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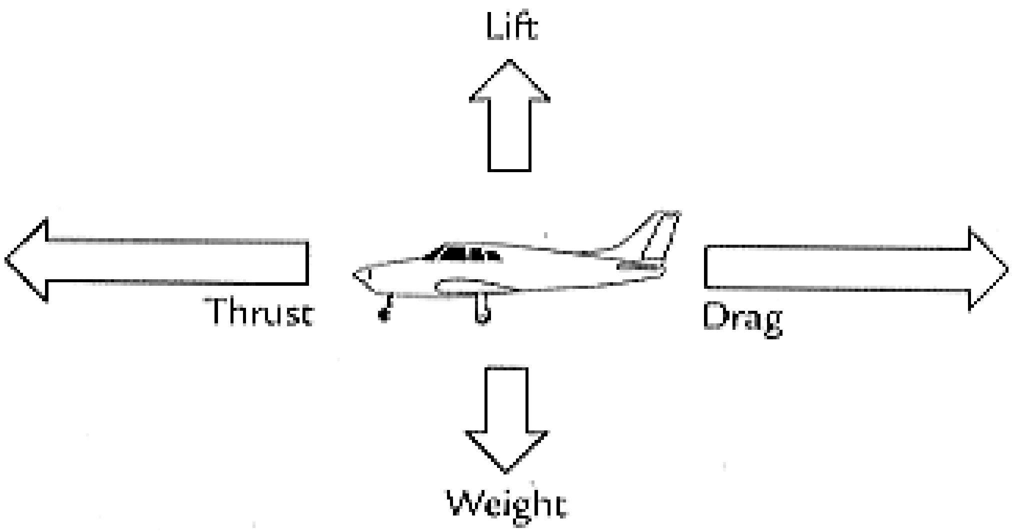
IGCSE Physics



Unit 1 – Forces and Motion

Name: ....

Class: ....

Summary

Topic	Objectives - Students will be assessed on their ability to:
1 - Measuring Speed	• use the following units: kilogram (kg), metre (m), metre/second (m/s), metre/second^2 (m/s^2), newton (N), second (s) • know and use the relationship between average speed, distance moved and time taken $v = \frac{x}{t}$
2 - Acceleration	• know and use the relationship between acceleration, velocity and time taken $a = \frac{\Delta v}{t}$
3 – Graphing Motion	• plot and interpret distance-time and velocity – time graphs • determine acceleration from the gradient of a velocity – time graph and the distance travelled from the area between the graph and the time axis
4 - Equation of Motion	• Use the relationship between final speed, initial speed, acceleration and distance. $v^2 = v_o^2 + 2ax$
5 - Forces	• express a force as a push or pull of one body on another • know that forces can change an objects; shape, speed and direction • identify various types of force (e.g. gravitational, electrostatic etc) • distinguish between vector and scalar quantities • find the resultant force of forces that act along a line
6 - Newton's Laws of Motion	• know and understand Newton's First Law • Newton's Second Law: know and use the relationship between unbalanced force, mass and acceleration: force = mass × acceleration, $F = m\,a$ • demonstrate an understanding of Newton's Third Law
7 - Friction	• understand that force is a vector quantity • understand that friction is a force that opposes motion
8 - Mass and Weight	• know and use the relationship between weight, mass and g: $w = m\,g$ • understand gravitational field strength, g, and recall that it is different on other planets and the moon from that on the earth
9 - Free Fall	• investigate the motion of falling • describe the forces acting on falling objects and explain why falling objects reach a terminal velocity
10 - Momentum	• know and use the relationship between momentum, mass and velocity $p = m\,v$ • use the conservation of momentum to calculate the mass, velocity or momentum of objects • use the relationship between force, change in momentum and time taken $F = \frac{\Delta p}{t}$

11 – Road Safety	• use the ideas of momentum to understand safety features • describe the factors affecting the stopping distance of a vehicle, including; speed, mass, road condition and reaction time.
12 - Hooke's Law	• describe experiments to investigate how extension varies with applied force for helical springs and metal wires • understand that the initial region of a force-extension graph is associated with Hooke's law
13 - Non-Hookian Materials	• describe how extension varies with applied force for rubber bands • associate elastic behaviour with the ability of a material to recover its original shape after the forces causing deformation have been removed
14 - Moments	• know and use the relationship between the moment of a force and its distance from the pivot. $\tau = Fr$ • know and use the principle of moments for a simple system of parallel forces acting in one plane
15 - Centre of Gravity and Stability	• recall that the weight of a body acts through its centre of gravity • understand that the upward forces on a light beam, supported at its ends, vary with the position of a heavy object placed on the beam

PW – Updated Sept 2022

Supporting resources are available on the website www.islandphysics.com

The intention is that this booklet will be a complete set of class notes and lab work, which should help with revision. Homework will be supplied independently. The emphasis this year will be on a more independent learning approach by students.

Grading: all the graded work has an oval space at the bottom. Grading is done in the same manner as the examiners do on the final exam (i.e. diagrams (2), short answer (1), long answer (varies), calculations (2 or 3), graphs (4 or 5)). Booklet grade is the mean value. I often award marks for quality of notes and include them in the adjoining classwork. All grades are recorded on Saltus Live and your termly reported grade is calculated as a 50-50 weighing between tests and 'interim' scores.

Percentage	Old style	New style
90%		
85%	A*	8
80%		
75%		7
70%	A	
65%		6
60%	B	
55%		5
50%	C	

Any sub-standard work will need to be re-done, and your advisor and/or parents may be notified

1 – Measuring Speed

Objectives:

- use the following units: kilogram (kg), metre (m), metre/second (m/s), metre/second^2 (m/s^2), newton (N), second (s)
- know and use the relationship between average speed, distance moved and time taken

The AC50s used in the America's Cup are the world's fastest sailing boats. How do you think that sailors and engineers could determine their speed? (2)

LAB 1.1: Measuring Speed of a Toy Car Circus

Scientific good practice: diagrams drawn assembled with a pencil and clearly labeled. (note: 2 marks)

A - Trundle Wheel

Diagram (2):

Instructions:

1. Use the trundle wheel and stopclocks to measure the time the car takes to travel a distance of 10 m. Use either the main hall or the roadway in front of the science building.

2. Show your calculations. Think about the number of significant figures that you should use. (2)

Experiment	Distance (m)	Time (s)	Speed (m/s)
1			
2			
3			

3. How could you improve the accuracy of your result? (1)

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B - Ticker Timer

Diagram (2):

Instructions:

1. The ticker timer puts a dot on the paper every 0.02 seconds (1/50th of a second)*
2. Tape a new length of ticker tape to the car, turn on the power supply and release the car.
3. How can you use this to calculate the speed of the car? Show the calculations. (2)

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**Actually, in Bermuda and the US it is 1/60th of a second, but the UK ones are 1/50th and this is what is used in the exam…*

C - Light Gate and Timer

Diagram (2):

Instructions:

1 Use the light gate and scalar timer to measure the time it takes the car to travel the length of the interrupt card. What is the distance that will be used in the equation?

$$v = \frac{x}{t}$$

Scientific good practice: units are only written in the column headers.

2 Show you calculations. Remember that 10 cm = 0.1 m. Think about the number of significant figures that you should use. (2)

Experiment	Distance (m)	Time (s)	Speed (m/s)
1			
2			
3			

3 How accurate do you think this is and why? (2)

....

....

D - Light gates and data logger I

Diagram (2):

Instructions:

1 Let the car move through the light gate. Record the time from the data logger

2 Calculate the speed, remembering that 10 cm = 0.1 m. Show you calculations. Think about the number of significant figures that you should use. (2)

Experiment	Distance (m)	Time (s)	Speed (m/s)
1			
2			
3			

3 How could this method be improved? (1)

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E - Metre Ruler and Stopclock

Diagram (2):

Instructions:

1. Run the car over a distance of 1.0 m. Think about where the measurements should be in order to be accurate. (i.e. from the front or back of the car?)

2. Measure the time using a stopclock. Show the steps in your calculations. Think about the number of significant figures. (2)

Experiment	Distance (m)	Time (s)	Speed (m/s)
1			
2			
3			

3. How could you improve the accuracy of your result? (1)

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F - Light Gates and Data Logger II

Diagram (2):

Instructions:

1. Run the car through the light gates. Record the time and the speed.

2. Use the equation to calculate the speed and compare with the value from the data logger. Think about the number of significant figures that you should use. (2)

Experiment	Distance (m)	Time (s)	Speed - calc (m/s)	Speed – logged (m/s)
1				
2				
3				

3. What factors affect the accuracy of your result? (1)

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G - VideoPhysics App on the iPad (or VidAnalysis for Android)

Diagram (2):

Instructions:

1. Load up the VideoPhysics app and arrange the car and metre ruler so that the iPad sees them square on. Angles can reduce the accuracy of the data.
2. Video the car moving along the bench. KEEP THE IPAD STILL!
3. Use the app functions to first calibrate the distance using the meter ruler in the video.
4. Click through the frames pinpointing a specific point on the car in each frame (e.g. the light at the top).
5. Scrolling through the graphs should give you an average speed! (1)

6. Think about the number of significant figures that you should use. (1)

Surprisingly, most phones now have a better video quality than the iPads. The smaller screen makes the analysis harder to do, so for higher speed applications, it is often better to record the video on a phone, and transfer to the iPad to do the analysis.

Alternatively, video analysis like this can also be done on a laptop using software called Tracker. Download free from:

https://physlets.org/tracker/

CW 1.1 - Calculating Speed

Remember to show equation, working, and answer with units.

1. Calculate the speed in the following cases – remember to show equation and working (12):

a) 16 m in 4 s	b) 100 m in 5 s	c) 90 m in 3 s
d) 36 m in 18 s	e) 60 miles in 2 hours	f) 340 km in 4 hours

2. Explain:

    a) The difference between average speed and instantaneous speed. (2)

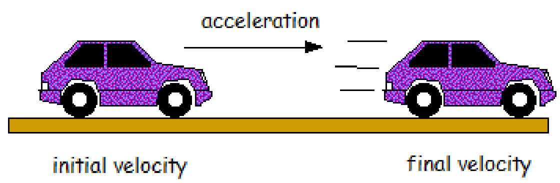
    b) The difference between speed and velocity. (2)

2 - Acceleration

Objectives:

- know and use the relationship between acceleration, velocity and time taken

Notes:



$$a = \frac{\Delta v}{t}$$

LAB 1.2 - Measuring Acceleration

A: Measuring Acceleration using the Equation

Aim: To use the data loggers and the equation for acceleration to determine the acceleration of a trolley.

Method: In order to measure the acceleration of an object we need to be able to measure the initial and final speeds and the time interval between them. This can be done using a data logger set up with TWO light gates. As the trolley passes through each light gate the data logger records the speed and as it passes through the second, the time interval is also recorded.

Diagram: (2)

Lab notes and calculations: (2)

B: Measure Acceleration Directly

Aim: To use the data logger to measure the acceleration directly. *This will be of great benefit later in the unit so worth getting right!*

Method: If we replace the single interrupt card that cuts the light gate with a double interrupt card, then the speeds of each of the upper sections is recorded by the data logger along with the time interval between them. Obviously we need a fast sample time to produce an accurate measurement! The data logger can be set up to calculate the acceleration internally.

Diagram: *(show details of the double interrupt card)* (2)

Lab notes and calculations: (2)

CW 1.2 - Calculating Acceleration

Remember to show equation, working, and answer with units.

1. Find the acceleration if the velocity changes from (12):

a) 2 m/s to 4 m/s in 4 s	b) 100 m/s to 120 m/s in 5 s	c) 11 m/s to 67 m/s in 3 s
d) 21 m/s to 35 m/s in 18 s	e) 124 m/s to 345 m/s in 12 s	f) 0 m/s to 12 m/s in 9 s

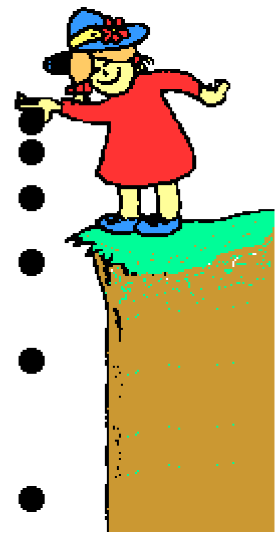
2. What is the acceleration of:

   a) A car reaching 20 m/s from rest in 3.2 seconds? (2)

   b) A car doing an emergency stop from 120 km/h in 3 seconds? Hint: change the unit! (2)

Extra Credit Challenge

Can you use the VideoPhysics app to measure the acceleration of a moving object? Use space below to show method and calculations.

