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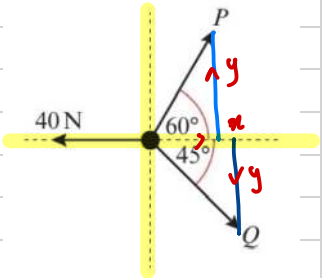
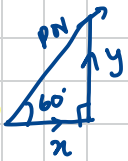
7·1 : Static particles

①



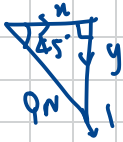
Resolve PN:



$\cos 60° = \frac{x}{P}$ $\quad \sin 60° = \frac{y}{P}$

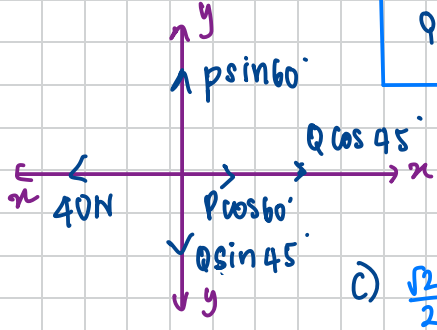
$x = \frac{1}{2}P$ $\quad y = \frac{\sqrt{3}}{2}P$

Resolve QN:



$\cos 45° = \frac{x}{Q}$ $\quad \sin 45° = \frac{y}{Q}$

$x = \frac{\sqrt{2}}{2}Q$ $\quad y = \frac{\sqrt{2}}{2}Q$



Static equilibrium ($\uparrow = \downarrow$; $\rightarrow = \leftarrow$)

a) $Q\cos 45° + P\cos 60° = 40$ — ①

b) $Q\sin 45° = P\sin 60°$ — ②

c) $\frac{\sqrt{2}}{2}Q + \frac{1}{2}P = 40$ — ① $\quad \frac{\sqrt{2}}{2}Q = \frac{\sqrt{3}}{2}P$ — ②

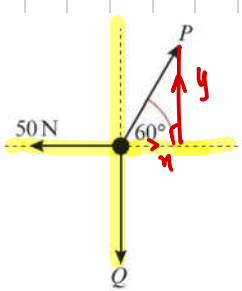
$\Rightarrow P = \frac{\sqrt{2}}{2}Q \times \frac{2}{\sqrt{3}} = \frac{\sqrt{6}}{3}Q$ $\quad P = \frac{\sqrt{6}}{3}Q$ — ②

Sub into ① $\Rightarrow \frac{\sqrt{2}}{2}Q + \frac{1}{2}\left(\frac{\sqrt{6}}{3}Q\right) = 40 \Rightarrow \frac{\sqrt{2}}{2}Q + \frac{\sqrt{6}}{6}Q = 40$

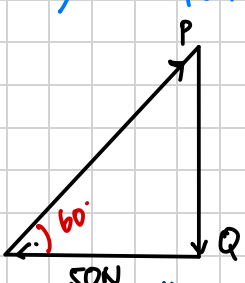
$\Rightarrow \frac{\sqrt{6}+3\sqrt{2}}{6}Q = 40 \Rightarrow Q = -20\sqrt{6} + 60\sqrt{2} = 35.9\text{ N (3sf)}$

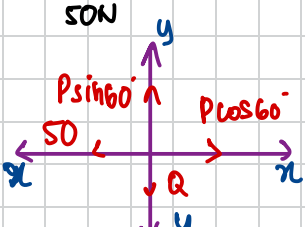
$\Rightarrow P = \frac{\sqrt{6}}{3}\left(-20\sqrt{6} + 60\sqrt{2}\right) = -40 + 4\sqrt{3} = 29.3\text{ N (3sf)}$

②

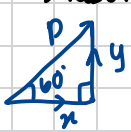


a)





b) Resolve PN:



$\cos 60° = \frac{x}{P}$ $\quad \sin 60° = \frac{y}{P}$

$x = P\cos 60° = \frac{1}{2}P$ $\quad y = P\sin 60° = \frac{\sqrt{3}}{2}P$

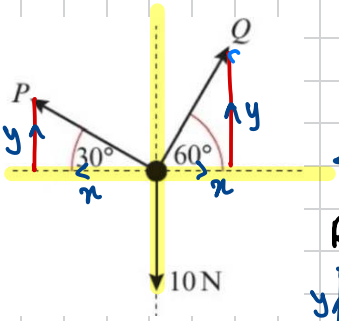
equilibrium: ($\uparrow = \downarrow$; $\rightarrow = \leftarrow$)

$50 = P\cos 60°$ $\quad Q = P\sin 60°$

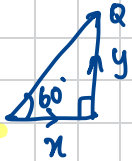
$50 = \frac{1}{2}P$ $\quad Q = 100\left(\frac{\sqrt{3}}{2}\right)$

