

PHYSICS EXPERIMENTS USER GUIDE

FOR

ADVANCED LEVEL

SENIOR SIX

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FOREWORD

Dear Teacher,

Rwanda Basic Education Board is honored to present to you this physics experiments user guide which serves as a guide to practical activities to ensure consistency and coherence in the teaching and learning of physics subject. The Rwandan educational philosophy is to ensure that you achieve full potential at every level of education which will prepare you to be well integrated in society and exploit employment opportunities.

The government of Rwanda emphasizes the importance of aligning teaching and learning materials with the syllabus to facilitate your learning process. Many factors influence what you learn, how well you learn and the competences you acquire. Those factors include the instructional materials available among others. Special attention was paid to the experiments that facilitate the learning process in which you can develop your ideas and make new discoveries during concrete experiments carried out individually or with peers.

In competence-based curriculum, learning is considered as a process of active building and developing knowledge and meanings by the learner where concepts are mainly introduced by an activity, a situation or a scenario that helps the learner to construct knowledge, develop skills and acquire positive attitudes and values.

For efficiency use of this guide, your role as teacher is to:

- Ensure that laboratory working conditions are safe, with proper equipment on hand to deal with any potential extreme hazard or mishap.
- Plan your experiment and prepare appropriate equipment.
- Provide instructions in laboratory technique and in handling materials before students conduct experiments
- Provide supervised opportunities for students to develop different competences by giving tasks which enhance critical thinking, problem solving, research, creativity and innovation, communication, and cooperation.
- Facilitate students while they conduct experiments.

I wish to sincerely extend my appreciation to REB staff who organized the development process of this book. Special gratitude goes to AIMS-TTP who supported financially the whole activities of the development of this user guide, the UR-CE Lecturers, IEE staff, teachers, independent people, illustrators, and designers who diligently worked to successful completion of this book. Any comment or contribution would be welcome for the improvement of this book.

Dr. MBARUSHIMANA Nelson

Director General, REB

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Table of Content

FOREWORDiii
ACKNOWLEDGEMENT	v
GENERAL INTRODUCTION	1
1. Laboratory experiments in the competence based curriculum	1
2. Type of laboratory experiments.....	2
3. Methods of organizing laboratory experiments.....	3
4. Safety rules and precautions during lab experiments.....	4
5. Guidance on the management of laboratory materials.....	6
6. Storage of laboratory materials and science kits.....	7
7. Maintenance of laboratory materials and science kits.....	8
8. Role and responsibilities of teacher and learners in lab experiment.....	9
9. Management of experimental data	10
UNIT 1: SOUND WAVES	26
ANIMATED EXPERIMENT 1.1: Production of sound waves in open and closed pipes	26
SIMULATED EXPERIMENT 1.2: Reflection and refraction (transmission) of a wave.....	28
SIMULATED EXPERIMENT 1.3: Interference of sound waves	30
SIMULATED EXPERIMENT 1.4: Principle of superposition of sound waves.....	32
SIMULATED EXPERIMENT 1.5: Properties of sound waves.....	34
EXPERIMENT 1.6: Melde’s experiment on variation of frequency.....	36
SIMULATED EXPERIMENT 1.7: Demonstration of the variation of frequency by dopler effect.....	40
UNIT 2: CLIMATE CHANGE AND GREENHOUSE EFFECT	43
EXPERIMENT 2.1: Determination of factors of the planets’ albedo [radiation and albedo experiment]	43
SIMULATED EXPERIMENT 2.2: Greenhouse effect.....	46
SIMULATED EXPERIMENT 2.3: Black body radiation	48
ANIMATED EXPERIMENT 2.4: Climate change	50

UNIT 3: APPLICATION OF PHYSICS IN AGRICULTURE.....	52
ANIMATED EXPERIMENT 3.1: Mechanical weathering (freezing of rocks)	52
ANIMATED EXPERIMENT 3.2: Water cycle.....	54
UNIT 4: EARTHQUAKES, TSUNAMI, FLOODS, LANDSLIDES AND CYCLONES..	56
ANIMATED EXPERIMENT 4.1: Earthquakes, tsunami, flood, landslides and cyclones, and their mitigation	56
UNIT 5: ATOMIC NUCLEI AND RADIOACTIVE DECAY	58
SIMULATED EXPERIMENT 5.1: Nuclear fission.....	58
SIMULATED EXPERIMENT 5.2: Half life period of a radioactive substance	60
UNIT 6 :APPLICATIONS OF OPTICAL FIBRE IN TELECOMMUNICATION. .	63
SIMULATED EXPERIMENT 6.1: Total internal reflection of light	63
ANIMATED EXPERIMENT 6.2: Working principle of optical fibers.	65
UNIT 7:BLOCK DIAGRAM OF TELECOMMUNICATION SYSTEM	67
ANIMATED EXPERIMENT 7.1: Block diagram for telecommunication system	67
UNIT 8: NATURE OF PARTICLES AND THEIR INTERACTION	69
ANIMATED EXPERIMENT 8.1: Classification of elementary particles	69
UNIT 9: PROPERTIES AND BASIC PRINCIPLES OF QUARKS	71
ANIMATED EXPERIMENT 9.1: Properties and basic principles of quarks..	71
UNIT 10: EFFECT OF X-RAYS.....	73
ANIMATED EXPERIMENT 10.1: The production of x-rays.....	73
ANIMATED EXPERIMENT 10.2: Treatment of cancer	75
ANIMATED EXPERIMENT 10.3: The application of x-rays in security checkups.....	76
UNIT 11: EFFECT OF LASER	79
ANIMATED EXPERIMENT 11.1: The production of laser.....	79
ANIMATED EXPERIMENT 11.2: The application of laser in security checkups	81

UNIT 12: MEDICAL IMAGING	83
ANIMATED EXPERIMENT 12.1: X-ray imaging.....	83
ANIMATED EXPERIMENT 12.2: Medical imaging techniques	85
ANIMATED EXPERIMENT 12.3: Ultrasonic imaging techniques	86
ANIMATED EXPERIMENT 12.4: Explaining endoscope working principle..	88
ANIMATED EXPERIMENT 12.5: Magnetic resonance imaging (mri).....	89
UNIT 13: RADIATION AND MEDICINE	92
ANIMATED EXPERIMENT 13.1: Dosimetry	92
ANIMATED EXPERIMENT 13.2: Animation on radiation dosimeter	94
ANIMATED EXPERIMENT 13.3: Safety precaution for handling radiation....	95
UNIT 14: COSMOLOGY, GALAXIES, AND EXPANSION OF UNIVERSE	97
ANIMATED EXPERIMENT 14.1: Structure of the milky way galaxy	97
ANIMATED EXPERIMENT 14.2: Structure of the spiral galaxies	99
ANIMATED EXPERIMENT 14.3: Structure of the elliptical galaxies.....	100
ANIMATED EXPERIMENT 14.4: Big bang theory	102
REFERENCES	104

GENERAL INTRODUCTION

1. LABORATORY EXPERIMENTS IN THE COMPETENCE BASED CURRICULUM

Physics, and natural science in general, is a reasonable enterprise based on valid experimental evidence, criticism, and rational discussion. It provides us with knowledge of the physical world, and it is an experiment that provides the evidence that grounds this knowledge. Experiment plays many roles in science. One of its important roles is to test theories and to provide the basis for scientific knowledge. It can also call for a new theory, either by showing that an accepted theory is incorrect, or by exhibiting a new phenomenon that is in need of explanation. Experiments can provide hints toward the structure or mathematical form of a theory, and it can provide evidence for the existence of the entities involved in our theories. Finally, it may also have a life of its own, independent of theory. Scientists may investigate a phenomenon just because it looks interesting. Such experiments may provide evidence for a future theory to explain. A single experiment may play several of these roles at once.

Physics experiments are largely concerned with the verification of physics laws and determination of constants, e.g refractive index, acceleration due to gravity, spring constant, etc. Some of the experiments are however designed to investigate the relationship between physical quantities. In every case there is need for an accurate use of the apparatus involved in order to realise the purpose of the experiment. Physics as a subject of study consists of two parts, i.e. the theory part and the practical part.

The theory involves the study of physics laws and principles. The practical part on the other hand involves the application of the theory knowledge to practical situations, assessment of experimental procedures and observations made. A course in practical physics is therefore designed to give the students an opportunity of acquiring the skills and techniques in the manipulation of apparatus, the use and understanding of the instruments involved. These skills and techniques can easily be acquired by students through regular practice.

Common mistakes made in physics practical physics

- Wrong recording of units and symbols.
- Wrong use of instruments
- Wrong recording of experimental values
- Wrong recording of data in the main table of results.
- Use of scales which are not suitable and convenient

- Wrong substitution of values into the given expression
- Drawing tables which are not detailed, thus leaving out some of the data.
- Misinterpretation of the given expressions
- Failure to hand in tracing papers for questions involving tracing the outline of glass block or prism
- Labelling columns of the table of results and axes of the graph wrongly.
- Interchanging starting points on the axes of the graph and starting the axes from zero even when the intercept is not required.

A competence-based curriculum (CBC) focuses on what learners can do and apply in different situations by developing skills, attitudes, and values in addition to knowledge and understanding. This learning process is learner-focused, where a learner is engaged in active and participatory learning activities, and learners finally build new knowledge from prior knowledge. Since 2015, the Rwanda Education system has changed from Knowledge Based Curriculum to Competence Based Curriculum for preparing students that meet the national and international job market requirements and job creation. Therefore, implementing the CBC education system necessitates qualitative laboratory experiments that equip youth with 21st century skills and competencies to take on future challenges.

2. TYPE OF LABORATORY EXPERIMENTS

The goal of laboratory experiment are defines three type of practical work and how they are organized. Therefore, before doing practical work, it is important to have a clear idea of its objective.

The three types of practical work that correspond with its three main goals are:

- **Equipment-based practical work:** the goal is for students to learn to handle scientific equipment like using a microscope, making an electric circuit, etc.
- **Concept-based practical work:** learning new concepts.
- **Inquiry-based practical work:** learning process skills. Examples of process skills are defining the problem and good research question(s), installing an experimental setup, observing, measuring, processing data in tables and graphs, identifying conclusions, defining limitations of the experiment etc.

Note:

- To learn the new concept by practical work, the lesson should start with the practical work, and the theory can be explained afterward (explore – explain). Starting by teaching the theory and then doing the practical work to prove what they have learnt is demotivating and offers little added value for student learning.
- The experiments should be useful for all learners and not only for aspiring scientists. Try to link the practical work as much as possible with their daily life and preconceptions.

3. METHODS OF ORGANIZING LABORATORY EXPERIMENTS

The organization of whole class practical activities depends on the factors such as time, availability of equipment, chemicals and space, type of practical work, class size, etc... There are three methods used to organize practical work.

i. Each group does the same experiments at the same time

Each group does the same experiments at the same time. The teacher can organize a sequence of experiments and form small groups of learners. Ideally not more than 3 learners per group because all learners must be actively involved. If the group is larger, the teacher may ask learners to perform the experiment twice where learner change roles. Each group will perform each and every experiment. This method requires a lot of materials. This means all groups are performing the same experiment at a time. In other words it is **one experiment-one class**.

ii. Experiments are divided among groups with rotation

The teacher assigns one experiment to each group and he/she will give a signal when each group will have to move to the next experiment. At the end of the lesson, each group will have done all experiments. This method doesn't require many materials but if the conclusion of the first experiment provides the research question for the next experiment, the method may not be suitable. Its organization is also a bit difficult since the time for all experiments should be the same and there should be a timer to show learners when to move to the next experiment. Here it is **one class-many experiments with rotation**

iii. All experiments are divided among groups

In this method, the teacher prepares many experiments and distributes them among various groups. At the end each group will present and share its findings to the whole class. The advantages of this method are to save time and materials. It also has shortcomings because each group performs only one experiment and only listen to the descriptions of others. This method can be ideal for similar or optional experiments.

It would be a bad choice if it is used in case of experiments that need to be grasped by each individual learner. Here it is **one class-many experiments without rotation**.

4. SAFETY RULES AND PRECAUTIONS DURING LAB EXPERIMENTS

Regardless of the type of lab you are in, there are general rules enforced as safety precautions. Each lab member must learn and adhere to the rules and guidelines set, to minimize the risks of harm that may happen to them within the working environment. It is important to know that some laboratories contain certain inherent dangers and hazards. Therefore, when working in a laboratory, you must learn how to work safely with these hazards to prevent injury to yourself and other lab mates around you. You must make a constant effort to think about the potential hazards associated with what you are doing and think about how to work safely to prevent or minimize these hazards as much as possible. Before doing any scientific experiment, you should make sure that you know where the fire extinguishers are in your laboratory, and there should also be a bucket of sand to extinguish fires. You must ensure that you are appropriately dressed whenever you are near chemicals or performing experiments. Please make sure you are familiar with the safety precautions, hazard warnings, and procedures of the experiment you perform on a given day before you start any work. Experiments should not be performed without an instructor in attendance and must not be left unattended while in progress.

A. Hygiene plan

A laboratory is a shared workspace, and everyone has the responsibility to ensure that it is organized, clean, well-maintained, and free of contamination that might interfere with the lab members' work or safety.

For waste disposal, all chemicals and used materials must be discarded in designated containers. Keep the container closed when not in use. When in doubt, check with your instructor.

B. Hazard warning symbols

To maintain a safe workplace and avoid accidents, lab safety symbols and signs need to be posted throughout the workplace. Chemicals pose health and safety hazards to personnel due to innate chemical, physical, and toxicological properties. Chemicals can be grouped into several different hazard classes. The hazard class will determine how similar materials should be stored and handled and what special equipment and procedures are needed to use them safely.

Each of these hazards has a different set of safety precautions associated with them.

C. Safety rules

Safety is the number one priority in any laboratory. All students are required to know and comply with good laboratory practices and safety norms; otherwise, they will be asked to leave the laboratory. Make sure you understand all the safety precautions before starting your experiments, and you are requested to help your learners to understand too.

The following are some general guidelines that should always be followed:

i. Lab coat

While working in the lab, everyone must always wear a lab coat to prevent incidental and unexpected exposures to the skin and clothing. The primary purpose of a lab coat is to protect against splashes and spills. The lab coat must be wrist-fitted and must always keep buttoned. A lab coat should be non-flammable and should be easily removed.

ii. Safety glasses

For eyes protection, goggles must always be worn over by all persons in the laboratory while students are working with chemicals. Safety glasses, with or without side-shields, are not acceptable. The eyes protection safety indicates the possibility of chemical, environmental, radiological, or mechanical irritants and hazards in the laboratory.

iii. Breathing Masks

Respirators are designed to prevent contamination from volatile compounds that may enter in your body through the respiratory system. “Half mask” respirators cover just the nose and mouth; “full face” respirators cover the entire face, and “hood” or “helmet” style respirators cover the entire head. The breathing mask safety sign lets you know that you are working in an area with potentially contaminated air.

iv. Eye Wash Station

Eyes wash stations consist of a mirror and a set of bottles containing saline solution that can be used to wash the injured eye with water. The eye wash station is intended to flood the eye with a continuous stream of water.

Eyes wash stations provide a continuous, low-pressure stream of aerated water in laboratories where chemical or biological agents are used or stored and in facilities where non-human primates are handled. The eyewash stations should easily be accessed from any part of the laboratory, and if possible, located near the safety shower so that if necessary, the eyes can be washed while the body is showered.

v. Footwear

Shoes that cover entirely the toes, heel, and top of the foot provide the best general protection. Closed shoes must always be worn while in the laboratory, regardless of the experiment or curricular activity. Shoes must fully cover your feet up to the ankles, and no skin should be shown. Socks do not constitute a cover replacement for shoes. Sandals, backless and open shoes are unacceptable.

vi. Gloves

When handling chemical, physical, or biological hazards that can enter the body through the skin, it is important to wear the proper protective gloves. Butyl, neoprene and nitrile gloves are resistant to most chemicals, e.g., alcohols, aldehydes, ketones, most inorganic acids, and caustics.

vii. Hair dressing

If hair is long, it must be tied back. It is good to report all accidents including minor incidents to your instructor immediately.

viii. Eat and drink

Never drink, eat, taste, or smell anything in the laboratory unless you are allowed by the lab instructor.

ix. Hot objects

Never hold very hot objects with your bare hands. Always hold them with a test tube holder, tongs, or a piece of cloth or paper.

5. GUIDANCE ON THE MANAGEMENT OF LABORATORY MATERIALS

A good management of science laboratory is characterized by:

- Clean laboratory room or shelves, without dust and any other undesirable materials. All materials should also be cleaned.
- Well stored and arranged materials with labels in the shelves or boxes.
- Timetable showing when classes occupy the laboratory room.
- Updated Soft or hard copies showing physical state and all quantities found in laboratory rooms held by persons in charge of the school laboratory. This copy may show also all quantities received during the delivery process.
- Inventory of laboratory or science kit items including received, damaged, stolen, expired and used up chemicals, and remaining items carried out every term. This should be printed and signed by the school representative.
- All waste materials should be stored in properly labeled closed containers in a secure waste storage area waiting for their disposal. The disposal may not take a long time.

6. STORAGE OF LABORATORY MATERIALS AND SCIENCE KITS

a. Storage of science kits

Science kits are supplied to schools without laboratory rooms. They are then stored in metal boxes designed to store the kits safely, but they can also be stored in shelves where they are available and accessible. It is recommended to store the box with the contents to a safe place where kit's items are not lost, stolen or intentionally damaged. It is preferred to keep them in the safe room equipped with shelves or cupboard to store items and tables. When the kits materials are stored in the cupboard, their items are grouped according to their types and purpose and labelling to facilitate the localization of items.

N.B: Only one teacher of science and/or mathematics chosen from his colleagues should manage the store of the kit materials.

b. Storage of laboratory materials (apparatuses and chemicals)

Normally, a laboratory is composed of two parts: A preparation room and learning and teaching room.

A preparation room is a room where science materials are stored, and a science teacher or laboratory technician prepare solutions prior to teaching. The Learning and teaching room is a room where science practical lessons are conducted. In the laboratory we find apparatuses and chemicals. Apparatuses are sometimes stored depending on the materials they are made of. In the laboratory, chemicals are whether solids or liquids. Science laboratory materials are supplied to schools with laboratory rooms. They are stored in shelves in the preparation room.

i. Storage of laboratory glassware

Laboratory glassware requires serious attention or mindful care. Once it's been cleaned and inspected, it should be stored to prevent it from becoming dirty, getting broken, or getting lost. Glassware is stored inside shelves in the preparation room out of the way of regular daily activities. Glass items are consistently in use in laboratories; when you need them, it's important to be able to find them without wasting time walking and searching. Glassware can be grouped with others of its type, size, or according to the purpose. For example, test tubes, beakers, conical flasks, measuring cylinders, distillation set of apparatus, ...; all these placed in shelves with clear labels. This will ensure that they are easily found when needed. Before storing them, the glassware equipment should have been cleaned.

Specific glassware may require certain guidelines to ensure their safety in storage. These are volumetric flasks, Burettes, Pipettes and Round-Bottom Flasks.

ii. Storage of other materials

Science laboratories are not equipped only by Glassware but also by other materials made of wood, plastic, rubber and metals. These laboratory materials are also stored in the preparation room arranged following their types or their usage. To facilitate their localization, labeling is needed.

7. MAINTENANCE OF LABORATORY MATERIALS AND SCIENCE KITS

The care and maintenance of laboratory equipment is an important part of quality assurance in the lab. Keeping your lab equipment clean means that it will always be ready for use when you need it, and ensures that no impurities contaminate samples and skew data. Lab equipment or science kits should be cleaned after every use. Making sure that devices are properly stored, cleaned, and well maintained will save you time and money, as well as making your projects and jobs much more comfortable. Inadequate maintenance can lead to dangerous situations, accidents and health problems.

a) How to clean laboratory equipment in general?

- Carry out a daily wipe down of all equipment exteriors.
- Carry out a weekly deep clean of all equipment.
- Carry out a regular deep clean of microscopes using a 70:30 mixtures of ether and alcohol, this ensures that they are sufficiently clean to yield most accurate results.

b) How to clean laboratory glassware?

