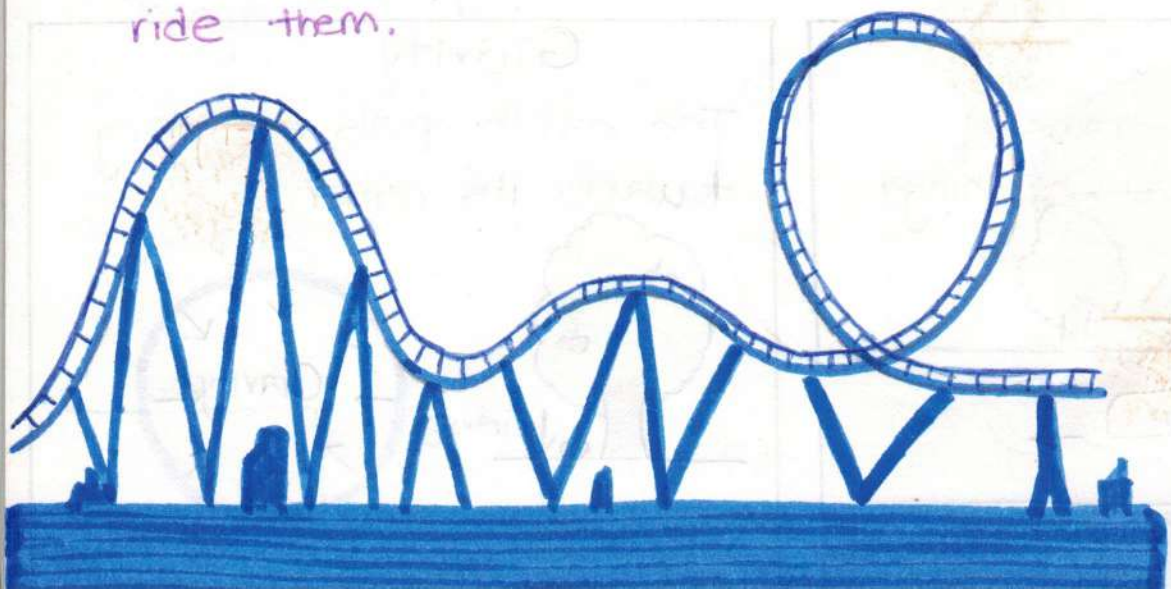
UNIT 1
MOTION

TASK INTRODUCTION

- Must understand basic concepts of motion to be able to design some amusement park ride. Also, be able to show different kinds of motion involved when people ride them.



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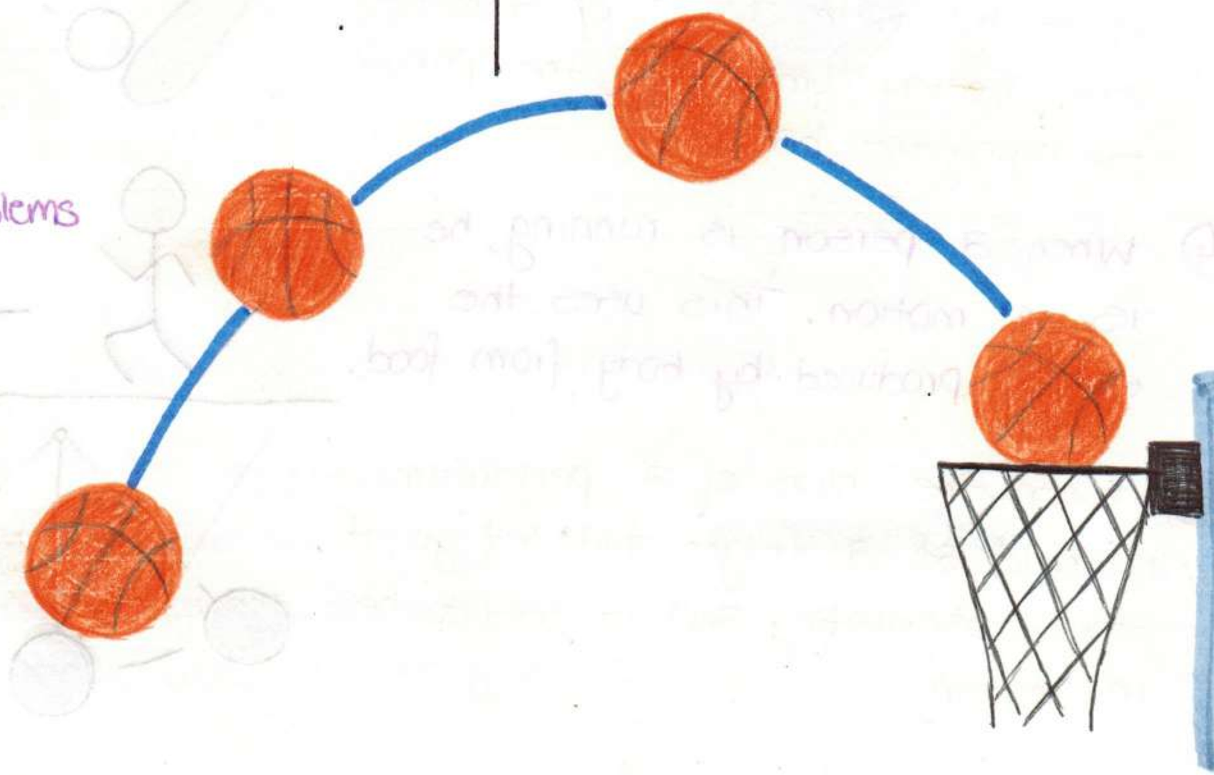


ESSENTIAL

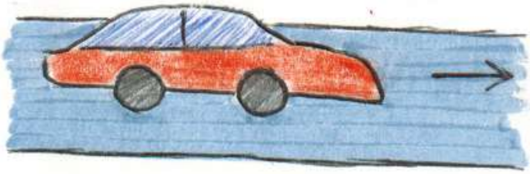
FIRST THOUGHTS

Motion – When an object is moving with respect to its surroundings it is said to be in motion. The object has to get energy from some source to be in motion.

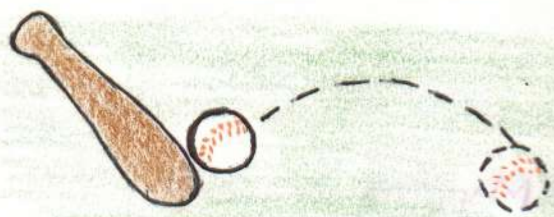
Examples

1. Earth always revolving around the sun in an eliptical path. The motion is due to gravitational forces of the solar system.

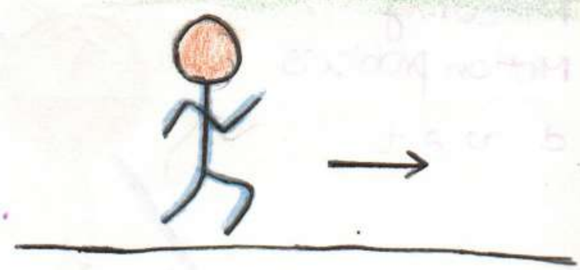
2. A car is in motion when it is being driven on the road. The energy comes from gasoline.



