



Module 2

Junior Secondary Science

Energy Use in
Electronic Communication



THE COMMONWEALTH *of* LEARNING

Science, Technology and Mathematics Modules
for Upper Primary and Junior Secondary School Teachers
of Science, Technology and Mathematics by Distance
in the Southern African Development Community (SADC)

Developed by
The Southern African Development Community (SADC)

Ministries of Education in:

- **Botswana**
- **Malawi**
- **Mozambique**
- **Namibia**
- **South Africa**
- **Tanzania**
- **Zambia**
- **Zimbabwe**

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SCIENCE, TECHNOLOGY AND MATHEMATICS MODULES

This module is one of a series prepared under the auspices of the participating Southern African Development Community (SADC) and The Commonwealth of Learning as part of the Training of Upper Primary and Junior Secondary Science, Technology and Mathematics Teachers in Africa by Distance. These modules enable teachers to enhance their professional skills through distance and open learning. Many individuals and groups have been involved in writing and producing these modules. We trust that they will benefit not only the teachers who use them, but also, ultimately, their students and the communities and nations in which they live.

The twenty-eight Science, Technology and Mathematics modules are as follows:

Upper Primary Science

- Module 1: *My Built Environment*
- Module 2: *Materials in my Environment*
- Module 3: *My Health*
- Module 4: *My Natural Environment*

Junior Secondary Science

- Module 1: *Energy and Energy Transfer*
- Module 2: *Energy Use in Electronic Communication*
- Module 3: *Living Organisms' Environment and Resources*
- Module 4: *Scientific Processes*

Upper Primary Technology

- Module 1: *Teaching Technology in the Primary School*
- Module 2: *Making Things Move*
- Module 3: *Structures*
- Module 4: *Materials*
- Module 5: *Processing*

Junior Secondary Technology

- Module 1: *Introduction to Teaching Technology*
- Module 2: *Systems and Controls*
- Module 3: *Tools and Materials*
- Module 4: *Structures*

Upper Primary Mathematics

- Module 1: *Number and Numeration*
- Module 2: *Fractions*
- Module 3: *Measures*
- Module 4: *Social Arithmetic*
- Module 5: *Geometry*

Junior Secondary Mathematics

- Module 1: *Number Systems*
- Module 2: *Number Operations*
- Module 3: *Shapes and Sizes*
- Module 4: *Algebraic Processes*
- Module 5: *Solving Equations*
- Module 6: *Data Handling*

A MESSAGE FROM THE COMMONWEALTH OF LEARNING



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Dato' Professor Gajaraj Dhanarajan
President and Chief Executive Officer

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CONTACTS FOR THE PROGRAMME

The Commonwealth of Learning
1285 West Broadway, Suite 600
Vancouver, BC V6H 3X8
Canada

National Ministry of Education
Private Bag X603
Pretoria 0001
South Africa

Ministry of Education
Private Bag 005
Gaborone
Botswana

Ministry of Education and Culture
P.O. Box 9121
Dar es Salaam
Tanzania

Ministry of Education
Private Bag 328
Capital City
Lilongwe 3
Malawi

Ministry of Education
P.O. Box 50093
Lusaka
Zambia

Ministério da Educação
Avenida 24 de Julho No 167, 8
Caixa Postal 34
Maputo
Mozambique

Ministry of Education, Sport and Culture
P.O. Box CY 121
Causeway
Harare
Zimbabwe

Ministry of Basic Education,
Sports and Culture
Private Bag 13186
Windhoek
Namibia

MODULE WRITERS

Mr. Emmanuel Chitare: *Writing Team Leader*
Education Officer (Science)
Curriculum Development Unit
Ministry of Education
Harare, Zimbabwe

Ms. Lindlewe Bhebhe: Dominican Convent High School
Bulawayo, Zimbabwe

FACILITATORS/RESOURCE PERSONS

Dr. James Murdoch: Deputy Head of Science
Northern College
Aberdeen, Scotland, UK

Dr. Stephen Mahere: Deputy Director (Schools)
Ministry of Education Sport & Culture
Zimbabwe

PROJECT MANAGEMENT & DESIGN

Ms. Kgomotso Motlotle: Education Specialist, Teacher Training
The Commonwealth of Learning (COL)
Vancouver, BC, Canada

Mr. André Ruhigisha: *Post-production editing*
Co-ordinator of Instructional Development
Open Learning Agency
Victoria, BC, Canada

Ms. Sandy Reber: *Graphics & desktop publishing*
Reber Creative
Victoria, BC, Canada

JUNIOR SECONDARY SCIENCE PROGRAMME

Introduction

Welcome to the programme in Teaching Junior Secondary Science. This series of four modules is designed to help you to strengthen your knowledge of science topics and to acquire more instructional strategies for teaching science in the classroom.

Each of the four modules in the science series provides an opportunity to apply theory to practice. Learning about science entails the development of practical skills as well as theoretical knowledge. Each science topic includes an explanation of the theory behind the science, examples of how the science is used in practice, and suggestions for classroom activities that allow students to explore the science for themselves.

Each module also explores several instructional strategies that can be used in the science classroom and provides you with an opportunity to apply these strategies in practical classroom activities. Each module examines the reasons for using a particular strategy in the classroom and provides a guide for the best use of each strategy, given the topic, context and goals.

The guiding principles of these modules are to help make the connection between theory and practice, apply instructional theory to practice in the classroom situation and support you, as you in turn help your students to apply science theory to practical classroom work.

Programme Goals

This programme is designed to help you to:

- strengthen your understanding of science topics
- expand the range of instructional strategies that you can use in the science classroom

Programme Objectives

By the time you have completed this programme, you should be able to:

- develop and present lessons on energy and energy transfer; the use of energy in electronic communication; the needs of living organisms and their environmental resources; and the study of scientific processes. The topics on energy and the environment will focus on learning, through the scientific inquiry method, ways to achieve a sustainable environment
- guide students as they work in teams on practical projects in science, and help them to work effectively as a member of a group
- use questioning and explanation strategies to help students learn new concepts related to energy and to support students in their problem solving activities
- guide students in the use of investigative strategies to learn more about particular technologies, and to find out how tools and materials are used in science
- prepare your own portfolio about your teaching activities
- guide students as they prepare their portfolios about their project activities

The relationship between this programme and the science curriculum

The science content presented in these modules includes some of the topics most commonly covered in the science curricula in southern African countries. However, it is not intended to cover all topics in any one country's science curriculum comprehensively. For this, you will need to consult your national or regional curriculum guide. The curriculum content that is presented in these modules is intended to:

- provide an overview of the content in order to support the development of appropriate teaching strategies
- use selected parts of the curriculum as examples for application of specific teaching strategies
- explain those elements of the curriculum that provide essential background knowledge, or that address particularly complex or specialised concepts
- provide directions to additional resources on the curriculum content

How to Work on this Programme

As is indicated in the programme goals and objectives, this programme provides for you to participate actively in each module by applying instructional strategies when exploring science with your students and by reflecting on that experience. There are several different ways of doing this.

Working on your own

You may be the only teacher of science in your school, or you may choose to work on your own so you can accommodate this programme within your schedule. If this is the case, these are the recommended strategies for using this module:

1. Establish a schedule for working on the module: choose a date by which you plan to complete the first module, taking into account that each unit will require between six to eight hours of study time and about 2 hours of classroom time for implementing your lesson plan. For example, if you have 2 hours a week available for study, then each unit will take between 3 and 4 weeks to complete. If you have 4 hours a week for study, then each unit will take about 2 weeks to complete.
2. Choose a study space where you can work quietly without interruption, for example, a space in your school where you can work after hours.
3. If possible, identify someone who is interested in science or whose interests are relevant to science (for example, a math or science teacher in your school) with whom you can discuss the module and some of your ideas about teaching science. Even the most independent learner benefits from good dialogue with others: it helps us to formulate our ideas—or as one learner commented, “How do I know what I’m thinking until I hear what I have to say?”

Working with colleagues

If you are in a situation where there are other teachers of science in your school or in your immediate area, then it is possible for you to work together on this module. You may choose to do this informally, perhaps having a discussion group once a week or once every two weeks about a particular topic in one of the units. Or, you may choose to organise more formally, establishing a schedule so that everyone is working on the same units at the same time, and you can work in small groups or pairs on particular projects. If you and several colleagues plan to work together on these modules, these are the recommended steps:

1. Establish and agree on a schedule that allows sufficient time to work on each unit, but also maintains the momentum so that people don't lose interest. If all of you work together in the same location, meeting once a week and allocating two weeks for each unit, this plan should accommodate individual and group study time. If you work in different locations, and have to travel some distance to meet, then you may decide to meet once every two weeks, and agree to complete a unit every two weeks.
2. Develop and agree on group goals, so that everyone is clear about the intended achievements for each unit and for each group session.
3. Develop a plan for each session, outlining what topics will be covered and what activities will be undertaken by the group as a whole, in pairs or in small groups. It may be helpful for each member of the group to take a turn in planning a session.

Your group may also choose to call on the expertise of others, perhaps inviting someone with particular knowledge about teaching or about a specific science topic to speak with the group, as long as this is in keeping with the goals of the module and of the group.

Your group may also have the opportunity to consult with a mentor, or with other groups, by teleconference, audioconference, letter mail or e-mail. Check with the local coordinator of your programme about these possibilities so that you can arrange your group schedule to be compatible with these provisions.

Colleagues as feedback/resource persons

Even if your colleagues are not participating directly in this programme, they may be interested in hearing about it and about some of your ideas as a result of taking part. Your head teacher or the local area specialist in science may also be willing to take part in discussions with you about the programme.

Working with a mentor

As mentioned above, you may have the opportunity to work with a mentor, someone with expertise in science education who can provide you with feedback about your work. If you are working on your own, your communication with your mentor may be by letter mail, telephone or e-mail. If you are working as a group, you may have occasional group meetings, teleconferences or audioconferences with your mentor.

Using a learning journal

Whether you are working on your own or with a group, it is strongly recommended that you use a learning journal. The learning journal serves a number of different purposes, and you can divide your journal into compartments to accommodate these purposes. You can think of your journal as a "place" where you can think out loud by writing down your ideas and thoughts, and this "place" has several "rooms".