- To remove organic residues, rinse glassware briefly with an organic solvent (acetone or ethanol, hexane). ...
- Use warm tap water and a brush with soapy water to scrub the inside of curved glassware.
- Remove soapsuds with deionized water to avoid harsh water stains.

c) Rinse All Glassware

- First, rinse glassware very thoroughly with running tap water, filling, shaking and emptying it at least six times. ...
- Then, rinse all glassware in a large bath of distilled or high purity water.
- Finally, rinse each piece individually in high purity water.

8. ROLE AND RESPONSIBILITIES OF TEACHER AND LEARNERS IN LAB EXPERIMENT

8.1. The roles and responsibilities of teacher during a lab experiment

Before conducting an experiment, the teacher will do the following:

- Decide how to incorporate experiments into class content best,
- Prepare in advance materials needed in the experiment,
- Prepare protocol for the experiment,
- Perform in advance the experiment to ensure that everything works as expected,
- Designate an appropriate amount of time for the experiment. Some experiments might be adapted to take more than one class period, while others may be adapted to take only a few minutes.
- Match the experiment to the class level, course atmosphere, and your students' personalities and learning styles.
- Verify lab equipment before lab practices.
- Provide the experiment protocol and give instructions to learners during lab session.
- During practical work, the teacher's role is to coach instead of helping with advice or questions. It is better to answer a learner's question with another question than to immediately give the answer or advice. The additional question should help learners to find the answer themselves.

8.2. The Role of a lab technician during a laboratory-based lesson

In schools having laboratory technicians, they assist the science teachers in the following tasks:

- Maintaining, calibrating, cleaning, and testing the sterility of the equipment,
- Collecting, preparing and/or testing samples,
- Demonstrating procedures.

8.3. The learners' responsibilities in the lab work

During the lab experiment, both learners have different activities to do. General learner's activities are:

- Experiment and obtain data themselves,
- Record data using the equipment provided by the teacher,

- Analyze the data often this involves graphing it to produce the related graph,
- Interpret the obtained results and deduct the theory behind the concept under the experimentation,
- Discuss the error in the experiment and suggest improvements and make a conclusion of the experiment,
- Cleaning and arranging material after a lab experiment.

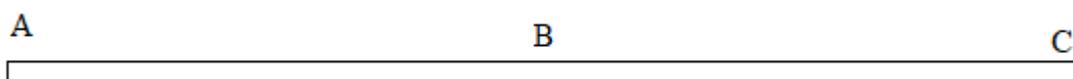
9. MANAGEMENT OF EXPERIMENTAL DATA

9.1. RECORDING EXPERIMENTAL MEASUREMENTS

In physics practicals, there are two types of measurements or readings i.e. single and repeated measurements.

9.1.1 RECORDING SINGLE MEASUREMENTS

Single measurements are measurements whose procedure is not repeated e.g measurement of diameter of the wire, thickness of wood or glass block, breadth (width) of wood or glass block, length of thread or wire etc. the common instruments for taking single measurements are: micrometer screw gauge, vernier callipers and meter rule, other instruments can also be used. Single measurements should be carried out three times, at different points of the objects under test. The measurements should be recorded according to the unit and the precision of the instrument being used. As an example, consider the measurement of the diameter d of a wire using a micrometer screw gauge.



Measure the diameter of the wire at A, B and C. suppose the measurements obtained are 0.34 mm, 0.34 mm, 0.35 mm, respectively. The measurements should be recorded as follows:

d_1 /mm	d_2 /mm	d_3 /mm
0.34	0.34	0.35

$$\begin{aligned} \text{Average } d &: \frac{d_1 + d_2 + d_3}{3} \\ &= \frac{0.34 + 0.34 + 0.35}{3} \\ &= 0.34 \text{ mm} \end{aligned}$$

Note:

1. The average should be recorded according to the precision of the instrument being used; in the above example a micrometer screw gauge precision is to 2 dp. In the case the value of the diameter is to be recorded in meters, the units in the table and average should be meters and the values converted from mm to m.
2. For measurement of the mass of an object, the measurement is carried out once thus there is no need to measure three times. This also applies to measurement of room temperature and focal length of converging lens or concave mirror.

9.1.2.RECORDING REPEATED READINGS

Repeated readings are noted twice in the procedure. They are reading taken on variable quantities like current, voltage, extension, angle of refraction, balance length for experiments involving potentiometer or meter bridges, etc. such readings must be recorded in the main table of results

9.2. DESIGN OF THE TABLE OF RESULTS

The table of results should be in columns and not in rows. This is by the agreed convention. The table should be closed at the top and bottom. The table of results can be drawn and written in pencil or pen (blue or black).

Each column should have a heading which includes: the physical quantity and its appropriate unit where applicable. The physical quantities should be separated from its unit by use of forward slash /, e.g. L/m, t/s, m/kg etc. The physical quantities should be on the same level with the unit except for the degree symbol, which should be written slightly the level of the quantity. The case (capital or small letter) of the symbol of the physical quantity given in the procedure must not be altered e.g. L should not be written as l, y should not be written as Y, $\frac{1}{x}$ should not be written as x^{-1} or $1/x$, t etc. this also applies when writing the title of the graph and labeling axes. units of the derived quantities should be written in a recommended way e.g. kgm^{-3} not kg/m^3 , Nm^{-2} not N/m^2 etc. in case a power of ten is used in the heading of a particular column, it should be written inside the brackets e.g. $\text{L} (10^{-2} \text{ m})$, $\sin \theta (10^{-1})$.

The examples below show typical tables of results:

Example 1:

L/m	$\frac{1}{L}(m^{-1})$	t/s	T/s	T ² /s ²

Example 2:

x/cm	X ² /cm ²	I/°	Sin i	Sin ² i	$\frac{1}{\sin^2 i}$

Note:

Once the units are written in the heading of a column, there is no need of repeating them within the column. The table of results should be systematic, neat and well organized as shown in the two examples above. The table of results must be as detailed as possible. As an example, consider an experiment to determine the width of a glass block. Suppose the student is given values of angle i and is required to obtain values of angle r , length x and to tabulate the results including values of $\sin r$, $1/x^2$ and $\sin^2 i$ the table of results should be drawn as:

i(°)	Sin i	Sin ² i	r (°)	Sin r	x/cm	x ² /cm	$1/x^2$ /cm ⁻²

The table of results must be self-explanatory.

In a given experiment the student is required to measure time for 20 oscillations. In case the symbol for time for 20 oscillations has not been given, the student can use any symbol say t , but must define it e.g. let t = time for 20 oscillations.

In a particular column in a table of results, values must be recorded to the same number of decimal places although the number of decimal places may differ from one column to another.

The method of calculation should not be shown in the table of results instead the final values should be recorded. Values recorded in the table of results from instruments must be according to the precision (decimal places) of the instruments. The trend of the values recorded from instruments varies; they can increase or decrease or both.

Note: The table of results should be drawn well in advance before the experiment is done, and there is no need to have a rough table.

9.3. MANIPULATION OF DATA

There are two categories of operations used in manipulation of data from the table of results:

- i. Addition and subtraction
- ii. Multiplication and division

9.3.1 Rule for adding and subtraction numbers

When adding and subtraction numbers, the answer should be expressed using the same number of decimal places as the quantity with the least number of decimal places.

Examples:

1. $2347.56(2dp) + 53.9521(4dp) = 2401.51(2dp)$
2. $3.2576(4dp) - 1.1(1dp) = 2.2(1dp)$
3. $43(float) + 0.62(2dp) = 43.62(2dp)$

Note:

- i. When adding two whole numbers, the total should be a whole number.
- ii. The difference between two whole numbers should be a whole number.

9.3.2. Significant figures

Non-zero digits 1, 2, 3, 4, 5, 6, 7, 8, 9 are counted as significant figures whether they're in the left hand side or right hand side of the decimal point. Zero (s) in the middle of a number is/are just as important as any digit and should therefore be counted as significant figures. Zero at the end of a number may be significant or not. If the zeros at the end of the numbers are as a result of rounding off, then they are not counted as significant. For example, if some distance is measure as 211 km, it can be written to one significant figure as 200 km, the zeros at the end are not significant but they keep/show place values and hence are called place values zeros. Without them the meaning of the number would change. To two significant figures 211 km would be written as 210 km.

As a further example, consider a value 3623.67. This can be expressed to different number of significant figures as follows:

- 4 significant figures the value is 3624
- 3 significant figures the value is 3620
- 2 significant figures the value is 3600
- 1 significant figure the value is 4000

If a distance is measured as 30.0cm, the zeros at the end are not as a result of rounding-off and thus they are counted as significant, in this case there are three significant figures. Zeros at the beginning of the number are present only to locate the decimal point and are not significant figures. Therefore, the number 0.0003405 has four significant figures. Significant figures are used to show the sensitivity or least count of the instrument from which the measurements were derived.

9.3.3. Rule for multiplying and dividing numbers

When multiplying and dividing numbers, the answer should be expressed to the same number of significant figures as that quantity with the least number of significant figures (sf).

Example:

1. $2.5765(5sf) \times 1.27(3sf) = 3.27(3sf)$
2. $0.265(3sf) \times 0.265(3sf) = 0.0702(3sf)$
3. $0.782(3sf) \div 0.218(3sf) = 3.59(3sf)$
4. $30.78(4sf) \div 1.9(2sf) = 16(2sf)$

When multiplying/dividing a whole number or recurring decimal with another number, the numbers of significant figures of the number are used. When adding/ subtracting a whole number or recurring decimal to/from another number, the numbers of decimal places of the number are used. For example

$\frac{1}{0.356}$, the numbers of significant figures to be used are those of 0.356 not of 1.

This is because 1 is called a float value which has infinite number of significant figures. In this case the answer should be expressed to three significant figures

of 0.356, thus $\frac{1}{0.356} = 2.81(sf)$

Example:

- a. Evaluate $4\pi (2.71)^2$.

$$(2.71)^2 = 7.34(3sf \times 3sf = 3sf)$$

4 and π are float values. Therefore, the final answer should be expressed to three significant figures of 2.71. Thus $4\pi (2.71)^2 = 4\pi \times 7.34 = 92.2(3sf)$

b. $0.678(sf) \times 3(float) = 2.03(3sf)$

9.4. APPROXIMATIONS

In every calculation, the answer obtained either terminates or recurs. It may be necessary to approximate the answer obtained to a whole number, to one or more number of decimal places. When approximating to a required number of decimal places, check the digit in the next (right hand side) number of decimal places. If the next digit is greater than five (5), then one is added to the digit in the number of decimal places required.

Example 1:

Express 2.786 to two decimal places.

$$2.786 \approx 2.79(2dp)$$

If the next digit is less than five (5), then one is not added to the digit in the number of decimal places required.

Example 2 :

Express 13.726 to one decimal place

$$13.726 \approx 13.7(1dp)$$

If the next digit is exactly five (5) and there is no digit on the right hand side of side (5), then the number is just half way and one is not added to the digit to the number of decimal places required.

Example 3 :

Express 0.625 to two decimal places

$$0.625 \approx 0.62(2dp)$$

If the next digit is exactly five (5) and there are digits on the right hand side of five (5), then the number is beyond half way and 1 is added to the digit in the number of decimal places required.

Example 4 :

Express 1.72501 to two decimal places. $1.72501 \approx 1.73(2dp)$

9.5. MANIPULATION OF DATA IN THE TABLE OF RESULTS

When manipulating data in the table of results, there is need to recall the rules for adding and subtracting numbers, multiplying and dividing numbers and approximations. When multiplying/dividing numbers, significant figures are used to determine the number of decimal places in a column. The following examples have been carefully selected to guide the students on how to manipulate data.

Table 1: $y = 0.950\text{m}$

x/m	d/m	$\frac{x}{y}$
0.100	0.002	0.105
0.200	0.004	0.211
0.300	0.006	0.316
0.400	0.008	0.421
0.500	0.011	0.526
0.600	0.014	0.632

In the column of x, the first value 0.100 has 3sf and the value of y has 3sf. The column of involves division, so significant figures are used when manipulating data in this column.

Thus, 3sf divided by 3sf give 3sf.

$0.100(3sf) \div 0.950(3sf) = 0.105(3sf)$. The value 0.105 has 3sf but 3dp. Therefore, values in the column of $\frac{x}{y}$ should be recorded to 3dp.

Table 2:

x/m	t/s	T/s	$\frac{1}{x}(m^{-1})$
0.90	19.0	0.950	1.1
0.80	21.0	1.050	1.2
0.70	23.0	1.150	1.4
0.60	27.0	1.350	1.7
0.50	32.5	1.625	2.0
0.40	39.5	1.975	2.5

Where: t = time for 20 oscillations

T = period

Column of T :

The values in the column of t are used to calculate the values of T . The first value 19.0, in the column of t has 3sf. To obtain the value of T , the value of t is divided by 20, which is a float. Therefore the values in the column of T will depend on only the number of significant figures to the first value in the column of t . The value of T should be recorded to 3sf.

$19.0(3sf) \div 20(float) = 0.950(3sf)$. The value 0.950 has 3sf but 3dp therefore; the values in the column of T should be recorded to 3dp.

Note: The number of sf and therefore number of dp of T will depend on the number of sf of the first value in the column of t but not on the number of sf of the values in the entire column.

Column of $\frac{1}{x}$:

The number of significant figures in the column of $\frac{1}{x}$ depends on only the number of significant figures in the first value of x since 1 is a float. The first value 0.90, in the column of x has 2 significant figures, thus $1(float) \div 0.90(2sf) = 1.1(2sf)$. The values in the column of $\frac{1}{x}$ should be recorded to 1 dp.

Table 3:

x/m	x^2/m^2	t/s	T/s	T^2/s^2
0.10	0.010	14.5	0.725	0.526
0.15	0.022	15.0	0.750	0.562
0.20	0.040	16.0	0.800	0.640
0.25	0.062	17.0	0.850	0.722
0.30	0.090	18.0	0.925	0.856
0.35	0.122	20.0	1.000	1.000

T = time for 20 oscillations

Column of x^2 :

The first value 0.10, in the column of x has 2 sf therefore the first value in the column of x^2 should have 2sf, $0.10(2sf) \times 0.10(2sf) = 0.010(2sf)$. The value 0.010 has 2sf but 3dp, therefore the values in the column of x^2 should be recorded to 3dp.

Column of T:

The first value 14.5 in the column of t has 3sf. The first value in the column of T should be recorded to 3sf. Thus $14.5(3sf) \div 20(float) = 0.725(3sf)$. The value 0725 has 3sf but 3dp therefore the values in the column of T should be recorded to 3dp.

Column of T²:

The first value 0.725 in the column of T has 3sf. The first value of T² should be recorded to 3sf. $0.725(3sf) \div 0.725(3sf) = 0.526(3sf)$. The value 0.526 has 3sf but 3dp, therefore the values in column of T² should be recorded to 3dp.

9.2.GRAPH WORK

Graph work is yet another method of analyzing data obtained from experiments. The main components of a good graph are:

9.5.1. TITLE OF THE GRAPH

The graph must have a title clearly written at the top of the graph paper. A title of graph should show what is being plotted on the graph e.g. A graph of T² against *l*. This means the values of T² are plotted along the vertical axis and the values of *l* along the horizontal axis. The title of a graph must not have units on the physical quantities being plotted. The case (capital or small letters) of the physical quantity must be maintained on the graph, as in the procedure. The word versus can be used in place of against, in the title but not vs. The title of a graph must not be written as: A plot of T² against *l* or A graph showing T² against *l* or Graph of T² against *l*. The title of a graph should be written on only one line.

9.5.2. AXES

=The axes should be drawn perpendicular to each other with an arrow on each axis, showing increasing values. Axes should be drawn without broken lines. Each axis must be clearly and correctly marked after every 10 small squares (2 cm) starting from the origin. It's important to note that the graph may not necessarily start from the origin (0,0). Axes should be labeled correctly with their appropriate units where applicable. When labeling the axis if a unit exists, it must be written on the same level with the physical quantity except for the unit degrees, which should be written slightly above the level of the physical quantity. The physical quantity should be separated from its unit by use of a forward slash /.

When drawing the axes, select a suitable position on the graph paper and draw the axes so as to cover all the values (positive and negative if any) in your table.

9.5.3. SCALE

Each axis must have a single scale, which should be uniform. The plotted points should cover at least half of the graph page except for intercept where the points may or may not cover at least half the graph page. The origins of each axis must be indicated i.e where exactly the axis starts. The origins of the axes may or may not be the same. When the intercept on the vertical axis is required, the origin of the horizontal axis must be zero; the origin of the vertical axis may be zero. When the intercept on the horizontal axis is required, the origin of the vertical axis must be zero; the origin of the horizontal axis may be zero. It is advisable that the values of the scale must not be recurring. It is also advisable that the multiples and sub-multiples of 1, 2, 5, be used as values are easy to use when plotting.

How to obtain convenient scale:

- a. Obtain the range on both the vertical and horizontal axes.
- b. Divide the vertical range by 110 or 100 small squares and the horizontal range by 90 or 80 small squares.
- c. The figure values obtained in (b) is what one small square represents on the vertical and horizontal axes respectively.
- d. For convenience we use scales involving digits 1,2,4,5,8 and 10, their multiples or their submultiples such as 0.1,0.2,0.4,0.5,0.8,1.0 or 0.01,0.02,0.04,0.05,0.08,0.1 or 10,20,40,50,80,100 etc. if the figure value obtained in (c) falls exactly on one of the convenient scale like the ones above, then use it as it is.
- e. If the value obtained in (b) does not fall exactly on one of the convenient scales, take the nearest upper value from the set of convenient scales e.g. if the figure value in (b) is 0.043, take 0.05, if the value obtained is 3.3, take 4, if the value in 0.008356, take 0.01 etc. the value chosen is what 1 small square will represent on the particular axis.
- f. Multiply the figure value obtained in (d) by 10 to obtain what 2 cm (10 small squares) will represent.
- g. If the scale used leaves out some values, then use a greater value from the set of convenient scales in (c) above e.g. if 0.01 fails try 0.02, if 0.02 fails try 0.04 or 0.05 etc.

9.5.4. PLOTTING POINTS ON THE GRAPH PAPER

How to use the scales to plot points on the graph paper.

To plot a given point on the graph paper, divide the values for the quantities to be plotted by their respective scales to obtain the number of small squares to be counted on each axis. Then locate the position of the point by counting the small squares obtained on each axis.

Example

Suppose you want to plot the value 0.174 on the vertical axis and 0.139 on the horizontal axis using the scales HA 1:0.005 and VA 1:0.01 then,

Horizontal axis

$$\text{Number of small squares} = \frac{0.139}{0.005} = 27.8$$

Vertical axis

$$\text{Number of small squares} = \frac{0.174}{0.01} = 17.4$$

Thus, to plot the point (0.139,0.174), we count 27.8 (and not 27 or 28) small squares on the horizontal axis and 17.4 (not 17 or 18) small squares on the vertical axis. This will give the exact position where the point lies.

This is only true if the axes begin from zero. If a given axis does not begin from zero, subtract the starting value (on that particular axis) from the value to be plotted and divide the figure value obtained by what 1 small square represents to get the number of small squares to be counted along that axis.

Symbols or signs used when plotting points

The experimental points should be plotted on the graph paper using a hard sharp pointed pencil marking them with a dot, . or a cross, x or a dot encircled

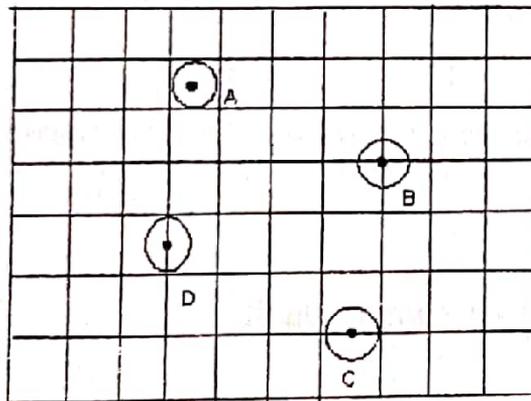
⊙ or across encircled ⊗ but not *

The cross and the circle should cover less than four small squares of your graph paper. When plotting, be consistent in the marking of points i.e points must be marked with the same sign. Do not use ⊗ for some points and X or ⊙ for others.

