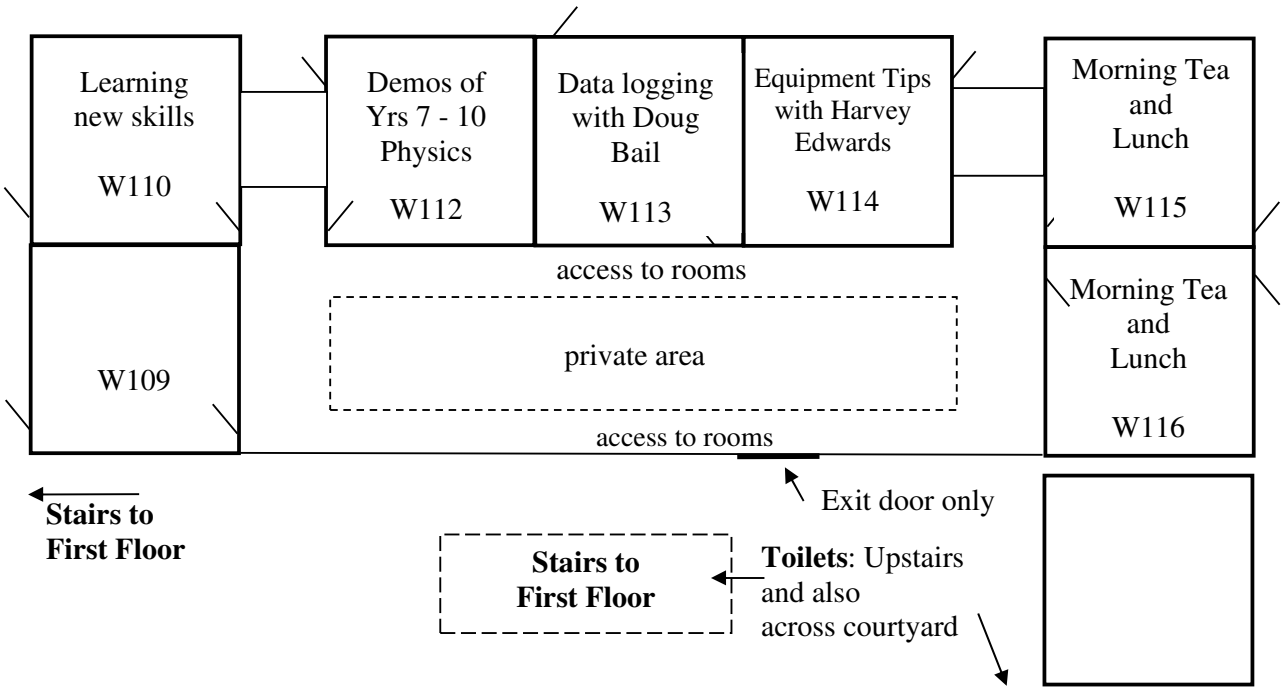
VicPhys

Lab Techs' Workshop

Program: Two groups A & B

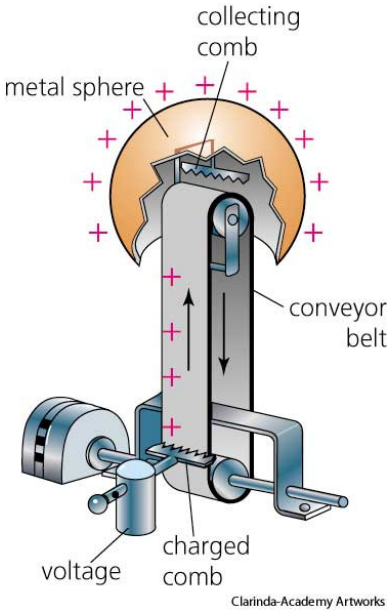
Time	Session	Room
9:00	Registration	W115
9:30	Setting up Physics Demonstrations for Years 7 - 10 (*Page 2*)	W112
10:15	A: Learning new skills: using a CRO, multimeter and a Ruhmkorff coil *(Pages 3 - 6)*	W110
	B: Tour of laboratories and prep areas, Laboratory management hints	W109
11:00	Morning Tea	W115 W116
11:20	A: Tour of laboratories and prep areas, Laboratory management hints	W109
	B: Learning new skills: using a CRO, multimeter and a Ruhmkorff coil	W110
12:05	A: Equipment tips with Harvey Edwards, Principles and Practice	W114
	B: Setting up data logging with Doug Bail, Ciderhouse ICT	W113
12:50	Lunch	W115 W116
1:30	A: Setting up data logging with Doug Bail, Ciderhouse ICT	W113
	B: Equipment tips with Harvey Edwards, Principles and Practice	W114
2:15	Storage and handling of radioactive sources *(Pages 7 - 14)*	W112
3:00	Old equipment: What is this?	W112



Setting up Physics Demonstrations: Van de Graaff Generator

The Van de Graaff generator is temperamental piece of equipment, particularly after being in storage for a while. The usual reasons for not operating properly are:

1. The air is too humid,
2. The dome is dented,
3. The dome and the interior are dusty,
4. The interior of the generator, the belt and rollers are not dry enough,
5. The belt is old, worn and loose,
6. The combs, top and bottom, are incorrectly adjusted.



Solutions to these problems are:

a. Use a hair dryer to dry the air inside and out as the belt is moving.
