



Forces as Vectors



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TOPIC

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1 [In this question, $\mathbf{i}$ and $\mathbf{j}$ are horizontal unit vectors due east and due north respectively.]

Two horizontal forces, $\mathbf{F}_1$ and $\mathbf{F}_2$, act on a particle P .

Given that $\mathbf{F}_1 = (4\mathbf{i} - 3\mathbf{j})$ N and $\mathbf{F}_2 = (-\mathbf{i} + 7\mathbf{j})$ N

- (a) find, in terms of $\mathbf{i}$ and $\mathbf{j}$, the **resultant force** acting on P . (1)
- (b) find the **magnitude** of the **resultant force** acting on P . (2)
- (c) find, to the nearest degree, the bearing of the **resultant force** acting on P . (3)

(Total for Question 1 is 6 marks)

2 [In this question, $\mathbf{i}$ and $\mathbf{j}$ are perpendicular unit vectors in a horizontal plane.]

A particle P is in equilibrium under the action of three horizontal forces.

$\mathbf{F}_1 = (5\mathbf{i} - 7\mathbf{j})$ N, $\mathbf{F}_2 = (-3\mathbf{i} + 3\mathbf{j})$ N and $\mathbf{F}_3 = (a\mathbf{i} + b\mathbf{j})$ N, where a and b are constants.

- (a) Find the values of a and b . (2)

The force $\mathbf{F}_3$ is removed. Given that forces $\mathbf{F}_1$ and $\mathbf{F}_2$ continue to act on P ,

- (b) find the **magnitude** of the **resultant force, $\mathbf{R}$** , acting on P , (2)
- (c) find, to the nearest degree, the angle between the line of action of $\mathbf{R}$ and the vector $\mathbf{i}$. (2)

(Total for Question 2 is 6 marks)



**3** [In this question, $\mathbf{i}$ and $\mathbf{j}$ are perpendicular unit vectors in a horizontal plane.]

Two horizontal forces, $\mathbf{F}_1$ and $\mathbf{F}_2$, act on a particle P .

$$\mathbf{F}_1 = (10\mathbf{i} + 5\mathbf{j}) \text{ N and } \mathbf{F}_2 = (-5\mathbf{i} + 7\mathbf{j}) \text{ N}$$

(a) Find, to the nearest degree, the angle between the line of action of $\mathbf{F}_1$ and the vector $\mathbf{i}$. (2)

(b) Find the **magnitude** of the **resultant force** acting on P . (3)

Two horizontal forces, $\mathbf{F}_3$ and $\mathbf{F}_4$, act on a particle Q .

$$\mathbf{F}_3 = (3\mathbf{i} - 3\mathbf{j}) \text{ N and } \mathbf{F}_4 = (a\mathbf{i} + 8\mathbf{j}) \text{ N, where } a \text{ is a constant.}$$

(c) Given that the magnitude of the resultant force acting on Q is equal to the magnitude of the resultant force acting on P , find the two possible values of a . (3)

(Total for Question 3 is 8 marks)

4 [In this question, $\mathbf{i}$ and $\mathbf{j}$ are perpendicular unit vectors in a horizontal plane.]

A particle P is in equilibrium under the action of three horizontal forces.

$$\mathbf{F}_1 = (-8\mathbf{i} + 3\mathbf{j}) \text{ N, } \mathbf{F}_2 = (b\mathbf{i} - a\mathbf{j}) \text{ N and } \mathbf{F}_3 = (a\mathbf{i} + b\mathbf{j}) \text{ N, where } a \text{ and } b \text{ are constants.}$$

(a) Find $|\mathbf{F}_1|$ (2)

(b) Find, to the nearest degree, the acute angle between the line of action of force $\mathbf{F}_1$ and the vector $\mathbf{j}$. (3)

(c) Find the values of a and b . (3)

(Total for Question 4 is 8 marks)

5 [In this question, $\mathbf{i}$ and $\mathbf{j}$ are perpendicular unit vectors in a horizontal plane.]

A particle P of mass 4 kg moves on a smooth horizontal plane under the action of two horizontal forces $\mathbf{F}_1$ and $\mathbf{F}_2$.

$$\mathbf{F}_1 = (5\mathbf{i} + 2\mathbf{j}) \text{ N and } \mathbf{F}_2 = (-\mathbf{i} + 4\mathbf{j}) \text{ N}$$

(a) Find, in terms of $\mathbf{i}$ and $\mathbf{j}$, the **resultant force** acting on P . (1)

(b) Find, in terms of $\mathbf{i}$ and $\mathbf{j}$, the acceleration of P . (2)

(c) Find the **magnitude** of the acceleration of P . (2)

(d) Given that P starts from rest, calculate the distance travelled by P in the first 9 seconds. (2)

(Total for Question 5 is 7 marks)





6 [In this question, $\mathbf{i}$ and $\mathbf{j}$ are perpendicular unit vectors in a horizontal plane.]

A particle P of mass 3 kg moves on a smooth horizontal plane under the action of two horizontal forces $(7\mathbf{i} - 18\mathbf{j})$ N and $(c\mathbf{i} - 27\mathbf{j})$ N, where c is a constant.

