PHYSICS EXPERIMENTS
(APPENDIX)

'In the matter of physics, the first lessons should contain nothing but what is experimental and interesting to see. A pretty experiment is in itself often more valuable than twenty formulae extracted from our minds.' - Albert Einstein

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LEAVING CERTIFICATE PHYSICS

LISTED EXPERIMENTS

APPENDIX

NOTE

For examination purposes any valid method will be acceptable for describing a particular experiment unless the syllabus specifies a particular method in a given case.
Students will be expected to give details of equipment used, assembly of equipment, data collection, data manipulation including graphs where relevant. Students will also be expected to know the conclusion or result of an experiment and appropriate precautions.

SAFETY

1. The Leaving Certificate Physics syllabus states on page three:

   'Standard laboratory safety precautions must be observed, and due care must be taken when carrying out all experiments.
   The hazards associated with electricity, EHT, lasers etc. should be identified where possible, and appropriate precautions taken. The careful use of sources of ionising radiation is essential. It is important that teachers follow guidelines issued by the Department of Education and Science.'

2. The guidelines referred to here consist of two books, which were published by the Department of Education in 1997. The books are

   'Safety in School Science'

   and

   'Safety in the School Laboratory (Disposal of chemicals)'

   When these books were published they were distributed to all schools. They have been revised and are available on the 'physical sciences initiative' web site at www.psi-net.org in the 'safety docs' link of the physics section.

3. Teachers should note that the provisions of the Safety, Health and Welfare at Work Act, 1989 apply to schools. Inspectors appointed under that act may visit schools to investigate compliance.

APPENDIX

TO ESTIMATE THE SPECIFIC HEAT CAPACITY OF WATER

Apparatus

Timer and plastic electric jug kettle (with power rating marked on it).

Procedure

1. Read the power rating (wattage) P of the kettle.
2. Fill the kettle with cold water to the one litre mark.
3. Take the temperature of the water θ_1.
4. Switch on the kettle for 50 s.
5. Read the temperature θ_2.

Calculations

Mass of water $m_w = 1$ kg
Rise in temperature of water $\Delta\theta = \theta_2 - \theta_1 =$
The electrical energy produced by the kettle $Pt =$
If it is assumed that all the electrical energy went into heating the water, then

$$Pt = m_w c\Delta\theta$$

$$\Rightarrow c = \frac{Pt}{m_w\Delta\theta} = \text{Specific heat capacity of water.}$$

This gives a reasonable value for c.

Notes

One litre of water has a mass of one kilogram.

TO ESTIMATE THE SPECIFIC LATENT HEAT OF VAPORISATION OF WATER

Apparatus

Plastic electric jug kettle with power rating marked on it, electronic balance and timer.

Procedure

1. Read the power rating (wattage) P of the kettle.
2. Half fill the kettle with water and place it on the electronic balance.
3. Switch on the kettle, leaving the lid off. This prevents it from switching off when it starts to boil.
4. Allow the kettle to boil.
5. When steam is coming freely from it take the reading m_1 on the balance and start the timer.
6. Allow the kettle to boil until the mass has decreased by about 50 g.
7. Read the mass m_2.
8. Stop the timer and note the time t taken.

Calculations

Mass of water converted into steam $m = m_1 - m_2 =$
Energy required to do this is ml_v, where l_v is the specific latent heat of vaporisation of water.
Electrical energy used to produce the steam equals Pt.
If it is assumed that all electrical energy went into producing steam

$$ml_v = Pt \qquad \Rightarrow l_v = \frac{Pt}{m}$$

This gives a value for l_v of the correct order of magnitude and helps to make the concept of specific latent heat of vaporisation more realistic.

Notes

This experiment is best done as a teacher demonstration.

Use a balance with a wide base so that the kettle will not overturn.

MEASUREMENT OF THE FOCAL LENGTH OF A CONCAVE MIRROR (APPROXIMATE METHOD)

For a concave mirror $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$.

If u is very much greater than the focal length, then $\frac{1}{u} \approx 0 \Rightarrow \frac{1}{f} = \frac{1}{v} \Rightarrow f = v$.