b. Remove dents if possible.
c. Clean the dome and the support column with a light volatile solvent, and if needs be, the interior including the rollers.
d. The belt can be washed, but needs to be dried thoroughly before use.
e. To test the age of the belt, lift the top section of the belt with a spring balance through a harness so as not to tear it. Record the reading for an extension of 5 cm. This should be done when the belt is new, so that deterioration can be monitored over time.
f. The combs don't need to touch the belt, a separation of 2 - 3 mm is desirable, but they should be sharp and clean.

Care and maintenance

The belt degrades with exposure to UV so cover it or store the generator in a cupboard.

Safety: The current is very low, but anyone with a heart condition should stay beyond 1 m. Electronic devices can be sensitive to strong electric fields.

A useful Resource with a Youtube video:
https://www.stem.org.uk/resources/elibrary/resource/27023/van-de-graaff-generator

Other electrical demonstrations:

- Ruhmkorff Coil : Needed to operate discharge tubes to show electron nature of electricity and other phenomena, e.g. Jacob's ladder.

Sound Demonstrations:

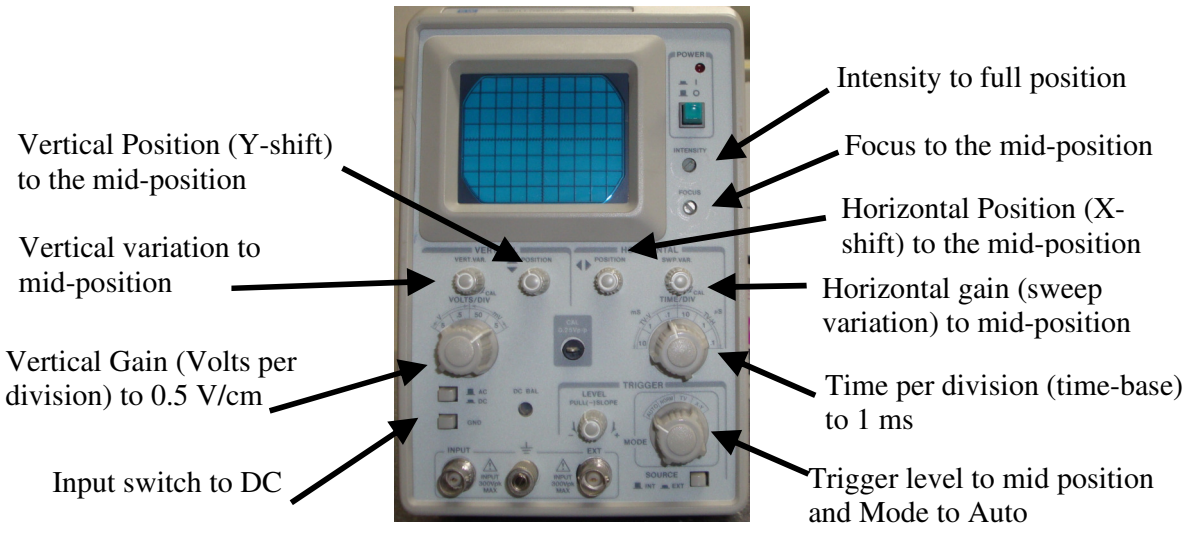
Oscilloscope with microphone:	To show wave nature of sound and the differences between sounds, e.g. musical instruments, Doppler effect, Beat frequencies
Large tube with Meeker burner:	To demonstrate resonance like in an organ pipe
Length of thin timber:	To show standing waves when one end is not fixed

