Oxford IB Physics Course Companion

Unofficial student made suggested solutions

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Contents

1 Topic A – Space, time and motion

1.1 Subtopic A.1 – Kinematics

A1:P11 Question 1

a) The total distance is given as the sum of distance traveled during each translation, $2.5 + 3.8 = 6.3\,[\mathrm{km}]$

b) Displacement is a vector quantity, thus taking the magnitude of the sum of the two vector displacements caused by the movement:

$$\begin{aligned} \left\| \begin{pmatrix} 2.5 \\ 0 \end{pmatrix} + \begin{pmatrix} 0 \\ 3.8 \end{pmatrix} \right\| &= \left\| \begin{pmatrix} 2.5 \\ 3.8 \end{pmatrix} \right\| \\ &= \sqrt{2.5^2 + 3.8^2} \approx \boxed{4.55\,[\mathrm{km}]} \end{aligned}$$

c) Since this can be scenario can be set up as a right angle triangle, with the boat as the hypothesis' outer vertex, using trigenometry the angle can is determined as:

$$\tan\theta = \frac{o}{a} \rightsquigarrow \theta = \tan^{-1}\frac{2.5}{3.8} \approx 33.3°$$

A1:P11 Question 2

a) 15 minutes corresponds to a 90 degree ($\frac{\pi}{2}\,[\mathrm{rad}]$) rotation on a clock, or one quarter of its perimeter. Therefore the distance travelled by the tip of the pointer must be:

$$s = \frac{2\pi r}{4} = \frac{15\pi}{2} \approx 23.6\,[\mathrm{cm}]$$

The displacement however is the distance between the points $\langle 0\,,15\rangle$ and $\langle 15\,,0\rangle$, thus using Pythagoras' theorem[a]:

$$s = \sqrt{15^2 + 15^2} = \sqrt{450} = 21.2\,[\mathrm{cm}]$$

b) Analagously to question a but for the 180 degrees ($\pi\,[\mathrm{rad}]$) rotation resulting from 30 elapsed minutes:

$$\begin{aligned} s_{\text{distance}} &= \frac{2\pi r}{2} = 15\pi \approx 47.1\,[\mathrm{cm}] \\ s_{\text{displacement}} &= \sqrt{0^2 + 30^2} = 30\,[\mathrm{cm}] \end{aligned}$$

A1:P12 Question 3

Since they are headed in completley oposite directions, $s_{\text{Ada}} + s_{\text{Matt}} = 580\,[\mathrm{m}]$. Ada's speed of $20\,[\mathrm{km\,h^{-1}}]$

is approximately $5.56\,[\mathrm{m\,s^{-1}}]$, as found by dividing through by 3.6. Since $s = \displaystyle\int v\,\mathrm{d}t$:

$$
\begin{aligned}
v_{\text{Ada}}t + v_{\text{Matt}}t &= 580 \\
5.56 \times 60 + v_{\text{Matt}} \times 60 &= 580 \\
\therefore v_{\text{Matt}} &\approx 4.11\,[\mathrm{m\,s^{-1}}] \equiv \boxed{14.8\,[\mathrm{km\,h^{-1}}]}
\end{aligned}
$$

A1:P12 Question 4

First multiply the speed of light by the length of a light-year in seconds to obtain $1\,[\mathrm{ly}]$.

$$
\begin{aligned}
1\,[\mathrm{ly}] &= 3 \times 10^8\,[\mathrm{m\,s^{-1}}] \times (60 \times 60 \times 24 \times 365)\,[\mathrm{s}] \\
&\approx 9.46 \times 10^{15}
\end{aligned}
$$

Then, find the conversion between $1\,[\mathrm{au}]$ and one light-year.

$$
1\,[\mathrm{au}] \approx \frac{1.5 \times 10^{11}}{9.46 \times 10^{15}} = 1.59 \times 10^{-5}\,[\mathrm{ly}]
$$

Therefore,

$$
5.5 \times 10^5\,[\mathrm{au}] \approx \boxed{8.72\,[\mathrm{ly}]}
$$

A1:P12 Question 5

a) Calculating the speed between stations A and B:

$$
v = \frac{1000}{80} = 12.5\,[\mathrm{m\,s^{-1}}]
$$

Multiplying by 3.6 to obtain the speed in $[\mathrm{km\,h^{-1}}]$:

$$
v = 12.5 \times 3.6 = \boxed{45\,[\mathrm{km\,h^{-1}}]}
$$

b) $\Delta y = 1800 - 1000 = 800\,[\mathrm{m}]$

c) The train travels $800\,[\mathrm{m}]$ in 60 seconds, therefore, analagously to part **a)**:

$$
v = \frac{800}{60} \approx 13.3\,[\mathrm{m\,s^{-1}}] = \boxed{47.9\,[\mathrm{km\,h^{-1}}]}
$$

[a] $a^2 + b^2 = c^2$

2 Topic B – The particulate nature of matter

2.1 Subtopic B.1 – Thermal energy transfers