Forces as Vectors

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1 [*In this question,* **i** *and* **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 **i** and **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,* **i** *and* **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, R,** acting on P, **(2)**

(c) find, to the nearest degree, the angle between the line of action of **R** and the vector **i**. **(2)**

(Total for Question 2 is 6 marks)

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

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

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

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

$\mathbf{F}_3 = (3\mathbf{i} - 3\mathbf{j})$ N and $\mathbf{F}_4 = (a\mathbf{i} + 8\mathbf{j})$ N, where a 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,* **i** *and* **j** *are perpendicular unit vectors in a horizontal plane.*]

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

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

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

(Total for Question 4 is 8 marks)

5 [*In this question,* **i** *and* **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 $\mathbf{F}_2$.

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

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

(b) Find, in terms of **i** and **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)

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6 [*In this question,* **i** *and* **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 $(8\mathbf{i} - 15\mathbf{j})$ 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,* **i** *and* **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 **i** and **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 **i** and **j** **(1)**

(Total for Question 7 is 7 marks)

8 [*In this question,* **i** *and* **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 **R**, the resultant force acting on P, is parallel to **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 **R**. **(2)**

(Total for Question 8 is 7 marks)

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9 [*In this question,* **i** *and* **j** *are horizontal unit vectors due east and due north respectively.*]

A single horizontal force, **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 **F** is 060°, find the values of *a* and *b*. **(4)**

(Total for Question 9 is 9 marks)

10 [*In this question,* **i** *and* **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 **i** and **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 **i** and **j**. **(1)**

(Total for Question 10 is 7 marks)

11 [*In this question,* **i** *and* **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 $\mathbf{F}_2$

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

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