Learning new skills: How to use your CRO

A CRO (cathode ray oscilloscope) is a visual voltmeter. The spot moves sideways when the Horizontal time-base is switched on, and the horizontal trace can be described as the x-axis or time axis of a graph. When the signal is applied across the y-terminals, the variation in the voltage is plotted on the y-axis. So the trace plots out the 'graph' of voltage against time.

Your Tasks

a To prepare the oscilloscope for use, plug into the mains supply and set the controls as follows:



b Now switch on. After warming up for about one minute, a trace should appear.
If no trace appears, leave the 'Intensity' in the fully clockwise position and adjust 'Horizontal position' and 'Vertical position' backwards and forwards until the trace appears. Move the Horizontal position relatively quickly, while slowly increasing the Vertical position.

c Once a trace is found, centre the trace with the horizontal and vertical controls, then adjust the Intensity and Focus to get a sharp trace.
The oscilloscope is now ready for use.

d To see how the controls work, connect the CRO lead to an AC low voltage power supply. You should see a sine wave. If the trace is not steady, adjust the trigger controls one at a time.

e Now adjust each of the controls in turn, clockwise and anticlockwise, and write down how the trace is changed.

Vertical Position (Y-shift) _____

Vertical Gain (Volts per division) _____

Vertical variation _____

Horizontal position (X-shift) _____

Horizontal or sweep variation _____

Horizontal gain (Time per division) _____

f Now connect the CRO to the DC terminals of the power supply

Describe the trace: _____

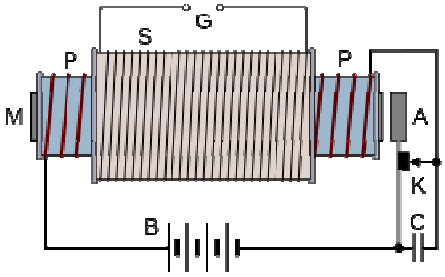
Safety: Do not measure mains voltage.

Websites: http://www.nuffieldfoundation.org/practical-physics/oscilloscope
https://www.youtube.com/watch?v=J1iqLB0RgOE

How to use the Ruhmkorff Coil

A Ruhmkorff Coil is a type of transformer that produces high voltage pulses from a low voltage DC power supply. Transformers normally only operate with AC, but the Ruhmkorff Coil uses an electric bell mechanism to stop and start the current to achieve a change so that the transformer can work.

The inner primary coil has a small number of turns of thick copper wire, while the outer secondary coil has thousands more turns of very thin copper wire. It is the ratio of the number of turns that enables the Ruhmkorff Coil to produce a voltage of several thousand volts from a 6V power supply. Although in so doing the available current in the secondary coil is several thousand times smaller than the current through the 6 V power supply.