Procedure

Using the concave mirror, focus a distant object, e.g. a tree, on a sheet of paper. The distance from the mirror to the paper is approximately equal to the focal length of the mirror.

This method is useful as it gives the student some idea of the answer to expect when the experiment is done using a more accurate method.

MEASUREMENT OF THE FOCAL LENGTH OF A CONVERGING LENS (APPROXIMATE METHOD)

For a converging lens $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$.

If u is very much greater than the focal length, $\frac{1}{u} \approx 0 \Rightarrow \frac{1}{f} = \frac{1}{v} \Rightarrow f = v$.

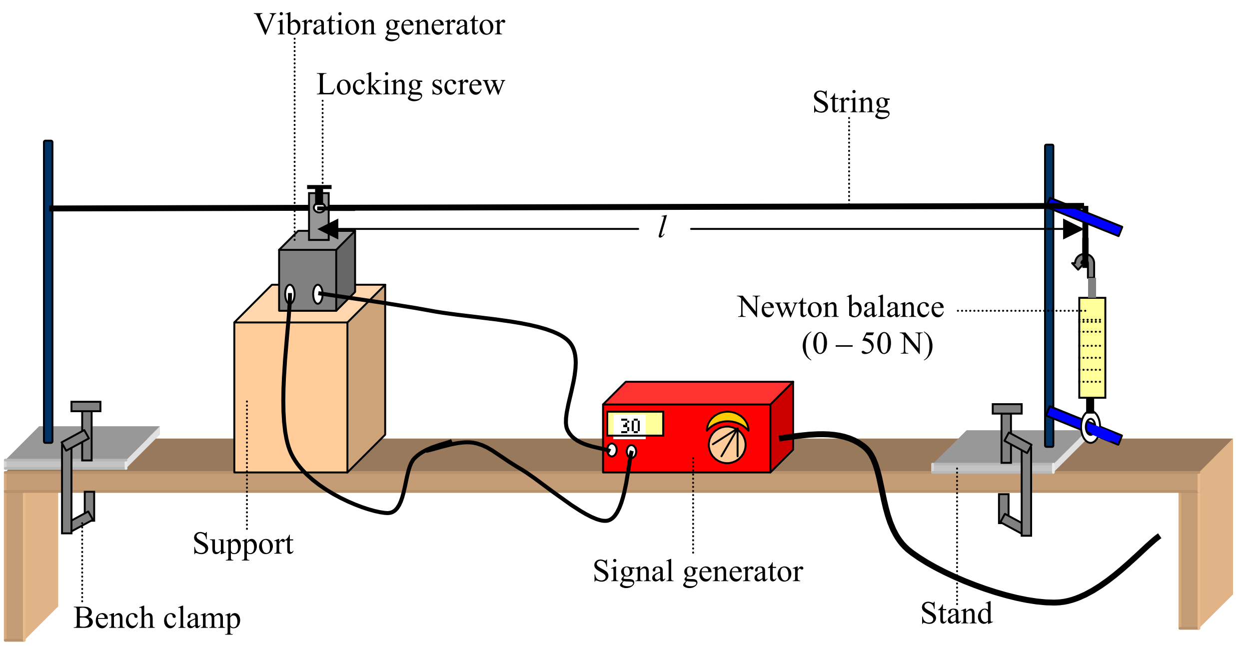
Procedure

Focus a distant object, e.g. a tree, on a screen. The distance from the lens to the screen is approximately the focal length of the lens.

This method is useful as it gives the student some idea of the answer to expect when the experiment is done using a more accurate method.

