A2 Phys T1 MS

Monday, July 28, 2025 12:25 AM

(b) (i) $T = 24$ hours C1

$\omega = 2\pi / (24 \times 3600)$ or $2\pi / T$ C1

$= 7.27 \times 10^{-5}$ rad s^{-1} ..... A1 [3]

(ii) $mr\omega^2 = GMm / r^2$ C1

$r^3 = 7.55 \times 10^{22}$ C1

$r = 4.23 \times 10^7$ m ..... A1 [3]

(a) (i) angle subtended at centre of circle B1

arc equal in length to the radius ..... B1 [2]

(ii) arc = $r\theta$ and for one revolution, arc = $2\pi r$ M1

so, $\theta = 2\pi r/r = 2\pi$ ..... A0 [1]

(b) (i) *either* weight provides/equals the centripetal force

or acceleration of free fall is centripetal acceleration B1

$9.8 = 0.13 \times \omega^2$ M1

$\omega = 8.7$ rad s^{-1} ..... A0 [2]

(ii) force in cord = weight + centripetal force (*can be an equation*) C1

force in cord = $(L - 13) \times 5/1.8$ *or* force constant = $5.0/1.8$ C1

$(L - 13) \times 5/1.8 = 5.0 + 5/9.8 \times L \times 10^{-2} \times 8.7^2$ C1

$L = 17.2$ cm ..... A1 [4]

(*constant centripetal force of 5.0 N gives L = 16.6 cm allow 2/4*)

(ii) angle swept out per unit time / rate of change of angle M1

by the string A1 [2]

(b) friction provides / equals the centripetal force B1

$0.72\,W = md\omega^2$ C1

$0.72\,mg = m \times 0.35\omega^2$

$\omega = 4.49$ (rad s^{-1}) C1

$n = (\omega/2\pi) \times 60$ B1

$= 43$ min^{-1} (allow 42) A1 [5]

(c) *either* <u>centripetal</u> force increases as r increases

or <u>centripetal</u> force larger at edge M1

so flies off at edge first A1 [2]

(*$F = mr\omega^2$ so edge first – treat as special case and allow one mark*)

(b) (i) point S shown below C — B1 [1]

(ii) (max) force / tension = weight + centripetal force — C1
centripetal force = $mr\omega^2$ — C1
$15 = 3.0/9.8 \times 0.85 \times \omega^2$ — C1
$\omega = 7.6$ rad s^{-1} — A1 [4]

(a) (i) rate of change of angle / angular displacement — M1
swept out by radius — A1 [2]

(ii) $\omega \times T = 2\pi$ — B1 [1]

(b) centripetal force is provided by the gravitational force — B1
either $mr(2\pi/T)^2 = GMm/r^2$ *or* $mr\omega^2 = GMm/r^2$ — M1
$r^3 \times 4\pi^2 = GM \times T^2$ — A1
$GM/4\pi^2$ is a constant (c) — A1
$T^2 = cr^3$ — A0 [4]

(c) (i) *either* $T^2 = (45/1.08)^3 \times 0.615^2$ *or* $T^2 = 0.30 \times 45^3$ — C1
$T = 165$ years — A1 [2]

(ii) speed $= (2\pi \times 1.08 \times 10^8) / (0.615 \times 365 \times 24 \times 3600)$ — C1
$= 35$ km s^{-1} — A1 [2]

(a) (i) $F = R\cos\theta$ — M1
$W = R\sin\theta$ — M1
dividing, $W = F\tan\theta$ — A0 [2]
(max. 1 if derivation to final line not shown)

(ii) <u>provides</u> the centripetal force — B1 [1]

(b) *either* $F = mv^2/r$ and $W = mg$
or $v^2 = rg/\tan\theta$ — C1
$v^2 = (14 \times 10^{-2} \times 9.8)/\tan 28°$ — C1
$= 2.58$
$v = 1.6$ m s^{-1} — A1 [3]