A-Level Physics

Circular Motion

Mark Scheme

Time available: 53 minutes
Marks available: 39 marks

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

To get 3.5 s ✓

2

(b) Arrow towards centre of turntable starting at the block. ✓

1

(c) Use of $F = mrw^2$ ✓

To give 0.10 N ✓

2

(d) Block constantly changing direction (at constant speed) ✓

Ref to N1 and therefore force must apply ✓

OR

Changing direction shows (centripetal) acceleration ✓

Reference to N2 and therefore force must apply ✓

2

(e) Use of pendulum equation ✓

To give 1.55 m ✓

2

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

Phase – time period decreases/changes as pendulum amplitude gets less/closer to zero so shadow of bob will move ahead of block/phase changes ✓

condone the two shadows remain in phase (as pendulum motion isochronous for small angles)

2

[11]

2. (a) Centripetal force acts inwards / towards the centre of rotation ✓

Links reaction force to centripetal force ✓

2

(b) Equates forces AND states **either** centripetal force with correct symbols✓

$F = m_A r\omega^2$

$F = m_B (L - r)\omega^2$

In MP1 condone: equations containing v; use of ω_A and ω_B for the angular velocities.

cancelling ω✓

$m_A r\omega^2 = m_B(L - r)\omega^2$

$r = \frac{m_B L}{m_A + m_B}$

E.g.

In MP2 it must be clear that the angular velocity and not the velocity.

2

(c) The angular speed is the same for A & B or

Rotational radius for B less than that for A ✓

Both of these points AND $v = r\omega$ so velocity of A is greater.✓

Alternative for MP2:

Both of points in MP1 AND

A travels greater distance in the same time.

2

(d) Use of safety factor e.g. maximum stress << 0.300 GPa ✓

$F = ma = 1.32 \times 10^6 \times 3.7$✓ $(= 4.9 \times 10^6$ N)

$A = \frac{F}{\sigma}$ valid substitution ✓

$\sqrt{\frac{4A}{\pi}}$ ✓ (expect > 0.144 m)

Valid justification for selection of maximum stress used e.g. using a stress that is from the linear / elastic section of the graph or reference to either safety factor or trying to limit weight of cable. ✓

Alternative for MP1: they can work through for a stress of 0.3 GPa and then increase the diameter, if justified as a safety factor. Do not allow use of stress ≈0.3 GPa for full marks.

Allow ecf for stress and force

5

[11]

3. (a) Radius of orbit = 5 tan 28.5 + 1 = 3.71 m ✓

1

Speed = 2 × 3.14 × 3.71/5.2 = 4.49 () ✓

For second mark only allow

Use of sin 28.5 gives orbit radius 3.39 m and speed = 4.1 m s^{-1}

Or

Forgets to add 1 giving radius 2.71 and speed 3.27 m s^{-1}

1

(b) Centripetal force = 85 × 4.49^2/3.71 = 460 N ✓

470 N if using 4.5 m s^{-1} leads to 1000 N

1

Centripetal force = T sin 28.5 ✓

Allow the following as ecf:

Forgetting to add the 1 m (using r = 2.71 m) leads to centripetal force = 630 N T = 1300 N)

*Using r =3.39 m as ecf from part **(e)** which leads to*

Centripetal force = 510 N giving T = 1070 N

1

T = 950 - 970 N ✓

1

OR

Weight = 85 × 9.8(1) 0r 834 N seen ✓

Weight = T cos 28.5 ✓

T = 950 (949) (N) ✓

OR

Centripetal force = 85 × 4.5^2/3.71 = 464 N ✓

Weight = 834 N ✓

$T = \sqrt{464^2 + 834^2}$ = 950 – 970 N ✓

Allow ecf for incorrect weight or centripetal force

Allow the following as ecf:

Forgetting to add the 1 m (using r = 2.71 m) leads to

Centripetal force = 630 N, T = 1050 N

Using r = 3.39 m leads to

Centripetal force = 510 N giving T = 980N

(c) Vertical (compressive) force **on the pole** increases ✓

1

Increases mass <u>increases weight</u> and hence tension in the rope(for the same angle) 1✓

1

<u>Centripetal Force</u>

on the acrobats/masses would be different/not equal

OR

Would be greater <u>on the more massive acrobat</u>(travelling at the same speed/same angle to vertical) 1✓

Unbalanced (horizontal) forces/resultant force exists (on the pole) ✓

OR

Unbalanced moments acting (on pole)/resultant torque acting (on pole) ✓

Causing the pole to sway/bend/move/ or tilt/topple the platform <u>toward more massive acrobat</u> 1✓

1
Max 3

[8]

4. (a) magnetic field direction: −*z* **(1)**

1

(b) direction changes meaning that velocity is not constant **(1)**

acceleration involves change in velocity
(or acceleration is rate of change of velocity) **(1)**

[**alternatively**

magnetic force on electron acts perpendicular to its velocity **(1)**
∴ force changes direction of movement causing acceleration **(1)**]

2

(c) (i) $BQv = \frac{mv^2}{r}$ **(1)** gives $v \left(= \frac{BQr}{m}\right)$

$= \frac{0.43 \times 10^{-3} \times 1.60 \times 10^{-19} \times 74 \times 10^{-3}}{9.11 \times 10^{-31}}$ **(1)** (= 5.59×10^{6} m s^{-1})

2

(ii) angular speed $\omega \left(= \frac{v}{r}\right) = \frac{5.59 \times 10^{6}}{74 \times 10^{-3}}$ = $7.5(5) \times 10^{7}$ **(1)**

unit: rad s^{-1} **(1)** (accept s^{-1})

2

(iii) frequency of electron's orbit $f\left(=\frac{\omega}{2\pi}\right)=\frac{7.55\times10^{7}}{2\pi}$ **(1)**

(= $1.20 \times 10^{7}\ s^{-1}$)

number of transits $min^{-1} = 1.20 \times 10^{7} \times 60 = 7.2 \times 10^{8}$ **(1)**

[**alternatively**

orbital period $\left(=\frac{2\pi r}{v}\right)=\frac{2\pi\times74\times10^{-3}}{5.59\times10^{6}}$ [**or** $\left(=\frac{2\pi}{\omega}\right)=\frac{2\pi}{7.55\times10^{-7}}$]

(= 8.32×10^{-8} s)

number of transits $min^{-1} = \frac{60}{8.32\times10^{-8}} = 7.2\times10^{8}$ **(1)**]

2

[9]