inkPhysics

ANSWER BOOK

Circular motion

Periodic motion · Year 13

AQA 3.6.1.1 · CIE 12.1.1, 12.1.2, 12.1.3, 12.2.1, 12.2.2, 12.2.3, 12.2.4
OCR A 5.2.1(a), 5.2.1(b), 5.2.1(c), 5.2.2(a), 5.2.2(b), 5.2.2(c), 5.2.2(d)(i)

19 questions · 52 marks

NAVY EDITION

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SECTION A · Warm-up

A1 Velocity is a vector, so although the speed is constant the direction of motion is continually changing (1). A changing velocity means the object is accelerating, towards the centre of the circle (1). [2]

A2 $\omega = 2\pi f = 2\pi \times 5.0$ (1)
$\omega = 31.4$ rad s^{-1} (1) [2]

A3 $\omega = v/r = 10/2.0$ (1)
$\omega = 5.0$ rad s^{-1} (1) [2]

A4 $\theta = s/r = 24/60 = 0.40$ rad (1). [1]

A5 $f = 3000/60 = 50$ revolutions per second (1)
$\omega = 2\pi f = 2\pi \times 50 = 314$ rad s^{-1} (1) [2]

A6 (a) The gravitational attraction of the Earth on the Moon (1). (b) Friction between the tyres and the road surface (1). [2]

SECTION B · Standard

B1 (a) $a = v^2/r = 8.0^2/4.0$ (1)
$a = 16$ m s^{-2} (1)
(b) $F = ma = 0.50 \times 16 = 8.0$ N (1) [3]

B2 $F = mv^2/r = (1000 \times 15^2)/50$ (1)
$F = 4500$ N (1) [2]

B3 (a) $\omega = 2\pi f$ (1)
$\omega = 12.57$ rad s^{-1} (1)
(b) $v = \omega r = 3.77$ m s^{-1} (1)
(c) $a = \omega^2 r = 47.4$ m s^{-2} (1) [4]

B4 $T = mv^2/r = (0.20 \times 4.0^2)/0.80$ (1)
$T = 4.0$ N (1) [2]

B5 At the minimum speed, the weight of the water alone provides the centripetal force at the top (1)
$mg = mv^2/r$, so $v = \sqrt{(gr)} = \sqrt{(9.81 \times 0.90)}$ (1)
$v = 3.0$ m s^{-1} (1) [3]

B6 $\omega = 2\pi \times 45/60 = 4.71$ rad s^{-1} (1) [4]
Force needed = $m\omega^2 r = 0.012 \times 4.71^2 \times 0.15$ (1)
Force needed = 0.040 N (1)
0.040 N is less than the 0.045 N available from friction, so the coin stays in place (1)

B7 $v = 2\pi r/T = 2\pi \times 25/18$ (1) [3]
$v = 8.7$ m s^{-1} (1)
$a = v^2/r = 8.7^2/25 = 3.0$ m s^{-2} (1)

SECTION C · Stretch

C1 (a) $\omega = 2\pi/T = 2\pi/0.40$ (1) [4]
$\omega = 15.71$ rad s^{-1} (1)
(b) $a = \omega^2 r = 123.4$ m s^{-2} (1)
(c) $F = ma = 0.10 \times 123.4 = 12.3$ N (1)

C2 At the maximum, $T = mv^2/r$ (1) [3]
$v = \sqrt{(Tr/m)} = \sqrt{(50 \times 1.0/0.25)}$ (1)
$v = 14.1$ m s^{-1} (1)

C3 The centripetal force acts towards the centre of the circle (1). If it is removed and no other force acts, then by Newton's first law the object travels in a straight line (1), along the tangent to the circle at the point of release (1). [3]

C4 At the lowest point the resultant upward force is $T - mg$ (1) [4]
$T - mg = mv^2/r$ (1)
$T = 0.40 \times 9.81 + (0.40 \times 3.2^2)/1.8$ (1)
$T = 6.2$ N (1)

C5 $\omega = 2\pi f = 2\pi \times 100 = 628$ rad s^{-1} (1) [3]
$a = \omega^2 r = 628^2 \times 0.080 = 3.16 \times 10^4$ m s^{-2} (1)
$a/g = 3.16 \times 10^4/9.81 = 3219$, which is about 3000 times g (1)

C6 The centripetal force acts towards the centre, at right angles to the velocity at every instant (1). The object therefore has no displacement in the direction of the force (1). Since $W = Fs \cos\theta$ with $\theta = 90°$, no work is done and the kinetic energy (and speed) stays constant (1). [3]