Senior Science

Information Systems

New Revised Edition

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Science Press

Contents

Use the table of contents to record your progress through this book. As you complete each topic, write the date completed, then tick one of the three remaining columns to guide your revision for later. The column headers use the following codes:

?? = Don't understand this very well at all. RR = Need to revise this. OK = Know this.

Acknowledgements

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Introduction

Each book in the *Surfing* series contains a summary, with occasional more detailed sections, of all the mandatory sections of the syllabus, along with questions and answers.

It is envisaged this book will be useful in class for both initial understanding and revision, while the more traditional textbook can remain at home for more detailed analysis.

All types of questions — multiple choice, short response, structured response and free response — are provided. Questions are written in exam style and use the verbs specified by the Board of Studies so that you will become familiar with the concepts of the topic and answering questions in the required way.

Answers to all questions are included.

A topic test at the end of the book contains an extensive set of summary questions, including multiple choice and free response questions. These cover every aspect of the topic, and are useful for revision and exam practice. Marking guidelines are supplied where appropriate.

Verbs To Watch

When you are answering questions in this book, your textbook or any examinations, make sure you answer what the question is asking. To do this you will have to know what each of the terms below means — they dictate what sort of an answer is required. It is essential that you learn their meanings as required by the Board of Studies. Your exam answers will be marked according to what these terms indicate your answer should be saying.

Account, account for	State reasons for, report on, give an account of, narrate a series of events or transactions.
analyse	Identify components and the relationships among them, draw out and relate implications.
apply	Use, utilise, employ in a particular situation.
appreciate	Make a judgement about the value of something.
assess	Make a judgement of value, quality, outcomes, results or size.
calculate	Determine from given facts, figures or information.
clarify	Make clear or plain.
classify	Arrange into classes, groups or categories.
compare	Show how things are similar or different.
construct	Make, build, put together items or arguments.
contrast	Show how things are different or opposite.
critically (analyse/ evaluate)	Add a degree of level of accuracy, depth, knowledge and understanding, logic, questioning, reflection and quality to an analysis or evaluation.
deduce	Draw conclusions.
define	State the meaning of and identify essential qualities.
demonstrate	Show by example.
describe	Provide characteristics and features.
discuss	Identify issues and provide points for and against.
distinguish	Recognise or note/indicate as being distinct or different from, note difference between things.
evaluate	Make a judgement based on criteria.
examine	Inquire into.
explain	Relate cause and effect, make the relationship between things evident, provide why and/or how.
extract	Choose relevant and/or appropriate details.
extrapolate	Infer from what is known.
identify	Recognise and name.
interpret	Draw meaning from.
investigate	Plan, inquire into and draw conclusions about.
justify	Support an argument or conclusion.
outline	Sketch in general terms; indicate the main features.
predict	Suggest what may happen based on available information.
propose	Put forward a point of view, idea, argument or suggestion for consideration or action.
recall	Present remembered ideas, facts or experiences.
recommend	Provide reasons in favour.
recount	Retell a series of events.
summarise	Express concisely the relevant details.
synthesise	Put together various elements to make a whole

1 Sending Messages

A number of technological developments have allowed human communication to expand to unprecedented levels in the last two hundred years. The invention of reliable sources of electricity began the process. It allowed the development of telegraph systems and then the telephone. The vacuum tube allowed the invention of radio and TV (Figure 1.1). Size was reduced, power consumption decreased and reliability increased with the invention of the transistor. The integrated chip has led to digital communication and mobile phones. All these technologies have had an enormous impact in Australia.

