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10.4 Motion in 2 directions

1.

a) $F = ma$

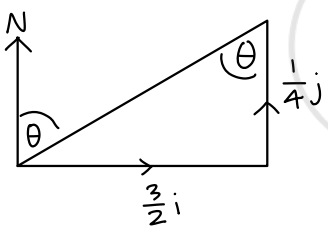
$6i + j = 4a$

$a = \frac{6i + j}{4}$

$a = \left(\frac{3}{2}i + \frac{1}{4}j\right) ms^{-2}$

b) $|a| = \sqrt{\left(\frac{3}{2}\right)^2 + \left(\frac{1}{4}\right)^2}$

$= \frac{\sqrt{37}}{4} ms^{-2}$



$\tan\theta = \frac{3/2}{1/4}$

$\theta = \tan^{-1}\frac{3/2}{1/4}$

$= 81°$

Bearing $= 081°$

2. $F = ma$

$7i + 2j = (28i + 8j)m$

$m = \frac{7i + 2j}{28i + 8j}$

$m = 0.25 kg$

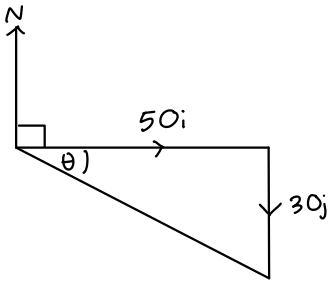
3.

a) $F = 5(10i - 6j)$

$= (50i - 30j) N$

b) $|F| = \sqrt{50^2 + 30^2}$

$= 10\sqrt{34} N$



$\tan\theta = \frac{30}{50}$

$\theta = \tan^{-1}\frac{30}{50}$

$\theta = 31$

Bearing $= 90 + 31$

$= 121°$

4.

a) $F = F_1 + F_2$

$= (3i + 8j) + (-2i + 3j)$

$= (i + 11j)\,N$

$F = ma$

$i + 11j = 0.5a$

$a = \frac{i + 11j}{0.5}$

$a = (2i + 22j)\,ms^{-2}$

b) $F = F_1 + F_2$

$= (8i - 6j) + (3i + 4j)$

$= (11i - 2j)\,N$

$F = ma$

$11i - 2j = 7a$

$a = \frac{11i - 2j}{7}$

$a = \left(\frac{11}{7}i - \frac{2}{7}j\right)ms^{-2}$

c) $F = F_1 + F_2$

$= (-50i - 40j) + (35i + 15j)$

$= (-15i - 25j)$

$F = ma$

$-15i - 25j = 12a$

$a = \frac{-15i - 25j}{12}$

$a = \left(-\frac{5}{4} - \frac{25}{12}\right)ms^{-2}$

d) $F = F_1 + F_2$

$= (8i) + (-5 - 10j)$

$= (3i - 10j)\,N$

$F = ma$

$3i - 10j = 2.5a$

$a = \frac{3i - 10j}{2.5}$

$a = \left(\frac{6}{5}i - 4j\right)ms^{-2}$

5.

a) $F = (2i+5j)+(-i-6j)+(3i-2j)$

$= (4i-3j)\,N$

$F = ma$

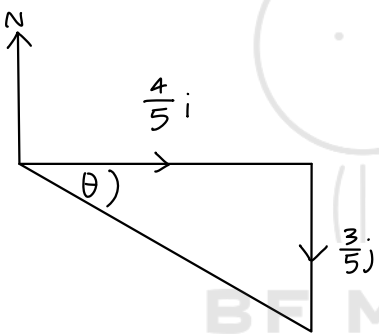
$4i-3j = 5a$

$a = \frac{4i-3j}{5}$

$a = \left(\frac{4}{5}i - \frac{3}{5}j\right) ms^{-2}$

$|a| = \sqrt{\left(\frac{4}{5}\right)^2 - \left(\frac{3}{5}\right)^2}$

$= 1 ms^{-2}$



$\tan\theta = \frac{3/5}{4/5}$

$\theta = \tan^{-1}\frac{3/5}{4/5}$

$\theta = 36.9$

Direction $= -36.9$ from i

b)

s	
u	$0 ms^{-1}$
v	$2 ms^{-1}$
a	$1 ms^{-1}$
t	?

