

EXPERIMENTS IN FIFTH FORM PHYSICS

**LABORATORY
MANUAL**

**Curriculum Development Unit
Ministry of Education, Heritage and Arts
SUVA**

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INTRODUCTION

The Experiments in Fifth Form Physics Manual was written for the first year of the FSLC Physics course.

Laboratory work is designed to help you better understand the basic principles of Physics. You will at the same time, gain a familiarity with the scientific methods and techniques employed in the laboratory.

The main purpose of experimentation is to discover the law which governs a certain phenomenon or to verify a given law which has been derived from a theory.

.....when you cannot measure what you are speaking about
and express it in numbers, you know something about it;
but when you cannot measure it, when you cannot express
it in numbers your knowledge is of a measure and unsatisfactory
kind, it may be the beginning of knowledge, but you have
scarcely, in your thoughts, advanced to the stage of science.

Lord Kelvin

Physics is an experimental science and history reveals that most of the notable discoveries in science have been made in the laboratory. It is important that students perform experiments themselves because it involves learning by doing. It needs to be emphasized that for a systematic and scientific training of young minds, genuine laboratory practice is a must.

The manual consists of 31 experiments pertaining to the core topics of Form 5 year of the FSLC Physics prescription. The experiments in this manual fall into four main categories.

- (i) confirming a theoretical model and thus providing support for the theoretical sections of the course
- (ii) measuring a physical quantity
- (iii) observing a physical phenomenon
- (iv) designing an experiment to produce a particular effect

Students will develop the following skills from above categories

- (i) setting up the apparatus according to a specification to obtain the required results
- (ii) measuring and assessing the value of those measurements
- (iii) analyzing and interpreting results
- (iv) presenting your experimental result in the form of an experimental report

The last point is often neglected. However irrespective of your skills as an experimental physicist, unless you can write a coherent report of your work, it will be of little value subsequently. Appendix 3 in this manual provides a guide to writing comprehensive lab reports.

The importance of graphical work in physics cannot go unnoticed. A graph paper is also appended which could be used for graphical work.

The Ministry of Education and Technology would like to thank the Australia International Development Assistance (AIDAB) for its financial support.

The Ministry would like to acknowledge the work of the Physics curriculum workgroup committee.

Thanks also to the Science Resource Center, Dunedin, for its kind permission to adapt some of the experiments and diagrams from its manual.

Experiment 1

MEASUREMENT

INTRODUCTION

Measurements have uncertainties. The true value is somewhere between minimum and maximum possible values. This is written as a recorded measurements + or – uncertainty. The recorded measurement can be thought of as the average of the maximum and minimum recorded values. The uncertainty is half of the difference between two smallest divisions of the scale.

AIM

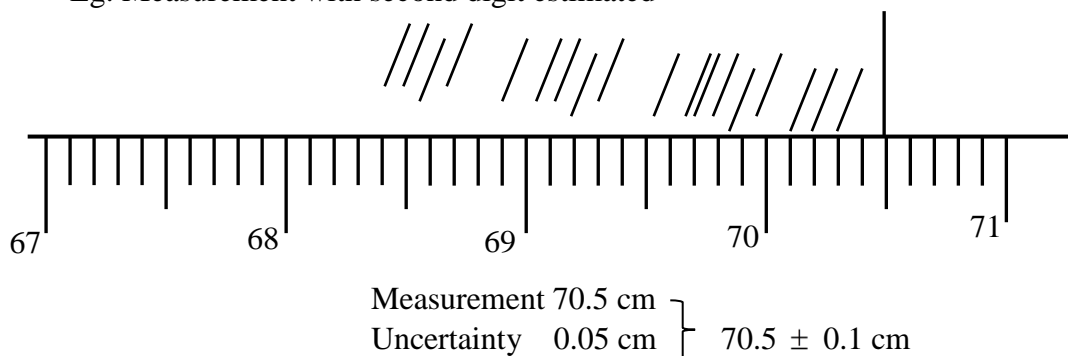
To determine the area of a desk top, writing its value with the appropriate numbers of significant digits and recording the uncertainty in the final value.

MATERIALS

Desk or laboratory bench top
Calculator
Ruler graduated in millimetres

DIAGRAM

Eg: Measurement with second digit estimated



METHOD

1. Use the ruler to measure the length of the table as precisely as possible.
Example the reading is 70.5cm. The uncertainty in the reading should also be recorded. It is plus or minus half the smallest division of the ruler, i.e. 0.05cm. Taking the error on both sides, the uncertainty in measurement comes to the smallest division on the ruler i.e. 0.1 cm.
2. Make a similar measurement for the breath of the table and record the results in a table. Say this is 30.4 cm.
3. The area of the table (length x breath) can then be calculated. In the example it would be: $(70.5 \pm 0.1) \times (30.4 \pm 0.1)$ square cm. The calculator readout for 70.5 x 30.4 is 2143.2. However the final answer in a multiplication or division can have only as many significant figures as appear in the reading with the least number of significant figures in the calculation, in this case 3 significant figures. The answer with 3 sig figs is 2140 sq cm.

4. Calculate the uncertainty in the final answer in the following way:
Using the measurement and the uncertainty the maximum possible value for the length of the table will be 70.5 ± 0.1 cm i.e 70.6. Similarly the maximum possible value for the breadth is 30.5 cm. Multiplying these together we find that the maximum possible value for the area of the table is 2150sq cm.

The minimum value for the length of the table is $70.5 - 0.1$, i.e. 70.4 cm. The minimum breadth is 30.3 cm. Multiplying these together the minimum area is 2130sq cm.

The final result is therefore 2140 ± 10 sq cm. This means that the value to be used is 2140 but the real value could be as large as 2150 and as small as 2130.

DISCUSSION

1. Measurement using a ruler is given as 42.37 cm. Which digit is guessed?
2. If a measurement is quoted as 20.3 ± 0.1 cm what are the likely maximum and minimum values for this measurements?
3. In the measurement quoted in question 2 what must the interval be between divisions on the scale?
4. Which of the following measurements is wrongly recorded?
 - (a) 44.2 ± 0.1
 - (b) 27.3 ± 0.16
 - (c) 2.00 ± 0.05

Experiment 2

PENDULUM MOTION

INTRODUCTION

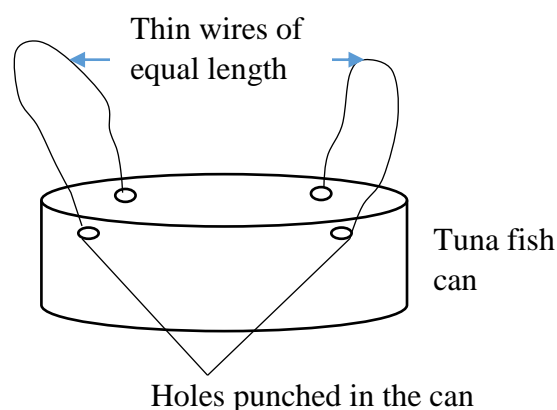
Pendulum motion provides an opportunity for students to identify important variables in an experiment. The period of a pendulum is determined by the length of the pendulum; the mass of the bob; and the amplitude of the swing. The students will learn that under ideal conditions, the length is the only relevant variable affecting the period. This experiment stresses the need to hold all variables constant except for the variable being tested.

AIM

To identify the variables affecting the motion of a pendulum.

MATERIALS

A metal hook screwed into a ceiling beam
A 2 metre string
A tin can with a capacity of 250ml - 1ℓ
Measuring tape
Sand
Beam balance
Clock
Retort stand



METHOD

1. Attach the string to the tin can; suspend it from the hook on the ceiling. This pendulum should swing freely.

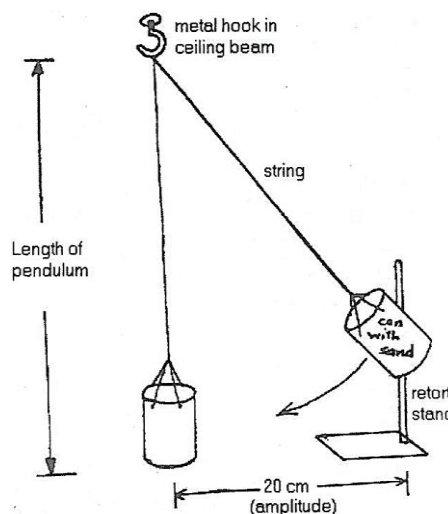
PART A

VARYING THE PENDULUM MASS

1. With the pendulum length at least 1.0m from the hook to the bottom of the can, fill it with 100g of sand and record this as the pendulum mass.
Move the retort stand 20cm away from the point directly beneath the stationary pendulum, record this distance as the amplitude; record the length; and keep both the length and amplitude constant.
2. Allow the pendulum to swing from the retort stand for 30 seconds, counting each time the pendulum returns to the retort stand as one swing. Record the number of swings.
3. Increase the pendulum mass by adding 100g of sand and repeat step 2. Do this until the can is full.

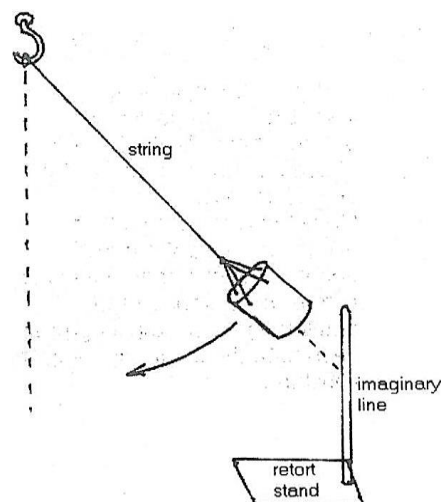
PART B VARYING THE PENDULUM AMPLITUDE

1. Record the final length and mass of the pendulum from the previous step. Keep these constant.
2. Move the retort stand 10cm away from the point beneath the stationary distance. Record this distance as the amplitude.
3. Allow the pendulum to swing from the retort for 30 seconds. Record the number of swings.
4. Increase the amplitude by 10cm and repeat step 3, continue until the swinging angle is as large as 45°.



PART C VARYING THE LENGTH

1. Use the same mass as in Part B, and move the retort stand to 20 cm as in part A.
2. Start with the same pendulum length as in Part A and B. Record the length. Allow the pendulum to swing from the retort stand for 30 seconds, record the number of swings.
3. Shorten the length by 10 cm. Record the new length, and repeat step 2. Note that the pendulum should be released from an imaginary line connecting the hook and the retort stand
4. Continue until pendulum cannot be shortened.



RESULTS

Record in the appropriate tables

Mass	No. of swings	Period		Amplitude	No. of swings	Period		Length	No. of swings	Period

DISCUSSION

1. Which of the three variables; mass, amplitude, or length; has the most effect on the period of the pendulum.
2. What is noticeable about the effect of amplitude?

Experiment 3 FORCE / EXTENSION GRAPH

INTRODUCTION

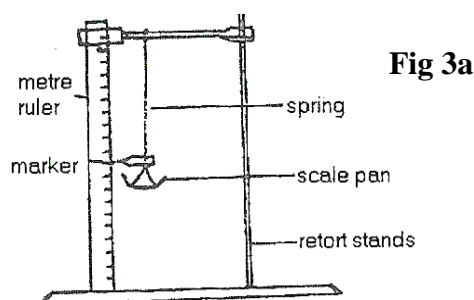
When a force is applied to a spring the spring is extended in length. As long as the spring is not extended too much (and distorted) the extension of the spring is directly proportional to the applied force. Springs can usually be doubled in length without much distortion.

AIM

To determine the relationship between the forces applied to a spring and the extension of the spring that it causes.

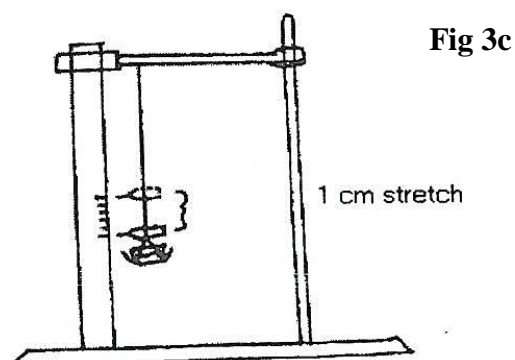
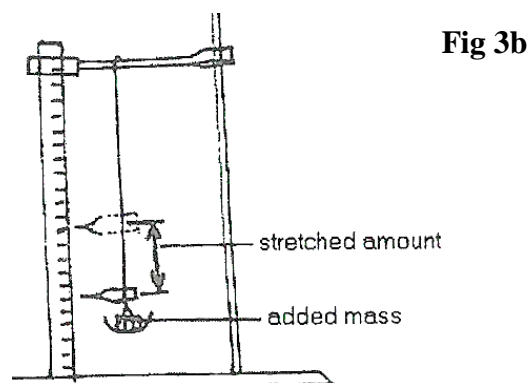
MATERIALS

Retort stand
Spring
Metre rule
Scale pan
Masses



METHOD

1. Set up the apparatus as shown in Fig 3a.
2. Place a small mass on the pan to make sure the spring is stretched and take the reading of the pointer on the ruler. Call this the starting point.
3. Record the reading in a table. Assume this is zero mass.
4. Add enough mass to the pan to cause an extension of about 1cm. Record, in a table, the mass added and the reading of the pointer on the ruler.
5. Continue adding equal masses and taking readings of the pointer on the table. Record all results.



NOTE:

1. Do not exceed more than double the length of the spring.
2. When readings have been completed remove all masses from the pan.

RESULTS

Set up a table of results and them as shown. Note that $F = ma$ so the force in Newton's is about $10 \times$ mass. Sample results are included in this table.

Reading #	1	2	3	4	...
New pointer Reading (cm)	37.2	38.3	39.2	40.0	
Starting point Reading (cm)	36.2	36.2	36.2	36.2	
Extension of spring (cm)	1.0	2.1	3.0	4.25	
Total mass (kg)	1.05	2.20	3.10	4.25	
Force (N)	10.5	22	31	42.5	

GRAPH

Plot a graph with Force (N) on the vertical axis and Extension (cm) on the horizontal axis.

DISCUSSION

1. Does then line pass through all the points? Explain why it may not.
2. Describe in one sentence the relationship between the force and the extension.
3. What does the slope of the graph represent?
4. Calculate the force constant of the spring and write down its proper units.
5. If a different spring is used what is likely to be the same and what will be different about the graph.

ALTERNATIVE MATERIALS

Spring: Rubber bands tied together and hung from the ceiling in a chain of length 1.5 m can be used. Add a small weight for the standing point and then add weights to extend the length by one centimetre increments to a maximum extension of no more than 15cm.

Pan: A used tin can, can be used. Holes are punched around the top of the can a string passed through the holes is used to suspend the pan from spring (see Fig 3b).

Weights: Items of known mass are needed. It is useful to have a number of items all of the same mass. As long as the mass of one of the identical items is known the mass on the pan can be recorded. The identical items might include: used batteries that are not yet leaking, vidi vidi board pieces. Alternatively, sand could be added to the pan, the pan and sand weighed then the pan could be attached to the spring.

Experiment 4

TICKER TIMER MOTION

INTRODUCTION

Ticker timers provide a record of motion by plotting distances at small regular time intervals. This tape can be analysed to show displacement, velocities and accelerations as a function of time.

AIM

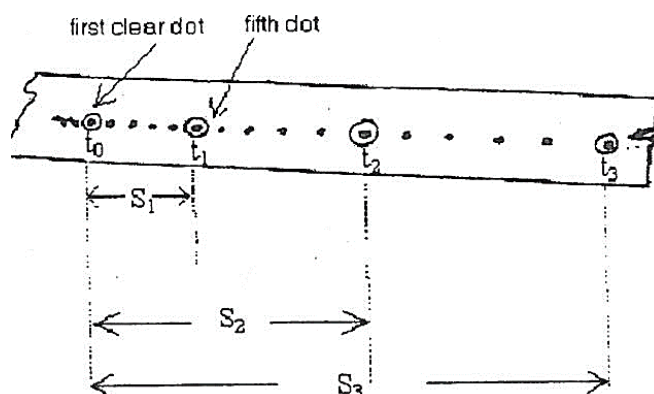
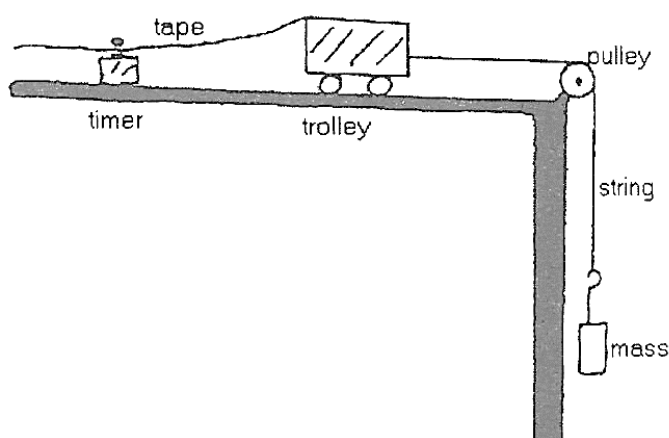
To use a ticker timer to obtain distance / time and velocity / time graphs and to interpret these graphs to obtain the acceleration.

MATERIALS

Ticker timer
Power supply
Timer tape
Metre rule
Trolley
Approx.200g mass
String
Pulley (optional)

METHOD

1. Hang the mass over the end of the table and tie the other end to the trolley. Attach timer tape to trolley and pass through timer. The set – up is shown in on the right.
2. Start the timer and check that it leaves marks on the tape. If not, try reversing the carbon paper. If the timer does not buzz, adjust tension. Check that AC timers are on AC and DC timers on DC power.
3. Release the trolley from the rest allowing it to accelerate due to the force of gravity on the mass.
4. Recover then timer tape and lay it flat beside the metre rule. Find the first clear point, circle it, and make all measurements from this point. Starting from this point, circle every fifth dot (circle – 1,2,3,4, circle –1,2,3,4, circle.....).



