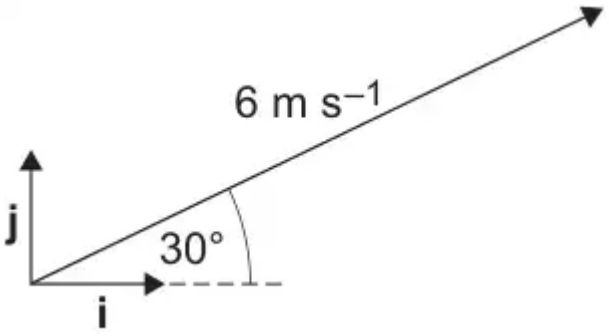
QQQ – Mechanics Year 1 – Chapter 8 – Introduction & Modelling (Version 2)

Total Marks: 22

(22 = Platinum, 20 = Gold, 18 = Silver, 15 = Bronze)

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1. A particle has a speed of 6 m s^{-1} in a direction relative to unit vectors **i** and **j** as shown in the diagram below.



The velocity of this particle can be expressed as a vector $\begin{bmatrix} v_1 \\ v_2 \end{bmatrix}$ m s^{-1}

Find the correct expression for v_2

Circle your answer. **[1 mark]**

- $v_2 = 6\cos 30^\circ$
- $v_2 = 6\sin 30^\circ$
- $v_2 = -6\sin 30^\circ$
- $v_2 = -6\cos 30^\circ$

(Total 1 marks)

2. A particle, P, is moving with constant velocity $8\mathbf{i} - 12\mathbf{j}$

A second particle, Q, is moving with constant velocity $a\mathbf{i} + 9\mathbf{j}$

Q travels in a direction which is parallel to the motion of P.

Find a.

Circle your answer. **[1 mark]**

- -6
- -5
- 5
- 6

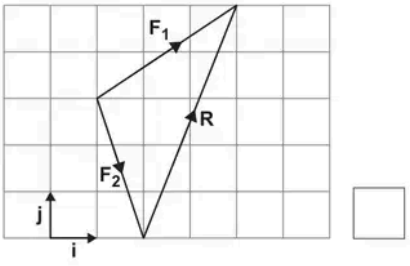
(Total 1 marks)

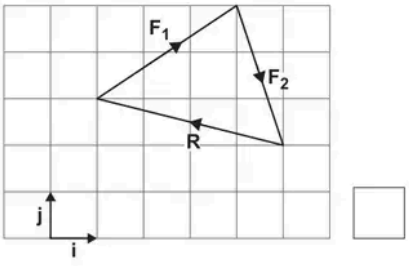
3. Two forces, $\mathbf{F}_1 = 3\mathbf{i} + 2\mathbf{j}$ newtons and $\mathbf{F}_2 = \mathbf{i} - 3\mathbf{j}$ newtons, are added together to find a resultant force, $\mathbf{R}$ newtons.

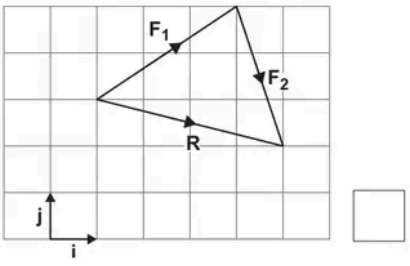
This vector addition can be represented using a diagram.

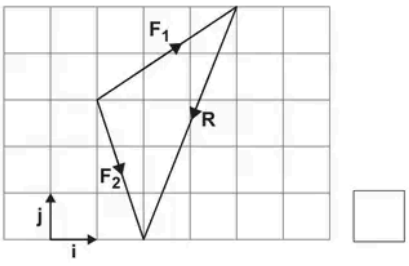
Identify the diagram below which correctly represents this vector addition.

Tick (✓) **one** box. **[1 mark]**









(Total 1 marks)

4. Two forces $\begin{bmatrix} 3 \\ -2 \end{bmatrix}$ N and $\begin{bmatrix} -7 \\ -5 \end{bmatrix}$ N act on a particle.

Find the resultant force.

Circle your answer. **[1 mark]**

- $\begin{bmatrix} -21 \\ 10 \end{bmatrix}$ N
- $\begin{bmatrix} -4 \\ -7 \end{bmatrix}$ N
- $\begin{bmatrix} 4 \\ 3 \end{bmatrix}$ N
- $\begin{bmatrix} 10 \\ 7 \end{bmatrix}$ N

(Total 1 marks)

5. Two forces $\mathbf{F}_1$ N and $\mathbf{F}_2$ N are given by $\mathbf{F}_1 = -6\mathbf{i} + 2\mathbf{j}$ and $\mathbf{F}_2 = -8\mathbf{i} + \mathbf{j}$.

Show that the magnitude of the resultant of these two forces is $\sqrt{205}$ N. **[2]**

(Total 2 marks)

6. In this question, the $\mathbf{i}$ direction is horizontal and the $\mathbf{j}$ direction is vertically upwards.

A particle of mass 3 kg is in equilibrium.

