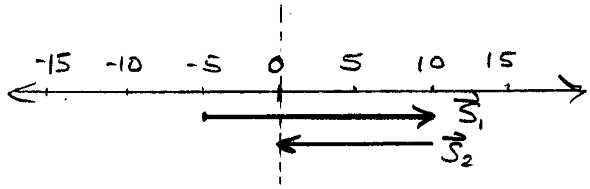
1. An object has a displacement of -5 m. It moves a distance to the right equal to 15 m and then a distance of 10 m to the left.



   a) What is the total distance travelled by the object?

   $s = 15m + 10m = \boxed{25m}$

   b) What is the final displacement of the object?

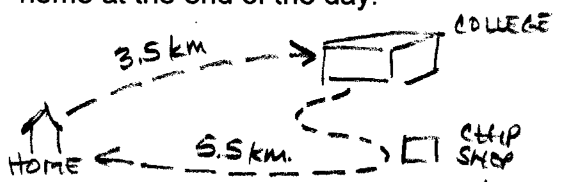
   From the diagram, $\boxed{\vec{s} = 0m}$

   c) What is the change in displacement of the object?

   From the diagram, $\boxed{\Delta\vec{s} = +5m.}$ ✓

   Also $\Delta\vec{s} = \vec{s}_f - \vec{s}_i$
   $= 0 - -5\hat{i}$ OR $\boxed{\Delta\vec{s} = +5m}$

2. A student walks a distance of 3.5 km from home to college. He returns home via the chip shop, covering a distance of 5.5 km. Find the total distance he was walking and his displacement from home at the end of the day.



   Total distance $= 3.5 + 5.5$
   $= \boxed{9.0 km}$

   $\boxed{\vec{s} = 0 km}$

3. Calculate the average speed in ms^{-1} of:

   a) a sprinter who completes 100.0 m in a time 10.0 s

   $v_{AVE} = \frac{\Delta s}{\Delta t} = \frac{100.0}{10.0} = \boxed{10.0 ms^{-1}}$

   b) a marathon runner who takes $2^1/_4$ hours to run 42.5 km.

   $\frac{2.25 hr}{1} \times \frac{3600s}{1hr} = 8100s$

   $v_{AVE} = \frac{\Delta s}{\Delta t} = \frac{42.5\times10^3}{8100} = \boxed{5.2 ms^{-1}}$

4. Starting from home, a jogger runs 4.0 km. She returns home after 20 minutes. What is:

   a) her average speed?

   $v_{AVE} = \frac{\Delta s}{\Delta t} = \frac{4.0\times10^3}{1200} = \boxed{3.3 ms^{-1}}$

   $\frac{20 min}{1} \times \frac{60s}{1min} = 1200s$

   b) her average velocity?

   $\vec{v}_{AVE} = \frac{\Delta\vec{s}}{\Delta t} = \frac{0}{1200} = \boxed{0 ms^{-1}}$ (Since $\Delta\vec{s} = 0$, as she ended where she started).

5. The speed of light is 3.00×10^8 ms^{-1}. Calculate:

   a) the distance travelled by the light in 1 complete earth year.

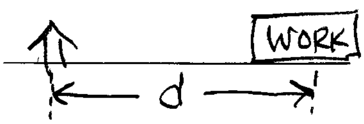
   $\frac{1 year}{1} \times \frac{365 days}{1 year} \times \frac{24 hr}{1 day} \times \frac{3600s}{1hr} = 3.15\times10^7 s.$

   $v = \frac{s}{t} \Rightarrow s = vt$
   $= (3.00\times10^8)(3.15\times10^7)$
   $= \boxed{9.46\times10^{15} m}$

   b) The time taken, in minutes, for the light to travel from the Sun to the Earth, a distance of 150 million km.

   $v = \frac{s}{t} \Rightarrow t = \frac{s}{v} = \frac{150\times10^9}{3.00\times10^8} = 500s = \boxed{8.3 min}$

✓HW **6.** A cyclist travels to work at an average speed of 3.0 ms^{-1} and returns home for tea at an average speed of 9.0 ms^{-1}. Calculate her average speed for the whole journey. *(The answer is **not** 6 ms^{-1}!)*

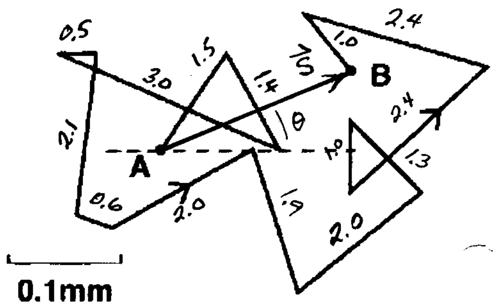


GOING TO WORK: $V_{AVE} = \frac{\Delta s}{\Delta t} \Rightarrow \Delta t = \frac{\Delta s}{V_{AVE}} = \frac{1}{3}d = t_1$

COMING FROM WORK: $V_{AVE} = \frac{\Delta s}{\Delta t} \Rightarrow \Delta t = \frac{\Delta s}{V_{AVE}} = \frac{1}{9}d = t_2$

FOR THE WHOLE TRIP: $V_{AVE} = \frac{\Delta s_{TOT}}{\Delta t_{TOT}} = \frac{2d}{t_1 + t_2} = \frac{2d}{\left(\frac{1}{3}d + \frac{1}{9}d\right)} = \left(2d\right)\left(\frac{9}{4d}\right) = \frac{9}{2} = \boxed{4.5\ ms^{-1}}$

✓HW **7.** The diagram shows the movement of a smoke particle in a Brownian motion experiment.



SCALE: 1.5cm = 0.1mm

(a) Use a ruler to find *(measure it properly!)*:

(i) the total distance moved by the smoke particle in going from A to B.

$\frac{23.1\ cm}{1} \times \frac{0.1\ mm}{1.5\ cm} = \boxed{1.5\ mm}$

(ii) the displacement AB.

$\frac{2.6\ cm}{1} \times \frac{0.1\ mm}{1.5\ cm} = \boxed{0.17\ mm,\ \theta = 23°}$

(b) If it took 1.20 s to travel from A to B, calculate

(i) the average speed

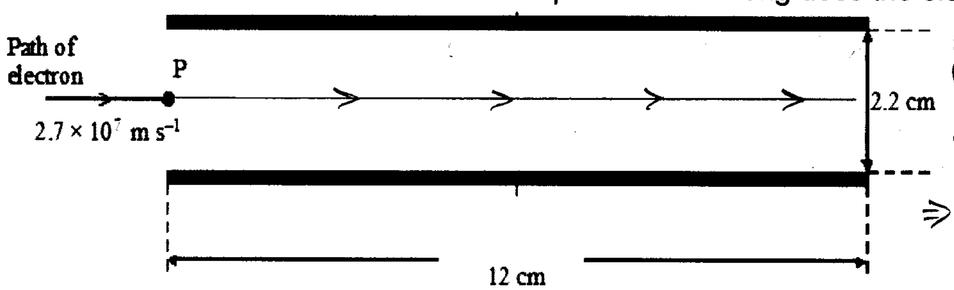
$V_{AVE} = \frac{\Delta s}{\Delta t} = \frac{1.5\ mm}{1.20\ s} = \boxed{1.3\ mm\,s^{-1}}$

(ii) the average velocity of the smoke particle.

$\vec{V}_{AVE} = \frac{\Delta \vec{s}}{\Delta t} = \frac{0.17\ mm}{1.20\ s} = \boxed{0.14\ mms^{-1}\ at\ \theta = 23°}$

(MEASURE W/ PROTRACTOR)

8. An electron enters a tube as shown at point P. How long does the electron spend inside the tube?



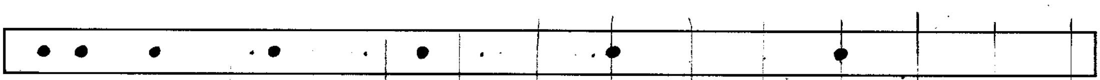
ASSUME THE ELECTRON'S VELOCITY DOES NOT CHANGE.

$V_{AVE} = \frac{\Delta s}{\Delta t}$

$\Rightarrow \Delta t = \frac{\Delta s}{V_{AVE}} = \frac{12 \times 10^{-2}}{2.7 \times 10^{7}} = \boxed{4.4 \times 10^{-9}\ s}$

9. Sketch the shape of a tickertape chart produced from a tape attached to a trolley moving:

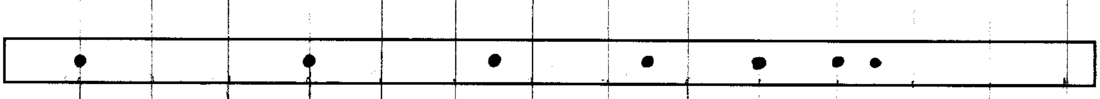
a) with a constant acceleration



b) at a constant speed

EVENLY SPACED

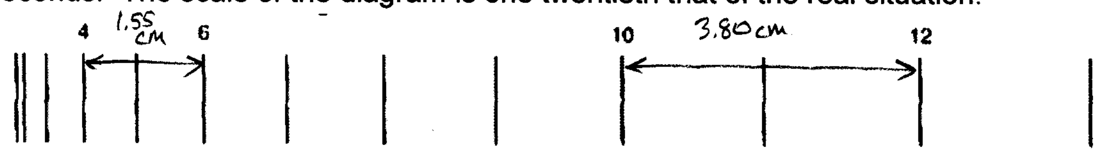
c) with a constant deceleration



SPACING INCREASES / DECREASES BY SAME AMOUNT EACH TIME...

My ruler has smallest graduation = 0.5 mm

10. The diagram shows the positions of a line drawn on an accelerating air track glider every 100 milliseconds. The scale of the diagram is one twentieth that of the real situation.



a) How far did the glider move between:

i) Positions 4 and 6 ?

$\Delta s = (20)(1.55) = \boxed{31.0\ cm}$

ii) Positions 10 and 12?

$\Delta s = (20)(3.80) = \boxed{76.0\ cm}$

b) Write down the average velocities of the glider between these two sets of positions.