Your Tasks:

1. Setting up the Ruhmkorff Coil

The electric bell mechanism needs to be adjusted to obtain the best spark.

a. Adjust the separation of the two pointed contacts so that the air gap, G, is about 1 cm. Tighten the clamp on each pointed contact.
b. Connect a 6V DC power supply to the sockets at one end.
c. Switch on the power supply.
d. Sparking will appear across the air gap. If the sparking is either absent or intermittent, there is a screw adjustment at the battery end which can be changed to optimise the sparking, then tightened.
e. Try putting a piece of paper between the two points.
f. Turn off the DC and increase the spacing of the points to several cms and connect the points to a discharge tube, then turn the DC back on. Does the tube work?

2. Polarity of the Ruhmkorff Coil

There is no electrical connection between the 6V power supply and the high voltage terminals, so it is not possible by observation to identify which of the two high voltage terminals is positive. An experimental test needs to be done and then the terminals can be permanently marked with + or - .

Method:

- Connect the discharge tube with the diagonal phosphorescent screen to the two high voltage terminals.
- Connect the 6V power supply.
- If there is a horizontal line across the screen, then the apparatus is connected correctly. If not, then reverse the connection from the 6V power supply.
- Once the line on the screen has been established, the power supply can be turned off and the two pairs of terminals can be labelled as + or -. The terminal connected to the 6V power supply will be easy to label. For the high voltage terminals, the positive one is connected to tube's connection to the screen, while the negative has been connected to the terminal for the electron source.

Safety

The high voltage is enough to give a strong shock. The current is small and safe, but the Ruhmkorff Coil produces a larger current than the Van de Graaff generator, even though the voltage is a lot less. Anyone with a heart condition should consider not using it.

Demonstrations with Ruhmkorff Coil

- Spark gap (approx 10kV per cm)
- Insulators placed in gap, e.g. paper

How to use a Multimeter

A multimeter, as the name suggests, is a combination voltmeter, ammeter and resistance meter. It is used in the classroom is for these functions. Unlike other meters, multimeters need a battery and also have a fuse. So lab techs need to know how to test a multimeter to see if the battery is flat of the fuse is blown.

Lab techs also use the multimeter as a continuity tester, that is, to see if there is a break or a loose connection in a wire or cable.

Testing a multimeter to see if it is fully functional requires some basic knowledge of how to use it. So this will be covered first.

Features of a Multimeter

Off position: Multimeters need to be turned off after use to save the battery. Students forget to do this.

Sockets: There are three sockets in multimeters.

COM: always used.

VΩmA: To measure voltage, resistance and DC current up to 200 mA.

10ADC: To measure currents up to 10 A. This is rarely needed.

Store multimeters with the plugs in the COM and VΩmA sockets to avoid the students putting the plugs in the wrong sockets.

Dial Settings: The dial has many settings. These are grouped.

V : DC voltage across several ranges

V~: AC voltage for two ranges

A: DC Current across several ranges

Ω : Resistance (ohms) across several ranges

The ranges indicate that on that setting, the multimeter will measure up to that value, but if the signal is greater than the setting, the screen will display '1". For example, to measure the voltage of a battery rated at 6V, a setting of 20 would display an accurate reading, whereas with a setting of 2, the display would show '1', because the voltage is likely to be greater than 2V, unless the battery was really flat.

Note: The setting of 200 could be used, but the display will not contain as many digits and so would not be as accurate.

Polarity: The plugs do not have to be put in specific plugs. If the voltage or current is the reverse of what is expected, then the display will show a negative sign (-) in front of the measurement on the display.

Using a multimeter

Before using one of the functions of a multimeter, the setting and range must be selected first, then the multimeter used as described below. It could damage the multimeter if it was connected to a circuit then the dial turned through the various settings.

Using the multimeter as a voltmeter.

To measure the voltage between two points in a circuit or just a power supply, connect the two cables across the two points. In this case the multimeter is connected in parallel with the circuit.

