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) $v = \sqrt{\frac{GM_E}{r}}$

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

(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 $= \frac{1\ day}{T}$

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

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

$a = 7.0\ ms^{-2}$ 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 $T^2 = \frac{4\pi^2 r^3}{GM_E}$

$T = 101.7$ min

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

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

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

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

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

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

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

∴ $\Delta V = V_f - V_i$

$= -6 - 6 = -12$

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

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

∴ $a = 1200\ ms^{-2}$ 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.

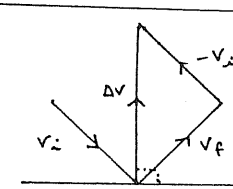
(6) Work $W = F.s$.
Force acts while ball is in contact with wall.
While in contact $s = 0$
∴ $W = 0 \Rightarrow \Delta KE = 0$

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

ΔV now $= -5 - 6 = -11\ ms^{-1}$

etc.

2.



$\Delta V = V_f - V_i = 2.8\ ms^{-1}$

away from the table at 90°.

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

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

(3) Away from the table at 90°

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

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

∴ $a = \frac{0 - (8.2)}{0.1} = -82.0$

$a = 82.0\ ms^{-2}$ 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) $F = ma$ ∴ $a = F/m$

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

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

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

∴ $1428 = \frac{V_f - 0}{0.017}$

∴ $V_f = 1428 \times 0.017$

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

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

$= 0.07 \times 24.3$

$= 1.7$ sN

5. (1) $\vec{p} = m\vec{v}$

$\vec{p} = 0.2 \times 25$

$\vec{p} = 5$ sN towards the hand.

(2) $\Delta\vec{p} = P_f - P_i$

$= 0 - (1) = -1$

$\Delta p = 1$ sN away from the hand

(3) $\vec{F} = \dfrac{\Delta\vec{p}}{\Delta t} = \dfrac{1}{1/75}$

$\therefore \vec{F} = 75$ N away from the hand.

(4) 75 N is the force on the cricketer's hand.

(5) The time of "collision" would be increased
∴ the acceleration would decrease
∴ the force would be less.

6. Force $= \dfrac{\Delta p}{\Delta t}$ (Newt. 2)

$\therefore \Delta\vec{p} = \vec{F} \times \Delta t$

∴ (a) golf club: $F = 30$ N
$\Delta t = 2\times10^{-3}$ s.

$\therefore \Delta p = 30 \times 2\times10^{-3}$
$= 6\times10^{-2}$ sN

(b) racquet: $F = 15$ N
$\Delta t = 3\times10^{-3}$ s.

$\therefore \Delta p = 15\times3\times10^{-3}$
$= 4.5\times10^{-2}$ sN

(2) golf club: $F = 30$ N

$\therefore a = F/m = \dfrac{30}{0.08} = 375\ ms^{-2}$

$\therefore a = \dfrac{V_f - V_i}{\Delta t}$ ∴

$\therefore 375 = \dfrac{V_f - 0}{2\times10^{-3}}$

$\therefore V_f = 0.75\ ms^{-1}$.

racquet $F = 15$ N

$\therefore a = F/m = \dfrac{15}{0.08}$

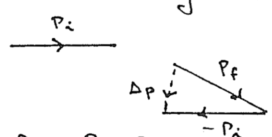
$a = 187.5\ ms^{-2}$

$\therefore a = \dfrac{V_f - V_i}{\Delta t}$

$\therefore 187.5 \times 3\times10^{-3} = V_f$

$\therefore V_f = 0.56\ ms^{-1}$

7. Use 3 images to represent the velocity



$\therefore \Delta p = P_f - P_i$
direction as shown ↓

(2) Because $\vec{F} = \dfrac{\Delta\vec{p}}{\Delta t}$,
the direction of Δp will be the direction of F
∴ force will be in the same direction ↓