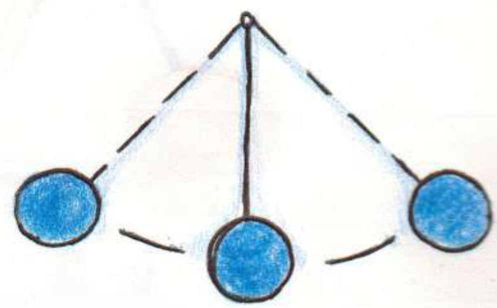
3. A baseball is in motion after it is hit with a bat or something else. Energy comes from the person swinging the bat.



4. When a person is running, he is in motion. This uses the energy produced by body from food.



5. When the bob of a pendulum is held at a height and let go, it starts oscillating and is said to be in motion.



QUESTION

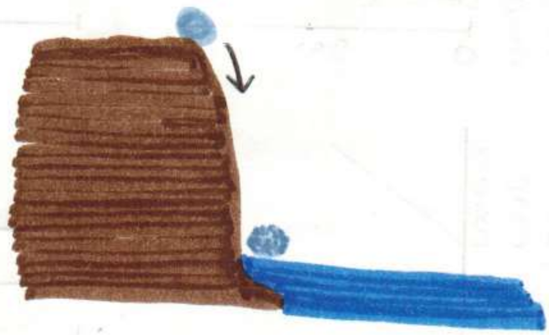
Q- How do you defin
describe motion?

LAST THOUGHTS

Motion - When the location of an object, from a reference point, changes, the object is said to be in motion. For motion to occur, displacement must be involved, and everytime displacement is involved, velocity is also involved

Examples

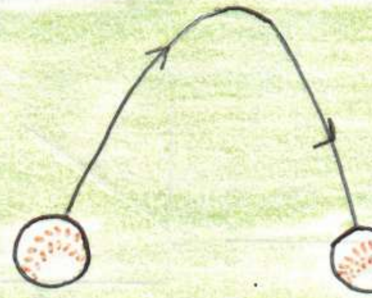
① When a rock falls from a cliff it is in motion. Source of motion might be a person who kicks it or it may be something else.



② When a toy car is pushed with some amount of force. The source would be the person who pushes the car.

③ When a helicoptor is rising in altitude. The energy source is fuel.

④ A. baseball is in motion when it is tossed up into the air by the player. It is the player who produces the motion

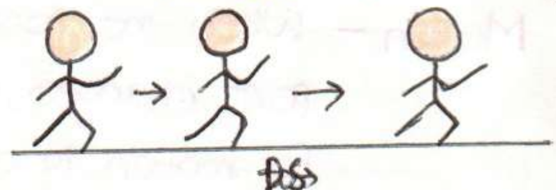


⑤ When a bullet is fired, it is in motion. The source of the motion is gunpowder and other chemicals used in the gun.

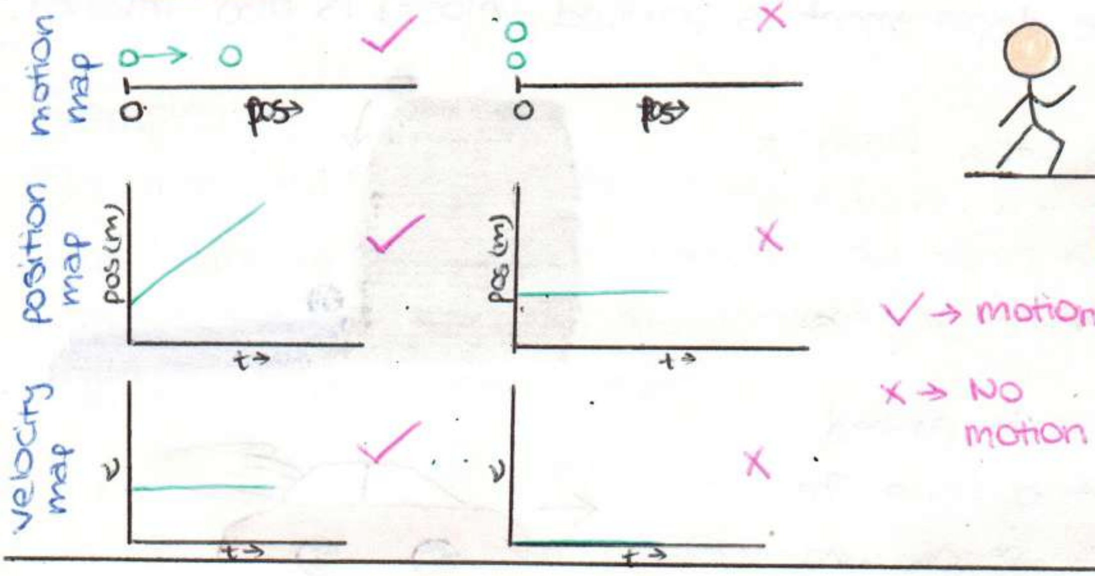
Q- How do we know that motion occured?

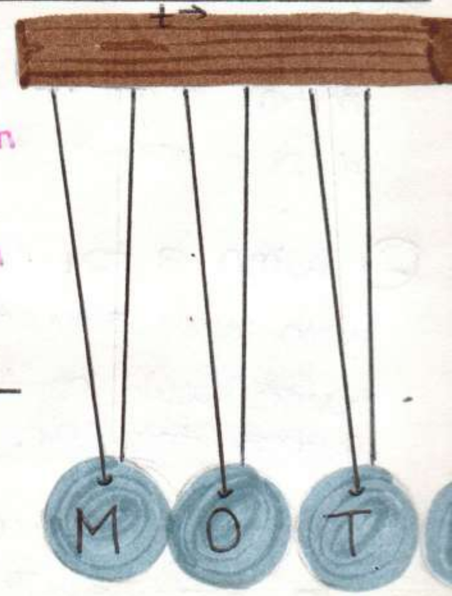
There are different ways to determine if motion occured.

- If we can clearly see that something is moving, that is, it is changing its position as time passes, then the object is in motion. Other wise, it is not in motion.