5. In the table, record the distance from the start at t_1, t_2, t_3, t_4 .
6. Put the tape away, but save it for additional measurements later. As the frequency is 50 Hz, the time interval between dots is 0.02s. The time interval between every fifth dot is then 0.1 s.

RESULTS

Prepare a table as shown. Sample results are included in this table.

Intervals	Time, t (s)	Distance, s (cm)	Δs (cm)	Velocity, v (cms^{-1})
0	0.00	0.0		
	0.05		3.5	35
1	0.10	3.5		
	0.15		4.5	45
2	0.20	8.0		
	0.25		5.5	55
3	0.30	13.5		
	0.35		6.5	65
4	0.40	20.0		

DISCUSSION

NOTE : The change in distance, s, is recorded halfway through the time interval. The velocity is the average velocity during the time interval; it is equal to the instantaneous velocity halfway through the time interval **only** if the acceleration is constant.

1. Calculate the velocity of the trolley in each of the sections.
2. Plot a graph of distance on vertical axis and time on horizontal axis. Plot a graph of velocity on vertical axis and time on horizontal axis.
3. Using the velocity time graph find the acceleration of the trolley.
4. There is another method of calculating acceleration.
 - (a) In a region of uniform acceleration, circle a dot, count N dots, circle a dot and count N more dots, then circle. The diagram shows $N=5$, N can be larger, but the 3 circled dots must be in a region of uniform acceleration.
 - (b) The time interval between circled dots is $t = N (0.02\text{s})$. Measure the distance during the two time intervals, call it X_1 and X_2 .

(c) The distance is then $a = \frac{X_2 - X_1}{t^2}$. The uncertainty in 'a' is proportional to $\frac{1}{t^2}$.

DISCUSSION

1. What factors in your experiment would affect the accuracy of your value of acceleration?
2. Sketch the shapes of distance – time, speed – time, acceleration time graphs of :
 - (i) Constant speed
 - (ii) Constant acceleration
3. Copy and complete
 - (i) Displacement of an object can be found fromof a speed – time graph.
 - (ii) Acceleration of an object can be found from of a speed – time graph

Experiment 5

NEWTON'S SECOND LAW

INTRODUCTION

If we apply the same force to two objects, one heavy, the other light, the light object will move with greater acceleration than the heavy object. Newton's Second Law describes a quantitative relationship between the mass and the acceleration of an object.

AIM

To show that, for a constant force, the acceleration, a , of an object is proportional to the reciprocal of its mass, m , i.e. $a \propto \frac{1}{m}$.

MATERIALS

(For an alternative dynamics trolley see end)

Dynamics trolley

Ticker timer

Tape

Metre rule

12V AC power supply

Five different masses (say 1kg, 2kg, 3kg, 4kg, and 5kg)

Bench pulley

METHOD

1. Find the mass of the trolley in kg.
2. Set up the equipment as shown in the diagram in fig 5.1

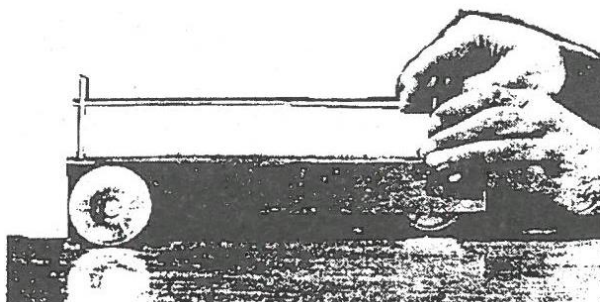
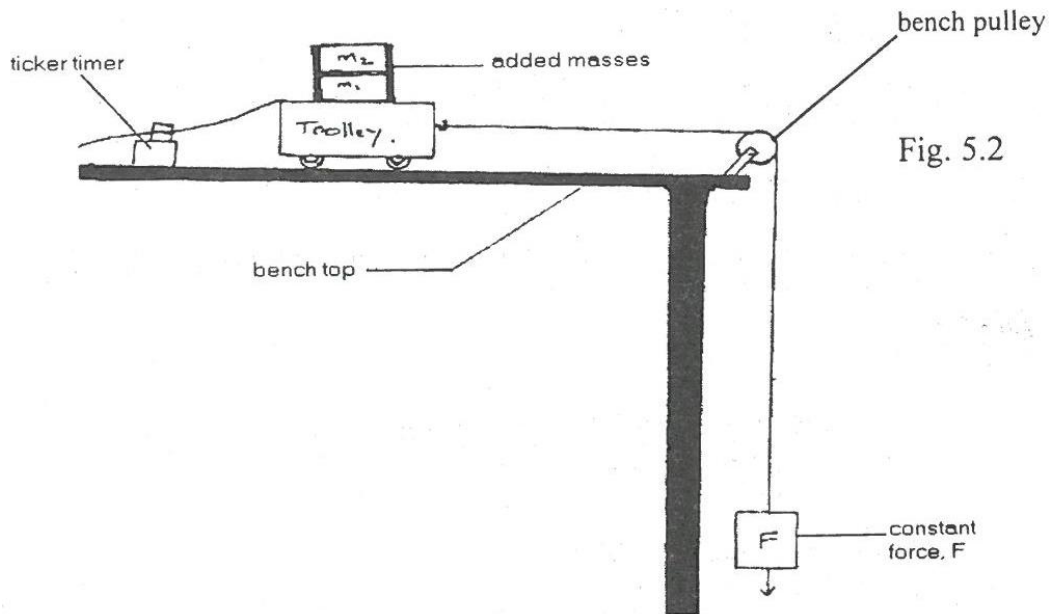


Fig. 5.1

3. Stretch the rubber band as far as the wooden pillar and hold the trolley in position so that it does not move.
4. Turn on the timer and, by holding on to the rubber band, pull the trolley along the bench top all the time keeping the rubber band stretched as far as the wooden pillar, i.e. stretched to a constant length.
5. Ignore the first few dots on the tape. Select one dot as a starting point. Calling this dot zero count out the next ten dots and draw a line through the tenth dot. Measure the distance between the lines. Call this distance X_1 . Repeat the process for the next series of dots. Call this distance X_2 .

For example:

- Alternatively you can use the set up shown in Fig. 5.2. The constant force is provided by a mass in the gravitational field.



RESULTS

1. Set up a table that includes the following headings :

Total mass trolley + mass (kg)	X_2 (cm)	X_1 (cm)	$X_2 - X_1$ (cm)	Acceleration $\frac{X_2 - X_1}{t^2}$ (cm / s ²)	$\frac{1}{m}$

2. The timer makes 50 dots per second. Therefore, the time interval between two dots is second.
3. Calculate the acceleration, a using: $\frac{X_2 - X_1}{t^2}$.
4. Using three different time intervals, $X_1 - X_2$, $X_2 - X_3$, $X_3 - X_4$, calculate the values of the acceleration of the object.
5. Calculate the average value for the acceleration of the object.
6. Record, in the table, the mass of the object (the trolley) and the average acceleration.
7. Add a 1kg mass to the trolley and record, in the table, the total mass of trolley plus added mass.

8. Repeat steps 3 – 6.
9. Repeat steps 3 – 8 with added masses of 2kg, 3kg etc.
10. Plot a graph of acceleration, a, against mass, m.
11. Plot a graph of acceleration, a, against the reciprocal of the mass, $\frac{1}{m}$.

DISCUSSION

1. Why is it important to keep the length of the stretched rubber band constant when measuring the acceleration?
 2. If the distance for ten time intervals is to be found why is it necessary to actually measure the distance between 11 dots?
 3. Say in your own words how the mass of an object and its acceleration are related.
- Alternative equipment for the dynamic trolley: Any freely running object on three or four fixed wheels could be used, for instance a toy car. A simple trolley might be made for you in a woodwork class from wood, metal axles and plastic wheels.

Experiment 6

PRINCIPLE OF MOMENTS

INTRODUCTION

The concept of moments is needed for an understanding of the theory of levers. The example in this experiment is analogous to the way a weighing balance works. Two factors affect a moment. One is the magnitude of the force applied. The other is the distance between the point of application of the force and the pivot point.

AIM

To verify the Principle of Moments.

MATERIALS

Metre ruler (or similar piece of wood)

Small nail

Retort stand

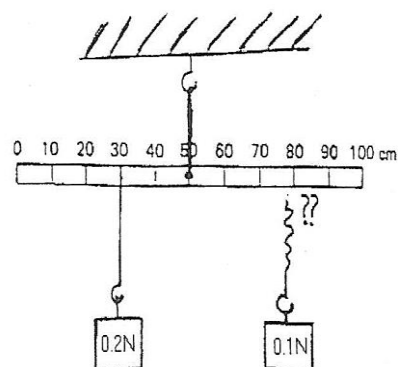
Bosshead clamp

String

10g, 50g, and 100g masses labelled by the teacher as weights in Newton's Ceiling hook.

METHOD

1. Make a small hole at the 50 cm point of a metre ruler. Put a fairly strong string through the hole and suspend the ruler from a hook in the ceiling as shown in the diagram.
2. Use drawing pins (or other small weights like paper clips) to adjust the ruler until it balances in a horizontal position.
3. Suspend a 0.2 N weight by string from the ruler at a position 20 cm to the left of the pivot point and tape this in position so that it does not move. Record in a table as shown in Table 6.1 the weight of the 0.2 N object (F_1) in Newton's and the distance from the pivot point (d_1) in metres. A student will have to hold the weight until the step is performed.
4. Take a 0.1N weight to which a string is attached and move the string along the ruler until the ruler again balances. Record in the same table the weight of the 0.1 N object (F_2) and the distance of the string from the pivot (d_2).
5. Increase then weight F_2 to 0.5N and again find the balance point. Record the weight of the 0.5 N object and the distance, d_2 , in the table.
6. Repeat this procedure for a total of 5 readings.



RESULTS

TABLE 6.1

Set up a table as shown

F_1 (N)	d_1 (m)	F_2 (N)	d_2 (m)	F_1d_1 (Nm)	F_2d_2 (Nm)

GRAPH:

Students should draw a graph of d_2 on the x – axis against F_2 on the y – axis.

DISCUSSION

1. What regularities can you see in the numbers in the table?
2. State these regularities as general rules.
3. Would the principle of moments be still valid if the ruler is pivoted at some point other than at the centre?

Experiment 7 BODIES IN A GRAVITATIONAL FIELD

INTRODUCTION

When an object moves in a gravitational field the effect of gravity on movement of the object is independent of the initial direction of travel of the object. So, for instance, as long as factors such as air resistance are not taken into account, an object falling to earth from rest will reach the earth at the same time as an object starting at the same height above the earth but initially moving horizontal. Similarly a heavy and a light object will fall at the same rate and land at the same time if dropped from the same point.

AIM

To investigate the free fall movement of objects under the influence of gravity.

MATERIALS

A large stone

A small stone

A bench top

Stop watch

Two objects of equal mass such as two ball bearings

Marble or stones.

METHOD A

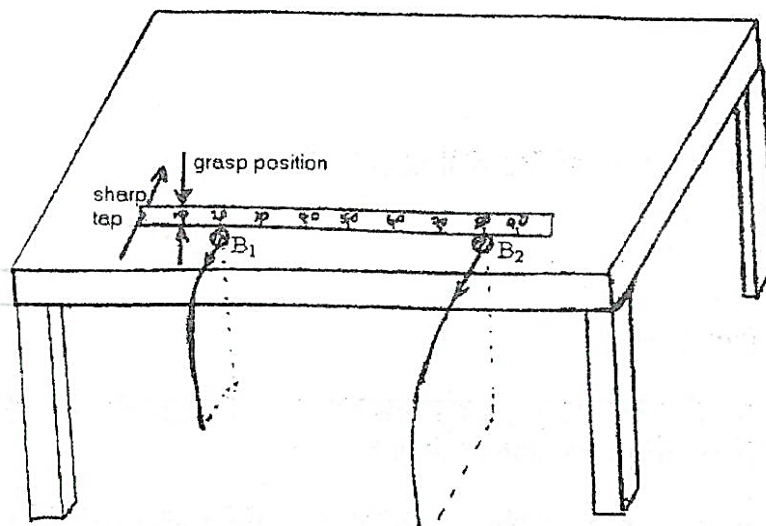
Dropping heavy and light objects

1. Ask students to predict whether a large stone or small stone would hit the ground first if dropped from the same height.
2. Drop the large stone from a height of about 4 metres and record the time taken. Repeat four more times to obtain an average.
3. Repeat the process for the small stone. Determine from the results which seems to fall fastest.
4. Drop the two stones simultaneously from the same height and determine which landed first. Repeat four more times.
5. Ask students to explain the observations.

METHOD B

Objects moving in different trajectories

Place a ruler sideways 10cm from the edge of a bench top and place a ball bearing or stone against the 80 cm mark. Place another stone or ball bearing of equal size against the 20 cm mark. Stand on the other side of the ruler from stones. With the ruler still resting on the table, grasp then ruler at the 10 cm mark with your right hand. Ask students to predict which stone will hit the ground first and why, when the ruler is hit and the stones are flown off the bench.



Hit the end of the ruler nearest your hand with sharp tap to propel the stones across the room. The stone at the 80 cm mark should be propelled farther across the room. Repeat a number of times to establish observations. Ask students to explain their observations.

DISCUSSION

1. In Method B one stone travels a considerable distance across the room. While it moves horizontally it also falls vertically. In which motion is its speed constant?
2. What do you understand by the term “free fall”?
3. If a ball is projected horizontally, what is its initial vertical velocity component?
4. If a ball is projected horizontally and another is dropped, what can you say about their time of flight?
5. If any two balls are projected horizontally at any given velocity, what can you say about their duration of flight?

Experiment 8

MOMENTUM

INTRODUCTION

Conservation of momentum is one of the most important concepts in Physics. By examining simple collisions of two trolleys carts, students can gain a qualitative understanding of elastic and inelastic one dimensional collisions.

AIM

To observe the effect of momentum conservation in one dimensional collisions.

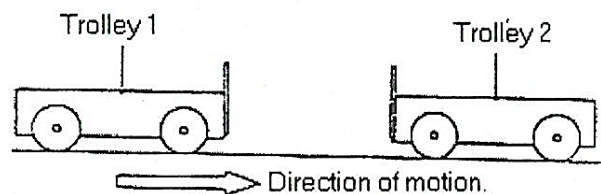
MATERIALS

2 trolleys carts of approximately equal masses
Plasticine
A heavy mass

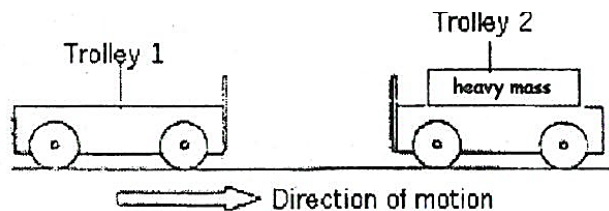
METHOD

1. Ensure the wheels of the trolley carts spins freely by oiling (sewing machine oil, or even coconut oil). Clear the top of a long table so the carts can move freely.
2. Try each of the following elastic collisions by allowing the carts to bounce off a spring plunger. Record the relative speeds with expressions such as: moves more slowly, move with same speed, or moves more quickly.

- a. One light cart moving, striking equal mass stationary cart.



- b. One light cart moving, striking very heavy (use the mass) stationary cart.

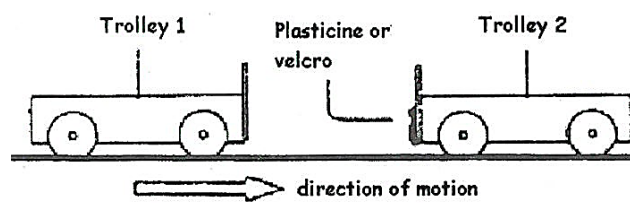


- c. One heavy (use the mass) moving cart striking light stationary cart.

- d. Two light equal mass carts moving towards each other, striking and bouncing.

- e. Two carts, one heavy, one light, moving towards each other, striking and bouncing.

3. Try the above as inelastic collisions by allowing the carts to stick together after collision (use the plasticine). Repeat all five instances in this way.



RESULTS

Record the observations in a sentence form. Example: When the moving heavy cart collided with the stationary light cart, the heavy cart moved forward at a slower speed while the light cart moved forward more quickly.

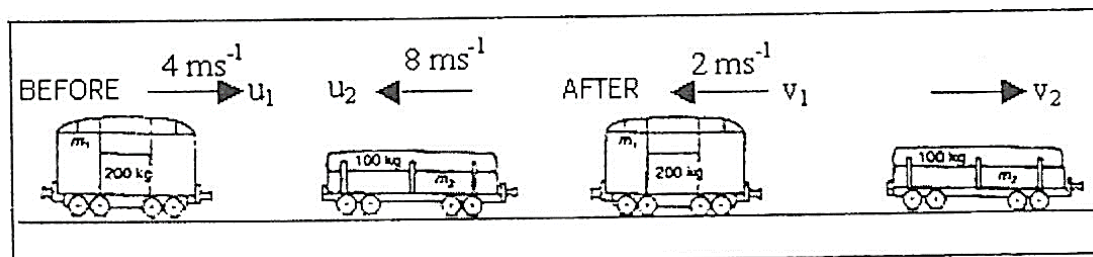
DISCUSSION

1. What effect did the heavy mass have on the change in speed of the cart?
2. Would change in velocity be directly or inversely proportional to the mass?
3. How did the final velocities differ between elastic and inelastic collisions?

EXERCISE

Copy and complete:

1. The total _____ remains unchanged in any collision provided no external _____ are present.
2. Two carts collide and rebound. The diagram below shows the situation before and after collision.