Ideas/Reflections/Questions

In one part of your journal, you can keep notes and a running commentary about what you are reading in each unit, write down ideas that occur to you about something in the unit, and note questions about the content or anything with which you disagree. You can use this part to record general ideas about how to use some of the content and strategies in the classroom. If you consistently keep these notes as you work through each unit, then they will serve as a resource when you work on the unit activity, since you will have already put together some ideas about applying the material in the classroom. This is also the section of the journal for your notes from other resources, such as books or articles you read or conversations with colleagues.

Plans

This is the section where you work on your activity for each unit. At the start of each unit, you should start considering what activity you will choose to do, and then develop your ideas as you go along. Each activity will also have specific guidelines.

Observations/Reflections

This is the section where you record your observations about classroom experiences, how students seem to tackle various situations and how each instructional strategy works in practice. This is the place to record your notes after you implement the unit activity about what you feel worked well and what could be improved. If you are part of a group, you can keep your notes about good practice and effective group dynamics, based on the group experience, in this section.

Resources available to you

Although these modules can be completed without referring to additional resource materials, your experience and that of your students can be enriched if you use other resources as well. There is a list of resource materials for each module provided at the end of that module. You can also identify other resources that can enhance the teaching/learning experience, from among materials that may be locally available. These include:

- working examples of energy use in electronic communication or of materials or tools that are available in your environment for scientific inquiries related to these examples
- magazines that have articles about science topics, with the emphasis on the subject of this module
- books and other resources about science that are in your school or community library
- Internet resources (if applicable).

Tips for selecting resources

Working with locally available resources may require selecting those that are most appropriate to help you explore further the module content to your context that may not be complete or relevant. When reviewing materials to see if they will help you with the module, consider:

- Which module topics does this material address?
- Is it possible the ideas in this material are transferable to the science classroom?
- Is it possible the ideas in this material are transferable to the technologies included in the module?

ICONS

Throughout each module, you will find some or all of the following icons or symbols that alert you to a change in activity within the module.

Read the following explanations to discover what each icon prompts you to do.

	Introduction	Rationale or overview for this part of the course.
	Learning Objectives	What you should be able to do after completing this module or unit.
	Text or Reading Material	Course content for you to study.
	Important—Take Note!	Something to study carefully, or a possibly harmful action/substance.
	Individual Activity	An exercise or project for you to try by yourself and demonstrate your own grasp of the content.
	Classroom Activity	An exercise or project for you to do with or assign to your students.
	Reflection	A question or project for yourself— for deeper understanding of this concept, or of your use of it when teaching.
	Summary	
	Unit or Module Assignment	Exercise to assess your understanding of all the unit or module topics.
	Suggested Answers to Activities	
	Equipment	List or description of any apparatus or tools that this activity requires

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Module 2: Energy Use in Electronic Communication



Module 2 Overview

This module is intended to be support material for you to use in your teaching of science. It provides strategies you can use to cover content on energy and electronic communications.

This topic is concerned with the latest communication technology available in our southern African countries. Unfortunately, there is very little documentation in our current text books on this latest communication technology. For this reason, more content than teaching/learning strategies have been included in this module. If you find the extra content familiar, you may go straight to the design of learning activities for your pupils. Remember—the learning activities should bring about hands-on practical work for the pupils.

You are advised to read the module outcomes carefully and to check if these have been achieved after using the module self assessment activities.

Module Objectives

This module aims to make you aware of the latest technology in communication in southern African countries, and to help you teach the scientific concepts behind this technology.



Learning Outcomes

- Identify the latest technology used in communications in your country.
- State the scientific principles on which the latest local electronic communications are based.
- Understand the energy conversions that take place in the latest communications technologies.
- Demonstrate the energy forms involved in electronic communication.

Unit 1: Energy Use in the Cell Phone



Introduction

Electronics equipment and technology seem far-fetched and out-of-this-world for many rural children in the majority of sub-Saharan countries. Despite the widespread use of electronics in the early 1950s in the western world, and the developments in miniaturisation that led to the production of integrated circuits and microprocessors, this technology only began to make an impact on most developing countries in the 1980s. The reasons for this and the importance of electronic communication in development are not, however, the subjects of this unit.

This unit is intended to increase your awareness of the ways energy is used in electronic communication technologies in the world in general, and in African countries in particular. Whether or not the technology is available at your school, it is likely that the technology covered in this unit will have an impact on your pupils' lives at one stage or another. For this reason, it is important for pupils to develop an awareness of the different types of electronic communication technologies available.



Objectives

By the end of this unit you should be able to:

- describe how a cell phone works
- explain the scientific principle that governs the working of a cell phone
- encourage pupils to carry out research in science
- learn the skills of planning and organising meaningful educational tours and field trips
- develop the skills to help pupils formulate research and survey instruments to collect data and interpret it in a scientific way



Content

Waves

In your own secondary school science classes, you probably remember learning about transverse and longitudinal waves. What is the difference between the two?

You might recall your teacher demonstrating waves using a rope tied to a fixed object at one end and shaken from the other, as shown in *Figure 2.1*.

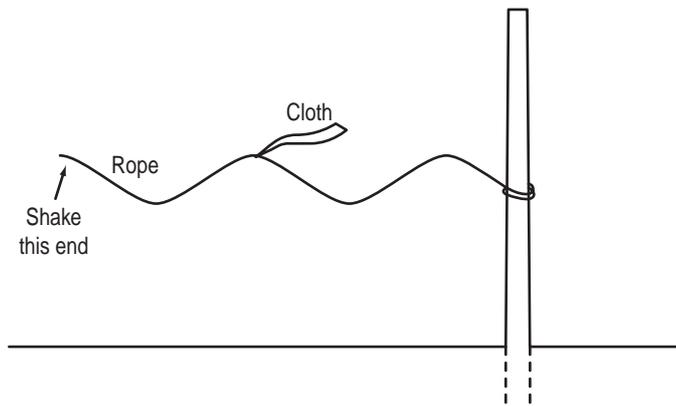


Figure 2.1: Demonstration of “waves” in a rope.

- What type of wave is formed?
- Give another situation where you can see this type of wave.
- Did your teacher ever draw your attention to an accordion or wind blowing over a wheat field? What type of wave is this? The first wave is a transverse wave, the second is a longitudinal wave.
- How can you show that there is energy in a wave? When you place a cork in a water wave you can see it bob up and down and energy is causing this to happen.



Electromagnetic Waves

Another type of wave you may not be familiar with is the **electromagnetic wave**. It is called an electromagnetic wave because it has an **electrical field** and a **magnetic field**. These two fields are always at right angles to each other. The following activity, illustrated in *Figure 2.2*, will help you demonstrate the two fields to your students. The conductor is connected to a source of a direct current (e.g., a battery).

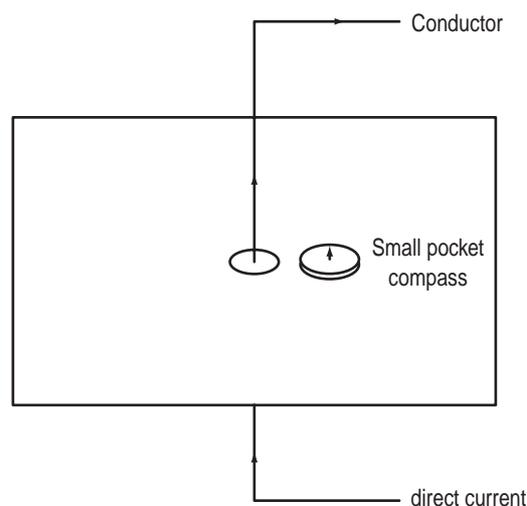


Figure 2.2: Experimental demonstration of electrical and magnetic fields.

- What happens when a conductor carrying a current is brought near a small pocket compass?
- What happens when the compass is brought near the conductor carrying the current?
- Why does the compass behave this way?
- What conclusion can you draw from your observation?

Set up another experiment as shown in *Figure 2.3*.

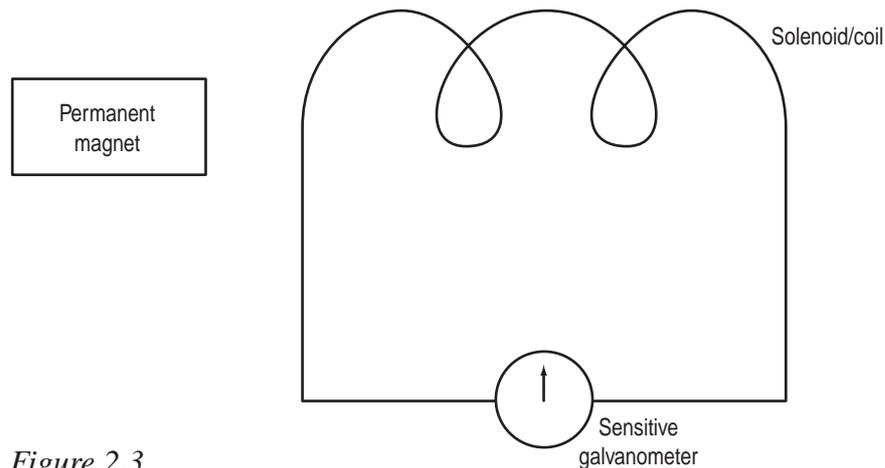


Figure 2.3

A **solenoid** is a coil of wire. When a current runs through the wire, the coil becomes an **electromagnet**. The magnetic strength of the solenoid depends mainly on:

- (a) the amount of current in the wire
- (b) the number of “turns” of wire
- (c) the magnetic “permeability” of the core (e.g., air versus iron bar)

Note: For more information on this topic please consult a physics textbook, electronic sources, or consult with a colleague who is knowledgeable in this field.

- What happens when the magnet is brought near the coil?
- What happens when the magnet is moved away?
- What conclusion can you draw from your observation?
- What two fields have we established in these two activities?



Electromagnetic Field

The electrical and magnetic fields co-exist, and they are always at right angles to each other, as shown in *Figure 2.6*. Get two pieces of cardboard paper (A & B), and make slits in the middle, as shown in *Figure 2.4*.