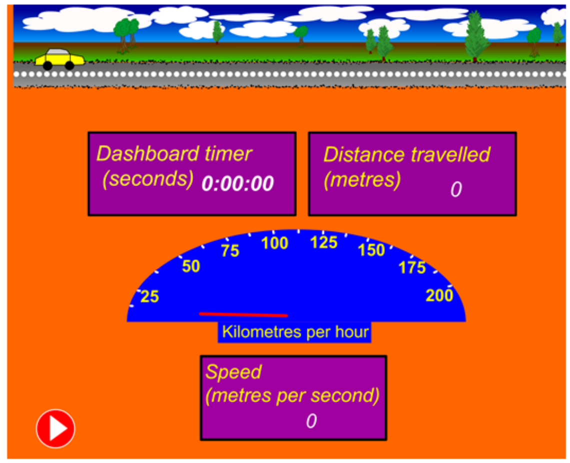


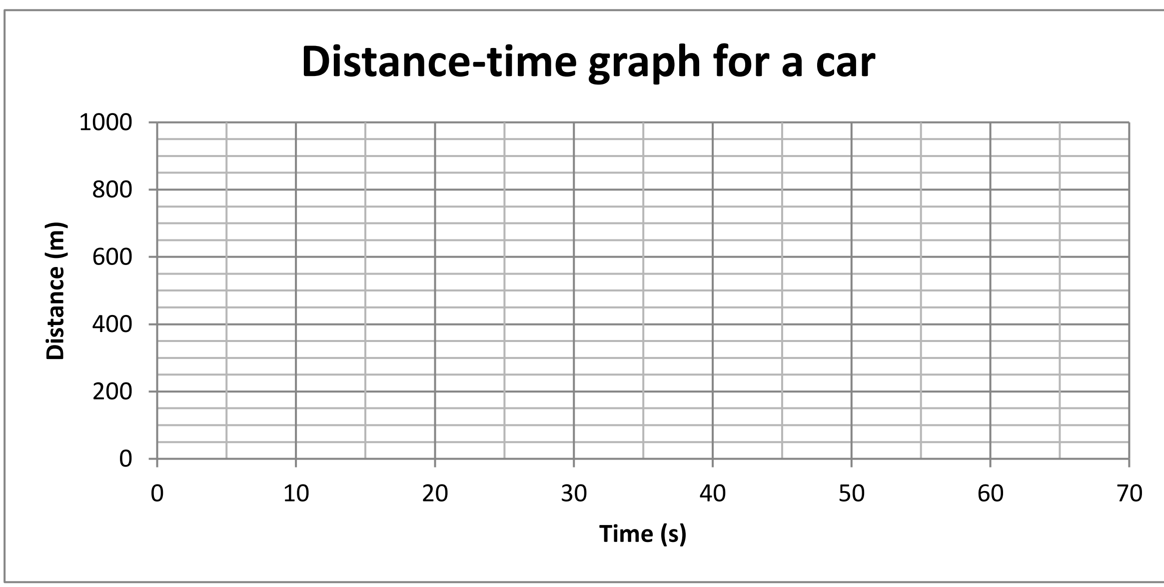
3 – Graphing Motion

Objectives:

- plot and interpret distance-time and velocity - time graphs
- determine acceleration from the gradient of a velocity - time graph and the distance travelled from the area between the graph and the time axis

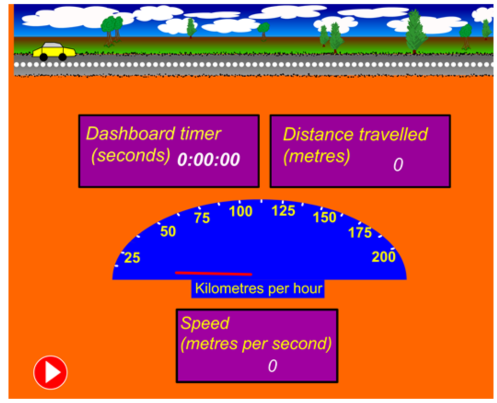
Time (s)	Distance (m)
0	0
5	16
10	76
15	186
20	334
25	484
30	634
35	784
40	904
45	974
50	994
55	994
60	994

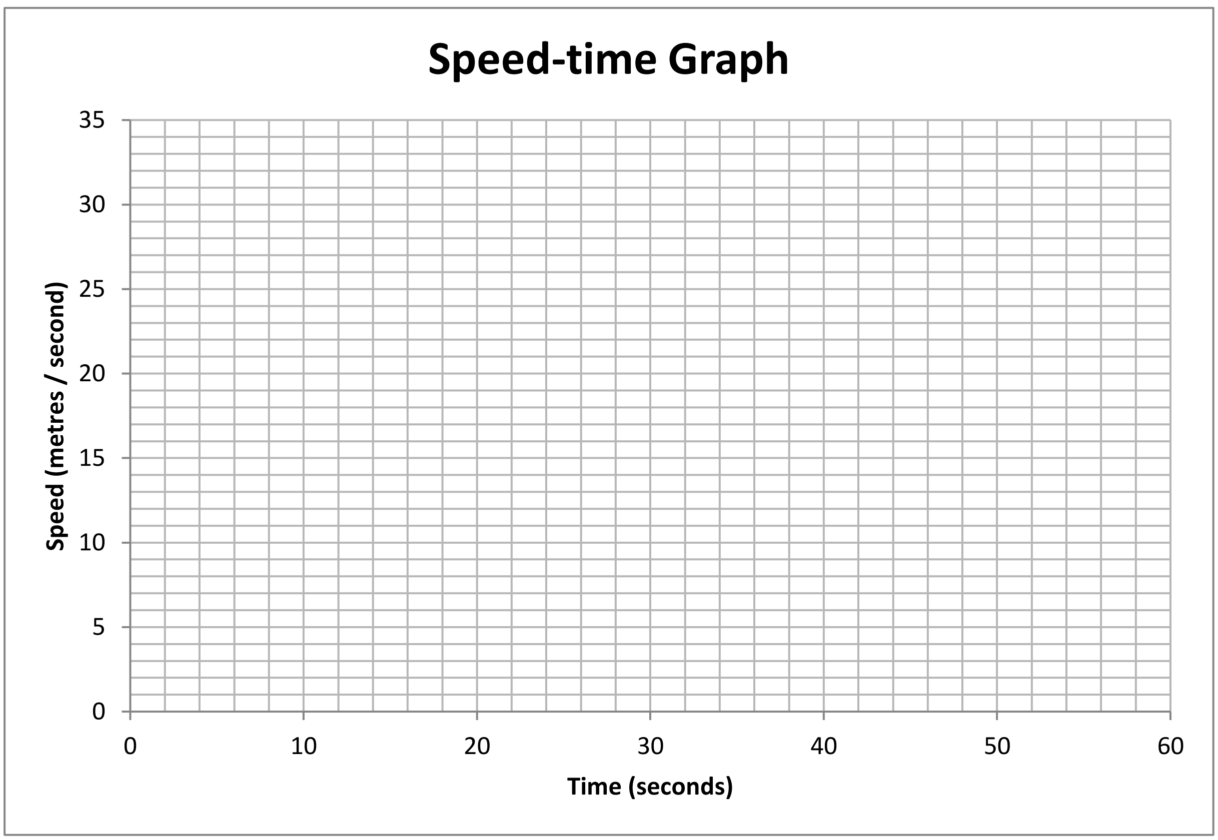




(4)

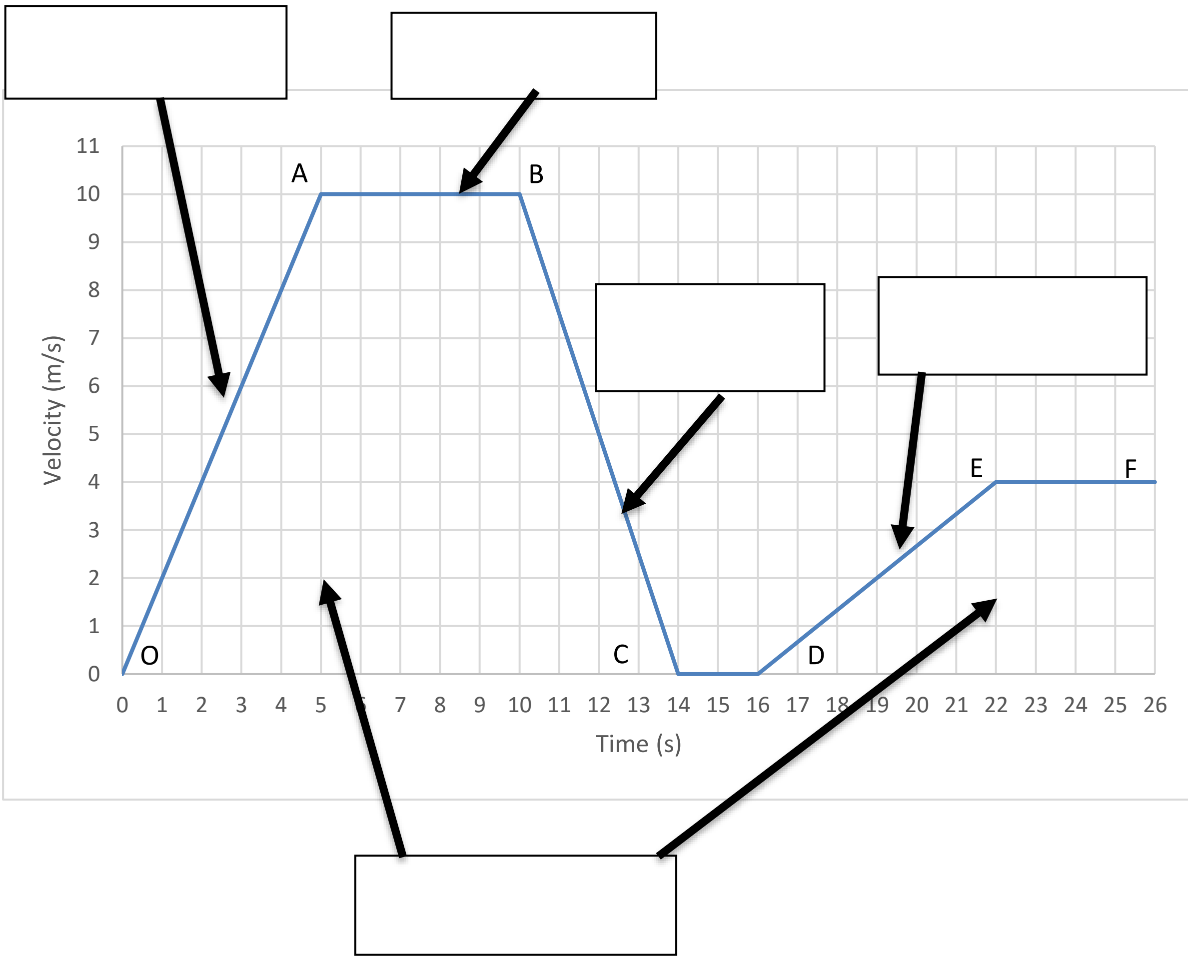
Time (s)	Velocity (m/s)
0	**0**
5	**6**
10	**16**
15	**26**
20	**30**
25	**30**
30	**30**
35	**30**
40	**20**
45	**10**
50	**0**
55	**0**
60	0





(4)

CW 1.3 – Graphing Motion



(5)

1. Calculate the accelerations
   a) O → A (2)

   b) A → B (2)

c) B → C (2)

d) C → D (2)

e) D → E (2)

f) E → F (2)

2. How can you tell from the graph that the accelerations O → A is greater than that from D → E? (1)

3. How far did the object travel in the 26 seconds? (2)

Properties of a velocity-time graph

Distance =

Acceleration =

4 – Equation of Motion

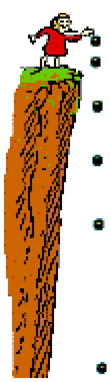
Objectives:

- Use the relationship between final speed, initial speed, acceleration and distance.

$$v^2 = v_o^2 + 2ax$$

$v_o =$	
$v =$	
$a =$	
$x =$	
$t =$	

So, if we know the height, initial velocity and the acceleration, we can determine the velocity of impact!