- (i) Find the momentum of m_1 and m_2 before collision.
- (ii) Determine the total momentum before collision.
- (iii) Find the momentum of m_1 after collision.
- (iv) Determine the speed v_2 of m_2 after collision.
Hint : $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

Experiment 9

POWER

INTRODUCTION

Power is the rate of doing work. That is, power is a measure of how quickly energy is transferred. The formula for power is: $P = w/t$.

AIM

To calculate the amount of useful power that your body can generate.

MATERIALS

Bathroom scales
Flight of stairs (or a nearby slope)
Stop watch

METHOD

1. Determine your mass using the bathroom scales.
2. Calculate your weight or the gravitational force exerted on you.
3. Measure the height of the flight of stairs (or the nearby slope).
4. Determine how long it takes you to run up the stairs, or the nearby slope.

RESULTS

Your mass (m) kg.
Your weight (mg) N (use $g = 10\text{N} / \text{kg}$)
Height of stairs (h) M
Time taken (t) s

1. Calculate the work done in climbing the stairs or slope.
2. Calculate the power produced.
3. As $1.34 \text{ H.P.} = 1 \text{ kW}$, what is your useful horse power?

DISCUSSION

1. For a student who takes a longer time to climb the stairs or slope, discuss what effects this has on the work done and the power generated.
2. In what form is the energy used for running originally stored as?
3. What would happen to the work done in climbing the stairs if the stairs were inclined at a much steeper angle?

Experiment 10

DENSITY

INTRODUCTION

Although density is an important concept, many students have difficulty comprehending it. In this experiment students can interpret density as the slope of a mass – volume graph. This provides experiences in graphing and recognizing direct relationships.

AIM

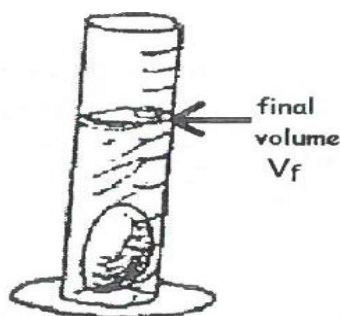
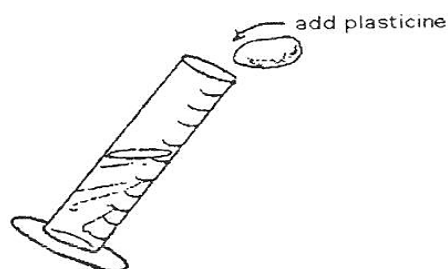
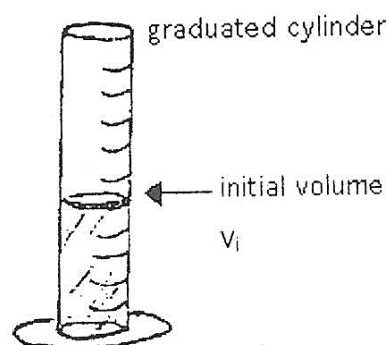
To derive a relationship between mass and volume for a substance and interpret the constant of proportionality.

MATERIALS

- A large lump of plasticine
- A graduated cylinder (250 ml)
- A beam balance

METHOD

1. Roll the plasticine into a length. Divide this into 8 to 10 approximately equal pieces. Choose 1 piece, make it into a lump that fits into the graduated cylinder
2. Take the mass of the lump of plasticine. Fill the 250ml graduated cylinder half way with water, record the initial Volume.
3. Allow the lump of plasticine to slide into the water. It should be completely immersed, record the new volume as the final volume.
4. Remove the lump of plasticine, Add on another piece, form into a new lump, and repeat from step 2.
5. Continue until all the plasticine is used. Note that only the change in volume $v_f - v_i$ of water is important.



RESULTS

Record in a table. [$1\text{cm}^3 = 1\text{m}\ell$]

Mass of plasticine M (g)	Final volume V_f (cm^3)	Initial volume V_i (cm^3)	Volume of plasticine $V = V_f - V_i$ ($\text{m}\ell$)

DISCUSSION

1. Plot a graph of volume on the horizontal axes against mass on the vertical axes for the plasticine.
2. What does the slope of this graph imply? Find the slope and identify the physical quantity that it represents.
3. What are some of the sources of experimental errors? Suggest how they may be reduced.
4. Discuss ways in which the density of following could be determined:
 - (i) Regular objects e.g. a cuboid, a spherical object, triangular prism etc.
 - (ii) Irregular objects e.g. an irregular rock / stone, an irregular piece of timber.

Experiment 11

ARCHIMEDES PRINCIPLES

INTRODUCTION

When an object is dipped into water its weight appears to be less. If the object floats its weight appears to be zero. This is because the water exerts a force which pushes up on the project. This force is known as up thrust. The size of the up thrust depends on how much the project is immersed in the liquid.

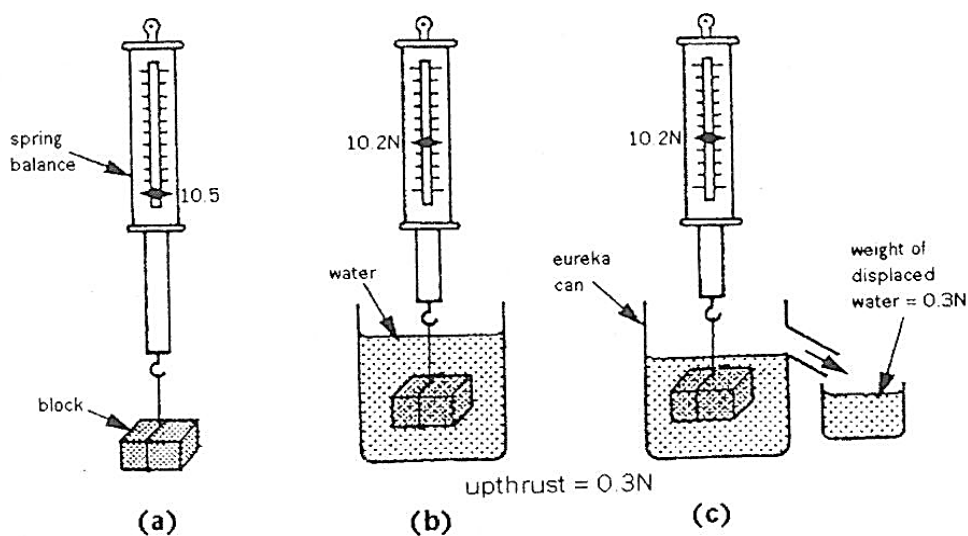
AIM

To show that when an object is immersed in a liquid it experiences an up thrust which equals the weight of the water displaced. (Note: In practice the weight of the displaced water is often 10 % lower than expected because surface tension of the water results in a meniscus retaining water in the overflow can.)

MATERIALS

Overflow can (eureka can)
4 or 5 objects, two of which sink and two which float
Spring balance
Beam balance
2 x 500 ml beakers
Cotton thread

DIAGRAM



METHOD

1. Use the cotton thread to tie the object to the hook of the spring balance.
2. Hold up the spring balance and object in the air and take a reading of the weight of the object from the scale of the spring balance. Record the result in a table.
3. Place the overflow can on the bench and add water to it until it overflows.

4. Weigh a clean dry beaker on the beam balance.
5. Place the weighed beaker under the spout of the overflow can.
6. Carefully lower the object into the water until it is partially immersed.
7. Read the apparent weight of the object from the scale of the spring balance. Record the result.
8. Carefully remove the object. Use the beam balance to find the mass of water that has been displaced into the beaker. Record the mass in the table.
9. Replace the beaker and water under the spout.
10. Lower the object into the water until it is totally immersed. Make sure the object does not touch the bottom of the overflow can.
11. Read the spring balance to determine the apparent weight of the object. Record the result.
12. Again weigh the beaker with its displaced water on the beam balance. Record the result.
13. Repeat steps 1 to 12 for the other objects making sure that the overflow can is refilled and the beaker is dried for each new object. For objects that float take a reading at step 6 where the objects is dipping in the water but not yet floating. For objects that float take a reading at step 10 where the object is free floating and the string between the spring and the object is slack.

RESULTS

Sample results are included in this table

	Partially immersed	Fully immersed
a) Weight of object in air (N)	10.5	10.5
b) Mass of a beaker (g)	95.2	95.2
c) Weight of object immersed in water (N)	10.4	10.2
d) Mass of beaker & water (g)	105.0	124.2
e) Mass of displaced water (d - b) (g)	9.8	29.0
f) Mass of displaced water In kg (e / 1000)	0.0098	0.029
g) Weight of displaced water (10 x f) (N)	0.098	0.29
h) Apparent loss of weight (a - c)	0.1	0.3

DISCUSSION

1. In the theory the apparent loss of weight should equal the weight of water displaced. Compare these two values in your experiment?
2. For objects that float in water :-
 - (a) What will be its weight when floating as measured by a spring balance?
 - (b) What will be the apparent loss in weight?
 - (c) What will be the up thrust on the object?

Experiment 12

BOYLE'S LAW: EFFECT OF PRESSURE ON THE VOLUME OF A GAS

INTRODUCTION

When pressure is exerted on a gas the particles of gas are pushed closer together so the volume of gas decreases. The gas particles themselves DO NOT decrease in size.

AIM

To investigate the relationship between the volume of a given mass of gas and the pressure at constant temperature.

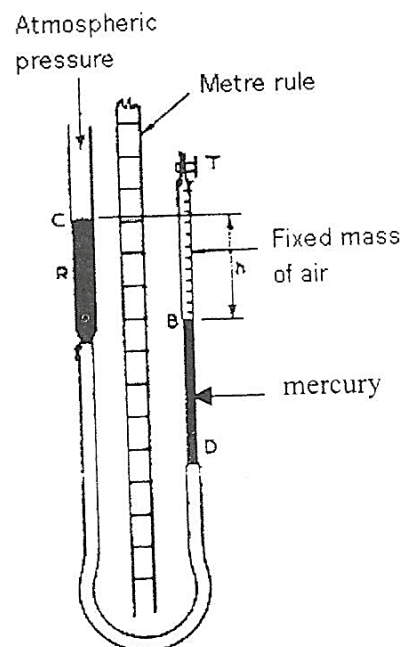
NOTE: Two different methods are given for this experiment. The second method avoids the use of mercury.

MATERIALS

A U – tube manometre
Metre ruler
Graph paper
Mercury

METHOD A

- (i) Set up the U – tube manometer, as shown in the diagram.
- (ii) With T open adjust the R to bring the mercury level to about the middle of TD, and then close T. This traps a fixed mass of air in the tube at atmospheric pressure.
- (iii) Read the atmospheric pressure in mm of mercury from a barometer .
- (iv) Raise R as high as possible so as to have as big a pressure on the air as allowed by the apparatus.
- (v) Measure the volume, V , of the air in terms of the length of the air column.
- (vi) Also measure the difference, h , in the heights of the mercury levels, adding this to the atmospheric pressure, A , to obtain the pressure P on the column.



- (vii) Lower R in stages and repeat the above measurements, making sure those six sets of measurements, are possible. Note that when C gets below B you have to subtract the difference in heights from the atmospheric pressure to obtain the pressure on the air.

The pressure P exerted by a column of mercury of height, h , is given by

$$P = \rho gh$$

Where $\rho = 1.36 \times 10^4 \text{ kgm}^{-3}$ is the density of mercury

And $g = 9.8 \text{ ms}^{-2}$ is the gravitational acceleration

- (viii) Convert your measurement of mercury, height difference, h , to pressures (in Pascal's) using the formula given above. Also for the atmospheric pressure, if you have used the laboratory mercury barometer instead of the aneroid barometer then use the formula above to find the pressure in Pascal's corresponding to the height of the mercury.
- (ix) Add the atmospheric pressure to h (in Pascal's) to obtain the total pressure acting on the trapped air.

RESULTS

- (i) Record your data in a table as shown.

$\ell (\propto V)$	h	$P = (A + h)$	$PV (= A + h) \ell$	$\frac{1}{V}$

- (ii) Use your table of data to plot a graph of pressure (P) against volume (in arbitrary length units)
- (iii) Plot another graph of pressure against the reciprocal of volume, $\frac{1}{V}$.

DISCUSSION

- Why do you think the length of the air column is taken as a measure of the volume of the air inside the column?
- Do then values of PV show up any pattern? Describe this pattern in your own words.
- What does the graph tell you about the relationship between the pressure and the volume for a fixed mass of gas.
- In this experiment one of these quantities is assumed to be unchanged: pressure, volume, temperature. Which one is it?
- (a) Determine the pressure 20 m below the surface of a fresh water lake (Assuming its density is uniform and is equal to 1000 kgm^{-3}).
- (b) Use your conclusion from this experiment to calculate the volume of a spherical air bubble as it bubble as it reaches the surface of the lake after being released from a 20 m depth where it had a diameter of 1 cm (assume the temperature of the water is uniform).

METHOD B

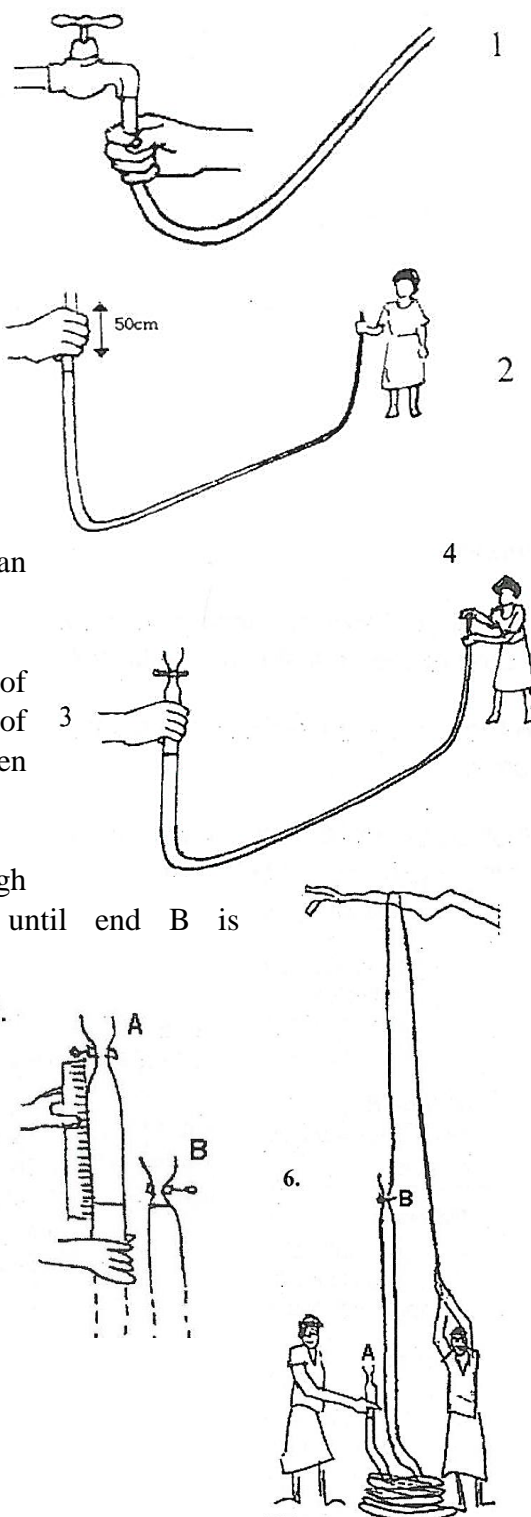
This method avoids the use of mercury which is toxic and not available in some schools.

MATERIALS

A 12 m length of clear plastic tubing of diameter 1 cm and 2cm; two clamps to clamp the tubing (Mohr clips or woodworkers G clamps); a metre ruler or tape measure ; a 12 m length of rope.

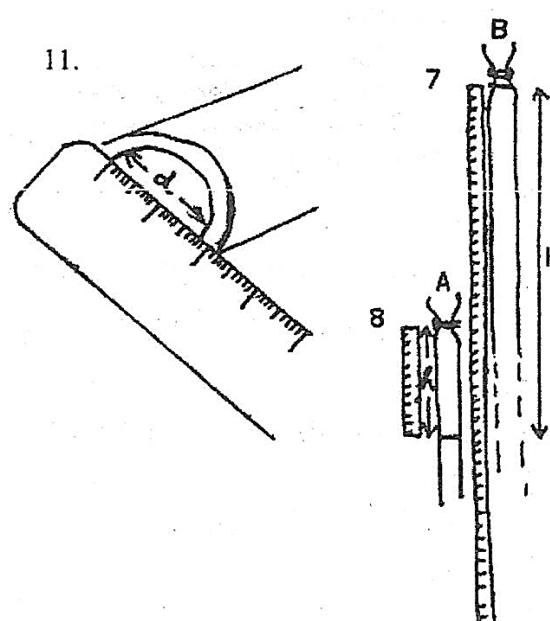
METHOD

1. Lay the plastic tube on the ground and run water through it from a tap or garden hose until the tube is full of water.
2. Hold the two ends of the tube up off the ground. Add water or remove it so that the water level is about 50cm from each end.
3. Clamp one end of the tube to completely seal it.
4. Add water to the other end until it reaches the top of the tube then also clamp that end so air can still get in and out.
5. Bring the two ends together so that the top of water are beside each other, measure the height of the air column in cm. Record the height (h) when the levels are the same.
6. Tie a rope end B and throw the end over a high tree branch or a verandah. Haul the rope up until end B is about 0.5 m above the water level in A.
7. Measure the exact difference of height between the water levels in B and A. Record results in table as H.
8. Measure the height of the column of air. Record results in a table as h.
9. Haul the end B up another 0.5m and repeat measurements. Record all results in a table.



10. Continue raising B by 0.5 m lengths and measuring height of air column until B cannot be raised any more. Try to take at least 6 measurements.

11. Bring the tube to the ground, Remove the water and measure the inner diameter of the plastic tube, d.



RESULTS

- 1) Calculate r, V, P. on graph paper with the vertical axis as P pressure (mm of water) and horizontal axis as volume, V.
- 2) Plot the graph of P versus V.
- 3) Plot a second graph of P versus 1/v.