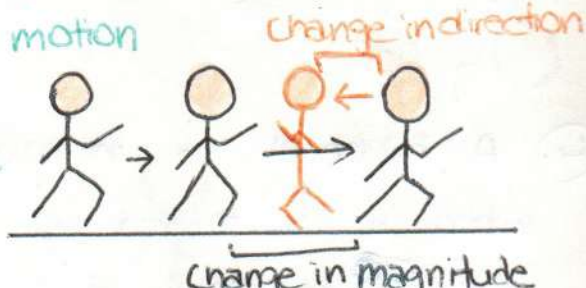
From graphs

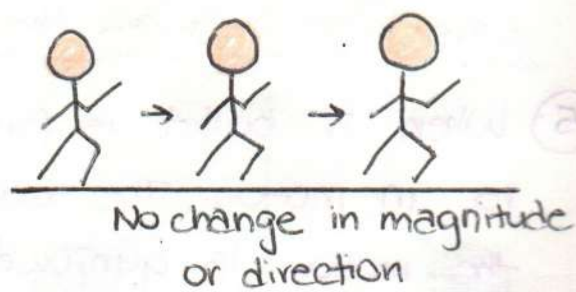


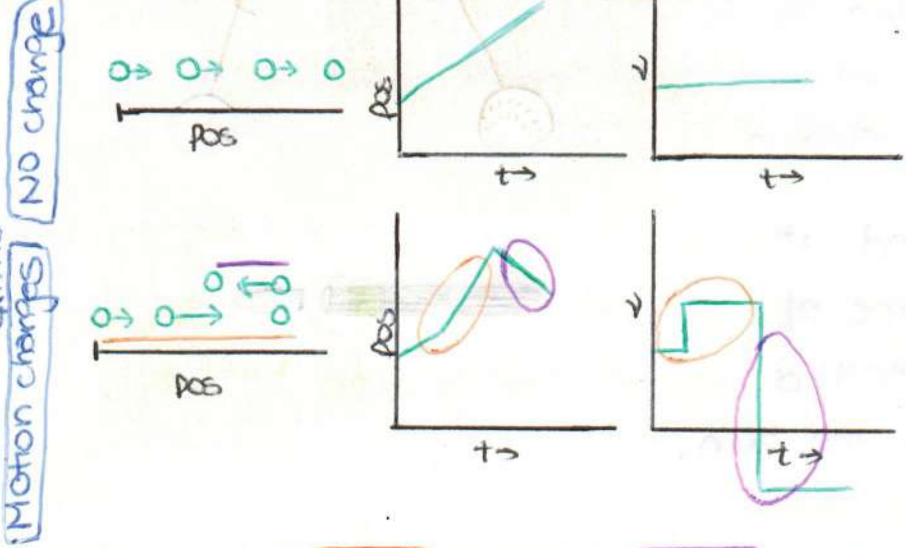


Q- What does it look like when motion changes?

If we are looking at an object and it speeds up or slows down (or stops) then the motion of the object has changed. Also, a change in direction is change in motion.

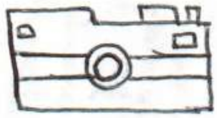


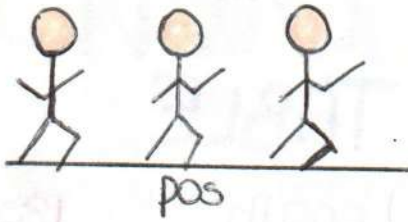




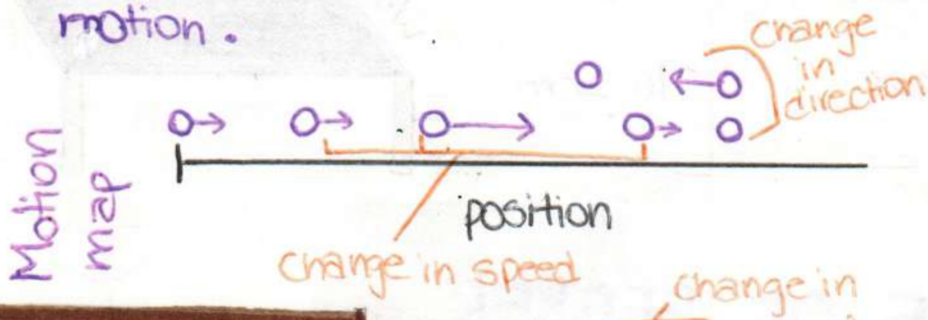
Q How can we document motion?

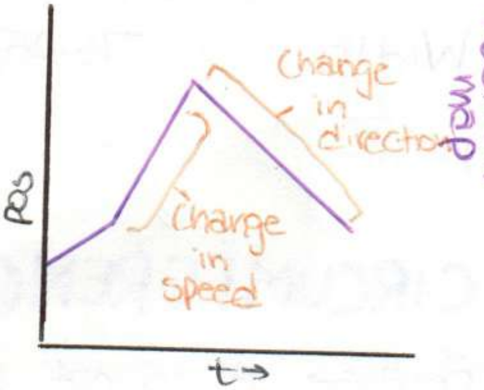
- In day to day routine you may take pictures of a moving object every time interval (or make video) to document motion.

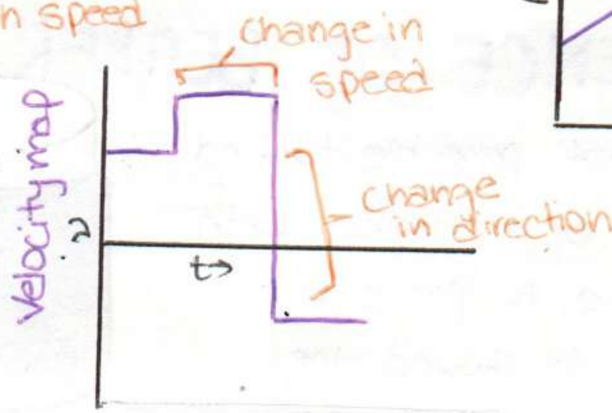


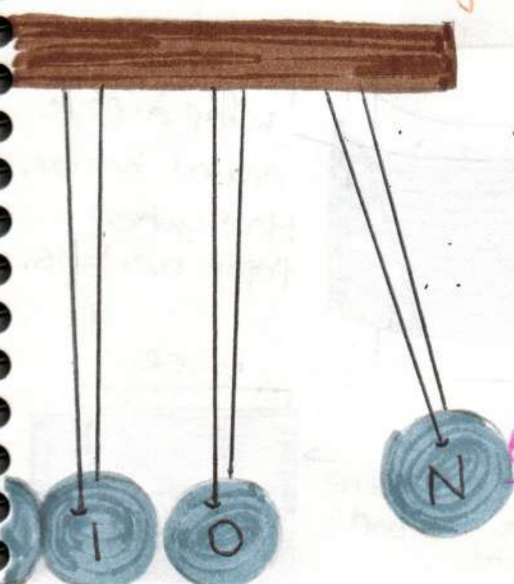


In physics, we use graphs to document motion.



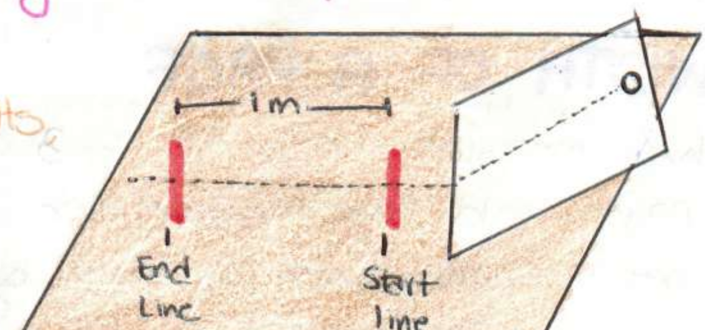






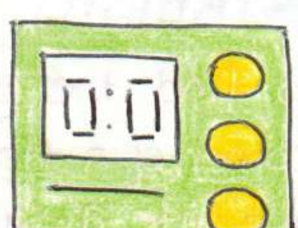
Q What are the challenges to measuring motion?

