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2.4 Resultant of a Parallel, Non Coplanar Force System.

The resultant of two parallel forces is either a single force parallel to the given forces or a couple in the plane determined by the action lines of the two forces. If additional parallel forces are added one at a time, each successive resultant must be either a force parallel to the given forces or a couple whose plane is parallel to the force of the system, and it is determined by the last force added and the resultant of all previously used forces of the system. In case the resultant of some of the forces is a couple and another parallel force is added, the system may be reduced to a single force by means of the transformation of a couple.

A. If the resultant is a single force , its magnitude is equal to the algebraic sum of the forces of the system, and its position in space can be determined by the coordinates of the intersection of its action line with any plane perpendicular to the forces of the system.

$$R = \sum F_y \qquad R\bar{x} = \sum M_z \qquad R\bar{z} = \sum M_x$$

Where:

$\bar{x}, \bar{z}$ are the coordinates of the intersection of the action line of the resultant with xz plane

B. If the sum of the forces is zero and the sum of the moments about one or both of two rectangular axes in plane perpendicular to the forces is not zero, the resultant is a couple, a convenient way of giving the characteristics of the resultant couple is to show it on a sketch by placing an upward force on one moment axis and an equal downward force on the other moment axis so spaced as to produce the proper resultant moments.

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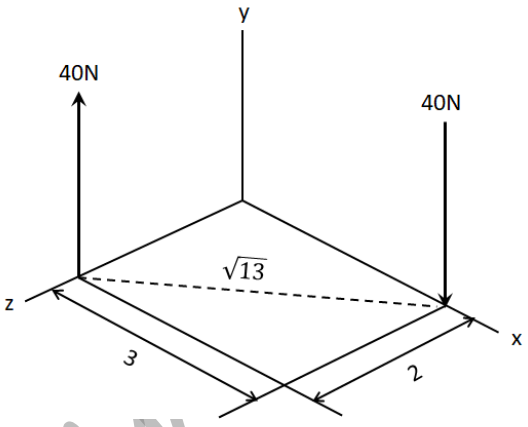
Example:-

$\sum F_y=0 \quad \sum M_z=120\ \text{N.cm} \quad \sum M_x=80\text{N.cm}$

$M = 40\sqrt{2^2+3^2} = 144.2\ \text{N.cm}$



Examples

Example (1)

Determine the resultant of the four parallel forces shown in figure and show it on a sketch. Each space represents 1m.

Solution:-

$$\uparrow R = \sum F_y = 60 - 75 + 32 - 40 = -23\text{N}$$

$$= 23\text{N} \downarrow$$

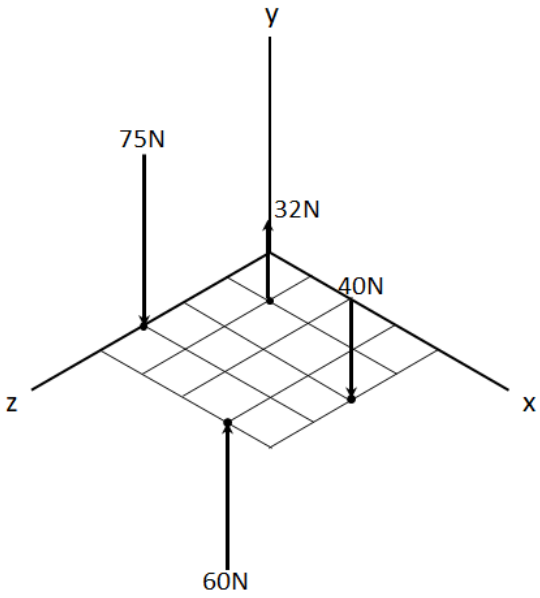
$$R\bar{z} = \sum M_x = -60(4) + 75(3) - 32(1) + 40(2)$$

$$= 33\text{N.m}$$

$$\bar{z} = \frac{33}{23} = 1.435\ \text{m}$$

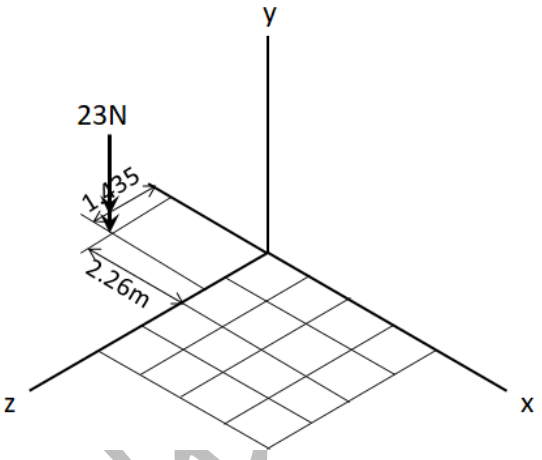
$$R\bar{x} = \sum M_z = 60(3) + 75(0) + 32(1) - 40(4)$$