[Assume Air Pressure = 103 cmH₂O]

TABLE

Height of air column, h (cm)	Volume of air Column $V = r^2h \text{ cm}^3$	Difference in height of water levels in A & B, H (cm)	Pressure on air Column $P=A+H \text{ (cm)}$	$\frac{1}{V}$
51.2 cm	161cm ³	0 cm	1034 cm	0.0062
48.8 cm	153 cm ³	51 cm	1085 cm	0.0065

DISCUSSION

1. How much error was there in your measurement of h, d and H ?
2. How will this error affect the values of V & P?
3. When the pressure on a gas is increased what happens to the volume of the gas?
4. Which quantity is assumed unchanged: volume, temperature or pressure?

Experiment 13 TEMPERATURE AND HEAT

INTRODUCTION

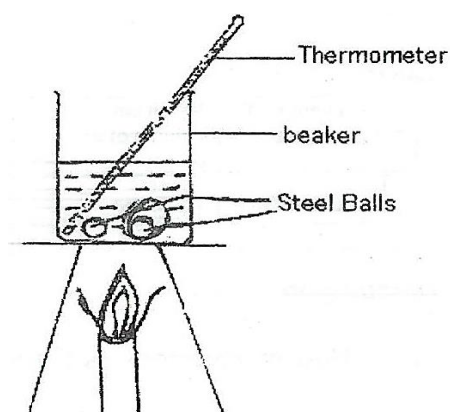
Temperature is a measure of the degree “hotness “of an object. Heat refers to the energy transferred when a hot object comes in contact with a cooler object or when work is done on an object to change its temperature. This heat is a form of energy.

AIM

To investigate the difference between temperature and heat in a body.

MATERIALS

Two steel (or lead) balls – one large and one small
Bunsen burner
Beaker
Thermometer
Paraffin block and tongs



METHOD

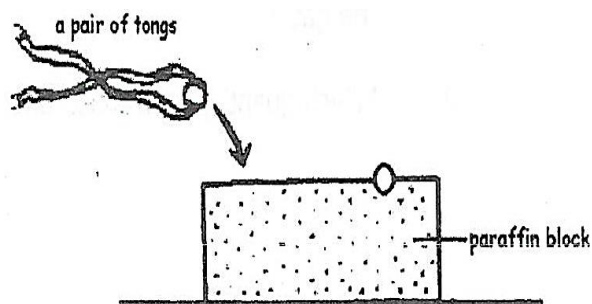
1. Place the two steel balls in the beaker and fill then beaker with water.

2. Heat the beaker and contents until the water boils.

3. Place the thermometer in the water and measure the temperature

4. Quickly transfer the two balls to the paraffin block using the tongs.

5. Observe what happens to the paraffin around each ball and record your observations carefully.



DISCUSSION

1. What should be the temperature of both balls when they are in the boiling water?
2. Briefly explain the terms of kinetic theory of matter why the temperature of the metal balls the same as that of the boiling water.
3. Around which ball has more paraffin melted? Since the balls were at the same temperature, what does this observation tell you about the energy of each ball as they are taken out of the water?
4. Do both balls have the same heat energy as indicated by the melting of the paraffin? Are both balls at the same temperature? Is heat energy the same as temperature?

Experiment 14

CHARLES' LAW

INTRODUCTION

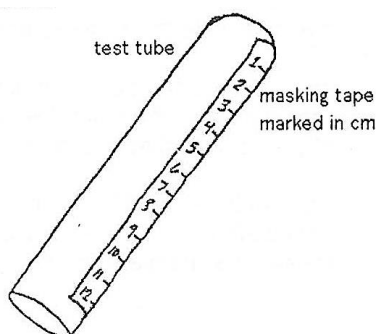
Most substances expand on heating; gases the most of all. Charles' Law describes the relation between the volume and temperature of gases. In this experiment students can make rough observations of the expansion of a gas.

AIM

To investigate the relationship between the volume of a given mass of air and the temperature of the air at constant pressure.

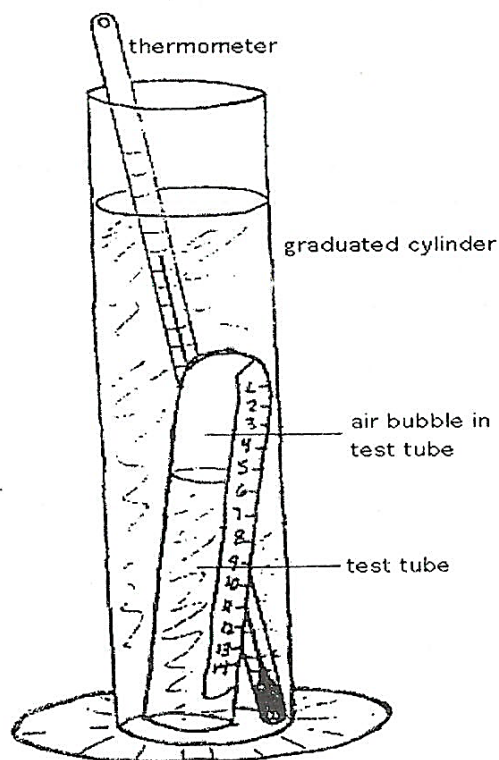
MATERIALS

Test tube
100ml graduated cylinder
Masking tape
Waterproof marker
Thermometer
Lead weight



METHOD

1. Place a 1cm wide strip of masking tape down the outside of the test tube; mark it off in centimetres.
2. Invert the test tube in a graduated cylinder filled with cool water so that the test tube is about $\frac{1}{4}$ filled with air. It is probably necessary to place a heavy object on the test-tube to keep it immersed. Slide the thermometer in beside it.
3. Record the length of the air in the test tube from the masking tape scale, and the temperature from the thermometer.
4. Pour some boiling water from the top (some will spill over, so put the graduated cylinder in the sink) record the new length of air and temperature.



5. Continue pouring in boiling water a little at a time, so that the temperature keeps increasing. When the gas has almost filled the test-tube then stop, cool water instead, continuing to take measurement of length of air column and temperature.

RESULTS

Record the temperature and length of air column, plot the results on a graph paper.

Temperature	Length
°C	cm

DISCUSSION

1. What is the shape of the graph, and what does this imply?
It is unlikely to be a straight line, but ideally it would be.
2. Sketching a straight line between the points, at what temperature does it cross the temperature axis? Ideally it should pass through $-273\text{ }^{\circ}\text{C}$.
3. What other measurement would you require in order to calculate the volume of air in the test –tube?
4. Calculate the volume of air in the test –tube (in cm^3) for every measurement of length of air column.
5. Why is it appropriate to draw a graph of temperature vs length of air column rather than temperature vs volume?

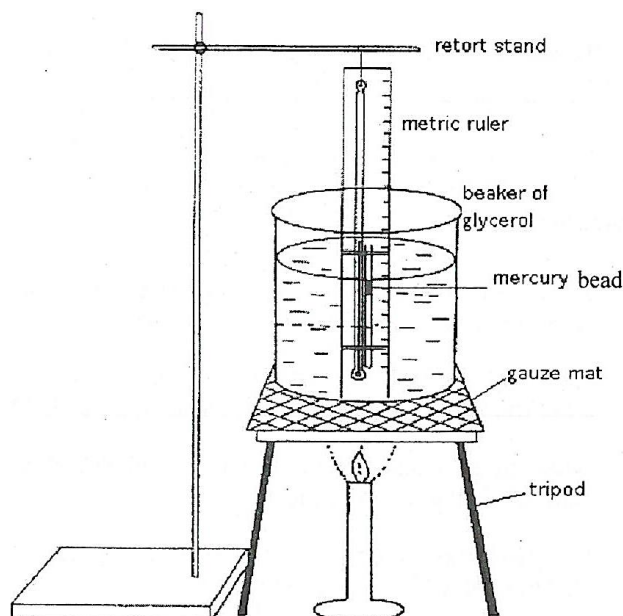
Experiment 15 CHARLES' LAW

AIM

To investigate the relationship between the volume of a given mass of air and the temperature of the air at constant pressure.

MATERIALS

Celsius thermometer (0-200°C)
Capillary tube closed at one end and containing a bead of mercury and trapped volume of air
Metric ruler
Beaker (500 cm³)
Coconut/soya bean oil or water or glycerol (sufficient to three-quarters fill the beaker)
Tripod
Retort stand
Gauze mat
Bunsen burner
Cotton
Rubber bands
Stirring rod



METHOD

1. Attach the capillary tube to the stem of the thermometer and then attach both to ruler using rubber bands. Tie cotton through the end of the thermometer and suspend it from the retort stand. Pour liquid (oil water or glycerol) into the beaker. Stand the beaker on the gauze mat on the tripod. Place the suspended thermometer into the liquid so that the open end of the capillary tube is quite clear of the liquid.
2. The mercury will be at the top of the volume of air trapped within the capillary tube. Use the ruler to measure the length of the trapped column of air to the bottom meniscus of mercury. Since the trapped volume of air is cylindrical, we can measure the volume of air in arbitrary units of length. As the air is heated you will measure changes in volume as changes in length.
3. Record the initial temperature of the liquid.
4. Begin heating the liquid and record at least 10 pairs of readings of the length of the column of air in the capillary tube (in cm) and the temperature of the liquid. Tabulate your results. Stir the liquid at frequent intervals to ensure that the heat is distributed evenly throughout the liquid.

5. Plot a graph of volume against temperature, from your table.

DISCUSSION

1. What quantity affecting both the volume and temperature of a gas is being kept constant throughout this experiment?
2. Find the gradient of your graph and use this and the y-intercept to find an equation for your graph. Use this to find where the graph cuts the temperature axis (i.e. when the volume=0). This is called absolute zero. Absolute zero is actually -273°C . How close is your result? Comment on any errors which might have occurred in your experiment.
3. Use the equation to determine the volume of a given mass of gas which initially occupied 250 cm^3 and was heated from 25°C to 50°C (at atmospheric pressure).
4. On a sketch of a volume against absolute temperature graph, draw in lines depicting the results you would expect to obtain if your experiment were carried out on days of different atmospheric pressure.
5. How does the volume of a fixed mass of gas vary with the temperature of the gas?

Experiment 16

COOLING CURVE OF NAPHTHALENE

INTRODUCTION

A solid requires heat to change to a liquid (heat of fusion). We can also investigate the release of heat as a liquid changes to a solid.

AIM

To plot the cooling curve for naphthalene.

MATERIALS

Naphthalene (moth balls)

Bunsen burner

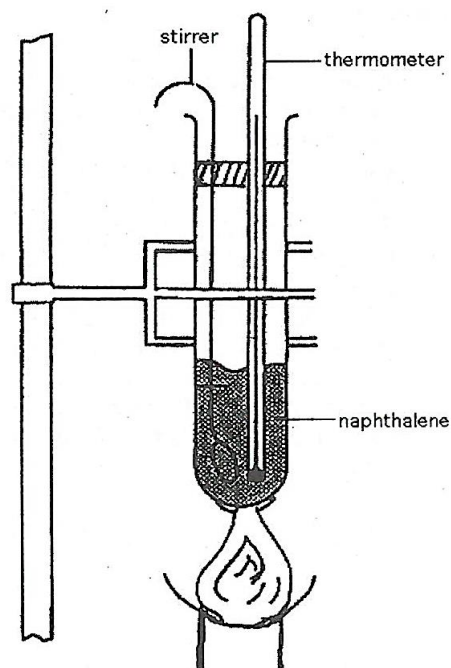
Test tube

Thermometer

Retort stand

METHOD

1. Place the naphthalene in a test tube and heat the test tube in a Bunsen flame.
2. Heat the naphthalene until it reaches 100°C , but no more.
3. Arrange the thermometer so that it does not touch the side or bottom of the test tube.
4. Remove the Bunsen burner and whilst the naphthalene is cooling, record the temperature at 15 second intervals.
5. Record the temperature at 30 second intervals once the temperature becomes steady.
6. Once the temperature starts to drop again take temperature reading at 15 second intervals.



RESULTS

Tabulate your results.

Reading No.	Time elapsed (s)	Temperature ($^{\circ}\text{C}$)
1	0	
2	15	
3	30	
4	45	

1. Plot a graph of temperature in °C (vertical axis) against time (t) in seconds.
2. Mark on the graph the regions xx^{-1} , where the curve is horizontal.

DISCUSSION

1. At the section xx^{-1} was the temperature increasing, decreasing or remaining constant?
2. Describe the changes in state occurring during section xx^{-1} .
3. During the melting of the naphthalene was energy absorbed or released from the naphthalene?

Experiment 17

IMAGES IN PLANE MIRRORS

INTRODUCTION

The apparent relative motion of two objects seen by a moving observer is called parallax. There is no parallax if the two objects are in same vertical line. This principle could help us accurately locate the position of an image formed by a mirror.

AIM

To find the position of an image in a plane mirror.

MATERIALS

Strip of plane mirror
Pins
Ruler
Sharp pencil
Plain paper
Protractor

Introductory Activity

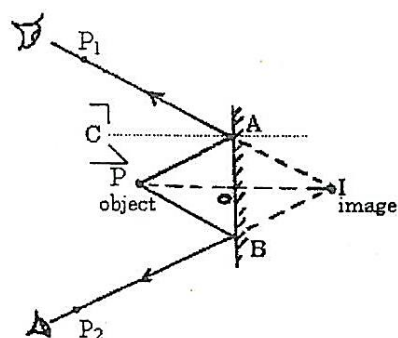
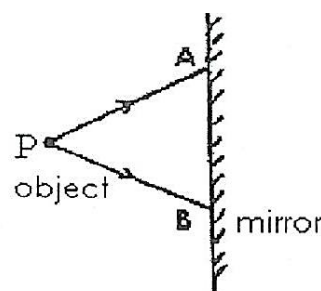
Finding Image Using Non Parallax Method

Hold up two pencils, one in each hand, at different distances from your face. Move your head to the right. Which pencil appears to move to the right? Predict what will happen when you move your head to the left and test your prediction. Now place the pencils above each other at the same distance from the eye. Do they appear to move relative to each other when you move your head?

Place one pencil in front of the mirror. Using a second pencil locate the image of the first pencil at the back of the mirror by the no parallax method.

METHOD

1. Support the mirror so that it stands vertically in the center of the paper and rule along its back surface.
2. Mark a point on the paper about 15cm from the mirror. Label it as P.
3. Temporarily remove the mirror, rule as finely as possible two lines from the point to different points on the mirror?
4. Replace the mirror in its position and place a pin



vertically at the point P.

5. The lines represent rays of light going from the foot of the pin to the mirror and, for each line, place another pin in the paper (as far from the mirror as possible so that its point is in line with the reflection of the line in the mirror). These are P_1 and P_2 .
6. Draw a line perpendicular to the mirror surface at point A.
7. Draw lines from P_1 and P_2 to meet the original lines at the mirror surface. Extend the lines behind the mirror line to find the point of intersection. This is the image position.

RESULTS

Measure and record	Angle IOA	= _____
	Length IO	= _____
	Length OP	= _____
	Angle P_1 AC	= _____
	Angle PAC	= _____

DISCUSSION

1. How do the lengths IO and OP compare with each other?
2. Does this experimental result suggest a simple rule for image and object distances under reflection in plane mirrors? State the relation.
3. What is the name of the line drawn perpendicular to the surface of the mirror?
4. Where, from your diagram, are the angles of incidence and reflection measured?
5. Is there any significant relation between the sizes of the angle of incidence and reflection as observed from the experiment? State, if there is any.
6. Suggest a reason for the use of dotted lines behind the mirror.

Experiment 18

IMAGES IN CONCAVE MIRRORS

INTRODUCTION

Concave mirrors have a wide range of uses, e.g. in solar cooker, telescope, shaving etc. It is important to be able to predict the location of an image if the object distance is known. In this experiment the students derive the relationship between the focal length, the image distance and the object distance.

AIM

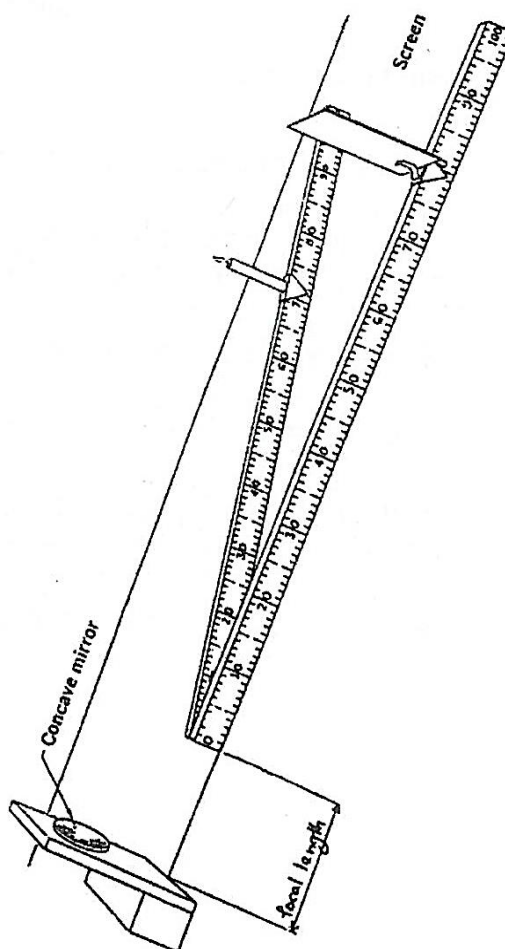
To determine the relationship between the image and object positions using a concave mirror.

MATERIALS

A concave mirror
Plasticine
Small light source (even a candle)
Paper strip 1-2 metres in length graduated in cm
Stiff white cardboard screen.