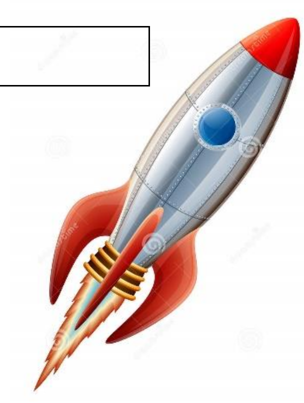
CW 1.4 – Equation of Motion

1. A road runner starts at rest and then accelerates at a rate of 6 m/s^2 over a distance of 100 m. What is its final velocity? (3)

v_o =	a =	x =

2. A rocket accelerates upwards from rest at a rate of 5 g (50 m/s^2) to a height of 1500 m. What is its final velocity? (3)

v_o =	a =	x =



3. Rearrange the equation to put x on the left hand side. (1)

4. A car is travelling at 20 m/s, when it decelerates at – 4 m/s^2. How far does it take to stop? (Braking distance!) (3)

v_o =	a =	v =

5. A diver dives from a cliff 20 m tall. If he accelerates at g = 10 m/s^2, what is the speed that he enters the sea? (3)

v_o =	a =	x =

Demonstration – Equation of Motion

Aim: To demonstrate that the equation of motion works for a freely falling object.

Method:

1. Set up a tube with a light gate mounted at the bottom of it.
2. Measure the length of the cylindrical object to be dropped down the tube. This is the value of the 'interrupt card' to be programmed into the data logger.
3. Measure the length of the tube, x.
4. Initial velocity, v_o, is zero as dropped from rest and acceleration, a, is g = 10 m/s^2.
5. Drop object and record the final velocity, v.

Diagram:

Data:

Length of tube (m)	**Expt 1**	**Expt 2**	**Expt 3**	**Mean velocity (m/s)**	**Predicted velocity (m/s)**

Evaluation:

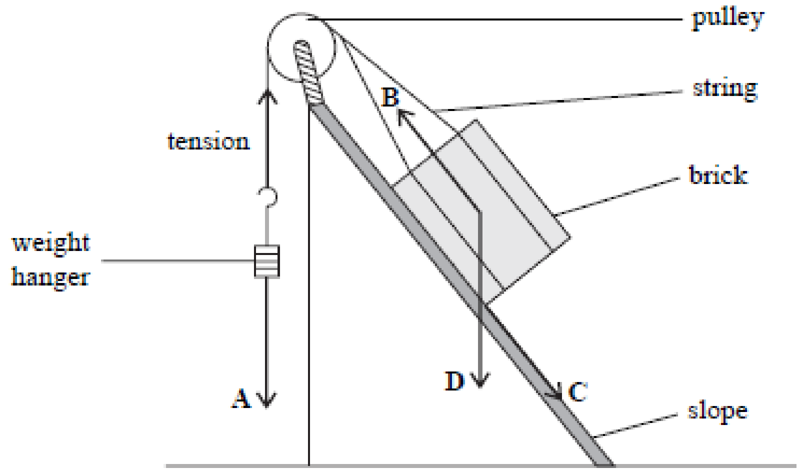
5 - Forces

Objectives:

- express a force as a push or pull of one body on another
- identify various types of force (e.g. gravitational, electrostatic etc)
- distinguish between vector and scalar quantities
- find the resultant force of forces that act along a line

CW 1.5 - Forces

1. Two students have made a model to demonstrate how egyptians dragged blocks of stone up a slope to build a pyramid. The set up is shown below. Some of the forces have been labeled with letters A – D.



a) Label the forces A, B, C and D on the brick with their correct names. (4)

A	C
B	D

b) One student removes some of the masses from the hanger so that the blocks start to slide down the slope. The upward tension in the string is 19 N and the force A is 25 N.

i) Calculate the resultant force on the mass hanger. (1)

ii) Will the hanger accelerates upwards, downwards or move at a constant velocity? Explain your answer (2)

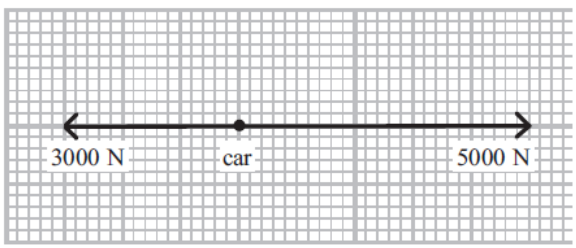
c) How could the students make it easier to pull the blocks up the slope? There are at least TWO methods. (2)

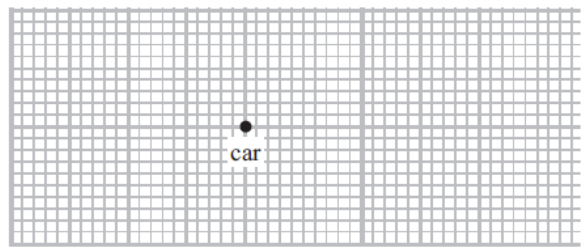
d) One force has been missed off the diagram above. Add the vector and label it (2)

2. A teacher has a new car. She drives the car along a horizontal road and the engine provides a driving force of 5000 N. At 30 mph the drag force is 3000 N.

a) Calculate the resultant force at this speed. (1)

b) The scale diagram below shows the two forces acting on the car. On the grid below, draw the resultant force to the same scale. (2)





3. Forces can change an object's: (3)

•
•
•

4. Forces, like velocity and acceleration, are vectors. Explain what is a vector. (2)

6 – Newton's Laws of Motion

Objectives:

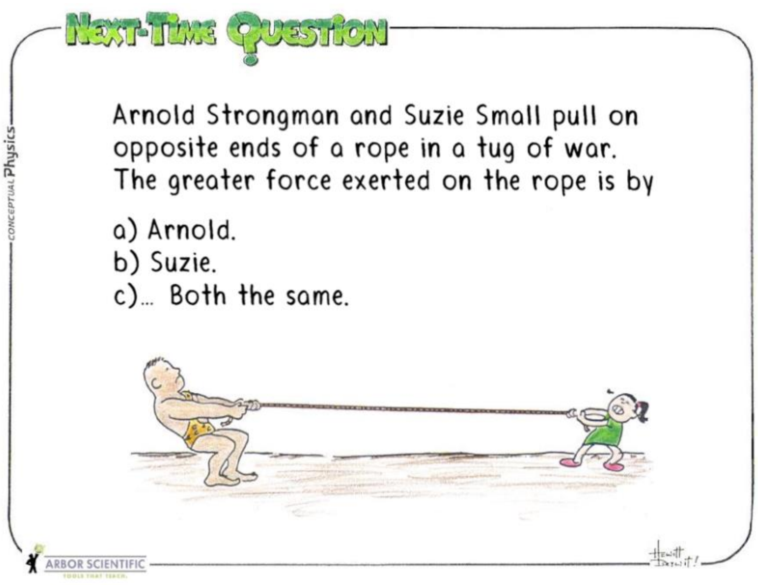
- know and understand Newton's First Law
- know and use the relationship between unbalanced force, mass and acceleration (Second Law)

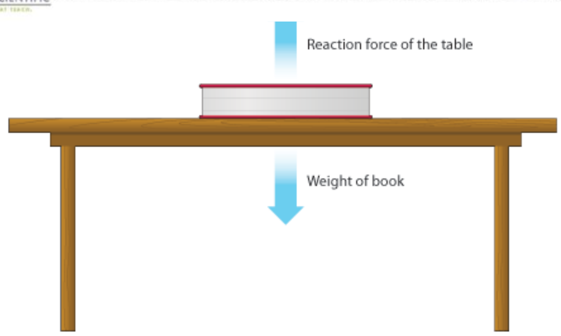
$$F = ma$$

- demonstrate an understanding of the Third Law

Notes:

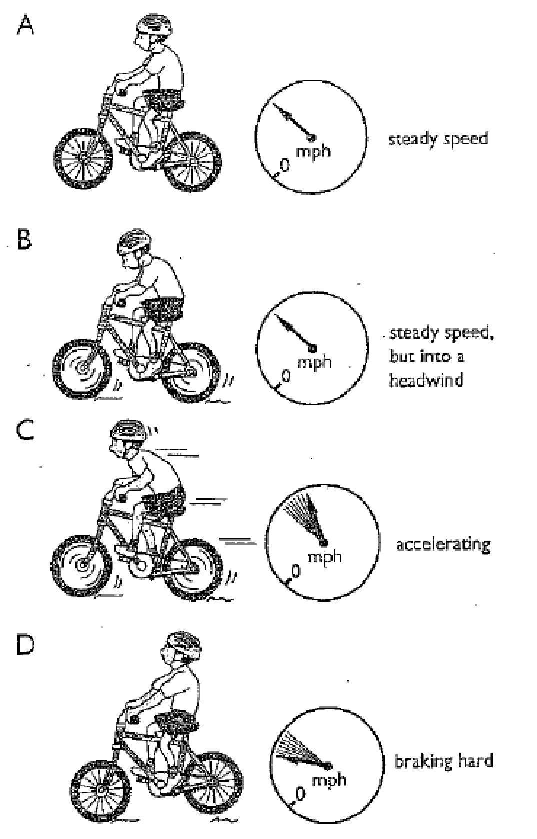
Newton's 1st Law
Newton's 2nd Law
Newton's 3rd Law


NEXT-TIME QUESTION
Arnold Strongman and Suzie Small pull on opposite ends of a rope in a tug of war. The greater force exerted on the rope is by
a) Arnold.
b) Suzie.
c)... Both the same.
CONCEPTUAL Physics
ARBOR SCIENTIFIC


Reaction force of the table
Weight of book

CW 1.6 – Newton's First Law

Look at the diagrams of the cyclists. For each diagram, draw a pair of arrows to show the horizontal forces acting on the bike using arrows like this: → Use the length of each arrow to represent the size of the force. (4)



Complete the following sentences (5):

1. To change an object's speed ....

2. A push or a pull ....

3. When the forces acting on a body cancel out they ....

4. When an unbalanced force acts on an object it ....

5. The greater the size of the unbalanced force ....

LAB 1.3 – Verifying Newton's Second Law (laptop)

Aim: To be able to use the scientific method, laptops and data loggers to verify Newton's second law of motion.

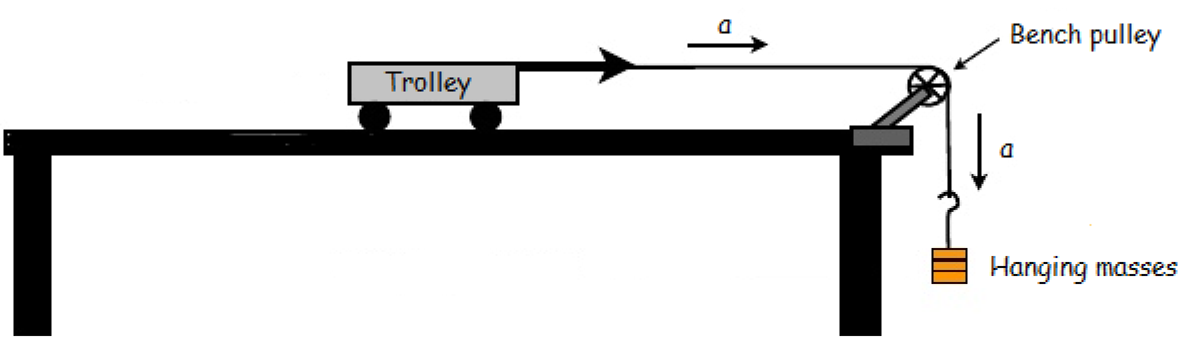
Method outline: You can now measure the acceleration of a trolley using a data logger. (see pages 14 - 15). Devise two sets of FAIR and ACCURATE tests to investigate:

a) the effect of increasing the force that is accelerating the trolley

b) the effect of increasing the mass of the trolley

You will be producing a detailed lab report on your investigation on your laptop. Please use a sensible 12 point font and include your detailed method, diagram, all raw data and mean data, the graphs to present the data (either by hand or using EXCEL), and your detailed conclusion and evaluation.

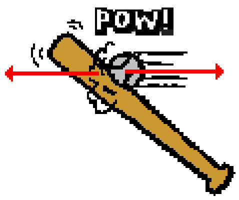
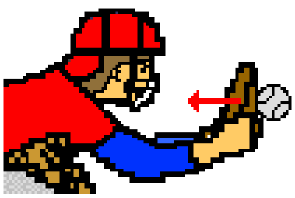
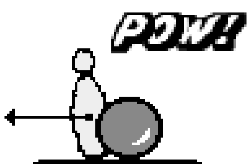
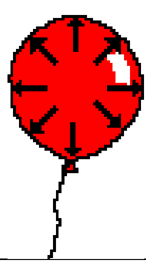
Basic set up:

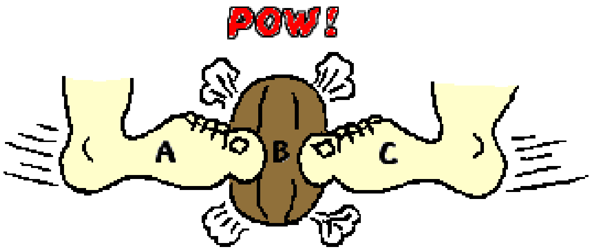


Mark scheme	Marks
Date, name, title and aim	(1)
Method (must include detail and state explicitly how your test will be fair)	(2)
Diagram (must include your own labels)	(2)
Data tables (must include raw data, headers and units)	(2 each)
Graphs (scales, axis labels, data points, trendlines, gridlines)	(5 each)
Conclusion (explain what your data demonstrates)	(2)
Evaluation (how did the experiment go, how could you improve on it?)	(2)
Presentation	(2)
Total	**(max 25 marks)**

Lab notes:

CW 1.7 – Newton's Third Law

Example	Action	Reaction
	The baseball pushes the bat to the **left** *(an action)*.	The bat pushes the ball to the **right** *(the reaction)*.
	Baseball pushes glove to the left.	
	Bowling ball pushes pin to the left.	
	Enclosed air particles push the wall of the balloon outwards.	

