InkMaths

ANSWER BOOK

Angular speed and horizontal circular motion

Further Mechanics 2 · Year FM

6 questions · 20 marks

NAVY EDITION

SECTION A · Warm-up

A1 Velocity is a vector, and although its magnitude is fixed its direction is continually changing, so the velocity is changing and there is an acceleration. It points towards the centre of the circle, with magnitude $r\omega^2$ or v^2/r. [2]

A2 $v = r\omega = 1.5 \times 4 =$ 6 m/s. Acceleration $= r\omega^2 = 1.5 \times 16 =$ 24 m/s², directed towards the centre. Using v^2/r gives $36/1.5 = 24$ as well. [3]

SECTION B · Standard

B1 Vertically: $T\cos40° = 0.4(9.8)$, so $T = 3.92/0.766 =$ 5.12 N. The radius is $1.2\sin40° = 0.771$ m. Horizontally: $T\sin40° = 0.4r\omega^2$, which after substituting gives $\omega^2 = g/(l\cos40°) = 10.66$, so $\omega = 3.27$ rad/s and $T = 2\pi/\omega =$ 1.92 s. [4]

B2 Vertically $R\cos\theta = mg$ and horizontally $R\sin\theta = mv^2/r$. Dividing removes both R and m: $\tan\theta = v^2/(rg)$, so $v^2 = 120 \times 9.8 \times \tan15° = 315.1$ and $v =$ 17.8 m/s. Below that speed friction must act up the slope, and above it down. [4]

B3 For the conical pendulum it is the horizontal component of the tension. For the car on a flat bend it is the friction between the tyres and the road, acting sideways towards the centre. For the satellite it is gravity, which is the whole of the force acting on it. [3]

SECTION C · Stretch

C1 On a flat bend the only inward force is friction, so $F = mv^2/r$, and the limiting value is $F = \mu mg = 0.6mg$. Setting them equal: $v^2 = \mu gr = 0.6 \times 9.8 \times 50 = 294$, so $v =$ 17.1 m/s. The mass cancels, so a lorry and a car slip at the same speed, which is not what intuition suggests. [4]