$\boxed{4:6}$ $v_{AVE} = \frac{\Delta s}{\Delta t} = \frac{0.310}{200\times10^{-3}} = \boxed{1.55\ ms^{-1}}$ $\boxed{10:12}$ $v_{AVE} = \frac{\Delta s}{\Delta t} = \frac{0.760}{200\times10^{-3}} = \boxed{3.80\ ms^{-1}}$

c) How long did the glider take to accelerate from position 4 to position 10 (or from position 6 to 12)?

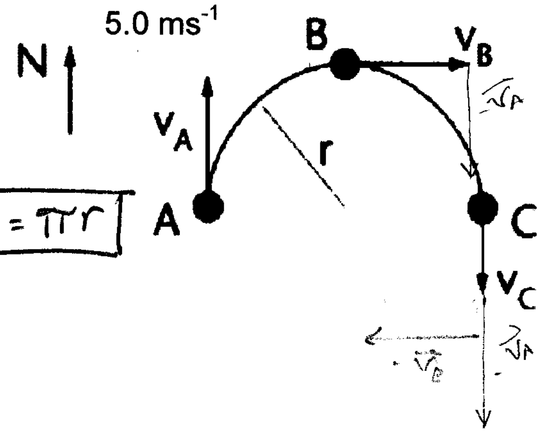
6 intervals, so $\Delta t = (6)(100\times10^{-3}) = \boxed{0.600\ s}$ ← Note: 3 sig figs is ok...

(Note: 4-10, 6-12 both move 6 intervals...)

d) What was the acceleration of the glider?

USE $\Delta v = v_{AVE\ 10\text{-}12} - v_{AVE\ 4\text{-}6}$
$= 3.80 - 1.55 = 2.45\ ms^{-1}$ → then $a = \frac{\Delta v}{\Delta t} = \frac{2.45}{0.600} = \boxed{4.09\ ms^{-2}}$

11. An object is travelling in a circular path as shown, starting at A and going through B and C. The radius of it's path is *r* and it take a time *t* to get from A to C. It's speed is a constant 5.0 ms^{-1} and initially the object is heading due north.



Determine, in terms of appropriate variables...

a) how far the object has travelled going from A to C.

HALFWAY AROUND THE CIRCLE.... SO $s = \frac{1}{2}C = \frac{1}{2}2\pi r \Rightarrow \boxed{s = \pi r}$

b) the displacement from A to C.

DIAMETER OF THE CIRCLE, TO THE RIGHT... $\boxed{\vec{s} = 2r\ m\ EAST}$

c) the time taken to get from A to B.

$\boxed{t_{AB} = \frac{1}{2}t}$

d) the change in velocity from A to B.

$\vec{\Delta v} = \vec{v_B} - \vec{v_A} = \vec{v_B} + -\vec{v_A} \Rightarrow \Delta v = (v_B^2 + v_A^2)^{\frac{1}{2}} = \boxed{7.1\ ms^{-1}\ SE}$

e) the change in velocity from B to C.

$\Delta v = \vec{v_C} - \vec{v_B} = v_C + -v_B \Rightarrow \Delta v = (v_B^2 + v_C^2)^{\frac{1}{2}} = \boxed{7.1\ ms^{-1}\ SW}$

f) the change in velocity from A to C.

$\Delta v = \vec{v_C} - \vec{v_A} = \vec{v_C} + -\vec{v_A} = -5\hat{j} + -5\hat{j} = \boxed{10.\ ms^{-1}\ S}$

g) the average acceleration between A and B.

$\vec{a}_{AVE} = \frac{\Delta\vec{v}}{\Delta t} = \frac{7.1}{t/2} = \boxed{\frac{14}{t}\ ms^{-2}\ SE}$

h) the average acceleration between A and C.

$\vec{a}_{AVE} = \frac{\Delta\vec{v}}{\Delta t} = \frac{10.}{t} \Rightarrow \boxed{\frac{10.}{t}\ ms^{-2}\ S}$

i) Determine the direction of the force(s) acting on the object (if any) at points A, B, and C.

From Newton's 2nd Law ($\vec{F} = m\vec{a}$), the force acting on the object is in the same direction as acceleration, and velocity.
∴ At A, B and C, $\vec{F}$ is acting toward the center of the circle.

12. Calculate the acceleration of an airplane if it accelerates from 15.0 ms^{-1} to 80.0 ms^{-1} in 1 minute.

$a = \frac{\Delta v}{\Delta t} = \frac{v-u}{t} = \frac{80.0-15.0}{60} = \boxed{1.08\,ms^{-2}}$

✓ HW **13.** Calculate the time taken for a car to increase its speed from 5.0 ms-1 to 25 ms^{-1} if its acceleration is 2.0 ms^{-2} .

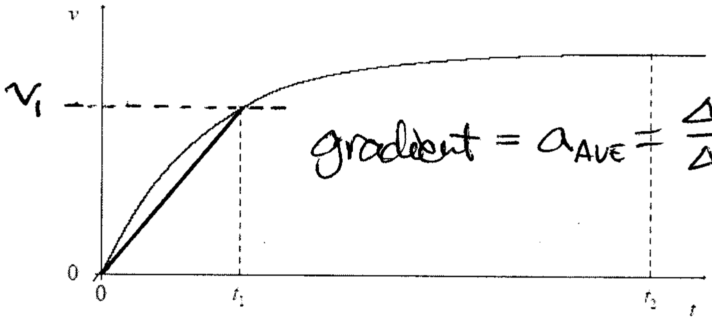
$v = u + at \Rightarrow t = \frac{v-u}{a} = \frac{25-5.0}{2.0} = \boxed{10.\ s}$

✓ HW **14.** A car accelerates away from traffic lights with an acceleration of 5.0 ms^{-2} for 6.0 seconds. It then brakes with an acceleration of –3.0 ms^{-2} for 2.0 seconds. What was its final speed?

PART 1: $v = u + at = 0 + (5.0)(6.0) = 30.\ ms^{-1} = u$ FOR PART 2

PART 2: $v = u + at = 30. + (-3.0)(2.0) = \boxed{24\,ms^{-1}}$

15. A small steel ball of mass *M* is dropped from rest into a long vertical tube that contains oil. The sketch graph shows how the speed *v* of the ball varies with time *t*.



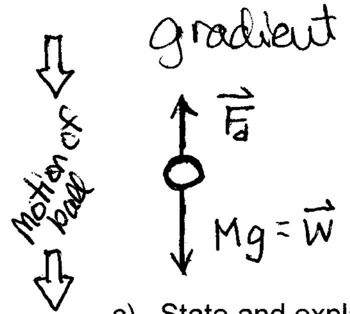
gradient $= a_{AVE} = \frac{\Delta v}{\Delta t} = \frac{v_1}{t_1}$

a) Explain how you would use the graph to find the average speed of the ball between $t = 0$ and $t = t_1$.

You could find the total distance covered by the ball by finding the area (estimating) under the graph, then dividing this by t_1, since $v_{AVE} = \frac{\text{TOTAL DISTANCE}}{\text{TOTAL TIME}}$.

b) The gradient of the graph at $t = t_1$ is k. Deduce an expression in terms of k, M and g, the acceleration of free fall, for the magnitude of the frictional force F acting on the ball at $t = t_1$.

gradient = acceleration = k



at t_1, $F < W$

$\Sigma F = ma = mk = mg - F$

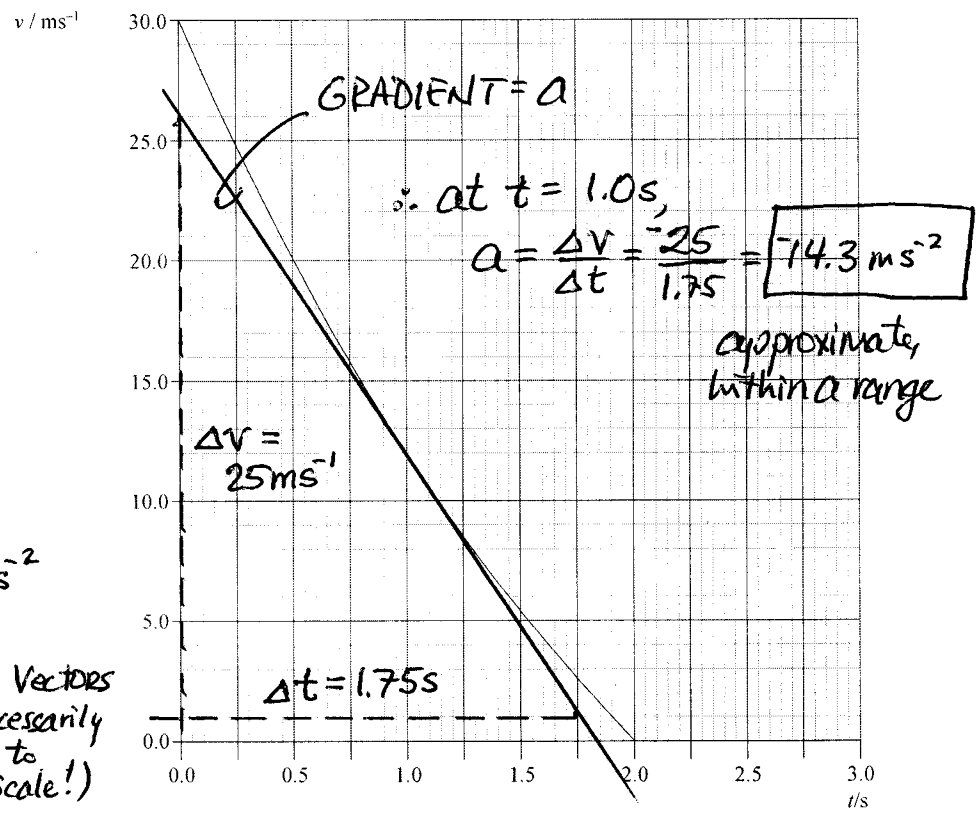
$\therefore \boxed{F = mg - mk = m(g-k)}$

c) State and explain the magnitude of the frictional force acting on the ball at $t = t_2$.

At $t = t_2$, $F = w = mg$; so $F = \frac{mg}{w}$

the frictional force is at a maximum, equal to the weight of the ball, and the ball is at it's terminal velocity v_t.

