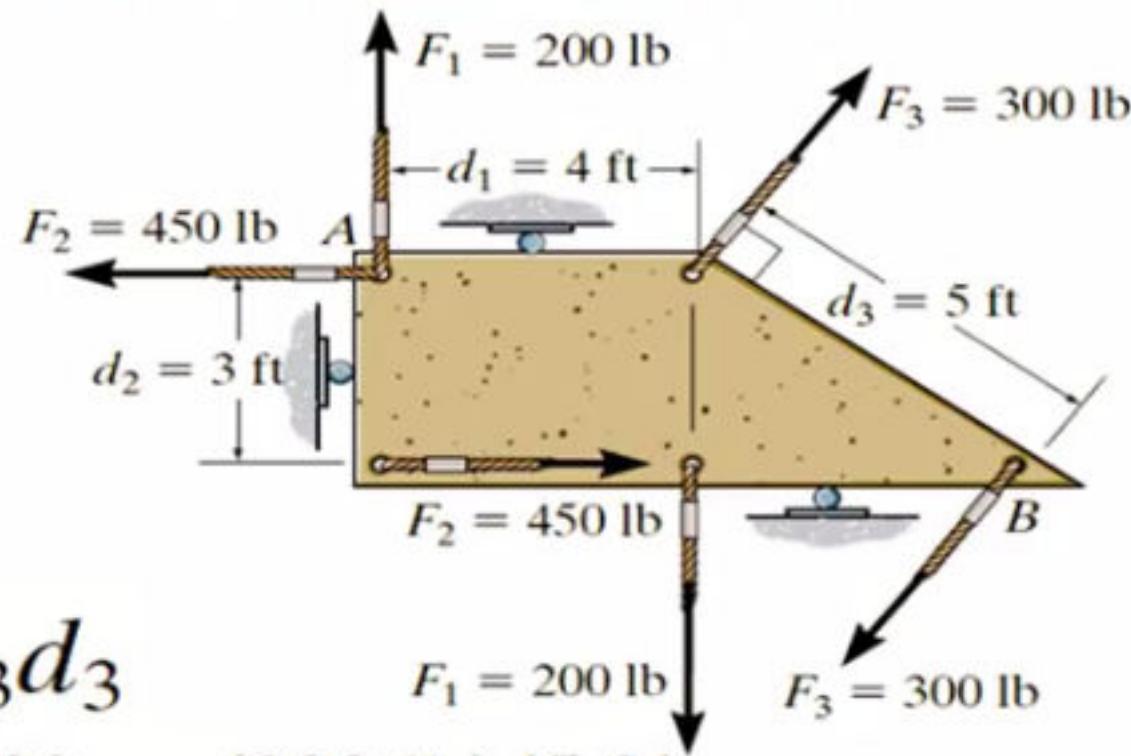


Examples



$$M_R = \sum M$$

$$\begin{aligned} M_R &= -F_1d_1 + F_2d_2 - F_3d_3 \\ &= (-200 \text{ lb})(4 \text{ ft}) + (450 \text{ lb})(3 \text{ ft}) - (300 \text{ lb})(5 \text{ ft}) \\ &= -950 \text{ lb} \cdot \text{ft} = 950 \text{ lb} \cdot \text{ft} \end{aligned}$$



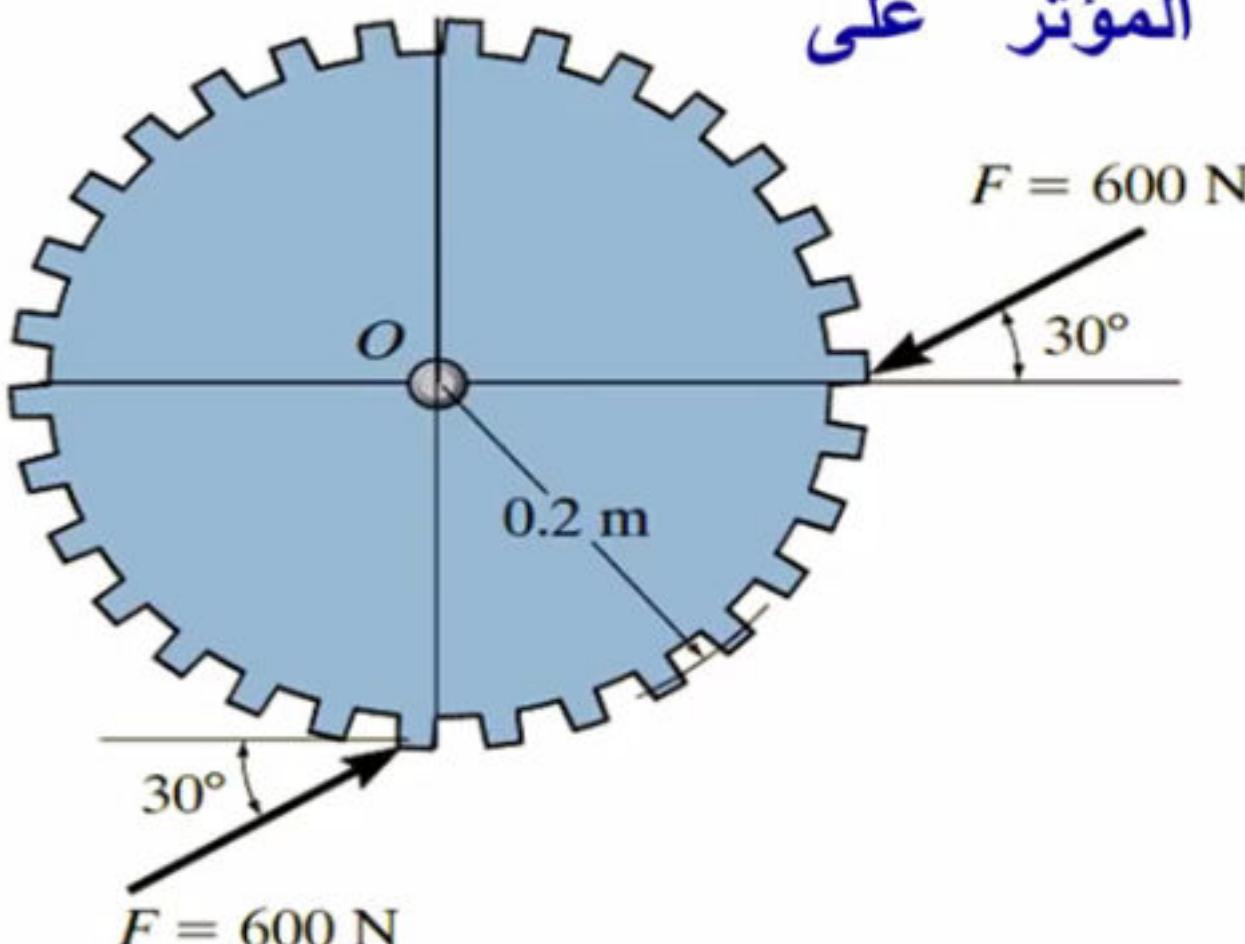
The negative sign indicates that M_R has a clockwise rotational sense.

Examples

Example (7) :

Determine the magnitude and direction of the couple moment acting on the gear

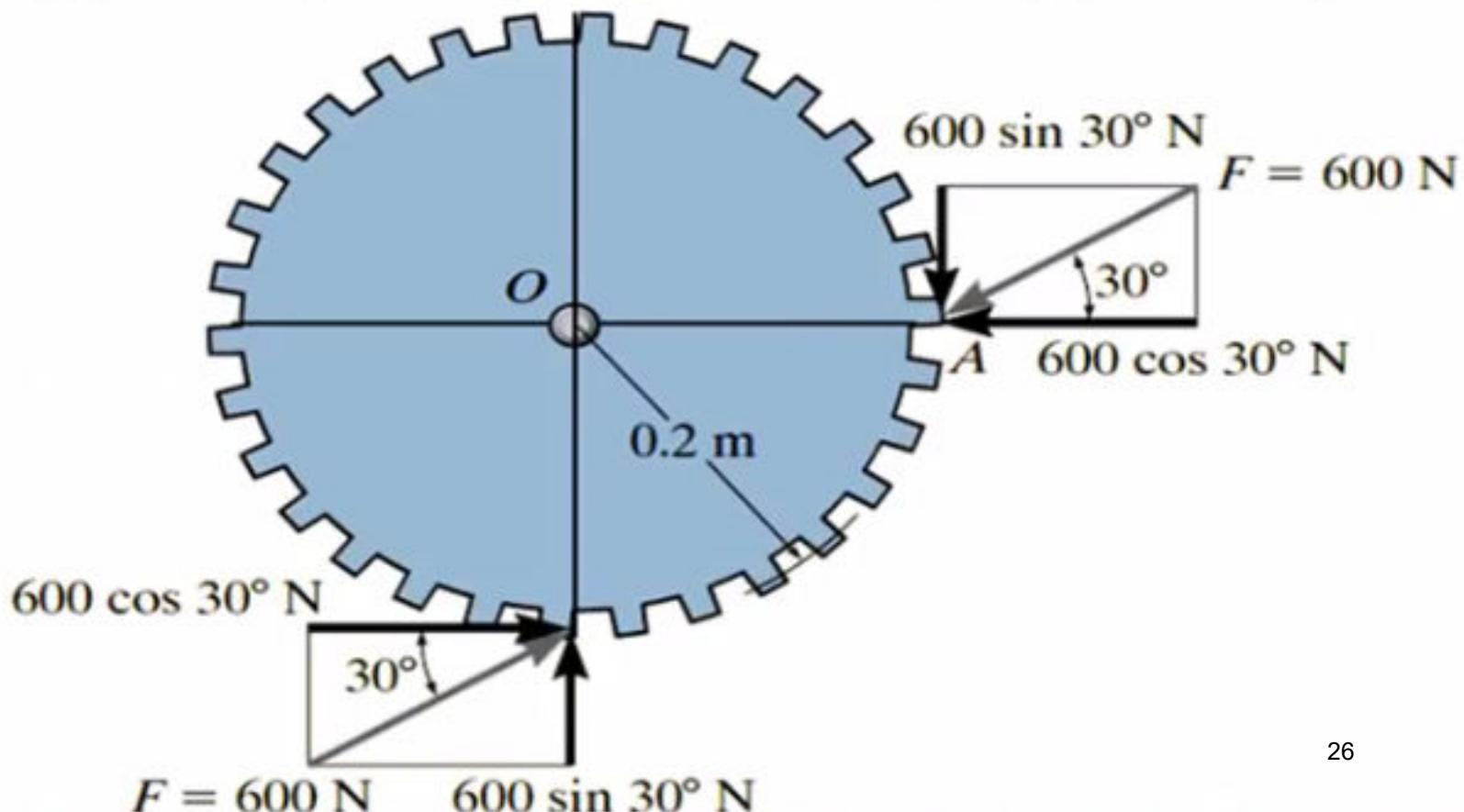
أحسب قيمة واتجاه عزم الازدواج المؤثر على الترس.



