# Past-paper walk-through

## Internal Structure and Density ▪ 8.1

eXercise

# Questions in this set

- 2018 Q4

# Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

# Question 4

2018 ▪ Q4

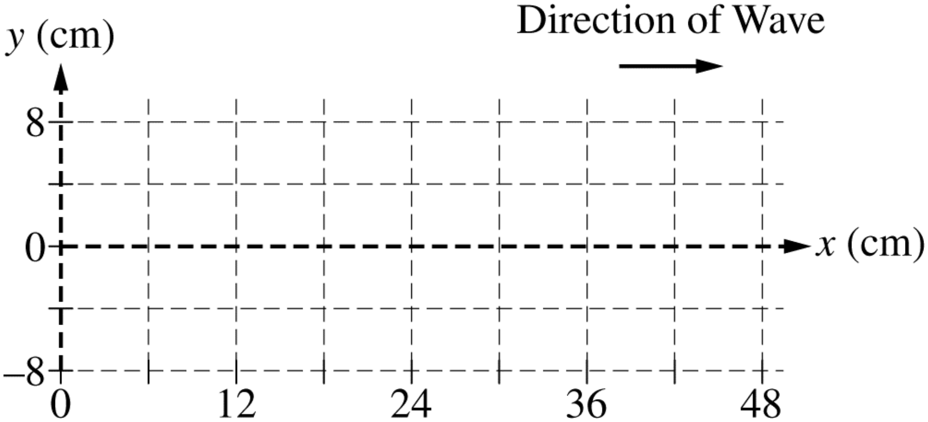
A transverse wave travels to the right along a string.
**(a)(i)** The figure below shows the string at an instant in time. At the instant shown, dot P has maximum displacement and dot Q has zero displacement from equilibrium. At each of the dots P and Q, draw an arrow indicating the direction of the instantaneous velocity of that dot. If either dot has zero velocity, write "$v = 0$" next to the dot.
[Figure: a transverse wave on a string (drawn with cross-hatching to show the string), moving right ("Direction of Wave" arrow shown above); dot P is marked at a trough of the wave (maximum displacement from equilibrium) and dot Q is marked at a zero-crossing point on the curve (zero displacement).]
**(a)(ii)** The figure below shows the string at the same instant as shown in part (a)i. At each of the dots P and Q, draw an arrow indicating the direction of the instantaneous

# Question 4

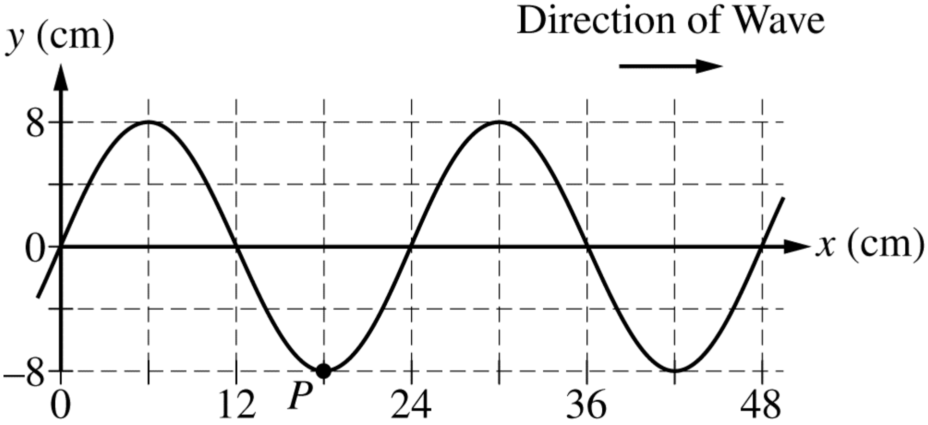
acceleration of that dot. If either dot has zero acceleration, write "$a = 0$" next to the dot.

[Figure: the same transverse wave snapshot repeated, moving right ("Direction of Wave" arrow shown above), with dot P at the trough and dot Q at the zero-crossing point, provided for the student to draw acceleration-direction arrows.]