16. A ball of mass 0.25 kg is projected vertically upwards from the ground with an initial velocity of 30 m s^{-1}. The acceleration of free fall is ~~10~~ m s^{-2}, but air resistance **cannot** be neglected. The graph shows the variation with time t of the velocity v of this ball for the upward part of the motion.

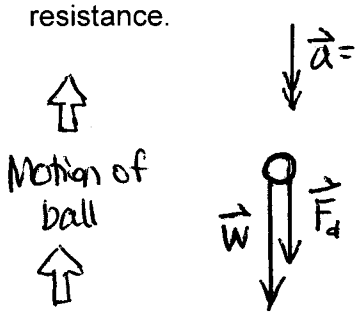


$\therefore$ at $t = 1.0s$,

$a = \frac{\Delta v}{\Delta t} = \frac{-25}{1.75} = \boxed{-14.3\ ms^{-2}}$

approximate, within a range

Determine, for the ball at $t = 1.0$ s, the acceleration and the magnitude of the force of air resistance.



(NOTE: Vectors not necessarily drawn to Scale!)

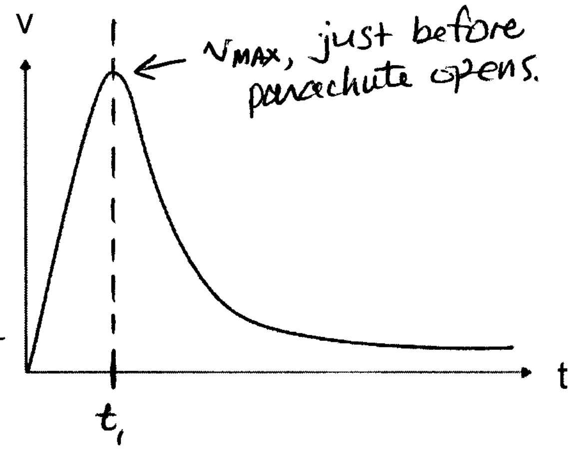
$\Sigma \vec{F} = m\vec{a} \Rightarrow \quad ma = mg + F_d$

$F_d = m(a-g) = (0.25)(-14.3 - {}^{-}9.81)$

$= -1.1\ N$

$\boxed{\therefore F_d = 1.1 N}$

17. The v-t graph shown is for the vertical motion of a person who jumps from a helicopter and a few seconds later opens a parachute.



a) When does the parachute open? Mark this point on the graph and explain your answer.

At t_1 indicated on the graph.
At the instant before the parachute opens, the person is at their maximum speed. But the person did not achieve terminal velocity before deploying the parachute.

b) When does the force of air resistance reach a maximum? Mark this point on the graph and explain your answer.

Since $F \propto v$, F_{MAX} corresponds to the time that v_{MAX} was reached, so again at t_1.

c) Is the air resistance force constant? Explain.

NO! Because $F \propto v$, F varies constantly in this situation.

18. This problem is about cars driving along a straight road.

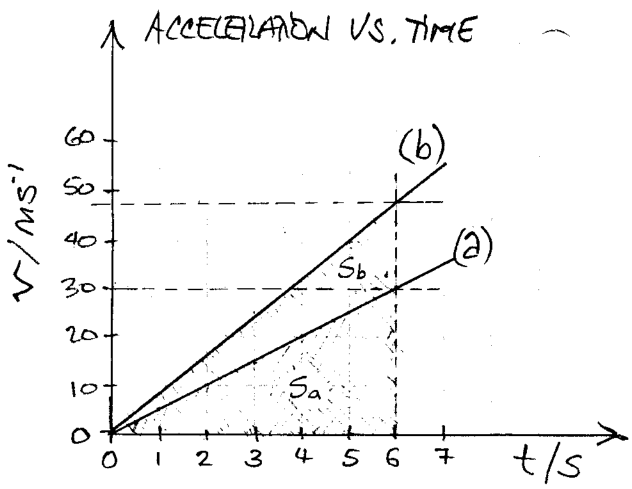
a) Complete the table showing the speeds of a car at 1 second intervals from starting out, if the acceleration of the car was 5.0 ms^{-2}, ~~and sketch a graph of speed vs. time for the car.~~

Time / s	0.0	1.0	2.0	3.0	4.0	5.0	6.0
Speed / ms^{-1}	0.0	5.0	10.	15	20.	25	30.

b) Repeat for an acceleration of 8.0 ms^{-2}.

Time / s	0.0	1.0	2.0	3.0	5.0	6.0
Speed / ms^{-1}	0.0	8.0	16	24	40.	48

c) Sketch a graph of data from both tables on the graph. Clearly label the graphs 'a' and 'b'.



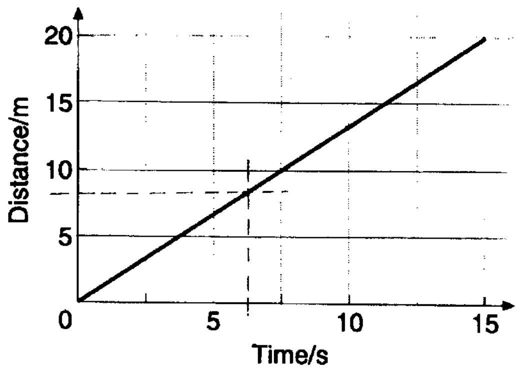
d) Deduce, using data from your graph, that the car in part (b) travelled further than the car in part (a) after 6.0 s.

FOR A v-t GRAPH, DISTANCE TRAVELLED = AREA BETWEEN GRAPH AND x-AXIS. IN 6 SECONDS:

CAR (a) TRAVELLED $S_a = \frac{1}{2}(30 \times 6) = 90$ m

CAR (b) TRAVELLED $S_b = \frac{1}{2}(48 \times 6) = 144$ m

19. Use the distance-time graph to find:



a) how far the body has moved after 10 s

$\boxed{13\,m}$

b) how long the body takes to travel 8 m

ABOUT $\boxed{6.5\,s}$

c) the average speed of the body after 15s

$v_{AVE} = \text{SLOPE OF LINE} = \frac{\Delta s}{\Delta t} = \frac{20\,m}{15\,s} = \boxed{1.3\,ms^{-1}}$

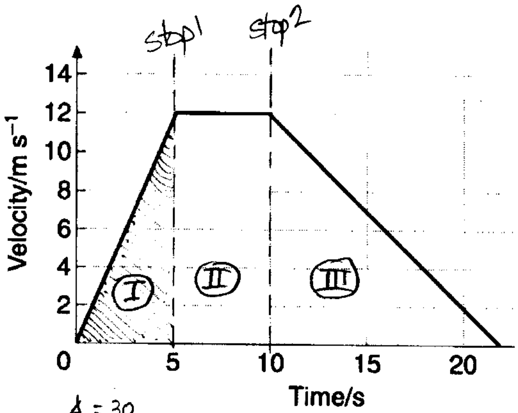
d) the instantaneous speed when t = 5s

AT EVERY INSTANT, $v = v_{AVE} = \boxed{1.3\,ms^{-1}}$

e) the equation of the line $y = mx + c$

$\boxed{s = 1.3t + 0}$

20. Use the velocity-time graph to find:



$A_I = 30$

$A_{II} = 60m$ $A_{III} = 72m$

TOTAL DISTANCE = 162m

a) the acceleration during the first 5s

$a = \text{SLOPE OF LINE} = \frac{\Delta v}{\Delta t} = \frac{12}{5} = \boxed{2.4\,ms^{-2}}$

b) the distance travelled during this acceleration

$s = \text{AREA BETWEEN GRAPH AND x-AXIS} = \frac{1}{2}(12 \times 5) = \boxed{30\,m}$

c) the total distance covered between 'stops'

$\Delta s = \Delta v \Delta t = (12)(5) = \boxed{60\,m}$

d) the average speed during the 22s journey.

$v_{AVE} = \frac{\Delta s}{\Delta t} = \frac{162\,m}{22\,s} = \boxed{7.4\,ms^{-1}}$

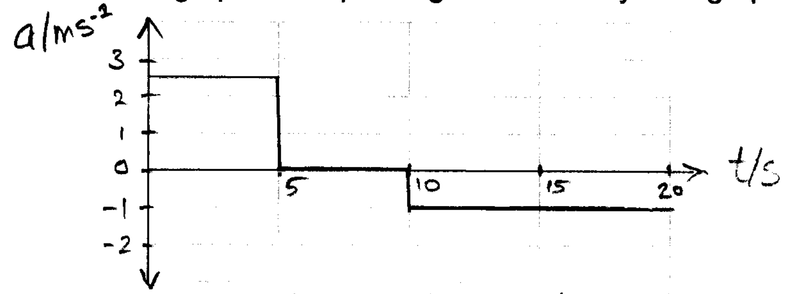
e) the equation of the graph IT IS A "PIECE-WISE DEFINED FUNCTION"

FOR $0 \le t < 5$: $v = 2.4t$
FOR $5 \le t < 10$: $v = 12$
FOR $10 \le t < 22$: $v = -t + 22$

IN PART III ; slope $= \frac{\Delta v}{\Delta t} = \frac{-12}{12} = -1.0$

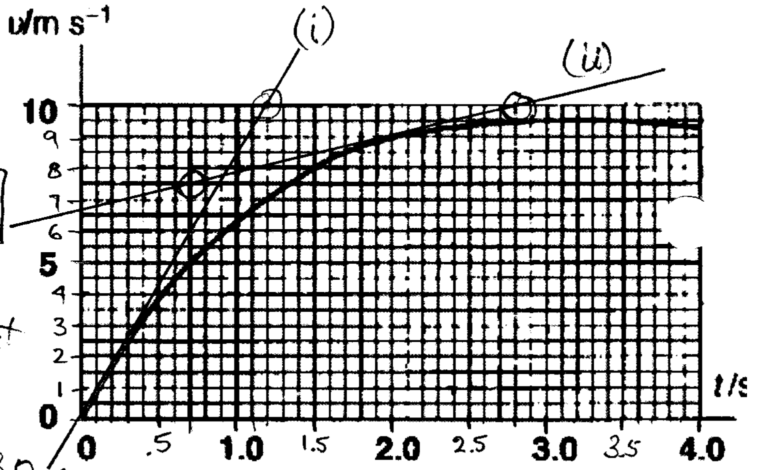
$v = -t + c$
$12 = -10 + c \Rightarrow c = 22.$ (one way to find y-int.)

