Section Check In – 3.03 Forces and Newton's Laws

Questions

1. A car of mass 1500 kg is travelling on a horizontal road. The driving force of the car is 2000 N, and the total resistance force is 200 N. Calculate the acceleration of the car.

2. A particle of mass 0.5 kg is acted on by forces $2\mathbf{i}+3\mathbf{j}$ N, $3\mathbf{i}-c\mathbf{j}$ N and $d\,\mathbf{i}+6\mathbf{j}$ N, where $\mathbf{i}$ and $\mathbf{j}$ are mutually perpendicular unit vectors, and c and d are constants. Find c and d, given that the particle has an acceleration of $3\mathbf{j}$ m s^{-2}.

3. With the aid of a force diagram, explain why you feel heavier when standing in a lift which is accelerating upwards.

4. A particle is acted on by a force $\left(F_1\mathbf{i}+F_2\mathbf{j}\right)$ N, where $\mathbf{i}$ and $\mathbf{j}$ are two mutually perpendicular unit vectors. When an additional force $\left(2\mathbf{i}+\mathbf{j}\right)$ N is applied to the particle, its acceleration is parallel to the vector $\mathbf{i}+\mathbf{j}$. When this additional force is applied in the reverse direction, the acceleration of the particle is parallel to the vector $\mathbf{i}+2\mathbf{j}$. Find F_1 and F_2.

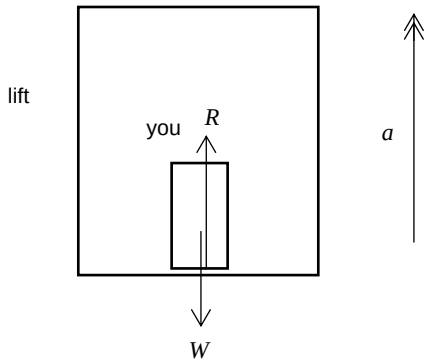
5. A stone of mass 150 grams is dropped from rest at ground level into a well. The resistance force on the stone is 0.12 N. When you drop the stone you hear it hit the water 4 seconds later.
   (i) Estimate the depth of the well. [Take $g=9.8$ m s^{-2}.]
   (ii) How accurate do you think the model is?

Worked solutions

1. $2000 - 200 = 1500a \Rightarrow a = \dfrac{1800}{1500} = 1.2\ \text{m s}^{-2}$.

2. $2\mathbf{i} + 3\mathbf{j} + 3\mathbf{i} - c\mathbf{j} + d\mathbf{i} + 6\mathbf{j} = 0.5 \times 3\mathbf{j}$
$\Rightarrow 2 + 3 + d = 0,\ d = 5, \quad 3 - c + 6 = 1.5,\ c = 7.5$

3.



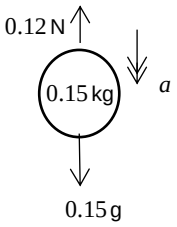
When accelerating upwards, $R - W$ must be positive, so $R > W$, so the normal reaction with the floor of the lift is greater than the weight, and you feel heavier.

4. $\begin{pmatrix} F_1 \\ F_2 \end{pmatrix} + \begin{pmatrix} 2 \\ 1 \end{pmatrix} = k\begin{pmatrix} 1 \\ 1 \end{pmatrix} \Rightarrow F_1 + 2 = F_2 + 1$, so $F_2 = F_1 + 1$

$\begin{pmatrix} F_1 \\ F_2 \end{pmatrix} - \begin{pmatrix} 2 \\ 1 \end{pmatrix} = l\begin{pmatrix} 1 \\ 2 \end{pmatrix} \Rightarrow 2(F_1 - 2) = F_2 - 1$, so $F_2 = 2F_1 - 3$

$\Rightarrow F_1 + 1 = 2F_1 - 3,\ F_1 = 4,\ F_2 = 5$

5. (i) Applying Newton's second law:
$0.15 \times 9.8 - 0.12 = 0.15a$
$\Rightarrow a = 9$
Applying suvat: $s = \dfrac{1}{2} \times 9 \times 4^2 = 72$
so the well is 72 metres deep.



(ii) Not very accurate, as the resistance will not be constant, but would increase with the speed of the stone.

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