Examples

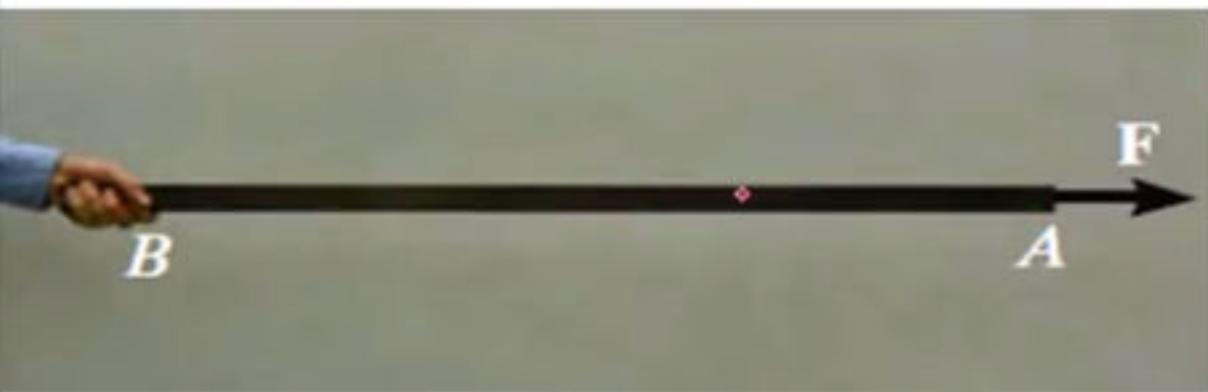
$$M = \Sigma M_O$$

$$M = (600 \cos 30^\circ \text{ N})(0.2 \text{ m}) - (600 \sin 30^\circ \text{ N})(0.2 \text{ m}) \\ = 43.9 \text{ N}\cdot\text{m} \uparrow$$



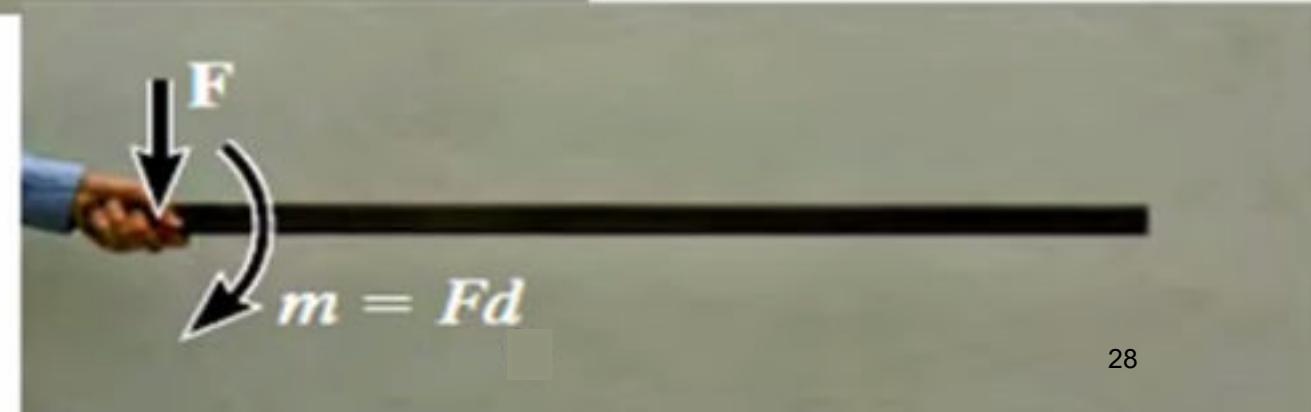
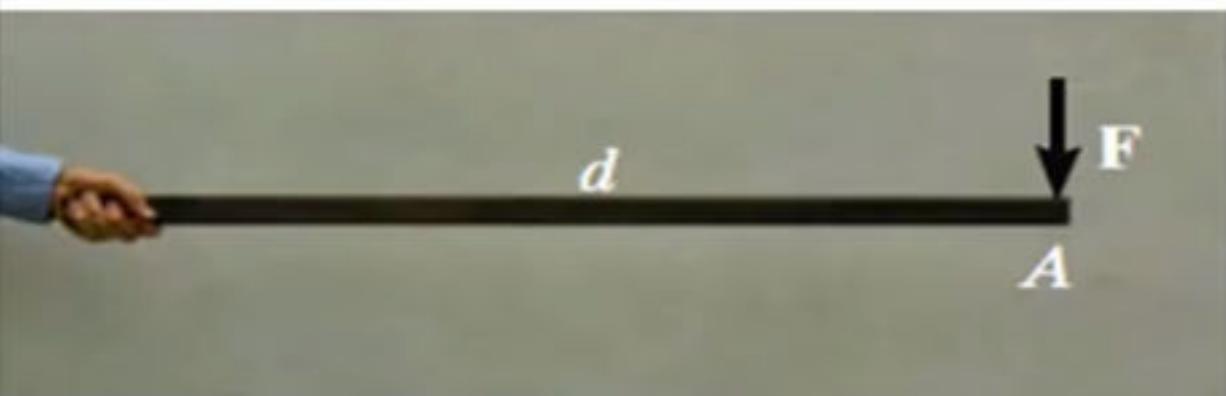
Force and Couple System

نظام القوى والأزدواج



Force and Couple System

نظام القوى والأزدواج



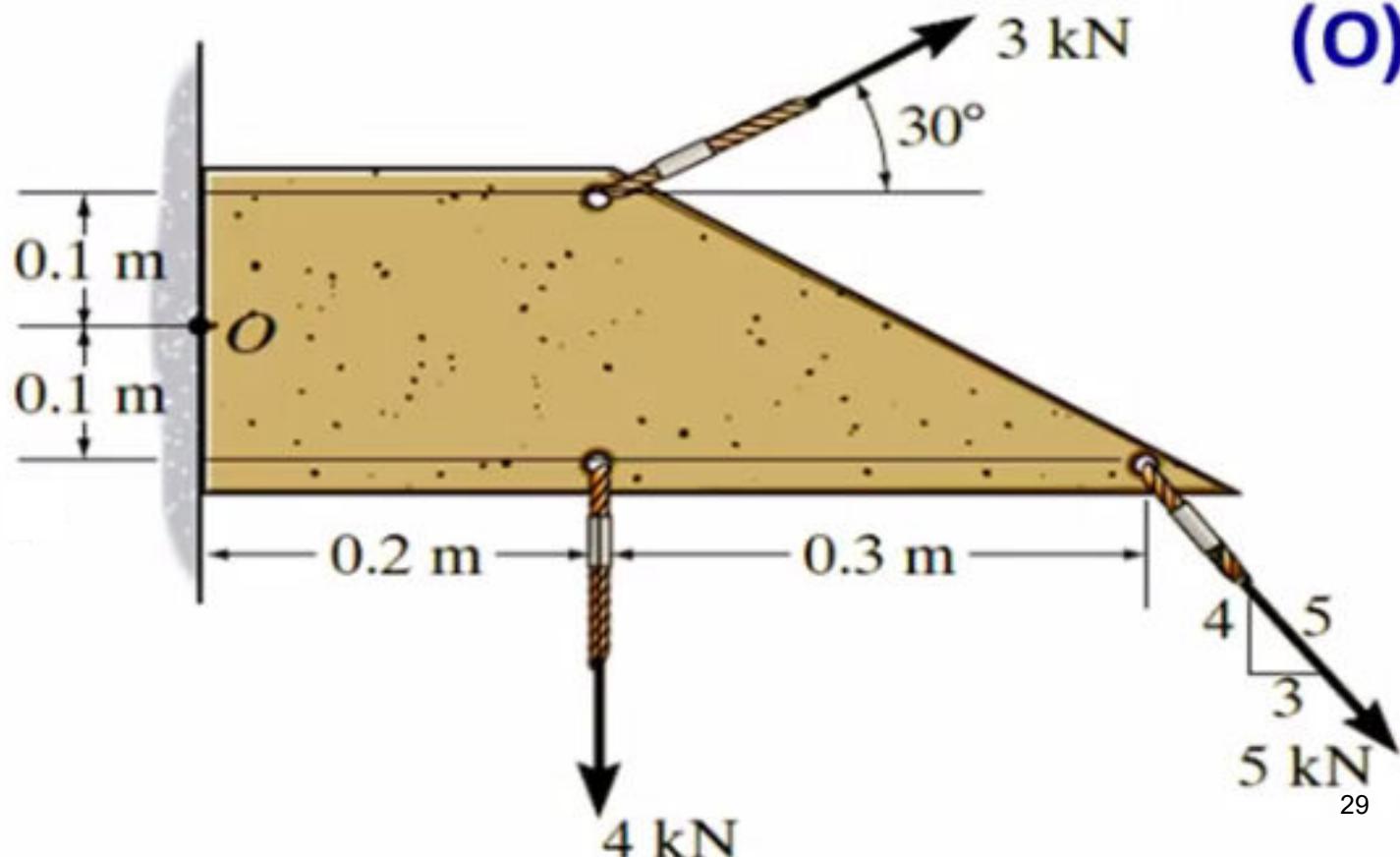
Examples

Example (8) :

Replace the force and couple system by an equivalent resultant force and couple moment acting at point O.