Note:

- The intersection of the cross is the correct point plotted and the circling is to enable the visibility of your plotted points.
- If the points are marked with a dot and a circle, the circle must be of half small square radius

The diagram below shows how this should be done for points lying at different positions on the graph paper.



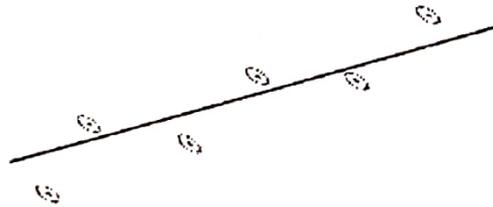
- If the point is in the middle of the square (A), the inclosing circle should not go beyond the boundaries of the square.
- If the point is at the intersection of lines (B), then the circle must cut the midpoints of the perpendiculars from it.
- If the point is on the horizontal (C), the enclosing circle must be between the boundaries of vertical lines before and after the point and should not touch the upper and lower lines.
- If a point is on the vertical (D), the enclosing circle must be between the boundaries of the upper and the lower lines and should not touch the lines before and after the point.

9.5.5. BEST STRAIGHT LINE OR BEST CURVE

For the best straight line use a 30cm transparent ruler and a sharp pencil. The best straight line is the line which passes through most or all the points plotted, leaving equal number of points below as above the line. Points which are below and above the line should approximately be the same distance from the line. Use a sharp pencil for drawing the best curve. The curve must be a smooth one.



If a line that satisfies the above condition cannot be obtained, draw a line that averages the plotted points. That is illustrated in the diagram below



If the graph is a curve, the best curve must be smooth and needs not to pass through all the plotted points.

9.5.6. SLOPE OR GRADIENT

In order to obtain a slope, a right-angled triangle is drawn touching the best straight line and enclosing all plotted points. The triangle should not touch any plotted points. The triangle should be drawn such that it touches the best straight line at the points of intersection of the squares. The coordinates of the slope must be accurately read from the triangle of the slope. The slope should be calculated from the coordinates read. A slope may or may not have units depending on physical quantities that have been plotted. To obtain number of decimal places of the slope, the number of significant figures of the first values in the columns in the table of results a being plotted are used. The rule for multiplying and dividing numbers is then applied.

The unit of the slope must be derived from the labels on the axes of the graph. If the value of the slope is not in SI units, convert to SI units before using it in the next stage except for light experiments.

9.6. ERROR PROPAGATION

This is aimed at helping students know the possible sources of errors and how they can be minimized for better accuracy. It's not necessary for the students to include the error bounds and the possible sources of error in their practical answers.

There are three main types of errors that are actually incurred during experimental investigations. Learners are advised to take the necessary precautions to minimize these errors.

9.6.1. INSTRUMENTAL ERRORS

These are errors inherent in the apparatus itself and in the instruments used for measuring a physical quantity.

It should be realized that, in a teaching laboratory, no apparatus can give high degree of accuracy. The results of any measurement should be considered with the degree of accuracy of the instrument in mind. However, measuring instruments used must be reliable enough.

Note: Instrumental errors cannot be eliminated by repeated measurements using the same apparatus. Generally, measuring instruments are accurate to about the smallest division.

9.6.2. SETTING OR ADJUSTMENT ERRORS

These are personal errors that arise from a faulty alignment of apparatus or wrong adjustment of apparatus.

Setting errors are perhaps the most common in teaching laboratory and may give rise to unnecessarily large errors in the final results. This calls for care and precision in setting up the apparatus for a given experiment.

Before arranging the apparatus, students are advised to ask for a clear set up of the experiment to avoid making a wrong alignment of the apparatus.

9.6.3. RANDOM ERRORS

These arise due to numerous fluctuating disturbances and uncertainties during an experimental investigation.

Sources of random errors include;

- i. Observational errors, which may arise due to parallax and scale interpolation estimates.
- ii. Pressure variation, where pressure is supposed to be constant.
- iii. Temperature fluctuations, where temperature is supposed to be constant.
- iv. Voltage or current fluctuations, where voltage or current is supposed to be constant.

The following example is used to guide on graph work.

Example 1: Determination of acceleration due to gravity by using Simple Pendulum

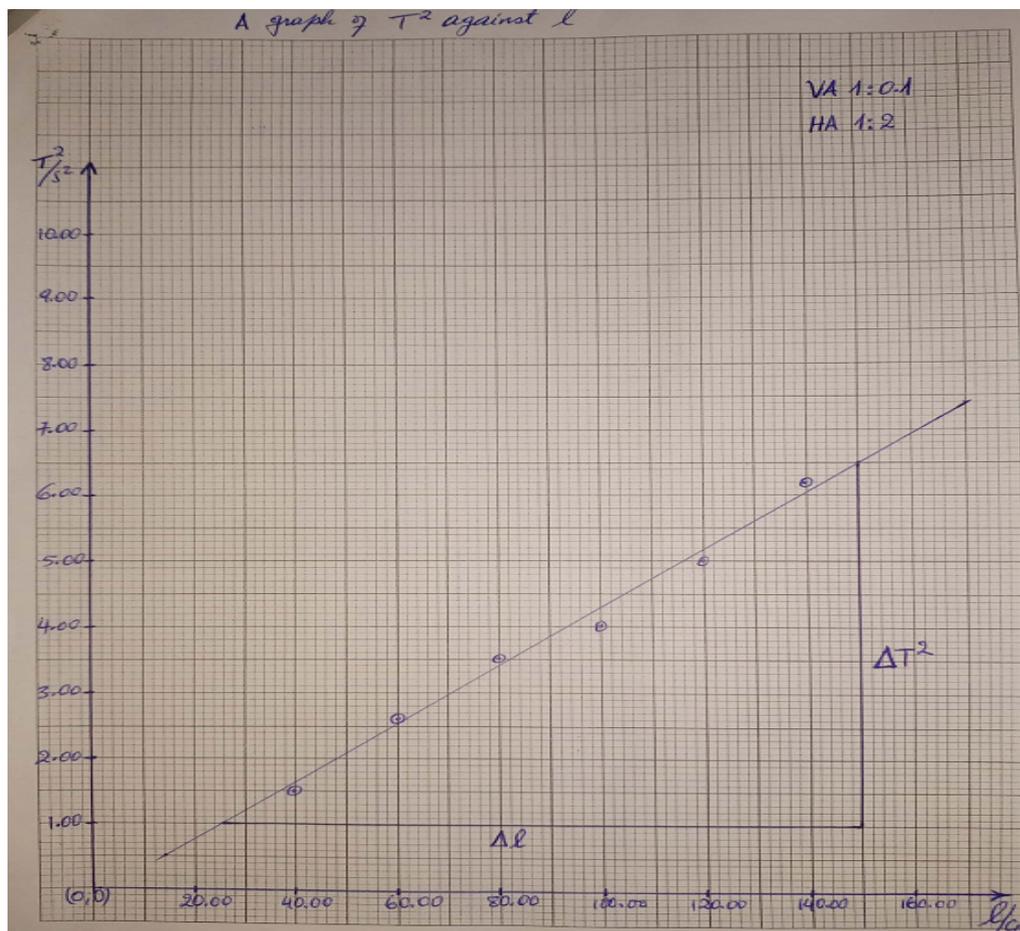
Table of results

L/cm	t/s	T/s	T ² /s ²
40.00	25.00	1.25	1.56
60.00	30.00	1.50	2.25
80.00	35.00	1.75	3.06

100.00	40.00	2.00	4.00
120.00	45.00	2.25	5.05
140.00	50.00	2.50	6.25

Where t is time for 20 oscillations

Answer to questions guiding the interpretation of results



1. Slope, $m = \frac{T_B^2 - T_A^2}{l_B - l_A} = \frac{(6.50 - 1.00) s^2}{(150.00 - 26.00) cm} = \frac{5.50 s^2}{124 cm} = 0.04 s^2/cm$
2. SI Unit of slope,

$$m = \frac{4\pi^2}{g}$$

$$g = \frac{4\pi^2}{m} = \frac{(3.14)^2 \times 4}{0.04 s^2/cm} = 985.96 cm/s^2$$

$$\text{Thus, } g = 985.96 cm/s^2 = 9.86 m/s^2$$

3. Yes, he was correct, since $T = 2\pi\sqrt{\frac{l}{g}}$, then $T \propto \sqrt{l}$. (i.e. as l increases, period T increases)
4. Air resistance affects the period T of the pendulum, by increasing.

Conclusion

As conclusion, the value of gravitational acceleration obtained in our experiment is 9.86 m/s^2 , the actual value of g is 9.81 m/s^2 . However due to errors which may be made in the experiment the value of g should vary in the range of 9.71 and 9.91 .

Note: The links of simulations, animations and videos used in this user guide were visited in november to december 2022

ANIMATED EXPERIMENT 1.1:

PRODUCTION OF SOUND WAVES IN OPEN AND CLOSED PIPES

Rationale

Through this animation, students will be able to understand the sound wave concepts, mechanism of producing a sound wave using either open or closed pipes. A sound wave is an effect physics concept as it helps in the process of daily communications and music art. It is therefore essential for physics students to understand the process of production of a sound and physical behaviors it presents when it is propagating or interacting with given media. The competency acquired from this animation will help students to understand the working principles of the existing pipe musical instruments like Saxophone, Organ pipe, Flute pipe, Trumpet, oboe, whistle, etc. and this may lead to a discovery of the new instruments that use sound waves and that are useful to humankind.

Objective

This animation gives students a better understanding of how sound waves are produced by means of pipes and how the produced sound may be useful to humankind.

Learners prediction Questions

The teacher first asks students (brainstorming or in the group) the following questions:

1. Have you ever seen a whistle used by a football referee?
2. How is it made (Its shape)?
3. How does it work?
4. How can it be compared to the flute?
5. Give any other pipe that can be used to produce a sound and explain how the sound can be produced by means of that pipe

6. In what mathematical form a sound wave is represented of a sound wave ?
7. What do you think are the daily applications of this mechanism of producing sounds by means of pipes?

Animation setup

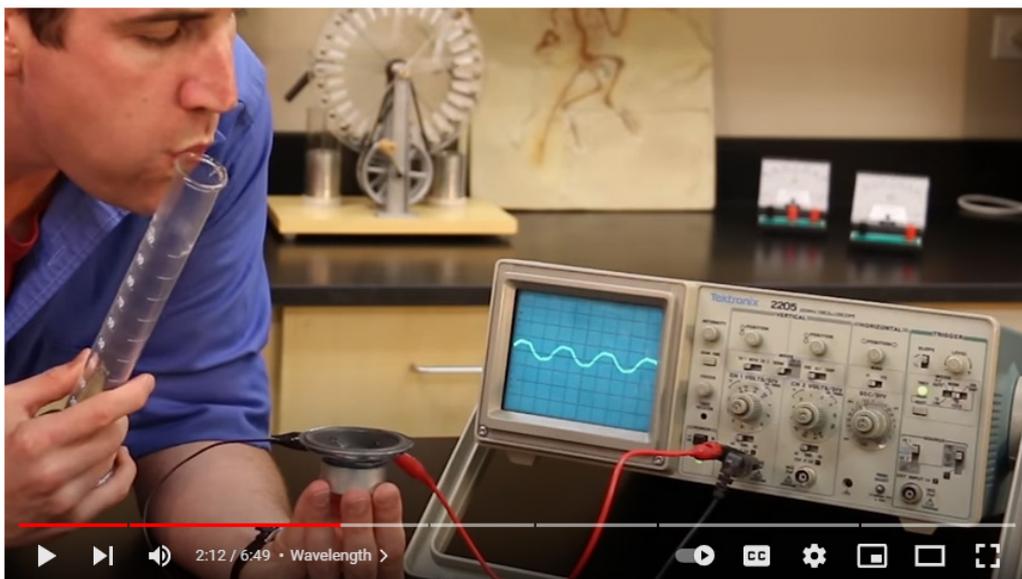


Figure 1.1. Production of sound waves

Teacher guidelines for watching animation

- Download the animation from the following link:
<https://www.youtube.com/watch?v=bHdHaYNX4Tk>, <https://www.youtube.com/watch?v=jRvy77r3Q4U>
- Save the downloaded animations on your computer (note that facilitator is required to check regularly the online updates or search for other useful animations).
- Request students to play a video, observe different features of it and write down their observations
- After watching the animation, students can brainstorm, discuss, or present what they have learned from the animation. Teacher is requested also to provide constructive feedbacks to learners' presentation and try to handle learners' alternative.
- Ask students to compare the observations to their predictions and draw a conclusion.

SIMULATED EXPERIMENT 1.2:

REFLECTION AND REFRACTION (TRANSMISSION) OF A WAVE

Rationale

Through this video, students will be able to understand reflections and refraction as waves properties, therefore will understand the effect of refractive index of the propagating medium on the speed of a wave, transmission and standing wave properties.

Objective

The purpose of this simulation is to help students to understand the reflection and refraction properties of a wave and the effect of refractive index on the speed of a wave.

Learners' prediction questions

The teacher will ask students some questions to trigger students' curiosity and motivate their insightful predictions about the simulation. Some of those questions are:

1. What happens to the wave when it reaches the boundary separating two media?
2. How does the speed change as the wave enters the second media?
3. What is the difference between reflection refraction and transmission of a wave?
4. Discuss wave properties using common vocabulary.
5. Predict the behavior of waves through varying medium and at reflective endpoints

Simulation setup

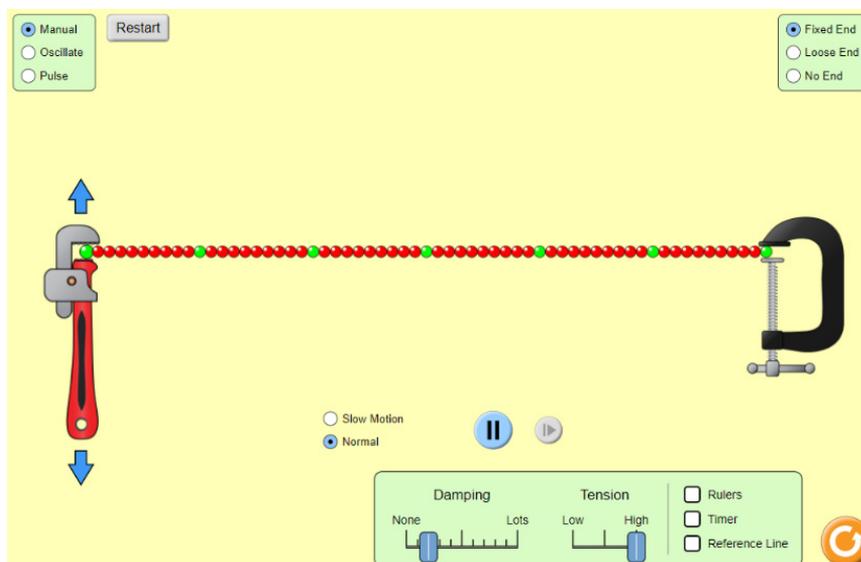


Figure 2: Reflection and refraction of sound waves

Teacher guidelines for manipulating the simulation

- Teacher will request students to download the simulation and the animation from the following link https://phet.colorado.edu/sims/html/wave-on-a-string/latest/wave-on-a-string_en.html and https://www.youtube.com/watch?v=k_YHcv8bxHI and save it on your computer (You can also use the same link if you want to work online) (note that facilitator is required to check regularly the online updates or search for other useful animations).
- Request students to run the simulation, observe different features of it and write down their observations
- After watching the simulation, the teacher asks students to brainstorm, discuss, or present what they have learned from the simulation. Teacher is requested also to provide constructive feedbacks to learners' presentation and try to handle learners' alternative.
- Ask students to compare their observations to the theory done in classroom and draw a conclusion.

SIMULATED EXPERIMENT 1.3:

INTERFERENCE OF SOUND WAVES

Rationale

Through this experiment, students will be able to understand the principle of superposition and the resulting phenomenon of interference. The competency acquired from this experiment will help students to be able to properly combine sound waves of different sources in order to get a resultant clear and reinforced sound, resonance phenomenon etc. This experiment will equip students with the competency of sound system installation in various buildings like conference halls, churches, etc.

Objective

The objective of this experiment is to study the interference pattern of sound waves, constructive and destructive interference (maxima/minima Fringers)

Learners' prediction questions

Students will predict the possible observations to be made depending on the types of changes on the simulation. Some of the questions to guide students' predictions are:

1. Discuss about interference phenomena
2. What do you think will happen if from the icon of example "Single slit" is chosen?
3. What do you think will happen if now "Double slit" is chosen?
4. What changes do we observe if the source frequency is increased?
5. Differentiate constructive and destructive interference

Simulation setup

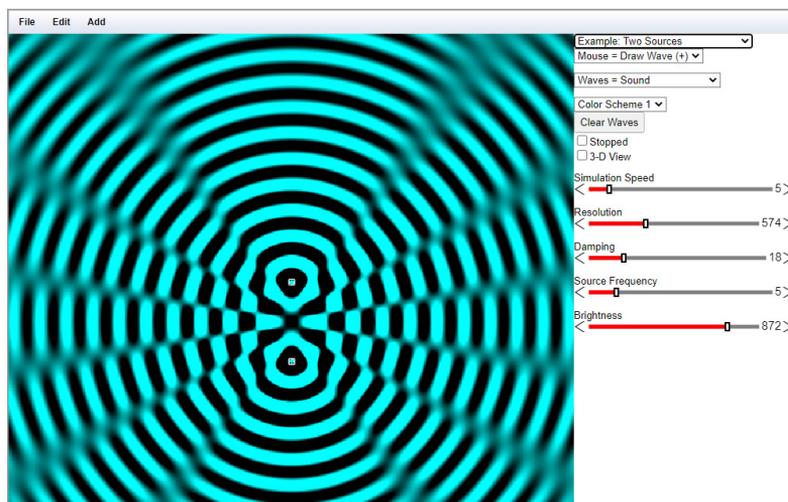


Figure 1.3 Interference of sound waves

Teacher guidelines for manipulating the simulation

- Download the simulation from the following link: <http://www.falstad.com/ripple/> and save it on your computer_(You can also use the same link if you want to work online)
- Request students to run the simulation, observe different features of it and write down their observations
- Open the simulation and choose “Example: single slit” and “wave = Sound”.
- Write down the description of what you seen on the simulation.
- Now, change and choose “Example: double slit” and keep (wave = Sound”.
- Describe what now is observed from the simulation.
- Compare the observations made form single slit to those made from double slit.
- Keep changing other parameters on the simulation like simulation speed, Resolution, Damping, Source Frequency, Brightness, Color scheme, etc. and for any change made, record the new observations.
- After running the simulation, students can brainstorm, discuss, or present what they have learned from the animation. Teacher is requested also to provide constructive feedbacks to learners’ presentation and try to handle learners’ alternative.
- Students can compare their observations to the prediction done and draw a conclusion.

SIMULATED EXPERIMENT 1.4:

PRINCIPLE OF SUPERPOSITION OF SOUND WAVES

Rationale

This principle of superposition helps students to understand the interference (constructive and destructive) as a wave property of a sound.

Objective

This simulation aims to demonstrate the superposition principle of sound waves, interference concepts such as constructive and destructive interference.

Learners' prediction questions

1. Students will predict the possible observations to be made depending on the types of changes on the simulation. Some of the questions to guide students' predictions are:
2. What do you think will happen on the simulation if two opposite signals are produced?
3. What do you think will happen on the simulation if two signals of same direction are produced?
4. How may you compare the resultant amplitudes of the produced signal in case of overlap of signals in opposite directions and overlap of signals in same direction?
5. What represent the maxima and minima of the resulting wave?
6. Any formula for constructive and destructive interference?