METHOD

1. Measure the focal length of the concave mirror. Place the mirror vertically on a table top with plasticine, and tape the paper strip ruled in cm with the zero length on the focal point.
2. Place the light source at the far end of paper strip. Hold the screen at the paper strip. Hold the screen at the zero end of the paper strip. Slowly move the screen away from the mirror until the image of the light source is clear and sharp.
3. Record the distance from the object to the focal point as shown on the paper strip (S_0). Record the distance from the image to the focal point as shown on the paper (S_i).
4. Decrease the object distance by 10cm and then repeat from step 2. Continue until the object is at the centre of curvature, then decrease object distance in steps of 2 cm.



RESULTS

Record results in a table as shown.

Object Distance S_o cm	Image Distance S_i cm	$\frac{1}{S_o}$ cm^{-1}	$S_o S_i$ cm^2

DISCUSSION

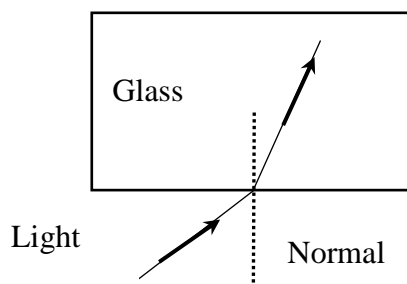
1. Sketch a graph of S_o on the horizontal axis against S_i on the vertical axis. What does the shape of this graph imply?
2. Plot a graph of $\frac{1}{S_o}$ on the horizontal axis against S_i on the vertical axis. What does the shape of this graph imply? What is the slope, and what physical quantity does it represent?
3. Was the image formed virtual or real?
4. If the mirror were convex what sort of image would be produced? Could you find the image on the screen?

Experiment 19

REFRACTION

INTRODUCTION

As light enters a medium like glass or water the rays bend. This bending of light is called refraction. When light enters into a more dense medium it refracts towards the normal as shown.



AIM

To trace and draw the path of light rays through glass slabs of various shapes.

MATERIALS

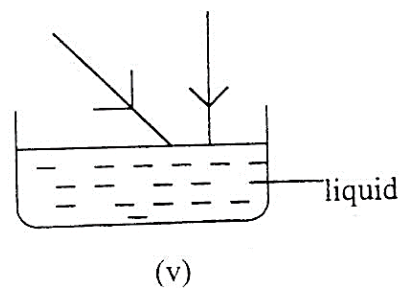
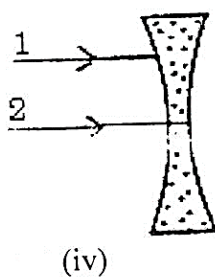
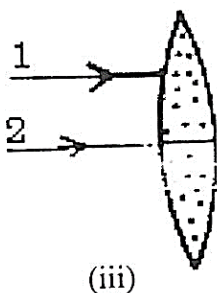
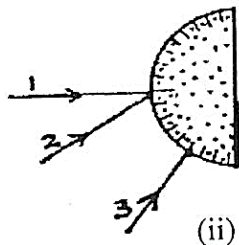
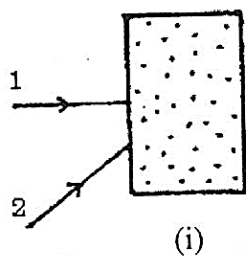
Parallel –sided glass slab
Semi – circular glass slab
Biconvex slab
Biconvex slab
Pins
Pencil
Ray box
Prisms

METHOD

1. Place a glass slab on a piece of paper and draw around its edges.
2. Using a ray box and a narrow single slit produce a narrow beam of light and trace the paths of two incident rays through a
 - (i) parallel sided glass block
 - (ii) semi –circular glass block
 - (iii) biconvex glass slab
 - (iv) biconcave glass slab.
3. In each case remove the block and complete the passage of the light ray through it.
4. You can also try trace light through some liquid placed in thin transparent containers.

RESULTS

Complete the ray diagrams



DISCUSSION

1. Does the entire incident light in each case enter the glass slab? Explain.
2. Does all the light transmitted through a glass slab come out into the air?
3. In terms of the changes in the densities of the medium through which a light ray passes explain briefly how the ray bends in relation to the normal.
4. How does the ray incident along the normal refract (bend) on entering the glass slab?

Experiment 20

IMAGES IN CONVEX LENSES

INTRODUCTION

Light passing through a convex lens bends (converges) towards the axis of the lens and for this reason a convex lens is called a converging lens. In a concave or diverging lens the light bends away from the principal axis of the lens so that the diverging light appears to come from the focus point.

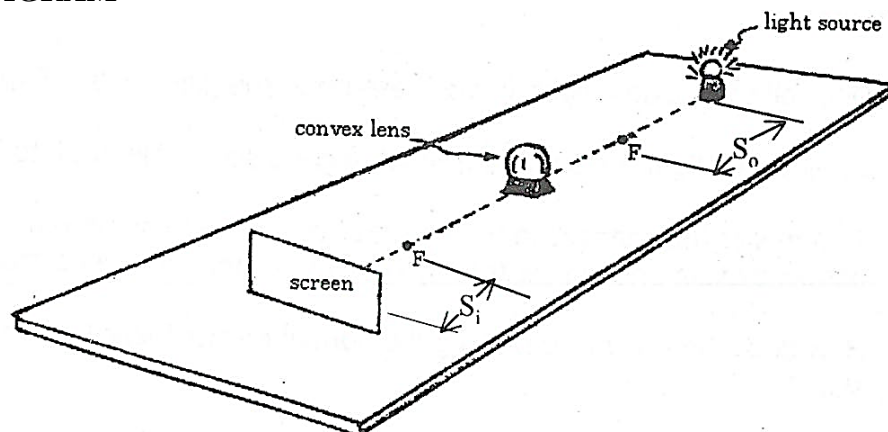
AIM

To discover the relationship between the object and the image distances formed by a lens.

MATERIALS

Convex (converging) lens
Metre rule
12 V lamp
Plasticine
Screen

DIAGRAM



METHOD

1. Stand the lamp on the bench and place the convex lens in position as shown in the diagram.
2. Determine the focal length of the lens by focusing the image of objects outside the laboratory on a paper screen. At focus the distance between the screen and the lens is the focal length, f .
3. Move the lamp to several different positions in relation to the lens and, when the sharpest image is obtained on the screen, measure the distances between the lamp and the focal point as S_o .

4. Measure the corresponding distance between the screen and the focal point (S_i) for each position of the lamp when the screen has a clear image of the lamp. This is S_i .
5. Tabulate your results as below.
6. Plot a graph of S_i against S_o .
7. Plot a graph of S_i against $\frac{1}{S_o}$.

RESULTS

Tabulate results as follows:

S_i	S_o	$S_i S_o$	$\frac{1}{S_o}$	f^2

DISCUSSION

1. What is the name of the shape of the graph in (6)?
2. What information does your graph in (6) and (7) tell you about the relationship between S_i and S_o ?
3. How do your $S_i S_o$ values compare with the f^2 values?
4. If the lens were concave, what sort of image would be produced?
5. Could you find this image on the screen?

Experiment 21

THE REFRACTIVE INDEX

INTRODUCTION

Refraction is the change in direction of propagation of waves when it enters into another medium. The change in direction is due to change in velocity of the waves. At zero angle of incidence the waves pass in deviated. The absolute refractive index, $n = \frac{\sin i}{\sin r}$.

AIM

To determine the relationship between $\sin i$ and $\sin r$.

MATERIALS

Rectangular or semi-circular transparent plastic or glass dish

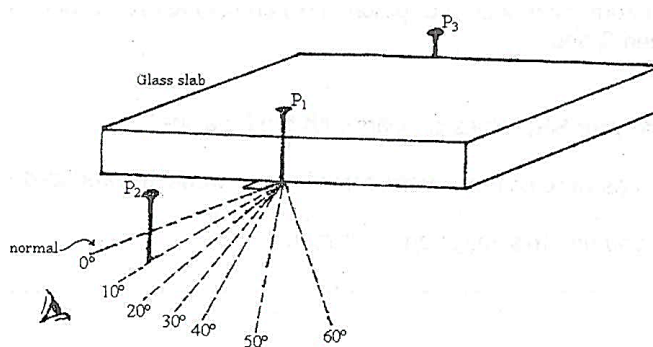
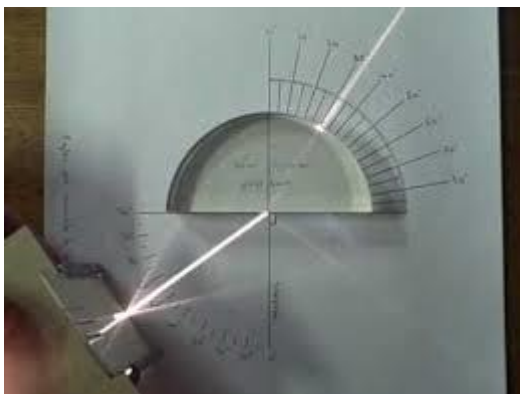
Rectangular semi-circular glass or Perspex slab

Large pins

Sheet of graph paper

Cardboard

DIAGRAM



Source: <http://keywordsuggest.org/gallery/632021.html>

METHOD

1. Place the rectangular or semi-circular glass slab in the middle of a clean sheet of paper and neatly draw around its edges with a sharp pencil.
2. Through the middle of one edge draw a line normal to this edge and using a protractor draw other lines at 10° intervals to one side of this normal. Stick a pin (P_1) through the intersection of the normal and that edge.

3. Stick another pin (P_2) about 4cm from P_1 and on the first line (ray 1) from the normal.
4. Now look at the pins through the slab from the other side and by moving a third pin (P_3) along the other edge, move your line of sight side and by moving a third pin (P_3) along the other edge, move your line of sight until the three pins are in line.
5. Mark this line of sight as ray 1.
6. Change the position of the P_2 to the next line representing an angle of incidence of 10° . Repeat (5) and label this next emergent ray 2.
7. Repeat this process for angles of incidence of 20° , 30° etc. up to about 70° .
8. The pinholes give a permanent record of the exact positions of the pins.
9. Complete the following table and plot a graph of “sin i against r”

RESULTS

I	r	sin i	sin r	$n = \frac{\sin i}{\sin r}$
0°				
10°				
20°				
30°				
40°				
50°				
60°				
70°				

DISCUSSION

1. Is your graph of sin i versus r a straight line or a curve?
2. State in one sentence the relation between sin i and sin r using the terms “direct “ or “inverse” proportionality.
3. From your graph determine the slope of the line.
4. If you used a more dense liquid or glass how would this affect your graph?

INTRODUCTION

Waves may be divided into two forms which are:

1. TRANSVERSE WAVES and
2. LONGITUDINAL WAVES.

In transverse waves the disturbances are at right angles to the wave direction and examples include light waves, water waves etc. In longitudinal waves the disturbances are parallel to the line of wave direction. The to-and -from movement of the end of slinky produces longitudinal waves. Sound waves are also longitudinal; a vibrating loudspeaker pushes backwards and forwards repeatedly on the surrounding air and this causes pressure waves which travel through the air.

AIM

1. To produce, observe and draw diagrams illustrating the difference between transverse and longitudinal waves.
2. To have an idea about the relationship between the tension of the spring and the speed of the waves.

MATERIALS

Slinky spring

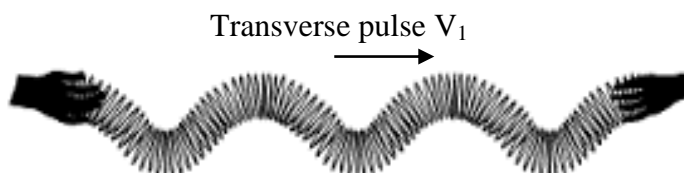
Pieces of string for fastening

A stop watch

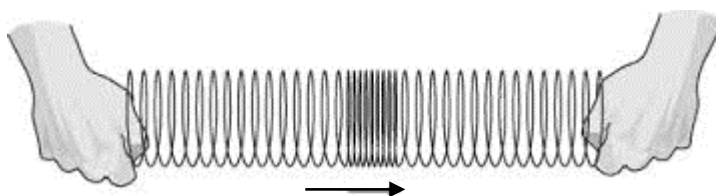
A measuring tape or a metre rule

DIAGRAM

A transverse pulse where the movement of the spring is perpendicular to the direction of travel.



A longitudinal pulse where the movement of the spring is in the direction of travel.

**METHOD**

1. Fix one end of the slinky to the wall or bench.
2. Hold the other end and stretch it horizontally to a length.

3. Make a quick to –and –fro movement of the end you are holding.
4. Observe the motion of the wave.
5. Repeat 3 and 4 for a number of times and record the time taken for the wave to travel from one end to another and back again for each try. Find the average time.
6. Now holding the other end stretched make a quick flick of the end up and down.
7. Record your observations carefully specially when the wave pulse reflects from the fixed end.
8. Repeat 6 and 7 several times and measure the time taken for the wave to travel to the end and back again.
9. By stretching or loosening, change the length of the spring and repeat 5 to 8.

RESULTS

1. Draw diagrams to illustrate your results.
2. Draw a table as shown below and record results for length and time and calculate the average speed of the wave through the slinky.

Longitudinal				Transverse		
	Length	Avg. Time	Av. Speed	Length	Time	Avg. Speed
1						
2						
3						
4						

DISCUSSION

1. Name the kind of wave produced in (3).
2. Name the kind of wave produced in (6).
3. Comment on the type of wave produced when the wave along the silky reflects from the fixed end (7).
4. When the spring is stretched more, tension of the spring increases. How did the speed of the waves change when the tension of the spring increases? How did the speed of the waves change when the tension was increased?
5. Compare the energy transfer in a slinky with the energy transfer when water is heated.

Experiment 23

SPEED OF SOUND

INTRODUCTION

The speed of sound depends on the materials through which it is passing. The speed of sound is greater in solids than in liquids or gases. The sound waves are reflected well from hard flat surfaces such as walls or cliffs and obey the same laws of reflection as light. The reflected sound forms an echo. In these experiments you are going to use the echo method to determine the speed of sound.

AIM

To determine the speed of sound by the echo method.

MATERIALS

Two small pieces of board for slapping together

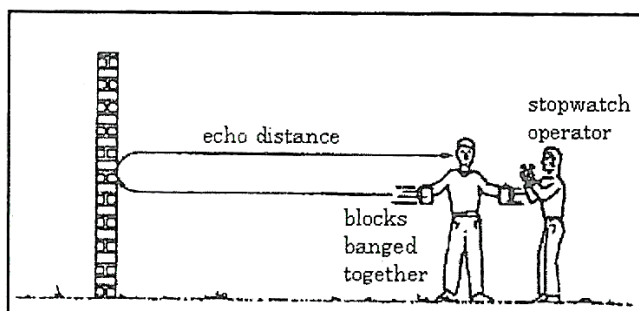
Stop watch

Building wall or mountain cliff

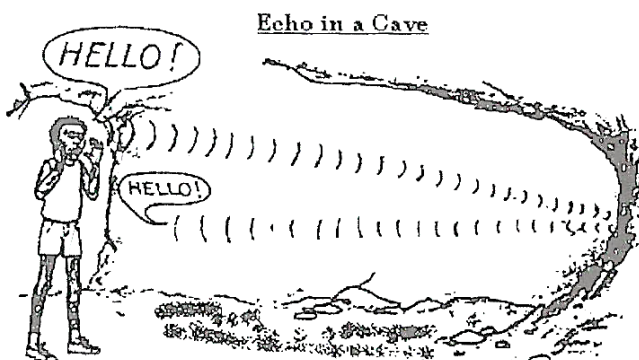
Measuring tape

METHOD

1. Using the tape, measure a distance of about 100 m perpendicular to the school building.
2. Slap the boards together and try to detect the echo of the sound from the wall. Repeat the board slaps trying to coincide with the echo of the sound from the wall.
3. When the slapping rate is such that each slap coincides with the echo of the previous one, the sound has travelled to the wall and back in the time between two slaps i.e. an interval.
4. Let one student record time, one to count the number of board slaps, one to record data and one to slap the boards together.
5. Time 30 intervals with a stop watch. The counter should count 3, 2, 1, start 1, 2, 3, 4,26,27,28,29, stop. Each count should coincide with the slap of the boards. The time keeper on hearing the word start switches on the stop watch and switches off on the count of "stop".



Using echoes to find the speed of sounds



RESULTS

1. Record the time for 30 intervals and find the time t for one interval [$t = (\text{time for 30 intervals}) / 30$]. Also measure the distance, d , to all the wall and obtain.

Speed of sound $\frac{2d}{t}$

2. Compare your experimental value with the accepted value of speed of sound in air.

DISCUSSION

1. What is the accepted value for the speed of sound in air?
2. How will the speed be affected if the sound travels in water?
3. Why is it better to time 30 intervals than to time one interval?
4. Is sound a longitudinal or transverse wave? Explain.

Experiment 24

ELECTROSTATICS

INTRODUCTION

When two objects (e.g. Glass and silk) are rubbed against each other some electrons are rubbed off. (Electrons are rubbed off the glass onto the silk). The two bodies have equal and opposite charges. This process of rubbing and removing charges is known as charging by friction or separation of charges by friction.

AIM

To observe, and try to explain, the effect of a charged rod on small pieces of paper.

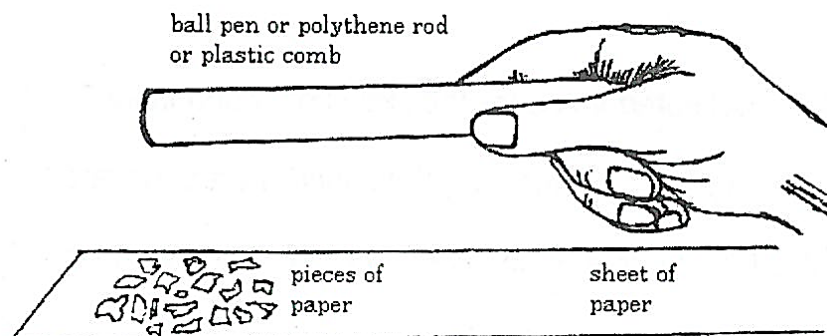
MATERIALS

Ball pen/ polythene rod /plastic ruler/comb

Dry hair on head

Small pieces of paper

DIAGRAM



METHOD

1. Tear to small pieces (1sq mm) some dry paper.
2. Get a ball pen made of some plastic frame and rub it many times through your dry hair.
3. Bring the ball pen near the small pieces of paper and observe very closely what happens.
4. Record all your observations carefully; drawing diagrams to show what happens.