- We roll a marble down 3 different ramps (different heights, same length)



Challenges

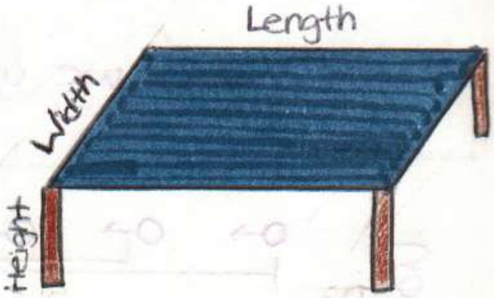
- Speed of marble poses a challenge. We do not know exactly when does marble start 1m and when it goes past 2nd tape. We cannot be that accurate.
- To make marble go in a straight line is difficult.



MEASUREMENTS

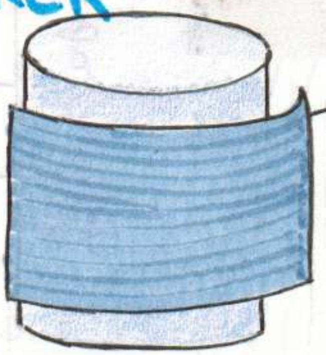
TABLE

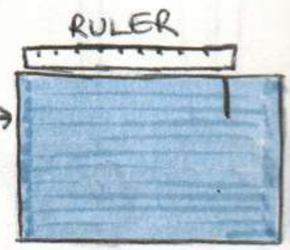
Length	182.95 cm	182.9 cm
Width	76.25 cm	76.2 cm
Height	76.15 cm	76.2 cm



CIRCUMFERENCE OF BEAKER

Because it is not possible to find the circumference of a beaker with a ruler, we take a piece of paper and wrap it around the beaker and mark it. Now with a ruler we can measure it.

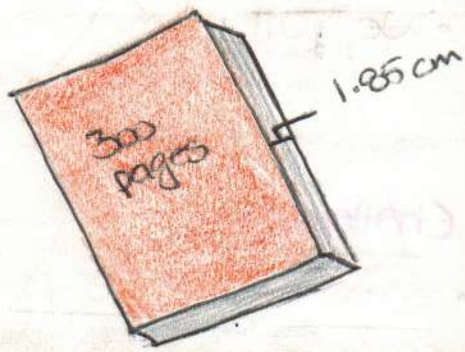




Circumference	21.95 cm	21.9 cm

WIDTH OF A PAGE

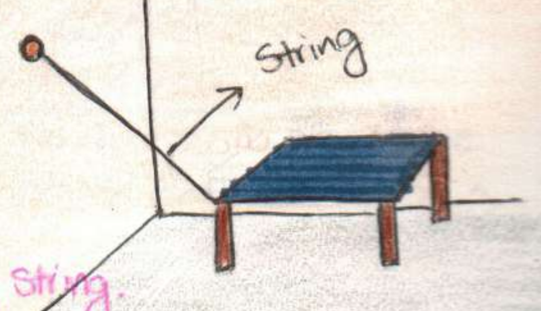
We measure the width of 300 pages held together. We then get 1.85 cm, which we divide by 300.



Width of 1 page	0.00617 cm	0.0060 cm

STRAIGHT LINE DISTANCE

To find the distance between a corner of a table and a point on wall, we use a string & measure the distance and then ruler to measure length of string.

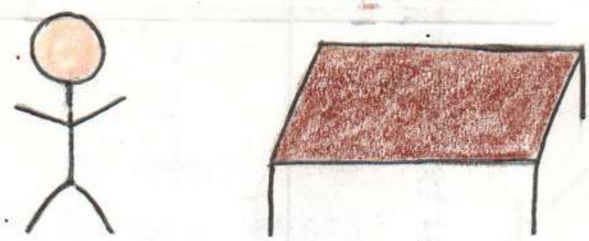


WHERE ARE YOU GOING

FIRST DISCUSSION

Position

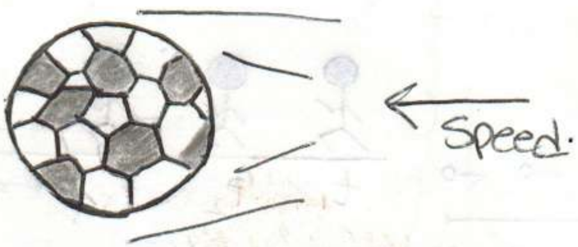
This is where an object is with respect to another object.



For example – Boy is next to the table

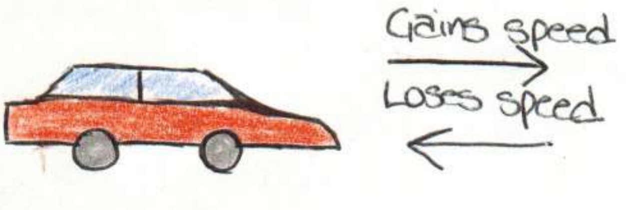
Velocity

It is a measure of how fast something moves.



Acceleration

It is the measure of how fast something gains or loses speed.

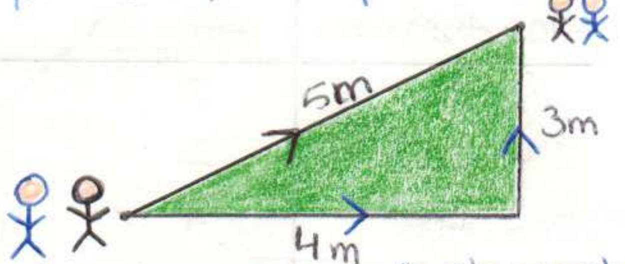


SECOND DISCUSSION

Distance – Scalar
Displacement – vector

Position

It is the location of an object from a reference point.

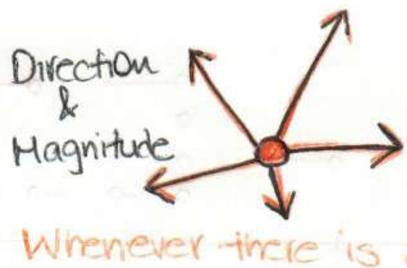


Both have same displacement but different distances travelled

Velocity

Δ displacemet

Change in position of an object over time. It is vector, that is, has both direction & magnitude.

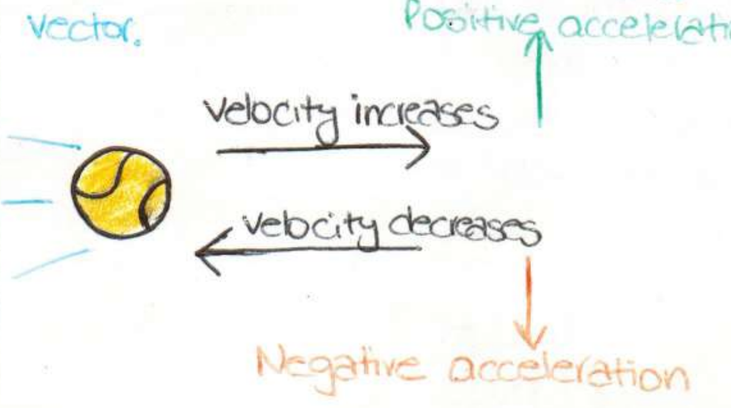


Velocity = displa / time

Whenever there is a displacement, velocity is involved.

Acceleration

Change in velocity over time is called acceleration. It is also a vector.