Simulation setup

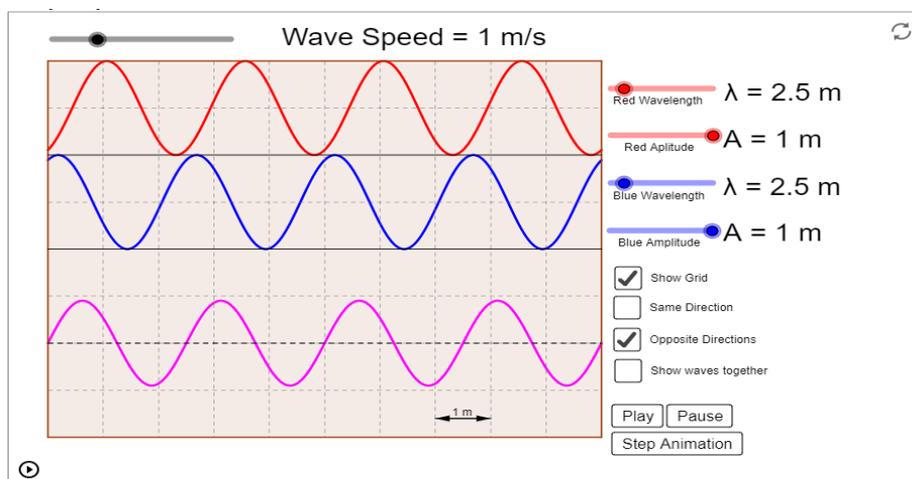


Figure 1.4. Principle of superposition of sound waves

Teacher guideline to manipulate the simulation

- Download the simulation from the following link: <https://ophysics.com/w3.html> and save it on your computer (You can also use the same link if you want to work online)
- Request students to run the simulation, observe different features of it and write down their observations
- This is a simulation of the superposition of two waves travelling in either opposite directions or same direction in the same medium.
- The magenta (signal in the lower end of the screen of the simulation) wave at the bottom is the sum of the red and blue waves.
- Use the sliders to adjust the wave speed, the amplitude of each wave, and the wavelength of each wave.
- Step through the animation with the simulation button or press the simulation button in the lower left corner to run the simulation.
- Use the check boxes to show or hide the grid, as well as change the direction of the red wave.
- After running the simulation, students can brainstorm, discuss, or present what they have learned from the animation. Teacher is requested also to provide constructive feedbacks to learners' presentation and try to handle learners' alternative.
- Students can compare the observations to their predictions and draw a conclusion.

SIMULATED EXPERIMENT 1.5:

PROPERTIES OF SOUND WAVES

Rationale

In this simulation you will learn the propagation of sound waves and their main properties. Sound waves require a material medium for their propagation. Since it is only vacuum in the space between earth and the other planets, the sound produced during an explosion cannot be heard from the earth. One of application of sound waves is in medicine and is called ultrasound medical imagining. It essentially uses sound propagation to create a two dimensional black-and-white image of organs and various parts of our body. It helps to detect various defects (tumors, etc) and helps to understand the way that our body functions.

Objective

The purpose of this simulation is to help you to understand different physical phenomenor related to sound waves (Propagation of sound wave, diffraction, interference and double slits).

Learners' prediction questions

The teacher will ask students some questions to trigger students' curiosity and motivate their insightful predictions about the simulation. Some of those questions are:

1. What factors that affect the sound diffraction?
2. What are the types of interference?
3. Can sound waves diffract and interfere?
4. What is diffraction use for?
5. Why does diffraction occur in sound waves?
6. How do wave effects depend on the size of the object with which the wave interacts? For example, why does sound bend around the corner of a building while light does not?
7. In a single slit diffraction experiment, the width of the slit is made double the original width. How does this affect the size and intensity of the central diffraction band?

8. In what way is diffraction from each slit related to the interference pattern in a double-slit experiment?

Simulation setup

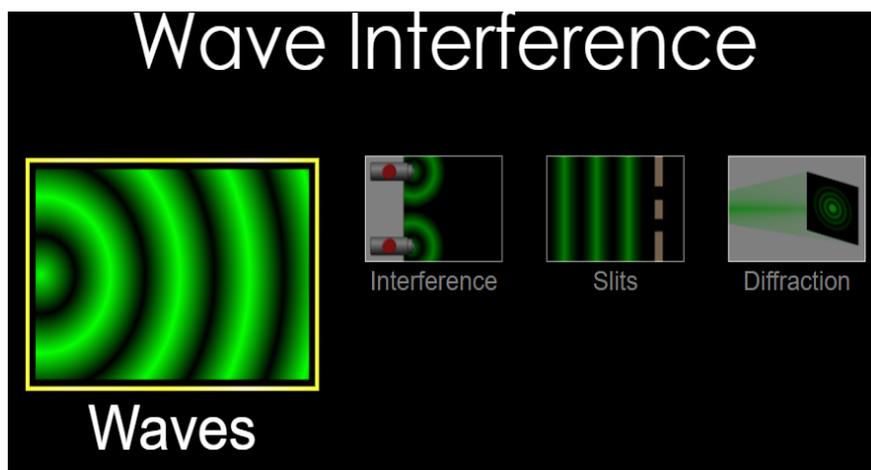


Figure: Properties of sound waves

Teacher guidelines for manipulating the animation

- Download the simulation from the following link: https://phet.colorado.edu/sims/html/wave-interference/latest/wave-interference_en.html and save it on your computer (You can also use the same link if you want to work online)
- Request students to run the simulation, observe different features of it and write down their observations
- Open simulation in waves mode and Use sound generator to explore the propagation of sound waves.
- Click on interference to explore the interference phenomenon for sound wave
- Click on diffraction to run simulation which show diffraction phenomena of sound waves
- Click on Slits to run simulation for single and double slits experiment
- While opening each part of simulation change you can change either amplitude or frequency and note your observations
- Use oscilloscope tool to observe graph of pressure against time and write your observations

- After manipulating the animation, student can brainstorm, discuss, or present what they have learned from the animation. Teacher is requested also to provide constructive feedbacks to learners' presentation and try to handle learners' alternative.
- Students can compare the observations to their predictions and draw a conclusion.

EXPERIMENT 1.6: MELDE'S EXPERIMENT ON VARIATION OF FREQUENCY

Rationale

Through this experiment, students will be equipped with the understanding of the factors affecting the frequency of a sound wave produced by a vibrating string. The competency acquired from this experiment will help students to understand the working principle of musical instrument like guitar, flute, violin, etc.

Objective

The objective of this experiment is to investigate the frequency of standing waves on a stretched elastic string.



Materials

- Frictionless pulley,
- string,
- blocks of known masses,
- Mechanical oscillator (turning fork),
- signal generator,
- electronic balance,
- scale pan and connecting wires.

Experiment setup

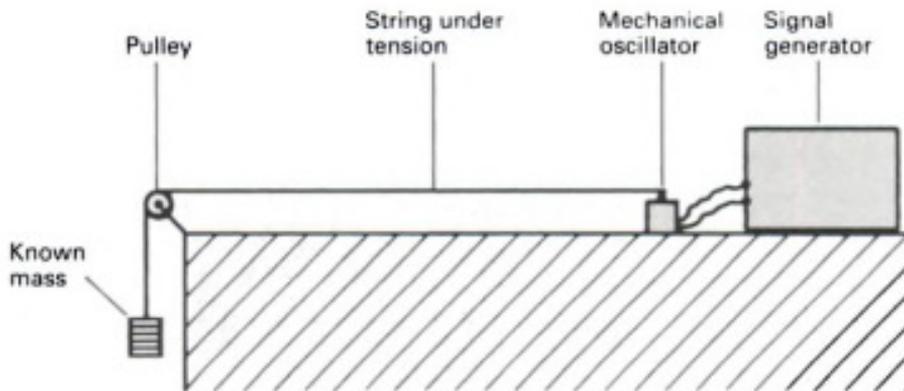


Figure (1.6): Experimental setup of Melde's experiment

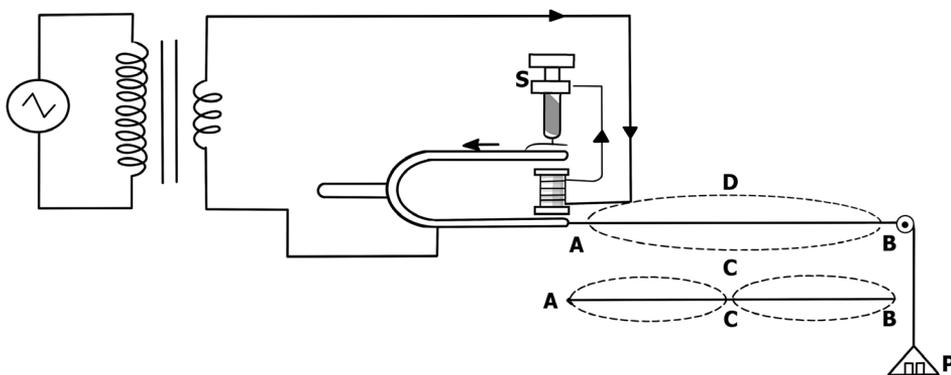


Figure (1.7): Arrangement for transverse mode of vibration

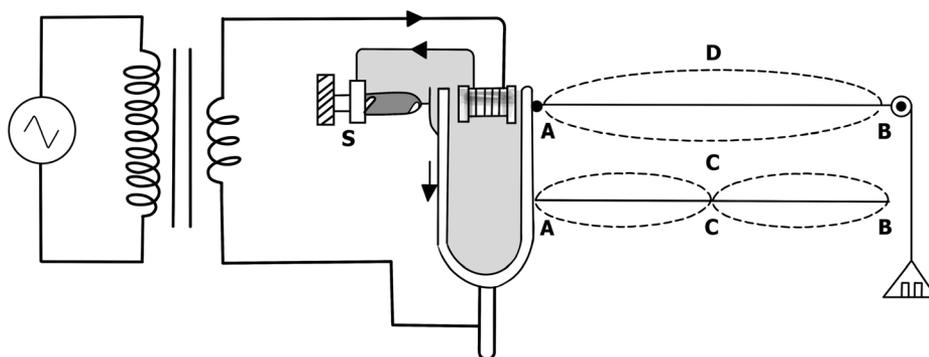


Figure (1.8): Arrangement for longitudinal mode of vibration



Procedures

1. Connect the signal generator (step down transformer) to A.C mains.
2. Connect the mechanical oscillator (turning fork) to the signal generator.
3. Tight the one end of string to the prong of tuning fork and other end to a scale pan. Hang the scale pan with pulley that is fixed at end of table.
4. Arrange the electrically maintained tuning fork in transverse situation (Fig.b) (i.e. arrange in such a way that length of string is parallel to the prong of tuning fork) and load a mass of 5grams on its pan. Now rotate the screw S (i.e. excite the tuning fork), so that vibration in tuning fork gets started.
5. Move the tuning fork toward or away from pulley to adjust the length of thread, so that loops could be formed. Now measure the length thread for one and two loop when stable loops are formed in horizontal plane. This will give the value for one and two loops.
6. Now increase the mass on scale pan ($m = 10, 20$ grams) and repeat the step 4.
7. After it arrange the electrically maintained tuning fork in longitudinal situation (Fig. c) (i.e. arrange in such a way that length of string is perpendicular to the prong of tuning fork) and load a mass of 5grams on its pan. Excite the tuning fork, so that vibrations get started in tuning fork.
8. Move the tuning fork toward or away from pulley to adjust the length of thread, so that loops could be formed. Now measure the length thread for one and two loop when stable loops are formed in transverse plane. This will give the value for one and two loops. The observed length should come double length of transverse case.
9. Now increase the mass on scale pan ($m = 10, 20$ grams) and repeat the step 7 for this arrangement.

10. Find out length of thread per loop $\frac{l}{p}$ for each case of load.
11. Measure the mass of 10m length of thread and mass of scale pan m_p . Value of $\frac{m_r}{10}$ gives mass per unit length of thread expressed as μ .
12. Calculate the frequency of tuning fork for transverse and longitudinal case using M, m and $\frac{l}{p}$.
13. Record your observations in the appropriate table
14. Mass per unit length of thread $m = \dots\dots\dots gm / cm$
15. Calculate the frequency for each mass and mode of vibration using expressions (1) and (2) as given below. Take mean of frequencies of both longitudinal and transverse case.

Calculations

The frequency of electrically maintained tuning fork in longitudinal mode of

vibration is determined by following formula: $f = \frac{p}{l} \sqrt{\frac{T}{\mu}}$

The frequency of electrically maintained tuning fork in transverse mode of vibration

is determined by following formula: $f = \frac{p}{2l} \sqrt{\frac{T}{\mu}}$

Where l loop length of the thread, $T = Mg$ tension applied to the wire, M total mass loaded on thread, μ mass per unit length of the thread

Questions to guide interpretation of results

1. How does the frequency of the sound change when the length of the string increases? How does it change when the length of the string decreases?
2. How does the frequency of the sound change when the tension in the string increases? How does it change when the tension in the string decrease?
3. Calculate the frequency of electrically maintained tuning fork in transverse arrangement =Hz
4. Calculate the frequency of electrically maintained tuning fork in longitudinal arrangement =Hz
5. Calculate the mean frequency of electrically maintained tuning fork =Hz

SIMULATED EXPERIMENT 1.7:

DEMONSTRATION OF THE VARIATION OF FREQUENCY BY DOPPLER EFFECT

Rationale

Through this simulation, you will understand the variation of the sound frequency as function of either source's velocity or observer's velocity. Basing on the observed variations in sound frequency, students will be able to verify the validity of the formula for Doppler effect when there is a relative motion between the source of sound and the observer.

Objective

Through this simulation, students will be able to verify the formula for Doppler effect.

Learners' prediction questions

Students will predict the possible observations to be made depending on the types of changes on the simulation. Some of the questions to guide students' predictions are:

1. What happens to the value of detected frequency when you change the velocity of either the source or the observer?
2. How does Doppler effect affect frequency?
3. Does Doppler effect change frequency or wavelength?
4. Can Doppler effect change the frequency of a wave?
5. What is Doppler effect formula for frequency?

Simulation setup

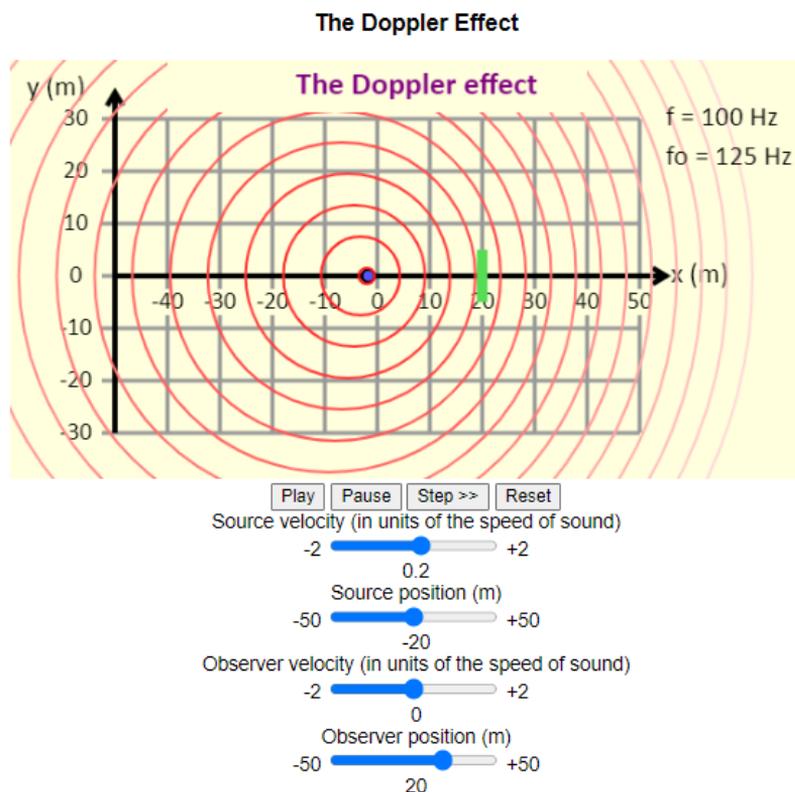


Figure 1.9: The variation of frequency by doppler effect

Teacher guidelines for manipulating the simulation

- Download the simulation from the following link: <http://physics.bu.edu/~duffy/HTML5/doppler.html> and save it on your computer (You can also use the same link if you want to work online)
- Alternatively, the following link can be used: <https://ophysics.com/w11.html> Request students to run the simulation, observe different features of it and write down their observations
- This is a simulation of the Doppler effect. You can set both the initial position and the velocity of the source (the small blue dot). and the initial position and the velocity of the observer (green rectangle), and then see the pattern of waves emitted by the source as the waves wash over the observer. The source emits a frequency of 100 Hz when the source is at rest. represents the observed frequency (the one heard by the observer).

- As you change the velocities, record their values and the values for resulting frequencies and calculate the frequency heard by the observer using the formula for Doppler effect
- After perform all steps of the simulation, students can brainstorm, discuss, or present what they have learned from the simulation. Teacher is requested also to provide constructive feedbacks to learners' presentation and try to handle learners' alternative.
- Students can compare the observations to their predictions and draw a conclusion.

EXPERIMENT 2.1:

DETERMINATION OF FACTORS OF THE PLANETS' ALBEDO [RADIATION AND ALBEDO EXPERIMENT]

Rationale

Different surfaces of the Earth reflect and absorb heat differently. Albedo is the ability to reflect sunlight out into outer space. Ice and snow, deserts, clouds, aerosols (particles in the air) all reflect sunlight. The higher albedo, the more solar energy reflected; the colder. When it is getting colder, ice cover expands, thus also increasing the albedo. Albedo affects climate by determining how much radiation a planet absorbs. The uneven heating of Earth from albedo variations between land, ice, or ocean surfaces can drive weather.

Objective

In this experiment, you will understand that the physical characteristics of the Earth's surface affect the way that surface absorbs and releases heat from the Sun.



Materials

- three pie pans or dishes
- dark potting soil
- light-colored sand or perlite
- water
- three thermometers
- reflector lamp within can descent light bulb
- watch with a secondhand



Procedures

1. This activity can be done as a class demonstration or in groups of 3-4 students. If you are doing it as a demonstration, you will need one set of materials, graph paper, and data tables for each student. Each group will need supplies if the activity is done in small groups.
2. Check the light bulbs to ensure they generate heat. Use incandescent light bulbs instead of LED or CFL bulbs.
3. Help students think about what they already know about how the color and type of material affect how hot it gets in the sunshine. For example, ask students, “When it is a hot day, what color shirt would you wear to keep cool and why? And “During the summer, what would it feel like to walk on asphalt or gravel with no shoes?”
4. Explain that, in this activity, they will explore how different types of surfaces found at the Earth’s surface (such as sand, soil, and water) heat up when the Sun’s energy reaches them and how they cool down when out of the sunshine.
5. Note that this experiment uses materials to model sunshine and Earth materials. Show students the materials and explain how each relates to the Earth system. (The lamp represents the Sun in this model. The sand represents beaches, sand dunes, and rocks. The potting soil represents large areas of soil outdoors. And the water represents lakes, rivers, and the ocean.)
6. Fill the pie pans to the same level, one with dark soil, one with light sand, and one with water. (If small groups are doing this activity on their own, distribute supplies to students.)
7. Place the pie pans on a table or desk and position the lamp about 12 inches above them. (Do not turn on the lamp yet.)
8. The lamp shines over three dishes with thermometers in them. The dishes contain water, light soil, and dark soil.

9. Place a thermometer into each pie pan, with the bulb just under the surface of the substance (soil, sand, or water) in the pan.
10. Provide students with data tables and explain how the tables relate to the experimental design.
11. Have students record the temperature right before they turn on the lamp (Time=0), entering the number into their data table.
12. Turn on the lamp and instruct students to record the temperature every minute in the three pie pans for ten minutes.
13. After ten minutes, turn the lamp off and instruct students to continue recording temperatures every minute for ten minutes.
14. Have students graph the temperature data using graph paper and colored pencils. Have students write a caption for their graph that describes how the three different materials change in temperature over time.
15. If several groups experimented simultaneously, have groups compare their graphs as they discuss findings.