Using the multimeter as an ammeter.
To measure the current in a circuit, the circuit needs to be broken and the two cables connected in the gap as part of the circuit. In this case the multimeter is connected in series with the circuit.

Using the multimeter as a resistance meter.
To measure the resistance of the resistor, the resistor can not be part of a circuit. The other components in the circuit will affect the reading. The resistor needs to be tested separately. The cables from the multimeter are connected to the ends of the resistor.
resistor,

Your Tasks:
Connect two plugs to the VΩmA and COM sockets
Measuring voltage

a. Set the multimeter dial to DC Volts and range of 20 V
b. Connect the ends of the multimeter cables to the DC sockets on the power supply.
c. Turn on the Power supply and record the readings in the table below for each voltage value from 2V to 12V

Voltage value (V)	Reading (V)	Voltage value (V)	Reading (V)
2		8	
4		10	
6		12	

Comment on your readings
_____

d. Disconnect the multimeter cables from the power supply and change the setting to AC volts and range of 200 V
e. Re-connect the cables to the AC sockets of the power supply.
f. Record the readings in the table below for each voltage value from 2V to 12V

Voltage value (V)	Reading (V)	Voltage value (V)	Reading (V)
2		8	
4		10	
6		12	

Comment on your readings
_____

Measuring Resistance

a. Set the multimeter dial to Resistance (Ω) and select any range.
b. Place a resistor across the ends of the cables and record its resistance. Change the dial setting until you get the most number of digits. This will be the most accurate reading.

Useful Videos:
https://dengarden.com/home-improvement/Using-a-Multimeter
https://learn.sparkfun.com/tutorials/how-to-use-a-multimeter
https://www.youtube.com/watch?v=zb7WHaL_dz8 (9 min)

Storage and handling of radioactive sources

Use of Radiation in Schools

- Part 1: Ionising Radiation
- Part 2: Lasers

https://www.arpansa.gov.au/sites/g/files/net3086/f/legacy/pubs/rps/rps18.pdf
ARPANSA: Australian Radiation Protection and Nuclear Safety Agency

Determining your exposure

Table 2: Typical Exposures to Ionizing Radiation

Source of Exposure	**Exposure**
Natural radiation (terrestrial and airborne)	1.5 mSv per year
Natural radiation (cosmic radiation at sea level e.g. Australian capital cities)	0.3 mSv per year
Cosmic radiation from a seven hour aeroplane flight	0.05 mSv
Chest X-ray	0.02 mSv
Cosmic radiation exposure of domestic airline pilot	2-6 mSv per year

Background radiation occurs everywhere, and in Australia we each receive an annual whole body dose that is typically about 2 millisievert (mSv). Medical radiation in Australia (X- rays and radioactive materials used in diagnosis), results in an average dose per person of about 1.2 mSv per year. By comparison, the dose received by the hand (not the whole body) during a standard school demonstration will be no more than 0.01 mSv .

Activity:

- Converting 2 mSv per year into a count rate gives 0.2 μSv per hour. So using your Geiger counter gives an equivalent counts per second.
- Measure counts in the classroom, outside and of an inflated balloon.

Table 3:
Sealed radioactive sources for use in schools and colleges

Radionuclide	**Max activity of sealed radioactive sources in NDRP for use in schools (kBq)**	**Exempt activity in NDRP (kBq)**
Cobalt-60	200	100
Strontium-90	80	10
Caesium-137	200	10
Polonium-210	–	10
Radium-226	20	10
Americium-241	40	10

NDRP: National Directory for Radiation Protection (RPS6)

The NDRP exempts the end user from the requirements of registration and of licensing to possess or use sealed radioactive sources with the activities specified in column 2 above when such sources are used for teaching. All jurisdictions will adopt the provisions of the NDRP in due course but you should check the current requirements in your jurisdiction with your radiation regulatory authority.

