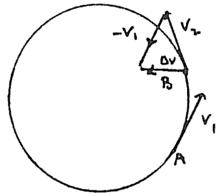
1. (1)

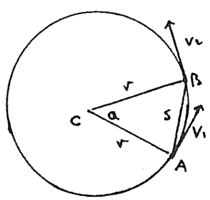


$\Delta V = V_2 - V_1$

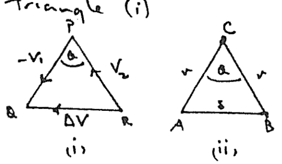
(2) Towards the centre of the circle.

(3) Towards the centre of the circle. As $a = \frac{\Delta V}{\Delta t}$, the direction of the change of velocity is the direction of the acceleration and the force.

(4)



Consider a particle moving in a circle from A to B. The change of its velocity (ΔV) is represented by this triangle (i)



The triangle CAB (ii) shows 'S' as the arc distance from A to B. Now if θ is very small, the arc s = the distance AB. (in time t)

$\therefore s = Vt$ where V is the tangential velocity of the particle. The triangles are similar $\therefore \frac{QR}{PQ} = \frac{AB}{CB}$

$\therefore \frac{\Delta V}{V} = \frac{s}{r}$

$\therefore \frac{\Delta V}{V} = \frac{Vt}{r}$

$\therefore \frac{\Delta V}{t} = V^2/r$

$\therefore$ centripetal acceleration

$\vec{a} = \frac{\Delta \vec{V}}{t} = V^2/r$ *

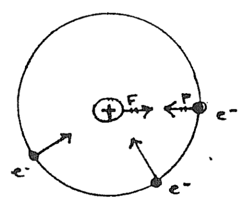
(5) $\vec{a} = \frac{v^2}{r} = \frac{20^2}{400}$

$\therefore a = 1\ ms^{-2}$ towards the centre of the circle.

2. (1) $\vec{a} = \frac{v^2}{r} = \frac{(1.03 \times 10^7)^2}{1.20 \times 10^{-11}}$

$\therefore a = 8.8 \times 10^{24}\ ms^{-2}$ towards the nucleus.

(2)



(3) Nucleus and the electron experience the same force (in magnitude) ie Newton's Third Law.

(4) $F = mv^2/r$

$= 9.11 \times 10^{-31} \times 8.8 \times 10^{24}$

$\vec{F} = 8.0 \times 10^{-6}\ N.$

2(5) Electrostatic attraction between the charges.

(6) Attraction described by Coulomb's Law

$\therefore F = \frac{\frac{1}{4\pi\varepsilon_0} q_1 q_2}{r^2}$

$\therefore 8.0 \times 10^{-6} = \frac{9 \times 10^9 \times q_1 \times 1.6 \times 10^{-19}}{(1.20 \times 10^{-11})^2}$

$\therefore q_1 = 8.0 \times 10^{-19} C$

(This is the nuclear charge)

$\therefore$ No. of protons = $\frac{\text{total charge}}{p^+}$

$\therefore$ No protons $= \frac{8.0 \times 10^{-19}}{1.6 \times 10^{-19}}$

= 5 protons.

3. (1) $\vec{a}_A : \vec{a}_B$

$= \frac{v_A^2}{r} : \frac{v_B^2}{r} = 1:1$

(2) $\frac{F_A}{F_B} = \frac{m_A a_A}{m_B a_B} = \frac{m_A}{m_B}$

$= \frac{1000}{2000} = \frac{1}{2}$

$\therefore F_A = \frac{1}{2} F_B.$

4. (1) $F = \frac{mv^2}{r}$ $\therefore F \propto v^2$

$\therefore$ if double the speed the force is 4 times the size.

(2) $F \propto \frac{v^2}{r}$

(i) $\frac{1}{4}$ speed, $\frac{1}{16}$th force

(ii) $\frac{1}{2}$ radius, double force

$\therefore$ New force = $\frac{1}{8}$th of 'old' Force

ie $F_{new} = \frac{F}{8}.$

5. (1) $\vec{a} = \frac{v^2}{r} = \frac{(0.60)^2}{2.4}$

$\vec{a} = 0.15\ ms^{-2}$ to the centre of the track.

(2) $\vec{F} = m\vec{a}$

$= 0.6 \times 0.15$

$= 0.09$ Newtons to the centre of the track.

6. 60 km/h = 16.7 ms^{-1}

(1) $a = \frac{v^2}{r} = \frac{(16.7)^2}{100}$

$a = 2.78\ ms^{-2}$ to the centre.

(2) $\vec{F} = m\vec{a}$

$= 2000 \times 2.78$

$= 5560 N.$

(3) To the centre of the track.

