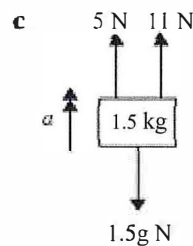
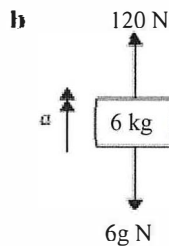
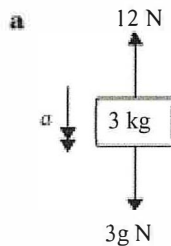


Mechanics 5 – Vectors

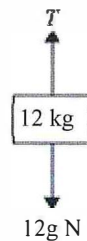
Please **complete** this homework by _____. Start it early. If you can't do a question you will then have time to ask your teacher for help or go to a drop in session.

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 $a \text{ ms}^{-2}$. 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

- an acceleration of 2.5 ms^{-2} ,
- at a constant speed of 12 ms^{-1} ,
- 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 $\begin{pmatrix} 56a \\ -42a \end{pmatrix} \text{ N}$ (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 \mathbf{i} and \mathbf{j} are directed due east and due north respectively.]

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