21. Sketch the acceleration-time graph corresponding to the velocity-time graph in question 17.



Note: vertical parts at t=5, 10 are not necessary.

22. The graph shows the result of studying a sprint start.



a) What, in m.p.h., was the maximum velocity reached? *(take 1.0 ms^{-1} to equal 2.24 m.p.h.)*

$v_{MAX} = 9.5\ ms^{-1} = \boxed{21.3\ mi\ hr^{-1}}$

Note: instantaneous slopes (of tangent straight lines) decrease as time passes. So acceleration is getting less and less, at $t = 3.0$, $a = 0$.

b) Calculate the acceleration of the sprinter in ms^{-2}....

i) as she leaves her blocks.

$a =$ SLOPE OF LINE (i)

$= \frac{\Delta v}{\Delta t} = \frac{10}{1.2} = \boxed{8.3 ms^{-2}}$
(approximately)

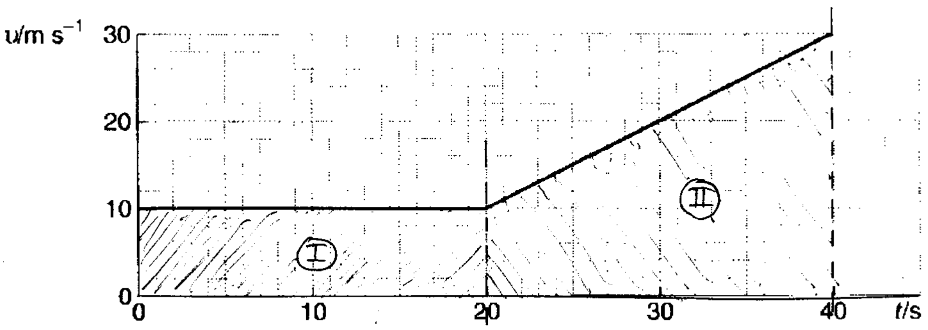
ii) after 2.0 s.

$a =$ SLOPE OF LINE (ii)

$= \frac{\Delta v}{\Delta t} = \frac{10 - 7.5}{2.8 - 0.7}$

$= \frac{2.5}{2.1} = \boxed{1.2 ms^{-2}}$
(approximately)

23. The graph describes the motion of a train moving in a speed- restricted area and then accelerating as it clears the area. *You are to calculate the total distance travelled by the train in the 40 s shown in two different ways.*



a) Use the average velocity of the train during each 20s interval to calculate two separate distances and add them together.

PART (I): $v_{AVE 1} = +10\ ms^{-1} = \frac{\Delta s_1}{\Delta t_1} \Rightarrow \Delta s_1 = v_{AVE 1} \Delta t_1 = (+10)(20) = 200\ m.$

PART (II): $v_{AVE 2} = +20\ ms^{-1} = \frac{\Delta s_2}{\Delta t_2} \Rightarrow \Delta s_2 = v_{AVE 2} \Delta t_2 = (+20)(20) = 400\ m.$

THEN $\Delta s_{TOT} = \Delta s_1 + \Delta s_2 = 200 + 400 = \boxed{600 m}$

b) Find the number of squares under the graph and the distance represented by one square.

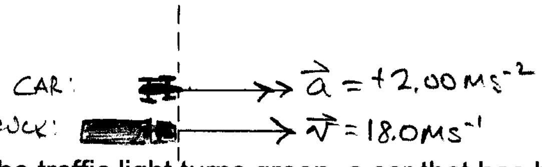
AREA (I) $= 10 \times 20 = 200\ m.$

AREA (II) $= (10 \times 20) + \frac{1}{2}(20 \times 20) = 400 m$

TOTAL AREA = AREA (I) + AREA (II)

$= 200 + 400$

$= \boxed{600 M}$



HW **24.** At the instant the traffic light turns green, a car that has been waiting at a junction starts ahead with a constant acceleration of 2.00 ms^{-2}. At the same instant a truck, travelling with a constant speed of 18.0 ms^{-1}, overtakes and passes the car.

a) How far beyond its starting point does the car overtake the truck?

FOR THE CAR: $s = \frac{1}{2}at^2$
FOR THE TRUCK: $s = vt$

equate: $\frac{1}{2}a\cancel{t^2} = v\cancel{t}$

So, $t = \frac{2v}{a} = \frac{2(18.0)}{2.00} = 18.0\,s$ AND At $t = 18.0\,s$, $\boxed{s = 324\,m}$

b) How fast is the car travelling when it overtakes the truck?

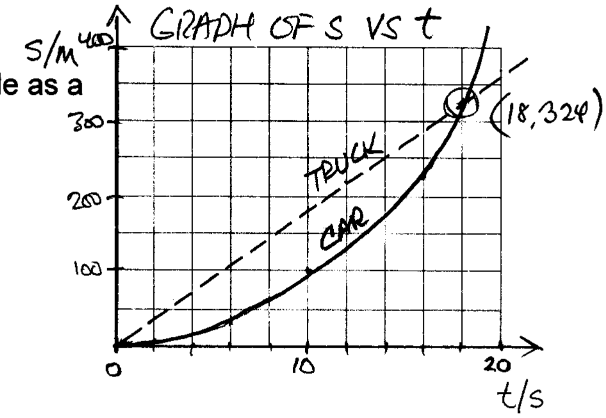
$a = \frac{\Delta v}{\Delta t} \Rightarrow v = at = (2.00)(18.0) = \boxed{36.0\ ms^{-1}}$

c) On a single graph, sketch the position of each vehicle as a function of time. *Take s = 0 at the junction.*

t / s	S TRUCK	S CAR
0	0	0
2	36	4
6	108	36
10	180	100
15	270	225
18 *	324 *	324 *
20	360	400

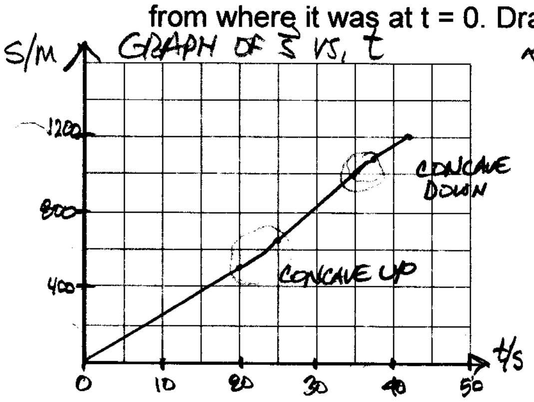
FOR TRUCK: $s = vt$

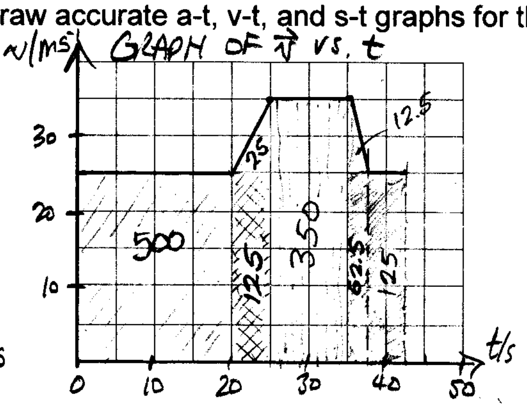
FOR CAR: $s = \frac{1}{2}at^2$

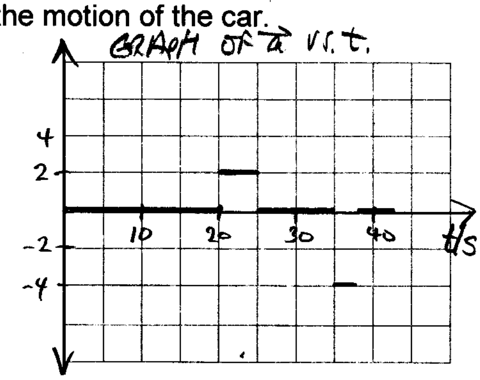


SOME SAMPLE DATA POINTS FOR THE GRAPH...

HW **25.** At t = 0 a car is stopped at a traffic light. When the light turns green, the car starts to speed up. It gains speed at a constant rate until it reaches a speed of 20 ms^{-1} eight seconds after the light turns green. The car continues at a constant speed for 40 m. Then the driver sees a red light up ahead at the next intersection and starts slowing down at a constant rate. The car stops at the red light, 180 m from where it was at t = 0. Draw accurate a-t, v-t, and s-t graphs for the motion of the car.



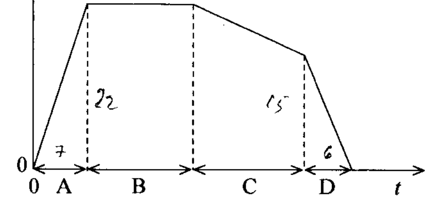




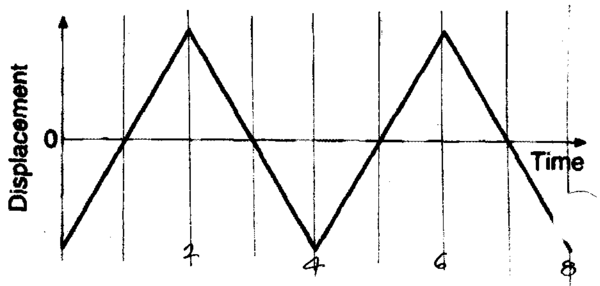
ENTIRE TRIP TAKES 42.5 S.

HW **26.** The graph below shows the variation with time *t* of the displacement *s* of a car. In which time interval is the speed greatest? Explain.

THE SECTION WITH THE STEEPEST SLOPE (+ OR - SLOPE DOESN'T MATTER); SECTION A.