MAPPING

Motion map - It shows where something was and its direction of travel

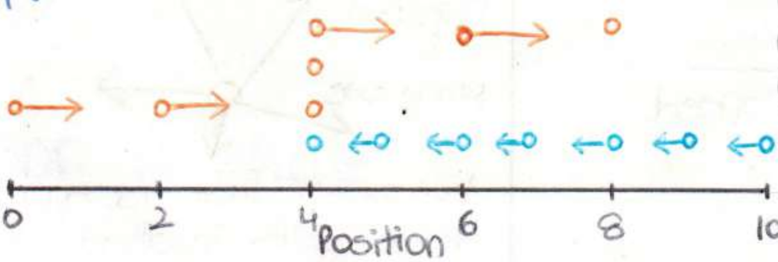
Position map - It is the plot of position vs. time with a single line drawn.

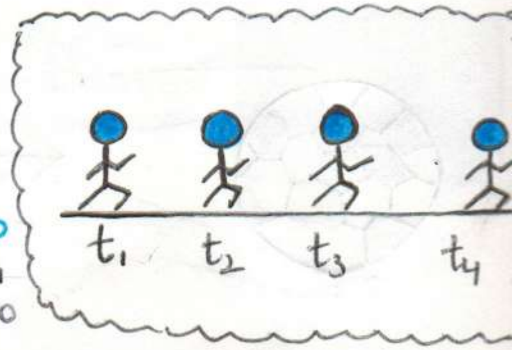
DATA

location (m)	time (s)
0	0
2	2
4	4
4	6
4	8
6	10
8	12

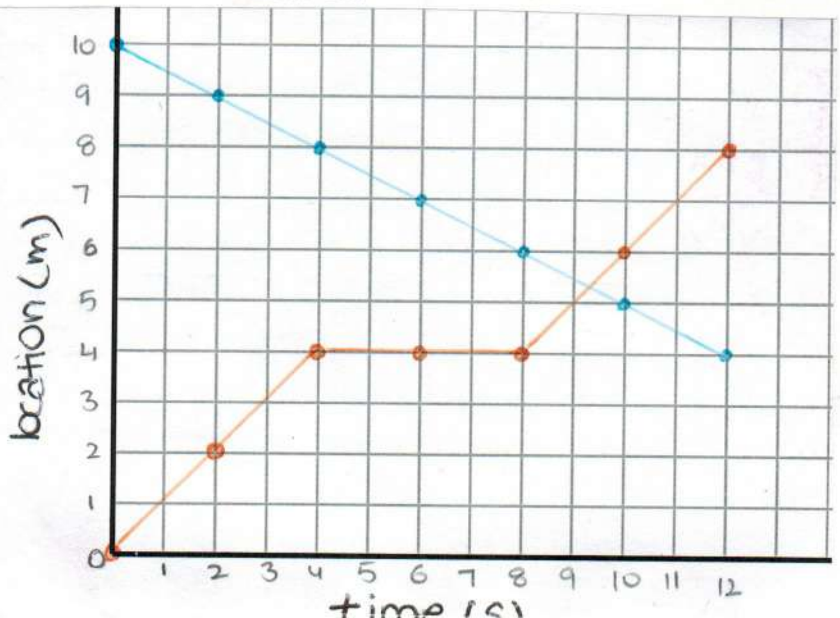
location(m)	time(s)
10	0
9	2
8	4
7	6
6	8
5	10
4	12

Motion Map:





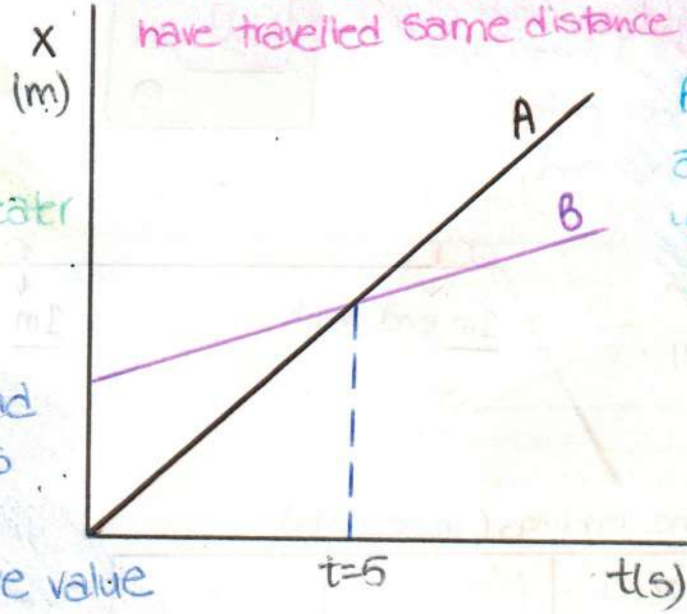
Position Map:



WORKSHEET

When lines intersect at t=5, Both A and B meet; that is, they have travelled same distance at t=5s.

At t=3s, A is travelling faster than B as slope of line (speed) is greater than that of B.



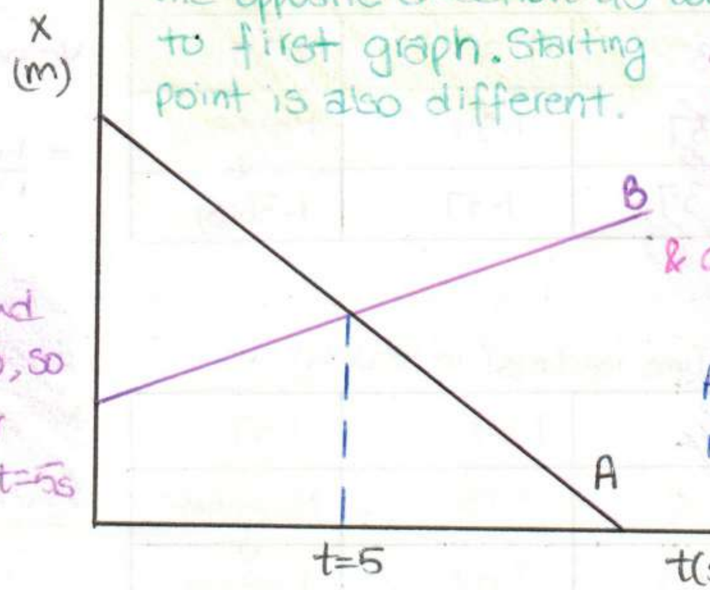
At t=7s, A is ahead of B as the 'y' value (distance) o
A is greater than B

'B' starts ahead of A as A starts at x=0, while B starts at a positive value

Their velocities are not equal at any point as slope of both A
B don't change an
slope of line A is st
A travels faster throu

'A' is going at higher speed as the line representing A has steeper slope than that of B.

In this graph A is going in the opposite direction as compared to first graph. Starting point is also different.



'B' is starting at same point and going in same direc
& at same speed as first graph.

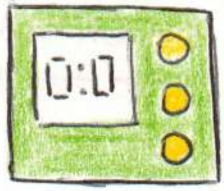
Since A has greater speed throughout and t=5s for both A & B, so A travelled greater distance than B at t=5s

At point of intersect
A & B meet, that is
both are at same
location after t=

MEASURING VELOCITY

- We set up a ramp.
- Next, we put tape on start and end points for 1 meter.
- Measure 10 time readings for 1m. Find average time and then find velocity.
- Then set up 2 more ramps and repeat all steps given above.