مثال

استبدل القوى المبينة بالشكل
بقوة وعزم ازدواج عند النقطة
(O)



Examples

Force Summation :

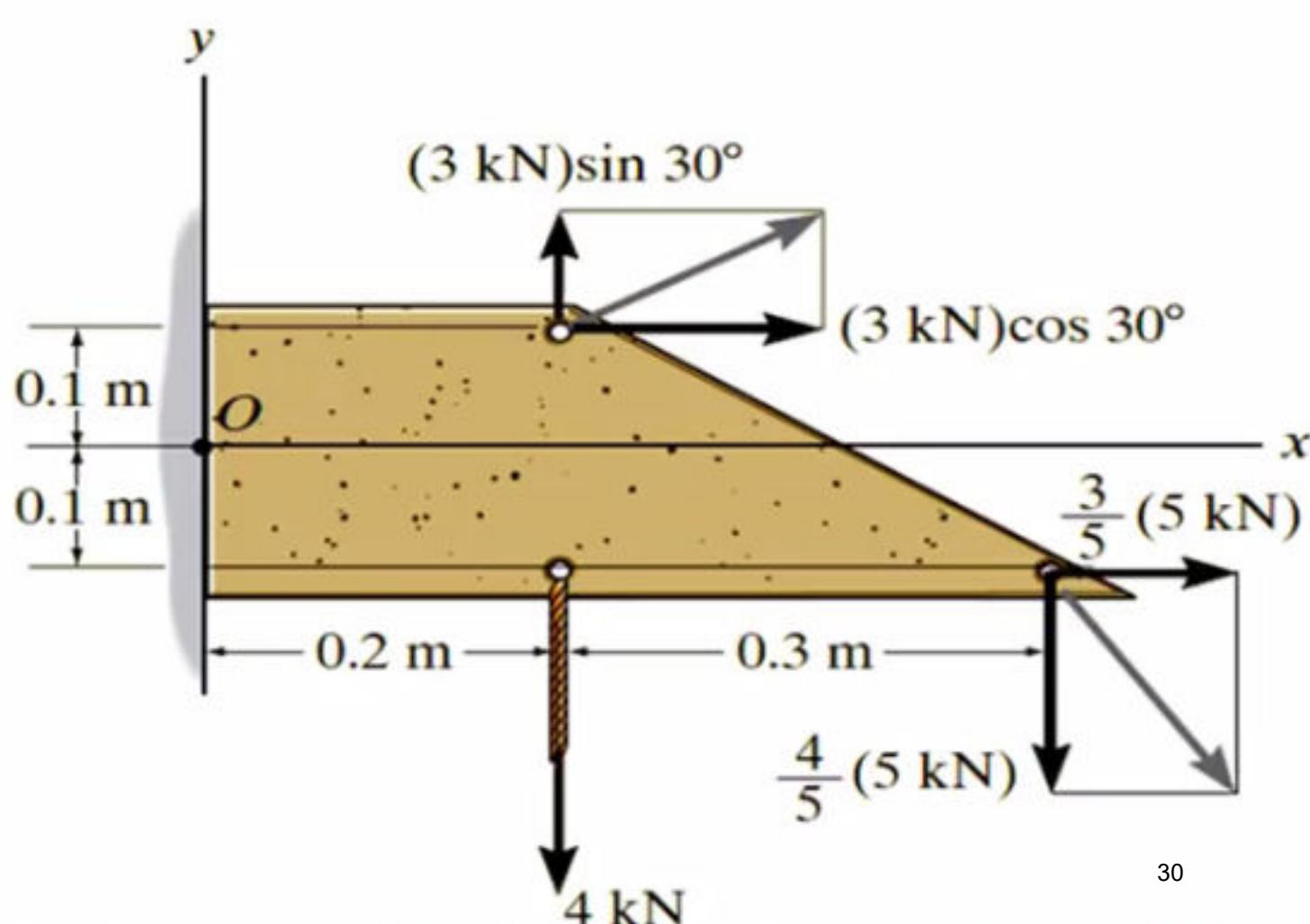
$$(F_R)_x = \sum F_x$$

$$\begin{aligned}(F_R)_x &= (3\text{kN})\cos 30^\circ \\ &\quad + (3/5)(5\text{kN}) \\ &= 5.598\text{kN}\end{aligned}$$

$$(F_R)_y = \sum F_y$$

$$\begin{aligned}(F_R)_y &= (3\text{kN})\sin 30^\circ \\ &\quad - (4/5)(5\text{kN}) - 4\text{kN} \\ &= -6.50\text{kN}\end{aligned}$$

مجموع القوى :



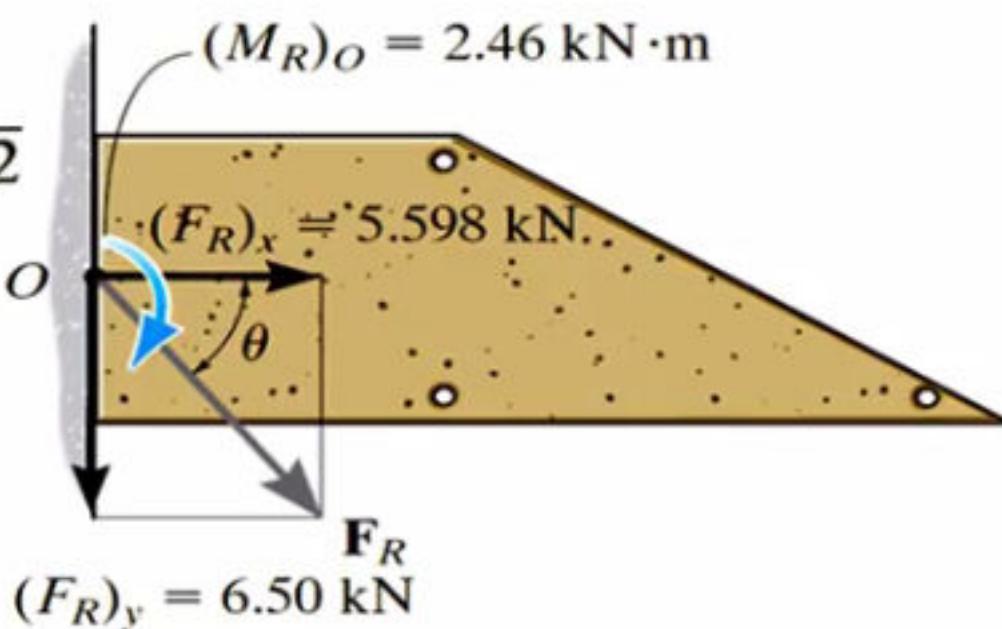
Examples

$$(F_R)_x = 5.598 \text{ kN}$$

$$(F_R)_y = -6.50 \text{ kN}$$

$$\begin{aligned} F_R &= \sqrt{(F_R)_x^2 + (F_R)_y^2} \\ &= \sqrt{(5.598 \text{ kN})^2 + (6.50 \text{ kN})^2} \\ &= 8.58 \text{ kN} \end{aligned}$$

$$\begin{aligned} \theta &= \tan^{-1}\left(\frac{(F_R)_y}{(F_R)_x}\right) \\ &= \tan^{-1}\left(\frac{6.50 \text{ kN}}{5.598 \text{ kN}}\right) = 49.3^\circ \end{aligned}$$



Examples

Moment Summation :

