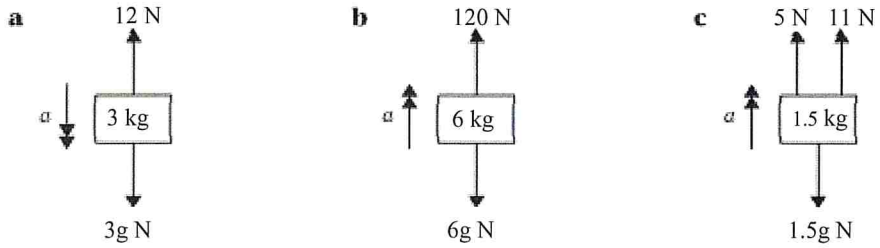
Godalming College

Mechanics 6 – Vectors

Please **complete** this homework by _____. Start it early. If you can't do a question you will then have time to ask your teacher for help or go to a drop in session.

Section 1 – Review of previous topics. Please complete all questions.

1. In each of the following scenarios, the forces acting on the body cause it to accelerate as shown with magnitude a ms^{-2}. In each case, find the value of a.



2. The diagram shows a block of mass 12 kg attached to a vertical rope.

Find the tension in the rope when the block moves downwards with
(i) an acceleration of 2.5 ms^{-2},
(ii) at a constant speed of 12 ms^{-1},
(iii) with a deceleration of 1.5 ms^{-2}.

Section 2 – Consolidation of this week's topic. Please complete all questions.

1. The forces F_1, F_2 and F_3 are in equilibrium. If $F_1 = 3i + aj$, $F_2 = bi - 7j$ and $F_3 = 2i + 6j$, find the values of a and b.

(4 marks)

2. The force $\begin{pmatrix} 56a \\ -42a \end{pmatrix}$ N (where a is a positive constant) has magnitude 35 N. Find the value of a.

(3 marks)

3. Given that $a = 3i + 4j$ and $b = i - 2j$, find
(a) λ if $a + \lambda b$ is parallel to $i + j$ (4)
(b) μ if $\mu a + b$ is parallel to $i + 3j$. (4)

(8 marks)

4. A force is given by $(24ai + 7aj)$ N, where a is a negative constant.
   (a) Find the bearing along which the force acts (i acts due East, j due North) (2)
   (b) Given that the magnitude of the force is 200 N, find a. (3)

(5 marks)

5. A particle of mass $\frac{2}{3}$ kg is acted upon by three forces: $F_1 = (pi - 8j)$ N, $F_2 = (5i + qj)$ N and $F_3 = (6i - 19j)$ N. The acceleration produced by the resultant force is $(36i - 15j)$ ms^{-2}. The initial velocity of the particle is $(4i + j)$ ms^{-1}.
   (a) Find the values of p and q. (6)
   (b) Find the magnitude of the resultant force. (2)
   (c) Find the angle that the resultant force makes with the vector i, correct to 1 d.p. (2)
   (d) Find the velocity of the particle after $\frac{1}{3}$ seconds. (2)

(12 marks)

6. A toy car of mass 0.7 kg has an initial velocity of $\begin{pmatrix} 8 \\ -5 \end{pmatrix}$ ms^{-1}. A constant force is applied to the car and after six seconds its velocity is $\begin{pmatrix} -1 \\ 7 \end{pmatrix}$ ms^{-1}.
   (a) Find the acceleration of the car in vector form. (3)
   (b) Find the force applied to the car in vector form and the magnitude of this force. (4)

(7 marks)

7. The forces a and b are represented by the vectors $a = 9i - 3j + 12k$ and $b = xi + yj + zk$. Given that the resultant force of a and b is $\lambda i + (\lambda - 15)j + 2\lambda k, (\lambda > 0)$ and that the magnitude of the resultant force is $5\sqrt{21}$ N, find the values of x, y and z.

(9 marks)

8. The force acting on a particle of mass 1.5kg is given by the vector $\begin{pmatrix} 6 \\ 9 \\ -3 \end{pmatrix}$
   (a) Write the acceleration of the particle as a vector (2)
   (b) Calculate the angle that the acceleration makes with the vector $\begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$ (2)
   (c) At a certain point in its motion the particle has a velocity of $\begin{pmatrix} -2 \\ 3 \\ 7 \end{pmatrix} ms^{-1}$. Calculate the displacement of the particle over the subsequent two seconds. (3)

(7 marks)

(Total 55 Marks)

Section 3 – Extension questions. If you are aiming for a top grade, you should attempt these questions.

1. The forces $\begin{pmatrix}3\\4\end{pmatrix}$ N and $\begin{pmatrix}4\\3\end{pmatrix}$ N act at the same point. Find the angle between these two forces.

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

   The velocity, **v** m s^{-1}, of a particle P at time t seconds is given by

   $$\mathbf{v} = (1 - 2t)\mathbf{i} + (3t - 3)\mathbf{j}.$$

   (*a*) Find the speed of P when $t = 0$.

   (*b*) Find the bearing on which P is moving when $t = 2$.

   (*c*) Find the value of t when P is moving

   (i) parallel to **j**,

   (ii) parallel to $(-\mathbf{i} - 3\mathbf{j})$.