Experiment setup

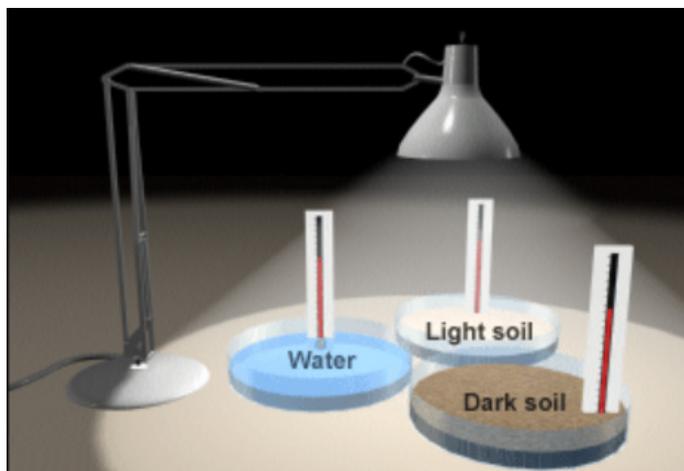


Figure 2.1: Factors of the planets' albedo

Questions to guide interpretation of results

- a. Which material absorbed more heat in the first ten minutes?
- b. Which material lost the most heat in the last ten minutes?
- c. Imagine that it's summer and the Sun is shining on the ocean and a stretch of land. Which will heat up more during the day?
- d. Which will cool more slowly at night? Explain.
- e. Imagine three cities in the desert, all at about the same altitude and latitude. Which city would likely have the highest average summer air temperature and why?
- f. A dark-colored rocky surface surrounds one city (A).
- g. A light-colored sandy surface surrounds another city (B).
- h. The third city (C) is built on the edge of a large man-made desert lake.
- i. The Earth's surface tends to lose heat in winter. Which of the above cities would have the warmest average winter temperature? Why?
- j. Since the Sun is approximately 93 million miles from the Earth and space has no temperature, how do we get heat from the Sun?

SIMULATED EXPERIMENT 2.2:

GREENHOUSE EFFECT

Rationale

In our daily real life, we face climate change caused by different natural and human activities. One effect is a greenhouse. It is a process that occurs when gases in Earth's atmosphere trap the Sun's heat

Objective

This simulation makes students understand the effect of greenhouse

Learners' prediction questions

Teacher will ask students the following questions and ask them to record their opinions before manipulating the simulation.

1. Did you ever heard about the greenhouse effect? What is it?
2. How do we protect it?

3. What is greenhouse used for?
4. What are the 4 types of greenhouse?
5. Why greenhouse effect is called greenhouse?

Simulation setup

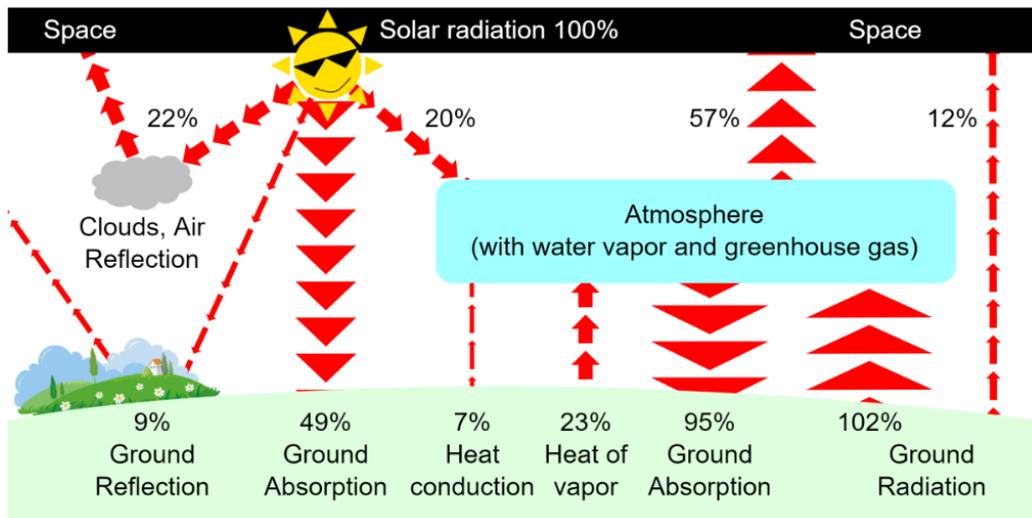


Figure2.2: Greenhouse

Teacher guidelines to manipulate simulation

- Download the simulation from the following link: https://javalab.org/en/equilibrium_of_radiation_en/ and save it on your computer (You can also use the same link if you want to work online). (note that facilitator is required to check regularly the online updates or search for other useful animations).
- Request students to run the animation, observe different features of it and write down their observations
- After watching the animation, students can brainstorm, discuss, or present what they have learned from the animation. Teacher is requested also to provide constructive feedbacks to learners' presentation and try to handle learners' alternative.
- Students can compare the observations to their predictions and draw a conclusion.

SIMULATED EXPERIMENT 2.3:

BLACK BODY RADIATION

Rationale

In this simulation you will learn the concept of blackbody radiation which is refers to the spectrum of light emitted by any heated object; common examples include the heating element of a toaster and the filament of a light bulb. The blackbodies are used for lighting, heating, security, thermal imaging, as well as testing and measurement applications.

Objective

This simulation allows students to observe the changes of radiations (both ultraviolet, visible, and infrareds spectra) of different light emitters due to temperature.

Learners' predication questions

1. What is blackbody radiation and how is it used?
2. Describe what happens to the blackbody spectrum as you increase or decrease the temperature. What happens to the shape of the curve and the peak of this curve?
3. Describe the blackbody spectrum of a light bulb. Why do light bulbs get hot? Do they seem efficient?
4. Imagine that you see 2 hot, glowing objects--one is glowing orange and the other is glowing blue. Which one is hotter?
5. Find the relationship between the temperature and the wavelength at the peak of the curve.
6. How will the intensity be if we take the temperature to the Earth?
7. Why do light bulbs get hot? Do they seem efficient?

Simulation setup

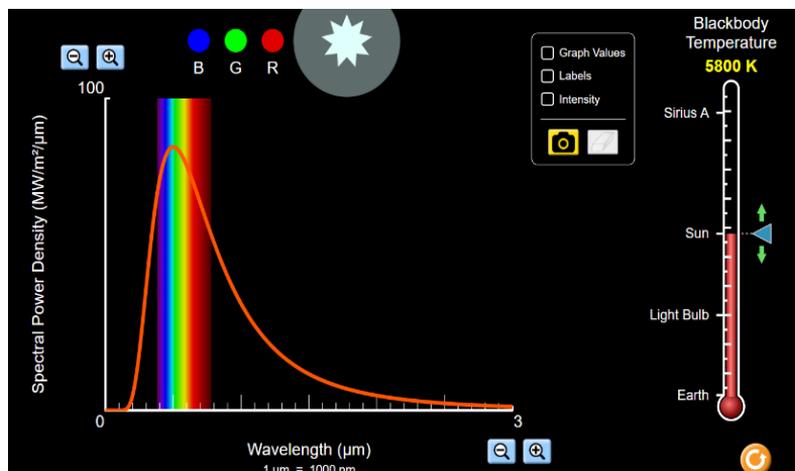


Figure 2.3: Blackbody radiation

Teacher guidelines to manipulate simulation

- Download the simulation from the following link: <https://phet.colorado.edu/en/simulations/blackbody-spectrum> and save it on your computer (You can also use the same link if you want to work online)
- Request students to run the simulation, observe different features of it and write down their observations
- When you open the simulation, you can see two sides. The right side comprises manipulation functions, while the left is reserved for observation.
- Change the temperature of a blackbody of different light emitters such as Earth, light bulbs, and Sun.
- Activate the intensity, labels, and graph values, then observe the changes on the left side.
- Magnify and reset the manipulation using buttons below these left and right outlets.
- After watching the animation, students can brainstorm, discuss, or present what they have learned from the animation. Teacher is requested also to provide constructive feedbacks to learners' presentation and try to handle learners' alternative.
- Students can compare the observations to their predictions and draw a conclusion.

ANIMATED EXPERIMENT 2.4:

CLIMATE CHANGE

Rationale

In our daily real life, we face climate change caused by different natural and human activities. Human kind needs decisive solution to keep the environment we are living in. Its most negative effect is the global warming.

Objective

This animation makes students understand the climate change and its mitigation

Learners' prediction Questions

The teacher first asks students (brainstorming or in the group) the following questions:

1. What do you feel when you hear about climate change?
2. What are the advantages and disadvantages of climate change?
3. Why are people hesitant to mitigate climate change?

Animation setup



Figure 2.4: the global warming.

Teacher guidelines for watching animation

- Download the animation from the following link: https://youtu.be/-D_Np-3dVBQ and save it on your computer(You can also use the same link if you want to work online). (note that facilitator is required to check regularly the online updates or search for other useful animations).
- Request students to run the animation, observe different features of it and write down their observations
- After watching the animation, students can brainstorm, discuss, or present what they have learned from the animation. Teacher is requested also to provide constructive feedbacks to learners' presentation and try to handle learners' alternative.
- Students can compare the observations their predictions and draw a conclusion.

ANIMATED EXPERIMENT 3.1:

MECHANICAL WEATHERING (FREEZING OF ROCKS)

Rationale

In this animation you will learn the Mechanical weathering which is the set of weathering processes that break apart rocks into particles (sediment) through physical processes. It is caused when any of the following factors act physically on a rock to break it down: water, ice, salt/mineral crystals, the release of pressure, extreme temperatures, wind, and even the actions of plants and animals.

Objective

This animation makes students understand the mechanical weathering (Freezing of rocks)

Learners' prediction questions

The teacher first asks students (brainstorming or in the group) the following questions:

1. Discuss examples of mechanical weathering
2. Have you ever seen where rocks are freezed?
3. What is Mechanical Weathering and What Causes It?
4. How does weathering cause the freezing of rocks?

Animation setup

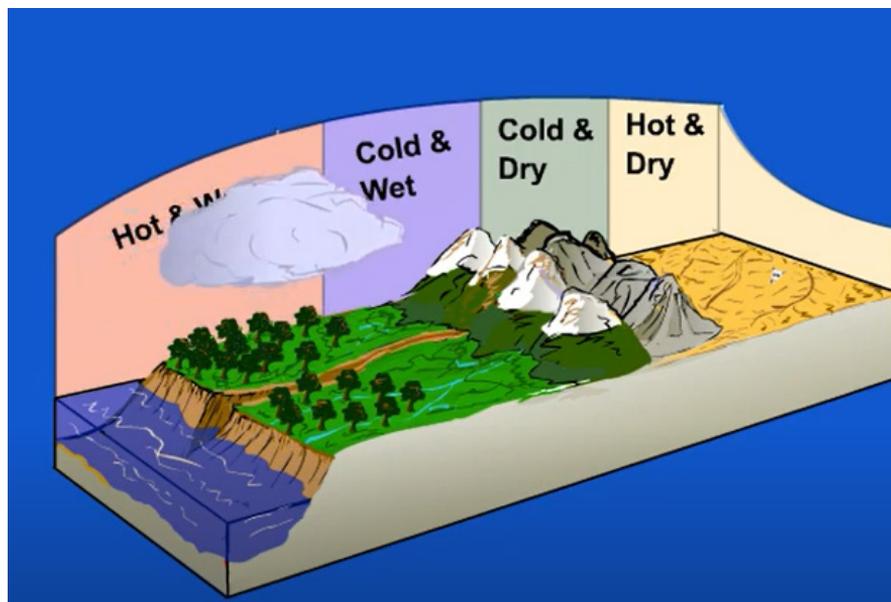


Figure 3.1: Freezing of rocks

Teacher guidelines for watching animation

- Download the animation from the following link: <https://youtu.be/YJJK9x1Ffhw> and save it on your computer (You can also use the same link if you want to work online). (note that facilitator is required to check regularly the online updates or search for other useful animations).
- Request students to run the animation, observe different features of it and write down their observations
- After watching the animation, students can brainstorm, discuss, or present what they have learned from the animation. Teacher is requested also to provide constructive feedbacks to learners' presentation and try to handle learners' alternative.
- Students can compare the observations their predictions and draw a conclusion.

Rationale

The water cycle, also known as the hydrologic cycle or the hydrological cycle, describes the continuous movement of water on, above and below the surface of the Earth. In the water cycle, when the warm, moist air rises in the atmosphere, it then cools transforming back into a liquid to form little water droplets. These little water droplets condense on small particles in the air such as dust or pollen forming clouds. The water cycle has a tremendous impact on the climate. For instance, the greenhouse effect will cause a rise in temperature. Without the evaporative cooling effect of the water cycle, the temperature on earth would rise drastically. During the water cycle process of precipitation, water vapours have to attach themselves on to particles of dust.

Objective

This animation makes students understand the water cycle process and its implications

Learners' prediction Questions

The teacher first asks students (brainstorming or in the group) the following questions:

1. What forces are involved in the water cycle?
2. What is the main force or energy that drives the water cycle?
3. What does the water cycle show?
4. Discuss the water cycle steps and its implications
5. Explore the implications of the water cycle on the environment
6. What process occurs when water changes from a gas to a liquid?

Animation setup



Figure 3.2: water cycle

Teacher guidelines for watching animation

- Download the simulation from the following link: <https://youtu.be/al-do-HGulk> and save it on your computer (You can also use the same link if you want to work online). (note that facilitator is required to check regularly the online updates or search for other useful animations).
- Request students to run the animation, observe different features of it and write down their observations
- After watching the animation, students can brainstorm, discuss, or present what they have learned from the animation. Teacher is requested also to provide constructive feedbacks to learners' presentation and try to handle learners' alternative.
- Students can compare the observations their predictions and draw a conclusion.

ANIMATED EXPERIMENT 4.1:

EARTHQUAKES, TSUNAMI, FLOOD, LANDSLIDES AND CYCLONES, AND THEIR MITIGATION

Rationale

Earthquake, tsunami, flood, landslides, and cyclones are different but interrelated natural phenomena that suddenly cause harm to humans and property. Its consequences can be remediated by humankind when he/she possesses effective and relevant knowledge. Thus, it is important to understand how these happen and in which circumstances they occur.

Objective

This animation gives students the best understanding of how earthquakes happen and how to mitigate them.

Questions to guide interpretation of results

The teacher first asks students (brainstorming or in the group) the following questions:

1. Have you ever heard about earthquakes, tsunami, flood, landslides, and cyclones?
2. What are they, and what are the causes?
3. What are the effects, and how to prevent their consequences?

Animation setup

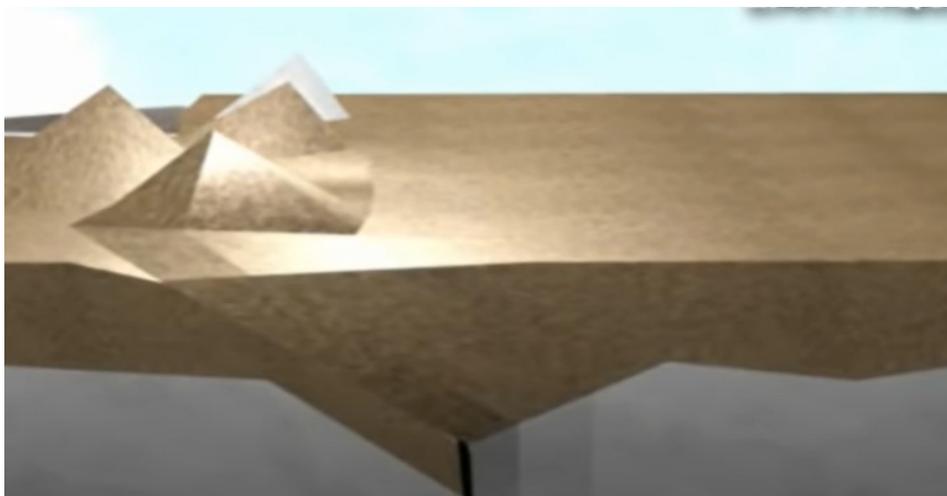


Figure 4.3 : animation for an earthquake

Teacher guidelines for watching animation

- Download the animations from the links indicated bellow and save it on your computer(You can also use the same link if you want to work online) (note that facilitator is required to check regularly the online updates or search for other useful animations).
- Link to animation for an earthquake: <https://youtu.be/T0AetX-uPLA>
- Link to animation for tsunami: <https://youtu.be/SlwZzbGh7Cw>
- Link to video for flood and landslide: <https://youtu.be/-NimBwYcUp4>
- Link to animation for the cyclone: <https://youtu.be/coBJtwccRwU>
- Request students to run the animation, observe different features of it and write down their observations
- After watching the animation, students can brainstorm, discuss, or present what they have learned from the animation.
- Teacher is requested also to provide constructive feedbacks to learners' presentation and try to handle learners' alternative.
- Students can compare the observations their predictions and draw a conclusion.

**SIMULATED
EXPERIMENT 5.1:****NUCLEAR FISSION****Rationale**

In nuclear fission, atoms are split apart and they release energy. All nuclear power plants use nuclear fission, and most nuclear power plants use uranium atoms. Controlled nuclear fission causes the release of a large amount of energy in the form of heat and radiation that operate the nuclear reactor during transformation of nuclear energy to electricity. This simulation intends to help students to understand and get acquainted with competencies required in the practical applications of nuclear fission such as transformation of nuclear energy to electricity by means of nuclear reactors and working principle of some of nuclear weapons.

Objective

This simulation allows students to understand the process of nuclear fission.

Learners' prediction questions

1. What will happen if we run the simulation for small number of Uranium-235 nuclei?
2. What will happen if we run the simulation for big population of Uranium-235 nuclei?
3. For which case the fission releases large number of neutrons? For small or big population of Uranium-235.

Simulation setup

The simulation interface will look like the one given on the picture below:

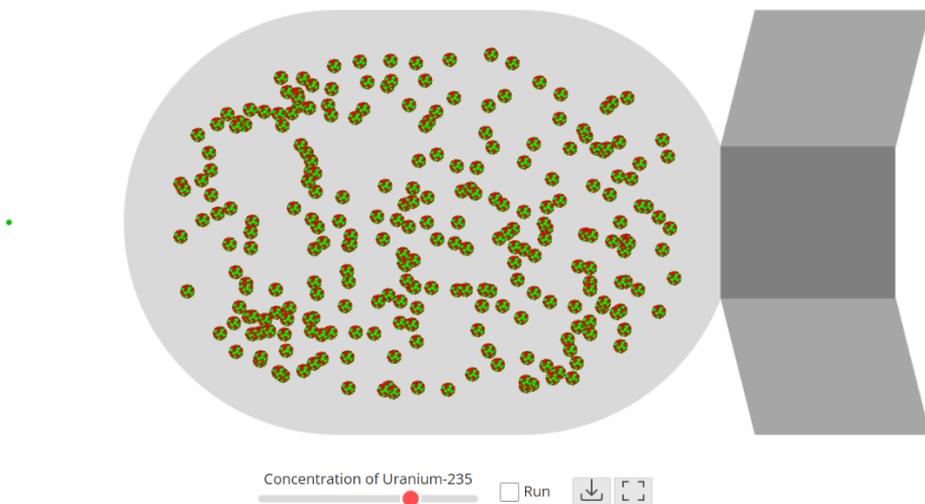


Figure 5.1. Nuclear fission. Source : https://javalab.org/en/nuclear_chain_reaction_en/

Teacher guidelines for manipulating the simulation

- Download the simulation from the links https://javalab.org/en/nuclear_chain_reaction_en/ and save it on your computer (You can also use the same link if you want to work online).
- To open the simulation, copy the link indicated above and paste it in google. From an opened interface of JAVALAB click on “ATOMES” and scroll down to select “RADIOACTIVITY”. From “RADIOACTIVITY” select “nuclear chain reaction.” At this stage, an interface similar to the one shown on the picture above will display.
- Observe the features of the simulation and record a description of what you observe.
- Explain the role of those physical features observed from the simulation.
- By clicking on the “Run” button, observe and record what you see.
- Vary the concentration of Uranium-235. How does the intensity (number of emitted photons) change when the concentration of Uranium-235 is increased? How does it change when the concentration is decreased?
- Students will compare the recorded observations and answers to the predictions they have made before manipulating the simulation. After comparison, students will present their findings in front of their classmates.

- In their groups, students will make a summary of their findings and highlight the governing physics theory behind the simulation. In case of some missing relevant ideas, classmates and /or teacher will contribute in order to let all students achieve comprehensive intended learning objectives.