ADDITIONAL ACTIVITY

Place charged object near a fine stream of running water from the tap. Carefully observe and discuss.

DISCUSSION

1. What do you think is the effect of stroking your hair with the ball pen?
2. How does damp hair affect the charging of the ball pen?

3. When the ball pen is brought near the pieces of paper are these pieces attracted or repelled.
4. After the pieces of paper have stayed for some time on the ball pen, are these then repelled by the pen or do they remain attracted?

INTRODUCTION

Early 17th century discoveries showed that there were only two types of charges present. Since these charges were able to neutralize each other, they were simply called positive and negative charges.

When two bodies are rubbed together they gain or lose electrons and become charged. Most materials made of plastic can be easily charged by rubbing with a dry cloth. When charged, they can pick up small bits of paper. Polythene is an example of a material which charges negatively and Perspex charges positively. Objects with like charges repel and objects with unlike charges attract.

AIM

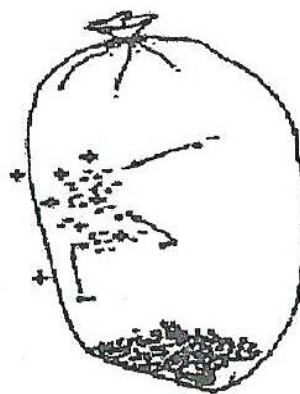
To investigate means of production and behavior of charged objects

MATERIALS

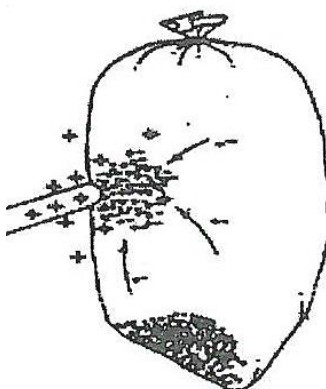
A large clear plastic bag
 Crumbled small bits of Styrofoam
 Hair dryer or vacuum cleaner
 A piece of string

METHOD

1. Take a piece of dry Styrofoam and crumble it into very small bits (4 mm or 2 mm in size).
2. Put a quantity of these crumble Styrofoam into a large clear plastic bag.
3. Inflate the bag with dry air using a vacuum cleaner or a hair dryer. (Do not blow into the bag).
4. Shake the bag vigorously and then rub an area on the outside of the bag quickly and firmly with your hand. Carefully observe and record what you see.

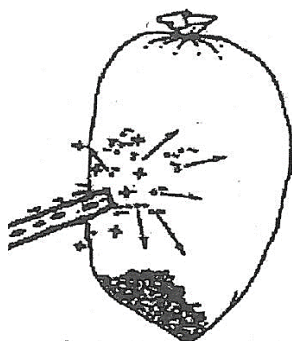


(a)
 Charged polystyrene balls are attracted to an oppositely charged area on the wall of the bag. If the bag has positive charge the balls which cling to the wall will be negative. The balls all have same type of charge and repel each other. (No two balls are touching)



(b)
 A charged plastic rod, with the appropriate charge, attracts more balls to the walls

5. Rub a plastic rod (a plastic ruler, pen etc) against your dry hair. Bring the rod closer to the plastic bag. Observe and record your results



(c)
A conductor becomes charged by induction. i.e. In this case electrons are attracted by the charged walls of the bags and the hand becomes negative. The negative charge lessens the attraction and the balls race away.

6. Rub different samples with dry cloth. Observe some which attract the balls and some which repel them.

All samples either attract or repel. This suggests that there are only two types of charges.

7. Bring a metal rod close to the bag. You will observe that the balls clinging to the wall are cleared away and they all fall to the bottom.

RESULTS

Write and draw diagrams to illustrate what you observed in step (4), (5), (6) and (7).

DISCUSSION

1. Explain what you observed in step (4) and (5).
2. What are the two types of charges mentioned in step (6)?
3. Explain the terms of electron movement how objects acquire positive and negative charge.
4. What is electrostatic induction? In terms of induction explain what you observed in step (7).

INTRODUCTION

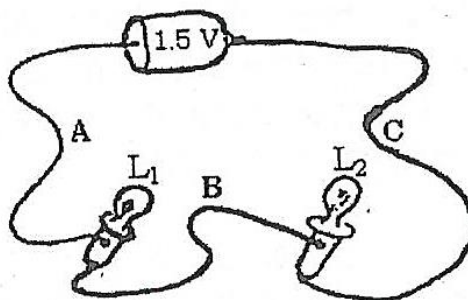
In a series circuit the potential differences are additive, while in a parallel circuit the currents are additive. Constructing simple circuits and measuring currents and voltages in various locations will provide students with understanding of basic circuit principles and manipulative experience with ammeters and voltmeters.

AIM

To verify some basic principles of simple parallel and series circuits

MATERIALS

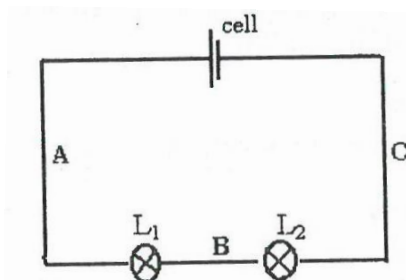
- Constant power supply
- 1 voltmeter
- 1 ammeter
- 2 sources of resistance (e.g. Light bulbs)
- Connecting wires



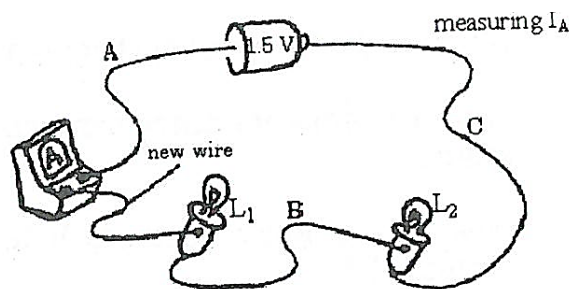
METHOD

Voltmeters are used in parallel; it is only necessary to touch the wire leads of the voltmeter to the two points in the circuit.

Ammeters are used in series, the circuit must be broken and the ammeter added to the loop of the circuit.



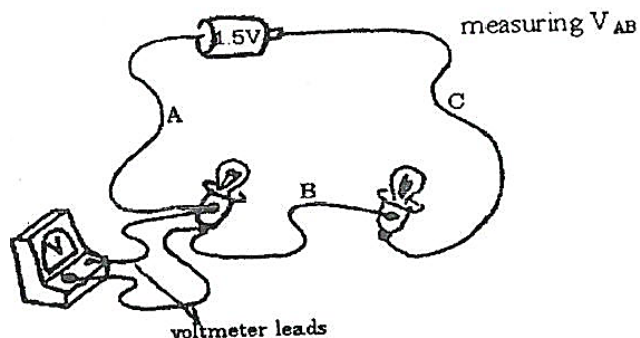
1. Construct a simple series circuit as shown. The wires have been labeled A, B, and C, the bulbs as L_1 and L_2 .



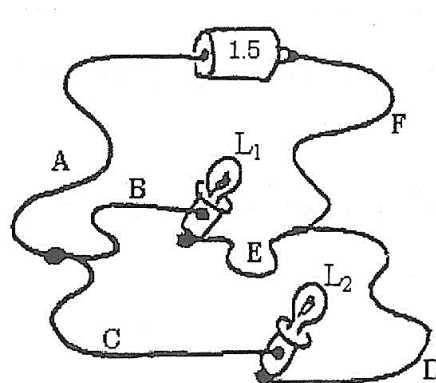
2. Measure the current through wire A, by disconnecting A at either end, or inserting an ammeter.

Do the same at wire B and wire C. Record the currents as I_A , I_B and I_C .

3. Measure the potential difference across L_1 by touching the voltmeter leads to wire A and B. Call this V_{AB} . Measure the potential difference across L_2 and call this V_{BC} . Measure the potential difference across L_1 and L_2 by connecting voltmeter leads to wire A and C. Call this V_{AC} .

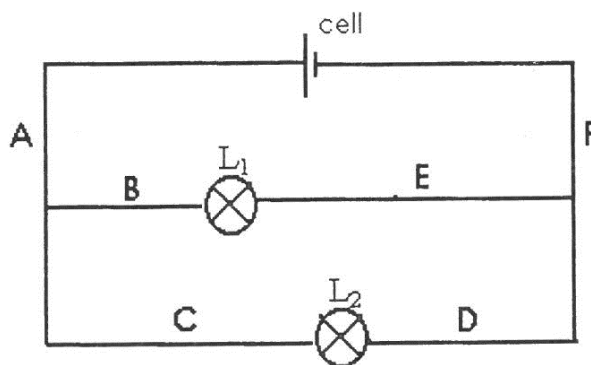


4. Construct a simple parallel circuit with two light bulbs in parallel with a cell. The bulbs are L_1 and L_2 and the wires are labeled A, B, C, D, E, and F.



5. Measure the potential difference across L_1 by placing the leads of a voltmeter at wires B and E, call this V_{BE} . Measure the potential difference across L_2 and call this V_{CD} . Also measure potential difference by placing leads at wire A and F and call this V_{AF} .

6. Measure the current through wires A, B and C and call these I_A , I_B and I_C .



RESULTS

For the series circuit

I_A _____ V_{AB} _____
 I_B _____ V_{BC} _____
 I_C _____ V_{AC} _____

For the parallel circuit

I_A _____ V_{BE} _____
 I_B _____ V_{CD} _____
 I_C _____ V_{AF} _____

DISCUSSION

1. For each circuit, can you describe a relationship between the current I_A , I_B , and I_C ?
2. In each circuit, is there any relationship between the voltage across the battery and the voltage across each lamp?

Experiment 27

OHM'S LAW

INTRODUCTION

Resistance of a substance is equal to the potential difference across, divided by the current through the substance. The resistance is often a function of both temperature and voltage. Those substances with constant resistance over a wide range of applied voltage are known as ohmic substances, and for these ohmic substances, the ratio $\frac{V}{I}$ is a constant

AIM

To plot a graph of voltage against current and determine the resistance of an ohmic material

MATERIAL

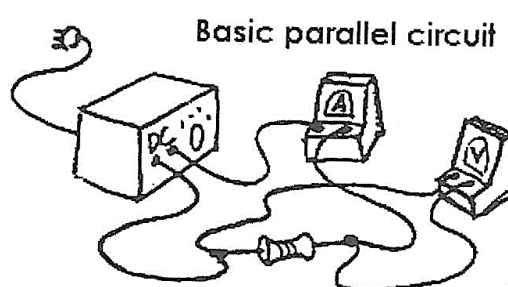
Voltmeter (0 to 12 V)

Ammeter (0 to 500 mA)

A 100 -200 ohms resistor (light bulbs will not Work)

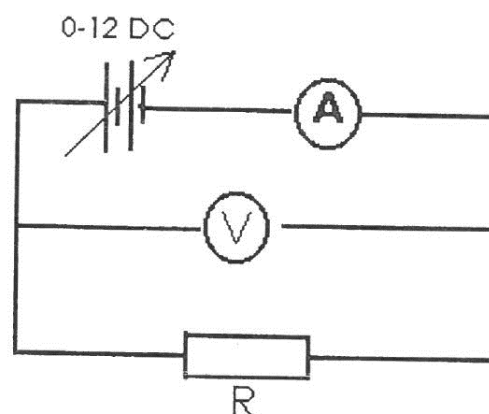
Variable DC power supply (0 to 12 V)

Connecting wires



METHOD

1. Connect in series the power supply, ammeter and resistor, in series. Connect the voltmeter across the resistor.
2. Vary the output voltage on the DC power supply, but read the voltages from the voltmeter, obtain readings for voltage and current in this manner for all of the possible outputs on the power supply.



RESULTS

Place results in a table.

Current from Ammeter I(A)	Voltage from Voltmeter V(V)

Plot a graph with current on the horizontal axis, and voltage on the vertical axis.

DISCUSSION

1. Calculate the slope of the graph.
2. What is the slope a measure of?
3. What effect would be observed on the graph if a different resistor is used?
4. Write down a mathematical relationship between V and I.

Experiment 28

MAGNETISM AND ELECTRICITY

INTRODUCTION

This experiment is in two parts. In the first part you will see that when a current flows in a wire there is a magnetic effect associated with it. The magnetic field induced is at right angles to the direction of the current. In the second part you will discover that when a current flows in a wire in a magnetic field there is a force on the current.

AIM

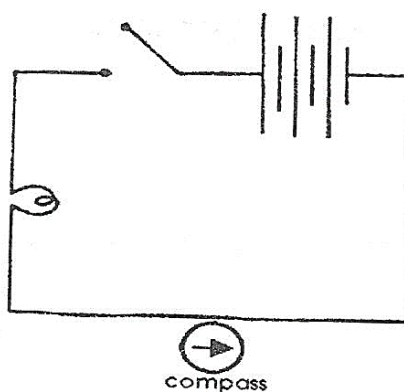
1. To show that there is a magnetic field near a wire carrying current.
2. To determine the direction of force experienced by a wire carrying current in a magnetic field.

MATERIAL

A bar magnet
A compass
Cells or power pack
A light bulb
Switch
Two rulers
A large horseshoe magnet
A length wire

METHOD A

1. Remind yourself that a compass detects a magnetic field (Note that the compass needle moves when the compass is brought near the bar magnet).
2. Connect this circuit.

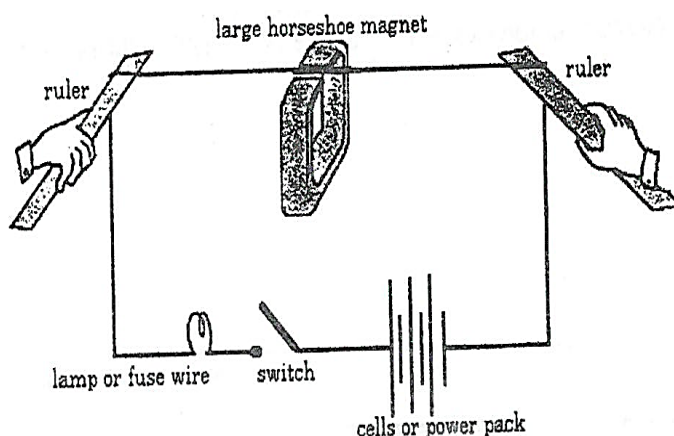


3. Close the switch while you watch the compass needle. Note what happens.
4. Repeat step 3 for several positions around the wire.
5. Open the switch and swap the connections to the battery or power pack over.

6. Close the switch while you watch the compass needle. Note what happens.
7. Repeat step 6 for several positions around the wire.
8. Draw the circuit diagram in your book and record your observations. Write down any conclusions you can draw from your observations.

METHOD B

1. Set the equipment up as shown in the diagram.



2. Close the switch while you watch the length of wire between the poles of the magnet. Note what you see.
3. Open the switch. Swap the connections to the power source. Close the switch. Note what happens.
4. Describe what you did and record your observations.

DISCUSSION

1. What is conventional current?
2. What is the direction of the magnetic field around the wire carrying current?
3. Write down the general rule to determine the direction of the magnetic field around a current carrying conductor.
4. What is the direction of the force on the wire carrying current inside a magnetic field? What happens when the polarity is reversed?
5. Write down the general rule for a force on a current carrying conductor.

Experiment 29

ELECTROMAGNETIC INDUCTION

INTRODUCTION

Electromagnetic induction was a basic discovery in electricity and magnetism made independently by Faraday and Henry in the nineteenth century. Here lay the basis for the generator and hence for the distribution of electric power today.

Motor and generator can be considered as “opposite machines, in that the motor turns electrical energy into mechanical energy, while the generator turns mechanical energy into electrical energy. In the motor a current sets up a field which attracts other magnets to produce motion; in the generator, the relative motion of magnetic field and coil produces current in the coil.

AIM

To demonstrate the principle of electromagnetic induction

MATERIALS

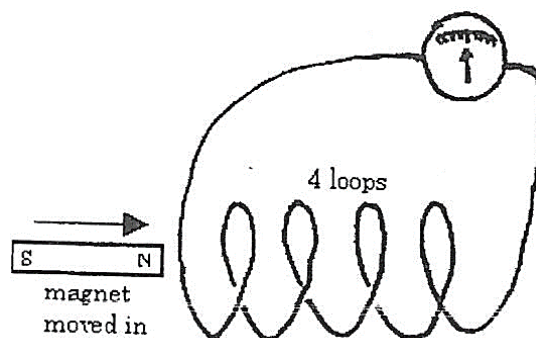
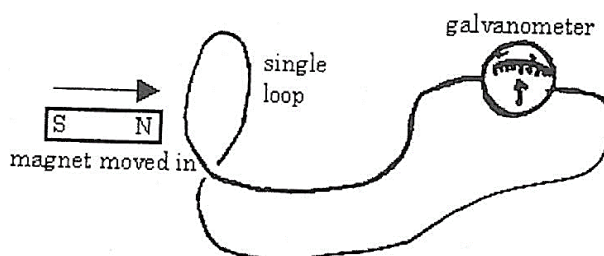
Thick copper wire

Strong magnets (students can use strong magnets of the type removed from discarded loud speakers).

