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

$\therefore$ acceleration $= \frac{4888}{1980}$

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

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

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

$r = 1025\ m$

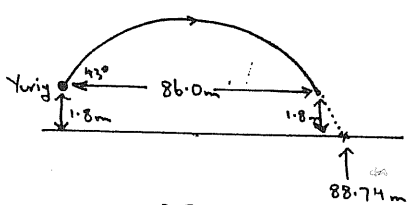
16.

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

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

$\therefore v = 37.0\ m\,s^{-1}$

17.



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

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

$\therefore U = 29.07\ m\,s^{-1}$

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

$\therefore a = 378.9\ m\,s^{-2}$ 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) $F = ma$

$\therefore a = F/m$

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

$a = 1.08 \times 10^{-9}\ m\,s^{-2}$

(3) Double distance will 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, 1/4 force

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

(2) $F \propto 1/d^2 \quad \therefore$ 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. $F = \frac{G m_1 m_E}{d^2}$

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

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

7 (2) $\vec{g} = \frac{GM_E}{d^2}$

$\vec{g} = \frac{6.67\times10^{-11} \times 5.98\times10^{24}}{(6.37\times10^6)^2}$

$\vec{g} = \underline{9.83\ ms^{-2}}$

(3) (a) $\vec{g} \propto 1/d^2$

$\therefore$ if double radius Then

$1/4\ g$

$\therefore$ new g is $\frac{9.83}{4}$

$\underline{\vec{g} = 2.46\ ms^{-2}}$

(b) $g \propto M$ $\therefore$ g increases by 20% $= \underline{11.8\ ms^{-2}}$

(c) $g \propto \frac{M}{r^2}$

$\therefore$ Half mass, Half g;

but Half radius, $4\times g$

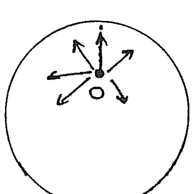
$\therefore$ "g_{new}" $= 2g = \underline{19.7\ ms^{-2}}$

8. . Different types of materials beneath The surface will change The value. .

eg iron-ore bodies compared to sand etc.

- also slight differences in The EarTh's radius will change "g" (mountains etc)

9. (1)



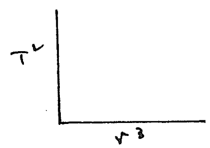
As an object O moves below The surface, mass above it attracts it in The opposite direction to The mass below it $\therefore$ The resultant force is less $\therefore$ less g.

(2) at The centre O is attracted equally in all directions $\therefore$ The resultant force is zero $\therefore g = 0$.

10 (1) Gravitational attraction between The satellite and The EarTh.

(2) see text

(3)



11. (1) see text.

(2) (a) no effect.

(b) If reduce The radius, T will decrease. Also if reduce The radius velocity will increase $(v \propto \frac{1}{\sqrt{r}})$

(c) Less mass (mars) $\therefore$ lower velocity

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

12. $T^2 = \frac{4\pi^2 r^3}{GM_E}$

$\therefore$ No! if They move at different speeds at The same radius The periods would be different ; cannot be $\therefore$ cannot have different speeds

13.

(1) $T = 1/f = \frac{1}{15}$ days

$= 96$ mins

$= \underline{5760\ s.}$

(2) $r = \sqrt[3]{\frac{T^2 GM_E}{4\pi^2}}$

$\therefore r = \sqrt[3]{\frac{(5760)^2 \times 6.67\times10^{-11} \times M_E}{4\pi^2}}$

$\underline{r = 6.95\times10^6\ m}$

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

$= \frac{2\pi \times 1.0\times10^7}{5760}$

$\underline{V = 1.09\times10^4\ ms^{-1}}$

14. (1) $V = \sqrt{\frac{GM_E}{r}}$

$\therefore V = \sqrt{\frac{6.67\times10^{-11} \times 5.977\times10^{24}}{7\times10^6}}$

$\underline{V = 7.5\times10^3\ ms^{-1}}$

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

$T = \frac{2\pi \times 7\times10^6}{7.5\times10^3}$

$T = \underline{97.2\ \text{mins}}$.

15. (1) It has The same period as The EarTh. ie $T = 24$ hours.

$\therefore$ it stays above The same point on The EarTh at all times.

(2) $T = 24$ hours.

(3) No. The centre of The orbit must coincide with The centre of The EarTh. And, it must be an equatorial orbit

(4) Same direction as The EarTh $\therefore$ west to East.

(5) $T = 24$ hours

$= 8.64\times10^4$ s.

Use $r^3 = \frac{GM_E T^2}{4\pi^2}$

$r = \underline{4.2\times10^7\ m}$

(6) Height above surface

$h = r - r_E$

$h = 4.2\times10^7 - 6.4\times10^6$

$\underline{h = 35{,}872\ km}$

16. See text.

17. Advantages

- Communication "dishes" antennae can be fixed in one direction - less complicated
- can maintain continuous surveillance.