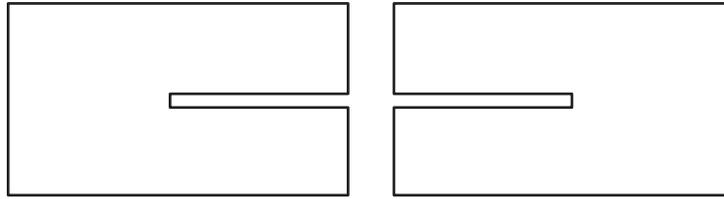


Figure 2.4: Illustration of components of electromagnetic fields (a)

Push Card A into the slit on Card B. The only way they fit together is if one card is horizontal and the other is vertical. (*Figure 2.5*).



Figure 2.5: Illustration of electromagnetic field components (b)

Draw a wave on the vertical card and draw another wave on the horizontal card, as shown in *Figure 2.6*.

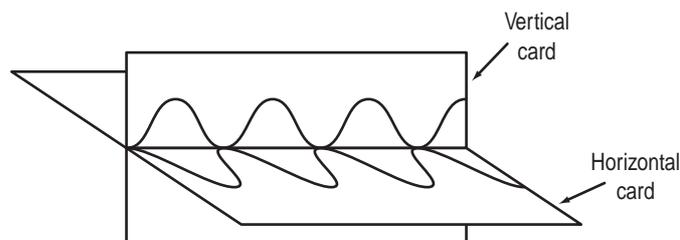


Figure 2.6: Illustration of electromagnetic field components (c)

This represents an electromagnetic wave, with an electrical field and a magnetic field. Each time you have a magnetic field near a conductor, an **electromagnetic force** (emf) is induced in the conductor. When you have an emf in a conductor, a magnetic field is produced. The two fields carry energy. The illustration in *Figure 2.6* is equivalent to the following representation of electromagnetic waves. (*Figure 2.7*)

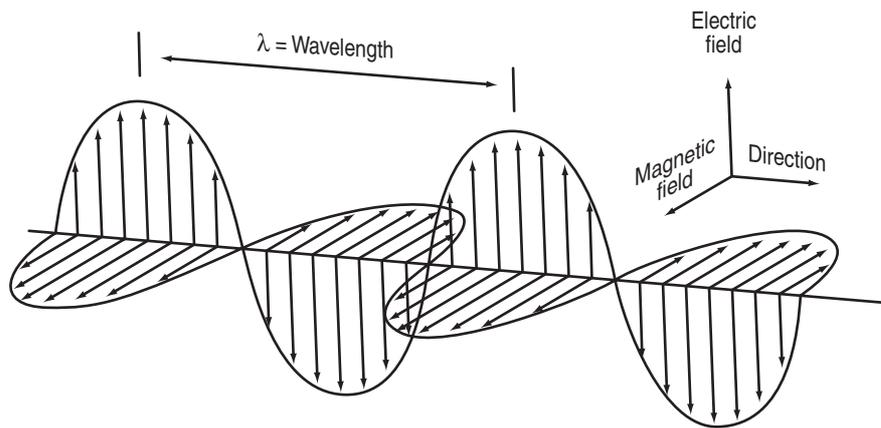
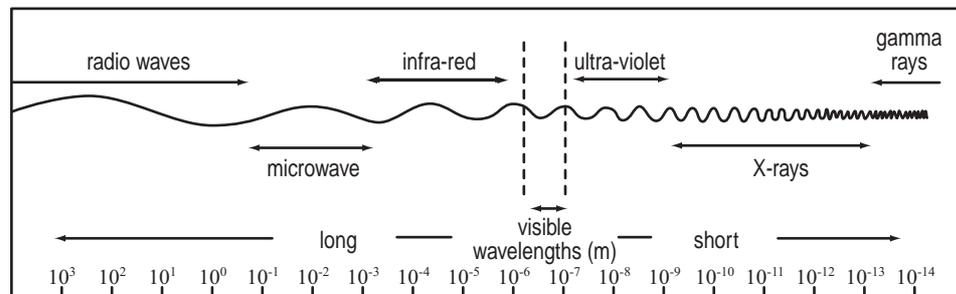


Figure 2.7: Electromagnetic waves



Electromagnetic Spectrum

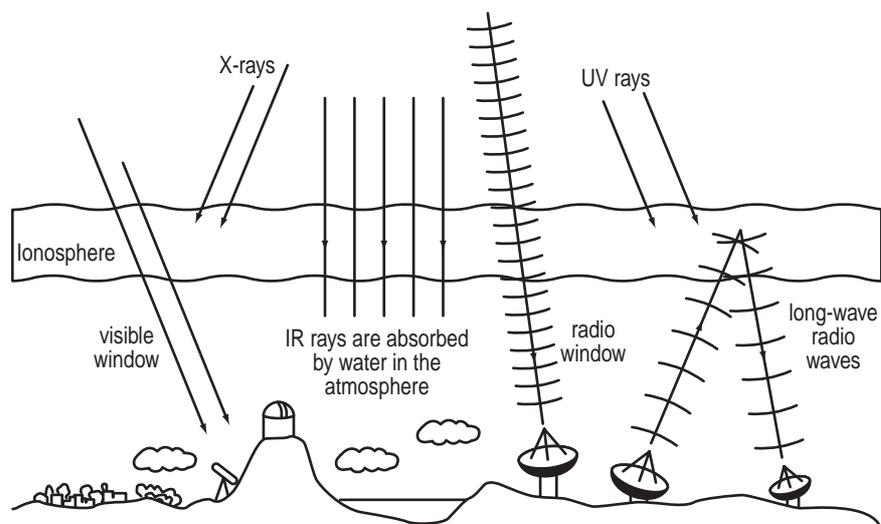
An electric current is not the only source of an electromagnetic wave. The sun is a higher source of the electromagnetic spectrum. The electromagnetic spectrum consists of many types of waves. Figure 2.8 shows the different types of waves.



The range of the electromagnetic spectrum

Figure 2.8: Types of waves in electromagnetic spectrum

Only a small fraction of the electromagnetic spectrum is covered by the visible wavelengths, as shown in Figure 2.9.



Only selected frequencies are allowed through the atmosphere

Figure 2.9: Types of electromagnetic spectrum waves that cross the atmosphere



Wavelength and Frequency

Did you notice that *Figure 2.7* is laid out according to the **wavelength** of the waves, while *Figure 2.8* refers to **frequency** of the waves? These are the two ways to measure a wave of any type. For the entire electromagnetic spectrum, they are in inverse relationship according to this formula:

$$\boxed{v \times \lambda = c} \Rightarrow \boxed{\lambda = \frac{c}{v}}$$

where v represents frequency in hertz, and λ is wavelength in metres.

The **wavelength** of a wave is the distance from one wave peak or crest to another.

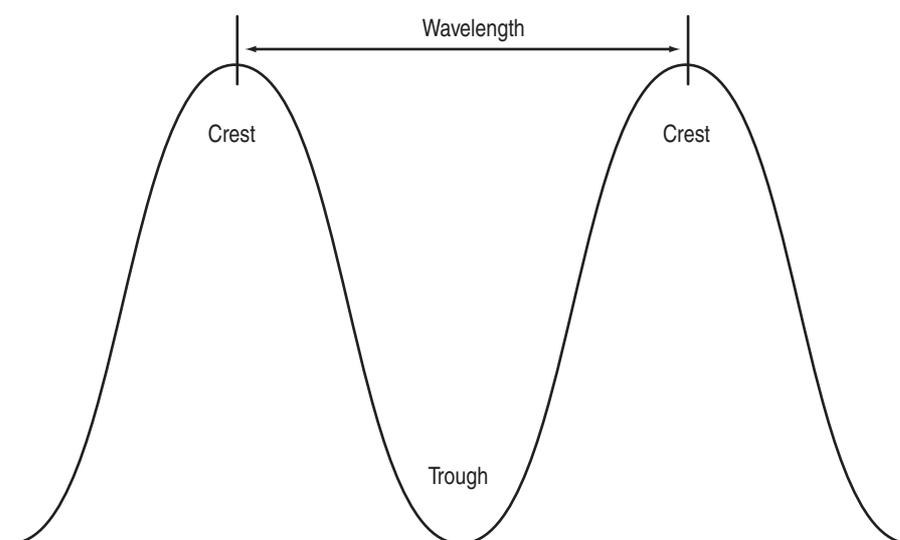


Figure 2.10: Wavelength

The **frequency** measured in hertz is the number of waves that pass one point in a second. “ c ” is the speed of light in a vacuum, equal to 3×10^8 metres per second. From the equation in the formula above, your students can determine the length of the waves coming from a local radio station. For example, if the station broadcasts at 610 kilohertz, the frequency of its carrier wave is 610,000 hertz, or waves per second. Divide that into “ c ”, and the resulting wavelength is about 492 metres.

$$\text{Wavelength } (\lambda) = \frac{c}{v} = \frac{300,000,000}{610,000} = 491,80 \cong 492 \text{ m}$$

The electromagnetic spectrum is usually defined by frequency. For example, radio stations always give their carrier frequency in kilohertz or megahertz, and those are the units on radio dials.

In later units of this module, we will use frequency when we discuss radio waves.



Electromagnetic Wave Windows

There are many types of waves in the electromagnetic spectrum and not all of them reach the earth. Some of these waves are dangerous to life on earth. There is a layer above the earth known as the **ionosphere**. This layer absorbs most of the dangerous waves coming from the sun.

The waves that do reach the earth are transmitted through areas known as windows. These are the **visible range window** and the **radio window** as shown in *Figure 2.9* above.