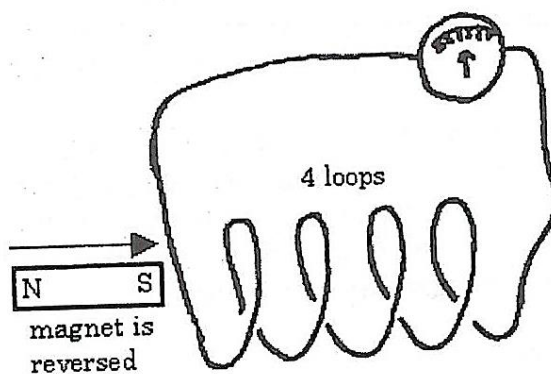
A sensitive galvanometer

METHOD

1. Make a single loop of the wire and connect it to the terminals of a sensitive galvanometer.
2. Then move the pole of a magnet in and out of the wire loop. Carefully observe the galvanometer needle. Is there any deflection? Note also the direction of the needle when the magnet is moved in and moved out.
3. Next, wind the wire into two turn loop and repeat the demonstration. Also try 5, 10, 15 and more turns of wire. Note the amount of deflection in each case.
4. Instead of moving the magnet, try to move the coils over the magnet. Take some coils of wire and connect them in turn to the galvanometer with flexible wire. Then move the coil over the magnet. Note all observations.



5. Next increase the speed of the motion and note the amount of deflection.
6. Now reverse the pole of the magnet and move it in and out of the coils. Observe the direction of the deflection of the galvanometer needle.
7. Use a stronger magnet and move it in and out of the coil.



RESULTS

Write all the observations recording the effects, relative magnitude and direction of the galvanometer deflection with respect to:

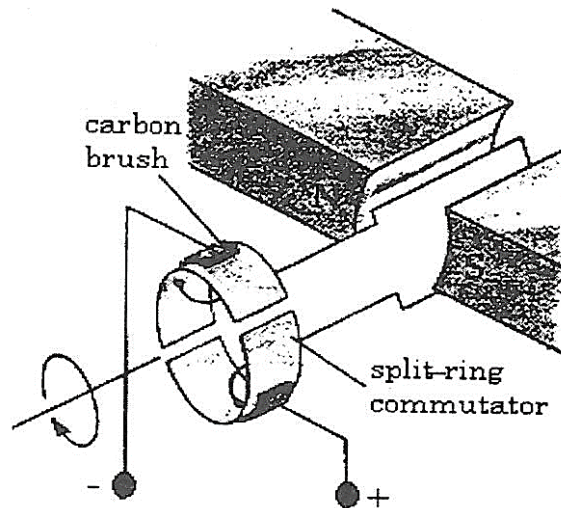
- (a) Relative speed of magnet and coil
- (b) Change of magnet polarity
- (c) Strength of the magnet
- (d) When the magnet is stationary in the coil.

DISCUSSION

1. What happens when the magnet is brought close to the coil in step 3? If there is a deflection in the needle, what causes it?
2. What happens to the galvanometer needle deflection as the number of turns in the loop increases? What can you conclude about the number of turns of wire and amount of current produced?
3. What is the purpose of step 4? What does it show?
4. From the results of step 5 what can you say about the relationship between the speed and the emf (electromotive force) induced?
5. What difference would you notice if the magnet used was even stronger?

INTRODUCTION

A simple electric motor is a coil mounted in a magnetic field. When there is a current in the wires there is a force on the current. A split ring commutator is attached to the coil to allow the motor to turn in one direction otherwise the coil will make a to – and – from movement every half turn. Carbon brushes touch the sides of these half rings.



AIM

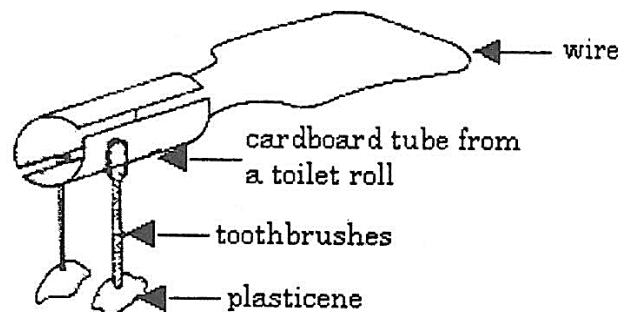
To construct a model of an electric motor.

MATERIALS

- Wire
- A cardboard tube from a toilet roll
- 2 toothbrushes
- Plasticine

METHOD

1. Bend the wire into a suitable shape.
2. Cut the toilet roll in half lengthwise and glue or tape the halves to the wire.
3. Fix the toothbrushes upright using the plasticine



4. Use your model to explain to somebody how an electric motor works. (It might be easier to do this if you color half your model by wrapping tape around the wire and painting one of the bits of toilet roll.)

DISCUSSION

1. What is the analogue of toothbrush and cardboard in the model diagram to that of an electric motor?
2. Use your model to explain how an electric motor works. Use diagrams to illustrate the directions of force experienced by the coil on each side.
3. What is the purpose of a split – ring commutator and the carbon brushes?
4. State some uses of electric motors.

Experiment 31

MOTORS AND GENERATORS

INTRODUCTION

Magnetic Force on current and induced currents in moving conductors are among the two most applied physical principles. A small DC motor provides a micro laboratory for observing the motor rule, the generator rule, and Lenz's law.

AIM

To observe some principles of electromagnetism using a small DC motor.

MATERIALS

A small (1.5 – 6 V DC) electric motor (available from old tape recorders)

A 3.0 V light bulb

An ammeter (0 – 500 mA optional)

1.5 Volt Dry Cell

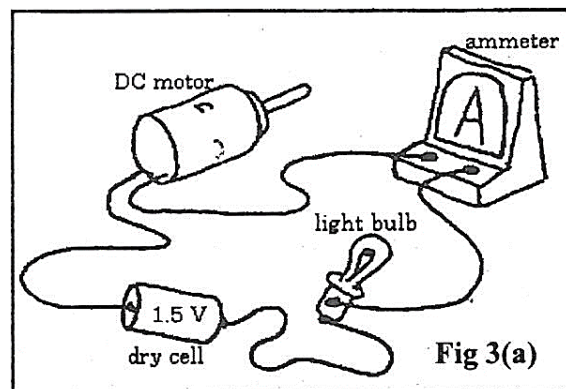
Connecting wires

Cotton thread

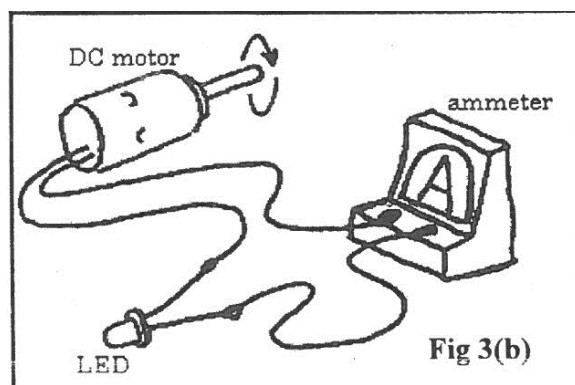
An LED (light emitting diode – the power on 'indicator of an old radio)

METHOD

1. Connect a series circuit: Electric motor, light bulb, ammeter (optional), dry cell as shown in Fig 3(a).
2. Insert extra dry cells into the circuit, and observe the speed of the motor (the pitch of the sound given off is a good measure of the motor speed: higher pitch means faster rotation).



3. Observe what happens if a load is placed on the motor (the motor is showed and even stopped). Pay attention to the reading on the ammeter and the brightness of the bulb.
4. Connect another series circuit: Fig 3(b) DC motor, ammeter, LED to glow, if not, reverse the LED connections. Ammeter should be on 0-5mA scale; a center scale microammeter might work better.



5. Either spin the shaft of the motor with fingers, or shaft with cotton thread and pull. Observe the dependence of the current on motor speed and direction.

RESULTS

Write down your observations and results for parts (2), (3) and (5) of the experimental method section.

DISCUSSION

1. How is the force of the motor related to the current?
2. When the motor is slowed, the current through the motor increased. Explain this using Lenz's Law.
3. Why is a stuck motor more likely to overheat than one that spins freely?
4. Starter motors on automobiles "burn out" when the battery voltage is too low. Explain.
5. How does the output voltage from a generator compare with rotation speed?
6. Current input into a DC motor will cause it to spin in one direction. If the DC motor is manually spun in the same direction, which way will the generated current flow?

If you follow instructions exactly and understand the potential hazards of the equipment and the procedure used in an experiment, the physics laboratory is a safe place for learning and applying your knowledge. You must assume responsibility for the safety of yourself, your fellow students, and your teacher. Here are some safety rules to guide you in protecting yourself and others from injury and in maintaining a safe environment for learning.

1. The physics laboratory is to be used for serious work.
2. Do not enter the laboratory until asked by the teacher.
3. In the laboratory, you are to be under the direct supervision of the teacher, and at no time you should be left on your own.
4. Some form of footwear should be worn at all time in the laboratory,
5. Never bring food, beverages, or make – up into the laboratory. Never taste anything in the laboratory. Never remove glassware from the laboratory, and never use this glassware for eating or drinking.
6. Do not perform experiments that are unauthorized. Always obtain your teacher’s permission before beginning an activity.
7. Study your laboratory assignment before you come to the lab. If you are in doubt about any procedure, ask your teacher for help.
8. Keep work areas and the floor around you clean, dry, and free of clutter.
9. Use the safety equipment provided for you. Know the location of the fire extinguisher, safety shower, fire blanket, eyewash station, and first aid kit.
10. Report any accident, injury, or incorrect procedure to your teacher at once.
11. Keep all materials away from open flames. When using any heating element, tie back long hair and loose clothing. If a fire should break out in the lab, or your clothing should catch fire, smother it with a blanket or coat or use a fire extinguisher. **NEVER RUN.**
12. In emergency if asked to evacuate then laboratory:
 - use the nearest exit to move out in a quiet orderly manner
 - do not stop to collect personal belonging
 - do no re – enter the building until told to do so
13. Allow enough time for hot glass ware to cool. Remember, hot glass looks like cool glass. Bath skin burn in cool water.
14. While using a balance, never place a chemical directly on the pan. Use a suitable container e.g. weighing bottle or a watch glass.
15. Laboratories and storage facilities should be locked when not under direct supervision of the teacher.
16. Handle toxic, combustible, or radioactive substances only under the direction of your teacher. If you spill, acid or other corrosive chemical, wash it off immediately with water.
17. Place broken glass and solid substances in designated containers. Keep insoluble waste material out of the sink.
18. Use electrical equipment only under the supervision of your teacher. Be sure your teacher checks electrical circuits before you activate them. Do not handle electric equipment with wet hands or when you are standing in damp areas.

19 When your investigation is completed, be sure to turn off the water and gas and disconnect electrical connections. Clean your work area. Return all materials and apparatus to their proper places. Wash your hands thoroughly after working in the laboratory.

Appendix 2 FIRST – AID IN THE LABORATORY

Report all accidents, injuries and spills to your teacher immediately. **YOU MUST KNOW**

- **Safe laboratory techniques.**
- **Where and how to report an accident, injury or spill**
- **the location of first – aid equipment, first – aid kit, fire alarm – fire extinguisher, fire hoses, fire blankets and sand bath**

Laboratory workers should be made to use and consider the values of safe laboratory practices. The supervisors or coordinators should be responsible in ensuring that :

1. Adequate emergency equipment is available and in perfect condition.
2. Training in the use of these equipment should be mandatory.
3. Use equipment for their designated purpose only and all glassware used in reactions should be positioned and clamped.
4. Access to emergency equipment, exits, switches and central valves should never be blocked.
5. Servicing of safety equipment should be arranged with the authorities concerned.
6. All mechanical equipment should have appropriate safety guards.
7. Laboratory workers should check all equipment before using them.

SITUATION	SAFE RESPONSE
Burns	Flush with cold water
Cuts and bruises	Treat as directed by instructions included in your first – aid kit
Electric shock	Provide person with fresh air, have person recline in a position such that the head is lower than the body; if necessary, provide artificial respiration
Fainting or collapse	See electric shock
Fire	Turn off all flames and gas jets; wrap person in fire blankets; use fire extinguisher to put out fire. Do not use water to extinguish fire, as water may react with the burning substance and intensify the fire
Foreign matter in eye	Flush with plenty of water, use eye bath
Poisoning	Note the suspected poisoning agent, contact your teacher for antidote; if necessary, call poison control center.
Severe bleeding	Apply pressure or a compress directly to the wound and get medical attention immediately.
Spills, general acid burns	Wash area with plenty water, use safety shower, use sodium hydrogen carbonate, NaHCO ₃ (baking soda)
Base burns	Use boric acid, H ₃ BO ₃

Appendix 3 WRITING PRACTICAL REPORTS

When writing reports on experiments you should remember that someone else will have to read it. You should therefore aim for a clear, concise and accurate presentation of relevant information. The report should contain the following details:

- (i) Each practical report should include the date, title, experiment number and reference from the laboratory manual.
- (ii) Each report should use most or all the following: aim, introduction, materials (used), procedure (or method), diagram (wherever necessary), result (data, calculations etc.), discussion questions and conclusions.
- (iii) A content page, at the front, on which following details should be shown: date, experiment number, title and mark allocation.

The types of information and method of presentation under various subheading are as follows:

DATE AND TITLE

This should include the date, title, experiment number and reference.

e.g.

8/4/99	NEWTON'S SECOND LAW (5)	EXPERIMENT NO .3
--------	---------------------------	------------------

The "Newton's Second Law (5)" indicates that this is experiment No. 5 from the Lab Manual, however "Experiment No 3" implies that this is the third experiment conducted by the class.

INTRODUCTION

The introduction should contain theoretical information or explanation relevant to the experiment. This does not have to be lengthy but main ideas should be clearly presented.

AIM

The aim should be consistent with the nature of the experiment. The objective (aim) may entail learning a particular skill, establishing a fact or testing a hypothesis.

MATERIALS

This should contain a list of chemicals and equipment actually used during the practical and not necessarily the items mentioned in the laboratory manual.

METHOD

This is a descriptive account of the actual conduct of the experiment. The procedure should always be written in the impersonal past tense e.g. "5 g of glucose was mixed with 40 ml of water", and not "I (or we) mixed 5 g of glucose with 40 ml of water."

The procedure should, as far as possible, reflect what was done and this does not necessarily have to be in line with the procedure given in the Laboratory Manual, especially if the method has been changed for one reason or another.

Appendix 3 WRITING PRACTICAL REPORTS

It should also include any precautions taken or difficulties encountered. In making the reports, the teacher would look for the use of the tense and an accurate description of what the students did.

RESULTS

The results consist of a record of all observations, measurements, reading, data, graphs and diagrams. Where appropriate, results should be presented in a tabular form. Note that inferences and interpretations normally fall under “conclusion” and should not appear under the “result” subheading.

Marks would be awarded for the manner in which the data are recorded and presented. The degree of accuracy of the measurements, clarity and labeling of diagrams and the other data deserves consideration for allocating marks.

DISCUSSION

The questions provided in the manual act as a guide to writing the conclusion. They do not in themselves constitute a conclusion. The questions also draw the students’ attention to the purpose of the steps in the procedure and clarify the basic concepts in the topic. For each question, the answer should be written in complete sentence (s) or the students could copy the question and then write the answer.

Each answer would be properly checked and marks given for mathematical accuracy, presentation, level of understanding and correct explanations.

CONCLUSION

The reports should always end with a conclusion, which briefly states what has been learnt in the experiment. The conclusion should contain statements that satisfy the aim of the experiment, together with reference and interpretations derived from the results and answer to questions. An explanation of the discrepancy between expected result and actual result should be provided wherever appropriate.

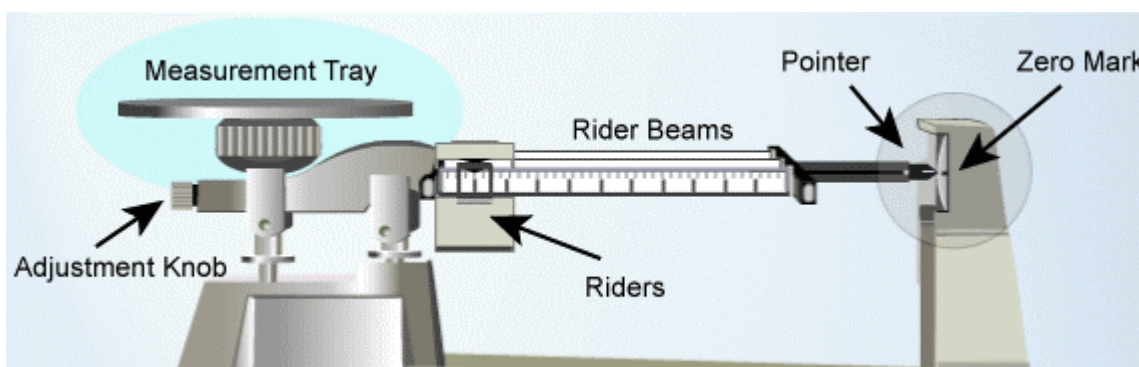
After the practical report has been marked and returned by the teacher, you should read through the comments made by the teacher and do the necessary corrections before you go for the next practical work..

The three common types of balances which may be available for you to use in the laboratory are:

- (i) Triple beam balance
- (ii) Cent – o – gram balance
- (iii) Dial – o – gram balance

(i) **TRIPLE BEAM BALANCE**

Triple beam balances have three mass beams along which the riders (sliding masses) are moved. Whenever you move the poises make sure the two rear poises are seated firmly in a notch. The balance usually weighs to the nearest 0.1g.



Source: <http://webpages.charter.net/jdaly40/balance5.htm>

Before weighing any object you should check the zero reading of your balance.

