PROBLEMS INVOLVING FORCES

1 Forces are acting on an object. Calculate the resultant force acting on the object for each of the following:

(a) $\underset{\sim}{F}_1 = 150\,\text{N}$ north, $\underset{\sim}{F}_2 = 120\,\text{N}$ south
(b) $\underset{\sim}{F}_1 = 67\,\text{N}$ east, $\underset{\sim}{F}_2 = 83\,\text{N}$ west
(c) $\underset{\sim}{F}_1 = 320\,\text{N}$ east, $\underset{\sim}{F}_2 = 210\,\text{N}$ west, $\underset{\sim}{F}_3 = 140\,\text{N}$ east
(d) $\underset{\sim}{F}_1 = 64\,\text{N}$ south, $\underset{\sim}{F}_2 = 56\,\text{N}$ north, $\underset{\sim}{F}_3 = 48\,\text{N}$ south

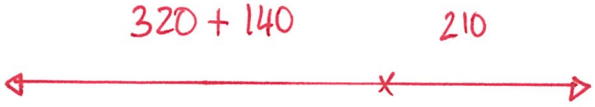
a)

Resulting force
30N north

b)

Resulting force 16N west

c)



Resulting force = 250 N west

d)

Resulting force 56 N south

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5 Three forces $\underset{\sim}{F}_1$, $\underset{\sim}{F}_2$ and $\underset{\sim}{F}_3$ are acting on an object: $\underset{\sim}{F}_1 = 200\,\text{N}$ at 057°T, $\underset{\sim}{F}_2 = 220\,\text{N}$ at 170°T and $\underset{\sim}{F}_3 = 150\,\text{N}$ at 245°T.

(a) Resolve each force into horizontal $\underset{\sim}{i}$ and vertical $\underset{\sim}{j}$ components.

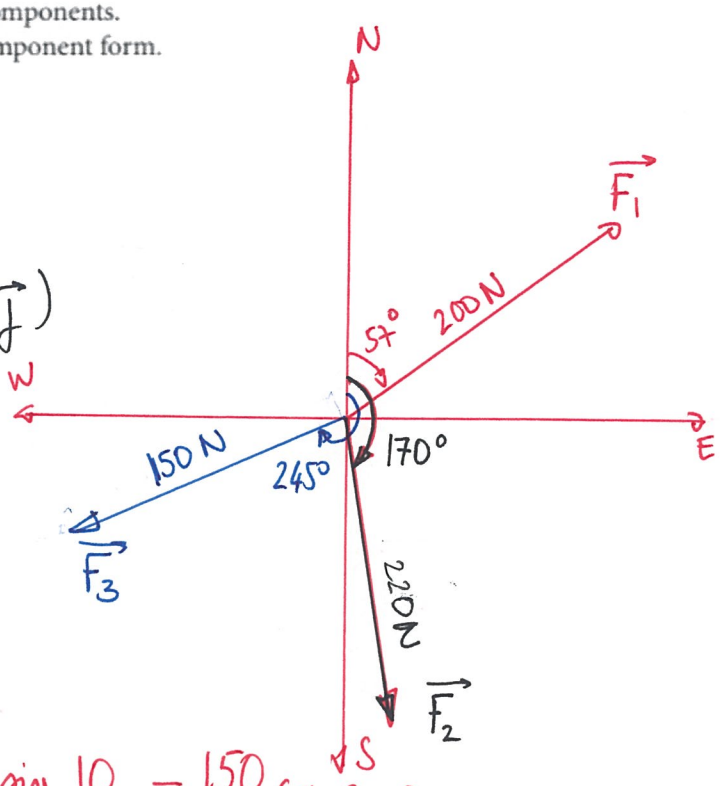
(b) Determine the resultant force $\underset{\sim}{F}$. Give answers in component form.

a)