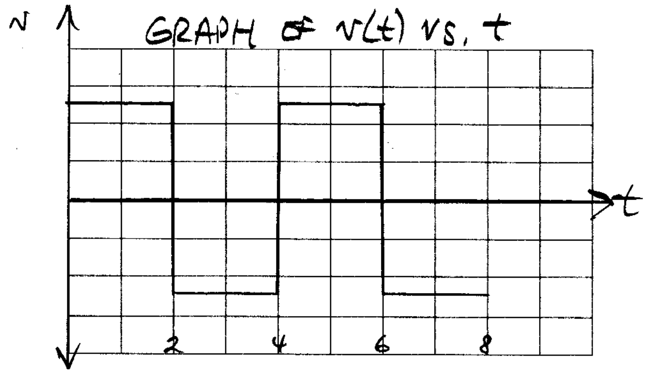
✓ HW **27.** This displacement-time graph is for the motion of a glider between two elastic buffers on an air track.

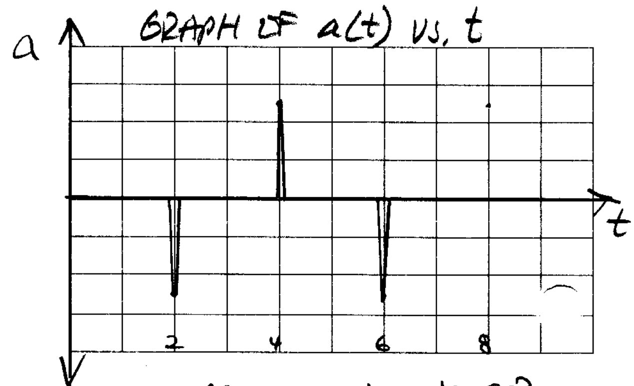


a) From what point on the track is the displacement being measured?

THE MID-POINT BETWEEN THE BUFFERS.

b) Sketch two more graphs, using the same time scale, showing how the velocity and acceleration of the glider vary with time.



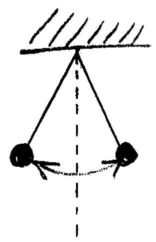


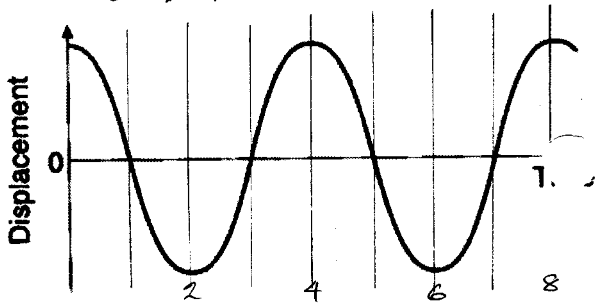
*

WHAT'S THE SIMPLIFYING ASSUMPTION WE ARE MAKING HERE?

s(t) ⇒ A COSINE CURVE!

✓ HW **28.** This displacement-time graph is for the motion of a swinging pendulum.

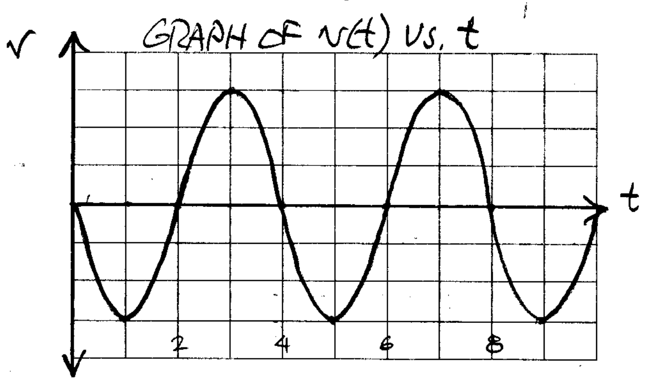


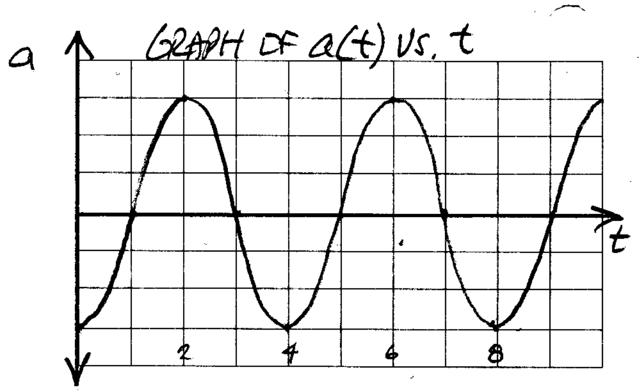


a) From what point is the displacement being measured?

The middle (vertical) position

b) Sketch two more graphs, using the same time scale, showing how the velocity and acceleration of the pendulum vary with time.





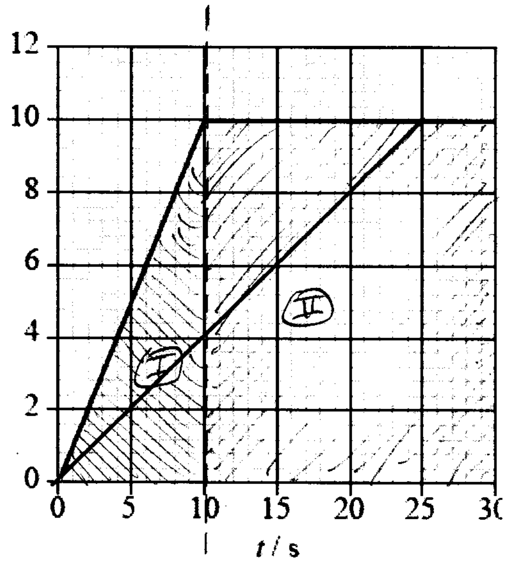
$\frac{d}{dt} s(t)$ (FIRST DERIVATIVE!)

$\frac{d^2}{dt^2} s(t) = \frac{d}{dt} v(t)$

(SECOND DERIVATIVE!)

NOTE: NO SCALES ON GRAPHS; GENERAL SHAPES ARE ALL WE CARE ABOUT...

C **29.** Joseph runs along a long straight track, starting from rest at t = 0 s. The variation of his speed v with time t is shown. At t = 25 s, determine:



a) how far he has run

AREA BETWEEN GRAPH AND X-AXIS = AREA I + AREA II

$= \frac{1}{2}(10\times10)+(10\times15) = \boxed{200M}$

b) his instantaneous speed

READ THE GRAPH: at $t=25$, $\boxed{v = 10ms^{-1}}$

c) his average speed since he started

$v_{AVE} = \frac{\Delta s}{\Delta t} = \frac{200}{25} = \boxed{8\ ms^{-1}}$

d) his instantaneous acceleration

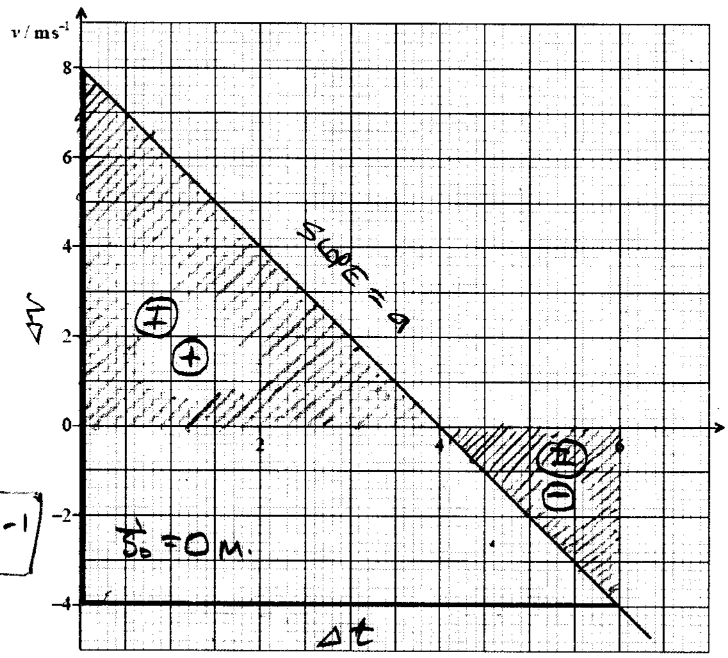
AT $t=25s$, SLOPE OF v-t = 0. SO $\boxed{a = 0ms^{-2}}$

e) his average acceleration since he started

SLOPE OF LINE DRAWN:

$a_{AVE} = \frac{\Delta v}{\Delta t} = \frac{10}{25} = \boxed{0.4\ ms^{-2}}$

✓ HW **30.** The graph shows the variation with time t of the velocity v of an object moving along a straight line. For the time interval 0 ≤ t ≤ 6 s determine:



$\vec{s}_1 = +16m.$ $\vec{s}_2 = -4m.$

$\vec{s} = \vec{s}_0 + \vec{s}_1 + \vec{s}_2$

a) the displacement of the object.

$\vec{s} = \vec{s}_0 + \vec{s}_1 + \vec{s}_2$ = AREA I + AREA II

$= \frac{1}{2}(8\times4) + {}^-\frac{1}{2}(4\times2)$

$= 16 + {}^-4 = \boxed{+12m}$

b) the average speed of the object.

$v_{AVE} = \frac{\Delta s}{\Delta t} = \frac{20}{6} = \boxed{3.3\ ms^{-1}}$

c) the average velocity of the object.

$\vec{v}_{AVE} = \frac{\Delta \vec{s}}{\Delta t} = \frac{\vec{s} - \vec{s}_0}{t - t_0} = \frac{+12-0}{6} = \boxed{+2\ ms^{-1}}$

* VISUALLY VERIFY THIS... HOW?

