7 ON THE MOVE | 7.1 Speed and velocity

1. a) 45 mins → 0.75 hours $\frac{60\,km}{0.75\,h} = \underline{\underline{80\,kmh^{-1}}}$

b) 45 mins → 2700 seconds $\frac{60\,000}{2700} = \underline{\underline{22.2\,ms^{-1}}}$

60 km → 60,000 m

2. a) instantaneous speed → gradient of tangent $= \frac{192-52}{50-20} = \underline{\underline{2.5}}$

b) Average speed $= \frac{\text{total distance}}{\text{total time}} = \frac{120}{40} = \underline{\underline{3\,ms^{-1}}}$

3. a) $v = \frac{2\pi r}{T} = \frac{2\pi(8000 \cancel{\times 10^3})}{(120/60)} = \cancel{2800}\ \underline{\underline{25130\,kmh^{-1}}}$

b) $v = \frac{2\pi r}{T} = \frac{2\pi(8000\times10^3)}{120\times60} = \underline{\underline{6981\,ms^{-1}}}$

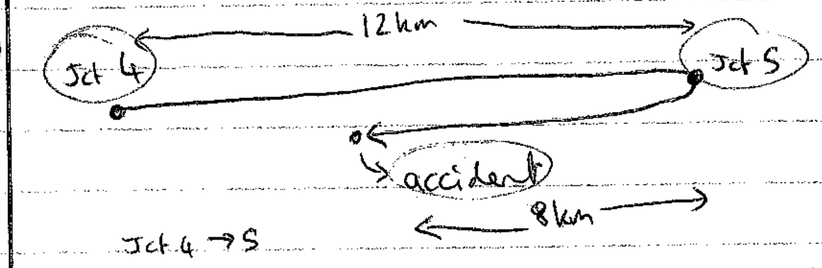
4. a) $s = vt = 25\times(30\times60) = \underline{45000\,m}$

b) Average speed $= \frac{\text{total distance}}{\text{total time}} = \frac{40{,}000 + 45{,}000}{(20+30)\times60}$

$= \underline{\underline{28.3\,ms^{-1}}}$

5. a) Speed : Scalar, no direction. Velocity: vector, has magnitu and direct

b)



i) Jct 4 ↔ accident $= 12 - 8\,km = \underline{\underline{4\,k}}$

Jct 4 → 5

ii) $v = \frac{s}{t} = \frac{12000}{400} = \underline{\underline{30\,ms^{-1}}}$

Jct 5 → accident

$v = \frac{s}{t} = \frac{8000}{320} = \underline{\underline{25\,ms^{-1}}}$

7.2 Acceleration

1\. a) $a = \frac{v-u}{t} = \frac{64-4}{40} = \underline{\underline{1.5\,ms^{-2}}}$

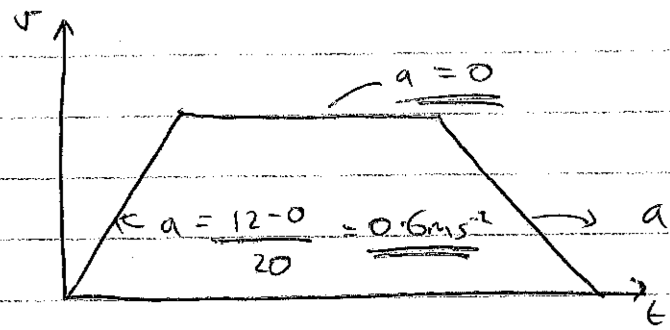
b) $a = \frac{v-u}{t} = \frac{0-20}{8} = \underline{\underline{-2.5\,ms^{-2}}}$ acceleration or $\underline{\underline{2.5\,ms^{-2}}}$ deceleration.

2\. a) $a = \frac{7-2.5}{10} = \underline{\underline{0.45\,ms^{-2}}}$ b) ~~Δv~~ $v-u = at$

$v - 7 = 0.45 \times 2$

$\underline{\underline{v = 7.9\,ms^{-1}}}$

3\.



$a = \frac{12-0}{20} = \underline{\underline{0.6\,ms^{-2}}}$

$a = \frac{0-12}{30} = \underline{\underline{-0.4\,ms^{-2}}}$

4\. velocity increases at a decreasing rate, reaching constant velocity.
Acceleration is initially >0, gradually decreases
a reaches zero when the object is at constant v.