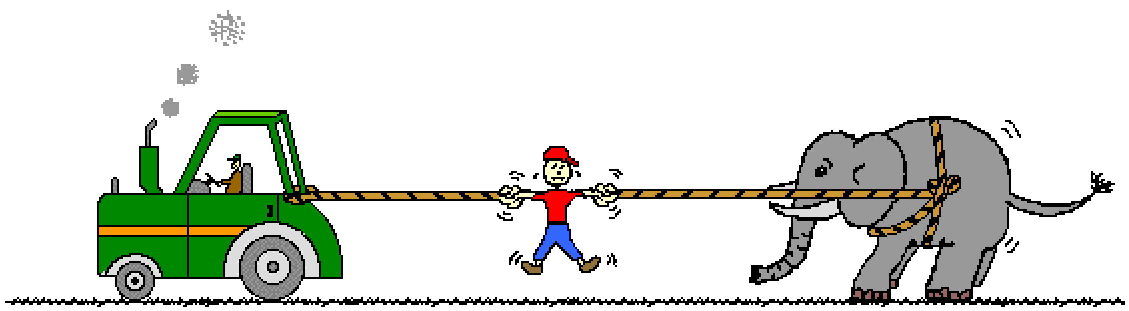


Action-Reaction Pair #1:

Action-Reaction Pair #2:

Identify **BOTH** action-reaction pairs in this situation with Foot A, Ball B, and Foot C

Identify at least **SIX** action-reaction pairs in this diagram.



7 – Friction

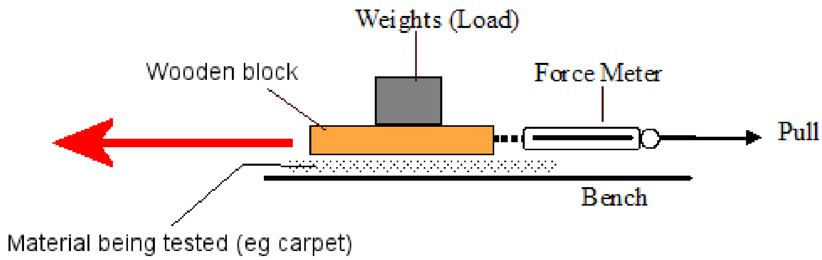
Objectives:

- understand that force is a vector quantity
- understand that friction is a force that opposes motion

LAB 1.4 - Investigating Surface Friction

Aim: to investigate how the nature of the surfaces and the mass of the object affects the friction.

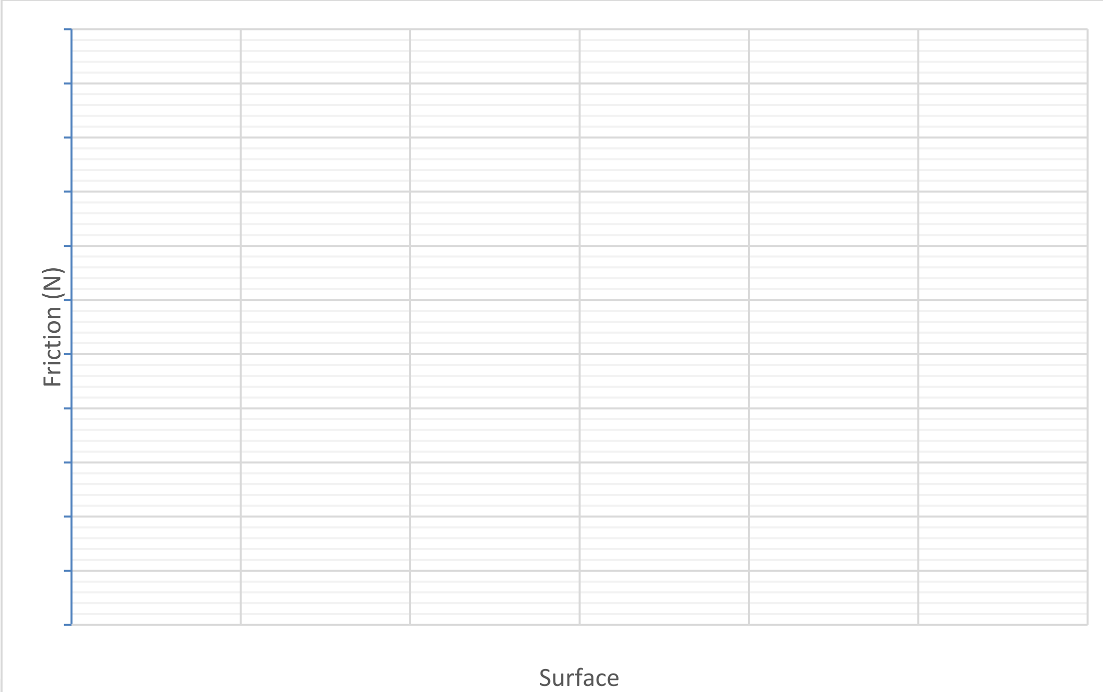
Diagram:

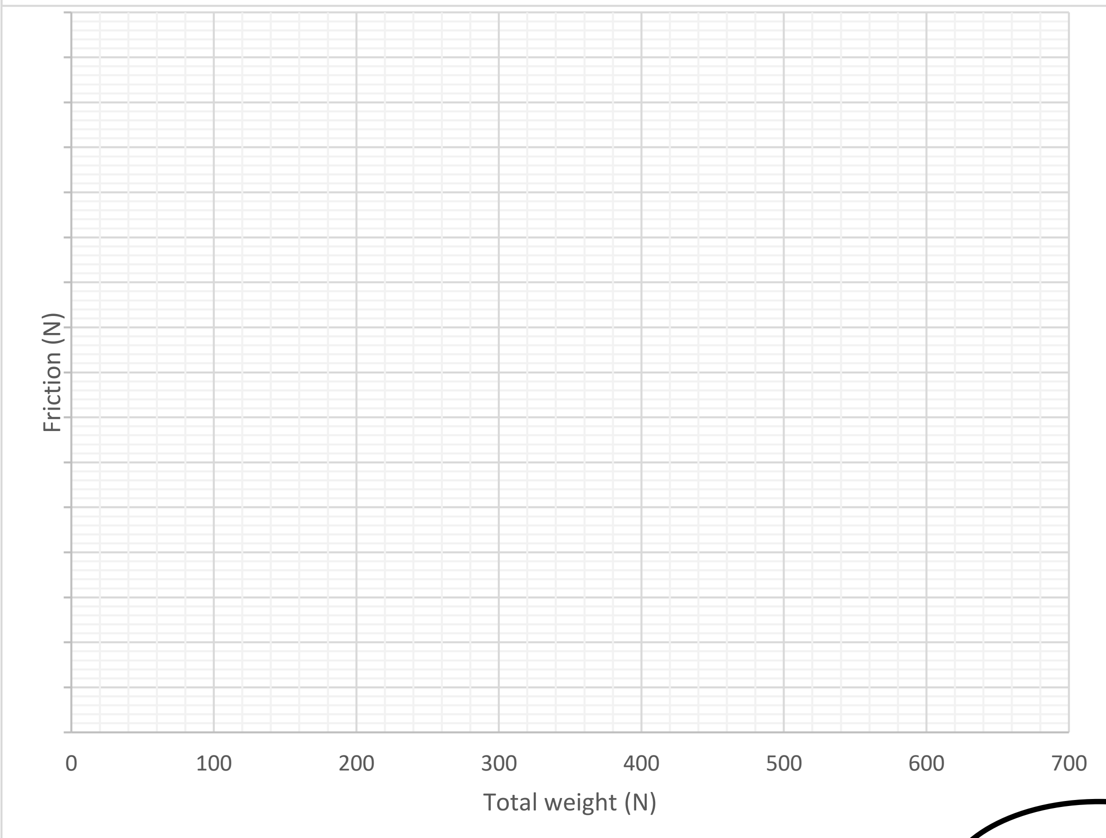


Data: (4)

Surface	Expt 1	Expt 2	Expt 3	Mean friction (N)

Total Weight (N)	Expt 1	Expt 2	Expt 3	Mean friction (N)


Friction (N)
Surface

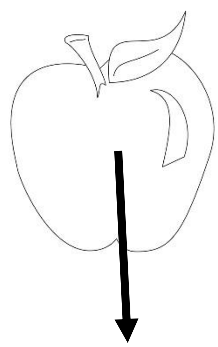

Friction (N)
0
100
200
300
400
500
600
700
Total weight (N)

(6)

8 – Mass and Weight

Objectives:

- know and use the relationship between weight, mass and g :
$$w = mg$$
- understand gravitational field strength and recall that it is different on other planets and moons.



CW 1.8 – Mass and Weight

1. When you 'weigh' yourself on the bathroom scales, they are newtonmeters that measure the force that gravity pulls down on you and then compresses the scales. Yet the 'weight' is measured in kg (or often in lbs). Why is it possible for the manufacturers to recalibrate the scales to measure mass rather than the force of weight? (1)

2. Would these scales work on the Moon, and if they did, would they be accurate? (2)

3. Garfield has been getting fat! He now has a mass of 12 kg.
   Calculate his weight. (2)

4. After a diet and exercise regime, Garfield now weighs 95 N. How much mass has he lost? (2)

5. A rock weighs 50 N on Earth. What is its mass? (2)

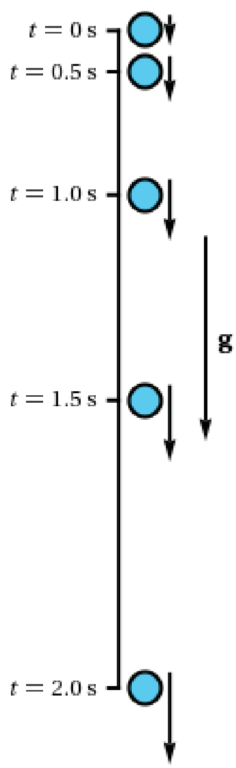
6. The same rock is taken to Mars where it now weighs only 20 N. What is the gravitational field strength on Mars? (2)

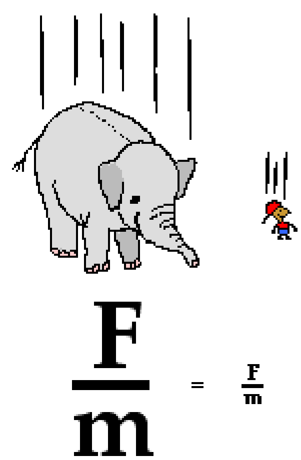
7. In your own words, what is the difference between MASS and WEIGHT? (2)