8. Law of Conservation of momentum

$P_i = P_f = 0$

$\therefore \vec{P}_{19} + \vec{P}_{36} = 0$

$\therefore m_{19}V_{19} = -m_{36}V_{36}$

$\therefore \dfrac{m_{19}}{m_{36}} = \dfrac{V_{36}}{V_{19}} = \dfrac{75}{60}$

$\therefore \dfrac{m_{19}}{m_{36}} = \dfrac{1.25}{1}$

9. (1) $\vec{p} = m\vec{v} = 0.170 \times 10.2$

$\vec{p} = 1.7$ sN South

(2) $\vec{p} = m\vec{v}$
$= 20{,}000 \times 27.8$
$= 5.5\times10^5$ sN W

(3) $F = ma$
$\therefore 5.9 = 0.890 \times a$
$\therefore a = 5.9/.890$
$a = 6.63\ ms^{-2}$

$\therefore V_f = V_o + at$
$= 0 + 6.63\times1.5$
$V_f = 9.9\ ms^{-1}$

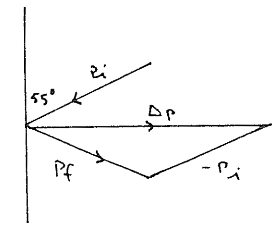
$\therefore \vec{p} = m\vec{v}$
$\therefore p = 0.89 \times 9.9$
$= 8.9$ sN West

(4) final velocity
$V_f^2 = V_o^2 + 2as$
$\therefore V_f^2 = 0 + 2\times9.8\times2$
$V_f = 6.26\ ms^{-1}$
$\therefore \vec{p} = mv$ ($m = 200$g)
$= .2 \times 6.26$
$= 1.25$ sN down

10. (1) $P_i = P_A + P_B$
$= (5.0\times1.1) + (5.0\times-1.1)$
$P_i = 0$ sN

(2) $P_i = P_A + P_B$
$= (5.0\times1.1) + (7.0\times-1.1)$
$P_i = -2.2$ sN
ie 2.2 sN in the direction of B.

11.



$P_i = mv = 0.12\times2.0 = 0.24$ sN
$P_f = 0.24$ sN
$\Delta p = P_f - P_i$ (vectors)
Δp (by scale diagram)
$= 0.45$ sN →

(2) $\vec{F} = \dfrac{\Delta\vec{p}}{\Delta t} = \dfrac{0.45}{0.01}$
$= 45$ N →

(3) $\vec{F}$ on wall $= 45$ N ←

12. (m)→ ←(3m)

$\vec{P}_i = P_A + P_B$

$\therefore \vec{P}_i = m(3.0) + 3m(-3.0)$

$P_i = 3.0m - 9.0m$

$\therefore P_i = -6.0m$
ie 6.0m in the direction of B.

(2) $\vec{P}_i = \vec{P}_f$

$\therefore -6.0m = [m + 3m]\,V_{new}$

$\therefore -6.0\cancel{m} = 4\cancel{m}V$

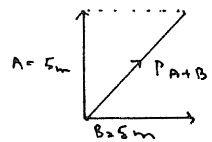
$\therefore V = -6.0/4 = -1.5\ ms^{-1}$

ie new speed $= 1.5\ ms^{-1}$

∴ new velocity $= 1.5\ ms^{-1}$ in the direction of B.

13. Velocities are all equal in magnitude as the initial momentum is zero ∴ the final must be zero.

14.



The total momentum of A & B is 7.1m as shown. But because $P_i = P_f = 0$ the momentum of the larger mass is 7.1m in the opposite direction to that of A & B.

$\therefore \quad P_{(2m)} = 7.1 \cancel{m} = 2\cancel{m}V$

$\therefore V = 7.1/2 = 3.55\ ms^{-1}$

∴ velocity of 2m $= 3.55\ ms^{-1}$ in the direction shown.

15. Possible answer could be based on the fact that the plasticine compresses a little on collision ∴ increasing the time of the collision ∴ reducing the collision force.

16. $P_i = P_f = 0$.

(1) Zero $[P_i = P_f = 0]$

(2) $P_f = 0 = P_1 + P_2$

$\therefore 0 = 2.5V + 6.0(4.0)$

$\therefore 0 = 2.5V - 24.0$

$\therefore V = 24/2.5 = 9.6$

is velocity of 2.5kg trolley $= 9.6\ ms^{-1}$

(3) as above

(4) $\vec{F} = \dfrac{\Delta\vec{p}}{\Delta t}$.