7.3 Motion along a straight line at constant acceleration

Equations:

1. $v = u + at$
2. $s = \frac{1}{2}(u+v)t$
3. $s = ut + \frac{1}{2}at^2$
4. $v^2 = u^2 + 2as$

1\. a) (1) $a = \frac{v-u}{t} = \frac{30-4}{13} = \underline{\underline{2\,ms^{-2}}}$

b) $s = \frac{1}{2}(30+4) \times 13 = \underline{\underline{221\,m}}$

2\. a) ~~$a =$~~ $s = \frac{1}{2}(u+v)t$ (2)

$\rightarrow t = \frac{2s}{(u+v)} = \frac{2(860)}{(40+0)} =$

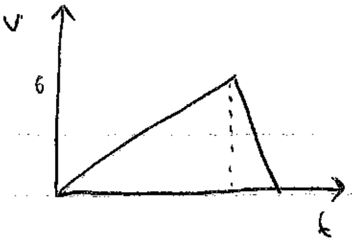
b) (4) $v^2 = u^2 + 2as \rightarrow a = \frac{v^2-u^2}{2s} = \frac{40^2-0}{2(860)}$

3\. a i) (1) $a = \frac{6-0}{30} = \underline{\underline{0.2\,ms^{-2}}}$ ii) (4) ~~a~~ $s = \frac{v^2-u^2}{2a} = \frac{6^2-0}{2(30)}$

$= \underline{\underline{90\,m}}$

b i) (4) $a = \frac{v^2-u^2}{2s} = \frac{0-6^2}{2(24)} = \underline{\underline{-0.75\,ms^{-2}}}$

ii) (2) $t = \frac{2s}{(u+v)} = \frac{48}{6} = \underline{\underline{8\,s}}$

3. c) 

d) Average velocity $= \dfrac{\text{total distance}}{\text{total time}}$

$= \dfrac{90+24}{30+8} = \underline{\underline{3ms^{-1}}}$

4. a) initial acceleration → gradient of line 0-1 seconds

$= \dfrac{\Delta y}{\Delta x} = \dfrac{2.5}{0.5} = \underline{\underline{5ms^{-2}}}$

b) Displacement → area under graph $= \frac{1}{2} \times b \times h = \frac{1}{2} \times 2 \times 7.5$

$= \underline{\underline{7.5m}}$

c) 

split into two shapes: $A = 2 \times 7.5 = 15m$

1.5 squares (approx.) $B = 1.5 \times 2.5 = 3.75m$

$\underline{18.75m}$

(different to book answers)

d) Average speed $= \dfrac{\text{total distance}}{\text{total time}} = \dfrac{7.5 + 18.75}{4} = \underline{\underline{6.56m}}$

7.4 Free Fall

["-" indicates downwards direction]

1. a) $s = \cancel{ut} + \frac{1}{2}at^2 = 0 + (-9.81) \times 0.9^2 = \underline{\underline{-4m}}$

b) $v = \cancel{u} + at = 0 + (-9.81) \times 0.9 = \underline{\underline{-8.8ms^{-1}}}$

2. a) $s = \cancel{ut} + \frac{1}{2}at^2 \rightarrow t = \sqrt{\dfrac{2s}{a}} = \sqrt{\dfrac{2 \times 50}{9.81}} = \underline{\underline{3.2s}}$

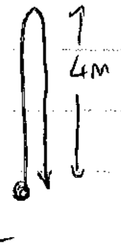
b) $v^2 = u^2 + 2a\cancel{s} \rightarrow v = \sqrt{0 + 2(-9.81)(-50)} = \underline{\underline{31ms^{-1}}}$

3. a) i) $t = \sqrt{\dfrac{2s}{a}} = \sqrt{\dfrac{(2 \times -75)}{(-9.81)}} = \underline{\underline{3.9s}}$

~~a) $v^2 = u^2 + 2as$~~ ~~$v^2 - u^2 = 2as$~~

ii) $v^2 = u^2 + 2as \rightarrow v = \sqrt{0 + (-9.81)(75)} = \underline{\underline{38ms^{-1}}}$

b) Air resistance greater as increased surface area → reduces net acceleration on jumper.