$$(M_R)_O = \sum M_O$$

$$(M_R)_O = (3\text{kN})\sin 30^\circ(0.2\text{m})$$

$$-(3\text{kN})\cos 30^\circ(0.1\text{ m})$$

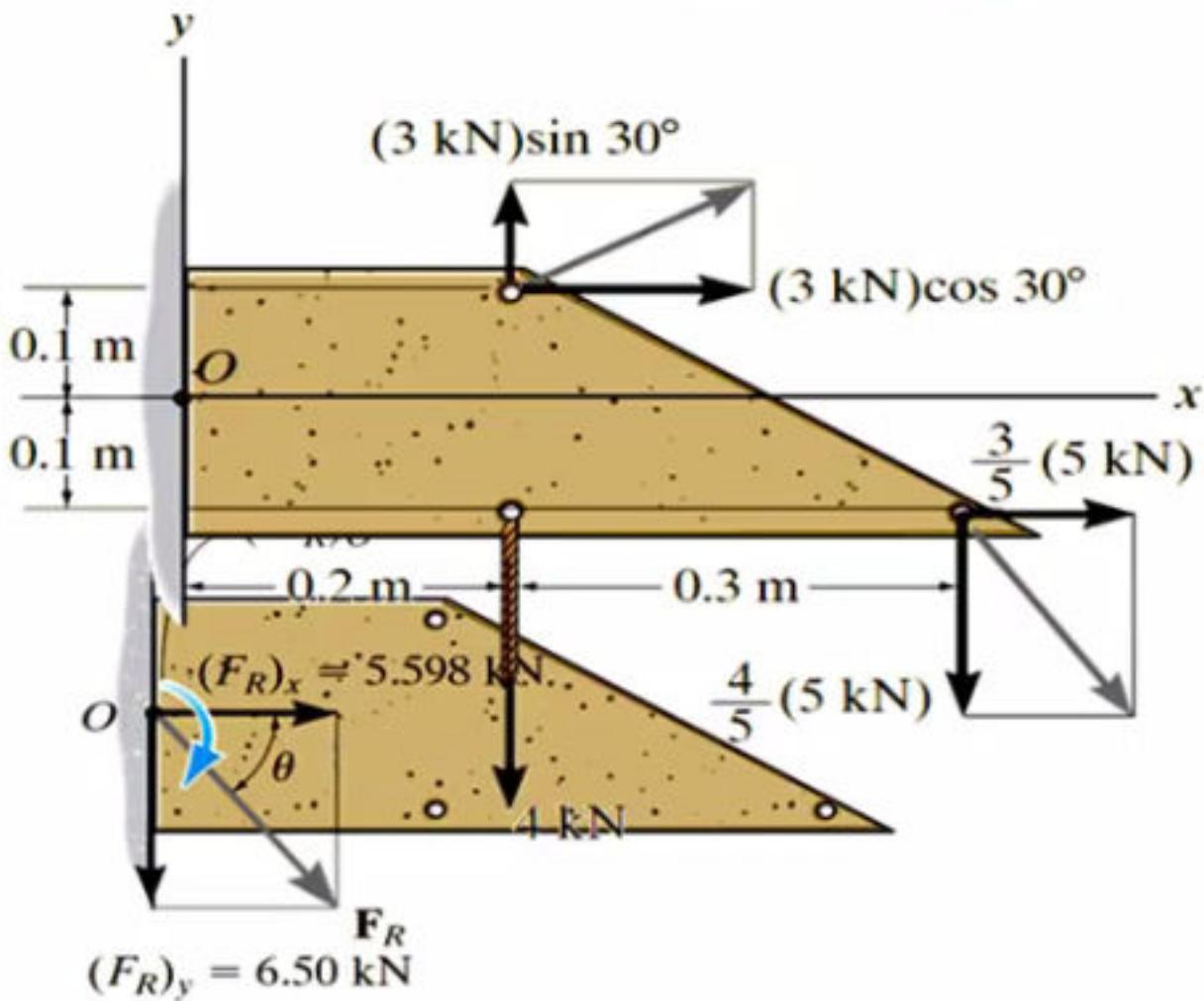
$$+(3/5)(5\text{kN})(0.1\text{m})$$

$$-(4/5)(5\text{kN})(0.5\text{ m})$$

$$-(4\text{kN})(0.2\text{m})$$

$$= -2.46\text{kN.m}$$

مجموع العزوم :

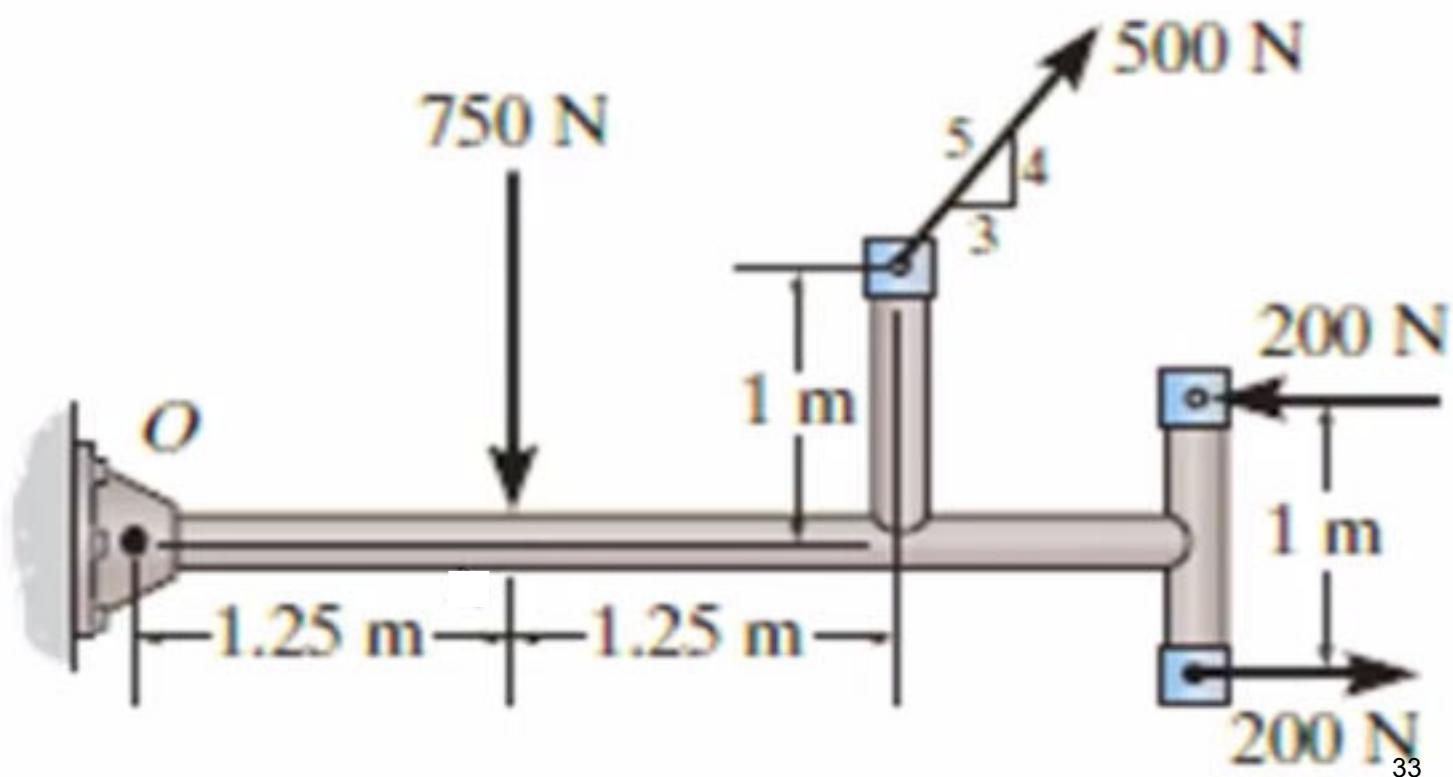


Examples

Example (9) :

Replace the force and couple system acting on the member by an equivalent resultant force and couple moment acting at point O

استبدل القوى والازدواج المبينين بالشكل بقوة وعزم ازدواج عند النقطة (O)



Examples

Force Summation : مجموع القوى :

$$\rightarrow (F_R)_x = \sum F_x$$

$$(F_R)_x = \left(\frac{3}{5}\right) (500 \text{ N}) = 300 \text{ N} \rightarrow$$

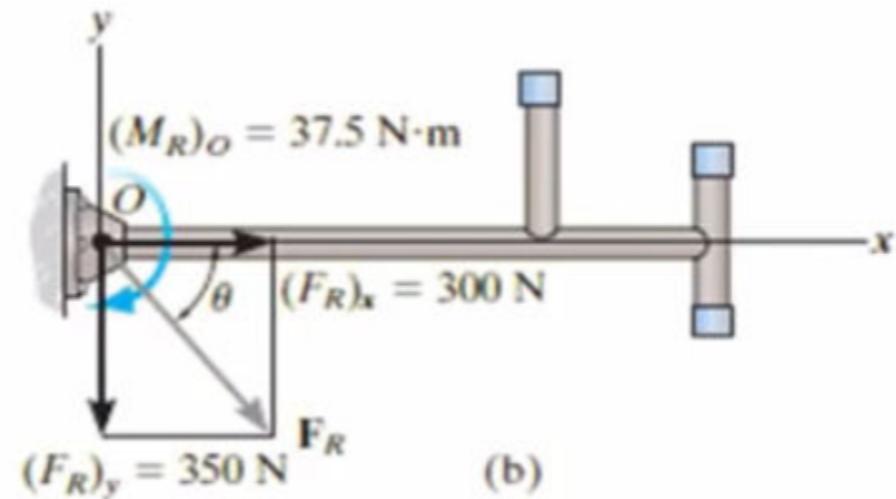
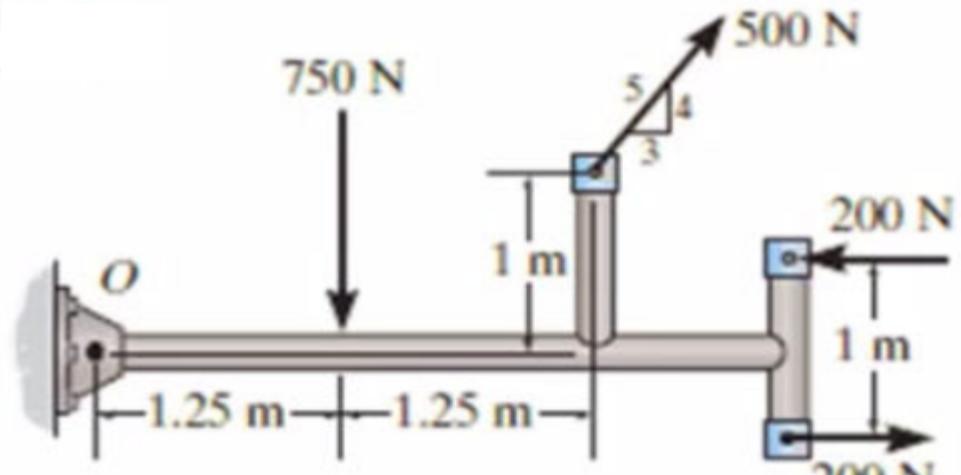
$$+ \uparrow (F_R)_y = \sum F_y$$

$$(F_R)_y = (500 \text{ N})\left(\frac{4}{5}\right) - 750 \text{ N} = -350 \text{ N} = 350 \text{ N} \downarrow$$