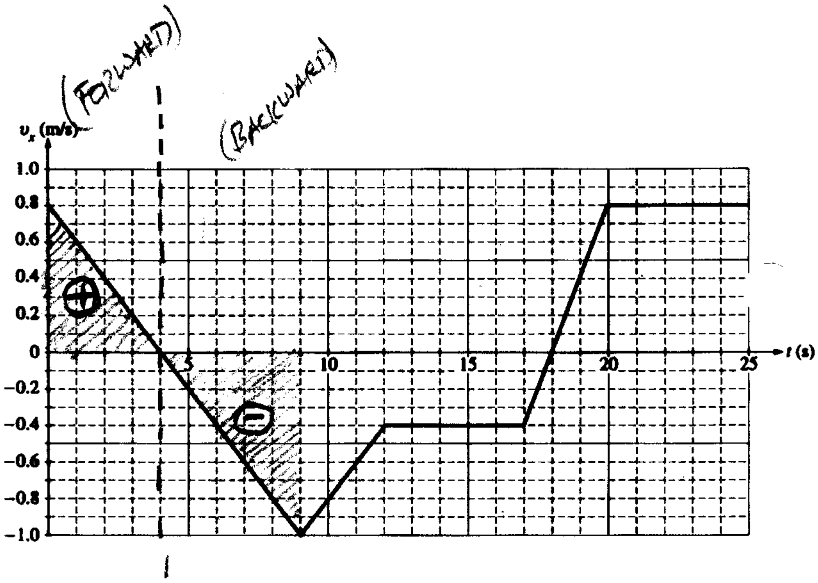
d) the acceleration of the object.

a = SLOPE OF v-t GRAPH

$= \frac{\Delta v}{\Delta t} = \frac{-12}{6} = \boxed{-2\ ms^{-2}}$

taking the entire Δ shown...

✓ HW **31.** A 0.50 kg cart is moving along a horizontal track. The graph of velocity v_x against time t for the cart is given:



a) Indicate every time t for which the cart is at rest.

$V_x = 0\,ms^{-1}$ at $\boxed{t = 4 \ \& \ 18s}$

b) Indicate every time interval for which the speed (the magnitude of the velocity) of the cart is increasing.

$\boxed{\Delta t = 4-9s, \ 18-20s}$

c) Determine the horizontal position x of the cart at $t = 9.0$ s if the cart is located at $x = 2.0$ m at $t = 0$.

$+\vec{s}$ (0-4s): AREA $= \frac{1}{2}(4 \times 0.8) = +1.6m = \vec{s}_1$

$-\vec{s}$ (4-9s): AREA $= \frac{1}{2}(5 \times 1.0) = -2.5m = \vec{s}_2$

SO, FINAL DISPLACEMENT IS $\vec{s}_0 + \vec{s}_1 + \vec{s}_2 = +2.0 + 1.6 + -2.5 = \boxed{+1.1m}$

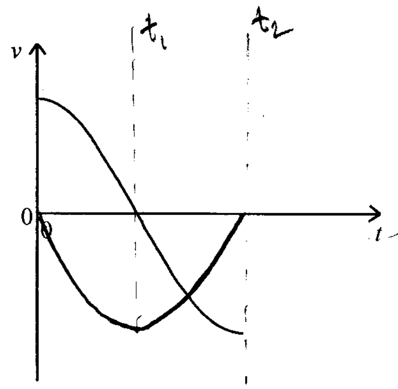
d) Find the maximum acceleration of the cart and determine the time(s) at which this occurs.

a_{MAX} CORRESPONDS TO STEEPEST PART OF THE v-t GRAPH.

THIS IS DURING $\Delta t = 17-20$ s AND IS:

$$\frac{\Delta y}{\Delta x} = \frac{0.8 - -0.4}{3} = \boxed{+0.4\,ms^{-2}}$$

✓ HW **32.** The graph shows the variation with time t of the velocity v of an object moving along a straight line. On the same graph, sketch the variation of time t of the acceleration a.



NOTE: a = SLOPE OF v-t GRAPH. EVERYWHERE ON THIS GRAPH THE SLOPE IS EITHER ZERO (AT THE ENDS) OR NEGATIVE, WITH MAXIMUM NEGATIVE STEEPNESS AT t_1

C **33.** A projectile is fired vertically upwards and reaches a height of 78.4 m. Find the velocity of the projection and the time it takes to reach its highest point.

s	u	v	a	t
+78.4	?	0	-9.81	?

$v^2 = u^2 + 2as \Rightarrow u = (v^2 - 2as)^{\frac{1}{2}}$

$= [0 - 2(-9.81)(78.4)]^{1/2} = \boxed{+39.2\,ms^{-1}}$ (upwards)

then, $s = \left(\frac{v+u}{2}\right)t \Rightarrow t = \frac{2s}{u} = \frac{2(78.4)}{39.2} = \boxed{4.00\,s}$

C **34.** A stone dropped from rest down a well takes 1.9 s to hit the surface of the water. Calculate the depth of the well.

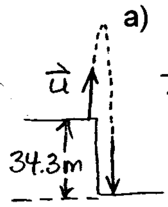
s	u	v	a	t
?	0		-9.81	1.9

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

$= \frac{1}{2}(-9.81)(1.9)^2 = \boxed{-18m}$ (downward)

C **35.** A stone is thrown vertically upwards with an initial velocity of 29.4 ms^{-1} from the top of a tower 34.3 m high. Find:

a) the time taken to reach the maximum height.



s	u	v	a	t
+34.3	+29.4	0	-9.81	?

$v = u + at$

$\Rightarrow t = \frac{v-u}{a} = \frac{0-29.4}{-9.81} = \boxed{3.00\text{ s}} = t_1$

b) the total time which elapses before it reaches the ground.

TIME TO GET BACK DOWN TO WHERE IT WAS THROWN = 3.00 s = t_2

NOW, TIME TO GET ALL THE WAY TO THE BOTTOM = t_3.

s	u	v	a	t
-34.3	-29.4	–	-9.81	?

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

$t = 0$ OR $4.00 = t_3$

SO, TOTAL TIME:

$t_1 + t_2 + t_3 = 3.00 + 3.00 + 4.00 = \boxed{10.0\text{ s}}$

C **36.** A small iron ball is dropped from the top of a vertical cliff and takes 2.5 s to reach the sandy beach below. Find:

a) the velocity with which it strikes the sand.

s	u	v	a	t
–	0	? (25)	-9.81	2.5

$v = u + at$

$= (-9.81)(2.5) = \boxed{-25\text{ ms}^{-1}}$

b) the height of the cliff.

$s = \cancel{ut} + \frac{1}{2}at^2 = \frac{1}{2}(-9.81)(2.5)^2 = \boxed{-31\text{ m}}$

OR

$s = \left(\frac{v+u}{2}\right)t = \left(\frac{-25}{2}\right)(2.5) = \boxed{-31\text{ m}}$

OR

$v^2 = u^2 + 2as \Rightarrow s = \frac{v^2 - u^2}{2a} = \frac{25^2 - 0^2}{2(-9.81)} = \boxed{-32\text{ m}}$ APPROX !!

C **37.** A particle starts from rest and moves in a straight line with a constant acceleration until it reaches a velocity of 15 ms^{-1}. It is then brought to rest again by a constant retardation of 3.0 ms^{-2}. If the particle is then 60.0 m from its starting point, find the time for which the particle is moving.

2 PART PROBLEM:

①

s	u	v	a	t
s_1	0	+15	–	t_1

$s_1 = \left(\frac{u+v}{2}\right)t_1 = \frac{15}{2}t_1 = 7.5t_1$

②

s	u	v	a	t
s_2	15	0	-3.0	t_2

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

$\Rightarrow s_2 = \frac{v^2 - u^2}{2a} = \frac{0 - 15^2}{2(-3.0)} = 37.5\text{ m}.$

NOW, $s_1 + s_2 = 60.0\text{ m} = 7.5t_1 + 35.0$

SO $t_1 = 3.0$ s (and $s_1 = 22.5$ m) AND $t_2 = 5.0$ s

$\therefore t = t_1 + t_2 = \boxed{8.0\text{ s}}$

C **38.** A car brakes with a deceleration of 2.5 ms^{-2} (an acceleration of –2.5 ms^{-2}) Calculate the distance it needs to stop, if its initial speed is

a) 20 ms^{-1}

s	u	v	a	t
?	+20	0	-2.5	–

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

$s = \frac{v^2 - u^2}{2a} = \frac{0^2 - 20^2}{2(-2.5)} = \boxed{80\text{ m}}$

b) 40 ms^{-1}

s	u	v	a	t
?	+40	0	-2.5	–

$s = \frac{v^2 - u^2}{2a} = \frac{0^2 - 40^2}{2(-2.5)} = \boxed{320\text{ m}}$

39. An antelope moving with constant acceleration covers the distance between two points 80.0 m apart in 7.00 s. Its speed as it passes the second point is 15.0 ms^{-1}.

a) What is its speed at the first point?

s	u	v	a	t
+80.0	? (7.86)	+15.0		7.00

$$s=\left(\frac{u+v}{2}\right)t \Rightarrow u=\frac{2s}{t}-v = \frac{2(80.0)}{7.00}-15.0 = \boxed{7.86\ ms^{-1}}$$

b) What is its acceleration?

$$v=u+at \Rightarrow a=\frac{v-u}{t}=\frac{+15.0-7.86}{7.00} = \boxed{1.02\ ms^{-2}}$$

40. One type of airplane has a maximum acceleration on the ground of 3.5 ms^{-2}.

* a) For how many seconds must it accelerate along a runway in order to reach its take off speed of 115 ms^{-1}?

s	u	v	a	t
	0	+115	+3.5	? (33)

$$v=u+at \Rightarrow t=\frac{v-u}{a}=\frac{+115}{+3.5}=\boxed{33s}$$

b) What is the minimum length of runway needed to reach this speed?

$$s=ut+\frac{1}{2}at^2 = \frac{1}{2}(3.5)(33)^2 \quad \boxed{s=1900m}$$

OR

$$s=\left(\frac{v+u}{2}\right)t = \left(\frac{115}{2}\right)(33) = \boxed{1900m}$$

OR

$$v^2=u^2+2as \Rightarrow s=\frac{v^2-u^2}{2a} = \frac{115^2}{2(3.5)} = \boxed{1900m}$$

41. An airplane travels 420 m down the runway before taking off. It starts from rest, moves with constant acceleration, and becomes airborne in 16.0 s. What is its speed, in ms^{-1}, when it takes off?

s	u	v	a	t
+420	0	?	–	16.0

$$s=\left(\frac{v+u}{2}\right)t \Rightarrow v=\frac{2s}{t}-u=\frac{2(420)}{16.0}=\boxed{53\ ms^{-1}}$$