4. 

time ↑ = 2.25s

time ↓ = 2.25s

↑ v = 0

↓ u = 0

a) ↓ $u = 0$, $t = 4.5/2$, $a = ?$ ~~9.81~~, $s = 4$

$s = ut + \frac{1}{2}at^2 \rightarrow a = \dfrac{2s}{t^2} = \dfrac{8}{2.25^2} = \underline{\underline{1.6ms^{-2}}}$

b) ↑ $u = ?$, $t = 2.25$, $s = 4$, $v = 0$

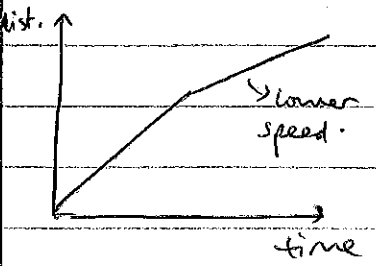
$s = \frac{1}{2}(u+v)t \rightarrow u = 2s/t + v = \dfrac{2 \times 4}{2.25} = \underline{\underline{3.6ms^{-1}}}$

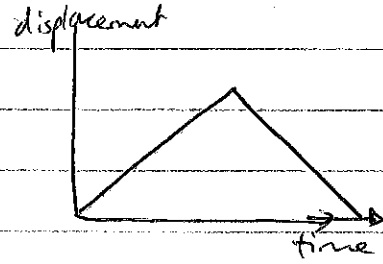
$v^2 = u^2 + 2as \rightarrow s = \frac{v^2 - u^2}{2a} = \frac{0 - 3.6^2}{(2 \times -9.81)} = \underline{\underline{0.66m}}$

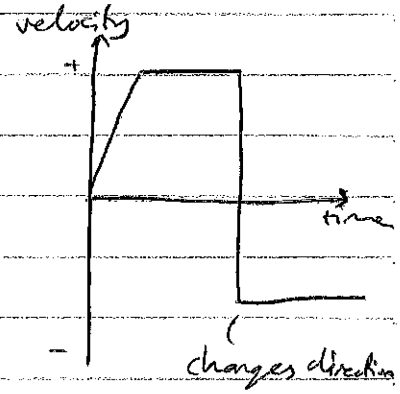
7.5 Motion Graphs

) $s = vt \rightarrow t = \frac{s}{v} = \frac{100}{1.2} = \underline{\underline{83.3s}}$

) $t = \underset{(total)}{210} - \underset{(1\ length)}{83.3} = \underline{\underline{126.7s}}$



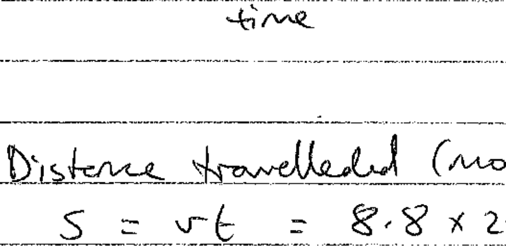




) Distance travelled (motorcyclist)

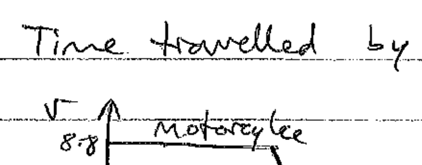
$s = vt = 8.8 \times 200 = \underline{1760m}$

Time travelled by cyclist in 1760m : $t = \frac{s}{v} = \frac{1760}{2.2} = \underline{\underline{800s}}$



"$-$"u, as downwards

u: Not zero, as balloon already moving



$a = 9.81$, so v must increase.

b) $s = ut + \frac{1}{2}at^2$

$= (-3.5 \times 3) + \frac{1}{2}(9.81) \times 3^2$

$= -10.5 + 44.145$

$= \underline{\underline{33.645m}} \sim 33.6$

a) i) $s = ut + \frac{1}{2}at^2 \rightarrow t = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2 \times 1.8}{(9.81)}} = \underline{\underline{0.61s}}$

ii) $a = \frac{v-u}{t} \rightarrow v = u + at = 0 + (-9.81) \times 0.61 = \underline{\underline{5.9ms^{-1}}}$

iii) $t = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2 \times 0.9}{9.81}} = \underline{\underline{0.43s}}$

7.6 More calculations on motion along a straight line

① $v = u + at$
② $s = \frac{1}{2}(u+v)t$
③ $s = ut + \frac{1}{2}at^2$
④ $v^2 = u^2 + 2as$