The ionosphere also internally reflects radio waves sent at a critical angle. (*Figure 2.11*)

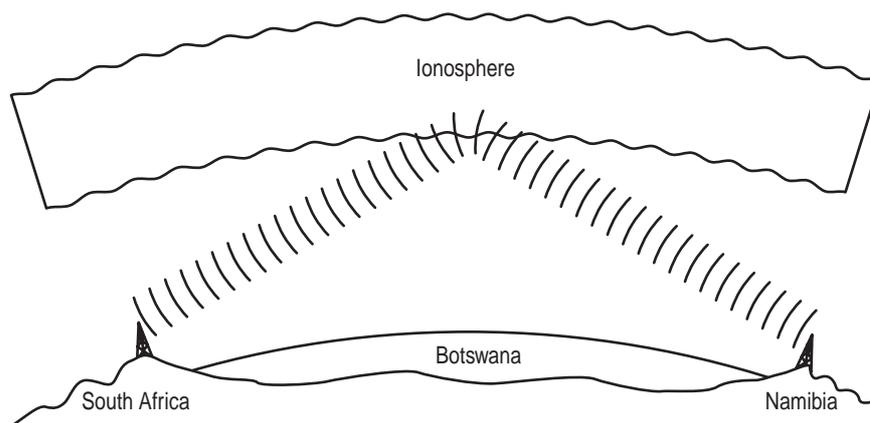


Figure 2.11: Reflection of radio waves by the ionosphere

This phenomenon of radio wave reflection by the ionosphere is taken advantage of in television and radio communications, as shown in *Figure 2.12*.

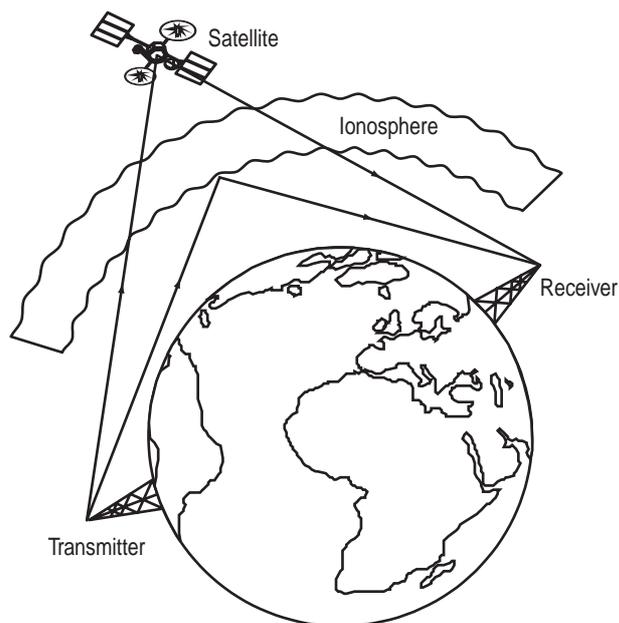


Figure 2.12: The role of the ionosphere in radio and TV communication



The Cell Phone

Radio waves are often associated with radio receivers. However, modern developments in technology have seen radio waves used in such telecommunication devices as the cell phone.

The cell phone is so named because it operates on cells that resemble a honeycomb. At the centre of each cell is a **radio base station (RBS)** which receives and transmits information in the form of radio waves. The cells are connected to a **mobile switching centre (MSC)**. This centre is responsible for directing calls to their destination in the cellular network or to a fixed line telephone. *Figure 2.13* shows the different stages of communication in using a cell phone (simplified).

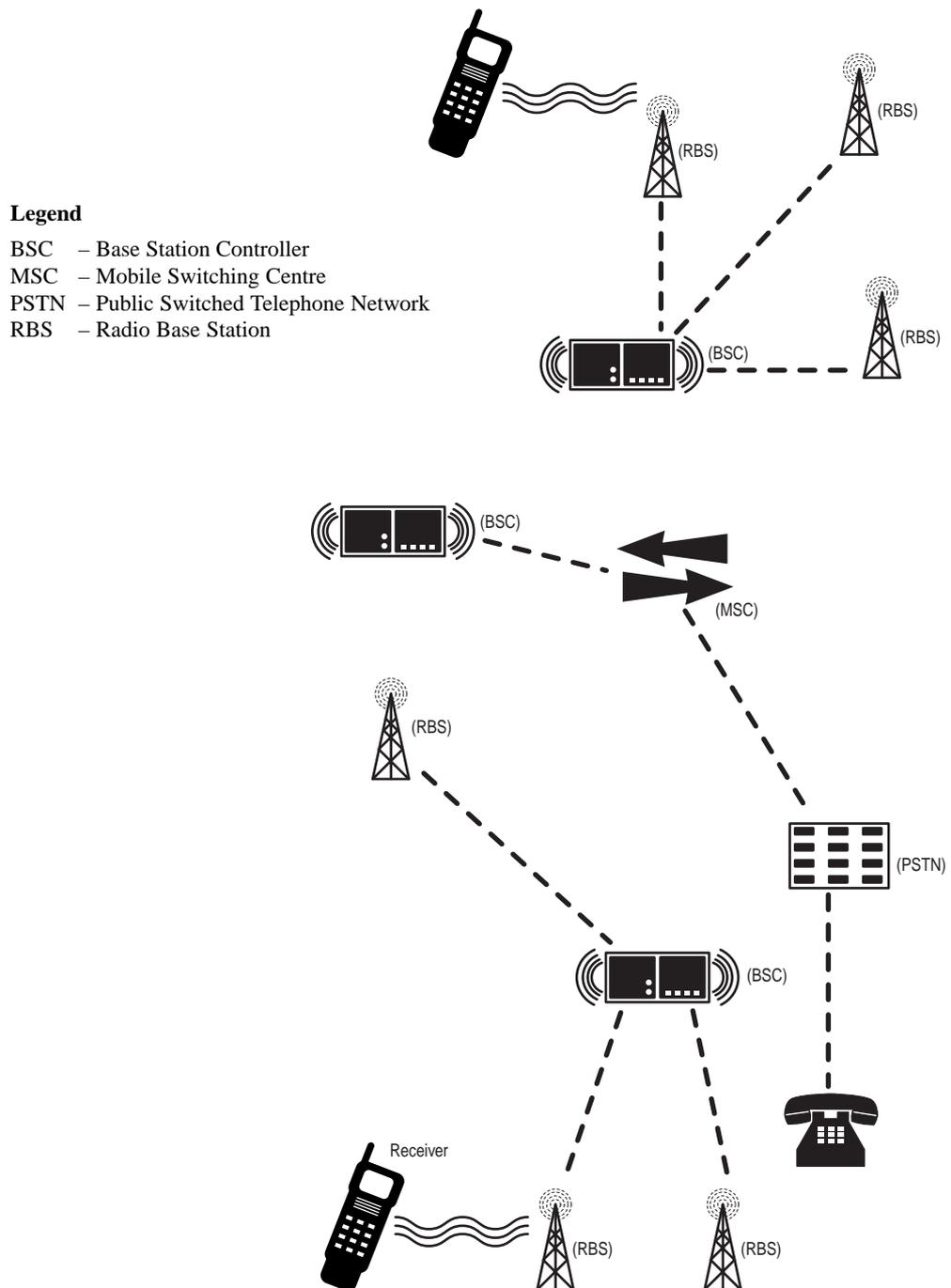


Figure 2.13



Optical Fibres

The different stages in communicating with a cell phone are connected by either radio waves or **optical fibres**.

- What is an optical fibre?
- How does it help in communication?

An optical fibre is a tube, made of pure glass, that is as thin as a single strand of hair. The tube has a cladding (covering or coating), also made of pure glass but which has a different optical density than the tube itself.

Sound and data are converted into light and transmitted through the tube. Because the central tube and the cladding have different refractive indices, total internal reflections occur when light is transmitted through the tube, as shown in *Figure 2.14*.

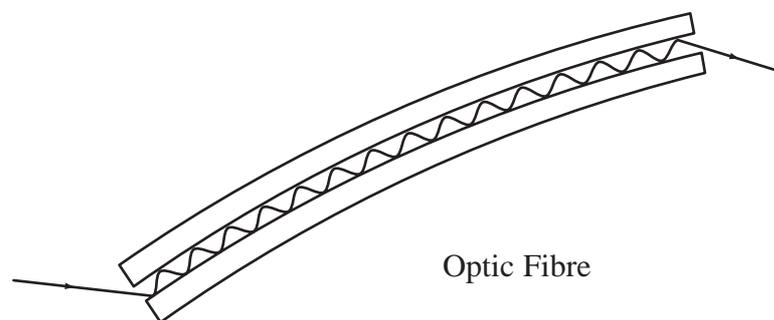


Figure 2.14

When we speak into a fixed telephone receiver, the sound energy is converted into electrical energy which goes to a light emitting diode. The diode flashes at the rate at which the electrical impulses reach it. These light impulses are sent through the tube to the other end where a light-dependent resistor converts light impulses into electrical impulses which are then converted back into sound. These optical fibres can carry over 9000 messages at a time without interference.



Classroom Activity 1

Pupils are likely to enjoy the study of the cell phone if they have an opportunity to visit a base station commonly known as a radio base station (RBS).

Organise your class and form a committee that will write and seek permission to visit a radio base cell phone network provider in your country. Be sure to get the permission of your school head, education officials, and parents to go on a field trip. If your school is far away from the RBS, you may need to source for funds to cover the cost of transportation. When all formalities and travel arrangements have been approved and completed, work may begin on the academic preparation for the trip.

Before you set out on the field trip, ask yourself the following questions:

- What does the RBS offer?
- What do you want your pupils to learn?
- Is there a relationship between what you want your pupils to learn and what the RBS can provide?
- Is it possible to get the same information by inviting one person from the RBS to come to the school, or, through gathering information by available channels of communications (e.g., mail, telephone, etc.)?

This means you have to decide whether to visit the RBS or invite a person from the RBS to speak to your class. If you decide to go to the RBS, you will need to assess what they have and how pupils can get maximum educational benefit from the visit. Once you are satisfied that your pupils will definitely benefit from the field trip, organise and produce a research questionnaire that your pupils will use on the trip. Consider the following points when preparing your questionnaire:

- What are the important points your research questionnaire needs to cover?
- What skills or new information are the pupils likely to acquire?
- Can they get most of this information from text books, or will a field trip be the most effective way for them to gather this information?



Compare your handout or research questionnaire with the example below:

Research Questionnaire

Place Visited: _____ Date of Visit: _____

Objectives of Visit are to:

- Learn about the technology used in cell phones and electronic communication.
- Identify sources of energy for the cell phone and how this energy is converted from one form to another.
- Identify and list the energy transducers in the **Global System for Mobile (GSM)** telephone network.
- Investigate the scientific principles involved in electronic communications systems used by the cell phone.
- Find out the technology used at the RBS that provides cell phone service.
- Assist your pupils to find answers to the following questions from the staff at the base station.