42. A bullet travelling at a speed of 110 ms^{-1} penetrates a tree trunk to a depth of 65 mm. Calculate

a) the impact time of the bullet

s	u	v	a	t
$+65\times10^{-3}$	+110	0		? (1.2×10^{-3})

$$s=\left(\frac{v+u}{2}\right)t \Rightarrow t=\frac{2s}{v+u}=\frac{2(65\times10^{-3})}{110}=\boxed{1.2\times10^{-3}s}$$

b) the deceleration of the bullet.

$$v=u+at \Rightarrow a=\frac{v-u}{t} = \frac{-110}{1.2\times10^{-3}} \quad \boxed{a=-9.2\times10^{4}ms^{-2}}$$

OR

$$v^2=u^2+2as \Rightarrow a=\frac{v^2-u^2}{2s} = \frac{-(110)^2}{2(65\times10^{-3})} = \boxed{-9.3\times10^{4}ms^{-2}}$$

OR

$$s=ut+\frac{1}{2}at^2 \Rightarrow a=\frac{2}{t^2}(s-ut) = \frac{2}{(1.2\times10^{-3})^2}\left(65\times10^{-3}-110(1.2\times10^{-3})\right) = \boxed{-9.3\times10^{4}ms^{-2}}$$

43. Electrons in a particle accelerator are moving at 8.0 x 10^5 ms^{-1} when they enter a tube where they are accelerated to 6.5 x 10^6 ms^{-1} in 3.0 x 10^{-7}s.

a) What is their acceleration in the tube?

s	u	v	a	t
?	+8.0x10^5	+6.5x10^6	? (1.9x10^{13})	3.0x10^{-7}

$v = u + at$

$\Rightarrow a = \frac{v-u}{t} = \frac{6.5\times10^6 - 8.0\times10^5}{3.0\times10^{-7}}$

$= \boxed{+1.9\times10^{13}\ ms^{-2}}$

b) What is the length of the tube?

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

$= (8.0\times10^5)(3.0\times10^{-7}) + \frac{1}{2}(1.9\times10^{13})(3.0\times10^{-7})^2$

$\boxed{s = 1.1m}$

OR $s = \left(\frac{v+u}{2}\right)t = \frac{6.5\times10^6 + 8.0\times10^5}{2}(3.0\times10^{-7})$

$= \boxed{1.1m}$

OR $v^2 = u^2 + 2as \Rightarrow s = \frac{v^2-u^2}{2a} = \boxed{1.1m}$

44. An electron moving at a speed of 1.30 x 10^5 ms^{-1} travels 20.0 cm through an electric field. It leaves in the same direction with a speed of 9.30 x 10^5 ms^{-1}. Find:

a) The acceleration of the electron while it is in the electric field.

s	u	v	a	t
+0.200	+1.30x10^5	+9.30x10^5	? (2.12x10^{12})	

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

$\Rightarrow a = \frac{v^2-u^2}{2s} = \frac{(9.30\times10^5)^2 - (1.30\times10^5)^2}{2(0.200)}$

$= \boxed{2.12\times10^{12}\ ms^{-2}}$

b) The time it spends in the electric field.

$v = u + at$

$\Rightarrow t = \frac{v-u}{a}$

$= \frac{(9.30\times10^5) - (1.30\times10^5)}{2.12\times10^{12}}$

$\boxed{t = 3.77\times10^{-7}s}$

OR $s = \left(\frac{u+v}{2}\right)t$

$\Rightarrow t = \frac{2s}{u+v}$

$= \frac{2(0.200)}{(1.30\times10^5) + (9.30\times10^5)}$

$= \boxed{3.77\times10^{-7}s}$

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

Solve the quadratic.... One of the answers will be $t = 3.77\times10^{-7}s$!

45. The human body can survive a negative acceleration trauma incident (sudden stop) if the magnitude of the acceleration is less than 250 ms^{-2} (approximately 25 **g**). If you are in an automobile accident with an initial speed of 88 km/h and are stopped by an airbag that inflates from the dashboard, over what distance must the airbag stop you if you are to survive the crash?

s	u	v	a	t
?	+24.4	0	-250	—

$\frac{88\ km}{1\ hr} \times \frac{1000m}{1km} \times \frac{1\ hr}{3600s} = 24.4\ ms^{-1}$

$v^2 = u^2 + 2as \Rightarrow s = \frac{v^2-u^2}{2a} = \frac{0^2 - 24.4^2}{2(-250)} = \boxed{+1.2m}$

c **46.** A car driver, travelling in his car at a steady speed of 8.0 ms^{-1}, sees a dog walking across the road 30.0 m ahead. The driver's reaction time is 0.20 s, and the brakes ~~of~~ producing a deceleration of 1.2 ms^{-2}. Calculate the distance from where the car stops to where the dog is crossing.

s	u	v	a	t
+30.0	+8.0	0	-1.2	

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

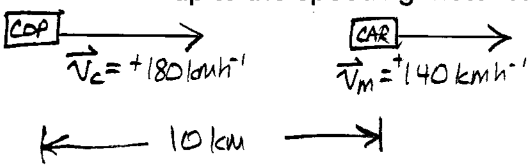
$$\Rightarrow s = \frac{v^2 - u^2}{2a} = \frac{0^2 - 8.0^2}{2(-1.2)} = 26.7\text{ m}.$$

IN 0.20 s, THE CAR TRAVELS:

$$v = \frac{\Delta s}{\Delta t} \Rightarrow \Delta s = v\Delta t = (8.0)(0.20) = \underline{1.6\text{ M}}.$$

NOW, 26.7 m + 1.6 m = 28.3 M WHICH IS $\boxed{\text{1.7 m FROM THE DOG.}}$

47. Consider a speeding motorist travelling at 140 km/hr along a highway. A police car travelling at 180 km/hr is chasing him but is 10.0 km behind the motorist. How long does it take the police car to catch up to the speeding motorist?



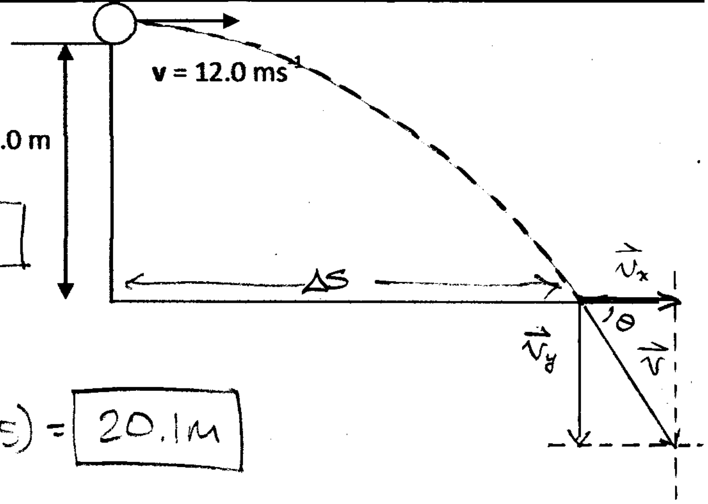
THINK OF IT AS THE POLICE CAR APPROACHING THE MOTORIST AT $v = 40\text{ kmh}^{-1}$!

then $v = \frac{\Delta s}{\Delta t} \Rightarrow \Delta t = \frac{\Delta s}{v} = \frac{10\text{ km}}{40\text{ km/hr}}$

$= .25\text{ hr}$

$= \boxed{15\text{ min}}$

48. A ball is kicked horizontally off a 15.0 m cliff at a velocity of 12.0 m/s as shown. Find:



a) the time of flight of the ball. **[1.75 s]**

TIME TO FALL 15.0 m :

$$s = \tfrac{1}{2}gt^2 \Rightarrow t = \sqrt{\frac{2s}{g}} = \sqrt{\frac{2(15.0)}{9.8}} = \boxed{1.75\,s}$$

b) the range of the ball. **[20.1 m]**

$$v_x = v_0 = \text{constant} = 12.0\,ms^{-1}$$

$$v_x = \frac{\Delta s}{\Delta t} \Rightarrow \Delta s = v_x \Delta t = (12.0)(1.75) = \boxed{20.1\,m}$$

c) the velocity of the ball at impact. **[~~21.1~~ 20.9 ms^-1 at ~~55.3~~ 55.0° below +x axis]**

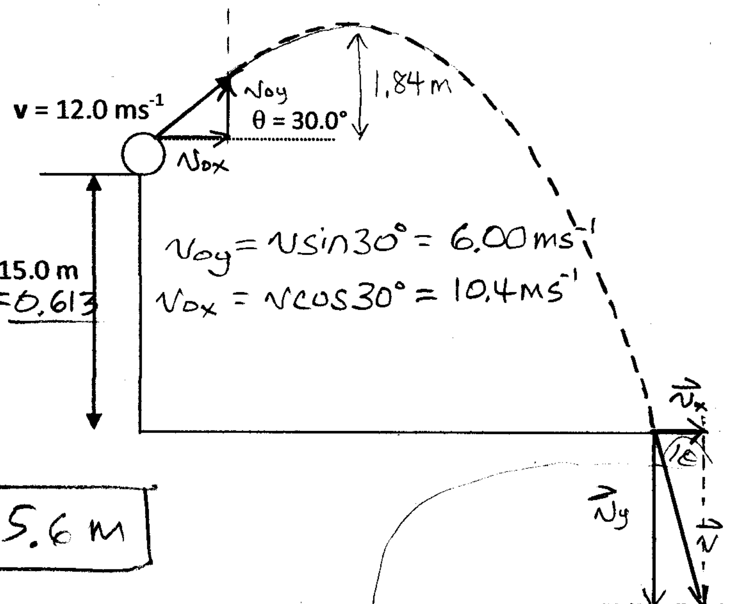
$$v_x = 12.0\,ms^{-1}$$

$$v_y^2 = \cancel{u_y^2}_{0} + 2gs \Rightarrow v_y = \sqrt{2gs} = (2(9.8)(15.0))^{1/2} = 17.15\,ms^{-1}$$

$$\therefore v = (v_x^2 + v_y^2)^{1/2} = \boxed{20.9\,ms^{-1}}$$

$$\tan\theta = \frac{v_y}{v_x} \Rightarrow \theta = \tan^{-1}\left(\frac{v_y}{v_x}\right) = \tan^{-1}\left(\frac{17.15}{12.0}\right) = \boxed{55.0^\circ}$$