$\vec{F_1} = 200(\sin 57\,\vec{i} + \cos 57\,\vec{j})$

$\vec{F_2} = 220(\sin 10\,\vec{i} - \cos 10\,\vec{j})$

$\vec{F_3} = 150(-\cos 25\,\vec{i} - \sin 25\,\vec{j})$



b) $\vec{F} = \vec{i}[200\sin 57 + 220\sin 10 - 150\cos 25]$

$+ \vec{j}[200\cos 57 - 220\cos 10 - 150\sin 25]$

$\vec{F} = 70\,\vec{i} - 171\,\vec{j}$

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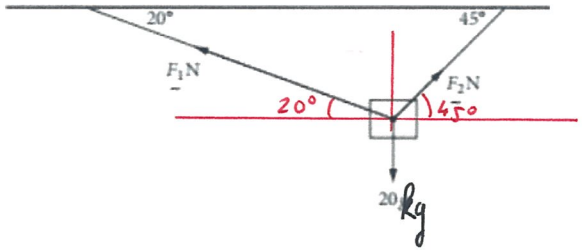
7 A particle of mass 20 kg is suspended by two strings attached to two points in the same horizontal plane. If the two strings make angles of 20° and 45° respectively to the horizontal, find the magnitude of the tension force in each string, in newtons correct to two decimal places.



* $F_1 \cos 20 = F_2 \cos 45$

$F_2 = F_1 \dfrac{\cos 20}{\cos 45} = 1.32893 F_1$

* $F_1 \sin 20 + F_2 \sin 45 = 20 \times 9.8$ taking $g = 9.8\ ms^{-2}$

So $F_1 \sin 20 + 1.32893 F_1 \sin 45 = 20 \times 9.8$

$F_1 = \dfrac{196}{(\sin 20 + 1.32893 \sin 45)} = 152.92\ N$

and $F_2 = 152.92 \times \dfrac{\cos 20}{\cos 45} = 203.22\ N$

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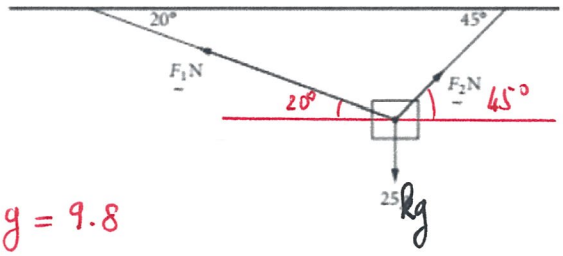
9 A particle of mass 25 kg is suspended by two strings attached to two points in the same horizontal plane. If the two strings make angles of 20° and 45° respectively to the horizontal, use component form to find the magnitude of the tension forces, F_1 and F_2 respectively in each string, in newtons correct to one decimal place.



Take $g = 9.8$

* $F_1 \sin 20 + F_2 \sin 45 = 25 \times g$

$F_1 \times 0.342 + 0.707 \times F_2 = 245$

* $F_1 \cos 20 = F_2 \cos 45$

$0.940\ F_1 = 0.707\ F_2$ so $F_2 = \frac{0.940}{0.707} F_1 = 1.330\ F_1$

so $F_1 \times 0.342 + 0.707 \times 1.330\ F_1 = 245$

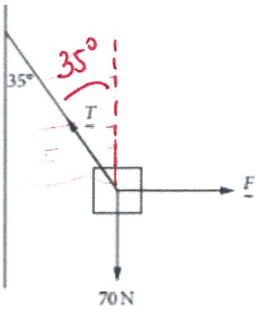
$F_1 (0.342 + 0.940) = 245$

so $F_1 = 191.1$ N

Then $F_2 = 1.330 \times 191.1 = 254.1$ N

11 An object that is being pulled vertically downwards by a force of 70 N is attached to a wall by a string of negligible mass. The object is also being pulled to the right by a horizontal force so that the object is not moving and the string makes an angle of 35° with the vertical, as shown.

