

Oxford Physics Course Companion

Unofficial suggested solutions

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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, $2.5 + 3.8 = 6.3$ [km]
b) Displacement is a vector quantity, thus taking the magnitude of the sum of the two vector displacements caused by the movement:

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

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

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

A1:P11 Question 2

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

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

The displacement however is the distance between the points $\langle 0, 15 \rangle$ and $\langle 15, 0 \rangle$, thus using Pythagora's theorem^a:

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

- b) Analogously to question a but for the 180 degrees (π [rad]) rotation resulting from 30 elapsed minutes:

$$s_{\text{distance}} = \frac{2\pi r}{2} = 15\pi \approx 47.1 \text{ [cm]}$$

$$s_{\text{displacement}} = \sqrt{0^2 + 30^2} = 30 \text{ [cm]}$$

A1:P12 Question 3

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

is approximately $5.56 \text{ [m s}^{-1}\text{]}$. Since $s = \int v dt$:

$$v_{\text{Ada}} t + v_{\text{Matt}} t = 580$$

$$5.56 \times 60 + v_{\text{Matt}} \times 60 = 580$$

$$\therefore v_{\text{Matt}} \approx 4.11 \text{ [m s}^{-1}\text{]} \equiv \boxed{14.8 \text{ [km h}^{-1}\text{]}}$$

A1:P12 Question 4

$$1 \text{ [ly]}$$

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

2 Topic B – The particulate nature of matter

2.1 Subtopic B.1 – Thermal energy transfers