DEMONSTRATION OF STANDING WAVES

Apparatus

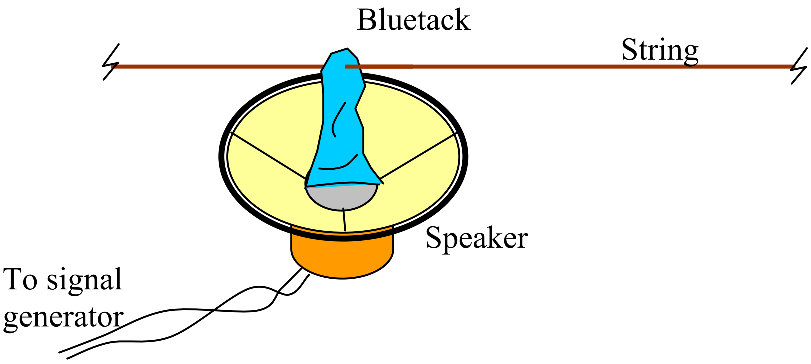


Procedure

1. Clamp two stands, positioned about 3 m apart, to a bench.
2. Place the vibration generator on a laboratory jack or other suitable support, to allow the string plenty of room to vibrate up-and-down.
3. Tie the string securely to the hook of a firmly anchored 50 N balance and drape it over the side arm attached to the RHS vertical bar.
4. Thread the string through the eye of the vibrator bar – do not tighten the locking screw yet.
5. Tension the string to 10 N by tying it securely to the LHS vertical bar.
6. Slide the vibration generator as far as practicable to the left and tighten the locking screw.
7. Connect the vibration generator to the low resistance output (4 Ω) of the signal generator.
8. Turn on the signal generator and select a frequency of 4 or 5 Hz.
9. Adjust the output control on the signal generator until the oscillations are visible.
10. Slowly increase the frequency until the string vibrates at its fundamental mode.
11. Increase the frequency until the first harmonic is visible.
12. Continue to increase the frequency to see a series of successive harmonics.

Notes

Clamp a loudspeaker (4 Ω or 8 Ω) with its diaphragm facing upwards. Build a column of bluetack taped to the diaphragm as shown.



Raise the loudspeaker and bluetack towards the string so that the string is surrounded and gripped by the bluetack. Connect the signal generator to the loudspeaker. Increase the frequency and observe the standing waves.

Observe longitudinal standing waves in a vertical spring supported from a ceiling hook and with its lower end attached to the vibration generator: note the compression maxima as the applied frequency is increased.

The experiments to investigate the variation of the fundamental frequency of a stretched string with length and tension could be performed using this apparatus.

THE ROTA OPTION

A POSSIBLE APPROACH TO EXPERIMENTAL WORK

The problem of how best to organise experimental work in physics is ever present. This arises mainly, but not exclusively, because of constraints imposed by the lack of availability of apparatus in many schools. The rota option addresses this problem in a creative way, with the added advantages of excellent educational and organisational outcomes.
A major difficulty against a rota system is a perceived problem in selecting a set of six/seven suitable listed experiments (the rota need not, of course, only consist of listed experiments) at the beginning of senior cycle physics. Many teachers feel that it is necessary to fully cover the background theory before any experimental work is undertaken. Certainly, some background theory is necessary, but a judicious selection of experiments can keep this to a minimum.
If we apply 'some contact and understanding at Junior Certificate level' as a selection criterion, the following initial list might be acceptable, with very little additional background required:

- Measurement of velocity and acceleration
- Verification of Boyle's Law
- To investigate the relationship between period and length of a simple pendulum.
- Calibration curve of a thermometer using the laboratory mercury thermometer as a standard
- Measurement of the speed of sound in air
- Measurement of the focal length of a concave mirror
- Verification of Snell's law of refraction
- To investigate the variation of resistance of a thermistor with temperature

A clear set of instructions for each experiment is essential.

Ideally the specific equipment required for each experiment should be in its own container. Initially it will be necessary to use some class time to select groups, draw up a rota calendar and explain the contents of each container. A wheel-in trolley makes an ideal storage and retrieval system.

It is much better from the point of view of student understanding to make contact with a concept in physics as often as possible. Each group of students becomes responsible for a specific experiment – the one that they carried out in week one of the rota. Each week they check the apparatus for that experiment and sort out any difficulties that a group may be having with it. This frees the teacher to deal with bigger issues and gives much more time for her/him to move among the groups during experimental work. This allows the teacher to get to know the students as individuals and to recognise the strengths and weaknesses in their developing knowledge of physics. From the calendar each group knows their upcoming experiment and is obliged (as homework) to familiarise themselves with it in the preceding days using the instruction sheet. Once the initial effort is made to get all of the experiments running in this fashion, things are effectively organised for long periods of time. Essentially the students run the practical class.