Mark schemes

Q1.

(a) Equates resultant force to *ma*

and shows *a* proportional to *y*, as *Aρmg* are all constant✓

In MP1:

Condone upthrust/buoyancy force for resultant force

F = ma = -Aρyg

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

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

2

(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.

2

(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

2

(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

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[9]

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

2

(b) Arrow towards centre of turntable. ✓

1

(c) Use of $F = mrw^2$ ✓

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

2

(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.

2

(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 N kg^{-1} gives 1.58 − do not allow for MP2

2

(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

2

[11]