PΣΛK

PHYSICS & CHEMISTRY

Physics

Preliminary Course

Module 1
Kinematics

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PHYSICS & CHEMISTRY

SCIENCE Years 7 – 10

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PHYSICS & CHEMISTRY Years 11 – 12

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Foundation

1. Convert the following speed values into $\mathrm{m\,s^{-1}}$.

   (a) $60\ \mathrm{km\,h^{-1}}$

   $$v = 60\ \mathrm{km\,h^{-1}} \times \frac{1\ \mathrm{m\,s^{-1}}}{3.6\ \mathrm{km\,h^{-1}}}$$
   $$= 16.7\ \mathrm{m\,s^{-1}}$$

   (b) $80\ \mathrm{km\,h^{-1}}$

   $$v = 80\ \mathrm{km\,h^{-1}} \times \frac{1\ \mathrm{m\,s^{-1}}}{3.6\ \mathrm{km\,h^{-1}}}$$
   $$= 22.2\ \mathrm{m\,s^{-1}}$$

   (c) $90\ \mathrm{km\,h^{-1}}$

   $$v = 90\ \mathrm{km\,h^{-1}} \times \frac{1\ \mathrm{m\,s^{-1}}}{3.6\ \mathrm{km\,h^{-1}}}$$
   $$= 25\ \mathrm{m\,s^{-1}}$$

2. Convert the following speed values into $\mathrm{km\,h^{-1}}$.

   (a) $10\ \mathrm{m\,s^{-1}}$

   $$v = 10\ \mathrm{m\,s^{-1}} \times \frac{3.6\ \mathrm{km\,h^{-1}}}{1\ \mathrm{m\,s^{-1}}}$$
   $$= 36\ \mathrm{km\,h^{-1}}$$

   (b) $27\ \mathrm{m\,s^{-1}}$

   $$v = 27\ \mathrm{m\,s^{-1}} \times \frac{3.6\ \mathrm{km\,h^{-1}}}{1\ \mathrm{m\,s^{-1}}}$$
   $$= 97.2\ \mathrm{km\,h^{-1}}$$

(c) $45\ \mathrm{m\,s^{-1}}$

$$\begin{aligned} v &= 45\ \mathrm{m\,s^{-1}} \times \frac{3.6\ \mathrm{km\,h^{-1}}}{1\ \mathrm{m\,s^{-1}}} \\ &= 162\ \mathrm{km\,h^{-1}} \end{aligned}$$

3. Define the following terms and give TWO examples of each.

   (a) Scalar quantity

   A scalar quantity is one which only has a magnitude. Examples include distance and speed.

   (b) Vector quantity

   A vector quantity is one which has both a magnitude and a direction. Examples include displacement and velocity.

4. Compare the differences between the following terms:

   (a) Distance and displacement

   Distance is a scalar quantity that measures the total length travelled from start to stop. In contrast, displacement is a vector quantity that measures the direct distance from start to stop.

   (b) Speed and velocity

   Speed is a scalar quantity and is the rate of change of distance with respect to time. In contrast, velocity is a vector quantity and is the rate of change of displacement with respect to time.

5. Calculate the distance travelled when:

   (a) A person walks for 3 hours at an average speed of $4\ \mathrm{km\,h^{-1}}$.

   $$\begin{aligned} s &= vt \\ &= 4\ \mathrm{km\,h^{-1}} \times 3\ \mathrm{h} \\ &= 12\ \mathrm{km} \end{aligned}$$

   (b) A car travels from home to school for 20 minutes at an average speed of $60\ \mathrm{km\,h^{-1}}$.

   $$\begin{aligned} t &= 20\ \mathrm{min} \times \frac{1\ \mathrm{h}}{60\ \mathrm{min}} \\ &= 0.33\ \mathrm{h} \\ s &= vt \\ &= 60\ \mathrm{km\,h^{-1}} \times 0.33\ \mathrm{h} \\ &= 20\ \mathrm{km} \end{aligned}$$

Development

1. A car travels 10 km east and then 40 km west.

   (a) Calculate the distance travelled by the car. **1**

$$\begin{aligned} s &= 10\text{ km} + 40\text{ km} \\ &= 50\text{ km} \end{aligned}$$

1 mark – Calculates the correct distance travelled by the car

   (b) Calculate the displacement of the car at the end of the trip. **1**

Take the east direction to be positive.

$$\begin{aligned} \vec{s} &= 10\text{ km} + (-40\text{ km}) \\ &= -30\text{ km} \end{aligned}$$

$\therefore$ The displacement of the car is 30 km west of its starting position.

1 mark – Calculates the correct displacement of the car

2. A car travels 10 km north and then 5 km south. The total trip took 15 minutes.

   (a) Calculate the average speed of the car during this trip in m s^{-1}. **2**

$$\begin{aligned} t &= 15\text{ min} \times \frac{60\text{ s}}{1\text{ min}} \\ &= 900\text{ s} \\ s &= 10\text{ km} + 5\text{ km} \\ &= 15\text{ km} \\ s &= 15\text{ km} \times \frac{1000\text{ m}}{1\text{ km}} \\ &= 15000\text{ m} \\ v &= \frac{s}{t} \\ &= \frac{15000\text{ m}}{900\text{ s}} \\ &= 16.67\text{ m s}^{-1} \end{aligned}$$

2 marks – Calculates the correct distance travelled and the correct speed of the car (1 mark each)

(b) Calculate the average velocity of the car during this trip in m s^{-1}. **2**

Take the north direction to be positive.

$$\begin{aligned}
\vec{s} &= 10\text{ km} + (-5\text{ km}) \\
&= 5\text{ km} \\
\vec{s} &= 5\text{ km} \times \frac{1000\text{ m}}{1\text{ km}} \\
&= 5000\text{ m} \\
\vec{v} &= \frac{\vec{s}}{t} \\
&= \frac{5000\text{ m}}{900\text{ s}} \\
&= 5.56\text{ m s}^{-1}
\end{aligned}$$

$\therefore$ The velocity of the car is 5.56 m s^{-1} north.

2 marks – Calculates the correct displacement and the correct velocity of the car (1 mark each)

3. A hare and a tortoise competed against each other in a 1 km race. The tortoise has a maximum speed of 0.075 m s^{-1} while the hare has a maximum speed of 20 m s^{-1}. Both animals ran at their maximum speed throughout the race, however, the hare took a nap in the middle of the race. **3**

If both the hare and the tortoise crossed the finish line at the same time, calculate the duration of the hare's mid-race nap.

$$\begin{aligned}
s &= 1\text{ km} \times \frac{1000\text{ m}}{1\text{ km}} \\
&= 1000\text{ m} \\
t_{\text{tortoise}} &= \frac{s}{v} \\
&= \frac{1000\text{ m}}{0.075\text{ m s}^{-1}} \\
&= 13333.33\text{ s} \\
t_{\text{hare}} &= \frac{s}{v} + t_{\text{nap}} \\
&= \frac{1000\text{ m}}{20\text{ m s}^{-1}} + t_{\text{nap}} \\
&= 50\text{ s} + t_{\text{nap}} \\
t_{\text{tortoise}} &= t_{\text{hare}} \\
\implies 13333.33\text{ s} &= 50\text{ s} + t_{\text{nap}} \\
t_{\text{nap}} &= 13283.33\text{ s}
\end{aligned}$$

2 marks – Calculates the correct times needed by the tortoise and hare to cross the finish line at their maximum speeds (1 mark each)

1 mark – Calculates the correct duration of the hare's nap