$v = u + at$

$t = \frac{v-u}{a}$

$= \frac{2-0}{1}$

$= 2s$

c)

s	$10m$	$v^2 = u^2 + 2as$
u	$0ms^{-1}$	$v = \sqrt{u^2 + 2as}$
v	$?$	$= \sqrt{0^2 + 2(1)(10)}$
a	$1ms^{-2}$	$= 2\sqrt{5}$
t	$2s$	$= 4.47ms^{-1}$

6. $R = \begin{pmatrix} 1 \\ -5 \end{pmatrix} + \begin{pmatrix} p \\ q \end{pmatrix}$

R is parallel to $\begin{pmatrix} 1 \\ -2 \end{pmatrix}$

let $R = \begin{pmatrix} \mu \\ -2\mu \end{pmatrix}$

$$\begin{pmatrix} 1 \\ -5 \end{pmatrix} + \begin{pmatrix} p \\ q \end{pmatrix} = \begin{pmatrix} \mu \\ -2\mu \end{pmatrix}$$

$1 + p = \mu \qquad -5 + q = -2\mu$

$-5 + q = -2(1 + p)$
$-5 + q = -2 - 2p$

$2p + q - 3 = 0$

7. $F = ma$
$F = 2.5(1.6i - 2.4j)$
$= (4i - 6j)N$

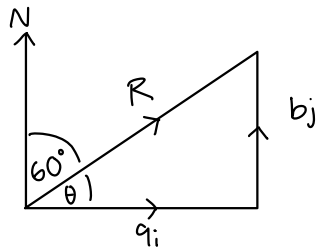
$F_1 + F_2 + F_3 = F$

$(3i + 8j) + (-7i - 10j) + (pi + qj) = 4i - 6j$
$(-4i - 2j) + (pi + qj) = 4i - 6j$
$pi + qj = 8i - 4j$

$p = 8 \quad q = -4$

8.

a)



$\theta = 90 - 60$
$= 30°$

$\tan 30 = \frac{b}{9}$
$b = \tan 30 \times 9$
$= 3\sqrt{3}$

b) $|R| = \sqrt{9^2 + (3\sqrt{3})^2}$
$= 6\sqrt{3}$ N

c) $F = ma$
$a = \frac{F}{m}$
$= \frac{6\sqrt{3}}{3}$
$= 2\sqrt{3}\ ms^{-2}$

d)

s	75m	$s = ut + \frac{1}{2}at^2$
u	$0ms^{-1}$	$s = \frac{1}{2}at^2$
v		
a	$2\sqrt{3}\ ms^{-2}$	$75 = \sqrt{3}\ t^2$
t	?	$\sqrt{3}\ t^2 - 75 = 0$
		$t = 6.58 \quad t = -6.58$

$t = 6.58s$

9.

a) $F_1 + F_2 + F_3 = 0$

$(-4i + 5j) + (-i + 7j) + (pi + qj) = 0$

$(-5i + 12j) + (pi + qj) = 0$

$pi + qj = 5i - 12j$

$p = 5 \quad q = -12$

b) F_2 is removed

$F = F_1 + F_3$

$= (-4i + 5j) + (5i - 12j)$

$= (i - 7j)\ N$

s	130m	$s = ut + \frac{1}{2}at^2$
u	$0ms^{-1}$	$s = \frac{1}{2}at^2$
v		
a	?	$a = \frac{2s}{t^2} = \frac{2 \times 130}{10^2} = 2.6ms^{-2}$
t	10s	

$|F| = \sqrt{1^2 + 7^2}$

$= 5\sqrt{2}$

$F = ma$

$m = \frac{F}{a}$

$= \frac{5\sqrt{2}}{2.6}$

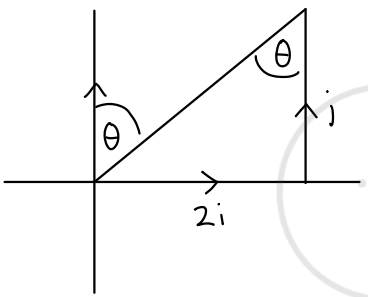
$= \frac{25\sqrt{2}}{13}\ kg$

10. $F = (10i+8j)+(4i+12j)+(-2i-4j)$
$= (12i+16j)N$

$|F| = \sqrt{12^2+16^2}$
$= 20N$

$F = ma$
$m = \frac{F}{a} = \frac{20}{5} = 4kg$

11.
a)



$\tan\theta = \frac{2}{1}$

$\theta = \tan^{-1}\frac{2}{1}$

$= 63.4°$

b) R is parallel to $(2i+j)$

let $R = (2\mu i + \mu j)$

$(6i-2j)+(pi+qj) = (2\mu i+\mu j)$

$6+p = 2\mu \qquad -2+q = \mu$

$6+p = 2(-2+q)$
$6+p = -4+2q$
$p-2q+10 = 0$

c) when $p=4$:
$6+4 = 2\mu$
$10 = 2\mu$
$\mu = 5$ so $R = (10i+5j)$

$$|R| = \sqrt{10^2 + 5^2}$$
$$= 5\sqrt{5}$$

$$F = ma$$
$$m = \frac{F}{a} = \frac{5\sqrt{5}}{2\sqrt{5}} = 2.5\text{kg}$$