$$= 52\text{N.m}$$



$$\bar{x} = \frac{52}{23} = 2.26\ \text{m}$$

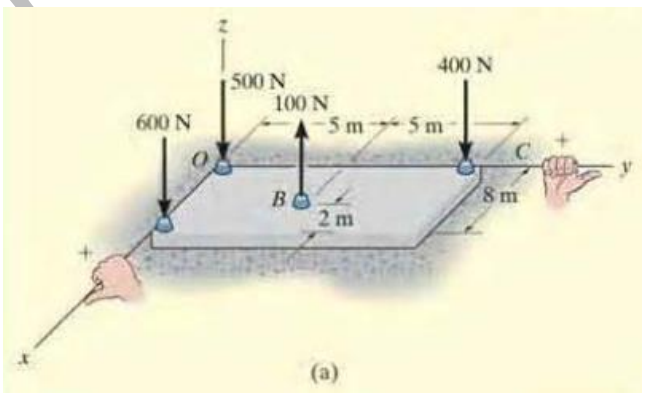
$$R = 23N \downarrow\ through(-2.26, 0, 1.435)$$



Example(2):-

The slab is subjected to four parallel forces. Determine the magnitude and direction of the resultant force and locate its point of application on the slab.

Solution:-



$$\uparrow R = \sum F_y = -600 + 100 - 400 - 500$$

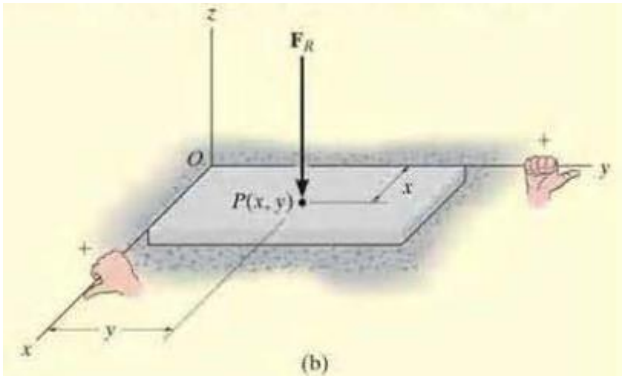
$$= -1400\text{N} = 1400\text{N} \downarrow$$

$$R\bar{y} = \sum M_x$$

$$= 600(0) + 100(5) - 400(10)$$

$$+ 500(0) = -3500\text{N.m}$$

$$\bar{y} = \frac{-3500}{-1400} = 2.5\ \text{m}$$



$$R\bar{x} = \sum M_y$$

$$= 600(8) - 100(6) + 400(0)$$

$$+ 500(0) = 4200\text{N.m}$$

$$\bar{x} = \frac{4200}{1400} = 3\ \text{m}$$

R=1400N placed at point P(3,2.5)

Example (3):-

Determine the resultant of the force system.

Solution:-

$$\uparrow R = \sum F_y = 60 + 40 - 80 - 20 = 0$$

The resultant is a couple

$$\sum M_x = 80(2) - 40(1) - 60(4)$$

$$= -120\text{N.m} = 120\text{N.m}$$

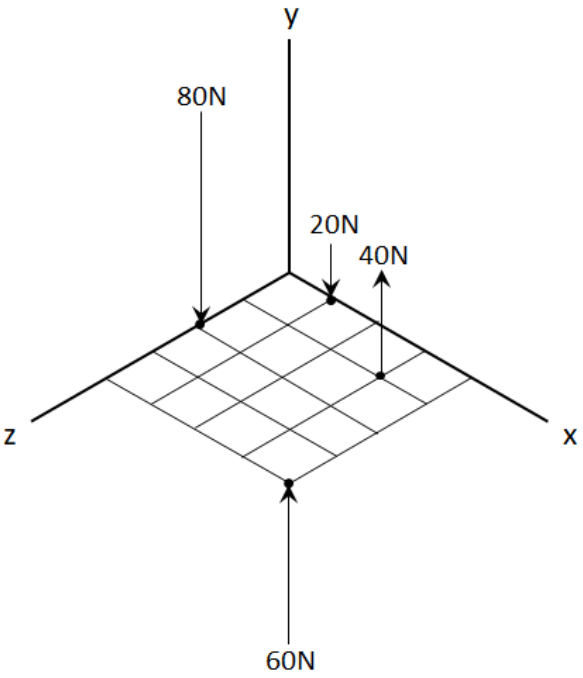
$$\sum M_z = 40(3) + 60(4) - 20(1) = 340\text{N.m}$$

