Year 12 Physics ***SOLUTIONS***

Formative Test – Circular Motion and Gravitation

1.

a) Acceleration is change in velocity, and velocity has both magnitude (speed) and direction. So a change in direction is a change in velocity, and therefore acceleration. /2

b) The force of gravitational attraction /1

2.

a) The tension in the rope. /1

b)

$$a = \frac{v^2}{r} \quad \text{and } F = ma$$

$$\therefore F = \frac{mv^2}{r}$$

$$v = \frac{2\pi r}{T} \quad \left\{ \text{since speed} = \frac{\text{distance}}{\text{time}}, \text{ circumference } 2\pi r \text{ is distance and period } T \text{ is time} \right\}$$

$$\therefore F = \frac{m\left(\frac{2\pi r}{T}\right)^2}{r}$$

$$\therefore F = \frac{m\frac{4\pi^2 r^2}{T^2}}{r}$$

$$\therefore F = \frac{m}{r} \times \frac{4\pi^2 r^2}{T^2}$$

$$F = \frac{4\pi^2 mr}{T^2}$$

/3

c)

$m = 60$ kg $\quad r = 10$ m $\quad T = 6.28$s

$$F = \frac{4\pi^2 mr}{T^2}$$

$$F = \frac{4\pi^2 \times 60 \times 10}{(6.28)^2}$$

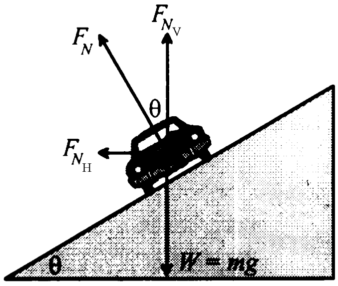
$$= 601$$

The magnitude of the tension in the rope is 6.0×10^2 N (2 s.f.)

/2

3.

a) Banking a curve means that the normal force (the road on the car) has a horizontal component. This horizontal component provides some (or all) of the centripetal acceleration for a car taking the curve. This means the friction does not need to provide as much acceleration.

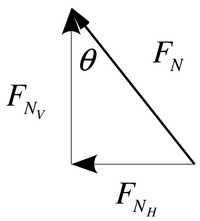


In the diagram, F_{NH} can be seen to provide at least some of the centripetal acceleration. /4

b) The vertical component must still be sufficient to keep the car from sinking into the road, so $F_{N_V} = mg$.

For the horizontal component to provide exactly all the centripetal acceleration (friction of the tyres not needed) $F_{N_H} = F_c = ma_c = m\frac{v^2}{r}$

The total normal force is the vector sum of its components, so:



$$\tan\theta = \frac{F_{N_H}}{F_{N_V}}$$

$$\therefore \tan\theta = \frac{m\frac{v^2}{r}}{mg}$$

$$\therefore \tan\theta = \frac{v^2}{rg}$$

4.

a)

$$v = \sqrt{\frac{GM}{r}}$$

G, r constant

$$\therefore v \propto \sqrt{M}$$

$$\therefore \frac{v_2}{v_1} = \frac{\sqrt{M_2}}{\sqrt{M_1}}$$

$$\therefore v_2 = \frac{\sqrt{M_2}}{\sqrt{M_1}} \times v_1 = \frac{\sqrt{4M}}{\sqrt{M}} \times 1552 = 2 \times 1552 = 3104 \text{ ms}^{-1}$$

/3

b) It must, since the centripetal acceleration is towards the centre of the orbit and this acceleration is provided by the gravitational force which is from centre-to-centre. /2

5. Since the Earth spins West-to-East, the satellite will already have some of the high orbital speed necessary. /2

6. Low altitude polar, as they are able to see any point on the Earth undistorted and close up. /2

Total /25