17 (cont)

Disadvantage: Too high ∴ signal strengths need to be high + time delays are a problem, especially with TV interviews etc.

18. The gases in the atmosphere will slow the satellite down ∴ it would spiral inwards.

19. (1) $v = \sqrt{\frac{GM_E}{r}}$

$v = 7.28 \times 10^3 \text{ ms}^{-1}$

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

$T = \frac{2\pi \times 7.52 \times 10^6}{7.28 \times 10^3}$

$T = 108$ mins.

(3) distance $= 2\pi r$

$d = 4.72 \times 10^7$ m

(4) # of orbits $= \frac{1 \text{ day}}{T}$

$= \frac{24 \times 60}{108} = 13.3$ revs.

(5) $a = \frac{v^2}{r} = \frac{(7.28 \times 10^3)^2}{7.52 \times 10^6}$

$a = 7.0 \text{ ms}^{-2}$ to the centre of the Earth

20.

(1)(a) Orbit radius

$= [850{,}000 + 6.37 \times 10^6]$

$= 7.22 \times 10^6$ m

∴ using $T^2 = \frac{4\pi^2 r^3}{G M_E}$

$T = 101.7$ min

(b) # of orbits $= \frac{1 \text{ day}}{T}$

$= \frac{24 \times 60}{101.7} = 14.2$ orbits

(c) $V = \frac{2\pi r}{T}$

$= \frac{2\pi \times 7.22 \times 10^6}{6100}$

$V = 7.44 \times 10^3 \text{ ms}^{-1}$

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

$= \frac{1}{2} \cdot m \cdot (7.44 \times 10^3)^2$

$K = 2.77 \times 10^7\, m$ Joules

(2) Slows down ∴ v gets smaller ∴ centripetal force reduces at this height ∴ the gravitational force produces a resultant force inwards.

∴ The satellite will spiral inwards

If 'r' gets smaller, T gets smaller.

∴ no. of revs per day increases.

1. (1) $V_i = 6 \text{ ms}^{-1}$

$V_f = -6 \text{ ms}^{-1}$ (vectors)

∴ $\Delta V = V_f - V_i$

$= -6 - 6 = -12$

∴ $\Delta V = 12 \text{ ms}^{-1}$ away from the floor

(2) $a = \frac{\Delta V}{\Delta t} = \frac{12}{0.01} = 1200 \text{ ms}^{-2}$

∴ $a = 1200 \text{ ms}^{-2}$ away from the floor

(3) away from the floor

(4) $F = ma$

$= 0.050 \times 1200$

$= 60$ N away from floor

(5) 60 N – Newton's Third Law – equal + opposite forces.

(6) Work $W = F.s.$

Force acts while ball is in contact with wall.

While in contact $s = 0$

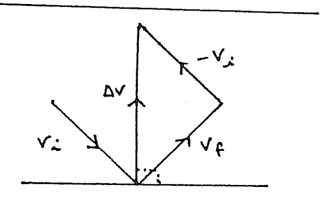
∴ $W = 0 \Rightarrow \Delta KE = 0$

(7) ΔV will be smaller ∴ acceleration will be smaller

ΔV now $= -5 - 6 = -11 \text{ ms}^{-1}$

etc.

2.



$\Delta V = V_f - V_i = 2.8 \text{ ms}^{-1}$ away from the table at 90°.

(2) $a = \frac{\Delta V}{\Delta t} = \frac{2.8}{0.02} = 140$

$a = 140 \text{ ms}^{-2}$ away from the table.

(3) Away from the table at 90°

(4) Into the table at 90° (Newton's Third Law)

3. (1) $a = \frac{\Delta V}{\Delta t} = \frac{V_f - V_i}{\Delta t}$

∴ $a = \frac{0 - (8.2)}{0.1} = -82.0$

$a = 82.0 \text{ ms}^{-2}$ away from the floor.

(2) $F = ma = 0.150 \times 82$

$F = 12.3$ N away from the floor at 90°.

(3) Force on floor = 12.3 N (Newton's Third Law)

4. (1) $F = ma$ ∴ $a = F/m$

∴ $a = \frac{100}{0.07} = 1428 \text{ ms}^{-2}$

$a = 1428 \text{ ms}^{-2}$ away from the racquet.

(2) $a = \frac{\Delta V}{\Delta t} = \frac{V_f - V_i}{t}$

∴ $1428 = \frac{V_f - 0}{0.017}$

∴ $V_f = 1428 \times 0.017$

$V_f = 24.3 \text{ ms}^{-1}$

(3) $\vec{p} = m\vec{v}$

$= 0.07 \times 24.3$

$= 1.7$ Ns