MEASUREMENT OF VELOCITY AND ACCELERATION

OL: 2004, 2008, 2012

A student carried out an experiment to measure the acceleration of a moving trolley.
The student calculated the velocity of the trolley at different times and plotted a graph which was then used to find its acceleration. The table shows the data recorded.

Velocity/ m s^{-1}	0.9	1.7	2.5	3.3	4.1	4.9
Time/s	0	2	4	6	8	10

(i) Draw a diagram to show how the student got the trolley to accelerate.

(ii) Describe how the student measured the final velocity of the trolley.

(iii) What other measurement did the student take?

(i) Using the data in the table, draw a graph on graph paper of the trolley's velocity against time. Put time on the horizontal axis (X-axis).

(ii) Find the slope of your graph and hence determine the acceleration of the trolley.

(iv) Give a precaution the student took to ensure an accurate result.

MEASUREMENT OF ACCELERATION DUE TO GRAVITY (*g*) USING THE FREEFALL METHOD

HL: 2009, 2004
OL: 2013, 2009, 2002

In an experiment to measure the acceleration due to gravity *g* by a free fall method, a student measured the time *t* for an object to fall from rest through a distance *s*.
This procedure was repeated for a series of values of the distance *s*.
The table shows the data recorded by the student.

s/cm	30	40	50	60	70	80	90
t/ms	244	291	325	342	371	409	420

(i) Draw a labelled diagram of the apparatus used in the experiment.

(ii) Indicate the distance *s* on your diagram.

(iii) Describe how the time interval *t* was measured.

(iv) What did you need to do to get a new set of data?

(v) Calculate a value for the acceleration due to gravity by drawing a suitable graph based on the recorded data.

(vi) Give two precautions that should be taken to ensure a more accurate result.

TO SHOW THAT ACCELERATION IS PROPORTIONAL TO THE FORCE WHICH CAUSED IT

2010 HL
2010 OL, 2005 OL, 2003 OL

You carried out an experiment to investigate the relationship between the acceleration of a body and the force applied to it.
You did this by applying a force to a body and measuring the resulting acceleration.
The table shows the data recorded during the experiment.

Force / N	0.20	0.25	0.30	0.35	0.40	0.45	0.50
acceleration / m s^{-2}	0.4	0.5	0.6	0.7	0.8	0.9	1.0

(i) Draw a labelled diagram of the apparatus you used.

(ii) How did you measure the applied force?

(iii) Describe the steps involved in measuring the acceleration of the body.

(iv) How did you minimise the effect of friction during the experiment?

(v) Plot a graph on graph paper of the body's acceleration against the force applied to it.
Put acceleration on the horizontal axis (X-axis).

(i) What does your graph tell you about the relationship between the acceleration of the body and the force applied to it?

(ii) Calculate the slope of your graph and hence determine the mass of the body.

(iii) On a trial run of this experiment, a student found that the graph did not go through the origin.
Suggest a reason for this.

(iv) Describe how the apparatus should be adjusted so that the graph would go through the origin.

TO VERIFY THE PRINCIPLE OF CONSERVATION OF MOMENTUM

HL: 2014, 2011, 2005
OL: 2006, 2011

A student carried out an experiment to verify the principle of conservation of momentum.
The student adjusted the apparatus till a body A was moving at a constant velocity *u*.
It was then allowed to collide with a second body B, which was initially at rest, and the two bodies moved off together with a common velocity *v*.
The following data were recorded:

mass of body A	230 g
mass of body B	160 g
velocity *u*	0.53 m s^{-1}
velocity *v*	0.32 m s^{-1}

(i) Draw a labelled diagram of the apparatus used in the experiment.

(ii) How did the student measure the mass of the trolleys?

(iii) State what measurements the student took and how these measurements were used to calculate the velocities.

(iv) What adjustments did the student make to the apparatus so that body A would move at constant velocity?

(v) How did the student know that body A was moving at constant velocity?

(vi) Describe how the student measured the velocity v of the bodies after the collision.

(vii) Using the recorded data, show how the experiment verifies the principle of conservation of momentum.

(viii) When carrying out this experiment the student ensures that there is no net external force acting on the bodies.
What are the two forces that the student needs to take account of to ensure this?

(ix) Describe how the student reduced the effects of these forces.

VERIFICATION OF BOYLE'S LAW

HL: 2013, 2011, 2003
OL: 2004

During an experiment to verify Boyle's law, the pressure of a fixed mass of gas was varied.
A series of measurements of the pressure p and the corresponding volume V of the gas was recorded as shown.
The temperature was kept constant.

