

Mark schemes

Q1.

- (a) Equates resultant force to
- ma

and shows a proportional to y , as $A\rho mg$ are all constant ✓*In MP1:**Condone upthrust/buoyancy force for resultant force*

$$F = ma = -A\rho yg$$

$$\rho = \frac{-A\rho yg}{m}$$

Condone missing minus signs in MP1.

Minus sign included and explained:

(restoring) force/acceleration directed to centre of oscillation ✓

(hence SHM)

*In MP2:**Minus because force/acceleration is in opposite direction to y OWTTE*

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- (b) (
- $T = 2\pi/\omega$
-) so
- $\omega = \sqrt{\frac{g}{l}}$
- ✓ (= 10.74 rad s
- ⁻¹
-)

$$(a_{\max} = -\omega^2 y_{\max} = \frac{g}{l} \times y_{\max} = (9.81 \div 0.085) \times 0.005)$$

*Alternative for MP1:**calculates time (0.58(5) s) AND then uses ω from this time*0.58 (m s⁻²) ✓ from some correct working*MP2 for correct calculation of acceleration.*

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- (c) Idea that (at resonance) frequency of forced vibrations equals natural/resonant frequency
- ₁
- ✓

Idea that amplitude (of vibrations/oscillations) is at a maximum ₂ ✓*Accept fully labelled graph of amplitude vs driving frequency with resonance frequency clearly labelled ₁ ✓ and an amplitude peak. ₂ ✓**Condone 'wave frequency' for 'driving frequency'**Ignore references to phase*

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(d) stopped: wave frequency ($= \frac{v}{\lambda}$) = 0.12 Hz ¹✓

moving: when ship continues at 8 m s⁻¹, forcing frequency will be further from resonant frequency ²✓

Moving option is better with reason,

eg for stopped option wave/forcing frequency very close to natural frequency, (so amplitude of oscillations will be high)

OR

for moving option resonance does not occur ³✓

¹✓ is for calculation of (driving) frequency when stopped. Condone reference to 'frequency of waves'.

If no reference to ship being stopped, evidence can come from the substitution. Reject simple "0.12 (Hz)"

²✓ is for a relevant comment about the moving situation

OR

calculation of forcing frequency with the ship moving (giving 0.05 Hz)

For ²✓ accept incorrect calculation from adding speeds provided comment that this frequency is further from resonant frequency.

³✓ is for statement of why moving is the better option

Allow answer for ³✓ that mentions that damping will be highly likely, so amplitudes may not reach high enough values to prevent operation

Q2.

- (a) Use of time = angle / angular speed ✓

To get 3.5 (s) ✓

Alternative for MP1: Accept distance ÷ speed when circumference has been calculated.

Accept answers that round to 3.49

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- (b) Arrow towards centre of turntable. ✓

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- (c) Use of $F = mr\omega^2$ ✓

OR

determination of centripetal acceleration and then $F = ma$ ✓

To give 0.097 N ✓

Shown by substitution.

Condone use of diameter or radius halved in MP1.

Accept negative answer.

Calculator value: 0.0972

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- (d) States block is (constantly) changing direction ✓

Uses appropriate Newton law of motion to link evidence (to show that a force acts) ✓

Alternative 1

Block constantly changing direction (at constant speed) ✓

Uses N1 to show that a force must apply ✓

Alternative 2

Changing direction shows (centripetal) acceleration ✓

Uses N2 to show that a force must apply ✓

Reference can be to the name of the law or to a description of what the law says.

Condone lack of "resultant force" in N1 and N2.

Use of "changing velocity" without reference to direction is not enough for MP1.

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- (e) Use of pendulum equation by substitution or manipulation ✓

To give 1.55 m ✓

Allow 2+ sf

Allow answer that rounds to 1.55

Use of $g = 10 \text{ N kg}^{-1}$ gives 1.58 – do not allow for MP2

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- (f) *Amplitude* – the pendulum shadow amplitude becomes less than the block shadow amplitude ✓

Phase – time period decreases/changes OR frequency increases/changes (as pendulum amplitude gets less) therefore phase changes ✓

Must see a comparison for MP1

Condone:

the time periods/ frequencies remain identical therefore the shadows remain in phase

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[11]