(a) Explain what is meant by a particle. **[1]**

The following forces are acting on the particle:

- the weight of the particle
- a horizontal force of $h\mathbf{i}$ N
- the force $\mathbf{F} = k\mathbf{i} + (k - 5)\mathbf{j}$ N.

(b) Calculate the value of h. **[3]**

(c) The force $\mathbf{F}$ is removed.

State the vector equation of motion of the particle. **[1]**

(Total 5 marks)

7. A particle P is moving with constant velocity $(-3\mathbf{i} + 2\mathbf{j})$ m s^{-1}. At time $t = 6$ s P is at the point with position vector $(-4\mathbf{i} - 7\mathbf{j})$ m. Find the distance of P from the origin at time $t = 2$ s.

(5)

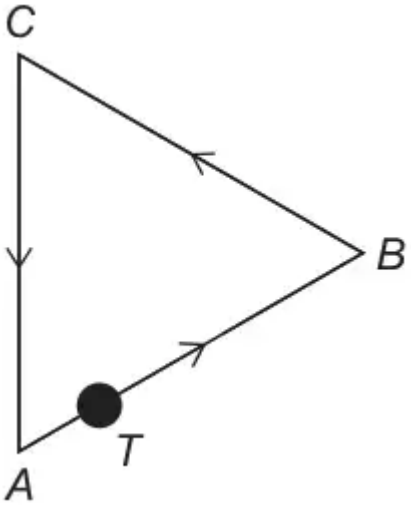
(Total 5 marks)

8. In this question $\mathbf{i}$ and $\mathbf{j}$ are perpendicular unit vectors representing due east and due north respectively.

A particle, T, is moving on a plane at a constant speed.

The path followed by T makes the exact shape of a triangle ABC.

T moves around ABC in an anticlockwise direction as shown in the diagram below.



On its journey from A to B the velocity vector of T is $\left(3\mathbf{i} + \sqrt{3}\mathbf{j}\right)$ m s^{-1}

(a) Find the speed of T as it moves from A to B **[1 mark]**

(b) On its journey from B to C the velocity vector of T is $\left(-3\mathbf{i} + \sqrt{3}\mathbf{j}\right)$ m s^{-1}

Show that the acute angle $ABC = 60°$ **[2 marks]**

(c) It is given that ABC is an equilateral triangle.

T returns to its initial position after 9 seconds.

Vertex B lies at position vector $\begin{bmatrix} 1 \\ 0 \end{bmatrix}$ metres with respect to a fixed origin O

Find the position vector of C **[3 marks]**

(Total 6 marks)

Solutions

1. AQA June 2021 Paper 2 Q12

Scheme	Marks	AO
Circles correct answer	B1	1.1b
	(1 mark)	

Typical solution

$$v_2 = 6\sin 30^\circ$$

2. AQA June 2020 Paper 2 Q12

Scheme	Marks	AO
Circles correct answer	B1	1.1b
	(1 mark)	

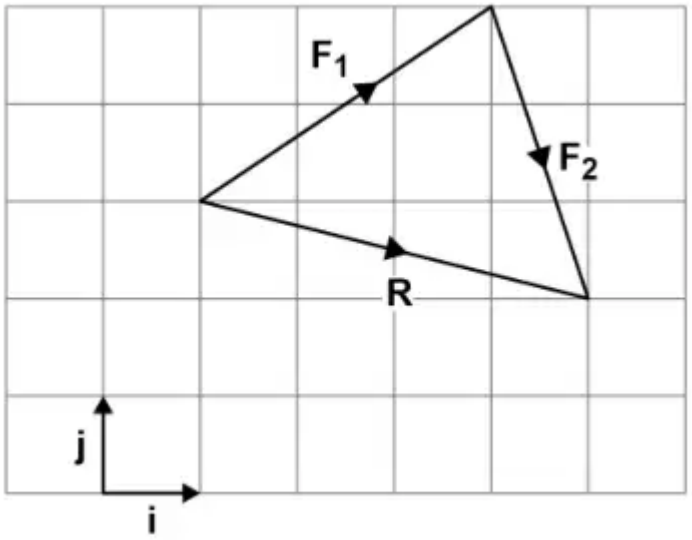
Typical solution

-6

3. AQA June 2024 Paper 1 Q14

Scheme	Marks	AO
Ticks bottom left box	B1	1.1b
	(1 mark)	

Typical solution



4. AQA June 2021 Paper 1 Q10

Scheme	Marks	AO
Circles correct answer	B1	1.1b
	(1 mark)	

Typical solution

$\begin{bmatrix} -4 \\ -7 \end{bmatrix}$ N

5. OCR MEI June 2024 Paper 1 Q2

Scheme	Marks	AO
$\mathbf{F}_1 + \mathbf{F}_2 = (-6\mathbf{i} + 2\mathbf{j}) + (-8\mathbf{i} + \mathbf{j}) = -14\mathbf{i} + 3\mathbf{j}$	M1	2.1
$\sqrt{(-14)^2 + 3^2} = \sqrt{205}$ [N]	A1	2.1
	[2]	

Notes

M1: Attempt to add vectors

A1: AG Must be clearly shown; do not allow for $\sqrt{-14^2 + 3^2}$

6. OCR MEI June 2025 Paper 1 Q10

Mark scheme (a)

Scheme	Marks	AO
A particle is an object [with mass] with negligible size	B1	1.2
	[1]	

Notes

B1: Also allow object whose size and shape does not matter. Accept point mass. Do not award if other wrong statements also made.