Radioactive sources with the activities specified in column 3 are exempt from all regulatory requirements and may be dealt with in general as though they were not radioactive. Radioactive sources with up to these activities may be suitable for many experiments and should be the first choice for sources.

Mini-generators

Unsealed radioactive materials can be useful in the form of ‘mini -generators‘, which are used to produce short half-life radioactive materials.

A risk assessment, however, may show that unsealed radioactive materials are not suitable for use at your school or college. The following information may assist you in making this decision.

One currently available mini-generator uses caesium-137/ barium-137m with an activity of 370 kBq. As this is an unsealed radioactive source, with activity higher than that specified in the NDRP for a sealed radioactive source, you should contact your radiation regulatory authority if you wish to use such a mini - generator.

Radioactive rocks

Radioactive rocks may also be used in schools. The NDRP exempts a geological sample that contains radioactive material from the requirements of registration, and of licensing the end user to possess or use, if:

- it emits radiation at a level not more than 5 microsieverts an hour, measured at a distance of 10 cm from its surface
- it is being used as a sample in teaching or for display as a geological specimen.

Such rocks are best kept in a box with a clear lid so that their radioactive properties may be demonstrated without the need to handle them

Cold Cathode Discharge Tubes

These may be a source of X-rays.

The radiation dose from X-rays is dependent on:

- operating factors of the X -ray tube (kV (peak) and mA)
- filtration of the X-rays by material in the beam
- amount of scattering of the primary beam that has taken place
- protective barriers between the tube and the body
- distance between the tube and the body
- duration of irradiation.

For some such devices, the X-rays are of such low level or energy that they are readily absorbed in the tube casing and these devices therefore pose no hazard.

Handling of radioactive materials

Exposure to ionising radiation sources can minimised by using the three principles of radiation protection:

- Time: keep to a minimum
- Distance: inverse square law applies
- Protection: the thicker the better

Use tongs or tweezers for sealed sources. For unsealed sources, e.g. mini-generators, conduct experiments on metal or plastic trays lined with absorbent disposable materials.

Classroom Use

<u>Year 10 and under:</u>

Class work with radioactive sources for students in year 10 and under is restricted to teacher demonstrations. Students should be kept at least 2 metres away from these sources during demonstrations. However, closer inspection of devices containing low-level radioactive sources (e.g. small cloud chambers, spinthariscopes, smoke alarms, radioactive watch dials) is acceptable, provided the source is fully enclosed.

Contamination of the fingers should be avoided, particularly with radioactive rocks, which should be kept in suitable transparent containers.

Year 11 and 12

Students in years 11 and 12 may handle sealed radioactive sources in order to carry out standard investigations of the properties of ionizing radiations. The teacher in charge should be satisfied that the students are sufficiently responsible, have received appropriate instruction and have seen and understood the appropriate sections of the local rules. The teacher should closely supervise all work.

Storage of radioactive materials

These should be locked in a secure store when a member of staff is not supervising them. Best practice is to keep each radioactive source in a suitable container. This is normally the container in which the source was supplied. It allows the source to be identified easily and carried safely.

Labelling on each container should uniquely identify the radioactive source(s) inside and include a trefoil warning sign with the wording 'radioactive materials'.

The store should be indoors, where security is better, access is easier and corrosion damage to sources is minimised. It should not be in the same room as highly flammable material. The minimum recommended requirement for a radioactive materials store is a strong, steel container (such as a tool box) that should be recognisable after a fire or other such major incident. A lead container or lead-lined wooden container alone is insufficient protection in a fire. The steel container should be kept in a fixed, locked cupboard or drawer.

Administrative Procedures

There should be a radiation supervisor within the school, who has designated responsibilities in regard to safety, risk assessment and compliance.