9 – Free Fall

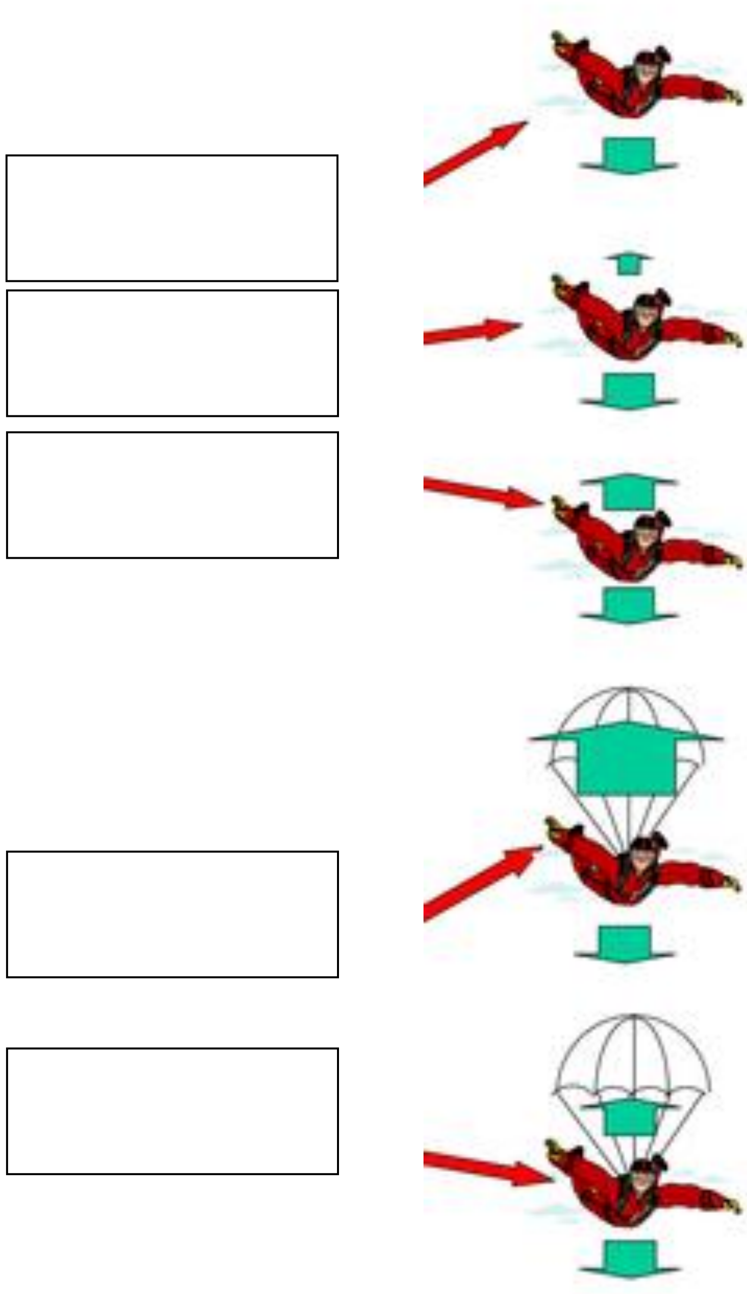
Objectives:

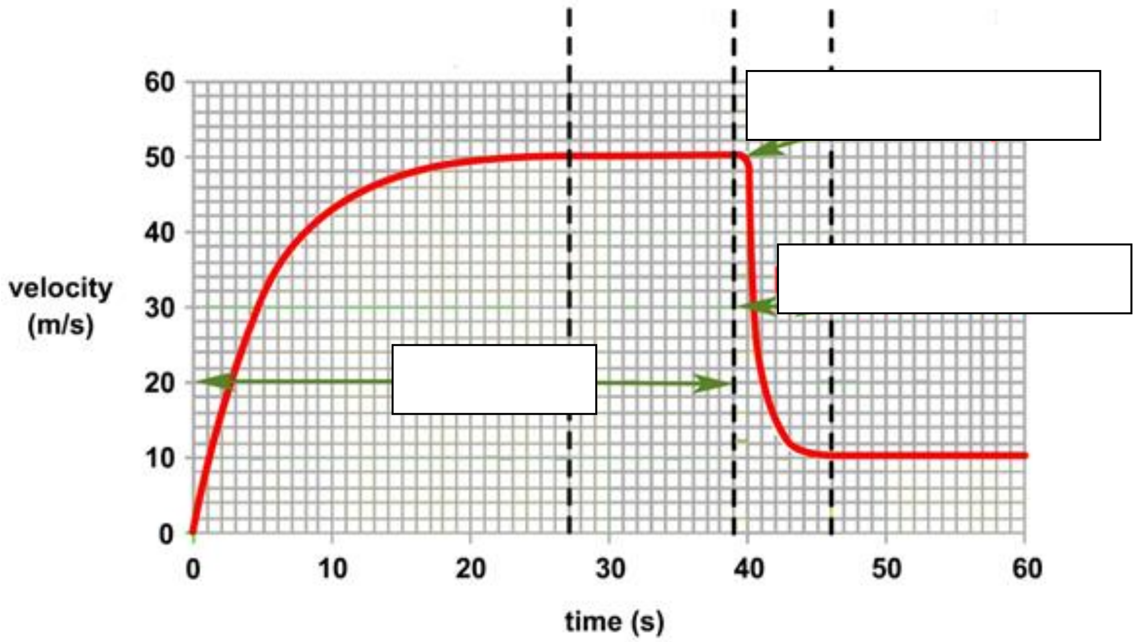
- investigate the motion of falling
- describe the forces acting on falling objects and explain why falling objects reach a terminal velocity





Terminal Velocity

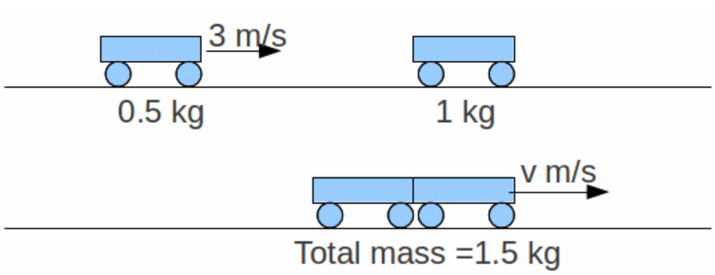



velocity (m/s)
time (s)
0
10
20
30
40
50
60

10 – Momentum

Objectives:

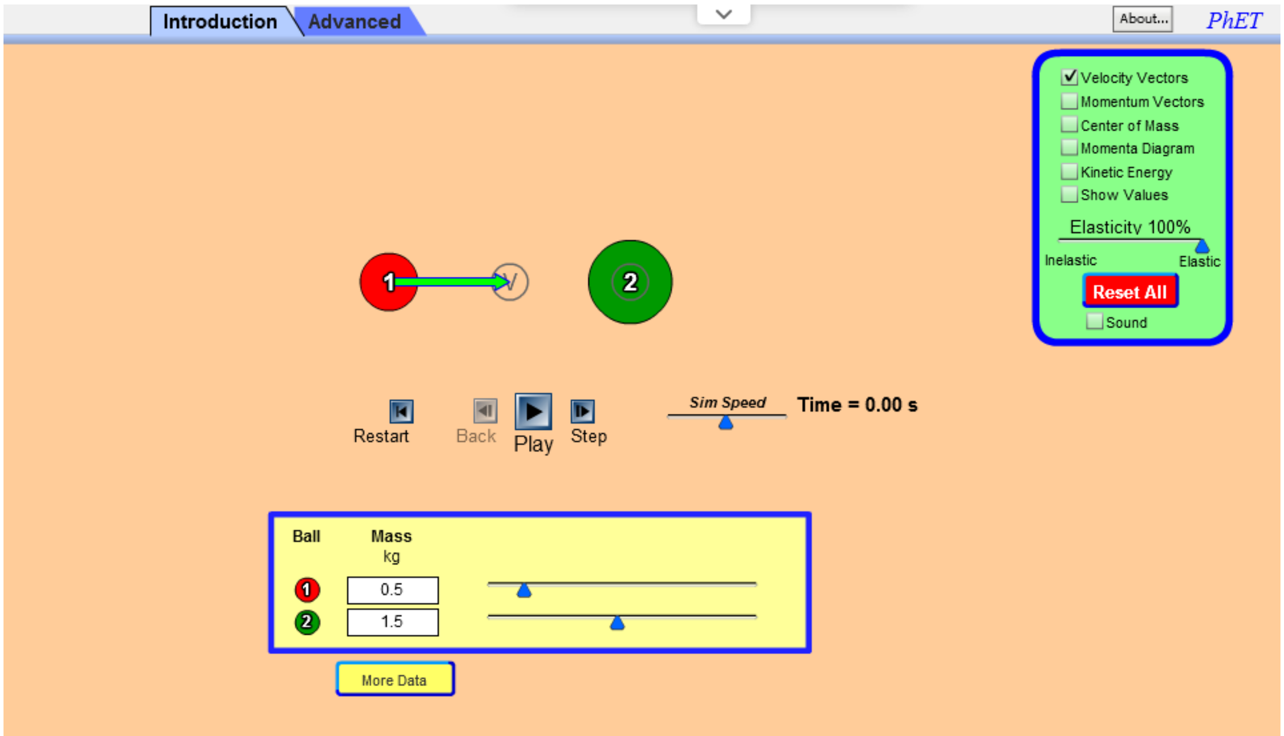
- know and use the relationship between momentum, mass and velocity
  $$p = mv$$
- use the conservation of momentum to calculate the mass, velocity or momentum of objects



PhET LAB 1.5 - Conservation of Momentum

Aim: to demonstrate the law of conservation of momentum

Load and run the PhET simulation "Collision Lab". As they are updating their material, please run the JAVA or FLASH version rather than the HTML 5 one. We will only use the Introductory tab. The advanced section is for 2-dimensional collsions which are AP level.



Set the elasticity to 'inelastic'. What do you notice about the collision? (1)

....

Set the elasticity to 'elastic'. Now what happens? (1)

....

What do you think "elasticity" means in this context? (1)

....

Set the elasticity back to inelastic for the remainder of the lab. Click the “more data” button to see the velocities of the balls. Predict the final velocity of the combined balls for each of the following, the final rows are your choice. (7)

Mass of ball 1 (kg)	Mass of ball 2 (kg)	Velocity of ball 1 (m/s)	Predicted velocity (m/s)	Actual velocity (m/s)
0.5	1.5	1.0		
1.5	0.5	1.0		
0.5	3.0	0.5		
3.0	0.5	0.5		
4.0	4.0	1.0		

Conclusion:

What have you learned about collisions and momentum from this lab and the demonstrations carried out in class? (2)

Extension: does using elastic collisions change the fundamental principle? Explain. (2)

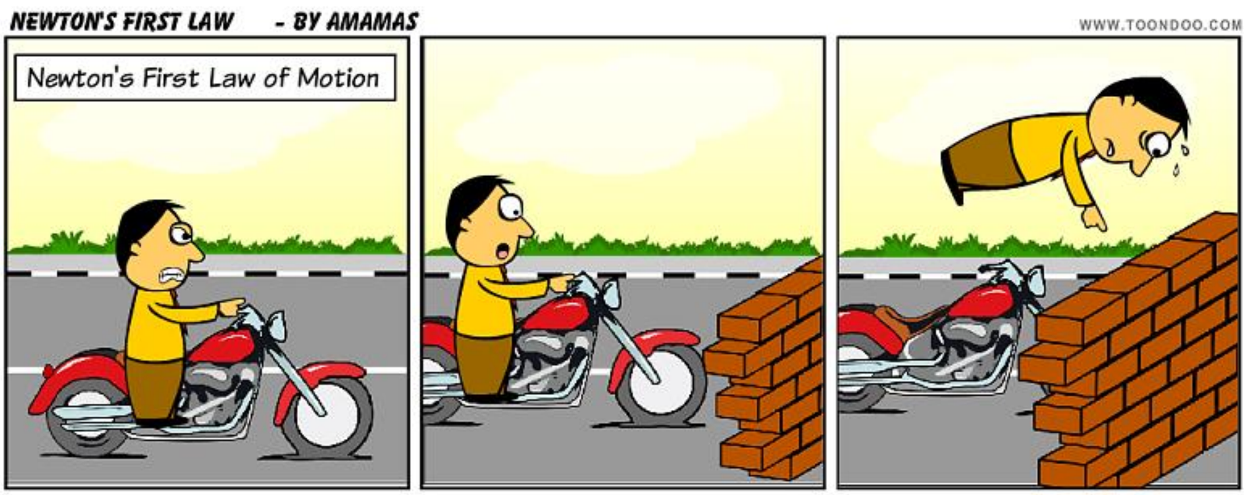
11 – Road Safety

Objectives:

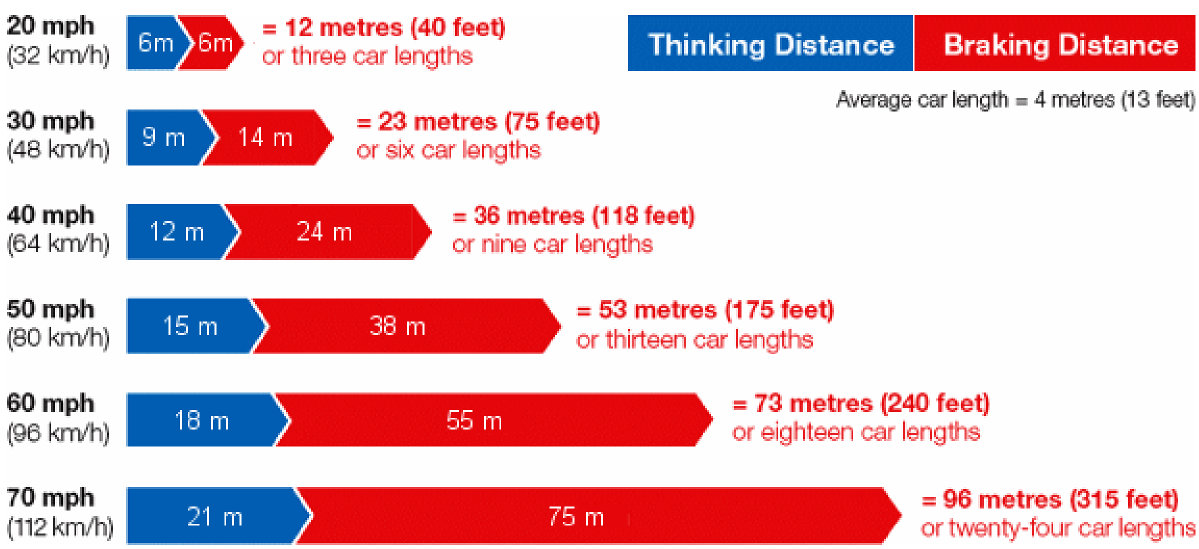
- use the ideas of momentum to understand safety features
- use the relationship between force, change in momentum and time taken

$$F = \frac{\Delta p}{t}$$

- describe the factors affecting the stopping distance of a vehicle, including; speed, mass, road condition and reaction time.