Sample Questions:

- What does GSM stand for?
- What is the infrastructure required for the cell phone to operate?
- What moves from the cell phone to the RBS?
- What is a **Silicon Light Machine** (SLM) card?
- What does the energy in the SLM card change into?
- How does the RBS transmit messages?
- What kind of energy is in an RBS?
- What is a base station controller?
- What is a cell phone tower?
- What form of energy is in a base station controller?
- What energy conversions take place in a **base station controller** (BSC)?
- What is an optical fibre?
- How does it transmit information from one point to another?
- Which scientific principle is the optical fibre based on?
- Is there any energy loss in an optical fibre?
- How does the optic in a **Special Sensor Microwave Network** (SSMN) telephone work?
- Where else are optical fibres used?
- What are the advantages of optical fibres over copper wires?

When you are satisfied with your handout, and the pupils have discussed it and added their own questions, you can use it on your field trip. You might also need to comment or ask the base station staff for additional questions and areas of interest in the cell phone communication system.



On the Field Trip

Ensure that pupils are in small, manageable groups and, if possible, try to have more than one person at the base station to attend to your class. Have the groups move from area to area throughout the station, asking questions where possible. At the end of the field trip, before you leave the RBS, have a plenary session so that areas and issues of concern can be clarified.

After the Field Trip

Back in the classroom/lab ask your pupils to do a summary of the work covered and stress those areas pointed out in the objectives. Design an exercise to consolidate work covered on the field trip to the GSM telephone network.

Compare your exercise to the example given in *Figure 2.15*, part of a GSM telephone network.

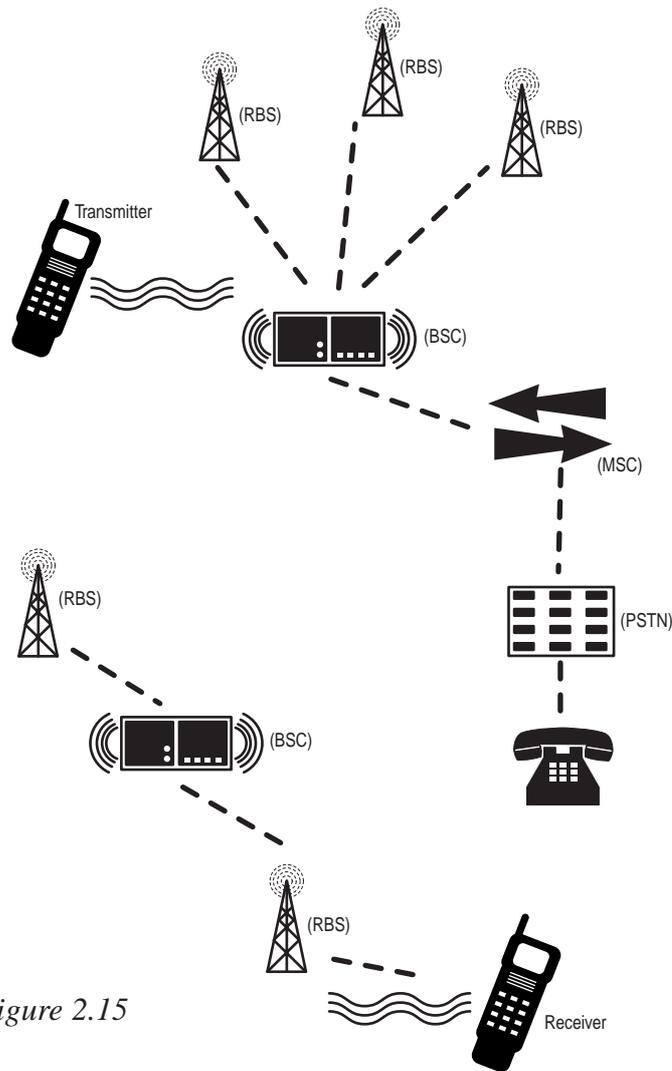


Figure 2.15

- What are the points marked:
 - RBS?
 - BSC?
- What is the source of energy in the part marked BSC?
- What are the energy conversions between:
 - MSC and RBS?
 - BSC and RBS?

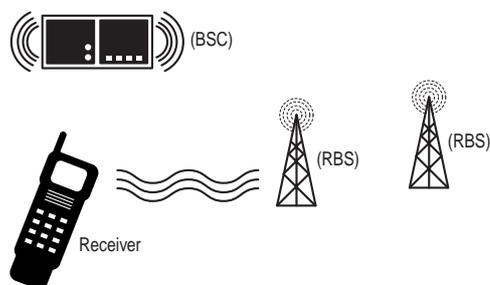


Figure 2.16: Communication from a base station controller (BSC) to a receiver.

- Where in the circuit are we likely to get optical fibres being used?
- Describe the energy conversions that take place between the RBS and the receiver via the optical fibre.
- What is the impact of this technology on the economy of countries dependent on copper mining?



Classroom Activity 2

Look through your syllabus for topics on communication and choose one which is suitable for pupils to research. Ask your pupils to design their own mini-research questionnaires, then carry out the research, collect data, and analyse it in order to reach a conclusion.



Summary

- Electromagnetic waves play an important role in electronic communication.
- The operation of a cell phone is based on electromagnetic waves.
- In telecommunications, fibre optics has the highest capacity for carrying messages.

During a call made from a cell phone, sound energy goes through many conversions:

- from electrical energy, to electromagnetic wave energy, to radio waves, to microwaves, to electrical energy, to light energy carried in an optical fibre, then to electrical energy, and finally to sound energy again.

Research and field work exposes pupils to the real life situations where they are able to see scientists and technicians at work, and possibly find role models.



Reflection/Assessment

Review the results of the field trip and your research questionnaire, and ask yourself the following questions:

- Have you ever taken your pupils on a field trip before this exercise?
- Are there any differences between your last field trip and this one? Describe the differences.
- Which questions really required a visit to the GSM telephone network?
- Which questions could be answered from reading literature on cell phone operation?
- What are the advantages of having a questionnaire that is easily understood by the pupils on a field trip?

- Are there ways you can improve your questionnaire?
- Can you think of ways to improve your field trip preparations?



Unit Assignment

1. What is total internal reflection?
2. Describe how a cell phone works.
3. On what scientific principle is the cell phone based?
4. What is an optical fibre?
5. Where in the cell phone communication are you likely to have optical fibres?
6. What is a wave?

Unit 2: Energy Use in Remote Sensors



Introduction

Many people are surprised when they see remote-controlled instruments such as TV sets, radios, car locking systems, remote-controlled gates, etc. Little do they realise that almost all animals have some form of remote sensors. You might be interested to know that most of our “remote sensor” technology is based on some part of the living organism. The camera is an imitation of the eye. The tape recorder is an imitation of the brain retaining information and later replaying when we remember things that happened long ago.

In this unit you will learn about sensors in our bodies and how the same principles, to some extent, have been used in different types of remote sensing techniques.



Objectives

By the end of this unit, you should be able to:

- explain what remote sensor technology is
- identify the different types of remote sensors
- describe how a remote sensor controls a TV/radio or central locking system of a car
- identify different types of satellites
- describe how a satellite works
- design learning activities that will help pupils learn about remote sensor technology through a practical hands-on approach



Content

Remote Sensor Technology

Remote sensor technology is not as complicated as it might seem, even though there are no connecting wires or levers involved. Think of what happens when a button is pressed and the doors of a car automatically lock or unlock. (*Figure 2.17*)

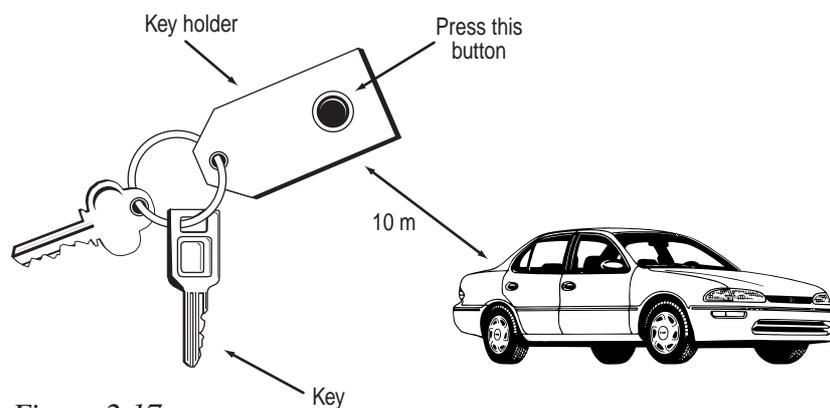


Figure 2.17

If you plug an electric heater into a socket and sit on a chair nearby, you are quite comfortable and enjoy the warmth from the heater. (*Figure 2.18*)

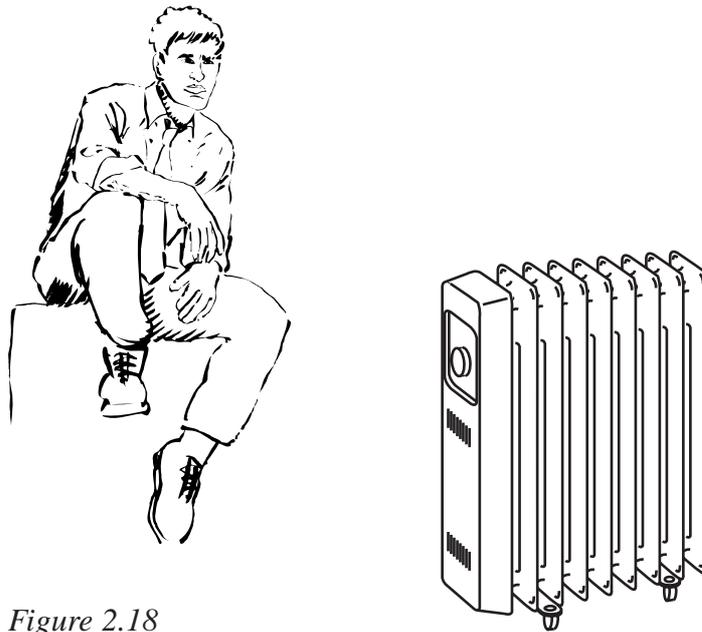


Figure 2.18

Ask yourself the following questions:

- How does the heater generate heat?
- What makes you keep the right distance where you are neither too hot nor too cold?
- Is there any other way to tell if the heater is on?