Risk Assessments

Local rules for the use of sealed radioactive sources (staff and supervised students in years 11 and 12)

2.1 Carry each source in its storage container and keep it there until it is required. Do not handle the container for longer than necessary.
2.2 Use only one source at a time in any one investigation.
2.3 Handle the source with a tool (e.g. metal or plastic tweezers or tongs), which keeps the fingers at least 10 cm away.
2.4 Keep the source well away from the eyes.
2.5 Complete the investigation in the shortest time possible, consistent with good results.
2.6 Return the source to its normal container immediately after completing the investigation.
2.7 The member of staff in charge is to check all sources for signs of damage on return.
2.8 Immediately report any event in which a source is dropped or may have been damaged to the member of staff in charge.
2.9 Always wash hands thoroughly immediately after working with any radioactive source

Radioactive rock

Description	Typical radioactive minerals offered by educational suppliers are allanite, autunite, davidite, monazite, phosphuranylite, pitchblende and torbenite. These usually contain thorium or uranium minerals. The geography or geology department may also keep rocks of this type and the radiation supervisor may wish to ensure that the control measures described here are applied as in the science area.
Use	To demonstrate that natural rocks contain radioactive minerals. A rock should be regarded as radioactive if the count rate at the surface is more than 50% above the background count.
Supplier	Sometimes collected in the field by enthusiastic students, geology or physics teachers.
Original activity	Typically from 0.18 kBq g^{-1} to 5 kBq g^{-1}.
Radionuclide	Thorium and/or uranium.
Main ionising radiations	α, β, γ in any combination.
Half-life	Typically millions of years.
Hazard	External irradiation of the body, including possibly more-sensitive organs such as the eyes. Internal irradiation of the body arising from rock fragments which have entered by inhalation, absorption through the skin, ingestion or through wounds.
Risk assessment	Provided the control measures given below are applied, the risk to health from small rock samples of this type is minimal. However, where large, and/or particularly active specimens are kept, the radiation supervisor should be consulted for advice.
Control measures	Always follow the local rules for the use of radioactive sources. Radioactive rocks should be treated in the same way as other radioactive sources.
During use	The lid of the container may be removed for inspection or checking the rock with a radiation monitor. The rock should not be touched with the hands.
Inspection	Annually or after use by students. A rock should be checked for damage and any chips or fragments disposed of. Forceps or disposable gloves should be used to handle rocks. Care should be taken to avoid chipping the rock with forceps. Handling time with gloves should be kept short.
Wipe test of source	Not required.
Contamination check of container	Annually or if damage to the rock is suspected. The container should be cleaned if necessary.
Storage and labelling	Radioactive rocks are best stored in sturdy, transparent, plastic or glass containers with secure lids, labelled with a radioactive warning sign and kept in the radioactive materials store or a locked drawer or cupboard. If rocks are to be displayed, they should always be kept in a locked cabinet and the count rate on the outside surface of the glass should be similar to the background level. Rocks of high activity should not be displayed.
Spills	A lab coat and disposable gloves should be worn. Should a radioactive rock be dropped, the area on to which it fell should always be checked for contamination and decontaminated if necessary.
Disposal	Small quantities of radioactive rocks may be disposed of in a strong plastic bag, tied and put in the refuse.