Factors that increase the THINKING DISTANCE	Factors that increase the BRAKING DISTANCE



CW 1.9 - Stopping Distances

1. A car crashes into a tree. A car crash is often caused because the driver cannot stop the car in a short enough distance.
   a) Which of these increases the stopping distance of a car? (2)

Variable	Increases the stopping distance?
Car full of passengers	
Driving slower	
Good brakes	
Wet roads	
Worn tyres	

   b) What happens to the reaction time of a driver if he consumes alcohol? (1)

   c) How will the speed of the car affect the stopping distance? (2)

   d) Seat belts reduce the risk of injury in a car crash. State how these work. (2)

2. What are the two main factors that affect the number of bike accidents in Bermuda? (2)

3. All motorcyclists must wear a crash helmet for safety. Scientists test the helmets by colliding them with a hard surface at different speeds. They then calculate the deceleration of the helmets as they come to a complete stop. For sufficient protection from brain injury, the deceleration of a helmet must be no larger than 2750 m/s2.

a) What feature(s) of a crash helmet reduce the deceleration of the head even more? (2)

b) Explain, in terms of physics, why the brain is protected by being surrounded by fluid inside a skull. (2)

c) What can happen if the head is decelerated too rapidly? (1)

d) In one test, the velocity of a helmet is 7.5 m/s (approx. 27 km/hr) with a stopping time of 2.5 ms.

i) Calculate the deceleration of the helmet in the test. (2)

ii) Is it of good enough quality for a motorcyclist? (1)

e) Some motorcyclists do not fasten their chin straps properly. Explain, using physics, why this will not help them in a collision. (2)

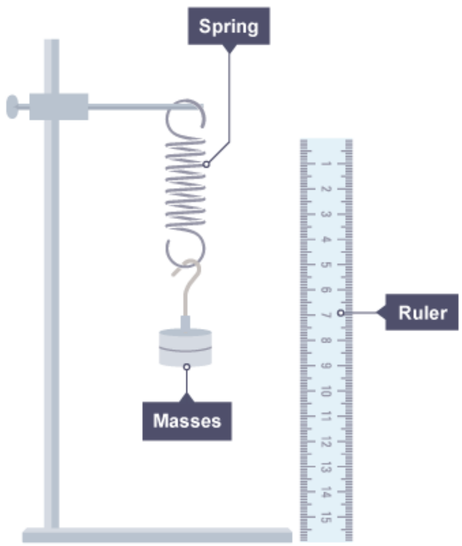
12 – Hooke's Law

Objectives:

- describe experiments to investigate how extension varies with applied force for helical springs and metal wires
- understand that the initial region of a force-extension graph is associated with Hooke's law

LAB 1.6 - Stretching a Spring

Aim: to demonstrate the behaviour of materials under load by applying a load to a spring.



1. Measure the length of the spring before any load has been applied. It is usually around 20 mm.
2. Add masses one at a time, measuring the total length of the spring between the loops – be as accurate as you can.
3. As the load approaches 12 N, ensure that you support the clamp stand and have a cushion under the masses. It generally breaks between 13 – 17 N.
4. To get the extension (stretch), subtract the original length from the length.

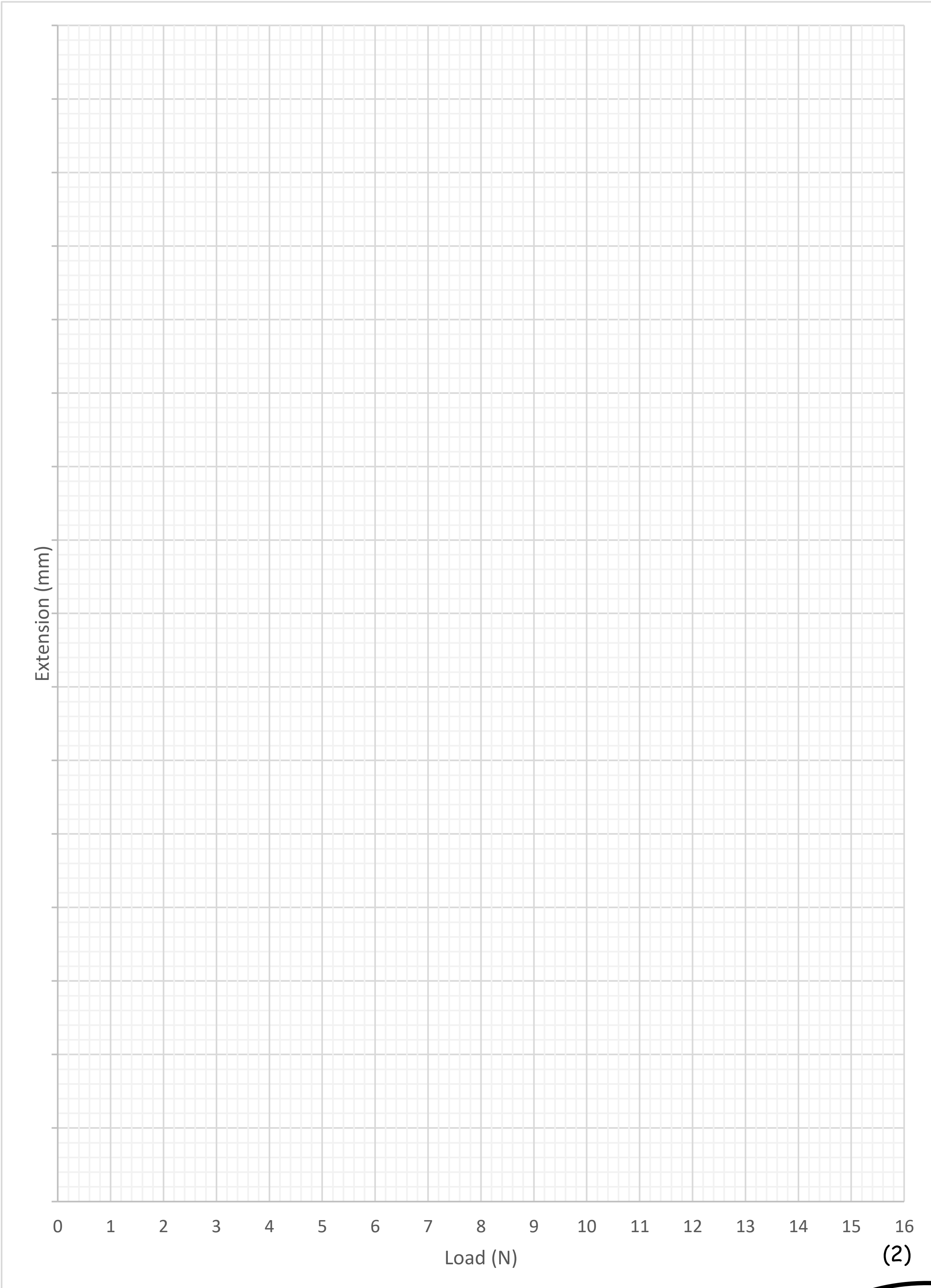
SAFETY: wear goggles and be aware that the clamp stand can topple and that the spring WILL break. Keep feet from being under the masses.

Load (N)	Length (mm)	Extension (mm)	Load (N)	Length (mm)	Extension (mm)
0			8		
1			9		
2			10		
3			11		
4			12		
5			13		
6			14		
7			15		

(2)

Conclusion:

(2)



(2)

13 – Non-Hookian Materials

Objectives:

- describe how extension varies with applied force for rubber bands
- associate elastic behaviour with the ability of a material to recover its original shape after the forces causing deformation have been removed

LAB 1.7 - Stretching a Rubber Band

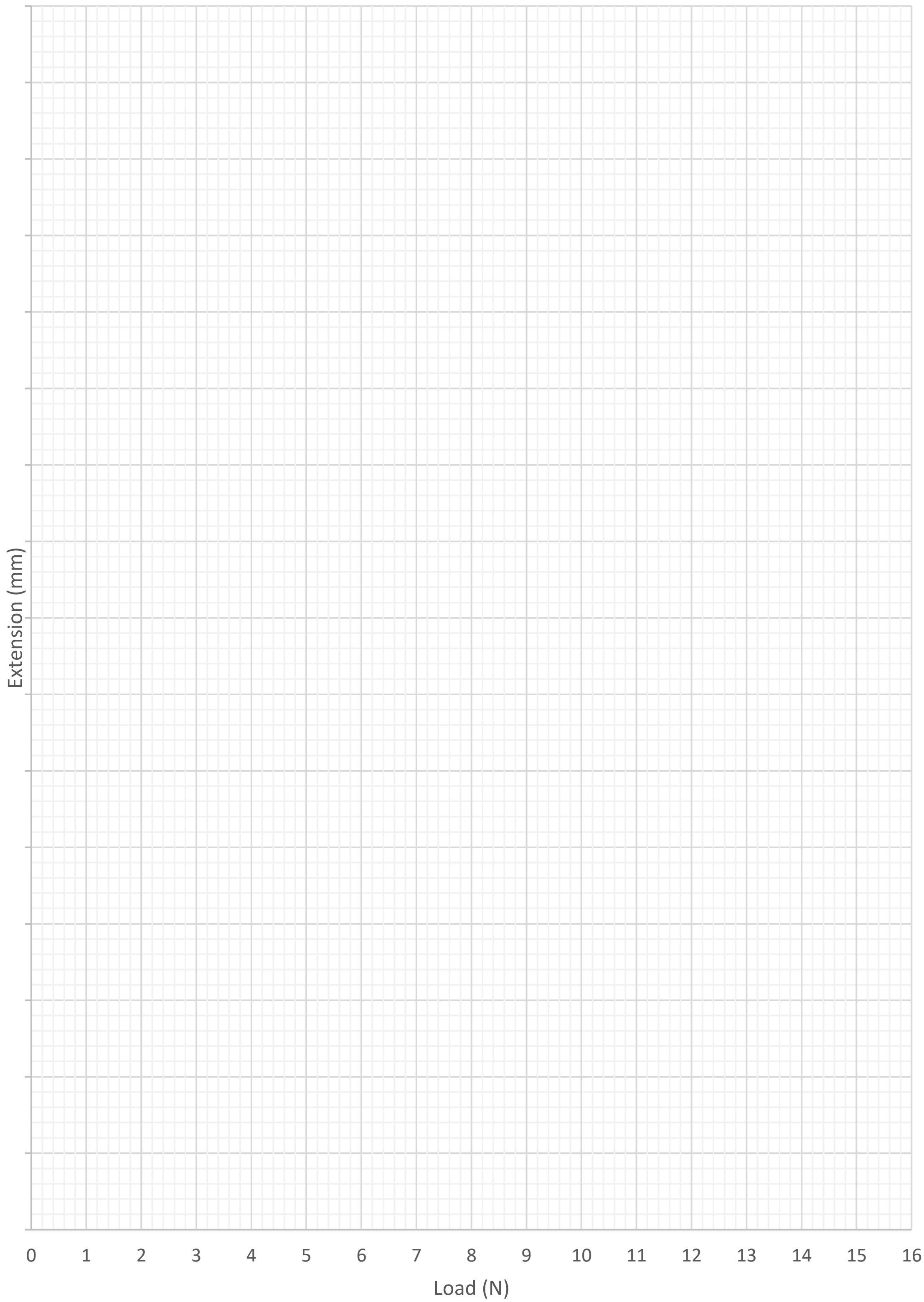
Aim: to demonstrate the behavious of a non-Hookian material using a rubber band.