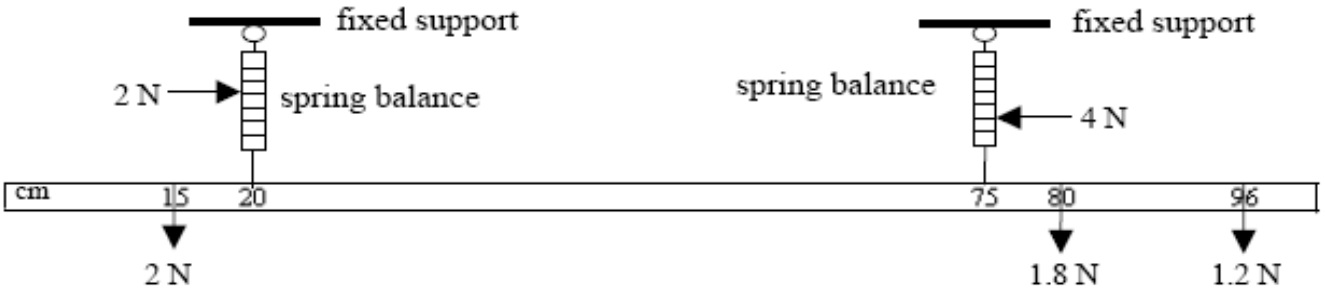
p/kPa	325	300	275	250	200	175	150	125
V/cm^3	12.1	13.0	14.2	15.5	19.6	22.4	26.0	31.1

(i) Draw a labelled diagram of the apparatus used in the experiment.
(ii) How was the pressure of the gas varied during the experiment?
(iii) Describe how the pressure and the volume of the gas were measured.
(iv) Why should there be a delay between adjusting the pressure of the gas and recording its value?
(v) Draw a suitable graph to show the relationship between the pressure and the volume of a fixed mass of gas.
(vi) Explain how your graph verifies Boyle's law.

INVESTIGATION OF THE LAWS OF EQUILIBRIUM FOR A SET OF CO-PLANAR FORCES

HL: 2007, 2013, 2002
OL: 2014, 2007

A student investigated the laws of equilibrium for a set of co-planar forces acting on a metre stick.
The weight of the metre stick was 1 N and its centre of gravity was found to be at the 50.5 cm mark.
Two spring balances and a number of weights were attached to the metre stick.
Their positions were adjusted until the metre stick was in horizontal equilibrium, as indicated in the diagram.
The reading on the spring balance attached at the 20 cm mark was 2 N and the reading on the other spring balance was 4 N.



The other end of each spring balance was attached to a fixed support.

(i) How did the student measure the upward forces?

(ii) Copy the diagram and show all the forces acting on the metre stick.

(iii) Find the total upward force acting on the metre stick.

(iv) Find the total downward force acting on the metre stick.

(v) Explain how these values verify one of the laws of equilibrium.

(vi) Find the sum of the *anticlockwise moments* of the *upward* forces about an axis through the 10 cm mark on the metre stick.

(vii) Find the sum of the *clockwise moments* of the *downward* forces about an axis through the 10 cm mark on the metre stick.

(viii) Explain how these values verify the other law of equilibrium.

(ix) How did the student know the metre stick was in equilibrium?

(x) How did the student find the weight, of the metre stick?

(xi) Why is the centre of gravity of the metre stick not at the 50.0 cm mark?

(xii) Describe how the centre of gravity of the metre stick was found.

(xiii) Why was it important to have the spring balances hanging vertically?

INVESTIGATION OF THE RELATIONSHIP BETWEEN PERIODIC TIME AND LENGTH FOR A SIMPLE PENDULUM AND HENCE CALCULATION OF g

HL: 2012, 2008, 2006

A student investigated the relationship between the period and the length of a simple pendulum. The student measured the length l of the pendulum.
The pendulum was then allowed to swing through a small angle and the time t for 30 oscillations was measured.
This procedure was repeated for different values of the length of the pendulum.
The student recorded the following data:

l /cm	40.0	50.0	60.0	70.0	80.0	90.0	100.0
t /s	38.4	42.6	47.4	51.6	54.6	57.9	60.0

(i) Why did the student measure the time for 30 oscillations instead of measuring the time for one?

(ii) How did the student ensure that the length of the pendulum remained constant when the pendulum was swinging?

(iii) Describe how the student obtained a value for the length of the pendulum and its corresponding periodic time.

(iv) Using the recorded data draw a suitable graph to show the relationship between the period and the length of a simple pendulum.

(v) What is this relationship?

(vi) Justify your answer.

(vii) Use your graph to calculate the acceleration due to gravity.

(viii) Give two factors that affect the accuracy of the measurement of the periodic time.

(ix) Explain why a small heavy bob was used.

(x) Explain why the string was inextensible.