7. (1) $V = \frac{2\pi r}{T} = \frac{2\pi \times 3.0}{20}$

$\therefore V = 0.94\ ms^{-1}$

(2) $F = mv^2/r = \frac{50 \times (0.94)^2}{3}$

$\therefore F = 14.8 N$ to the centre.

(3) $V = \frac{2\pi r}{T} = \frac{2\pi \times 4.5}{20}$

$V = 1.41\ ms^{-1}$

8. (1) $F = ma$, $80 = 4a$

$\therefore a = 20\ ms^{-2}$ to the centre.

(2) $\vec{a} = \frac{v^2}{r}$ (centripetal)

$\therefore 20 = \frac{v^2}{0.4}$

$\therefore v = 2.83\ ms^{-1}$

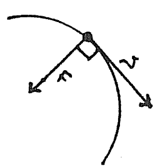
(3) $T = \frac{2\pi r}{v} = \frac{2\pi \times 0.4}{2.83}$

$\therefore T = 0.89s.$

(4) # of revolutions = $\frac{60s}{0.89}$

$\therefore$ # revs = 67 complete revs.

9. (1)



The force is at 90° to the velocity (a centripetal force) $\therefore$ it will not change the speed of the object, just its direction; hence the velocity changes but not the speed.

(2) as above, the speed will not change $\therefore$ $K = \frac{1}{2}mv^2$ will not change. The force does no work on the moving particle

10. (1) electrostatic force:
– between electron and nucleus in an atom.

(2) gravitation force:
– between Earth & Moon.

(3) a frictional force:
– between car tyres and the road for a car moving around a bend.

(4) a tension force:
– The force provided by the wire holding a 'hammer' being thrown on a sports day.

(5) a magnetic force:
– The force on a moving charge in a magnetic field (as in a cyclotron)

11. (1) $V = \frac{2\pi r}{T}$

$\therefore V = \frac{2\pi \times 3.844 \times 10^8}{27.32 \times 24 \times 60 \times 60}$

$= 1021\ ms^{-1}$

(2) $a = \frac{v^2}{r}$

$= \frac{(1021)^2}{3.844 \times 10^8}$

$= 0.0027\ ms^{-2}$ to the centre of its orbit.

12. (1) Speed $= \frac{2\pi r}{T}$

$= \frac{2\pi \times 100}{12.0}$

Speed $= 52.36\ ms^{-1}$

(2) $F = \frac{mv^2}{r} = \frac{800 \times (52.36)^2}{100}$

$F = 2.19 \times 10^4$ Newtons

On each tyre $F/4$

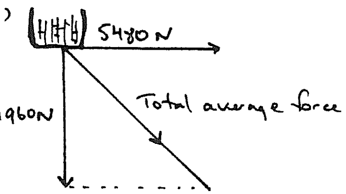
$= 5.48 \times 10^3\ N$
(to centre of track)

12. (3) Total force (weight)
$= mg = 800 \times 9.8$

$F = 7840\ N$

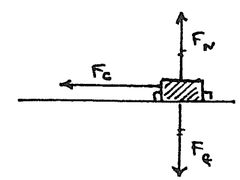
$\therefore$ per tyre $= \frac{7840}{4} = 1960N$

(4)

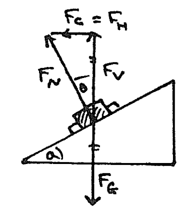


Total average force (by Pythag.) = 5820 N @ 19.6° to the horizontal

13 (1)



(2)



14. (1) See text

(2) Using the diagram in 13(2)
F_V is equal and opposite to F_G
$\therefore F_V = mg$.
But $F_V = F_N \cos\theta$.

$\therefore F_N = \frac{mg}{\cos\theta}$

But the force providing the centripetal force $F = mv^2/r$ is F_c, $\therefore F_c = F_N \sin\theta$

$\therefore F_N \sin\theta = \frac{mv^2}{r}$

$\therefore \frac{mg}{\cos\theta} . \sin\theta = \frac{mv^2}{r}$

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

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

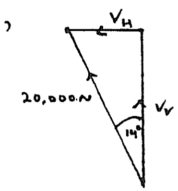
(3)(a) $\tan\theta = \frac{v^2}{rg} = \frac{(60)^2}{600 \times 9.8}$

$\therefore \theta = 31.5°$

(b) $a = \frac{v^2}{r} = \frac{(60)^2}{600} = 6\ ms^{-2}$

$\therefore \vec{a} = 6\ ms^{-2}$ to the centre of the track.