The change in momentum of trolley mass 6.0kg

$\Delta\vec{p} = P_f - 0$

$= 24.0 - 0$

$= 24.0\ sN$

$\therefore$ Force $= \dfrac{24.0}{0.4} = 60N \rightarrow$

(force on smaller trolley is equal & opposite)

17. (1) as $P_i = P_f$

$P_f = 0$.

(2) as $P_f = 0 = P_1 + P_2$

$\therefore P_1 = -P_2$

∴ both have the same recoiling momentum.

(3) $P_1 = -P_2$

$\therefore m_\alpha V_\alpha = -m_N V_N$

$\therefore \dfrac{V_\alpha}{V_N} = \dfrac{57}{1}$

$\therefore V_\alpha = 57 V_N$

18. (1) $\vec{P} = m\vec{v} = 0.9 \times 1000$

$= 900\ sN$ down

(2) $P_i = P_f$

$\therefore 0 = \vec{P}_R + \vec{P}_F$

$\therefore \vec{P}_R = -\vec{P}_F$

∴ momentum rocket $= 900\ sN$ up.

(3) $\vec{F} = \dfrac{\Delta\vec{p}}{\Delta t} = \dfrac{900 - 0}{0.1}$

$F = 9000N$ up.

(4) Accel. rocket $= F/m$

$a = \dfrac{9000}{.1} = 90{,}000\ ms^{-2}$

$\therefore V_f = V_o + at$

$V_f = 0 + 90{,}000 \times 0.1$

$V_f = 9000\ ms^{-1}$ up

19. $\vec{P}_{fuel} = m\vec{v}$

$= 6.23 \times 12{,}000$

$= 74{,}760\ sN$

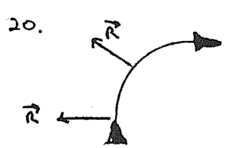
$\therefore \vec{P}_{rocket}$ in opposite direction $= 74{,}760\ sN$

$\therefore m\Delta\vec{v} = 74{,}760$

$\therefore \Delta V = \dfrac{74{,}760}{20{,}000}$

$\Delta V = 3.74\ ms^{-1}$

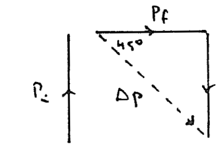
20.



(2)

$\Delta\vec{p} = \vec{P}_f - \vec{P}_i$

$P_i = P_f = 4.4 \times 10^7\ sN$



$\therefore \Delta p = 6.2 \times 10^7\ sN$

(3) Force $= \dfrac{\Delta\vec{p}}{\Delta t}$

$= \dfrac{6.2 \times 10^7}{4.00}$

$F = 1.6 \times 10^7\ N$ in the direction of $\Delta\vec{p}$.

21.

$P_i = m \times V = 2.0 \times 0.5$

$= 1\ sN \rightarrow$

$\therefore P_f = 1\ sN \rightarrow$

$\therefore 1\ sN = \vec{P}_A + \vec{P}_B$

$\therefore 1 = m_A V_A + m_B V_B$

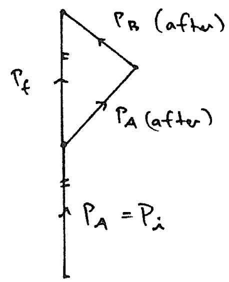
$\therefore 1 = 1.0 \times V_A + 1.0(0.7)$

$\therefore 1 = V_A + 0.7$

$\therefore V_A = 1 - 0.7$

$\therefore V_A = 0.3\ ms^{-1}$ in the same direction.

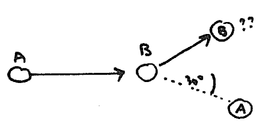
22.  Take the velocity vectors as the distance between 3 images (as above)



By measurement $\vec{P_i} = \vec{P_f}$

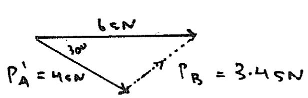
∴ The Law holds.