49. The same ball in the previous exercise is now initially kicked at an angle of 30.0° above the horizontal. Find:



$$v_{oy} = v\sin 30^\circ = 6.00\,ms^{-1}$$

$$v_{ox} = v\cos 30^\circ = 10.4\,ms^{-1}$$

a) the time of flight of the ball. **[2.46 s]**

$$\text{TIME UP: } s = \left(\frac{u+v}{2}\right)t \Rightarrow t = \frac{2s}{u} = \frac{2(1.84)}{6.00} = 0.613$$

$$\text{TIME DOWN: } t = \sqrt{\frac{2s}{g}} = \left(\frac{2(16.8)}{9.81}\right)^{1/2} = 1.855$$

$$\therefore \text{TOTAL TIME} = 1.85 + 0.613 = \boxed{2.46\,s}$$

b) the range of the ball. **[25.6 m]**

$$v_x = \frac{s}{t} \Rightarrow s = v_x t = (10.4)(2.46) = \boxed{25.6\,m}$$

c) the velocity at impact. **[20.9 ms^-1 at 60.3° below the +x axis]**

$$v_x = v_{ox} = 10.4\,ms^{-1}$$

$$v_y^2 = u_y^2 + 2as \Rightarrow$$

$$v_y = \sqrt{2gs} = (2(9.81)(16.8))^{1/2} = 18.155\,ms^{-1}$$

$$v = (v_x^2 + v_y^2)^{1/2} = (10.4^2 + 18.15^2)^{1/2} = \boxed{20.9\,ms^{-1}}$$

$$\theta = \tan^{-1}\left(\frac{v_y}{v_x}\right) = \tan^{-1}\left(\frac{18.15}{10.4}\right) = \boxed{60.2^\circ}$$

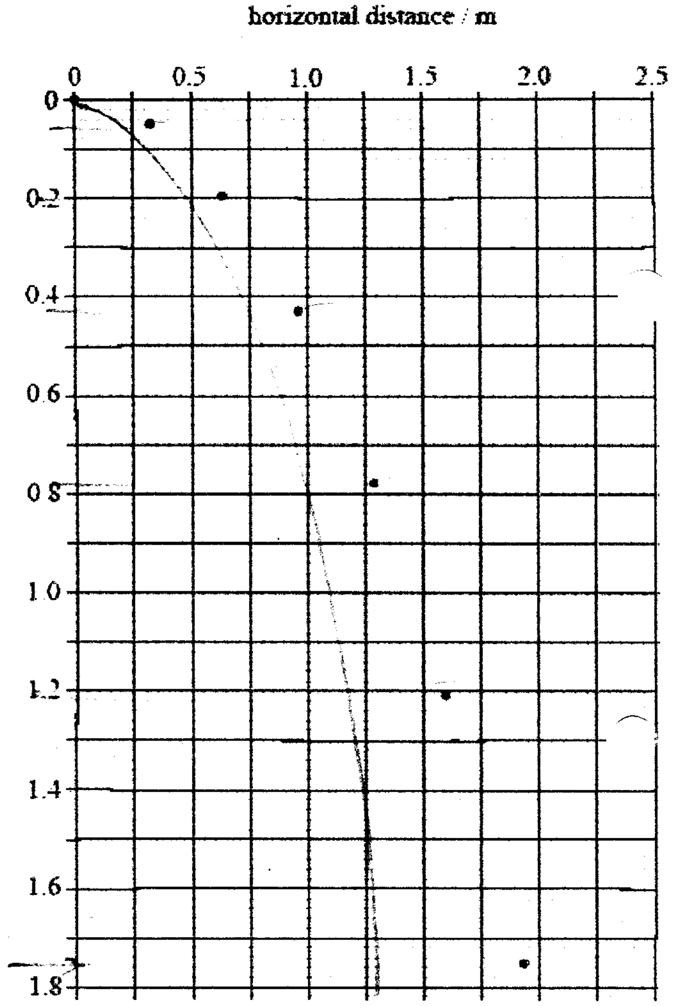
d) the maximum height of the ball. is when $v_y = 0$; **[~~1.84 m~~ 16.8 m]**

$$\cancel{v^2}^{\,0} = u^2 + 2gs$$

$$s = \frac{-u^2}{2g} = \frac{-(6.00)^2}{2(-9.8)} = 1.8367\,m = 1.84\,m$$

$$\therefore \text{MAX HEIGHT} = 15.0 + 1.84 = \boxed{16.8\,m}$$

50. A sphere is projected horizontally. The sphere is photographed at intervals of 0.10 s. The images of the sphere are shown against a grid on the diagram. Air resistance is negligible.



(a) Use data from the diagram to determine the acceleration of free fall. **[9.7 ms^{-2}]**

FROM FIRST TO LAST POINT TAKES 0.60 S. DISTANCE COVERED IS 1.75 M.

using $s = \frac{1}{2}at^2$

$\Rightarrow a = \frac{2s}{t^2} = \frac{2(1.75)}{(0.60)^2} = 9.722\,ms^{-2} = \boxed{9.7\,ms^{-2}}$

(b) Determine the speed of the sphere 1.2 s after release. **[12 ms^{-1}]**

$v = \cancel{u}^{0} + at$

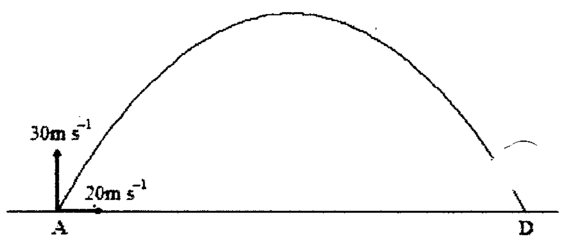
$= (9.7)(1.2)$

$= 11.64\,ms^{-1} = \boxed{12\,ms^{-1}}$

(c) On the grid, draw the path of the sphere assuming air resistance is not negligible.

Slope is steeper at all points and no longer a true parabola.

51. A golfer hits a golf ball at point A on a golf course. The ball lands at point D as shown on the diagram. Points A and D are on the same horizontal level. The initial horizontal component of the velocity of the ball is 20 m s^{-1} and the initial vertical component is 30 m s^{-1}. The time of flight of the golf ball between point A and point D is 6.0 s. Air resistance is negligible. Calculate:



a) the maximum height reached by the golf ball. **[45 m]**

TIME TAKEN TO REACH MAXIMUM HEIGHT = 3.0 s

$s = \frac{u + \cancel{v}^{0}}{2}t = \frac{30}{2}(3.0) = \boxed{45\,m}$

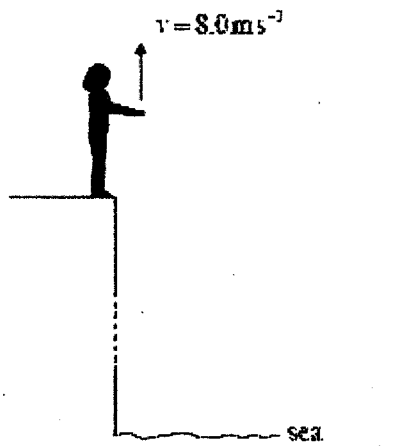
b) the range of the golf ball. **[120 m]**

$v_x = \frac{s}{t} \Rightarrow s = v_x t$

$= (20)(6.0)$

$= \boxed{120\,m}$

52. A girl stands at the edge of a vertical cliff and throws a stone vertically upwards. The stone leaves the girl's hand with a speed v = 8.0 ms^{-1}. Ignore air resistance and determine:



a) the maximum height reached by the stone. **[3.3 m]**

$\cancel{v^2} = u^2 + 2as$

$s = \frac{-u^2}{2g} = \frac{-(8.0)^2}{2(9.81)} = 3.26\text{m} = \boxed{3.3\text{m}}$

b) the time taken by the stone to reach its maximum height. **[0.80 s]**

$s = \frac{u+\cancel{v}}{2}t \Rightarrow t = \frac{2s}{u+v} = \frac{2(3.3)}{8.0}$

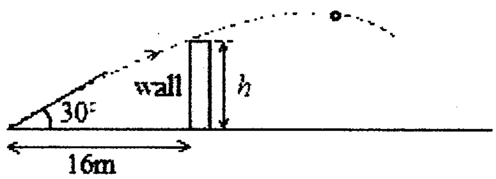
$= 0.825 = \boxed{0.83\text{s}}$ * slightly different answer based on method used.

c) The time between the stone leaving the girl's hand and hitting the sea is 3.0 s. Determine the height of the cliff. **[21 m]**

WHEN GOING DOWN, $v = -8.0\text{ms}^{-1}$ AT EDGE OF CLIFF, AND IT TAKES 3.0 − 1.6 = 1.4 s TO TRAVEL FROM EDGE OF CLIFF TO THE SEA

$s = ut + \frac{1}{2}gt^2 = (8.0)(1.4) + \frac{1}{2}(9.81)(1.4)^2 = 20.81\text{ m} = \boxed{21\text{ m}}$

53. A ball is projected from ground level with a speed of 28 m s^{-1} at an angle of 30° to the horizontal as shown below.



There is a wall of height h at a distance of 16 m from the point of projection of the ball. Air resistance is negligible. Calculate the initial magnitudes of:

a) the horizontal velocity of the ball; **[24 ms^{-1}]**

$v_x = v\cos\theta = (28)(\cos 30°)$

$= \boxed{24\text{ ms}^{-1}}$

b) the vertical velocity of the ball. **[14 ms^{-1}]**

$v_y = v\sin\theta = (28)(\sin 30°)$

$= \boxed{14\text{ms}^{-1}}$

c) The ball just passes over the wall. Determine the maximum height of the wall. **[7.1 m]**

Time to reach wall: $v_x = \frac{s}{t} \Rightarrow t = \frac{s}{v_x} = \frac{16}{24} = 0.67\text{s}$

$s = ut + \frac{1}{2}gt^2 = (14)(0.67) + \frac{1}{2}(\bar{9}.81)(0.67)^2$

$= 7.18\text{m} = \boxed{7.2\text{m}}$ * Slightly different answer based on method used.