1. a i) ② ~~$v^2 = u^2 + 2as$~~ $s = \frac{1}{2}(u+v)t \rightarrow t = \frac{2s}{(u+v)}$

$t = \frac{2(850)}{4+29} = \underline{52\,s}$

ii) ④ $v^2 = u^2 + 2as \rightarrow a = \frac{v^2 - u^2}{2s} = \frac{29^2 - 4^2}{2(850)} = \underline{0.49\,ms^{-2}}$

b i) ② $s = \frac{1}{2}(u+v)t = \frac{1}{2}(29+0)\times 28 = \underline{406\,m}$

ii) ① $a = \frac{v-u}{t} = \frac{0-29}{28} = \underline{-1.04\,ms^{-2}}$

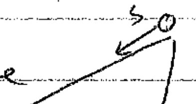
2. a) ② $s = \frac{1}{2}(u+v)t = \frac{1}{2}(2+0)\times 15 = \underline{15\,m}$

b) ④ $v^2 = u^2 + 2as \rightarrow a = \frac{v^2-u^2}{2s} = \frac{2^2 - 0}{2\times(15)} = \underline{-0.133\,ms^{-2}}$

(or $a = \frac{v-u}{t}$)

c) After 20s, 5 seconds after it has stopped.

$u = 0$, $t = 5$, $a = 0.13$ (from (b), same force - weight, so same acceleration)



① $v = u + at = 0 + (0.133\times 5) = \underline{0.67\,ms^{-1}}$

③ $s = \cancel{ut} + \frac{1}{2}at^2 = 0 + \frac{1}{2}(-0.133)\times 5^2 = 1.67\,m$

So $(15 - 1.67) = \underline{13.3\,m}$ from top

3. a i) ③ $s = \cancel{ut} + \frac{1}{2}at^2 = 0 + \frac{1}{2}0.4\times 20^2 = \underline{80\,m}$

ii) ① $v = u + at = 0 + (0.4\times 20) = \underline{8\,ms^{-1}}$

b. i) $s = \frac{1}{2}(u+v)t \rightarrow t = \frac{2s}{(u+v)} = \frac{2\times(260)}{(8+0)} = \underline{65\,s}$

ii) $a = \frac{v-u}{t} = \frac{0-8}{65} = \underline{-0.12\,ms^{-2}}$

4. a) i) ① $v = u + at = 0 + (6\times 30) = \underline{180\,ms^{-1}}$

ii) $s = \cancel{ut} + \frac{1}{2}at^2 = 0 + \frac{1}{2}(6)\times 30^2 = \underline{2700\,m}$

b) (only gravity acting)

$u = 180\,ms^{-1}$, $a = -9.81$, $v = 0$, $s = ?$

$s = v^2 - u^2/2a = -180^2/2\times(-9.81) = 1651$

$\therefore$ Total $= 2700 + 1651 = \underline{4351\,m}$

c) $v^2 = u^2 + 2as = 0 + 2(-9.81)\times 4351 = \underline{292\,ms^{-1}}$

7.7 Projectile Motion 1

1. a) $u = -4$, $a = -9.81$, $s = 50$, $v = ?$

$v^2 = u^2 + 2as \Rightarrow v = \sqrt{(-4)^2 + 2(-9.81)\times(-50)} = \underline{\underline{32\,ms^{-1}}}$

b) $v = u + at \rightarrow t = \frac{v-u}{a} = \frac{-32-(-4)}{-9.81} = \underline{\underline{2.85s}}$

c) Balloon travelling at a constant speed, so $s = ut$

$= (-4)\times 2.85 = 11.4$

so $(50 - 11.4) = \underline{\underline{38.6m}}$

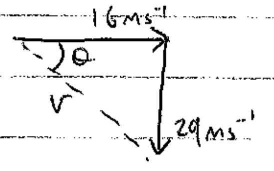
2. b) $\rightarrow$ $a = 0$, so $\underset{\rightarrow}{s} = \underset{\rightarrow}{u}t$