23.



$P_i = P_A = 2.0 \times 3.0 = 6\,sN \rightarrow$

∴ $P_f = 6.0\,sN \rightarrow$



$P_B = 3.4\,sN = mV$

∴ $3.4 = 3.0 \times V$

∴ $V = 3.4/3.0$

$V = 1.13\ ms^{-1}$

24.

(1) No. It is moving with constant speed in a straight line ∴ not accelerating ∴ no force

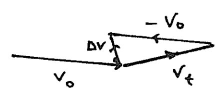
(2) Use the velocity vector as the distance between 3 images

∴ $\vec{P_A} = 3m \times 2 = 6m$

$\vec{P_B} = m \times 2.3 = 2.3m$

∴ A has the biggest momentum

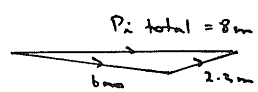
(3)



ie $\Delta V = V_f - V_0$

(4)

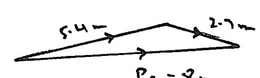
Before collision



after collision

$P_A' = 3m \times 1.8 = 5.4m$

$P_B' = m \times 2.7 = 2.7m$



Momentum is conserved.

1. (1) Coulombic force

∴ $F = \frac{\frac{1}{4\pi\varepsilon_0} q_1 q_2}{d^2}$

∴ $F = \frac{9\times10^9 \times 1.44\times10^{-6} \times 2.0\times10^{-6}}{(1.2)^2}$

$F = 0.018\,N$ attraction.

(2) (a) $F \propto 1/d^2$

∴ double distance, 1/4 the force.

$F_{new} = 0.0045\,N$

(b) 0.30m is 1/4 distance

∴ F is 16 times the size

$F = 16 \times 0.018$

$= 0.288\ N$

(c) Same magnitude force now repulsion.

(3) Equal and opposite forces as per Newton's Third Law.

(4) as $F = ma$, need the mass of q_2

2. (1) $F = \frac{\frac{1}{4\pi\varepsilon_0} q_1 q_2}{d^2}$

$F = \frac{9\times10^9 \times 1.6\times10^{-19} \times 1.6\times10^{-19}}{(5.32\times10^{-11})^2}$

$F = 8\times10^{-8}$ Newtons.

(2) The attraction force is a centripetal force.

∴ $F = \frac{mv^2}{r}$

∴ $8\times10^{-8} = \frac{9.11\times10^{-31} \times v^2}{5.32\times10^{-11}}$

∴ $v = \sqrt{\frac{8\times10^{-8} \times 5.32\times10^{-11}}{9.11\times10^{-31}}}$

$v = 2.2\times10^6\ ms^{-1}$.

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

∴ double distance, 1/4 the force.

∴ $F_{new} = \frac{6.0\times10^{-7}}{4}$

$= 1.5\times10^{-7}\,N$

(2) $3.6\times10^{-6}\,N$ is 6 times the force.

∴ $\frac{F_1}{F_2} = \frac{d_2^2}{d_1^2}$

∴ $\frac{F_1}{6F_1} = \frac{d_2^2}{d_1^2}$

∴ $d_1^2 = 6 d_2^2$

∴ $d_1 = \sqrt{6}\, d_2$

∴ new distance $= \frac{10}{\sqrt{6}}$

$= 4.1\,cm$

(3) $F \propto q_1 q_2$

∴ double one charge will double the force

∴ $F_3 = 1.2\times10^{-6}\,N$

4. $F = \frac{\frac{1}{4\pi\varepsilon_0} q_1 q_2}{d^2}$

$1.0\times10^{-6} = \frac{9\times10^9 \times 2.0\times10^{-6} \times 6.0\times10^{-6}}{d^2}$

∴ $d = \sqrt{\frac{9\times10^9 \times 2\times10^{-6} \times 6\times10^{-6}}{1.0\times10^{-6}}}$

$d = 328\ m$.

5. Force between A & C

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

$F = \frac{9\times10^9 \times 20\times10^{-6} \times 10\times10^{-6}}{(0.5)^2}$

$F = 7.2\,N$ repulsion.