1. Measure the length of the rubber band before any load has been applied.
2. Add masses one at a time, measuring the total length of the spring between the loops – be as accurate as you can.
3. As the load approaches 12 N, ensure that you support the clamp stand and have a cushion under the masses.
4. Unload the masses – one at a time. Record the length of the rubber band.
5. To get the extension (stretch), subtract the original length from the length.

SAFETY: wear goggles and be aware that the clamp stand can topple and that the rubber band MAY break. Keep feet from being under the masses.

Loading		Unloading	
Load (N)	**Extension (mm)**	**Load (N)**	**Extension (mm)**
0		15	
1		14	
2		13	
3		12	
4		11	
5		10	
6		9	
7		8	
8		7	
9		6	
10		5	
11		4	
12		3	
13		2	
14		1	
15		0	

(2)

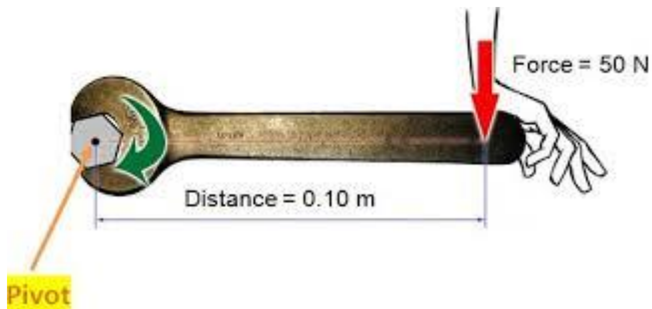


(4)

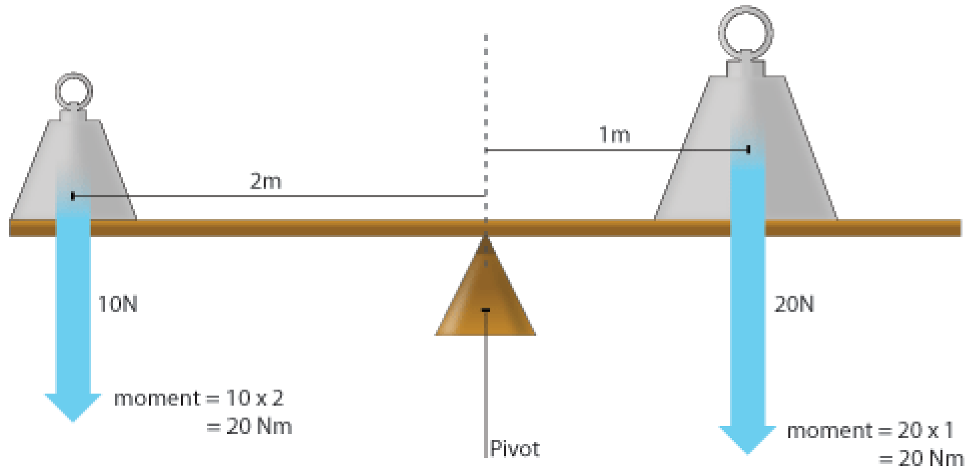
14 – Moments

Objectives:

- know and use the relationship between the moment of a force and its distance from the pivot.
- know and use the principle of moments for a simple system of parallel forces acting in one plane



$$\tau = Fr$$


2m
1m
10N
20N
moment = 10 x 2
= 20 Nm
Pivot
moment = 20 x 1
= 20 Nm

PhET LAB 1.8 - Balancing Act

The simulation can be found at https://phet.colorado.edu/en/simulation/balancing-act (if using the iPad – run using HTML 5)

Part 1:

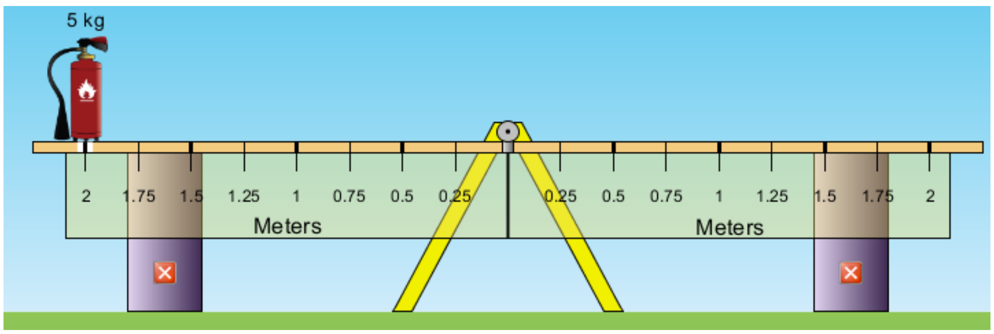
Objective: To be able to determine the variables that affect the balancing of a seesaw and predict where an object of a certain mass will have to be placed to balance the seesaw.

Method:

1. Investigate *Balancing Act* using the *Intro* tab at the top by moving the tanks and trash cans around and removing the supports to try to balance the seesaw. While you play with this tool, make observations about when the beam balances and when it doesn't. Use the tools on the side (mass labels, rulers, forces from objects and the level) to help you make your observations. Describe what you discovered about balancing the seesaw. (1)

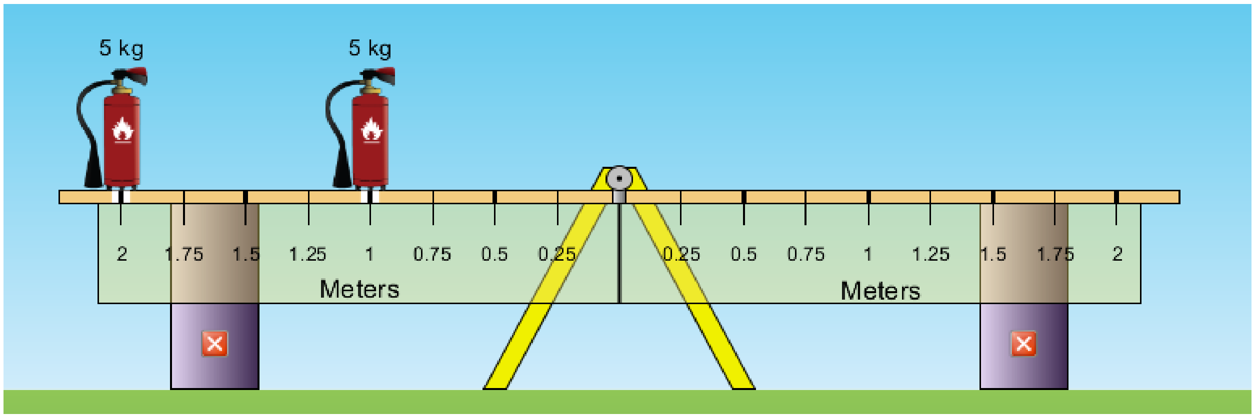
2. Use the scenarios below to make predictions about where the 10 kg trash can would need to be placed, without using *Balancing Act*. Sketch what you think the beams would look like for the following scenarios and justify your reasoning. **CHECK AFTERWARDS!**

Scenario 1:



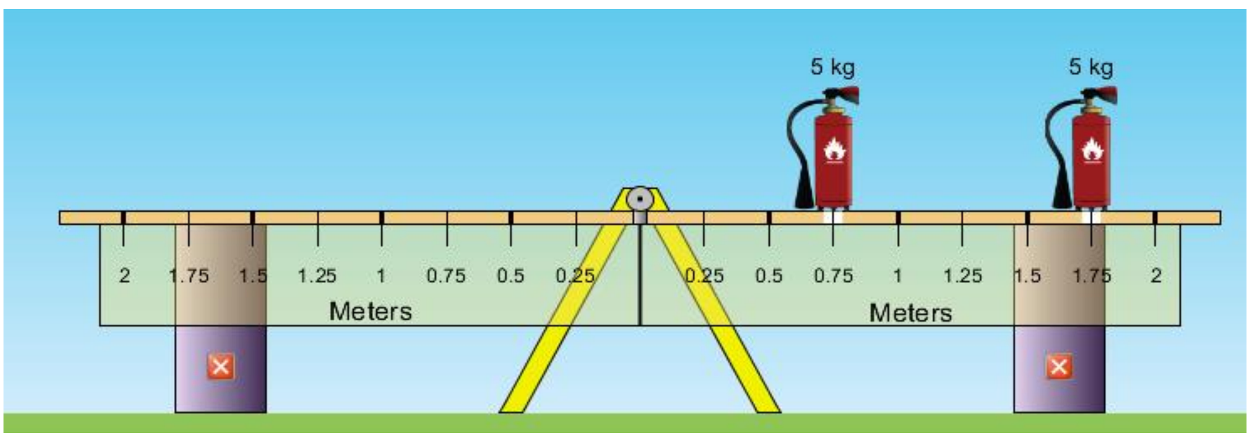
(2)

Scenario 2:



(2)

Scenario 3:



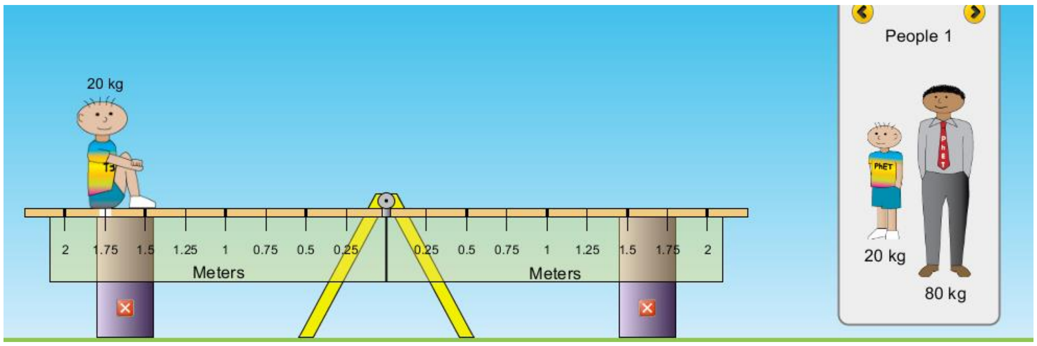
(2)

Part 2:

Objectives: To be able to calculate where a mass needs to be placed on a beam to balance the beam and then confirm or correct their calculations using the *Balancing Act* simulation.

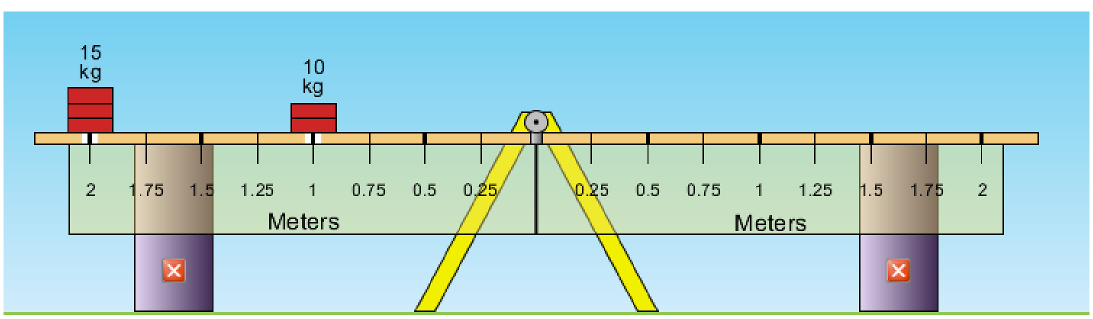
Method:

1. Calculate where the 80 kg man would need to sit to balance the beam. Show all work including formulas and substitutions with units. CHECK AFTERWARDS!



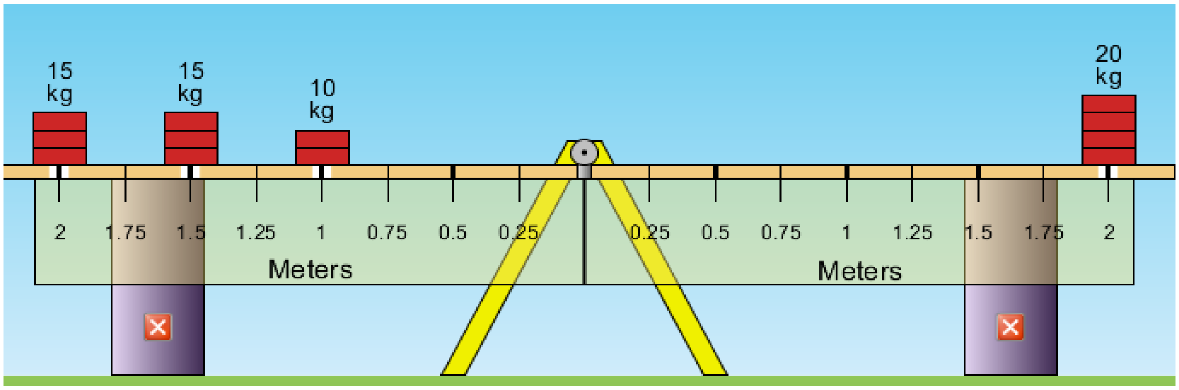
(2)

2. Predict where you would place the 20 kg pile of bricks to balance the beam? Show all calculations including formula and substitutions with units.