Possible answers include:

- The electricity passes through the wire on the heating coil and the coil becomes an energy converter (electrical energy is converted into heat and light energy).
- The skin can feel the heat. It is a remote sensor.
- You can see the heater glowing. The eye is also a remote sensor.



Body Sensors

The basic and natural processes that occur in the human body were copied and transformed into the remote sensor technology that controls TV, radio, and many other gadgets.

Ask your students to name other **sensors** in the human body. Take note that we refer to them as sensors, not remote sensors.

Passive Sensor/Active Sensor

There are different types of sensors.

1. Passive sensors only receive signals.
2. Active sensors send out signals which are then reflected back and detected by the sensor.

The active sensor principle is used in some satellites and will be discussed later in this unit.



Classroom Activity 1

Different types of sensors respond to different stimuli. Have your students copy and complete the table shown by writing in the appropriate stimuli.

Sensor	Stimuli
Ear	
Eye	
Nose	
Tongue	
Skin	



Satellites

These are launched into orbit by powerful rockets. To understand how the satellite stays in orbit, have your pupils work through the following activity.

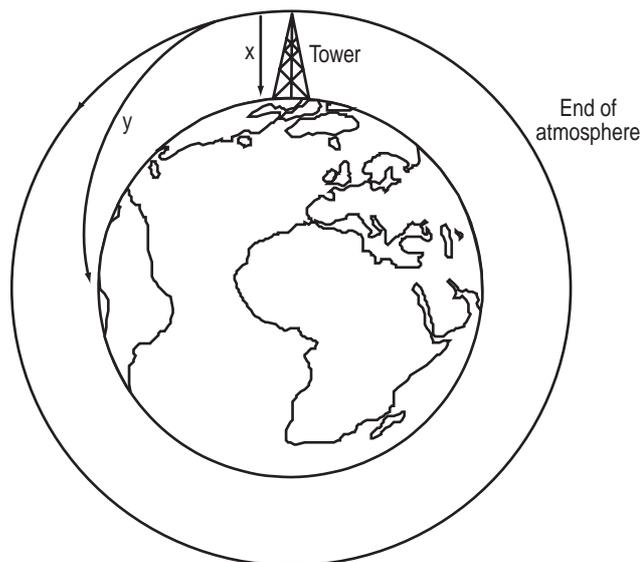


Figure 2.19

Imagine an astronaut standing on a very tall tower that goes to where the atmosphere ends (*Figure 2.19*). The astronaut has three balls. The first ball is dropped downward and it follows the path marked x. Another ball is thrown sideways. What happens to it? It would fall but further away from the tower as shown by the path marked y. If the astronaut were able to throw the ball hard enough the ball would follow a curved path around the earth and would not fall. This ball would then be “in orbit” around the earth.

This is what happens with satellites. They are launched into orbit by very powerful rockets. Some satellites remain close to the earth and are called low orbit satellites. Low orbit satellites travel at very high speeds. A satellite which is 300 km above the earth moves at a speed of 29 000 km/hr in order to maintain its circular path and orbits the earth once every ninety minutes. If this low orbit satellite were to slow down, even by a fraction of a kilometre per second, it would fall and crash to the Earth.

Did you know there are satellites orbiting about 36 000 km above the earth? These satellites move at a slower speed, at about the same speed as the earth rotates. Because they orbit the earth every 24 hours, they appear to be stationary. This type of stationary satellite is called the **Geo Stationary Satellite**. (*Figure 2.20*)

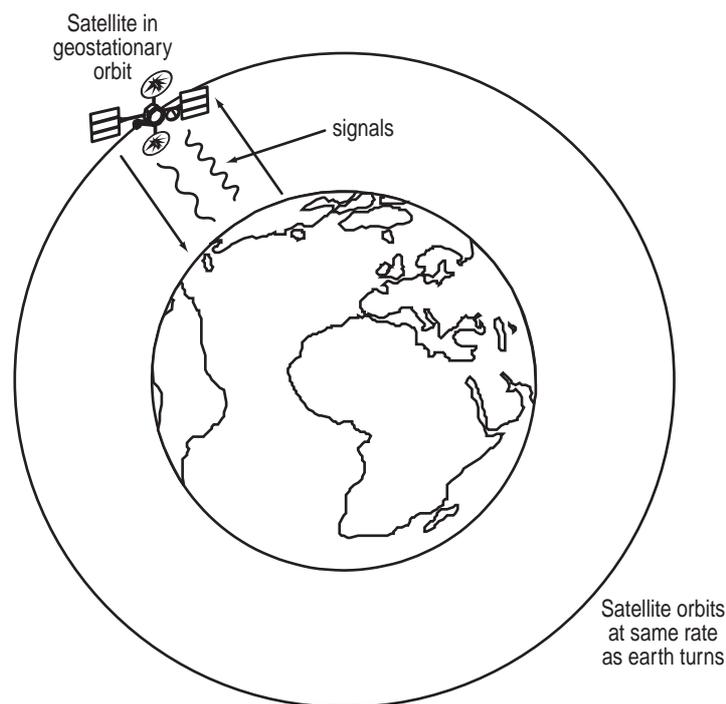


Figure 2.20

A Geo-Stationary Satellite is used for communication. It beams microwaves, carrying TV and radio waves, that are received by fixed dishes at satellite stations or on the roofs of buildings or homes.

Ask your students to explain why it is not necessary to move the satellite dish in order to track the satellite.

Communication is so important that the development of a nation can be measured by the degree of sophistication of its communication systems. Electronic communications are becoming increasingly popular because of the low cost in sending and receiving messages.

Among the many and varied communications systems, remote sensing appears to be ultra-modern in that the first remote sensing weather satellite was launched in the 1960s, and the first satellite used to study the earth's surface was launched in 1972. It is known as Land Sat 1.



Classroom Activity 2

Figure 2.21 shows a group of children warming themselves by the fireside. Design a set of questions that you would use to introduce or talk about natural remote sensing in a human being or in other animals.



Figure 2.21

If you find this diagram too restrictive, try to think of other interesting ways to help pupils learn independently about natural remote sensors.

The first thing you must do is make sure your pupils have experienced and understand remote sensing as being able to get information from a source without having direct contact with it (in this case, heat from the fire). Once they understand this, you can ask them questions about the children standing by the fireside.

Have your pupils look at and discuss the illustration. The following questions are suggestions for the type of questions you can use to guide your pupils through this activity.

1. What is remote sensing?
2. Which parts of the human body are sensors?
3. (a) Which sensors are remote sensors?
(b) Why are the others not remote sensors?
4. What does each of the sensors respond to?
5. List and explain the limitations of each sensor.
6. Describe an artificial sensor you have used in your life.
7. What are the limitations of these artificial sensors?

You should answer these questions yourself before asking your pupils to answer them. Compare the answers given by your pupils to your answers.

Following are some possible answers to questions above. They are open to debate and should not be considered to be the only correct answer.

1. Remote sensing involves getting information from a source without having direct contact with it.
2. Tongue, ears, eyes, skin, nose.
3. (a) Ears, eyes, skin.
(b) The tongue is not a remote sensor as the substances must be touched by the tongue to be tasted.
4. Eyes respond to visible electromagnetic radiation.
Ears are stimulated by pressure waves in the atmosphere.
Skin is stimulated by the thermal infra-red band and detects heat energy.
5. The eyes cannot see through thick clouds or opaque substances. The eyes cannot see around corners or through walls.
The ears can only detect sound within the range of 30Hz – 20 000Hz.
The skin cannot detect other forms of radiation and can be damaged by some types of radiation.
6. The camera is an imitation of the eye. It makes use of the electromagnetic spectrum to form images.
7. A camera cannot photograph through opaque or solid objects, and cannot photograph around corners.



Individual Activity 1

Using a device such as a remote-controlled TV or radio, design learning activities for your pupils. Your activities should include the study of the remote-controlled central locking system of a vehicle. Your activity should force pupils to carry out meaningful and relevant practical work.

Once more compare your learning activity with those suggested below. Try to analyse the two learning activities by identifying the weaknesses with a view to improving them.

Try to secure a television, radio, or car with a remote control system and do the following activities or have your pupils perform them.

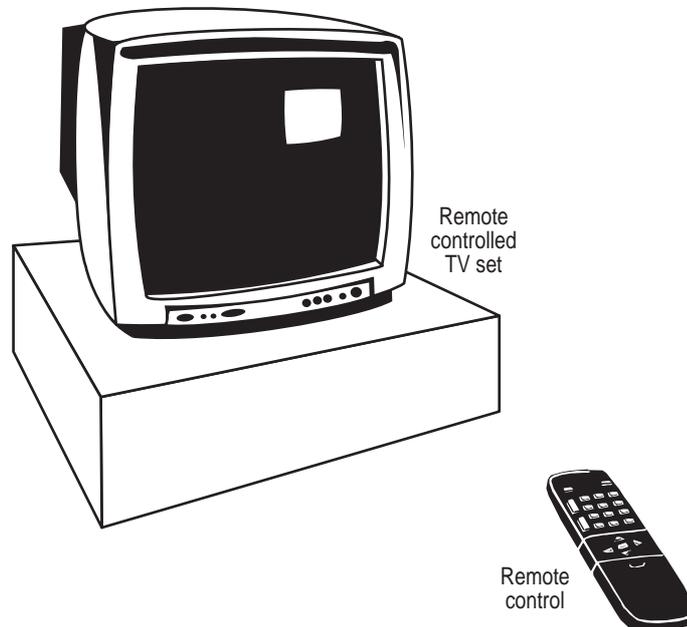


Figure 2.22

1. Place a remote-controlled TV set (or other remote-controlled device) at least two metres from the sensor. Switch on the remote sensor so it triggers an action on the TV set. (*Figure 2.22*)
2. Switch off the remote control. What happens?
3. Switch on the remote control. What happens?
4. Point the remote control in different directions:
 - away from the TV set
 - upwards
 - sideways
 - downwardsSwitch the remote control on and off in each case. What happens?
5. What do experiments 2, 3 and 4 tell us about the nature of the energy travelling between the remote control and the TV set?
6. Try blocking the remote control with such materials as plastic, paper, glass, cloth, your hand, and any others materials you have available. What happens in each case? Create a table like the one below to record the results of your investigations.