SIMULATED EXPERIMENT 5.2:

HALF LIFE PERIOD OF A RADIOACTIVE SUBSTANCE

Rationale

Since radioactive decay proceeds at a constant rate irrespective of external conditions, we can measure the samples' age by carbon-14 dating, carry out earth sciences analysis by radiometric dating techniques, study environmental impact (water and air pollution), perform medical analysis (cardiac output, plasma volume and fat metabolism) and use them for industrial applications such as cross-linking of polymers, induction of mutation in plants, killing microorganisms, etc. This simulation will help students to analyze and understand basing properties of radioactive elements and will serve as a prerequisite to understanding some of the practical applications of the resulting decays as highlighted above.

Objective

This simulation allows students to understand the radioactive decay process and half-life period of a radioactive substance.

learners' predication questions

1. What will happen to the number of atoms in the sample of radioactive element if we run the first trial (first click on "**Radioactive decay button**")?
2. What will happen to the number of atoms in the sample if we run the second trial (second click on "**Radioactive decay button**")?
3. What will happen at the number of atoms in the sample if we run the third trial (third click on "**Radioactive decay button**")?
4. At which trial (Click), the sample will remain with only one atom?
5. What is the relationship between the number of remained radioactive atoms with change in time?

- Predict how the graph of radioactive atoms against time looks like.
- Teacher will ask students to record their predicted ideas in the notebook for further references.

Simulation setup

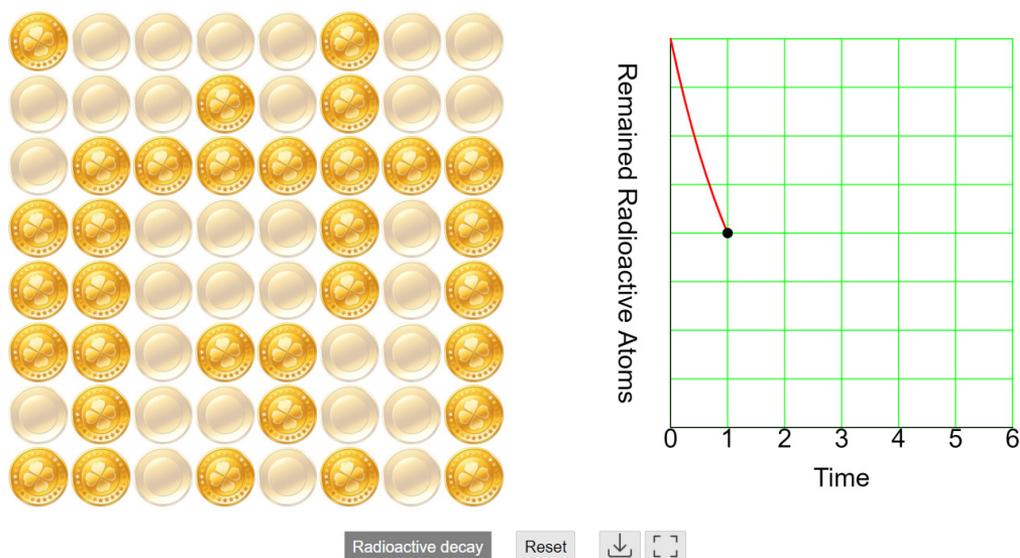


Figure 5.2: The radioactive decay process. Source: https://javalab.org/en/half_life_period_en/

Teacher guidelines for manipulating the simulation

- Download the simulation from the following link https://javalab.org/en/half_life_period_en/ and save it on your computer (You can also use the same link if you want to work online).
- Open the simulation and observe it before manipulating. Record your observations relating to the simulation features.
- Click on the “**radioactive decay**” button and record what happens to the number of the atoms of the sample. Record also the changes indicated by the “Remained radioactive atoms against time” graph.
- With a second click on the “**radioactive decay**”, observe and record the changes on both the number of atoms of the sample and on the graph.
- With a third click, on the “**radioactive decay**”, observe and record the changes on both the number of atoms of the sample and on the graph.

- Click on “Reset” button and then on “Radioactive decay” button to repeat the process and keep recording any additional observation from the simulation.
- How may you describe the “Remained radioactive atoms against time” graph? To which mathematical function can it be assimilated?
- Students will compare the recorded observations and answers to the predictions they have made before manipulating the simulation. After comparison, students will present their findings in front of their classmates.
- In their groups, students will make a summary of their findings and highlight the governing physics theory behind the simulation. In case of some missing relevant ideas, classmates and /or teacher will contribute in order to let all students achieve comprehensive intended learning objectives.

SIMULATED EXPERIMENT 6.1:

TOTAL INTERNAL REFLECTION OF LIGHT

Rationale

Total internal reflection takes place within the fibers and some other optical instruments, no incident energy is ever lost due to the transmission of light across the boundary. The intensity of the signal remains constant. From this simulation, students will be equipped with the understanding of what a total internal reflection is and its practical applications in the field of optics (such as in periscope and telescope) and telecommunication (in optical fibers).

Objective

After manipulating this simulation, students will be able to practically understand and explain the phenomenon of total Internal reflection of light.

learners' predication questions

1. What is a total internal reflection of light?
2. What are conditions to realize total internal reflection of light?
3. Does the change in wavelength (colour) of the source affect the angle of refraction?
4. What do you think will be the effect of changing the surrounding medium on the total internal reflection?
5. Record your answers to above questions in the notebook for further reference.

Simulation setup

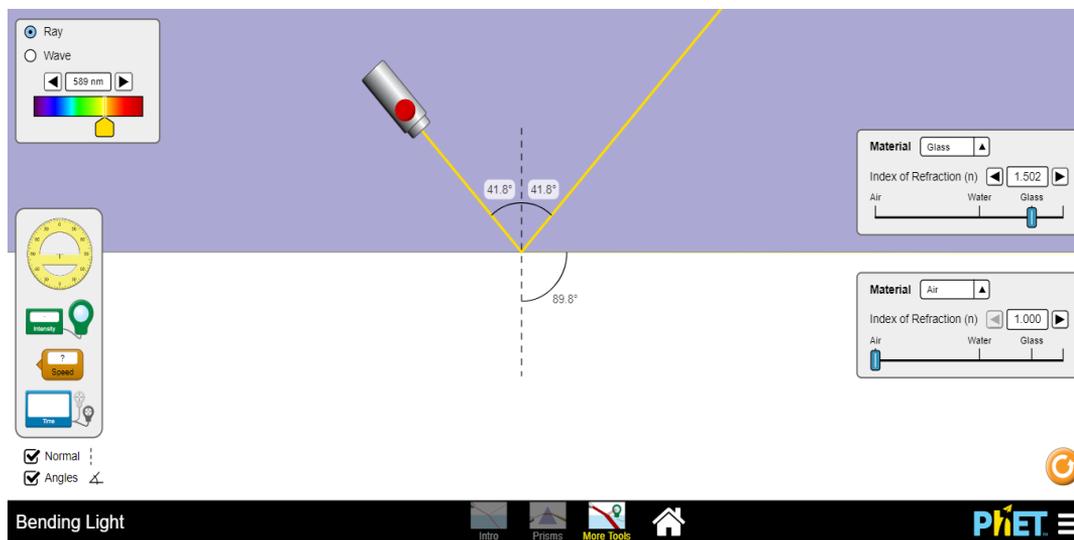


Figure 6.1: Reflection of light

Teacher guidelines for manipulating the simulation

- Download the simulation from the following link https://phet.colorado.edu/sims/html/bending-light/latest/bending-light_en.html and save it on your computer (You can also use the same link if you want to work online).
- After opening the simulation, click on “prisms” button.
- Click on the red button of the source of light.
- From the lower side of the simulation, select either the prism or the Plano-convex lens and shift it up to the position where the light from the source intersects it.
- By clicking and holding the bolt attached to either prism or Plano-convex lens, rotate either the prism or the Plano-convex lens and observe the changes in the direction of the emerging light ray.
- Record your observations regarding the changes in the direction of the refracted light rays.
- What are the positions of either the prism or Plano-convex lens from which the light can be reflected inside the prism or the lens instead of being refracted?
- From your observation, what might be the conditions for this light to reflect inside the prism or lens instead of being refracted?

- Change the refractive index of the surrounding medium and observe its effect on the direction of the refracted or reflected light rays.
- Change the colour (wavelength) of the incident light and observe its effect on the direction of the reflected or refracted light.
- Now enjoy changing and adjustment of different tools and buttons and note down your observation for any change/adjustment made.
- Students will compare the recorded observations and answers to the predictions they have made before manipulating the simulation. After comparison, students will present their findings in front of their classmates.
- Teacher is requested also to provide constructive feedbacks to learners' presentation and try to handle learners' alternative.

ANIMATED EXPERIMENT 6.2:

WORKING PRINCIPLE OF OPTICAL FIBERS.

Rationale

When the incident ray falls on the cladding, it suffers total internal reflection as the angle formed by the ray is greater than the critical angle. Optic fibers have revolutionized the speed with which signals are transferred, not only across cities but across countries and continents making telecommunication one of the fastest modes of information transfer. Optical fibers are also used in endoscopy. This animation intends to help students to practically understand the working principle of optical fibers and their daily applications in various fields such as telecommunication and medicine.

Objective

After watching this animation, students will be able to explain the working principle of optical fibers and identify some of their applications in daily lives.

Learners' prediction questions

The teacher first asks students the following questions:

1. Have you ever heard about optic fibers?
2. Explain the term "Optical fibre cables". How do they work?
3. What is the physical phenomenon that is used in optical fibers to carry information?

4. What are the main parts of an optical fiber?
5. How do we call the loss of the signal strength when the information is sent via an optic cable?

Animation setup

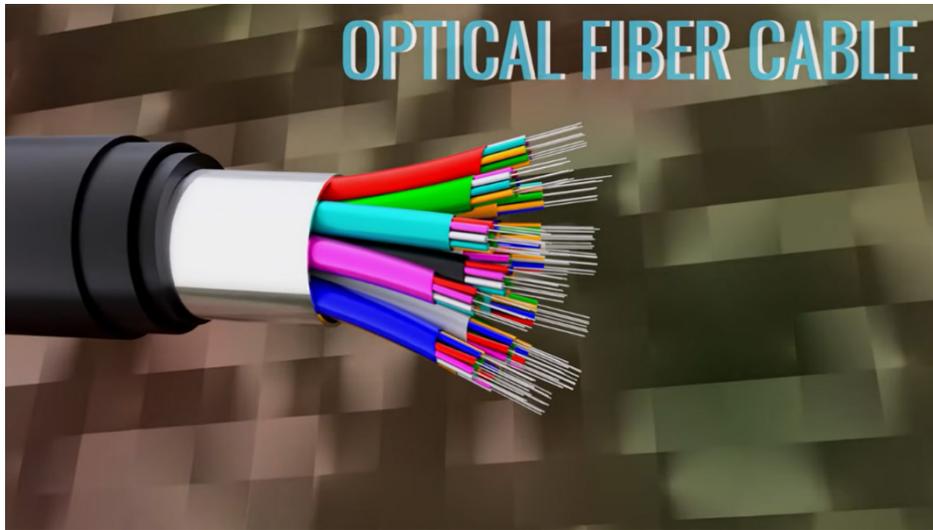


Figure 6.2: Working principle of optical fibers.

Teacher guidelines for watching animation

- Download the simulation from the following link: <https://www.youtube.com/watch?v=jZ0g39v73c4> and save it on your computer (You can also use the same link if you want to work online). (note that facilitator is required to check regularly the online updates or search for other useful animations).
- The teacher will request students to open the link for animation and watch it.
- After watching the video, the teacher asks students to discuss and present what they have learned from the video. The presentation of findings will be guided by the answers to the questions asked previously..
- While watching, students will be requested to carefully listen to the explanations given by the presenter and keep recording possible answers to the questions asked in the previous section of this animation.
- The teacher will provide a constructive feedback to learners' presentations, clarify the incomplete or missing explanation. and try to handle learners' alternative ideas

ANIMATED EXPERIMENT 7.1:

BLOCK DIAGRAM FOR TELECOMMUNICATION SYSTEM

Rationale

Telecommunication Network Diagrams solution extends Concept Drawing software with samples, templates, and great collection of vector stencils to help the specialists in a field of networks and telecommunications, as well as other users to create Computer systems networking and Telecommunication network diagrams for various fields, to organize the work of call centers, to design the GPRS networks and GPS navigational systems, mobile, satellite and hybrid communication networks, to construct the mobile TV networks and wireless broadband networks. To be able to understand what a block diagram for telecommunication system is, how it works and what practical applications are associated with it, students need to watch this kind of animation.

Objective

After watching this animation, students will be able to describe a block diagram telecommunication system and its working principle.

Learners's prediction questions

The teacher first asks students (brainstorming in the group) the following questions:

1. What is communication?
2. Have you ever heard about block diagram?
3. Explain the term "block diagram". How are they designed?
4. What is the main use of block diagram in the development of telecommunication system?
5. What types of information can be transmitted in the communication process?

6. What is the role of each component found in a block diagram of a telecommunication system?

Animation setup

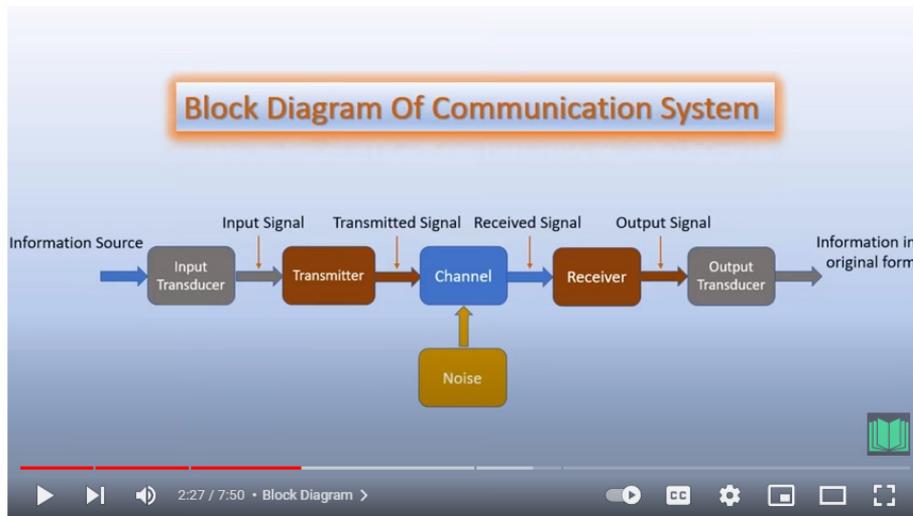


Figure 7.1: Telecommunication Network

Teacher guidelines for watching animation

- Download the simulation from the following link: <https://www.youtube.com/watch?v=0NMpnrXLYI0> and save it on your computer (You can also use the same link if you want to work online). (note that facilitator is required to check regularly the online updates or search for other useful animations).
- The teacher will request students to open the link for animation and to watch it. As they are watching the movie, students will keep their attention on possible answers to the previously asked questions. As learners are watching the video, the teacher will also ask learners to write down the answers to the asked questions.
- After watching the video, the teacher asks students to discuss about it, summarize and present what they have learned from the video. The teacher will provide a constructive feedback to learners presentation, clarify the incomplete or missing explanation and address learners alternative ideas (Misconceptions).

ANIMATED EXPERIMENT 8.1:

CLASSIFICATION OF ELEMENTARY PARTICLES

Rationale

Elementary particle physics helps to understand the most fundamental laws which govern our universe, and to understand the structure and nature of the universe at the deepest level. Elementary particles are categorized on the basis of their nature and properties. They are classified on the basis of mass, charge, average lifetime, spin, interaction etc.. Through this animation, students will be equipped with the understanding of how elementary particles are classified and how they interact.

Objective

After watching this movie, students will be able to provide a full and clear explanation on the classification of elementary particles and their interactions.

Learners' prediction questions

The teacher will first ask students the following questions:

1. What do you understand by elementary particles?
2. How can elementary particles be classified?
3. What are the criteria used in the classification of the elementary particles?
4. Which particles are made up of one quark and one anti-quark?
5. What are the sub-atomic particles which are made up of 3 quarks?

Animation setup

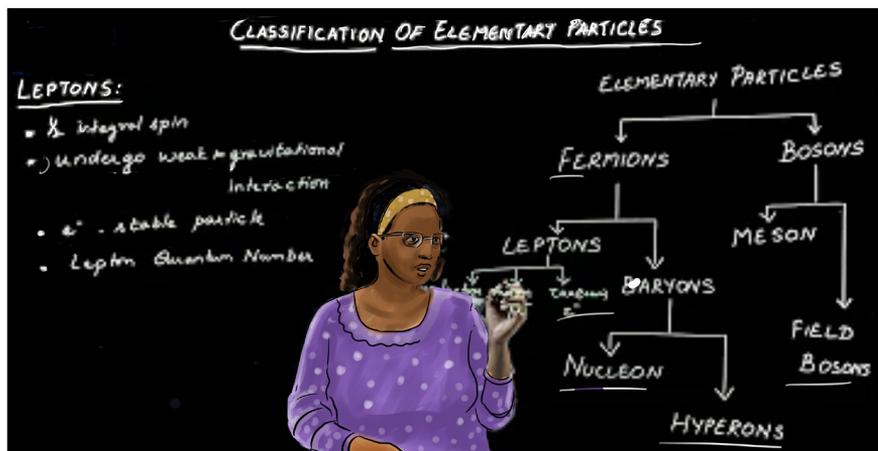


Figure 8.1: Elementary particles

Teacher guidelines for watching animation

- Download the simulation from the following link: [Classification of Elementary Particles | Jeya P | Department of Physics - YouTube](#) and save it on your computer (You can also use the same link if you want to work online). (note that facilitator is required to check regularly the online updates or search for other useful animations).
- The teacher will request students to open the link for animation and to watch it. As they are watching the movie, students will keep their attention on possible answers to the previously asked questions.
- The teacher will request students to watch the animation and record what they observe.
- After watching the video, the teacher asks students to brainstorm, discuss, or present what they have learned from the video. The teacher will provide a constructive feedback to learners presentation, clarify the incomplete or missing explanation and address learners alternative ideas (Misconceptions)

ANIMATED EXPERIMENT 9.1:

PROPERTIES AND BASIC PRINCIPLES OF QUARKS

Rationale

Quarks have properties such as mass, electric charge, and color. Their mass tells you something about what matter they are made of or how heavy they would be if you could weigh them. They can have a positive (+) or negative (–) electric charge. All of these and other properties of quarks are very important for the understanding of various aspects of matter and their interaction. Through this animation, students will be equipped with a functional understanding of the properties of quarks.

Objective

After watching this video, students will be able to explain clearly the properties and basic principles of quarks.

Learners' prediction questions

The teacher first asks students the following questions:

1. What is a quark?
2. What do you understand by colour of quarks?
3. What do you understand by colour of quarks?
4. What is a quark confinement?
5. How can you classify quarks?

Animation setup

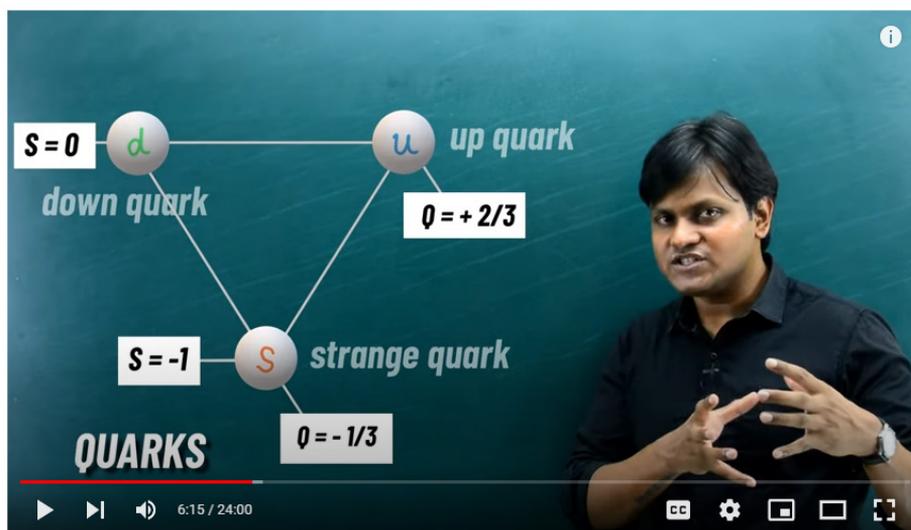


Figure 10.2: Properties and basic principles of quarks

Teacher guidelines for watching animation

- Download the simulation from the following link: <https://www.youtube.com/watch?v=fWPvhFcDjEs> and save it on your computer (You can also use the same link if you want to work online). (Note that facilitator is required to check regularly the online updates or search for other useful animations).
- Request students to watch the animation and record what they observe. After watching the video, the teacher asks students to brainstorm, discuss, or present what they have learned from the video.
- Ask students to compare the observations made to their predictions and draw a conclusion
- Provide a constructive feedback to learners presentation, clarify the incomplete or missing explanation and handle learners' alternative ideas.