Find the magnitudes of the horizontal force $\underset{\sim}{F}$ N and the tension force in the string, $\underset{\sim}{T}$ N. Give answers correct to two decimal places.



$$\begin{cases} T \sin 35 = F \\ T \cos 35 = 70 \end{cases}$$

$$\text{so } T = \frac{70}{\cos 35} = 85.45 \text{ N}$$

$$F = T \sin 35 = \frac{70}{\cos 35} \sin 35$$

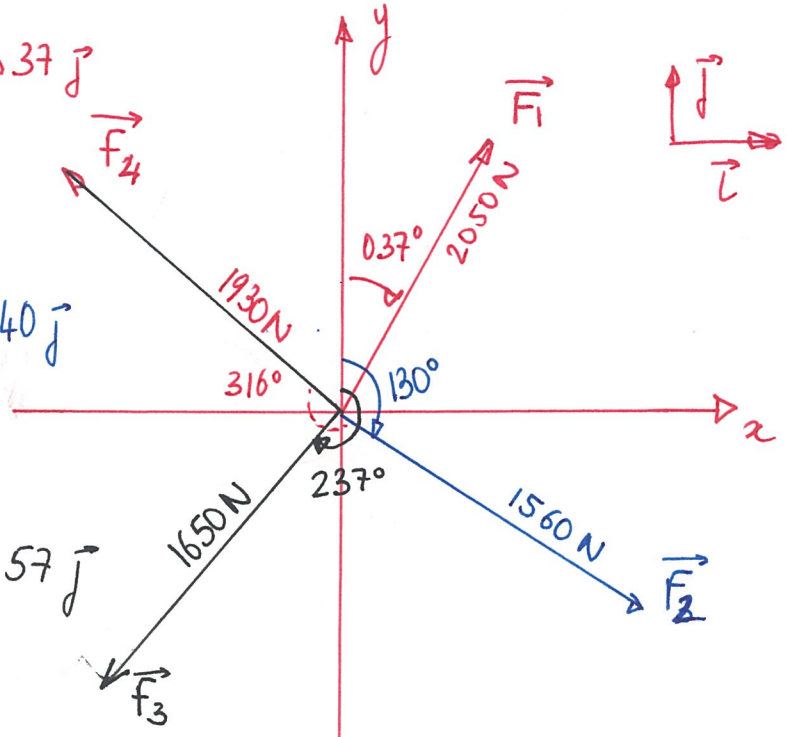
$$F = 49.01 \text{ N}$$

PROBLEMS INVOLVING FORCES

15 A section of a new bridge is being moved by four cranes that will move it horizontally into position. The chains that are connected from the cranes to the bridge section exert forces that are acting on the bridge simultaneously and in the same plane. The four forces are $\underline{F}_1 = 2050$ N at 037°T, $\underline{F}_2 = 1560$ N at 130°T, $\underline{F}_3 = 1650$ N acting at 237°T and $\underline{F}_4 = 1930$ N acting at 316°T.

(a) Resolve each force into horizontal $\underline{i}$ and vertical $\underline{j}$ components.

(b) Calculate the magnitude and direction of the resultant force applied to the bridge section.



a) $\vec{F}_1 = 2050 \sin 37\ \vec{i} + 2050 \cos 37\ \vec{j}$

$\vec{F}_1 = 1{,}233.7\ \vec{i} + 1{,}637.2\ \vec{j}$

$\vec{F}_2 = 1{,}560 \cos 40\ \vec{i} - 1{,}560 \sin 40\ \vec{j}$

$\vec{F}_2 = 1{,}195\ \vec{i} - 1{,}003\ \vec{j}$

$\vec{F}_3 = -1650 \sin 57\ \vec{i} - 1650 \cos 57\ \vec{j}$

$\vec{F}_3 = -1384\ \vec{i} - 899\ \vec{j}$

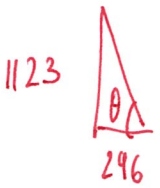
$\vec{F}_4 = -1930 \cos 46\ \vec{i} + 1930 \sin 46\ \vec{j}$

$\vec{F}_4 = -1341\ \vec{i} + 1388\ \vec{j}$

b) $\vec{F}_{Total} = [1{,}234 + 1{,}195 - 1{,}384 - 1{,}341]\ \vec{i}$

$+ [1{,}637 - 1{,}003 - 899 + 1{,}388]\ \vec{j}$

$\vec{F}_{Total} = -296\ \vec{i} + 1123\ \vec{j}$



$|\vec{F}_{total}| = \sqrt{296^2 + 1123^2} = 1161$ N

$\tan\theta = \frac{1123}{296}$ so $\theta = 75°$ so 1161 N with direction 345°T