15. (1)



$V_H = 20{,}000 \sin 14° = 4838\ N$

$V_V = 20{,}000 \cos 14° = 19{,}406\ N$

(2) F_{grav} = vertical component
$= 19{,}406\ N$

(3) $F = mg$ $\therefore 19{,}406 = m \times 9.8$

$m = 1980\ kg$

(4) F_c = horizontal component
$= 4838\ N$

15 (5) $F = ma \quad \therefore a = F/m$

$\therefore$ acceleration $= \frac{4838}{1980}$

$\therefore a = 2.44\ ms^{-2}$ to the centre of the curve.

(6) $a = v^2/r \quad \therefore r = v^2/a$

$\therefore r = \frac{(50)^2}{2.44}$

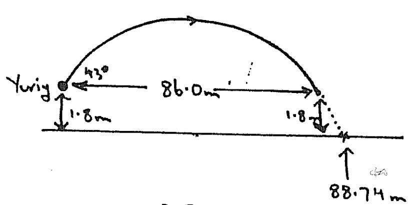
$r = 1025\,m$

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

$\therefore \tan 25° = \frac{v^2}{300 \times 9.8}$

$\therefore v = 37.0\ ms^{-1}$

17.



(1) $R = \frac{u^2 \sin 2\theta}{g}$

$\therefore 86.0 = \frac{u^2 \sin 2(43)}{9.8}$

$\therefore u = 29.07\ ms^{-1}$

(2) $a = \frac{v^2}{r} = \frac{(29.07)^2}{2.23}$

$\therefore a = 378.9\ ms^{-2}$ to the centre of rotation.

(3) $F = \frac{mv^2}{r} = 7.62 \times 378.9$

$= 2887\ N$ in.

(4) $T = \frac{2\pi r}{v}$

$= \frac{2\pi \times 2.23}{29.07}$

$T = 0.48$ seconds – time for each rotation

$\therefore f = \frac{1}{T} = \frac{1}{0.48}$

$f = 2.08\ Hz$

$= 2.08 \times 60$

$= 125$ revs/s.

(5) $K = \frac{1}{2}mv^2$

$= \frac{1}{2} \times 7.62 \times (29.07)^2$

$= 3219\ J.$

(6) Power $= \frac{\text{work done}}{\text{time}}$

$= \frac{\Delta K}{\Delta t}$

$= \frac{3219}{3.4}$

$= 947$ watts

1. The gravitational force between two masses is proportional to the product of the masses and inversely proportional to the square of the distance between them.

2. (1) Each $5.20 \times 10^{-10}\ N$
This is consistent with Newton's Third Law.

(2) $F = \frac{G m_1 m_2}{d^2}$

$F = 5.20 \times 10^{-10}$

$\therefore 5.20 \times 10^{-10} = \frac{6.67 \times 10^{-11} \times 10 \times 12}{d^2}$

$\therefore d = 3.9\,m$

3. (1) $F = \frac{G m_e m_m}{d^2}$

$F = 2.0 \times 10^{20}\ N$

(2) Both accelerate. They both experience the same force $\therefore$ they accelerate. But the moon accelerates more because it has a smaller mass.

4. (1) $F = \frac{G m_1 m_2}{d^2}$

$F = \frac{6.67 \times 10^{-11} \times 55 \times 65}{(2.0)^2}$

$F = 5.96 \times 10^{-8}\ N$ attraction.

(2) $F = ma$

$\therefore a = F/m$

$\therefore a = \frac{5.96 \times 10^{-8}}{55}$

$a = 1.08 \times 10^{-9}\ ms^{-2}$

(3) Double distance will $\frac{1}{4}$ the force, because

$F \propto 1/d^2$

$\therefore$ force now $= 1.49 \times 10^{-8}\ N$

5. (1) $F \propto 1/d^2$

$\therefore$ double distance, $\frac{1}{4}$ force

$\therefore$ new force $= F/4$.

(2) $F \propto 1/d^2 \quad \therefore \frac{1}{4}$ distance
Force is now 16 times the size

$\therefore$ new force $= 16F$.

(3) $F \propto m_1 m_2$

$\therefore$ new force $= 4F$.

(4) Same force – the forces are taken centre to centre of each mass $\therefore$ no change.

6. see text

7. The force on a mass (m_1) in the Earth's gravitational field is $F = m\vec{g}$ (its weight)
But also the force is given by

$F = \frac{G m_1 m_2}{d^2}$

i.e. $F = \frac{G m_1 m_E}{d^2}$

$\therefore \cancel{m_1} g = \frac{G \cancel{m_1} m_E}{d^2}$

$\therefore \vec{g} = G m_E / d^2$