ANIMATED EXPERIMENT 10.1:

THE PRODUCTION OF X-RAYS.

Rationale

X-rays are produced within the X-ray machine, also known as an X-ray tube. They are generated via interactions of the accelerated electrons with electrons of tungsten nuclei within the tube anode. There are two types of X-ray generated: characteristic radiation and bremsstrahlung radiation. In real life, X-rays have a number of uses such as Medical Imaging, airport security, radiation therapy, engineering application, industries, research and development, astronomy, etc.

Objective

This animation provides a deep and visual understanding of X-rays production.

Learners' prediction questions:

The teacher first asks students (brainstorming or in the group) the following questions:

1. What is cathode rays made of and why?
2. How are the x-rays produced?
3. What is the meaning of X in X-rays?
4. How are x-rays different from other electromagnetic radiations?

Animation setup

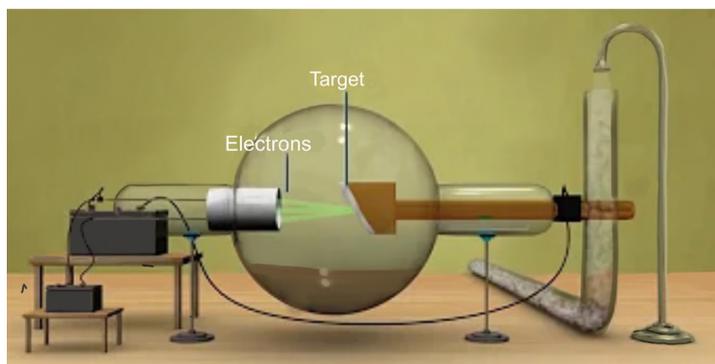


Figure 10.1: X-ray tube, Link to animation: <https://www.youtube.com/watch?v=F7hdNVA2yqU>

Teacher guidelines for watching the video

- Download the animated video from the following link: <https://www.youtube.com/watch?v=F7hdNVA2yqU> and save it on your computer (You can also use the same link if you want to work online). (Note that facilitator is required to check regularly the online updates or search for other useful animations).
- Request learners to open the video, observe it and write down their observations
- To request the students to watch the video and record their observations. Alert them that they will present what they have observed to call attention.
- After watching the video, the teacher asks students to brainstorm, discuss, or present what they have learned from the video. And the students have to reflect again on the questions asked before watching the video to see whether their understanding is on the other level.
- Give more time to the learners for searching other videos in line with the x rays production.
- Ask students to compare the observations to their predictions and draw a conclusion.
- Provide a constructive feedback to learners presentation, clarify the incomplete or missing explanation and handle learners' alternative ideas.

ANIMATED EXPERIMENT 10.2:

TREATMENT OF CANCER

Rationale

Cancer cells grow and multiply quickly than normal cells. In radiotherapy we use high energy radiation such as X-Rays radiations to to treat cancer. Radiations work by making small breaks in the DNA inside cells. Hence, these breaks **keep cancer cells from growing and dividing and cause them to die**. It is why it is recommended to protect healthy cells from x-rays.

Objective

This animated video will provide a deep understanding of the treatment of cancer using X-Rays and X-Rays' effect to the tumor of cancer.

Learners' prediction questions:

The teacher first asks students (brainstorming or in the group) the following questions:

1. What do you understand by cancer?
2. How cancer propagated in human body?
3. How do X-Rays interact with human body?

Animation setup



Figure 10.2: Treatment of cancer Link: https://www.youtube.com/watch?v=_moypMx05Fw

Teacher guidelines for watching the video

- Download the simulation from the following link: https://www.youtube.com/watch?v=_moypMx05Fw and save it on your computer (You can also use the same link if you want to work online). (Note that facilitator is required to check regularly the online updates or search for other useful animations).
- Request learners to open the video, observe it and write down their observations
- Request the students to watch the video and record their observations. Alert them that they will present what they have observed to call attention.
- After watching the video, the teacher asks students to brainstorm, discuss, or present what they have learned from the video. And the students have to reflect again on the questions asked before watching the video to see whether their understanding is on the other level.
- Give more time to the learners for searching other videos in line with the x-rays in security application.
- Ask students to compare the observations done to their predictions and draw a conclusion.
- Provide a constructive feedback to learners presentation, clarify the incomplete or missing explanation and handle learners' alternative ideas.

ANIMATED EXPERIMENT 10.3:

THE APPLICATION OF X-RAYS IN SECURITY CHECKUPS

Rationale

In real life, body scanners are devices that detect objects on or inside a person's body for security screening purposes, without physically removing clothes or making physical contact. X-rays are used to inspect backpacks, suitcases, purses, and luggage to allow operators to detect threatening objects hidden in cluttered bags. Dense substances, such as lead, absorb the most radiation, blocking the X-rays' progression, based on the amount of radiation that has passed the piece of baggage, a computer forms a close to a real-time image of the items.

Objective

The purpose of this video is to help learners to understand the application of X-rays in security checkups for both people and bags/luggage.

Learners' prediction questions:

The teacher first asks students (brainstorming or in the group) the following questions:

- What is the relationship between the x-rays and the electromagnetic waves?
- What is the working principle of an x-ray scanner?
- What is the difference between x-rays and microwaves?
- What do you think is the reason of passengers' scanners not to be harmful, no matter the effects of microwave radiations to human body?

Animation setup



Figure 10.3: X-rays in security checkups, Link: https://www.youtube.com/watch?v=bXNbe_jsoMg

Teacher guidelines for watching the video

- Download the animated video from the following link: https://www.youtube.com/watch?v=bXNbe_jsoMg and save it on your computer (You can also use the same link if you want to work online). (Note that facilitator is required to check regularly the online updates or search for other useful animations).
- Request learners to open the video, observe it and write down their observations
- To request the students to watch the video carefully and record their observations. Alert them that they will present what they have observed to call attention.

- After watching the video, the teacher asks students to brainstorm, discuss, or present what they have learned from the video. And the students have to reflect again on the questions asked before watching the video to see whether their understanding is on the other level.
- Give more time to the learners for searching other videos in line with the x rays application in security checkup.
- Ask students to compare their observations to the theory done in the classroom and draw a conclusion.
- Provide a constructive feedback to learners presentation, clarify the incomplete or missing explanation and handle learners' alternative ideas.

ANIMATED EXPERIMENT 11.1:

THE PRODUCTION OF LASER

Rationale

A laser is created when electrons in the atoms in optical materials like glass, crystal, or gas absorb the energy from an electrical current or a light. That extra energy “excites” the electrons enough to move from a lower-energy orbit to a higher-energy orbit around the atom’s nucleus. In real life, Lasers are used in many surgical procedures such as cancer diagnosis, in technologies of bar code reading, material processing, security checkups, etc.

Objective

This animation will give students an idea of how lasers are produced with the help of an energy source after the photons are disturbed by that electric energy.

Learners’ prediction questions

The teacher first asks students (brainstorming or in the group) the following questions:

1. How is Laser light different from normal light (e.g lamp torch light)
2. From your own understanding, what are conditions for laser light to be produced?
3. Does production need source of energy like electricity? Explain your reasoning.
4. Particles in atoms are either in ground states or excited states. Among the two states, which one favors production of Laser when it is more populated
5. According to you, what is the role played by electric current for laser production

Animation setup

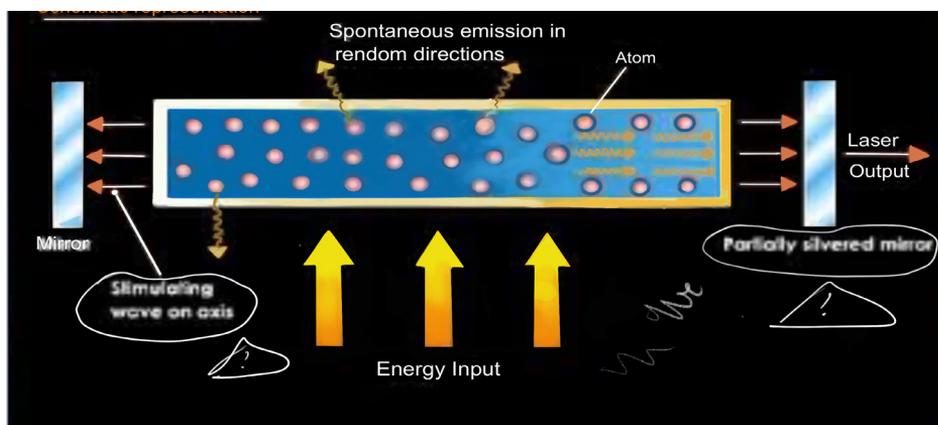


Figure 11.2: laser production

Teacher guidelines for the animation

- Download the videos from the links: <https://www.youtube.com/watch?v=C23cRCZ2J98> and save it on your computer (You can also use the same link if you want to work online). (Note that facilitator is required to check regularly the online updates or search for other useful animations).
- Request students to open the video, observe it carefully and write down their new understanding.
- After watching the video, the teacher asks students to brainstorm, discuss, or present what they have learned from the animation. The teacher is requested also to provide constructive feedback to learners' presentations and try to handle learners' alternatives ideas.
- Ask students to compare the observations to their predictions and draw a conclusion.
- Teacher will give time to the learners to search for other videos in line with the radiation and medicine. Make sure that you are using the light keywords.

Rationale

A laser security system is one that emits a narrow beam of light and gets to know the intruder's presence by getting the beam reflected from the intruder. There are some other security cards that are in the same form as the service cards with the bar codes on them, on which the lasers are used to scan the identity of the person registered to pass a certain entrance. The laser system is able to know the distance, size and speed of the intruder and differentiate it from other objects. On the basis of the reflected beam, you won't have to worry about protecting your house far enough out because that laser beam is going to travel further than you might think. It's also able to reflect and bounce around several times in that distance, meaning a single beam can cover more distance than you might think.

Objective

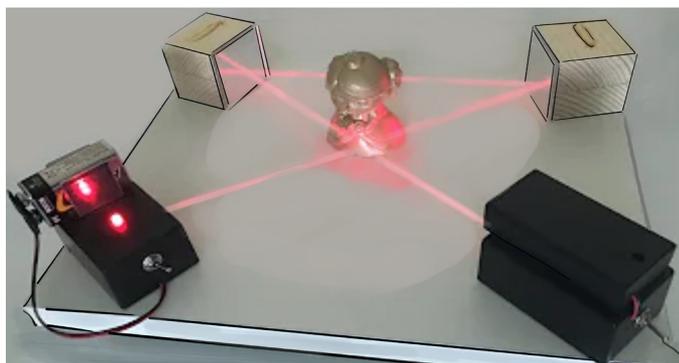
This animation provides a full package of how lasers are used in security checkups. It is one of the examples of the application of laser, aside from medical, information processing, and material processing.

Learners' prediction questions

The teacher first asks students (brainstorming or in the group) the following questions:

1. List all applications or LASERS you may know
2. In group, discuss what are the background principal of working of LASER
3. Which working principle do the lasers use when being used in security systems?

Animation setup



Link to animated Video: https://www.youtube.com/watch?v=I3zNh3F_pAg

Teacher guidelines for watching the animation

- Download the animation from the following link: https://www.youtube.com/watch?v=I3zNh3F_pAg and save it on your computer (You can also use the same link if you want to work online). (Note that facilitator is required to check regularly the online updates or search for other useful animations).
- The teacher will request students to open the link for animation and warn them not to watch it before his instruction.
- Request students to run the animation, observe different features of it and write down their observations
- After watching the animation, the teacher asks students to brainstorm, discuss, or present what they have learned from the animation.
- Ask students to compare their observations to the theory done in the classroom and draw a conclusion.
- Provide a constructive feedback to learners presentation, clarify the incomplete or missing explanation and handle learners' alternative ideas.

ANIMATED EXPERIMENT 12.1: X-RAY IMAGING.

Rationale

This animation allows learners to observe how a radiography is conducted in a safe virtual reality environment which looks like as a hospital or clinic. From this animation, learner will observe the basic methods of radiography as well as some fundamentals of electromagnetism. An X-ray imaging is a quick, painless test that produces images of the structures inside your body — particularly your bones.

Objective

After watching this video, learners will explain the functioning principle of x-ray imaging confidently.

Learners' prediction Questions

1. What are X-rays radiations?, how are they produced?
2. Characterize X-rays as compared to visible rays?
3. Who discovered X-rays
4. Explain the formation of image by x-rays.
5. Can x-rays be dangerous? If yes, what are factors determining the harmfulness

Animation setup

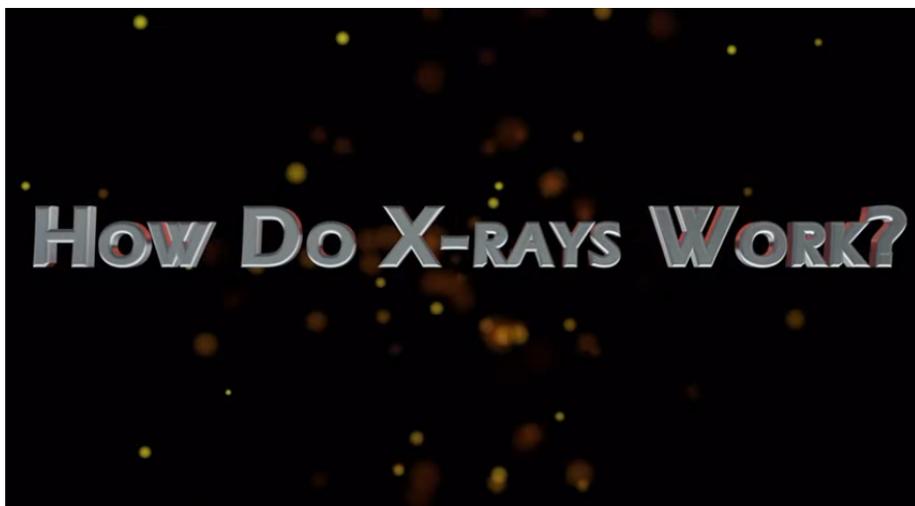


Figure 12.1: X-ray imaging

Teacher guidelines to manipulate animation

- Download the video from the links https://www.youtube.com/watch?v=hTz_rGP4v9Y and <https://www.youtube.com/watch?v=b8kex8rzR5A> and save it on your computer (You can also use the same link if you want to work online). (Note that facilitator is required to check regularly the online updates or search for other useful animations).
- Request learners to run the video, observe different features of it and write down their observations
- After watching the video, the teacher asks learners to brainstorm, discuss, or present what they have learned from the video.
- Teacher is requested also to provide constructive feedbacks to learners' presentation and try to handle learners' alternative ideas.
- Ask learners to compare the observations to their predictions and draw a conclusion.

ANIMATED EXPERIMENT 12.2:

MEDICAL IMAGING TECHNIQUES

Rationale

Medical imaging is the technique and process of imaging the interior of a body for clinical analysis and medical intervention, as well as visual representation of the function of some organs or tissues. Medical imaging seeks to reveal internal structures hidden by the skin and bones, as well as to diagnose and treat disease. Medical imaging also establishes a database of normal anatomy and physiology to make it possible to identify abnormalities.

Objective

Explain various medical imaging techniques for particular purposes.

Learners' prediction questions.

1. What do you understand by medical imaging?
2. What is the importance medical imaging?
3. What do you understand by medical imaging and radiology?
4. List and explain medical imaging techniques.

Animation setup



Figure 12.2: Medical imaging techniques

Teacher guidelines to manipulate animation

- Download the video from the link: <https://www.youtube.com/watch?v=oW0ffeK2pT0> & <https://www.youtube.com/watch?v=0q9wTyGhqFs> and save it on your computer (You can also use the same link if you want to work online). (Note that facilitator is required to check regularly the online updates or search for other useful animations).
- Request learners to run the video, observe different features of it and write down their observations
- After watching the video, the teacher asks learners to brainstorm, discuss, or present what they have learned from the video.
- Teacher is requested also to provide constructive feedbacks to learners' presentation and try to handle learners' alternative.
- Ask learners to compare the observations to their predictions and draw a conclusion.

ANIMATED EXPERIMENT 12.3:

ULTRASONIC IMAGING TECHNIQUES

Rationale

In this animation you will learn ultrasound imaging which uses sound waves to produce pictures of the inside of the body. It helps diagnose the causes of pain, swelling and infection in the body's internal organs and to examine an unborn child (fetus) in pregnant women. In infants, doctors commonly use ultrasound to evaluate the brain, hips, and spine. It also helps guide biopsies, diagnose heart conditions, and assess damage after a heart attack. Ultrasound is safe, noninvasive, and does not use radiation.

Objective

This animation will help you to explain ultrasonic imaging techniques.

Learners' prediction Questions

1. What do you understand by ultrasonic imaging? What is its use?
2. What is the human hearing range?
3. How does ultrasound machine works?

4. Explain and give examples of acoustic window.
5. Explain safety needed in using ultrasonic imaging.
6. Explain i) piezoelectric crystals.
ii) obstetric ultrasound.

Animation setup



Figure 12.3: Ultrasonic imaging techniques

Teacher guidelines to manipulate animation

- Download the video from the link: <https://www.youtube.com/watch?v=X8ab6NAIV5I> and save it on your computer (You can also use the same link if you want to work online)
- Request learners to run the video, observe different features of it and write down their observations
- After watching the video, the teacher asks learners to brainstorm, discuss, or present what they have learned from the video.
- Teacher is requested also to provide constructive feedbacks to learners' presentation and try to handle learners' alternative ideas.
- Ask learners to compare the observations made to their predictions and draw a conclusion.

Rationale

These videos will explain you how an endoscope works to examine and treat the inside of the body. It also provides more details on endoscopes are used to look inside the body directly through a natural opening, or through a 'keyhole' incision.

Objective

In these videos you will get the explanation on how an endoscope works to examine and treat the inside of the body.

Learners' prediction Questions

1. How does an endoscopy works?
2. What are the uses of endoscopy?
3. How does endoscopy create an image?
4. What waves does an endoscope use?
5. What are the advantages and disadvantages of endoscopy?
6. What are preparations of patient before endoscopy?

Animation setup

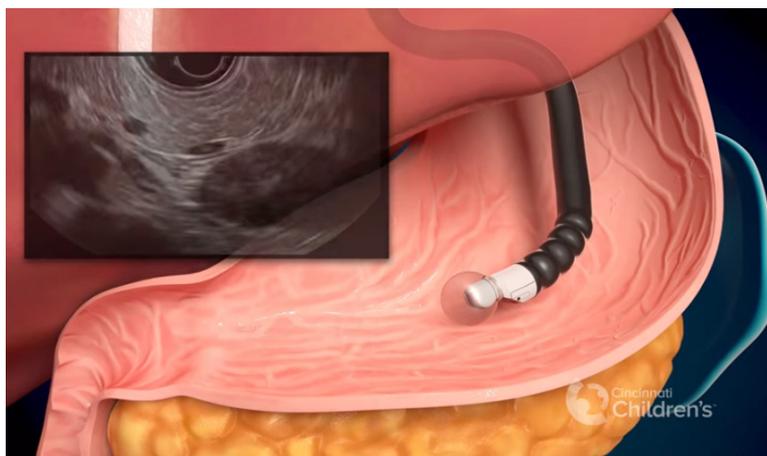


Figure 12.4: Endoscopic Ultrasound (EUS) Procedure

Teacher guidelines for watching animation

- Download the video from the link: <https://www.youtube.com/watch?v=F6hdQJdWFkk>, <https://www.youtube.com/watch?v=ArtGHJy0hII> https://www.youtube.com/watch?v=DexCXX_yYyE .
- You can also use the same link if you want to work online. (Note that facilitator is required to check regularly the online updates or search for other useful animations).
- To help learners to get skills on how an endoscope works to examine and treat the inside of the body ask them to observe all three videos and write their observations in their note books.
- After watching the video, the teacher asks learners to brainstorm, discuss, or present what they have learned from the video.
- Teacher is requested also to provide constructive feedbacks to learners' presentation and try to handle learners' alternative ideas.
- Ask learners to compare the observations made to their predictions and draw a conclusion.