Timer



RAMP 1

Time readings (in seconds)

1.90	1.86	1.9	1.9
1.86	1.68	1.9	Mean time ↓
1.80	1.80	1.9	1.85 (s)

Velocity = $\frac{\text{displacement}}{\text{time}}$

$= \frac{1.00m}{1.85s} = 0.541\ m/s$

RAMP 2

Time readings (in seconds)

1.34	1.37	1.37	1.37
1.37	1.37	1.34	Mean time ↓
1.37	1.37	1.37	1.36(s)

Velocity = $\frac{\text{displacement}}{\text{time}}$

$= \frac{1.00m}{1.36s} = 0.735\ m/s$

RAMP 3

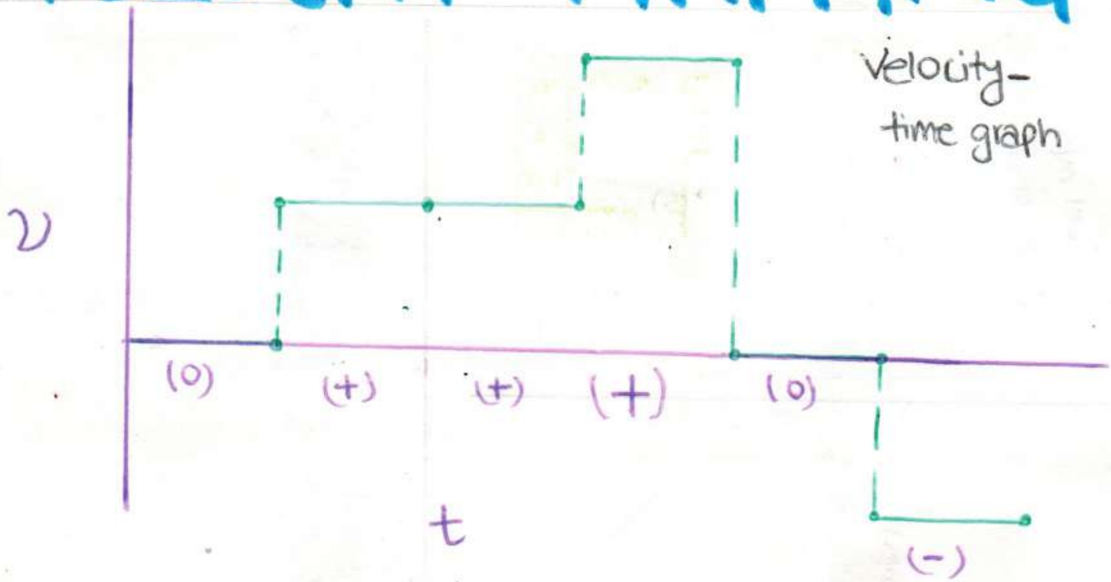
Time readings (in seconds)

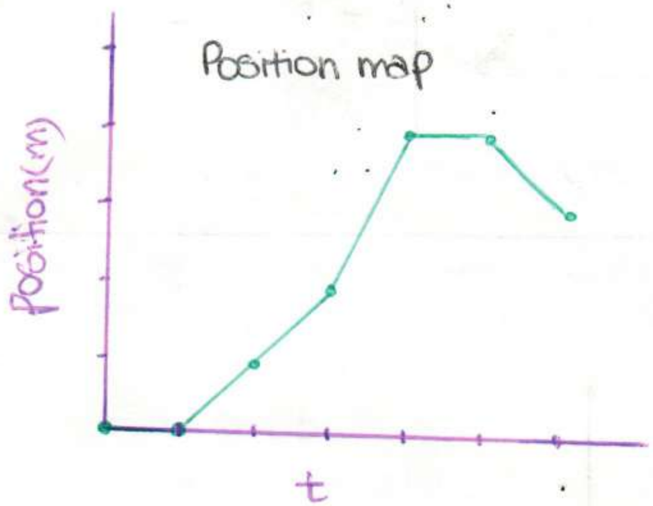
1.09	1.02	1.09	1.09
1.06	1.06	1.18	Mean-time ↓
1.06	1.09	1.09	1.08(s)

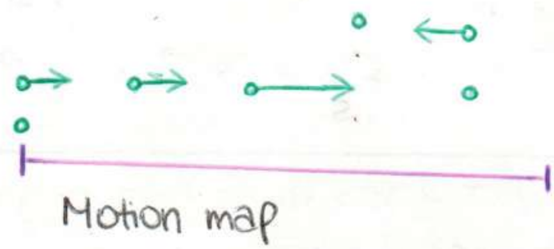
Velocity = $\frac{\text{displacement}}{\text{time}}$