Given that the acceleration of P is $(8\mathbf{i} - 15\mathbf{j}) \text{ ms}^{-2}$

- (a) Find the **magnitude** of the acceleration of P . (2)
- (b) Find the magnitude of the **resultant force** acting on P . (2)
- (c) Find the value of c . (2)
- (d) Given that P starts from rest, find the speed of P after 5 seconds. (2)

(Total for Question 6 is 8 marks)

7 [In this question, $\mathbf{i}$ and $\mathbf{j}$ are horizontal unit vectors due east and due north respectively.]

A particle P of mass 5 kg moves on a smooth horizontal plane under the action of two horizontal forces $\mathbf{F}_1 = (-8\mathbf{i} + 13\mathbf{j})$ N and $\mathbf{F}_2 = (18\mathbf{i} + 7\mathbf{j})$ N

- (a) Find, to the nearest degree, the bearing of force $\mathbf{F}_1$. (2)
- (b) Find, in terms of $\mathbf{i}$ and $\mathbf{j}$, the acceleration of P . (2)
- (c) Find the **magnitude** of the acceleration of P . (2)

Two more horizontal forces, $\mathbf{F}_3$ and $\mathbf{F}_4$, are now applied to P .

Under the action of $\mathbf{F}_1$, $\mathbf{F}_2$, $\mathbf{F}_3$ and $\mathbf{F}_4$, the acceleration of P remains unchanged.

- (d) Given that $\mathbf{F}_3 = (6\mathbf{i} - 3\mathbf{j})$ N, find $\mathbf{F}_4$ in terms of $\mathbf{i}$ and $\mathbf{j}$ (1)

(Total for Question 7 is 7 marks)

8 [In this question, $\mathbf{i}$ and $\mathbf{j}$ are perpendicular unit vectors in a horizontal plane.]

Three horizontal forces, $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$, act on a particle P .

$\mathbf{F}_1 = (5\mathbf{i} - 6\mathbf{j})$ N, $\mathbf{F}_2 = (4\mathbf{i} - 2\mathbf{j})$ N and $\mathbf{F}_3 = (a\mathbf{i} + b\mathbf{j})$

Given that $\mathbf{R}$, the resultant force acting on P , is parallel to $\mathbf{i}$, and $|\mathbf{F}_3| = 17$ N, find

- (a) the value of b . (2)
- (b) two possible values for a . (3)
- (c) two possible values for the magnitude of $\mathbf{R}$. (2)

(Total for Question 8 is 7 marks)





9 [In this question, $\mathbf{i}$ and $\mathbf{j}$ are horizontal unit vectors due east and due north respectively.]

A single horizontal force, $\mathbf{F}$, acts on a particle P , of mass $\frac{2}{3}$ kg.

The magnitude of $\mathbf{F} = \sqrt{12}$ N

The magnitude of the acceleration of P is $\sqrt{k}$ ms⁻², where k is an integer.

(a) Find the value of k . (3)

(b) Given that P starts from rest, find, to 3 significant figures the time taken for P to reach a speed of 10 ms⁻¹ (2)

(c) Given that $\mathbf{F} = (a\mathbf{i} + b\mathbf{j})$ N and the bearing of $\mathbf{F}$ is 060°, find the values of a and b . (4)

(Total for Question 9 is 9 marks)

10 [In this question, $\mathbf{i}$ and $\mathbf{j}$ are perpendicular unit vectors in a horizontal plane.]

A particle P of mass m kg moves on a smooth horizontal plane under the action of two horizontal forces $\mathbf{F}_1 = (-8\mathbf{i} + 10\mathbf{j})$ N and $\mathbf{F}_2 = (-10\mathbf{i} + 14\mathbf{j})$ N

(a) Given that the magnitude of the acceleration of P is 40 ms⁻², find m . (4)

(b) Find, in terms of $\mathbf{i}$ and $\mathbf{j}$, the acceleration of P . (2)

A third horizontal force, $\mathbf{F}_3$, is now applied to P .

Under the action of $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$, the particle moves with **constant velocity**.

(c) Find $\mathbf{F}_3$, giving your answer in terms of $\mathbf{i}$ and $\mathbf{j}$. (1)

(Total for Question 10 is 7 marks)

11 [In this question, $\mathbf{i}$ and $\mathbf{j}$ are perpendicular unit vectors in a horizontal plane.]

A particle P of mass 0.5 kg moves on a smooth horizontal plane under the action of two horizontal forces $\mathbf{F}_1$ and $\mathbf{F}_2$

$$\mathbf{F}_1 = (2\mathbf{i} - 4\mathbf{j}) \text{ N}$$

$\mathbf{F}_2$ acts in a direction that is parallel to the vector $(\mathbf{i} + \mathbf{j})$

Given that the magnitude of the acceleration of P is $10\sqrt{2}$ ms⁻², find the two possible values of the magnitude of $\mathbf{F}_2$.

(Total for Question 11 is 5 marks)