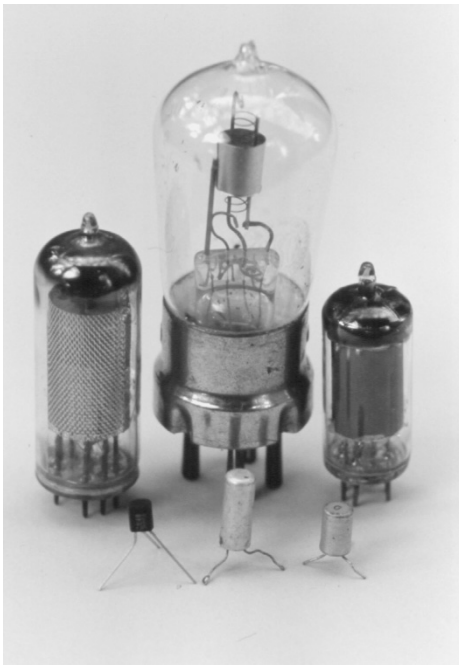

Figure 1.1 **Electronics** Glass-encased valves and small solid state transistors allowed the development of radio and TV.

Types of Communication Systems

Humans have been communicating from the very beginning. Body language such as smiles and frowns are part of human communication. Speech allows for a vastly expanded communication system and permits us to communicate our thoughts. Music and art also allow communication. Electrical communication began in Australia with the telegraph and morse code in the mid-1850s. The telephone came in the 1880s. Electrical communication requires the presence of wires to connect the sender and receiver of the message. Coaxial cables are a sophisticated type of metal wire connection. To avoid the necessity of such cables, microwave links were established between our cities. Microwaves are also used for satellite communication between continents. Now all of those technologies are to some degree out of date. Optical fibre has replaced nearly all of this technology except for microwave communication with satellites, and in remote areas. Light has a higher frequency and thus shorter wavelength than signals in electrical wires or even microwaves. As a result it can carry much more information per unit of time. Information travels along optical fibres as a digital signal. This method of transmission allows huge numbers of messages to be sent in the same period of time. Optical fibres now connect our major towns and cities, and join telephone exchanges within the towns and cities. The only reason optical fibre does not come directly to your home is the cost of replacing the existing copper wires. Even here, new digital technologies such as ADSL allow much larger amounts of information to be transferred over these wires.

Table 1.1 lists a wide range of communication systems currently in use.

Information Transfer

Communication systems share a number of common features (Figure 1.2). Firstly there is a **code** that is able to be understood by the sender and receiver. With speech, the code is language. If both parties do not understand the same language or code, communication is not possible. It is also possible to convey information using music and pictures. In music, compositions in certain keys convey moods and feeling. With pictures, the code may be certain accepted symbols as used in circuit diagrams or the use of various colours to convey meaning. When it comes to communicating between computers, the agreed code is often a series of 0s and 1s called ASCII. If you want to send and receive web pages over the Internet, you need to be able to use the computer code called HTML. Table 1.2 lists a number of codes used in communication.

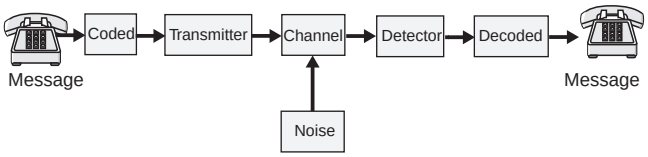

Figure 1.2 **Communication model**

The **message** is the information to be transmitted from sender to receiver. The message is expressed in terms of the code used. If we are communicating person to person, the message will be conveyed using language. If the communication is between computers, the message may use ASCII or some other computer code. Sometimes, the code used for the message has to be changed. If we speak into a telephone, the language code has to be converted into analog electrical signals. When the message reaches the telephone exchange, the code is changed from analog to digital for transmission along optical fibres.