$$F_R = \sqrt{(F_R)_x^2 + (F_R)_y^2}$$

$$= \sqrt{(300 \text{ N})^2 + (350 \text{ N})^2} = 461 \text{ N}$$

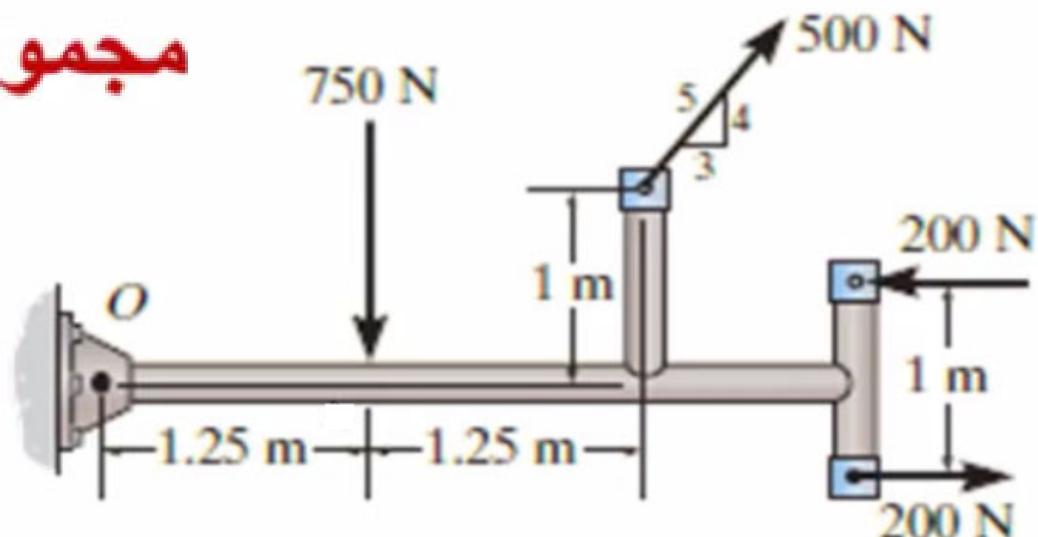
$$\theta = \tan^{-1}\left(\frac{(F_R)_y}{(F_R)_x}\right) = \tan^{-1}\left(\frac{350 \text{ N}}{300 \text{ N}}\right) = 49.4^\circ$$



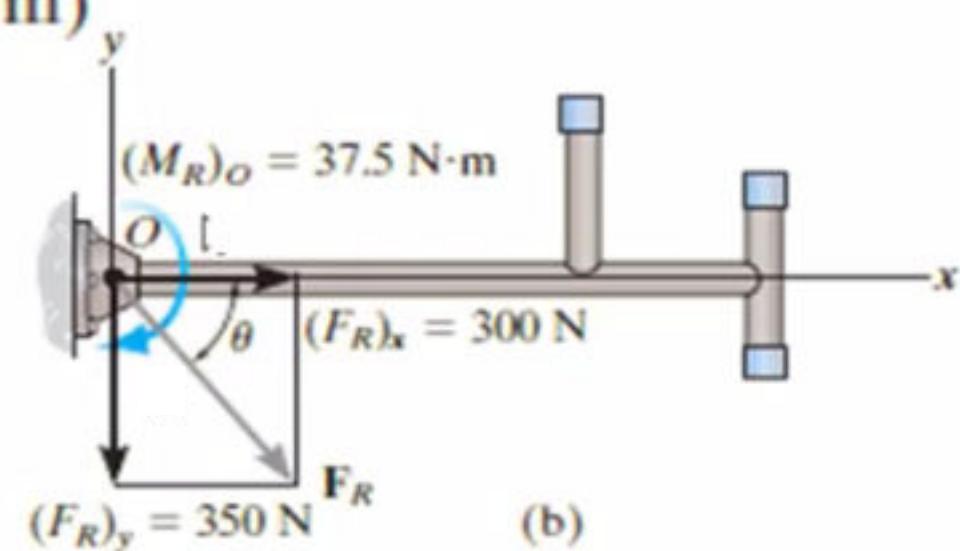
Examples

مجموع العزوم : : Moment Summation :

$$\zeta + (M_R)_O = \sum M_O + \sum M_C$$



$$\begin{aligned}
 (M_R)_O &= (500 \text{ N})\left(\frac{4}{5}\right)(2.5 \text{ m}) - (500 \text{ N})\left(\frac{3}{5}\right)(1 \text{ m}) \\
 &\quad - (750 \text{ N})(1.25 \text{ m}) + 200 \text{ N} \cdot \text{m} \\
 &= -37.5 \text{ N} \cdot \text{m} = 37.5 \text{ N} \cdot \text{m}
 \end{aligned}$$



The force system can be further reduced to an equivalent single resultant force provided the lines of action of F_R and (M_R) are *perpendicular to each other.*

نظام القوى والعزوم يمكن اختزاله إلى قوة محصلة وعزم محصل

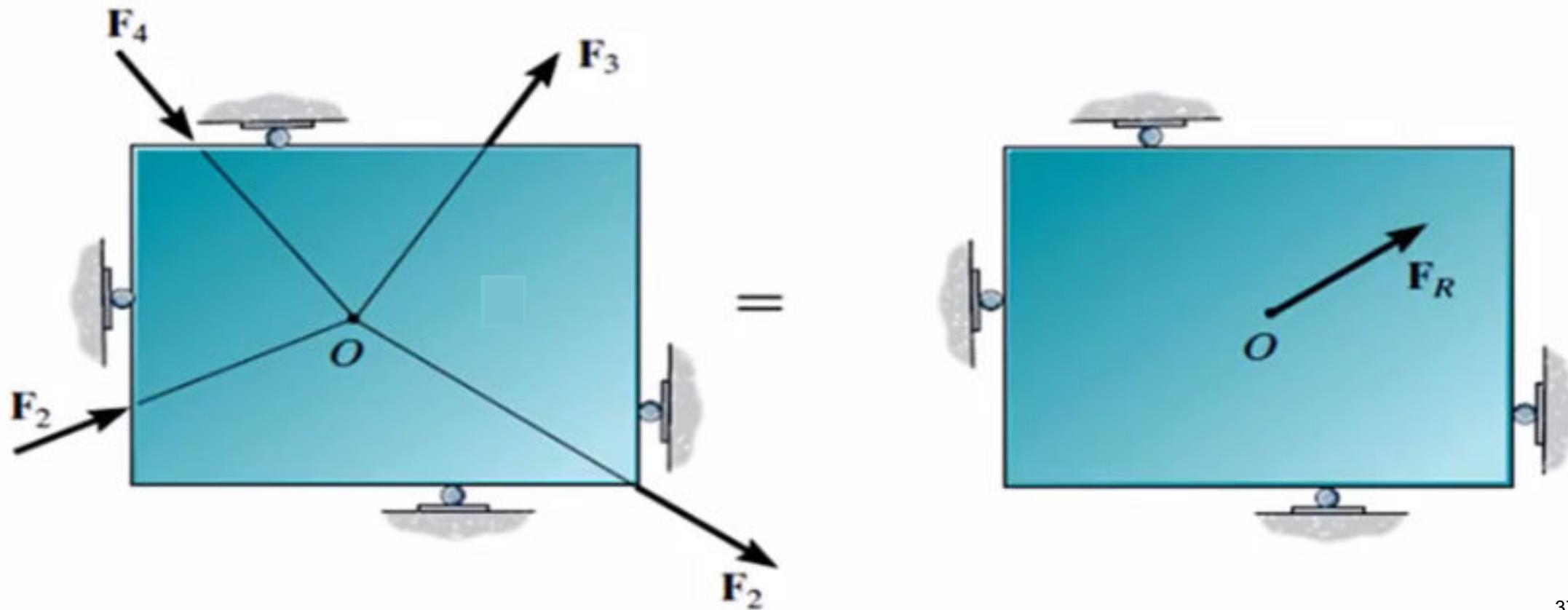
Force and Couple System

نظام القوى والأزدواج

Concurrent Force System :

نظام القوى المتلاقيّة :

$$\mathbf{F}_R = \sum \mathbf{F}$$

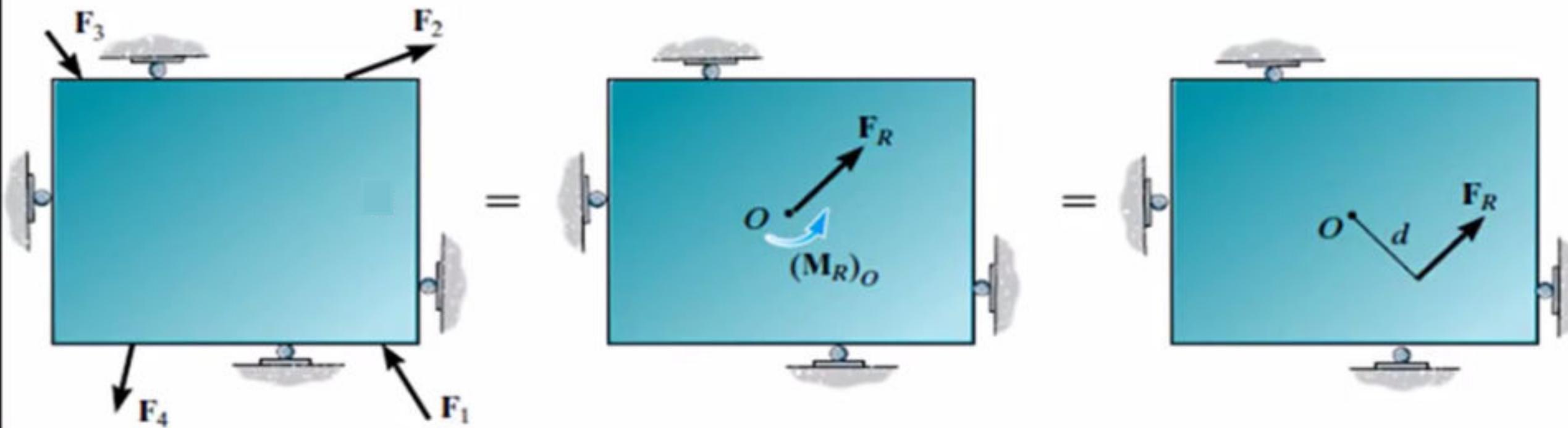


Force and Couple System

نظام القوى والأزدواج

Coplanar Force System :

