

Forces and Motion in 3 Dimensions (From OCR 4761)**Q1, (Jan 2005, Q3)**

A particle is in equilibrium when acted on by the forces $\begin{pmatrix} x \\ -7 \\ z \end{pmatrix}$, $\begin{pmatrix} 4 \\ y \\ -5 \end{pmatrix}$ and $\begin{pmatrix} 5 \\ 4 \\ -7 \end{pmatrix}$, where the units are newtons.

- (i) Find the values of x , y and z . [4]
- (ii) Calculate the magnitude of $\begin{pmatrix} 5 \\ 4 \\ -7 \end{pmatrix}$. [2]

Q2, (Jan 2008, Q4)

Force \mathbf{F} is $\begin{pmatrix} 4 \\ 1 \\ 2 \end{pmatrix}$ N and force \mathbf{G} is $\begin{pmatrix} -6 \\ 2 \\ 4 \end{pmatrix}$ N.

- (i) Find the resultant of \mathbf{F} and \mathbf{G} and calculate its magnitude. [4]
- (ii) Forces \mathbf{F} , $2\mathbf{G}$ and \mathbf{H} act on a particle which is in equilibrium. Find \mathbf{H} . [3]

Q3, (Jun 2010, Q3)

The three forces $\begin{pmatrix} -1 \\ 14 \\ -8 \end{pmatrix}$ N, $\begin{pmatrix} 3 \\ -9 \\ 10 \end{pmatrix}$ N and \mathbf{F} N act on a body of mass 4 kg in deep space and give it an acceleration of $\begin{pmatrix} -1 \\ 2 \\ 4 \end{pmatrix}$ m s⁻².

- (i) Calculate \mathbf{F} . [4]

At one instant the velocity of the body is $\begin{pmatrix} -3 \\ 3 \\ 6 \end{pmatrix}$ m s⁻¹.

- (ii) Calculate the velocity and also the speed of the body 3 seconds later. [4]

Q4, (Jun 2011, Q3)

Force \mathbf{F} is $\begin{pmatrix} -2 \\ 3 \\ -4 \end{pmatrix}$ N, force \mathbf{G} is $\begin{pmatrix} -6 \\ y \\ z \end{pmatrix}$ N and force \mathbf{H} is $\begin{pmatrix} 3 \\ -5 \\ -1 \end{pmatrix}$ N.

- (i) Given that \mathbf{F} and \mathbf{G} act in parallel lines, find y and z . [2]

Forces \mathbf{F} and \mathbf{H} are the only forces acting on an object of mass 5 kg.

- (ii) Calculate the acceleration of the object. Calculate also the magnitude of this acceleration. [5]

In this question the origin is a point on the ground. The directions of the unit vectors $\begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$, $\begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}$ and $\begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}$ are east, north and vertically upwards.



Alesha does a sky-dive on a day when there is no wind. The dive starts when she steps out of a moving helicopter. The dive ends when she lands gently on the ground.

- During the dive Alesha can reduce the magnitude of her acceleration in the vertical direction by spreading her arms and increasing air resistance.
- During the dive she can use a power unit strapped to her back to give herself an acceleration in a horizontal direction.
- Alesha's mass, including her equipment, is 100 kg.
- Initially, her position vector is $\begin{pmatrix} -75 \\ 90 \\ 750 \end{pmatrix}$ m and her velocity is $\begin{pmatrix} -5 \\ 0 \\ -10 \end{pmatrix}$ m s⁻¹.

At a certain time during the dive, forces of $\begin{pmatrix} 0 \\ 0 \\ -980 \end{pmatrix}$ N, $\begin{pmatrix} 0 \\ 0 \\ 880 \end{pmatrix}$ N and $\begin{pmatrix} 50 \\ -20 \\ 0 \end{pmatrix}$ N are acting on Alesha.

- (ii) Suggest how these forces could arise. [3]
- (iii) Find Alesha's acceleration at this time, giving your answer in vector form, and show that, correct to 3 significant figures, its magnitude is 1.14 m s⁻². [3]

One suggested model for Alesha's motion is that the forces on her are constant throughout the dive from when she leaves the helicopter until she reaches the ground.

- (iv) Find expressions for her velocity and position vector at time t seconds after the start of the dive according to this model. Verify that when $t = 30$ she is at the origin. [6]
- (v) Explain why consideration of Alesha's landing velocity shows this model to be unrealistic. [2]
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Q6, (Jun 2013, Q3)

In this question take $g = 10$.

The directions of the unit vectors $\begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$, $\begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}$ and $\begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}$ are east, north and vertically upwards.

Forces \mathbf{p} , \mathbf{q} and \mathbf{r} are given by $\mathbf{p} = \begin{pmatrix} -1 \\ -1 \\ 5 \end{pmatrix}$ N, $\mathbf{q} = \begin{pmatrix} -1 \\ -4 \\ 2 \end{pmatrix}$ N and $\mathbf{r} = \begin{pmatrix} 2 \\ 5 \\ 0 \end{pmatrix}$ N.

(i) Find which of \mathbf{p} , \mathbf{q} and \mathbf{r} has the greatest magnitude. **[2]**

(ii) A particle has mass 0.4 kg. The forces acting on it are \mathbf{p} , \mathbf{q} , \mathbf{r} and its weight.

Find the magnitude of the particle's acceleration and describe the direction of this acceleration. **[4]**