$= 16 \times 30 = \underline{\underline{48m}}$

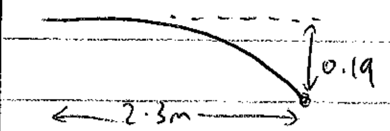
a) $\downarrow$ $s = \frac{1}{2}at^2 \rightarrow t = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2\times 45}{9.81}} = \underline{\underline{3.0s}}$

c) $\underset{\rightarrow}{v} = 16ms^{-1}$ $\quad v_{\downarrow}^2 = u^2 + 2as$

$v = \sqrt{0 + 2(-9.81)(-45)} = \cancel{29}\ 29.7\,ms^{-1}$



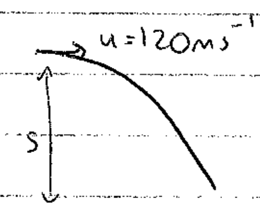
Pythagoras: $v = \sqrt{16^2 + 29.7^2} = \underline{\underline{33.7ms^{-1}}}$ $\quad \theta = \tan^{-1}\left(\frac{29}{16}\right) = \underline{\underline{62^\circ}}$

3.) 

a) $\downarrow s = \frac{1}{2}at^2 \rightarrow t = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2\times 0.19}{9.81}} = \underline{\underline{0.20s}}$

b) $v = \frac{s}{t} = \frac{2.3}{0.2} = \underline{\underline{11.5ms^{-1}}}$

Constant velocity

4.) 

a) $s = \cancel{ut} + \frac{1}{2}at^2 = \frac{1}{2}(-9.81)(8.5)^2$

$= \underline{\underline{354m}}$

b) i) $s = ut = 120 \times \cancel{354}\ 8.5$

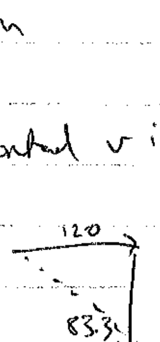
no horizontal acceleration

$= \underline{\underline{1020m}}$

ii) $\underline{\underline{1020m}}$ (horizontal v independent of vertical)

c) $\underset{\rightarrow}{v} = 120$ $\quad \downarrow v^2 = u^2 + 2as$

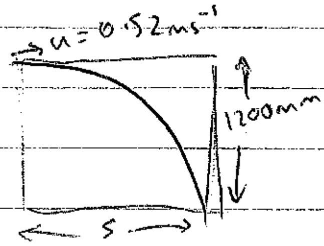
$\downarrow v = \sqrt{0 + 2(-9.81)(-354)} = 83.3\,ms^{-1}$



$v = \sqrt{120^2 + 83.3^2}$

$= 146ms^{-1}$

7.8 Projectile Motion 2

1. 

a) $\underset{\rightarrow}{s} = \underset{\rightarrow}{u} \times t = 0.52 \times 0.9 = 0.47\text{m}$ or 470mm

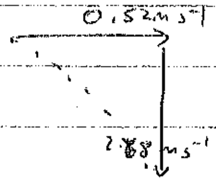
b) $\downarrow s = \frac{1}{2}at^2 \rightarrow a = \frac{2s}{t^2}$

$= \frac{2 \times 1.2\text{m}}{0.9^2} = 3.0\text{ms}^{-2}$

c) $\underset{\rightarrow}{v} = 0.52\text{ms}^{-1}$

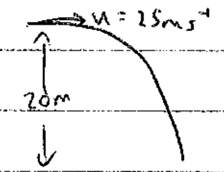
$\downarrow v^2 = u^2 + 2as$

$\downarrow v = \sqrt{0 + 2(3.0) \times (1.2)} = 2.68\text{ms}^{-1}$



$v = \sqrt{0.52 + 2.68}$

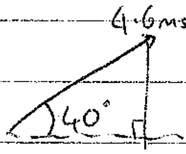
$= 2.72\text{ms}^{-1}$

2. 

a) $\downarrow s = \frac{1}{2}at^2$

$t = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2 \times 20}{9.81}}$ 2.02s

b) $\underset{\rightarrow}{s} = \underset{\rightarrow}{u}t = 25 \times 2.02 = 50.4\text{m}$

3. 

a) $\underset{\rightarrow}{u}: \cos 40^\circ = \frac{a}{(h)\,4.6} \rightarrow \underset{\rightarrow}{u} = 3.5\text{ms}^{-1}$

$\uparrow u : \sin 40^\circ = \frac{o}{h} \rightarrow \uparrow u = 3\text{ms}^{-1}$

b) i) $\downarrow s = \frac{1}{2}at^2 = \frac{1}{2}(9.81) \times 5.8^2 = 150\text{m}$

ii) $\underset{\rightarrow}{s} = \underset{\rightarrow}{u}t = 20\text{m}$