نظام القوى المستوية :



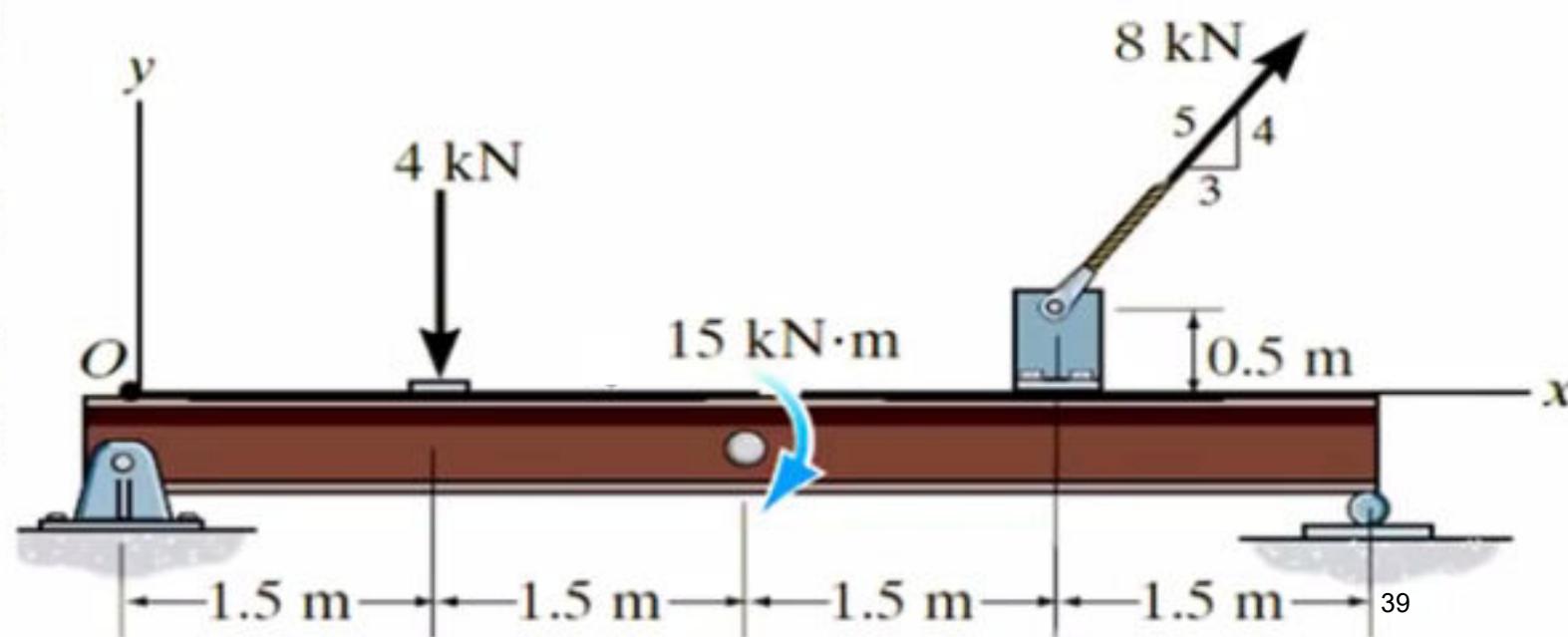
$$(M_R)_O = F_R d = \sum M_O \text{ or } d = (M_R)_O / F_R.$$

Examples

Example (10) :

Replace the force and couple moment system acting on the beam by an equivalent resultant force, and find where its line of action intersects the beam, measured from point O.

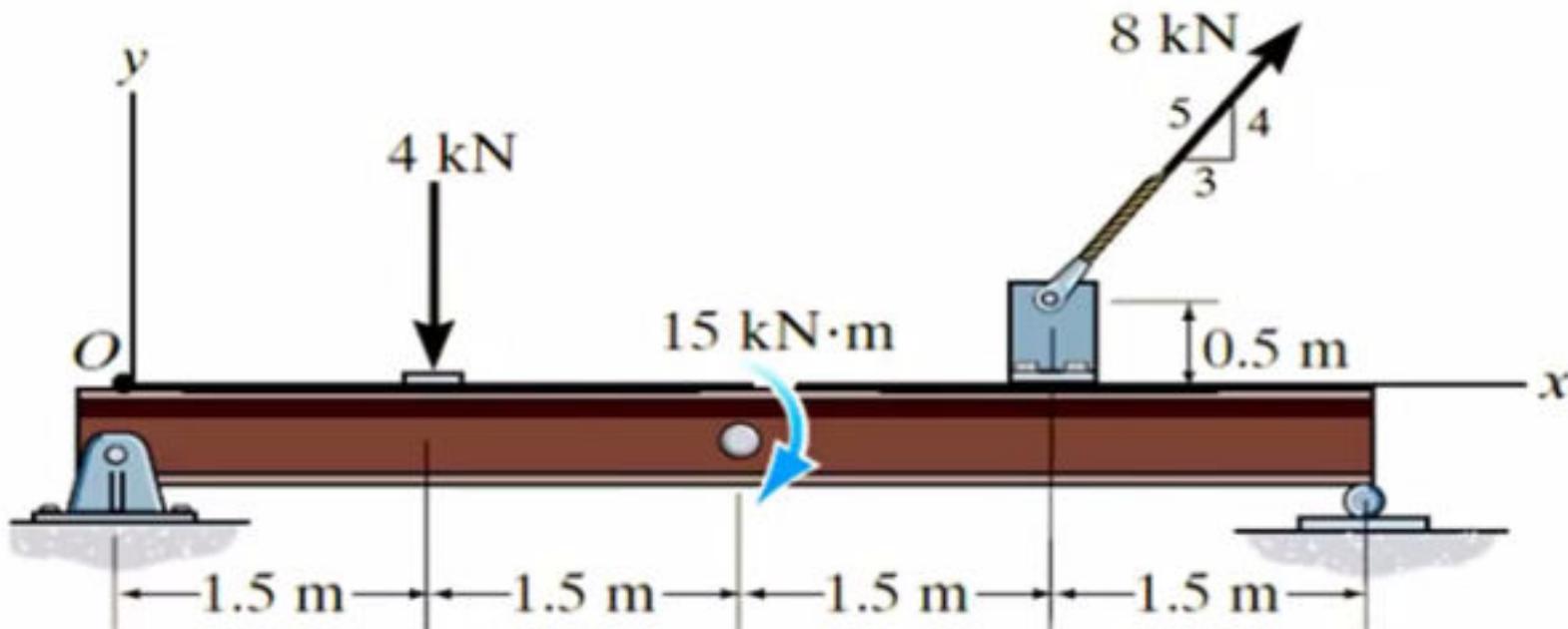
استبدل نظام القوة والعزم المبين بالشكل بقوة محصلة. واحسب مسافة نقطة تقاطع خط تأثيرها على الكمرة من النقطة (O)



Examples

مجموع القوى :

Force Summation :



$$\rightarrow (F_R)_x = \Sigma F_x \rightarrow (F_R)_x = 8 \text{ kN} \left(\frac{3}{5}\right) = 4.80 \text{ kN} \rightarrow$$

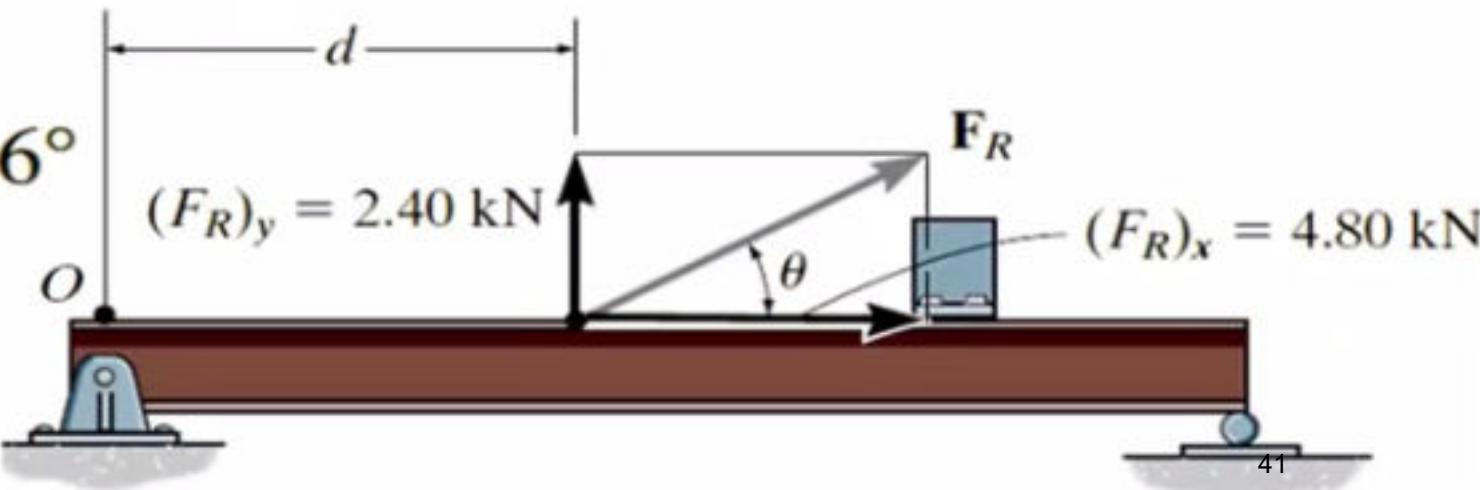
$$+ \uparrow (F_R)_y = \Sigma F_y \rightarrow (F_R)_y = -4 \text{ kN} + 8 \text{ kN} \left(\frac{4}{5}\right) = 2.40 \text{ kN} \uparrow$$