ANIMATED EXPERIMENT 12.5: MAGNETIC RESONANCE IMAGING (MRI)

Rationale

Magnetic resonance imaging, or MRI, is a noninvasive medical imaging test that produces detailed images of almost every internal structure in the human body, including the organs, bones, muscles and blood vessels. MRI scanners create images of the body using a large magnet and radio waves. No radiation is produced during an MRI exam, unlike X-rays. These images give your physician important information in diagnosing your medical condition and planning a course of treatment.

Objective

This simulation will help you to explain MRI working principle.

Learners' prediction Questions

1. Be sure wave view is activated. Adjust power and observe changes in atomic nucleus and energy. Compare changes in lower and higher power settings.

2. Vary main the magnetic field from 0 up to 2.5T and observe what will happen on the spin and on the detector
3. Compare changes to lower and higher magnetic field.
4. Switch radio wave source from wave view to photon view and observe changes.
5. Change the frequency of the wave and write your observations
6. Switch from simplified NMR to MRI and repeat from question (1) to (4).
7. Activate show head, show atomic nucleus and show magnetic field.
8. Activate add and remove tumor and write down change observed in atomic nucleus for both cases.
9. Activate add tumor and write down change observed in atomic nucleus
10. Vary main magnetic field horizontally and then vertically and observe changes in atomic nucleus and energy. Compare changes to lower and higher magnetic field.

Simulation setup

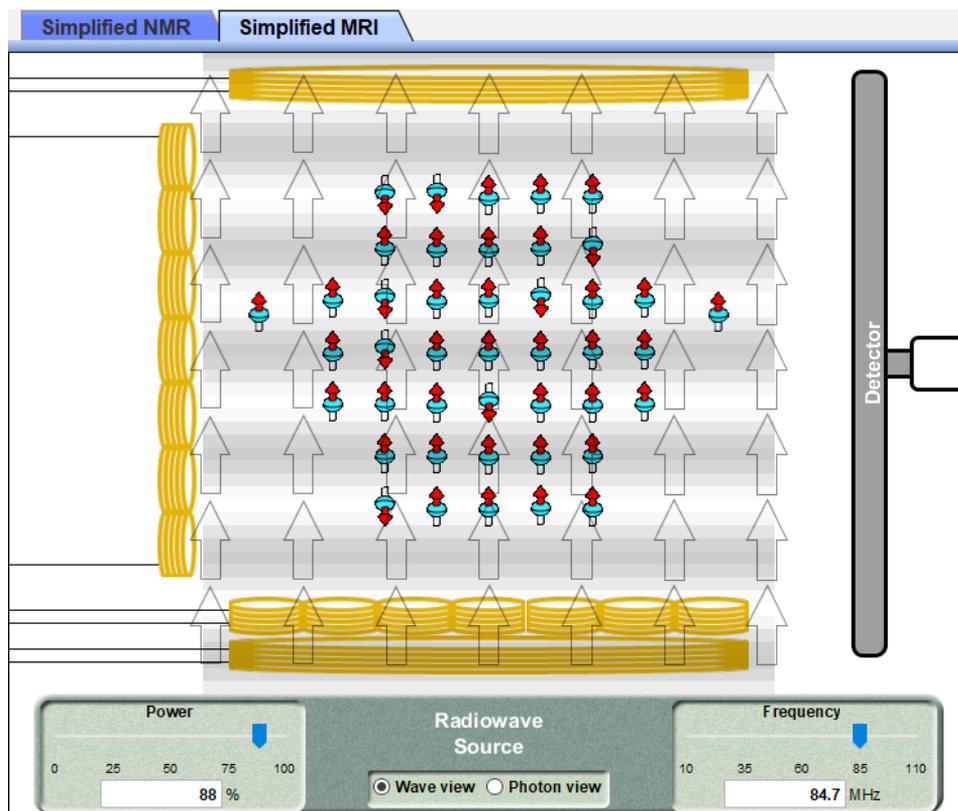


Figure 12.5: MRI working principle.

Teacher guidelines to manipulate the simulation

- Download the simulation from the link: <https://phet.colorado.edu/en/simulations/mri> & <https://phet.colorado.edu/sims/cheerpj/mri/latest/mri.html?simulation=mri> and save it. (You can also use the same link if you want to work online). (Note that facilitator is required to check regularly the online updates or search for other useful animations).
- Ask learners to brainstorm, discuss, or present what they have learned from the simulation.
- Provide constructive feedbacks to learners' presentation and try to handle learners' alternative ideas.
- Ask learners to compare the observations made to their predictions and draw a conclusion.

ANIMATED EXPERIMENT 13.1: DOSIMETRY

Rationale

Dosimetry is the process of evaluating the administered amount of radioactive rays to the absorbed radiation dose in tumors, organs, or the whole body. Dosimetry is the measurement of radiation exposure from x-rays, gamma rays, or other types of radiation used in the treatment or detection of diseases, including cancer or tumor. In dosimetry, the detector/dosimeter is used to measure the absorbed radioactive dose for effective cancer or tumor treatment.

Objective

This video allows learners to understand the concept of dosimetry, why and how it is done.

Learners prediction questions

1. In your group discuss, the importance of taking precautions while working in an environment with radioactivity.
2. why is dosimetry important while working in an environment with radioactivity
3. What is dosimetry and why is it important in medicine?
4. What are different types of dosimetry?
5. Discuss on the importance of dosimetry in cancer treatment.

Animation video setup

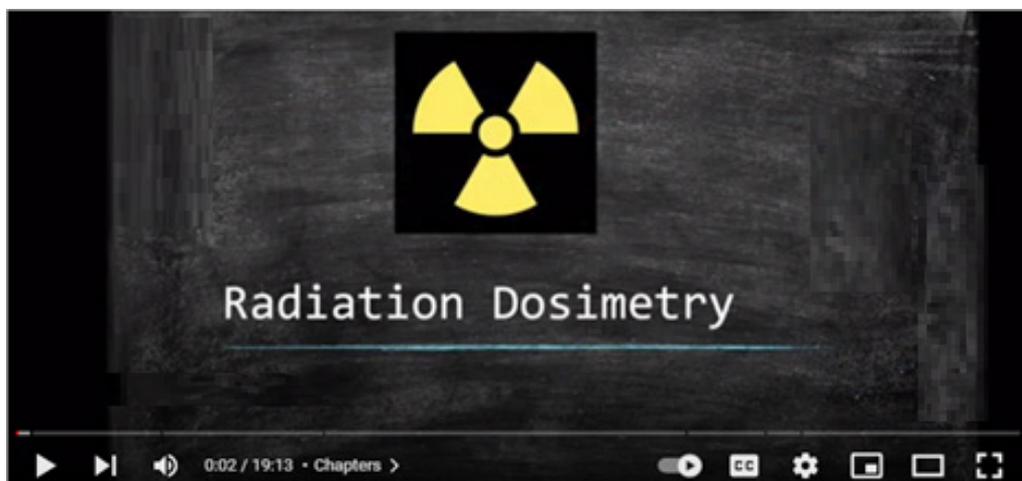


Figure 13.1. Radiation Dosimetry

Teacher guidelines for the animation

- Download the videos from the link <https://www.youtube.com/watch?v=p9bX9PsJXkg> and save it on your computer (You can also use the same link if you want to work online). (Note that facilitator is required to check regularly the online updates or search for other useful animations).
- Request students to open the video, observe it carefully and write down their new understanding.
- After watching the video, the teacher asks students to brainstorm, discuss, or present what they have learned from the animation.
- Provide constructive feedback to learners' presentations and try to handle learners' alternatives.
- Ask students to compare the observations made to their predictions and draw a conclusion.
- Medical imaging is used around in hospitals, teacher can plan a field visit to see the instrumentation and how it works

ANIMATED EXPERIMENT 13.2:

ANIMATION ON RADIATION DOSIMETER

Rationale

Dosimeters are instruments issued to measure and record the amount of occupational radiation dose an individual receives as required by regulations. They record the dose anyone has received. Modern electronic dosimeters give a continuous readout of cumulative dose and current dose rate and can warn the wearer with an audible alarm when a specified dose rate is exceeded. Other dosimeters, such as thermoluminescent or film types, require processing after use to reveal the cumulative dose received, and cannot give a current indication of dose while being worn.

Objective

This animated video gives students the best understanding of radiation dosimeter

Learners' prediction Questions

The teacher first asks students (brainstorming or in the group) the following questions:

1. Have you ever heard about radiation dosimeter?
2. Explain the term "radiation dosimetry"?
3. How a dosimeter works and what is its importance in medical imaging?

Animation setup

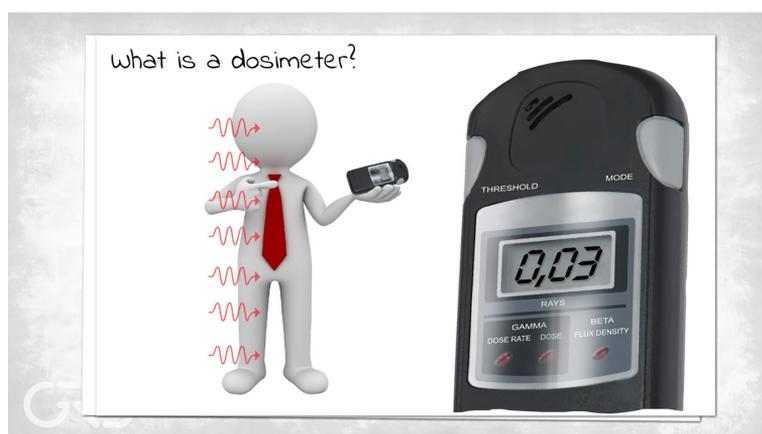


Figure: what is dosimetry Link to animation: <https://www.youtube.com/watch?v=5XIUWqOPEEc>

Teacher guidelines for watching animation

- Download the video from the link <https://www.youtube.com/watch?v=5XIUWqOPEE> and save it on your computer (You can also use the same link if you want to work online). (Note that facilitator is required to check regularly the online updates or search for other useful animations).
- Request students to open the video, observe it carefully and write down their new understanding.
- After watching the video, the teacher asks students to brainstorm, discuss, or present what they have learned from the animation. The teacher is requested also to provide constructive feedback to learners' presentations and try to handle learners' alternatives ideas.
- Ask students to compare their observations to the theory done in the classroom and draw a conclusion.

ANIMATED EXPERIMENT 13.3:

SAFETY PRECAUTION FOR HANDLING RADIATION

Rationale

Radioactive materials are hazardous. Nuclear radiation can ionize atoms and molecules in the body, which may change the way cells behave. It can also transfer large amounts of energy into the body which can damage or destroy cells.

Objective

In this video, you will understand why safety precautions are needed when handling radiation

Learners prediction questions

The teacher first asks students (brainstorming or in the group) the following questions:

1. Why is it important to be careful while dealing with radioactive materials?
2. Have you ever heard about radiation precautions?
3. Explain what precautions to be taken while working in an environment with radioactive materials.

Video setup



Figure 13.3: Safety precaution for handling radiation Link to animation: <https://www.youtube.com/watch?v=arprZAK5Aj4>

Teacher guidelines for the animation

- Download the videos from the links: <https://www.youtube.com/watch?v=arprZAK5Aj4> and save it on your computer (You can also use the same link if you want to work online). (Note that facilitator is required to check regularly the online updates or search for other useful animations).
- Request students to open the video, observe it carefully and write down their new understanding.
- After watching the video, the teacher asks students to brainstorm, discuss, or present what they have learned from the animation.
- Provide constructive feedback to learners' presentations and try to handle learners' alternatives ideas.
- Ask students to compare the observations made to their predictions and draw a conclusion.
- Teacher will give time to the learners to search for other videos in line with the radiation and medicine. Make sure that you are using the light keywords.

ANIMATED EXPERIMENT 14.1:

STRUCTURE OF THE MILKY WAY GALAXY

Rationale

The Milky Way Galaxy's structure is fairly typical of a large spiral system. This structure can be viewed as consisting of six separate parts: (1) a nucleus, (2) a central bulge, (3) a disk (both a thin and a thick disk), (4) spiral arms, (5) a spherical component, and (6) a massive halo. Some of these components blend into each other.

Objective

In this video, you will understand structure of the Milky Way Galaxy.

Learners' prediction Questions

1. What do you understand by galaxy?
2. We are in the Milky Way Galaxy; how did we photograph its structure?
3. Estimate how many stars would be in one galaxy
4. Classify galaxies. Milky Way Galaxy is in which class?
5. Characterize main structures of the Milky Way Galaxy.
6. Locate our solar system in Milky Way Galaxy.

Video setup



The Milky way Galaxy Facts | How do we know our Galaxy is spiral? |

Figure 14.1: Structure of the milky way galaxy

Teacher guidelines for watching animation

- Download the video from the link: <https://www.youtube.com/watch?v=w5LEtILN8vI&t=16s> and save it on your computer (You can also use the same link if you want to work online). (Note that facilitator is required to check regularly the online updates or search for other useful animations).
- Request learners to run the video, observe different features of it and write down their observations
- After watching the video, the teacher asks learners to brainstorm, discuss, or present what they have learned from the video. Teacher is requested also to provide constructive feedbacks to learners' presentation and try to handle learners' alternative ideas.
- Ask learners to compare the observations to their predictions and draw a conclusion.

ANIMATED EXPERIMENT 14.2:

STRUCTURE OF THE SPIRAL GALAXIES

Rationale

By studying the cosmos beyond our own planet, we can understand where we came from, where we are going, and how physics works under conditions which are impossible to recreate on Earth.

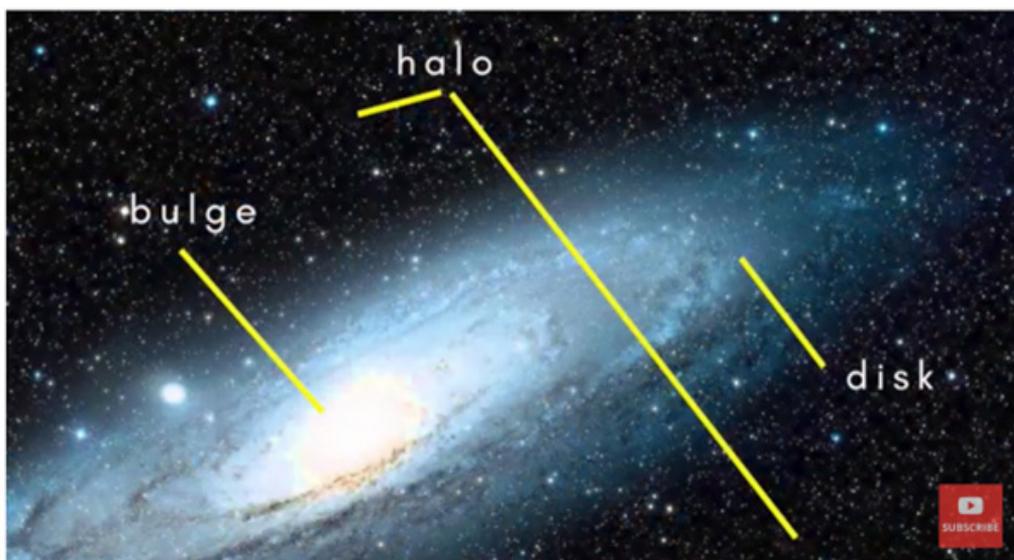
Objective

In this video, you will explore the structure of the spiral galaxies

Learners' prediction Questions

1. Characterize spiral galaxies.
2. What are two main types of spiral galaxies and corresponding subtypes.
3. What types of galaxies together form disc galaxies class.

Video setup



Spiral galaxies

Figure 14.2: The spiral galaxies

Teacher guidelines to manipulate animation

- Download the video from the following link: https://www.youtube.com/watch?v=T_wNvAWAJkE and save it on your computer (You can also use the same link if you want to work online). (Note that facilitator is required to check regularly the online updates or search for other useful animations).
- Request learners to run the video, observe different features of it and write down their observations
- After watching the video, the teacher asks learners to brainstorm, discuss, or present what they have learned from the video. Teacher is requested also to provide constructive feedbacks to learners' presentation and try to handle learners' alternative.
- Ask learners to compare their observations to the theory done in classroom and draw a conclusion.

ANIMATED EXPERIMENT 14.3: STRUCTURE OF THE ELLIPTICAL GALAXIES

Rationale

Astronomy has given us essential knowledge about the fundamental forces of the Universe in addition to multiple technology spin-offs and a large body of skills and technologies in optics, detectors, radio receivers and communications, which are essential to space travel.

Objective

In this video, you will explore the structure of the elliptical galaxies and more other galaxies.

Learners' prediction Questions

1. Define galaxy.
2. From Edwin Hubble's classification scheme, differentiate elliptical galaxies from spiral galaxies.
3. Give main characteristics of elliptical galaxies.
4. Explain other types of galaxies rather than elliptical and spiral galaxies.

Animation setup



Stargazing Basics

Types of Galaxies in Space - Spiral, Elliptical, Irregular plus more

Figure 14.3: Structure of the elliptical galaxies

Teacher guidelines to manipulate animation

- Download the video from the following link: <https://www.youtube.com/watch?v=Ey00Dv2vp-0> and save it on your computer (You can also use the same link if you want to work online). (Note that facilitator is required to check regularly the online updates or search for other useful animations).
- Request learners to run the video, observe different features of it and write down their observations
- After watching the video, the teacher asks learners to brainstorm, discuss, or present what they have learned from the video.
- Provide constructive feedbacks to learners' presentation and try to handle learners' alternative ideas.
- Ask learners to compare their observations to the theory done in classroom and draw a conclusion.

ANIMATED EXPERIMENT 14.4: BIG BANG THEORY

Rationale

The Big Bang Theory is our best guess about how the universe began. The Big Bang Theory is the leading explanation for how the universe began. Simply put, it says the universe as we know it started with an infinitely hot and dense single point that inflated and stretched — first at unimaginable speeds, and then at a more measurable rate — during the past 13.8 billion years to the still-expanding cosmos that we know today

Objective

This animation gives students the best understanding of how universe began, the big bang theory.

Learners' prediction Questions

1. What do you understand by the universe?
2. Make a small statement of big bang theory.
3. Explain how and when the universe started.
4. State two major stages of the universe evolution?
5. State and characterize each epoch of radiation era?
6. State and characterize each epoch of matter era?
7. In which era and epoch was helium formed?
8. In which era and epoch was hydrogen formed?

Video setup



Origins of the Universe 101 | National Geographic

Figure 14.4: The Big Bang Theory

Teacher guidelines for manipulating animation

- Download the video from the following link: <https://www.youtube.com/watch?v=HdPzOWLrbE> and save it on your computer (You can also use the same link if you want to work online). (Note that facilitator is required to check regularly the online updates or search for other useful animations).
- Request learners to run the video, observe different features of it and write down their observations
- After watching the video, the teacher asks learners to brainstorm, discuss, or present what they have learned from the video.
- Provide constructive feedbacks to learners' presentation and try to handle learners' alternative ideas.
- Ask learners to compare the observations to their predictions and draw a conclusion.
- You may explore this too <https://www.youtube.com/watch?v=wNDGgL73ihY> and find some evidence that the universe started with big bang.

REFERENCES

1. UR-CE (2021), Continuous Professional Development Certificate in Innovative Teaching Mathematics and Science, Student Manuel, Module 1: Innovative Teaching Methods for Mathematics and Science (Secondary) (CMS1141), Part 3: Physics Laboratory Experiments
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5. <https://phet.colorado.edu/en/simulations/filter?type=html,prototype>