$= \frac{1.00m}{1.08s} = 0.926\ m/s$

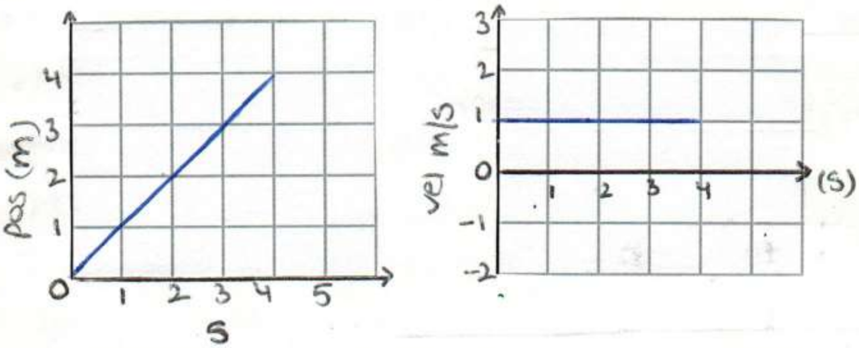
VELOCITY MAPPING

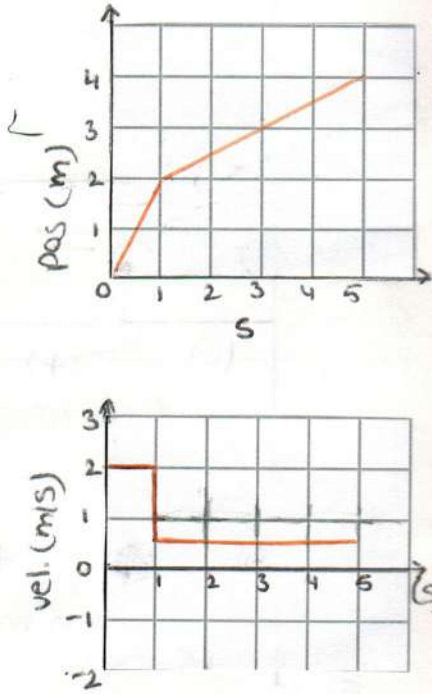


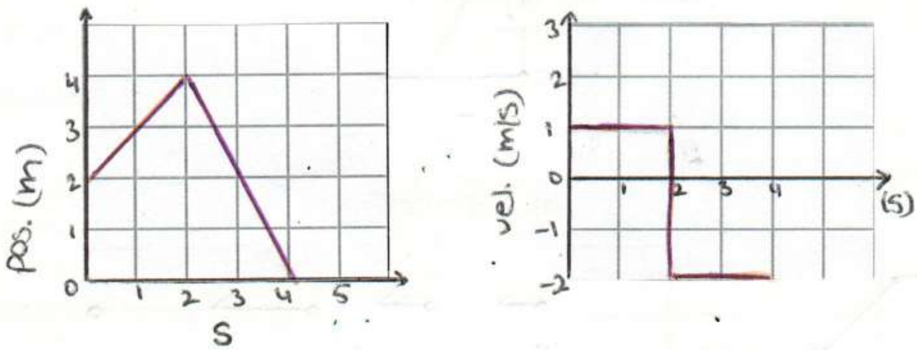




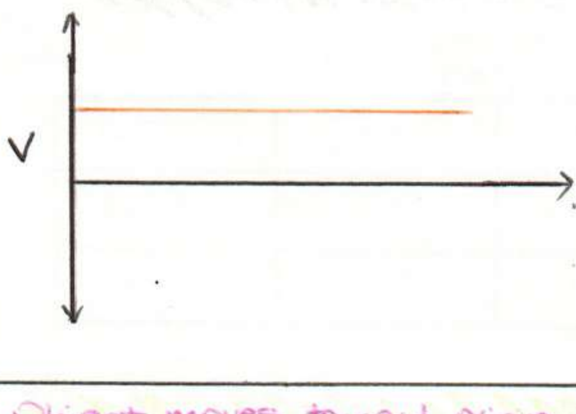
WORKSHEET



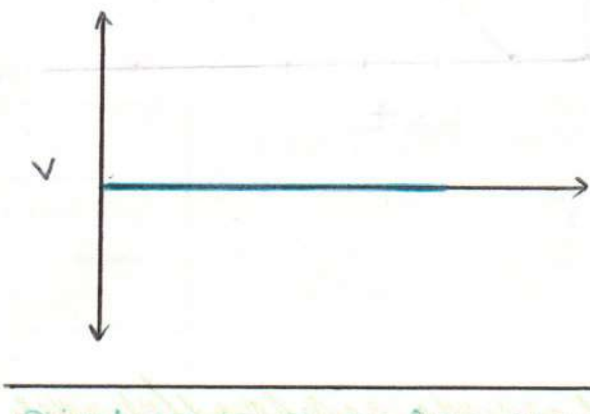




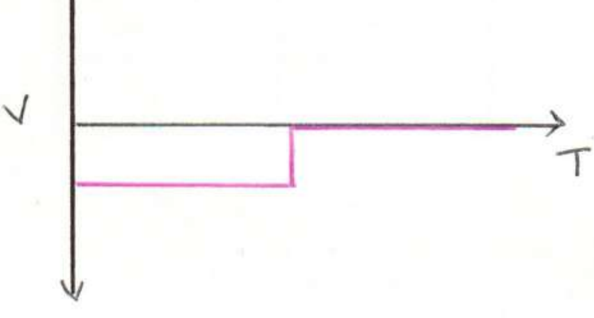
Object moves away from origin at constant speed



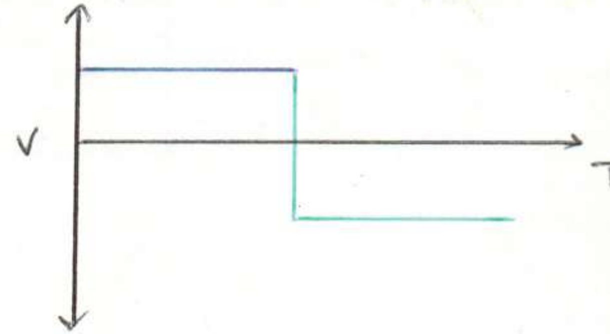
Object stands still



Object moves toward origin at steady speed for 10s, then stands still for 10s.



Object moves away from origin at steady speed for 10(s), reverses direction & moves back towards origin at same speed



MOTION IN 1D

Picture → List variables → Fill in known values → Formula → Plug in numbers (with units)

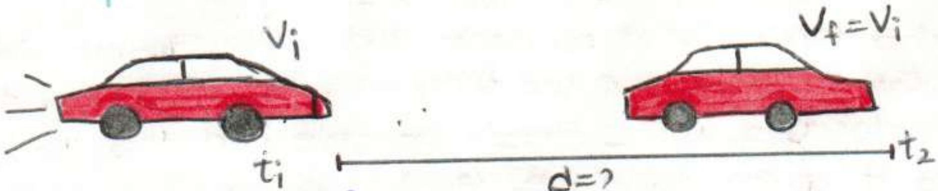
$V_i = 17 m/s$ | $d \rightarrow$ not needed
$V_f = ?$
$a = 2.3 m/s^2$
$t = 17s$

$V_i = V_f + at$

$V_f = 17m/s + 2.3m/s^2 (17s) \Rightarrow \boxed{V_f = 56.1 m/s}$

①

$V_i = 15.2 m/s$ | $t = 0.75$
$V_f \rightarrow$ not needed | $d = ?$
$a = 0 m/s^2$

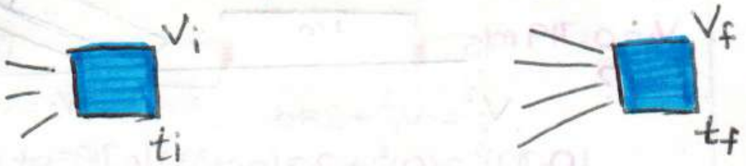


$d = V_i t + \frac{1}{2} a t^2$

$d = 15.2 m/s (0.75s) + \frac{1}{2} (0 m/s^2)(0.75^2 s) \Rightarrow \boxed{d = 11.4 m}$

②

$V_i = 32 m/s$ | $t = 8.0s$
$V_f = 96 m/s$ | $d \rightarrow$ not needed
$a = ?$



$V_f = V_i + at$

$= 32 m/s + a(8.0s) \Rightarrow a = \frac{96 - 32}{8.0} = \boxed{8.0 m/s^2}$

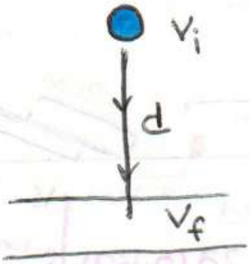
③

$V_i = 0 m/s$ | $t =$ Not needed
$V_f = 600 m/s$ | $d = 0.9m$
$a = ?$

$V_f^2 = V_i^2 + 2ad$

$a = \frac{V_f^2 - V_i^2}{2d} = \frac{360000 - 0}{1.8} = \boxed{200,000 m/s^2}$

④



$V_f^2 = V_i^2 + 2ad$

$V_f^2 = 0^2 + 2(9.81)(12)$

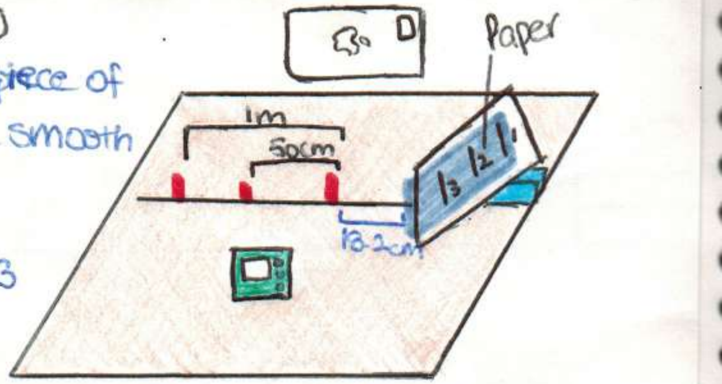
$\sqrt{V_f^2} = \sqrt{235.44} m/s \Rightarrow \boxed{V_f = 15.3 m/s}$