Examples

مجموع القوى :

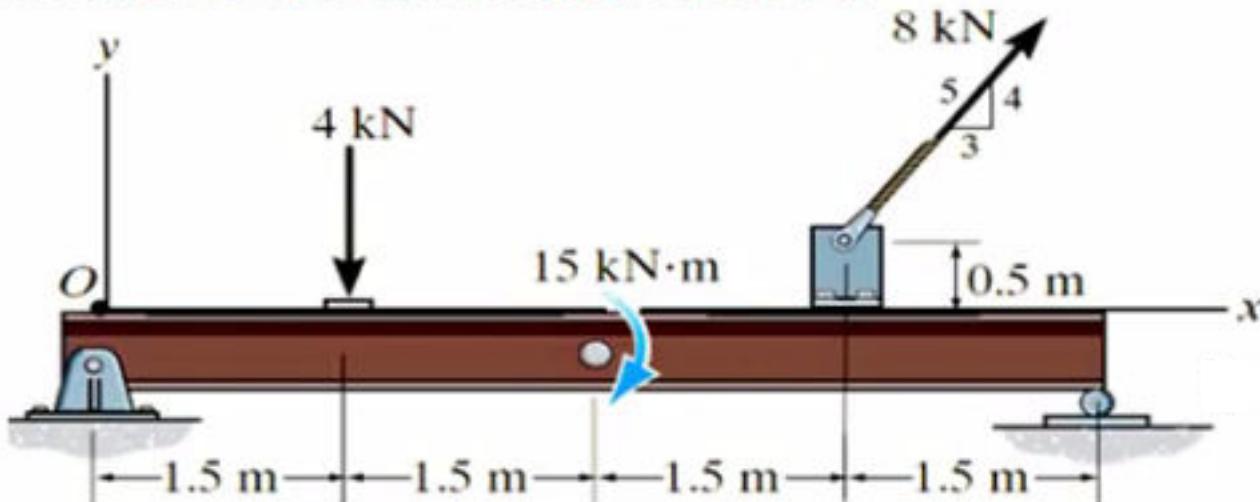
$$F_R = \sqrt{(4.80 \text{ kN})^2 + (2.40 \text{ kN})^2} = 5.37 \text{ kN}$$

$$\theta = \tan^{-1}\left(\frac{2.40 \text{ kN}}{4.80 \text{ kN}}\right) = 26.6^\circ$$

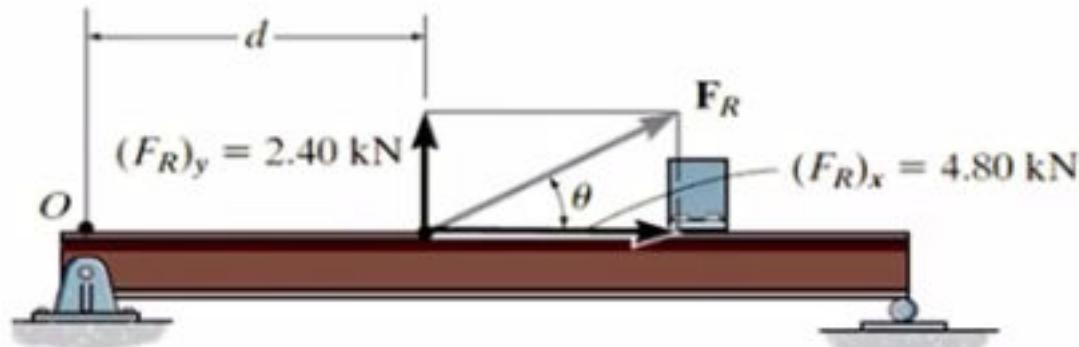


Examples

Moment Summation :



مجموع العزوم :



$$(M_R)_O = \sum M_O$$

$$2.40 \text{ kN}(d) = -(4 \text{ kN})(1.5 \text{ m}) - 15 \text{ kN}\cdot\text{m} \\ - [8 \text{ kN}(\frac{3}{5})] (0.5 \text{ m}) + [8 \text{ kN}(\frac{4}{5})](4.5 \text{ m})$$

$$d = 2.25 \text{ m}$$

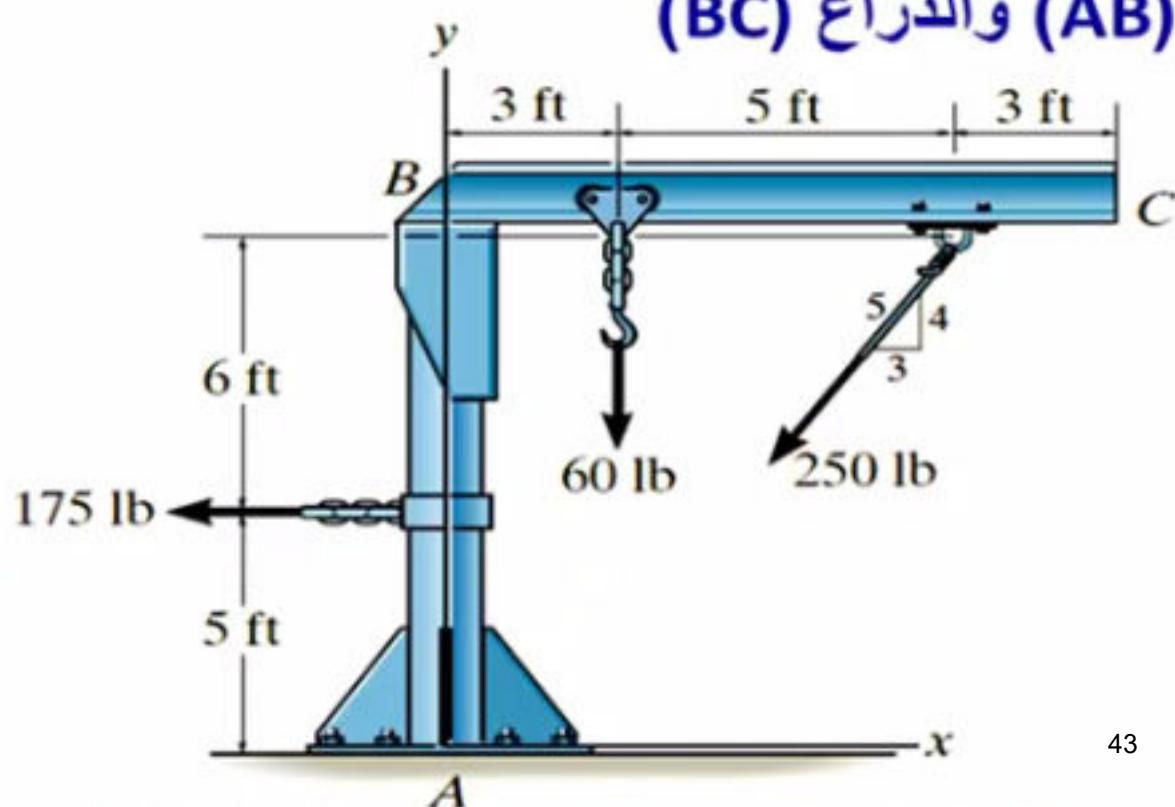
Examples

Example (11) :

The jib crane is subjected to three coplanar forces.

Replace this loading by an equivalent resultant force and specify where the resultant's line of action intersects the column AB and boom BC.

الونش المبين بالشكل معرض لثلاث قوى مستوية. استبدل هذه القوى بقوة واحدة وأحسب نقطة تقاطع خط عملها مع العمود (BC) والذراع (AB)



Examples

Force Summation : مجموع القوى :

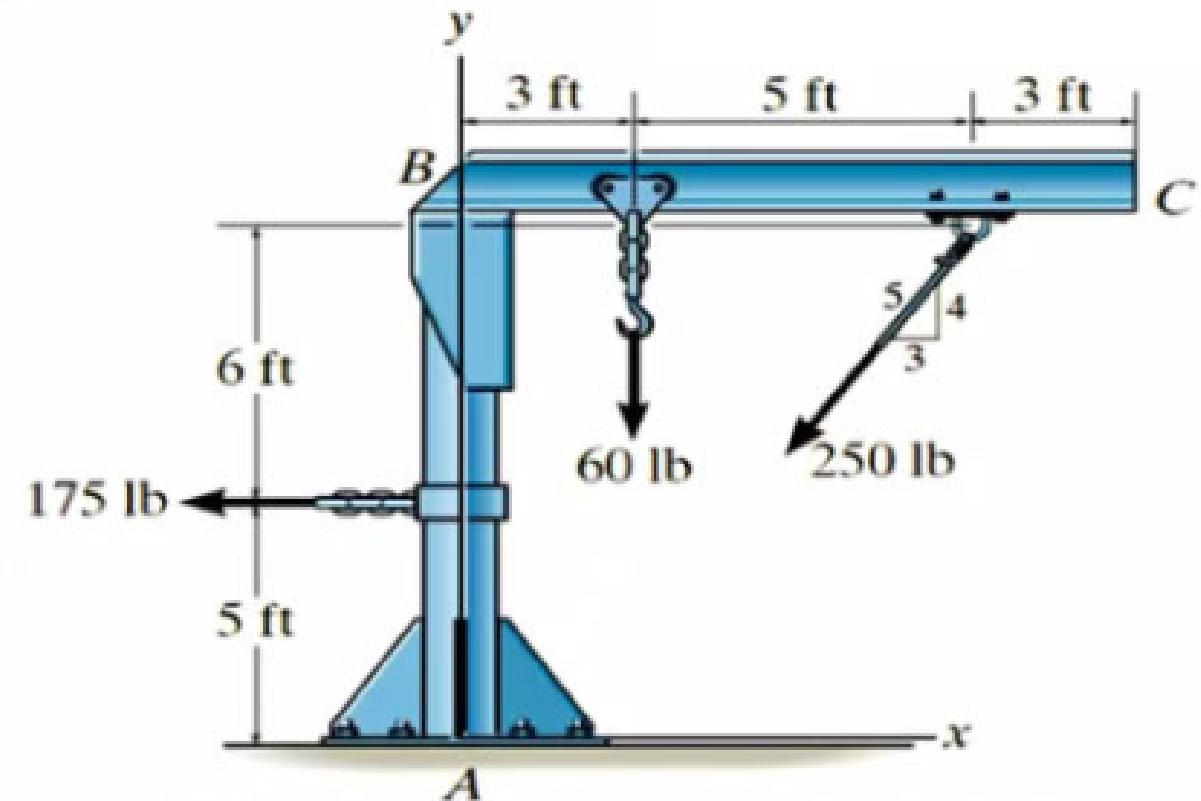
$$F_{R_x} = \sum F_x$$

$$\begin{aligned} F_{R_x} &= -250 \text{ lb} \left(\frac{3}{5}\right) - 175 \text{ lb} \\ &= -325 \text{ lb} \end{aligned}$$