Mark scheme (b)

Scheme	Marks	AO
Weight is $-3g\mathbf{j}$	B1	1.1
For equilibrium $-3g\mathbf{j} + h\mathbf{i} + k\mathbf{i} + (k-5)\mathbf{j} = \mathbf{0}$		
In the $\mathbf{j}$ direction $-3g + k - 5 = 0$ [so $k = 34.4$]	M1	3.1b
$\mathbf{i}$ direction $h + k = 0$ so $h = -34.4$	A1	1.1
	[3]	

Notes

B1: Accept $-29.4\mathbf{j}$. May be implied by the use of weight (with correct sign) in their vertical equation and not their horizontal equation. May be implied by $k = 34.4$ seen with no equation

Vector equation need not be seen explicitly

M1: Uses the $\mathbf{j}$-direction to find a value for k. Allow only sign errors. Need not be simplified. May be implied by $k = 34.4$ seen

A1: Cao

Mark scheme (c)

Scheme	Marks	AO
$h\mathbf{i} - 3g\mathbf{j} = 3\mathbf{a}$	B1FT	2.5
	[1]	

Notes

B1FT: Must be vector equation

FT their h from (b) and accept numerical equivalents (e.g. note $-34.4\mathbf{i} - 29.4\mathbf{j} = 3\mathbf{a}$ is fully correct)

ISW if $\mathbf{a}$ is evaluated

7. Edexcel M1 June 2010 Q1

Scheme	Marks
$(-4\mathbf{i} - 7\mathbf{j}) = \mathbf{r} + 4(-3\mathbf{i} + 2\mathbf{j})$	M1 A1
$\mathbf{r} = (8\mathbf{i} - 15\mathbf{j})$	A1
$\lvert\mathbf{r}\rvert = \sqrt{8^2 + (-15)^2} = 17\text{ m}$	M1 A1 ft
	(5 marks)

8. AQA June 2023 Paper 2 Q18

Mark scheme (a)

Scheme	Marks	AO
Obtains correct speed of $\sqrt{12}$ OE AWRT 3.46 Condone missing units	B1	1.1b
	(1)	

Typical solution

Speed $= \sqrt{(3)^2 + \left(\sqrt{3}\right)^2} = 2\sqrt{3}\text{ m s}^{-1}$

Mark scheme (b)

Scheme	Marks	AO
Uses $\tan^{-1}\dfrac{\sqrt{3}}{3}$ or $\tan^{-1}\dfrac{3}{\sqrt{3}}$ to find the angle between one of the velocity vectors relative to the $\mathbf{i}$ direction or the $\mathbf{j}$ direction. Sight of sine rule or cosine rule using a magnitude for AC scores M0 R0	M1	3.1a

Completes a reasoned argument to obtain 30° for both angles relative to the **i** direction and adds them together to obtain angle ABC = 60° or Completes a reasoned argument to obtain 60° for both angles relative to the **j** direction and adds them together and subtracts them from 180° to obtain angle ABC = 60° Solution must include clear reference to angle ABC or indicate angle ABC with a letter on a diagram. When using trigonometric ratios the vectors **i** and **j** must not be included.	R1	2.1
	(2)	

Typical solution

Angle between AB and **i** direction

$$= \tan^{-1}\frac{\sqrt{3}}{3} = 30^\circ$$

Angle between BC and **i** direction

$$= \tan^{-1}\frac{\sqrt{3}}{3} = 30^\circ$$

Angle ABC = 30° + 30° = 60°

Mark scheme (c)

Scheme	Marks	AO
Deduces time taken from B to C is 3 seconds.	R1	2.2a
Obtains an expression for displacement from B to C of the form $t\begin{bmatrix}-3\\\sqrt{3}\end{bmatrix}$ **where** $1 < t \leqslant 9$	M1	3.1a
Obtains $\begin{bmatrix}-8\\3\sqrt{3}\end{bmatrix}$	A1	1.1b
	(3)	

	(6 marks)	

Typical solution

Time taken from B to $C = \frac{9}{3} = 3$

$$\overrightarrow{OC} = \begin{bmatrix} 1 \\ 0 \end{bmatrix} + 3 \begin{bmatrix} -3 \\ \sqrt{3} \end{bmatrix}$$

$$= \begin{bmatrix} -8 \\ 3\sqrt{3} \end{bmatrix}$$