(2)

3. Calculate where a 15kg pile of bricks would need to be placed to balance the beam. Show all calculations.



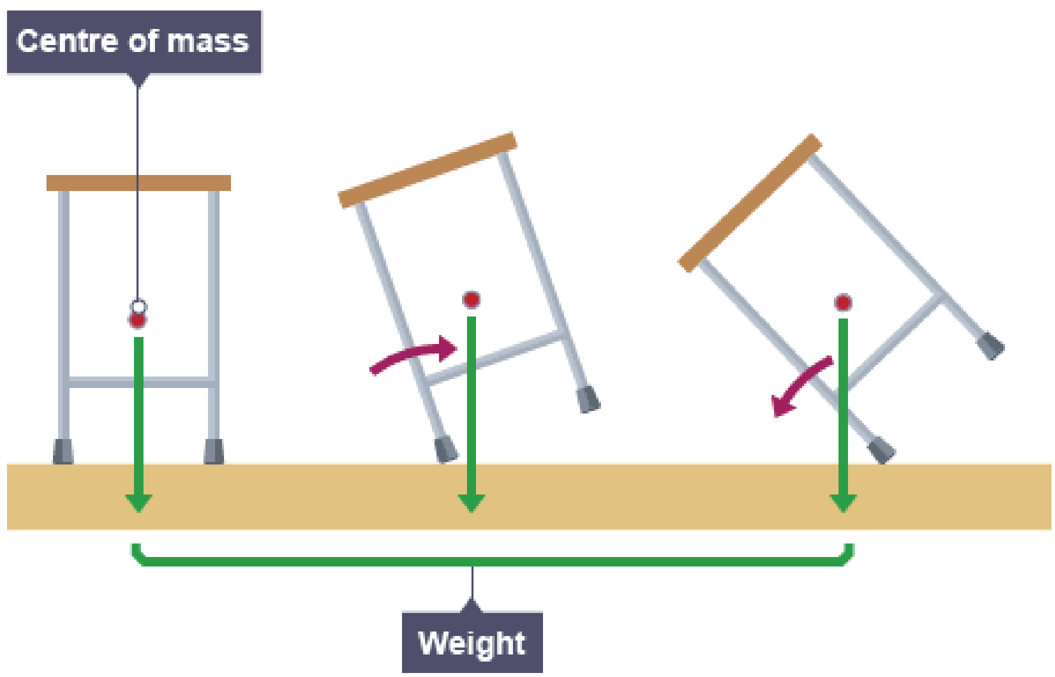
(2)

Try to play the game. For the higher levels you may need a pencil and paper to work out the answers!

15 – Centre of Gravity and Stability

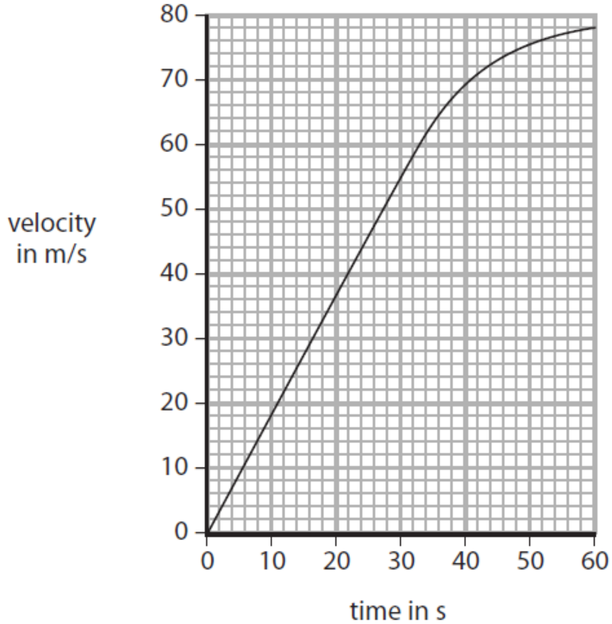
Objectives:

- recall that the weight of a body acts through its centre of gravity
- understand that the upward forces on a light beam, supported at its ends, vary with the position of a heavy object placed on the beam



PAST IGCSE QUESTIONS (graded as Interim)

11 The graph shows how the velocity of an aircraft changes as it accelerates along a runway.



What does it mean by 'average' acceleration?

Part b) is hard to get 3 marks for. Think about what is making the plane's velocity increase and what is making it decrease.

(a) Use the graph to find the average acceleration of the aircraft.

(3)

Acceleration = ... m/s^2

(b) Explain why the acceleration is not constant, even though the engines produce a constant force.

(3)

....

....

....

....

....

....

....

(Total for Question 11 = 6 marks)

5 A student investigates the principle of moments.

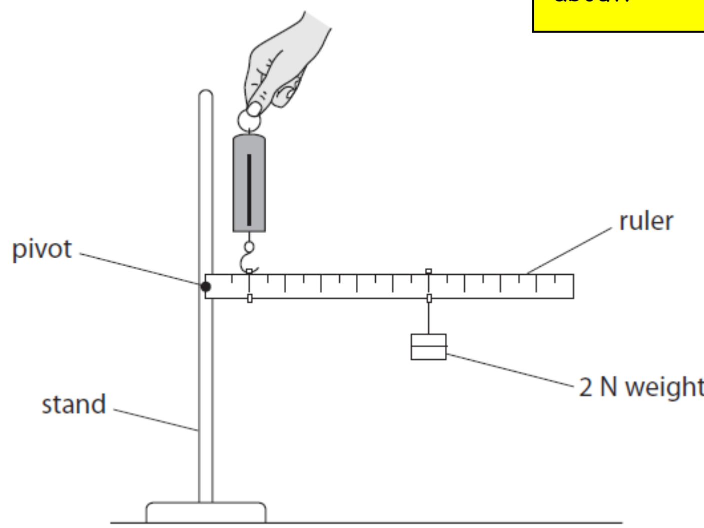
He connects a ruler to a stand with a pivot.

He hangs a 2 N weight from the 60 cm mark on the ruler.

He uses a forcemeter to hold the ruler horizontal.

The scale on the forcemeter reads from 0 N to 10 N.

Pretty standard moments questions. Note the number or marks. Also, imagine that YOU are doing the experiment. What has the student forgotten about?



(a) How could the student check that the ruler is horizontal?

(2)

....

....

....

....

(b) (i) State the equation linking moment, force and distance from the pivot.

(1)

(ii) Calculate the moment of the 2 N weight.

State the unit.

(3)

Moment = ... Unit ....

(c) The student holds the ruler horizontal with the forcemeter at the 10 cm mark.

He expects the reading on the forcemeter to be 12 N.

The actual reading is 10 N.

(i) Explain why the correct reading should be **larger** than 12 N.

(2)

....

....

....

....

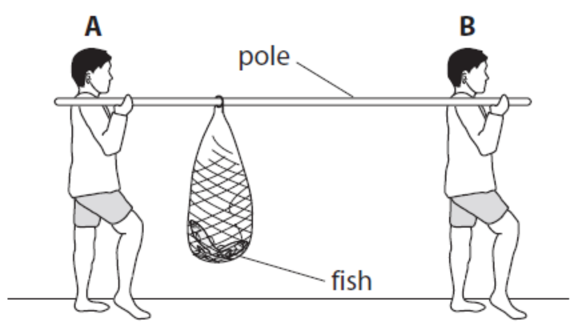
(ii) Explain why the actual reading is only 10 N.

(1)

....

....

(d) A picture in the student's textbook shows two fishermen using a pole to carry some fish.



Fisherman **A** and fisherman **B** feel different forces on their shoulders.

Use ideas about moments to explain why fisherman **A** feels the larger force.

(3)

....

....

....

....

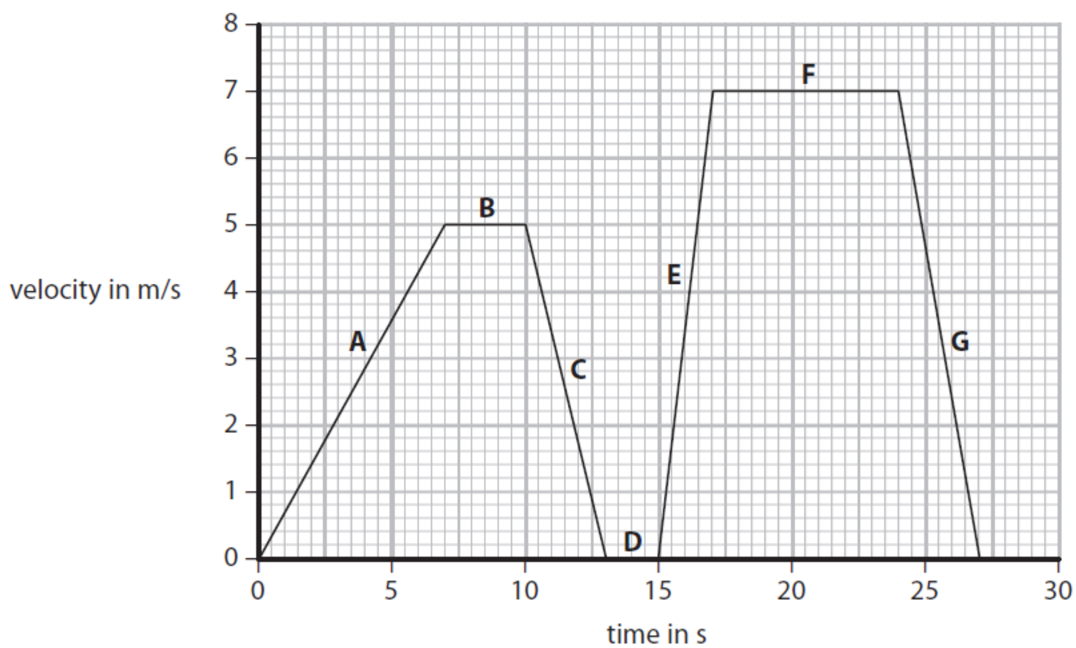
....

....

(Total for Question 5 = 12 marks)

5 A student cycles to school.

The graph shows the stages A to G of the journey.



(a) Describe the motion of the student during stages B and D.

(2)

Stage	Description
B	
D	

(b) State how the graph shows that the acceleration for stage E is greater than the acceleration for stage A.

(1)

....

....

....

(c) Calculate the distance that the student travels in the last 10 s of the journey.

(4)

4 marks - Don't even begin to think about using:

$$v = \frac{x}{t}$$

distance = ... m

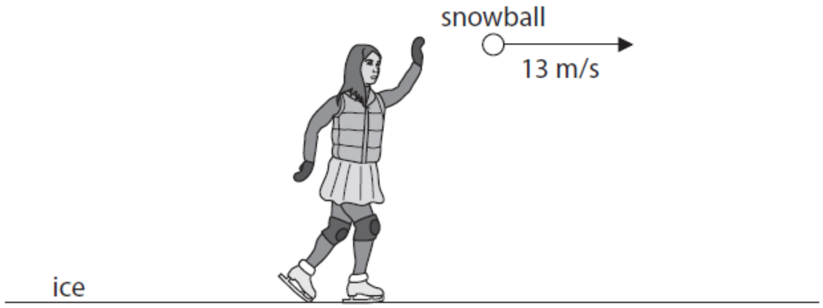
(d) The total distance travelled is 106.5 m.

Show that the average speed of the journey is about 4 m/s.

(3)

(Total for Question 5 = 10 marks)

5 An ice skater throws a 0.23 kg snowball with a velocity of 13 m/s.



(a) (i) State the equation linking momentum, mass and velocity.

(1)

(ii) Calculate the initial momentum of the snowball.

(2)

initial momentum = ... kg m/s

(b) When the skater throws the snowball forwards, she slides backwards on the ice.

Explain why she moves in this direction.

(3)

Remember the conservation of momentum

....

....

....

....

....

....

....

(c) The skater wears soft knee pads that compress easily.

Explain how the pads protect her knees when she falls on the ice.

(3)

....

....

....

....

....

....

....

....

....

(Total for Question 5 = 9 marks)

Hard question – try to use the equation in your answer

$$F = \frac{\Delta p}{t}$$