Material	Allows Energy to Pass	Energy Does Not Seem to Pass
Paper		
Cloth		
Glass		
Hand		
Plastic		

3. Design and carry out an experiment to find the farthest point from which the remote sensor is effective.
 - Based on your observations and the data collected, what conclusions did you reach?
 - What is the source of energy for the remote control?
 - What travels between the remote control and the TV set?
 - Explain the energy conversions from the remote control to the TV set.
 - What do you think the properties are of whatever passes between the remote control and the TV set?
4. Does the sensor in a car with a remote-controlled central locking system operate on the same principle as the TV set? Explain your answer.
5. How does this remote control system compare with radar?



Summary

- Remote sensing involves the detection of stimuli from a distance, or the response to stimuli from a distance.
- There are natural and artificial remote sensors. Natural sensors are such things as the skin, eyes, ears, nose, and tongue. Artificial remote sensors include your TV remote control and the control for the central locking system of a car.
- Satellites are launched into space using powerful rockets. The nearer a satellite is to earth, the faster it has to move. There are many satellites orbiting the earth, which are used for communications, monitoring the weather, and many other uses.



Reflection/Assessment

- Identify the lower order questions in the list of questions in your unit activity.
- Identify the higher order questions in the list of questions in your unit activity.
- Design a learning activity that will help your pupils learn about satellite communication.

Sample activity:

Satellite communication provides the satellite images and weather reports you receive on your TV set. Show your pupils the satellite image of southern Africa in *Figure 2.23* below. Ask them to identify and describe the steps involved, from the capture of the image to having it broadcast on your TV set.

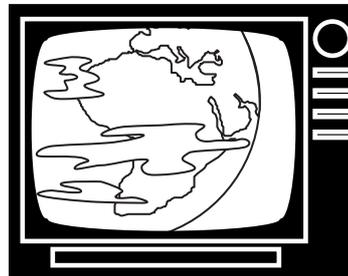


Figure 2.23



Unit Assignment

1. What is remote sensing?
2. Which of the following are remote sensors?
 - a. geo-stationary satellite
 - b. weather satellite
 - c. TV remote control
 - d. eyes
3. Explain how a remote sensor controls a TV set?
4. How is a satellite placed in orbit?
5. How does a satellite work?
6. What is likely to happen if a satellite near Earth suddenly reduces speed by a fraction of a kilometre per second?
7. If a satellite were to be put in a higher orbit, how would this affect:
 - a. the speed of its orbit?
 - b. the time required for one orbit?

Unit 3: Energy Use in Radio Communications



Introduction

In this unit we will discuss how a radio operates and how radio signals are generated, transmitted, and received by your set. You are encouraged to design practical learning activities for your pupils. After all the practical activities, you should organise a field trip for your pupils to a broadcast station near your school, if possible. This will help your pupils understand what they have learned in this unit.



Objectives

At the end of the unit you should be able to:

- describe the characteristics of radio waves
- classify different types of radio waves
- describe how a radio wave is generated, transmitted, and received
- design practical activities that will enable pupils to learn how the radio operates



Content

Radio Waves

It might be helpful to review Unit One, paying particular attention to the electromagnetic spectrum. You will remember that radio waves are transmitted through the ionosphere through the radio wave window. Radio waves have a range of frequencies, all greater than 30 kHz. A classification of radio wave frequencies is provided in the table in *Figure 2.24* below.

Radio Wave Classification	
<i>Frequency Band</i>	<i>Classification</i>
30kHz – 300kHz	Low Frequency (LF)
300kHz – 3MHz	Medium Frequency (MF)
3MHz – 30MHz	Very High Frequency (VHF)
30MHz – 3GHz	Ultra High Frequency (UHF)
Above 3GHz	Super High Frequency (SHF)

Figure 2.24



Individual Activity 1

1. Does this information on frequency bands remind you of anything?
2. What do the following abbreviations stand for: kHz, mHz, gHz?
3. Which frequency is commonly used by the police in your country?
4. What do kilo, mega, and giga mean?



Individual Activity 2

1. Radio waves reach their destinations in a variety of ways, depending on the strength of the transmitter. Some radio waves travel through space to a communication satellite and are then beamed to a receiving aerial. Other radio waves are reflected by the ionosphere to the receiving aerial, and some radio waves travel just above the surface of the earth to the receiving aerial.

Draw a diagram that clearly shows the three different radio waves.

2. Which frequency range is likely to constitute the space waves?



Modulation

A **modulator** combines the audio frequency from a microphone with a radio frequency. The combined signal is sent to an amplifier before being transmitted. The combination of audio and radio frequencies takes place in the transmitter, as shown in *Figure 2.25*. The amplitude modulation commonly referred to as AM is used for medium, long, and short wave broadcasting.

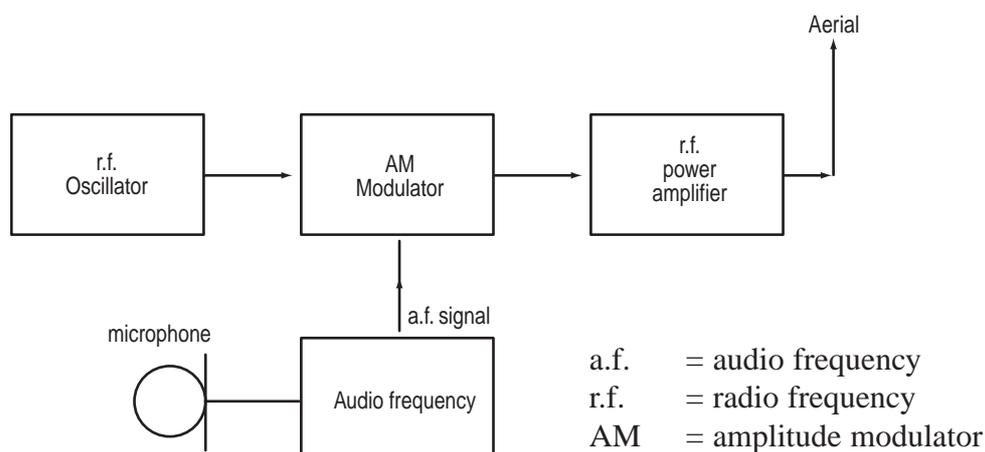


Figure 2.25

At the receiving station, the combined signal is detected in the **demodulator**. The modulated signal is separated and the audio frequency goes to the speaker where sound is produced. This is summarised in *Figure 2.26*.

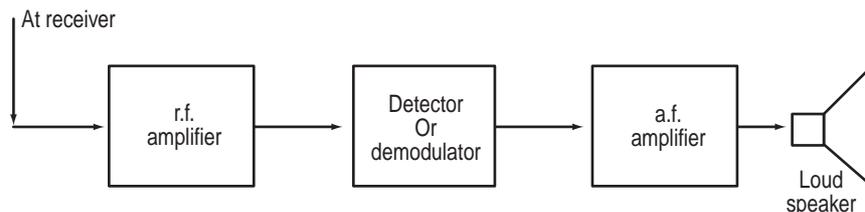


Figure 2.26



Individual Activity 3

Despite the block diagram explanation on the transmitter, you need more information on transmission. You should be asking questions such as how is the radio wave transmitted? How does this transmission take place?

The following examples in this activity show how radio waves are generated by the transmitter. However, there are more sophisticated devices that generate radio waves of constant frequency and wave length.

Let us start with a simple circuit connected to a single bulb (*Figure 2.27*). What happens when you switch on the circuit?

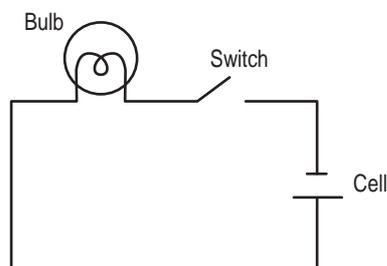


Figure 2.27

You notice that the bulb lit up. Did you also remember that a magnetic field was produced around the wire? How can you verify the existence of the magnetic field around the wires?

Turn off the circuit.

If you remove the bulb and replace it with two copper ball bearings, as shown in *Figure 2.28*, then switch on the circuit, what happens? If one ball were positive and the other negative, which one would be positive? What kind of field surrounds this ball? Or, is there a field at all?

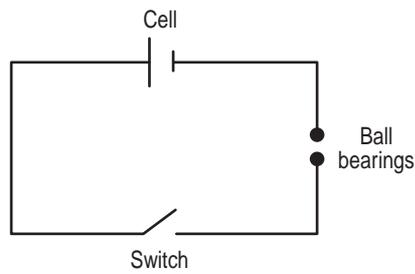


Figure 2.28

Turn off the circuit.

Place a small pocket compass between the two ball bearings and switch on the circuit. What happens to the plotting compass? What conclusion can you draw from your observation?

If you remove the cell and the switch and replace them with an alternating current, as shown in Figure 2.29, what happens?

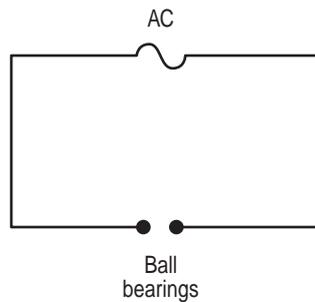


Figure 2.29

Remember each time you switch on the current, a magnetic field is produced. This is shown in Figure 2.30.

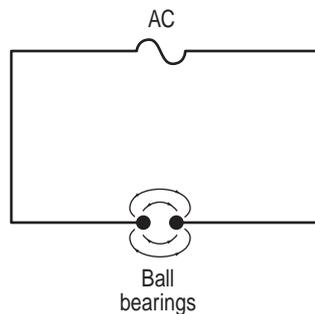


Figure 2.30

Every time you switched the current on and off, you sent an electromagnetic wave into the atmosphere. The backward and forward surges in alternating current act as your switch, and electromagnetic waves are sent out.