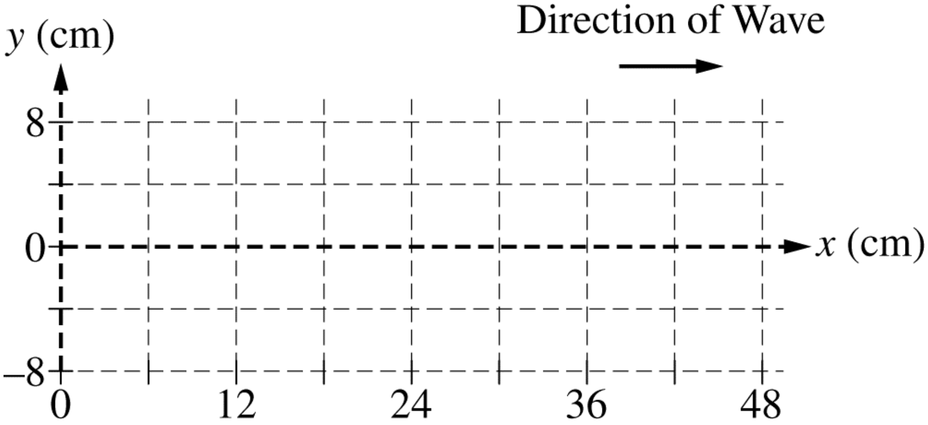
# Question 4



# Question 4



# Question 4



# Question 4

2018 ▪ Q4

A transverse wave travels to the right along a string.

**(b)(i)** The figure below represents the string at time $t = 0$, the same instant as shown in part (a) when dot P is at its maximum displacement from equilibrium. For simplicity, dot Q is not shown.

[Figure: a graph of $y$ (cm) vs $x$ (cm) showing a sinusoidal wave of amplitude 8 cm and wavelength 24 cm, with a "Direction of Wave" arrow pointing in the $+x$ direction; dot P is marked on the curve at $x = 12$ cm, $y = 0$.]

On the grid below, draw the string at a later time $t = T/4$, where $T$ is the period of the wave.

[Figure: a blank $y$ (cm) vs $x$ (cm) grid, same scale as above ($-8$ to 8 cm vertical, 0 to 48 cm horizontal) with a "Direction of Wave" arrow, provided for the student to sketch the string's new shape.]

# Question 4

Note: Do any scratch (practice) work on the grid at the bottom of the page. Only the sketch made on the grid immediately below will be graded.

**(b)(ii)** On your drawing above, draw a dot to indicate the position of dot P on the string at time $t = T/4$ and clearly label the dot with the letter P.

# Question 4

2018 ▪ Q4

A transverse wave travels to the right along a string.

**(c)** Now consider the wave at time $t = T$. Determine the distance traveled (not the displacement) by dot P between times $t = 0$ and $t = T$.

# Solution 4

## (a)(i)

**Mark scheme**

- At the instant shown, dot $P$ is at maximum displacement from equilibrium, so its instantaneous transverse velocity is zero: write '$v = 0$' next to $P$. Dot $Q$ is at zero displacement (passing through equilibrium), where its transverse speed is maximum; applying the transverse-wave rule for a wave moving to the right, the arrow at $Q$ points upward. Scoring (2 points, 1 each): (1) writing '$v = 0$' at point $P$; (2) an upward arrow at point $Q$.

# Solution 4

## (a)(ii)

**Mark scheme**

- At maximum displacement, the restoring effect (and hence acceleration) on a string element is at its maximum, directed back toward equilibrium; at $P$ this is an upward arrow. At $Q$, which is at zero displacement (the equilibrium position), the transverse acceleration is zero: write '$a = 0$' next to $Q$. Scoring (2 points, 1 each): (1) an upward arrow at point $P$; (2) writing '$a = 0$' at point $Q$.

# Solution 4

## (b)(i)

**Mark scheme**

- A transverse wave translates rigidly to the right without changing shape, so at $t = T/4$ the entire waveform is simply the original curve shifted right by one-quarter wavelength (one grid unit), keeping the same amplitude (8 cm) and wavelength (24 cm) – for example, the curve now shows a negative minimum at $x = 0$. Scoring (1 point): for a curve shifted to the right by $1/4$ of a wavelength (1 gridline) with the same wavelength as the original wave (as indicated, for example, by a negative minimum at $x = 0$).

# Solution 4

## (b)(ii)

### Mark scheme

- Dot $P$ is a fixed material point on the string, so it does not move horizontally as the wave passes – only its vertical displacement changes over time. Its $x$-position therefore stays at its original location, $3/4$ of a wavelength (3 grid units) to the right of the origin, but now lying on the $t = T/4$ curve drawn in part (b)(i). Scoring (1 point): for placing dot $P$ on the shifted string, at the dot's original $x$-position, $3/4$ of a wavelength (3 grid units) to the right of the origin, clearly labeled $P$.

# Solution 4

## (c)

**Mark scheme**

- In one full period $T$, a point on a transverse wave completes one full oscillation cycle – from maximum displacement, through equilibrium, to the opposite maximum, back through equilibrium, and back to the starting maximum – traveling a total path length of four amplitudes: $4 \times 8$ cm $= 32$ cm. Scoring (1 point): for the correct numerical answer, 32 cm.