$P = 100\text{ N}$ $\quad Q = 50\sqrt{3}\text{ N}$

③



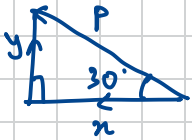
Resolve Q:



$\sin 60° = \frac{y}{Q}$ $\cos 60° = \frac{x}{Q}$

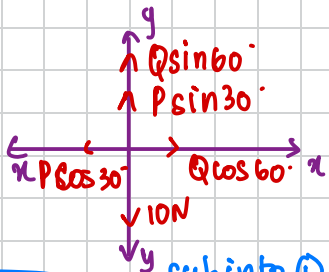
$y = \sin 60° Q = \frac{\sqrt{3}}{2} Q$ $x = \cos 60° Q = \frac{1}{2} Q$

Resolve P:



$\sin 30° = \frac{y}{P}$ $\cos 30° = \frac{x}{P}$

$y = P\sin 30° = \frac{1}{2} P$ $x = P\cos 30° = \frac{\sqrt{3}}{2} P$



$\therefore$ equilibrium ($\uparrow = \downarrow$; $\rightarrow = \leftarrow$)

$10 = P\sin 30° + Q\sin 60°$

$10 = \frac{1}{2} P + \frac{\sqrt{3}}{2} Q$ -①

$Q\cos 60° = P\cos 30°$

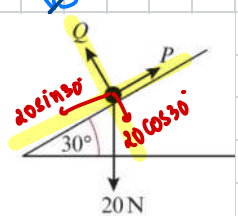
$\frac{1}{2} Q = \frac{\sqrt{3}}{2} P$ -②

$P = \frac{1}{\sqrt{3}} Q$ sub into ①

$\Rightarrow \frac{1}{2}\left(\frac{1}{\sqrt{3}} Q\right) + \frac{\sqrt{3}}{2} Q = 10 \Rightarrow \frac{2\sqrt{3}}{3} Q = 10$ $Q = 5\sqrt{3}\,N$

$\Rightarrow P = \frac{1}{\sqrt{3}}(5\sqrt{3}) = 5N$

④

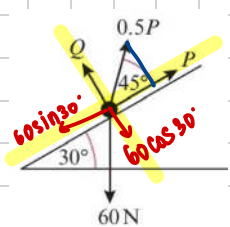


Equilibrium ($\uparrow = \downarrow$; $\rightarrow = \leftarrow$)

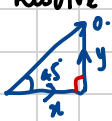
$\Rightarrow P = 20\sin 30° = 20(0.5) = 10N$

$\Rightarrow Q = 20\cos 30° = 20\left(\frac{\sqrt{3}}{2}\right) = 10\sqrt{3}\,N$

⑤

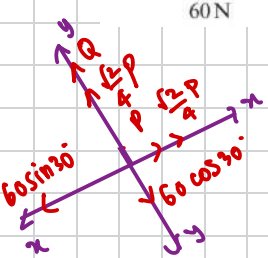


Resolve 0.5P:



$\Rightarrow \cos 45° = \frac{x}{0.5P}$ $\sin 45° = \frac{y}{0.5P}$

$y = \frac{\sqrt{2}}{2} \times \frac{1}{2} P = \frac{\sqrt{2}}{4} P$ $x = \frac{\sqrt{2}}{2} \times \frac{1}{2} P = \frac{\sqrt{2}}{2} P$



$\therefore$ equilibrium ($\uparrow = \downarrow$; $\rightarrow = \leftarrow$)

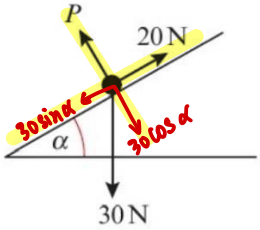
$Q + \frac{\sqrt{2}}{4} P = 60\left(\frac{\sqrt{3}}{2}\right) \Rightarrow Q + \frac{\sqrt{2}}{4} P = 30\sqrt{3}$ -①

$P + \frac{\sqrt{2}}{4} P = 60\left(\frac{1}{2}\right) \Rightarrow \frac{4+\sqrt{2}}{4} P = 30$ -②

$P = 30 \times \frac{4}{4+\sqrt{2}} = 22.2\,N$ (3sf)

$\Rightarrow Q = 30\sqrt{3} - \frac{\sqrt{2}}{4}P \Rightarrow 30\sqrt{3} - \frac{\sqrt{2}}{4}(22.163\ldots) \Rightarrow 44.1\,N\ (3sf)$

(6)



equilibrium ($\uparrow = \downarrow$; $\rightarrow = \leftarrow$)

a) $30\sin\alpha = 20 \Rightarrow \sin\alpha = \frac{2}{3}$ $\quad \alpha = \arcsin\left(\frac{2}{3}\right) = 41.8°\ (3sf)$

b) $P = 30\cos\alpha = 30\cos(41.8\ldots) = 22.4\,N\ (3sf)$

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