$V_i = 0 m/s$ | $t \rightarrow$ not needed
$V_f = ?$ | $d = 12 m$

SUMMATIVE TASK

THE SETUP & DIFFICULTIES FACED

- A white board is used as ramp. A piece of paper is put on the ramp to provide smooth transition from ramp to table.
- We start with marble at 3 different heights. We put lines on paper at these 3 points and use a ruler a barrier and lift it to ~~let~~ marble roll.

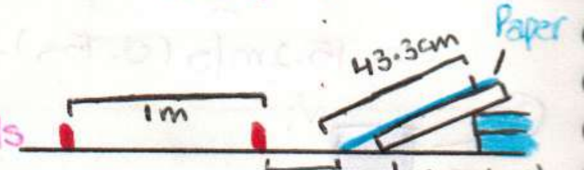


- Because at slower speeds friction plays a larger part for Ramp 3, we use distance of 0.5m, while we use 1m for Ramp 1 & 2.
- To monitor time, we start a timer, put it on table, and make slo-mo video of marble rolling across our distances. We use timer in video to get our 't'.
- From 'd' and 't' we find velocity of marble across the table and this is final velocity of marble as it comes down the ramp.

RAMP 1

	T_i (s)	T_f (s)	$T_f - T_i$ (s)	Average t (s)	Velocity (m/s)
1	3.80	5.19	1.39	$\frac{1.39+1.37+1.40}{3}$ = 1.39	$\frac{1.00}{1.39}$ = 0.719
2	2.22	3.59	1.37		
3	2.95	4.35	1.40		

$V_i = 0$ m/s
$d = 0.433$ m
$V_f = 0.719$ m/s
$a = ?$



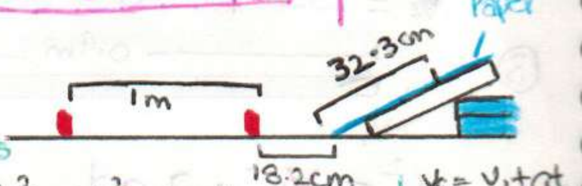
$$V_f^2 = V_i^2 + 2ad$$
$$(0.719)^2 = (0)^2 + 2a(0.433)$$
$$0.517 = 0 + 0.866a$$
$$\boxed{a = 0.597 \text{ m/s}^2}$$

$$V_f = V_i + at$$
$$0.719 = 0 + 0.597t$$
$$t = 1.20 \text{ s}$$
(time on ramp)

RAMP 2

	T_i (s)	T_f (s)	$T_f - T_i$ (s)	Average t	Velocity (m/s)
1	3.37	4.9	1.56	$\frac{1.56+1.54+1.54}{3}$ = 1.55	$\frac{1.00}{1.55}$ = 0.645
2	3.05	4.59	1.54		
3	1.51	3.85	1.54		

$V_i = 0$ m/s
$d = 0.323$ m
$V_f = 0.645$ m/s
$a = ?$



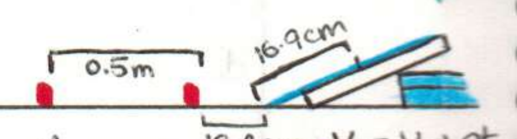
$$V_f^2 = V_i^2 + 2ad$$
$$(0.645)^2 = (0)^2 + 2a(0.323)$$
$$0.416 = 0 + 0.646a$$
$$\boxed{a = 0.644 \text{ m/s}^2}$$

$$V_f = V_i + at$$
$$0.645 = 0 + 0.644t$$
$$t = 1.00 \text{ s}$$
(time on ramp)

RAMP 3

	T_i (s)	T_f (s)	$T_f - T_i$ (s)	Average t	Velocity (m/s)
1	0.50	1.50	1.00	$\frac{1.00+1.03+1.00}{3}$ = 1.01	$\frac{0.50}{1.01}$ = 0.495
2	2.90	3.93	1.03		
3	2.37	3.37	1.00		

$V_i = 0$ m/s
$d = 0.169$ m
$V_f = 0.495$ m/s
$a = ?$

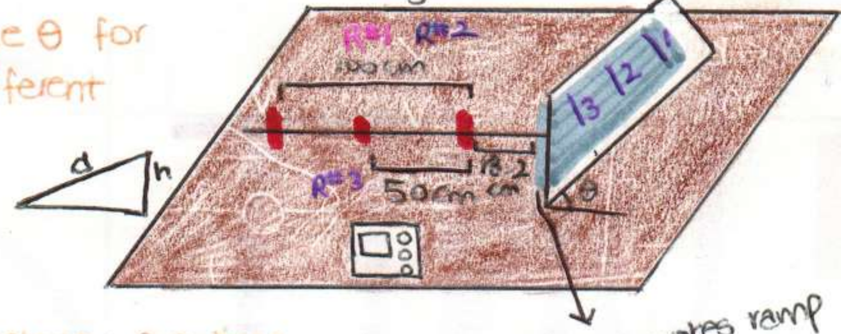


$$V_f^2 = V_i^2 + 2ad$$
$$(0.495)^2 = (0)^2 + 2a(0.169)$$
$$0.245 = 0 + .338a$$
$$\boxed{a = 0.725 \text{ m/s}^2}$$

$$V_f = V_i + at$$
$$0.495 = 0 + 0.725t$$
$$t = 0.683 \text{ s}$$
(time on

TASK REPORT

Q- How is acceleration connected to velocity?



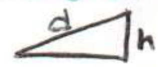
<u>Evidence</u>- We did not change angle θ for the ramp. We only used 3 different points on ramp, thus changing 'd' and height(h) to get different velocities and thus different accelerations because acceleration is the change in velocity over time.

The velocity of marble across the table is also its final velocity off the ramp.

DATA COLLECTED

	Length of Ramp	V_i	V_f	Acceleration
R#1	.433 m	0	0.719 m/s	0.597 m/s²
R#2	.323 m	0	0.645 m/s	0.644 m/s²
R#3	.169 m	0	0.495 m/s	0.725 m/s²

• Velocity of marble increases with increase in 'd' and 'h'



<u>Claim</u> - Acceleration is the change in velocity over time

$$a = \frac{V_f - V_i}{t}$$

<u>Reasoning</u>- • We roll the marble from a ramp. It accelerates down the ramp and travels across the table with a certain velocity - we find this velocity using distance covered by marble across the table ('d' is used for R#1 & R#2, d for R#3) and time taken. $V = \frac{\Delta d}{t}$