- Can you think of other instances where an electromagnetic wave is generated?
- What happens when lightening occurs?
- What happens when you switch on a battery-powered radio?
- Can you think of other examples of this type of phenomena?



Classroom Activities

Classroom Activity 1

Design an activity that will help your pupils learn what happens when their radio receives radio waves and sound is produced from the speaker. Before embarking on this activity, make sure you have an old or broken radio you can dismantle and show your pupils the major parts, including the aerial, speaker, and transformer. This activity will help your pupils understand the processes illustrated in the block diagrams in *Figures 2.26* and *2.27*.

Classroom Activity .2

Remind your pupils of the model of electromagnetic waves that you made in Unit One (*Figures 2.4* and *2.5*) and try the following activity.

Study the model of an electromagnetic wave approaching a conductor, shown in *Figure 2.31*.

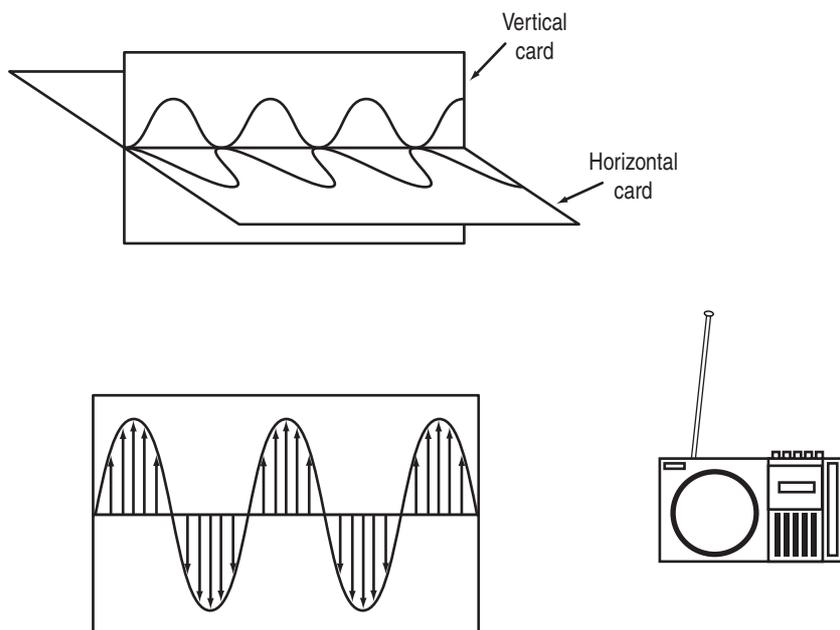


Figure 2.31

1. Which wave is likely to excite particles in the aerial?
2. Why is it likely to excite the particles?
3. What is likely to happen if the electromagnetic waves move backward and forward?

Compare the explanation found in the answer section (at the end of this module) with what you have produced for your pupils. Are there any areas that need improvement? What will you do in order to improve them?

Classroom Activity 3

When you are satisfied with your pupils' understanding of how the radio works, organise a field trip to a local radio station. Remember to go through what you learned in Unit One on your visit to a local cell phone base station or head office. You will need to follow the same procedures for a field trip to a radio station. These procedures are to:

- request permission from staff at the radio station, your head of school, and the parents
- plan the field trip activities
- review the field trip by giving pupils a challenging exercise composed of questions at various levels of difficulty



Summary

- Radio waves are part of the electromagnetic wave spectrum.
- Radio waves can be reflected by the ionosphere. If the wave has a high enough frequency, it can pass through this layer.
- Radio waves can have a variety of purposes, depending on their frequencies.



Reflection/Assessment

1. Did your pupils understand how radio waves are:
 - generated?
 - transmitted?
 - received?
2. Are there areas on how the radio works that need to be clarified to pupils?
3. Can you think of better practicals to demonstrate radio wave generation and reception?
4. Describe these practicals and demonstrate them to your pupils. What was their response?
5. Did you use different types of questions to help pupils learn about the radio? Were these questions effective?
6. Was the activity with the radio worth spending time on? How did your pupils benefit from it? How could you improve this activity?



Unit Assignment

1. What are the forms of energy involved in the radio transmitter?
2. Describe the energy conversions that take place at the transmitting station.
3. Which forms of energy are involved at the receiving radio set?
4. Explain the energy conversions taking place from the transmitter to when you hear your favourite station.
5. Describe the kind of wave that interacts with a TV aerial.
6. Explain why the TV aerials out in the country are often horizontal bars.

Module 2: Suggested Answers for Activities



Unit One

Possible Answers to Unit Assignment

1. Total internal reflection occurs when the angle of incidence is greater than the critical angle.
2. When a call is made on a cell phone, the following events take place:
 - The phone call is transmitted to the RBS at the centre of the cell where you are calling from.
 - RBS transmits the call via microwave or optical fibre cable to the BSC.
 - The BSC transmits the call via microwave link to fibre optic cable to Mobile Switching Centre (MSC).
 - Some calls will be destined for the fixed line telephone network.
 - The MSC re-routes these calls to the Public Switched Telephone Network (PSTN).
 - The PSTN routes these to a specific fixed line telephone.
 - If a cellular call is destined for another cell phone, the MSC transmits the call to BSC and then to the RBS where the recipient of the call is located.

These events all take place in a matter of milliseconds.

Unit Two

Possible Answers to Unit Assignment

1. Being able to detect or respond to stimuli at a distance.
2. Weather satellite.
3. A remote control releases an infrared wave that is detected by the remote sensor on a TV set, radio, car central locking system, etc.
4. Launched by a powerful rocket into space, the speed and fall curvature keeps the satellite in orbit.
5. Satellites are involved in communication. They receive various radio and television signals and beam them back to receiving stations on Earth. Some satellites orbit at the same speed as the Earth rotates and appear to be stationary.
6. The satellite would fall to Earth.
7. a. the speed will be increased.
b. the time to make one orbit will be increased.

Unit Three

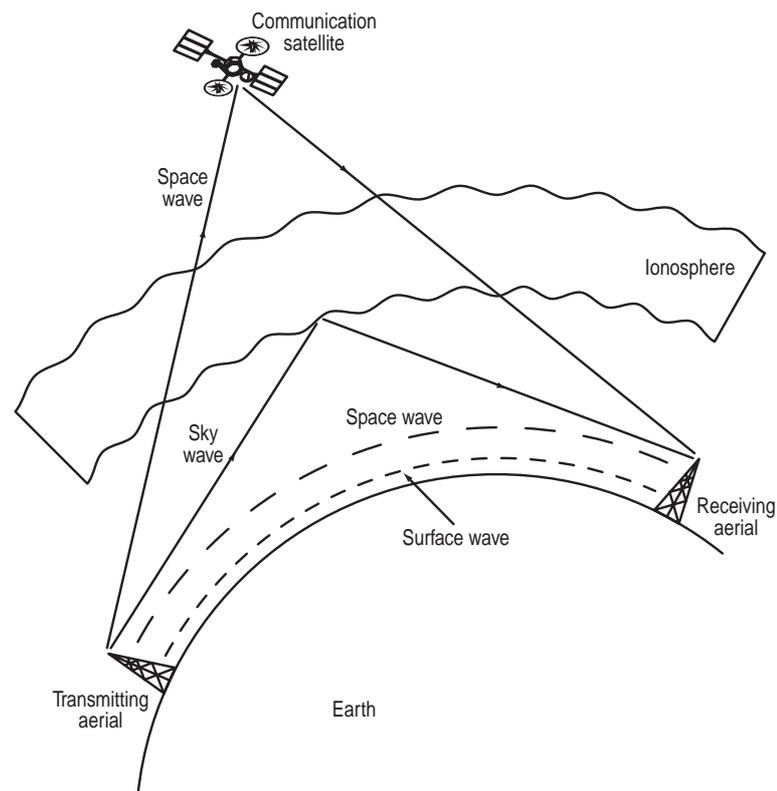
Possible Answers to Individual Activity 1

You may have given the following answers to these questions.

1. The radio wave classification may have reminded you of communication systems used by the police in your country.
2. kHz \Rightarrow kilo hertz
mHz \Rightarrow mega hertz
gHz \Rightarrow giga hertz
3. VHF or UHF
4. Kilo = one thousand
Mega = one million
Giga = one billion

Possible Answers to Individual Activity 2

1. Your diagram should look like the following one:



2. You may have guessed right. The wave must be very powerful to travel this long distance and therefore must be either UHF or SHF.

Different frequency bands are used for different purposes as you can see from the table below.

Frequency Band	Surface Waves	Sky Waves	Space Waves
low frequency	medium range communication	long range communication	
medium frequency	low sound broadcast	distant sound broadcast	
very high frequency		distant sound broadcast	
ultra high frequency			television
super high frequency			microwave communication weather satellites telephone links

Possible Answers to Classroom Activity 2

- Remember what happens when a conductor cuts across a magnetic field? An **electromotive force** (emf) is created on the conductor. If there is a complete circuit, a current will flow around the circuit. The same thing will happen if the magnetic field cuts across a conductor. An electromotive force (emf) is created and an electrical surge in the conductor is produced.
- Whenever a conductor cuts across a magnetic field, an emf is produced.
- The free particles (**electrons**) in the conductor will move backward and forward (**oscillate**). This vibration of free electrons is caused by the generation of an emf. Again, if there is a complete circuit, a current will flow into the electronic components of the radio. This electronic impulse is decoded, as shown in *Figure 2.26*, and your radio broadcasts your favourite radio station.

Possible Answers to Unit Assignment

- Electrical energy, magnetic energy, heat energy.
- Electrical \Rightarrow electromagnetic \Rightarrow electrical \Rightarrow sound energy
- Electrical \Rightarrow electromagnetic \Rightarrow electrical \Rightarrow sound
- Electromagnetic wave
- The component of the electromagnetic wave which interacts with the aerial is in a vertical orientation. As a result the conductor in the aerial will cut across this component at right angles and an electrical surge will be produced. This component is likely to be the magnetic component of the electromagnetic wave.

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