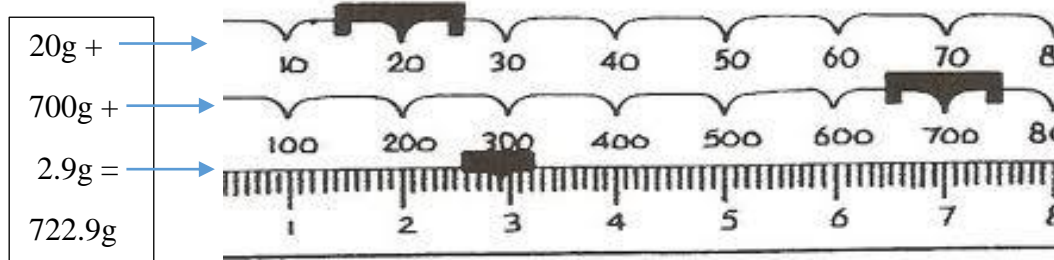
To zero the balance:

- ◆ slide all the three riders (sliding masses) to their zero position at the left – hand end.
- ◆ check that the pointer is aimed exactly at the zero mark.
- ◆ if the pointer does not coincide with the zero marking then turn the end screw (Balance compensator knob) to bring the pointer in line with zero mark.

WEIGHING AN OBJECT

1. Place the object to be weighed on top of the pan. (Chemicals and organisms should not be placed directly on the pan). The beam arm will rise.
2. Move the largest mass (rider) notch by notch until the zero pointer drops.
3. Now move that mass (rider) back one notch. The beam arm should be above the zero mark.
4. Repeat steps 2 and 3 for the medium rider (mass).
5. Finally, slide the smallest mass (rider) along the beam until the pointer is exactly in line with the zero mark. It is easier to use a tip of a pencil to slide this rider (mass).

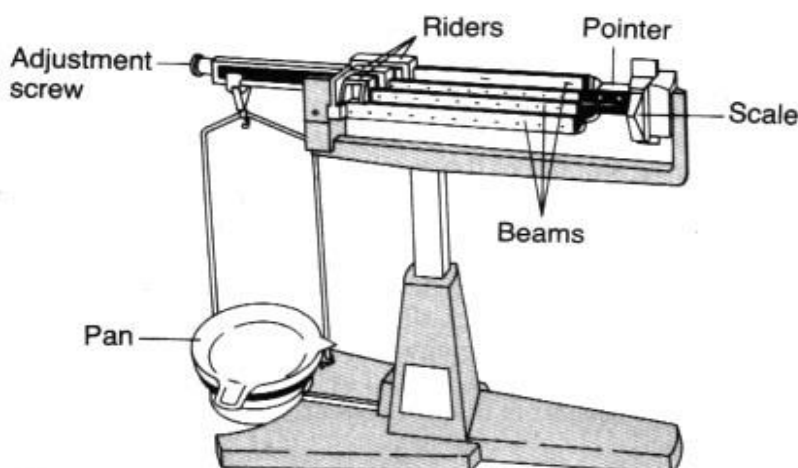
6. The mass of the object is the sum of all values shown on each scale (beam)



Source: <https://www.superteachertools.net/speedmatch/speedmatchfromj.php?gamefile=1412017343#.WJO00FN97cs>

(ii) CENT – O –GRAM BALANCE

Cent – o –gram balances have four mass beams (200g, 100g, 10g, and 1g) along which the riders (Masses) are moved. The balance can be read to the nearest 0.01g.



Source: <http://middle3.fatcow.com/triplebeambalance.htm>

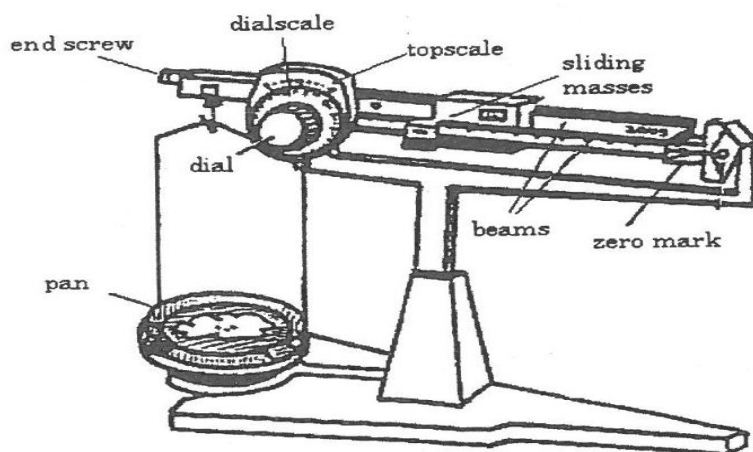
Before weighing any object you should check the zero reading of the balance. The balance can be zero in the same manner as for triple beam balance. In cent – o – gram balance, whenever you move the poises (sliding masses) make sure that the three rear poises are seated firmly in a notch.

WEIGHING AN OBJECT

1. Place the object on the pan. (The beam arm will rise)
2. Move the largest rider (200 g mass) notch by notch until the zero pointer drops.
3. Now move the rider back by one notch. (The beam arm should be above the zero mark)
4. Repeat steps 2 and 3 for each of the 100g rider and 10 g rider.
5. Finally, slide the 1 g rider until the beam arm drops and zero markings line up.
6. The mass of the object is the sum of all the values shown on each beam.

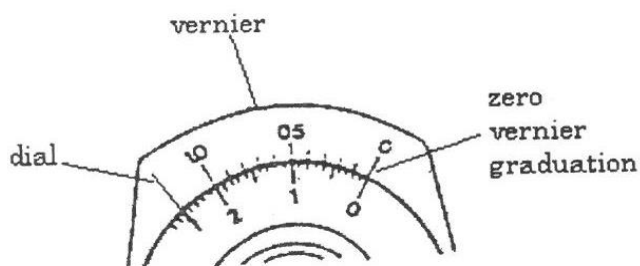
(iii) **DIAL – O – GRAM BALANCE**

Dial – o – gram balances have two mass beams and a dial which are used to bring the instrument into balance. These balances can be read to the nearest 0.01g.



Before an object is weighed the balance should show zero reading. In order to zero the dial-o-gram balance, you should:

- ◆ Slide both the poises to their zero position at the left – hand end of each beam. The poises should sit in their notches.
- ◆ Rotate the dial to bring the zero on the dial in line with the Vernier zero.

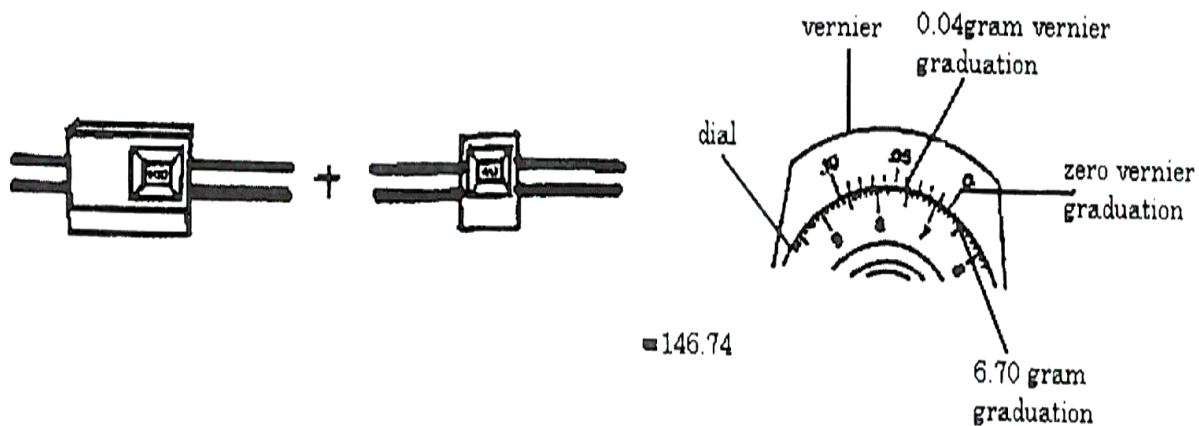


- ◆ Turn the end screw (balance compensator knob) to bring the pointer in line with zero marking.

WEIGHING AN OBJECT

1. Place the object on the pan.
2. Move the larger poise (200 g) notch by notch until the zero pointer drops.
3. Now move the poise (200 g) back by one notch (the beam arm should move around the zero mark)
4. Repeat steps 2 and 3 for the 100 g poise (sliding mass)

5. Finally slowly rotate the dial clockwise until the pointer lines up exactly with the zero marking.
6. The mass of the object is the sum of the values shown on each beam plus the values



indicated by the dial and the vernier, example,

READING THE DIAL AND VERNIER GRADUATION

Each graduation on the dial has a value of 0.1 g. A Vernier adjacent to the dial breaks down these values to 0.01 g increments.

To read the dial scale, read the lowest gram value adjacent to (i.e. the nearest mark to the right of) the zero vernier graduation. (It is 6.70g in the illustration given above). Add to the vernier graduation value at the vernier line which most closely lines up with any of the other dial graduations. (In the illustration above, the value is 0.04 g)

$$6.70 \text{ g} + 0.04 \text{ g} = 6.74 \text{ g}.$$

Appendix 5

TABLE 1: PREFIXES OF THE METRIC SYSTEM

Factor	Prefix	Symbol
10^{12}	Tera	T
10^9	Giga	G
10^6	Mega	M
10^3	kilo	k
10^2	hecto	h
10^1	deca	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

TABLE 2: PHYSICAL CONSTANTS

Quantity	Symbol	Value
Atmospheric pressure, normal	Atm	$1.01325 \times 10^5 \text{Nm}^{-2}$
Atomic mass unit, united	u	$1.66024 \times 10^{-27} \text{kg}$
Avogadro number	N_A	6.02252×10^{23} / molecules / mole
Charge to mass ratio for electron	e/m_e	$1.758796 \times 10^{11} \text{Ckg}^{-1}$
Electron rest mass	m_e	$9.1019 \times 10^{-31} \text{kg} = (5.48597 \times 10^{-4} \text{u})$
Electron volt	eV	$1.6027 \times 10^{-19} \text{J}$
Electrostatic constant	k	$9.00 \times 10^9 \text{Nm}^2 \text{C}^{-2}$
Elementary charge	e	$1.60210 \times 10^{-19} \text{C}$
Gas constant, universal	R	$8.3143 \text{ J/mol}^\circ \text{K}$
Gravitational acceleration, standard	g	9.78049 ms^{-2}
Mechanical equivalent of heat	J	4.1868 J/cal
Neutron rest mass	m_n	$1.67482 \times 10^{-27} \text{kg}$ ($=1.0086654 \text{ u}$)
Plank's constant	h	$6.6256 \times 10^{-34} \text{Js}$
Proton rest mass	m_p	$1.67252 \times 10^{-27} \text{kg}$ ($= 1.00727663 \text{ u}$)
Speed of light in a vacuum	c	$2.997925 \times 10^8 \text{ ms}^{-1}$
Speed of sound in air at S.T.P	v	$3.3145 \times 10^2 \text{ ms}^{-1}$
Universal gravitational constant	G	$6.673 \times 10^{-11} \text{Nm}^2 \text{kg}^{-2}$
Volume of ideal gas, standard	V_o	$2.24136 \times 10^1 \text{ l / mole}$

Appendix 5

TABLE 3: THE INTERNATIONAL SYSTEM OF UNITS

Quantity	Quantity Symbol	Unit Fundamental Units	Unit Symbol	Dimension
Length	<i>l</i>	Metre	m	m
Mass	m	Kilogram	kg	kg
Time	t	Second	s	s
Electric current	I	Ampere	A	A
Temperature	T	Degree Kelvin	°K	°K
Luminous intensity	I	Candela	cd	cd
Derived Units				
Acceleration	a	Metre per second squared	ms ⁻²	m/sec ²
Area	A	Square metre	m ²	m ²
Capacitance	C	Farad	F	A ² S ⁴ /kgm ²
Density	D	Kilogram per cubic metre	Kgm ⁻³	Kgm ⁻³
Electric charge	Q	Coulomb	C	A
Electric field strength	E	Volt per metre	Vm ⁻¹	kgm/s ³ A
Electric resistance	R	Ohm	Ω	kgm ² /s ³ A ²
Energy	E	See work	J	J
Force	F	Newton	N	Kgmsec ⁻²
Frequency	f	Reciprocal second	s ⁻¹	s-1
Heat	Q	See work		
Inductance	L	Henry	H	kgm ² /s ² A
Luminance	L	Candela per square metre	cdm ⁻²	Cdm ⁻²
Magnetic flux	Φ	Weber	wb	kgm ² /s ² A
Magnetic flux density	B	Weber per square metre	Wbm ⁻²	kg/s ² A
Potential difference (see voltage)	V	Volts		
Power	P	Watt	w	kgm ² s ⁻³
Pressure	p	Newton per square metre	Nm ⁻²	kg/ms ²
Velocity	v	Metre per second	ms ⁻¹	m/s
Voltage	V	Volt	V	kgm ² /s ³ A
Volume	V	Cubic metre	m ³	m ³
Work	W	Joule	j	kgm ² s ⁻²

Appendix 5

TABLE 4: CONVERSION FACTORS

<p>LENGTH</p> <p>1 m = 10^3 km = 10^2 cm = 10^3 mm = 10^{10} Å</p> <p>1 Å = 10^{-6} m = 10^{-4} cm = 10^{-3} mm = 10^3 mÅ = 10^4 Å</p> <p>1 mÅ = 10^{-9} m = 10^{-7} cm = 10^{-8} mm = 101 Å</p> <p>1 Å = 10^{-10} m = 10^{-8} cm = 10^{-4} Å = 10^{-10} Å</p>
<p>AREA</p> <p>1 m² = 10^6 km² = 10^4 cm² = 10^6 mm²</p>
<p>VOLUME</p> <p>1 m³ = 10^9 km³ = 10^3 l = 10^6 cm³</p> <p>1 l = 103 ml = 10^3 cm³ = 10^{-3} m³</p>
<p>ANGULAR</p> <p>1° = 1.74×10^{-2} radian = 2.78×10^{-3} revolution</p> <p>1 radian = $57.3^\circ = 1.59 \times 10^{-1}$ revolution</p> <p>1 revolution = $360^\circ = 6.28$ radians</p>
<p>MASS</p> <p>1 kg = 10^3 g = 10^6 mg = 6.02×10^{26} u</p> <p>1 g = 10^{-3} kg = 10^3 mg = 6.02×10^{23} u</p> <p>1 u = 1.66×10^{-24} g = 1.66×10^{-21} mg = 1.66×10^{-27} kg</p>
<p>TIME</p> <p>1 hr = 60 min = 3.6×10^3 sec</p> <p>1 min = 60 sec = 1.67×10^{-2} hr</p> <p>1 sec = 1.67×10^{-2} min = 2.78×10^{-4} hr</p>
<p>VELOCITY</p> <p>1 km/hr = 10^3 m/hr = 16.7 m.min = 2.78×10^{-1} m/sec</p> <p>1 m.mm = 10^2 cm/mmin = 1.67×10^{-2} m/sec = 1.67 cm/sec</p> <p>1 m/sec = 10^{-3} km/sec = 3.6 km/hr = 10^2 cm/sec</p>
<p>ACCELERATION</p> <p>1 cm/sec² = 10^{-2} m/sec² = 10^{-5} km/sec²</p> <p>1 m/sec² = 10^2 cm/sec² = 10^{-3} km/sec²</p> <p>1 km/hr/sec = 10^3 m/hr/sec = 2.78×10^{-1} m/sec² = 2.78×10^1 cm/sec² = 2.78×10^2 mm/sec</p>
<p>PRESSURE</p> <p>1 atm = 760.00 mmHg = 1.013×10^5 N/m² = 1.013×10^6 dynes.cm²</p> <p>1 n/m² = 10 dynes/cm² = 9.87×10^{-6} atm</p>
<p>ENERGY</p> <p>1 j = 10^7 ergs = 2.39×10^{-1} cal = 2.39×10^{-4} kcal = 2.78×10^{-7} kw hr = 1.49×10^{18} ev</p> <p>1 cal = 10^{-3} kcal = 4.19 j = 1.16×10^{-6} kw hr</p> <p>1 kcal = 10^3 cal = 4.19×10^3 j = 1.16×10^{-3} kw hr</p> <p>1 ev = 10^{-3} mev = 1.60×10^{-12} erg = 1.60×10^{-19} j</p> <p>1 kw hr = 10^3 w hr = 3.6×10^3 kw sec = 3.6×10^6 w sec = 8.6×10^5 cal</p> <p>1 w sec = 2.78×10^{-4} w hr = 2.78×10^{-7} kw hr</p>
<p>MASS – ENERGY</p> <p>1 j = 1.11×10^{-17} kg = 1.11×10^{-14} g = 6.69×10^9 u</p> <p>1 ev = 1.07×10^{-9} u = 1.78×10^{-33} g</p> <p>1 u = 1.49×10^{-3} erg = 1.49×10^{-10} j = 931 Mev = 9.31×10^8 ev</p> <p>1 kg = 9.00×10^{16} j = 9.00×10^{23} ergs</p>

Appendix 5

TABLE 5: ELECTRICAL SYMBOLS

OBSOLETE SYMBOL	PREFERRED SYMBOL		OBSOLETE SYMBOL	PREFERRED SYMBOL	
		wire crossing			Earth
		wires joined			Aerial
		resistance			diode
		rheostat			zener diode
		potential divider			Transistor(npn)
		potentionmeter			
		fuse			Transistor (pnp)
		heater			Transistor (unijunction p type base)
		lamp			Thyristor (n gate)
		Terminal			Thyristor (p gate)
		Plug and Socket			Triac
		Switch (single Pole)			Diac
		Switch (double pole)			Photo - conductive cell
		Contact (normally open)			photo-voltic cell
		Contact (normally closed)			Photocell device
		Contact (change over)			Photo-diode
		Relay cell (with coil resistance)			Light-emitting diode
		Cell			
		Battery			