$$F_{R_y} = \sum F_y$$

$$\begin{aligned} F_{R_y} &= -250 \text{ lb} \left(\frac{4}{5}\right) - 60 \text{ lb} \\ &= -260 \text{ lb} \end{aligned}$$

$$\begin{aligned} F_R &= \sqrt{(325 \text{ lb})^2 + (260 \text{ lb})^2} \\ &= 416 \text{ lb} \end{aligned}$$



$$\theta = \tan^{-1} \left(\frac{260 \text{ lb}}{325 \text{ lb}} \right) = 38.7^\circ$$

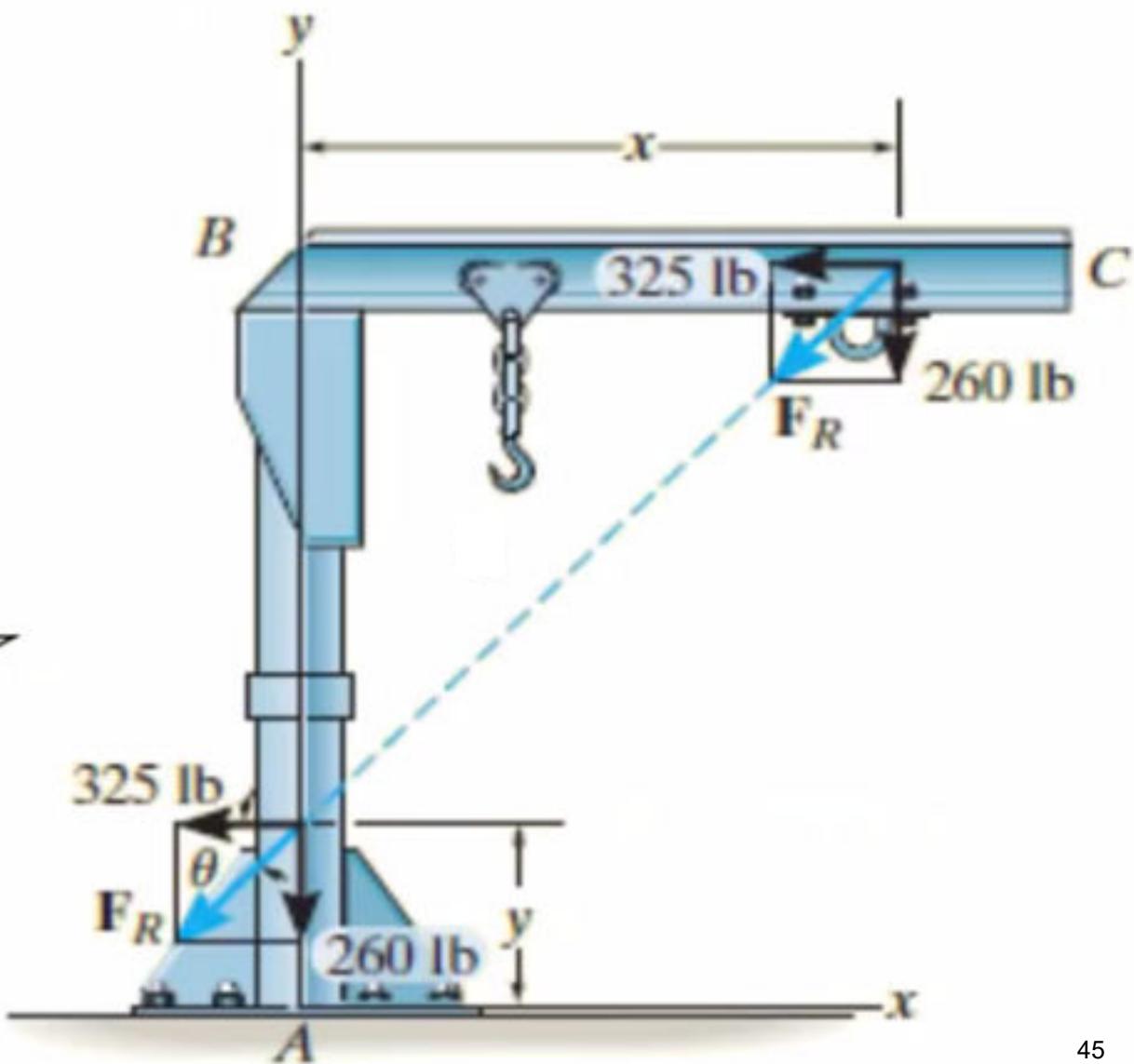
Examples

$$F_{R_x} = -325 \text{ lb}$$

$$F_{R_y} = -260 \text{ lb}$$

$$F_R = 416 \text{ lb}$$

$$\theta = \tan^{-1}\left(\frac{260 \text{ lb}}{325 \text{ lb}}\right) = 38.7^\circ$$



Examples

Moment Summation :

مجموع العزوم :

$$M_{R_A} = \sum M_A$$

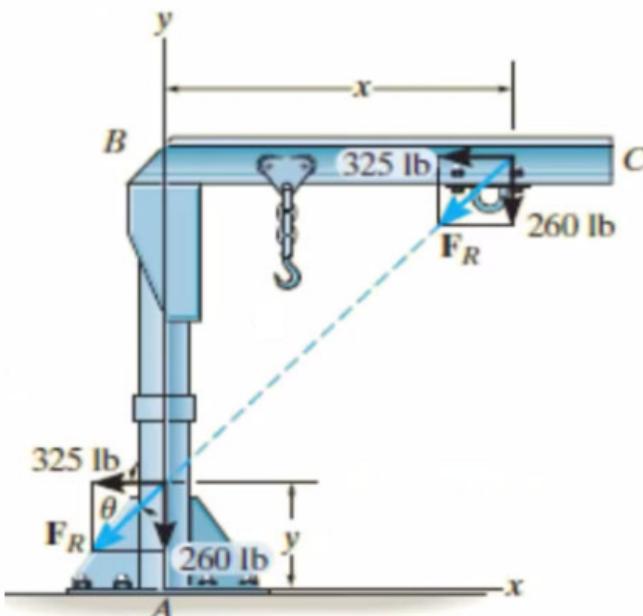
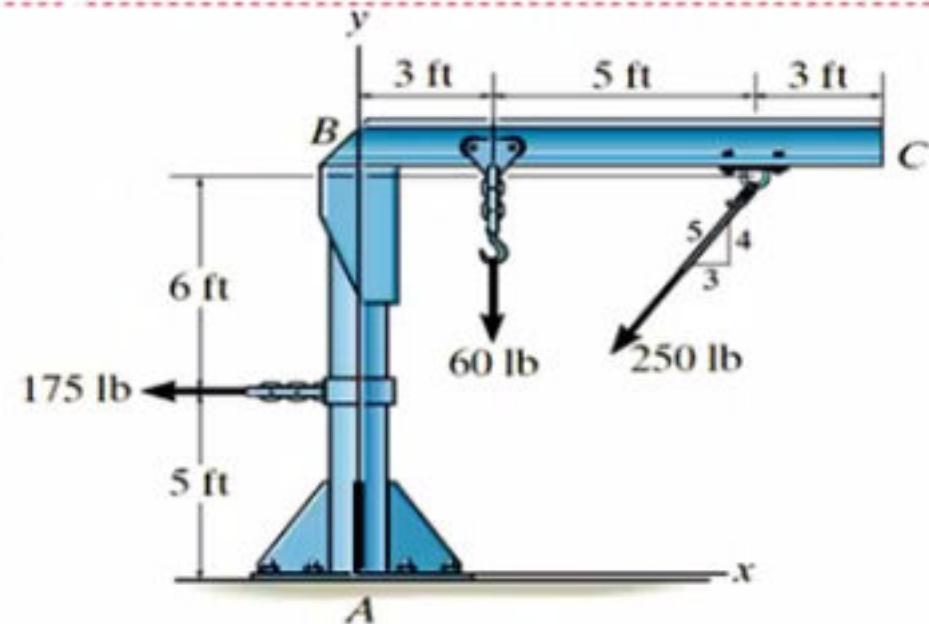
$$325\text{lb}(11\text{ft}) - 260\text{lb}(x) =$$

$$175\text{lb}(5\text{ ft}) - 60\text{lb}(3\text{ft})$$

$$+250\text{lb}(3/5)(11\text{ft})$$

$$- 250\text{lb}(4/5)(8\text{ft})$$

$$x = 10.9 \text{ ft}$$



Examples

Moment Summation :

مجموع العزوم :

$$M_{R_A} = \sum M_A$$

$$325 \text{ lb (y)} + 260 \text{ lb (0)} =$$

$$175 \text{ lb (5 ft)} - 60 \text{ lb (3 ft)}$$

$$+ 250 \text{ lb} (3/5)(11 \text{ ft})$$

$$- 250 \text{ lb} (4/5)(8 \text{ ft})$$

$$y = 2.29 \text{ ft}$$