Sealed Sources

Description	The radioactive material is embedded in a plastic disc. Details of the radionuclide and original activity are usually stamped on the outside. Sources are usually supplied in a small lead pot with a lead lid inside a suitably-labelled, hardwood, storage container.				
Typical dimensions	A small disc, about 3 cm in diameter and 0.5 cm thick				
Use	Investigation of basic properties of ionising radiations.				
Supplier	IEC				
Original activity	3.7 kBq (0.1 μCi) to 370 kBq (10 μCi), depending on type. Most commonly 185 kBq (5 μCi).				
Radionuclide	Cobalt-60,	Strontium-90,	Americium-241,	Plutonium-239,	Radium-226
Main ionising radiations	γ (β)	β	α (γ)	α	α, β, γ
Half-life (years)	5.26	28.1	432	2.44×10^4	1602
Hazard	External irradiation of the body, including possibly more-sensitive organs such as the eyes. Internal irradiation of the body arising from materials which have entered by inhalation, by absorption through the skin, by ingestion or through wounds.				
Risk assessment	Provided the control measures given below are applied, the risk to health from a source of this type is minimal.				
Control measures	Always follow the local rules for the use of radioactive sources.				
During use	This type of source should be held by tongs. Only one source should be used at a time. Between investigations, the source should be returned to its container.				
Inspection	Annually and after use by students. The whole source should be checked for signs of damage.				
Wipe test of source	Annually or if damage is suspected. The outer surface should be tested.				
Contamination check of container	Not required unless leakage is suspected. However, due to the very small amounts of radon gas emitted from radium sources, an annual check should be made on the containers of these sources, which should be cleaned if necessary.				
Storage and labelling	The source should be stored in its lead-lined container, labelled with a radioactive warning sign and kept in the radioactive materials store.				
Spills	A lab coat and disposable gloves should be worn. If a source is dropped, the area on to which it fell should always be checked for contamination and decontaminated if necessary.				
Disposal	To comply with the NDRP, disposal of this type of source can only be via an authorised route. The radiation regulatory authority should be consulted.				

Smoke alarm

Description	Most domestic smoke alarms use an ionization chamber smoke detector. This is a small metal chamber containing a radioactive source. If smoke enters the chamber, the level of ionization reduces, decreasing the flow of electric current in a circuit and triggering a siren.
Use	To show that most domestic smoke alarms contain a radioactive source. To explain the widespread agreement that the very low radiological risk and the substantial benefits in terms of life-saving, make it well worth installing such devices in the home.
Supplier	Hardware stores.
Original activity	Typically 37 kBq (1 μCi).
Radionuclide	Americium-241.
Main ionizing radiations	α, γ.
Half-life	432 years.
Hazard	External irradiation of the body, including possibly more-sensitive organs such as the eyes. Internal irradiation of the body arising from materials which have entered by inhalation, by absorption through the skin, by ingestion or through wounds.
Risk assessment	Provided the control measures given below are applied, the risk to health from a source of this type is minimal. Note: such control measures are not required for smoke alarms used in the home, which are extremely unlikely to suffer damage in the normal position on the ceiling. Climbing a step ladder to reach the alarm is likely to present a far greater risk to health and safety than the radioactive material.
Control measures	Always follow the local rules for the use of radioactive sources.
During use	The plastic cover of the smoke alarm may be opened for observation, to detect ionizing radiation and to insert the battery. Under no circumstances should the metal ionization chamber be opened. The test button or smoke can be used to trigger the alarm.
Inspection	Annually and after use by students. Check that the ionization chamber is undamaged.
Wipe test of source	Annually or if damage is suspected. The accessible surfaces of the ionization chamber should be tested.
Contamination check of container	Not required unless leakage is suspected.
Storage and labelling	A smoke alarm should be put in a strong, self-sealing, plastic bag (to avoid any contamination from other sources), labelled with a radioactive warning sign and kept in the radioactive materials store.
Spills	A lab coat and disposable gloves should be worn. If a smoke alarm is dropped, it is most unlikely that any radioactive spill will occur. Should damage occur, the fragments should be swept into a strong plastic bag, which is tied and put in the refuse, the area checked for contamination and decontaminated if necessary.
Disposal	A single smoke detector may be securely wrapped in a strong plastic bag and put in the refuse.

Use of Radiation in Schools ARPANSA

- Part 1: Ionising Radiation
- Part 2: Lasers

https://www.arpansa.gov.au/sites/g/files/net3086/f/legacy/pubs/rps/rps18.pdf

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Annex C Laser Risk Assessment Template For Use When Assessingexperiments
Radiation Regulatory Authorities
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