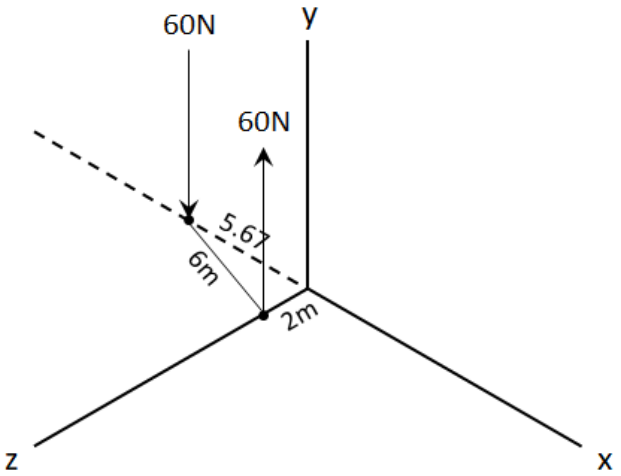
$$d_x = \frac{340}{60} = 5.67\ \text{m}$$

$$d_z = \frac{120}{60} = 2\ \text{m}$$

$$d = \sqrt{5.67^2 + 2^2} = 6$$

$$\text{couple} = M = 60 \times 6 = 360\text{N.m}$$

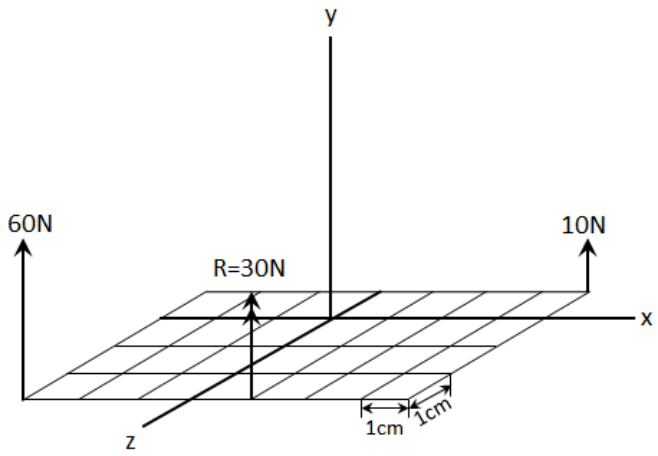




Example (4):-

In the parallel force system, the 30N force is the resultant of three forces two of which are shown. Determine the third force, and locate it on sketch.

Solution:-



$\uparrow R = \sum F_y$

$30 = 60 + 10 + \mathrm{F}$

$\mathrm{F} = -40\mathrm{N} = 40\mathrm{N} \downarrow$

Let F pass point$(\mathrm{x}, 0, \mathrm{z})$

$R\bar{x} = \sum M_z$

$30(1) = 10(4) - 60(3) + 40x$

x=4.25cm

$R\bar{z} = \sum M_X$

$-30(3) = 10(1) - 60(3) + 40z$

z=2cm

$\therefore F = 40N \downarrow through\ (-4.25,0,2)$

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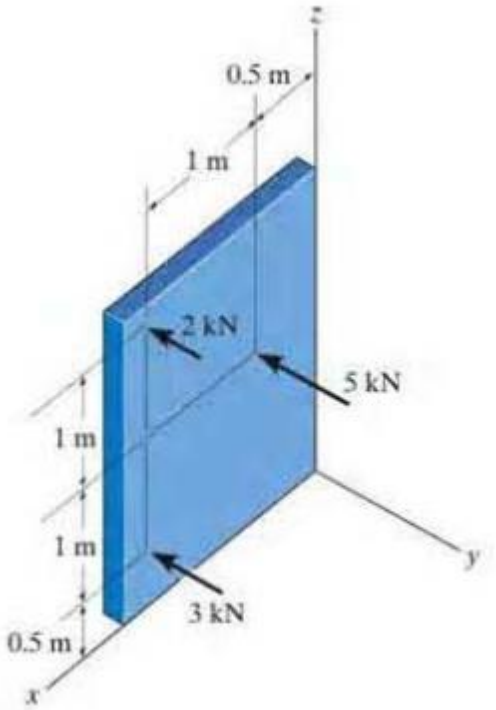
Home Work

H.W 5

Replace the parallel force system acting on the plate by a resultant force and specify its location on the x-z plane.



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