Table 1.1 Communication systems

System	Description
ADSL broadband	Fast digital communication system using the normal copper telephone wires
Bar codes	System of parallel bars on a label used to identify a part or product (see the back cover of this book)
Body language	Facial expressions (e.g. smile, frown), hand gestures (e.g. thumbs up or down) and other body positions and movements that convey meaning
Cable broadband	Fast digital communication system using fibre optics and coaxial cable used to bring pay television and the Internet to homes
Cassette tape	The recording of sound on a plastic tape coated with magnetic material
CB radio	Citizen band radio using a section of the radio spectrum devoted to public use
Compact discs (CD)	Music, text and computer programs are recorded in digital form as a spiral of tiny pits on the surface of the disc and read by reflecting laser light from the surface
Digital video disc (DVD)	Music, text, computer and video programs are recorded in digital form as a spiral of tiny pits on the surface of the disc and read by reflecting laser light from the surface. The laser has a shorter wavelength, allowing the pits and spirals to be closer together and more information to be stored than on a CD.
Email	Transmission of text messages using the Internet or intranet
Facsimile (fax)	Digital signals are used to transmit text and images over standard telephone lines
Film	Images recorded on thin strips of plastic
Internet	National and international communication system used to send email, data and web pages
Intranet	An Internet confined to a particular company or organisation
Mobile phone: digital and analog	Telephone communication between a mobile handset and cell base stations
Print media	Newspapers, books, magazines used to transmit text and pictures
Public address system (PA)	A system of microphones, amplifiers and loudspeakers used to amplify the human voice to be heard in public places
Radio (AM)	Amplitude modulated radio waves used to transmit voice and music
Radio (FM)	Frequency modulated radio waves used to transmit voice and music
Satellite telephone	Telephone communication between a mobile handset (larger than mobile phone) and a satellite
Satellite communic-ation	Communication between base stations on Earth and satellites in geosynchronous orbits
Short message service (SMS)	A two-way paging service using your mobile phone. It allows you to read and write messages by using the phone's screen and keypad.
Sign language	Visual means of communication for the hearing impaired using hand signals
Smell	The transmission of chemicals detected by the nose (e.g. perfume vs body odour)
Sound	The use of voice and hearing to communicate using sound waves
Taste	The transmission of chemicals detected by receptors on the tongue (e.g. sweet vs bitter)
Telegraph	Use of morse code to send electrical signals along wires or using radio waves
Telephone networks	Traditional telephone system using copper wires and fibre optics
Teletext	Transmission of text using a TV system
Television	Transmission of images and sound using short wavelength microwaves (TV waves)
Touch	The use of touch receptors in the skin (e.g. a caress vs a punch)
Video	The recording of images and sound on a plastic tape coated with magnetic material
Wireless Application Protocol (WAP)	You can receive specially written Internet pages on the screen of your mobile phone

Table 1.2 Communication codes

Code	Use
ASCII	A standard binary data transmission code that is used by smaller and less powerful computers to represent both textual data (letters, numbers and punctuation marks) and non-input-device commands (control characters)
HTML	A standard for communicating web pages — a page markup language
EPS	A standard for graphics software mainly used to produce line drawings
JPG	A standard for graphics software mainly used to record photographs
Morse code	Sending text messages along telegraph wires or using radio as a series of dots and dashes
Language	The use of sounds and symbols to communicate from person to person
Alphabet	The system of letters and symbols used to communicate language
Sign language	The system of hand signs used to communicate with people who are hearing impaired
Semaphore	The system of flag positions or light positions used to communicate messages

Once the message has been coded, it has to be **transmitted**. The transmission will take place along a communications **channel**. Speech uses the communications channel of sound. Telegraph used electrical pulses sent along a copper wire. Telephones connected to our houses still use the communications channel of electric current transmitted along copper wires. Most modern communications systems use electromagnetic waves as the communications channel. Thus, between telephone exchanges the communication channel is light passing along optical fibres.

One major problem with all communication channels is **noise**. We are most aware of this when the channel is sound. Trying to communicate in a crowded room with everyone talking makes it very hard for the message to be understood. That is why sound has a very short range for communication. Noise is a problem with all communications channels. If you are listening to the radio and pass under high voltage power lines, there is a large amount of static or noise. A lot of effort is expended trying to get rid of noise in communication systems.

Finally the message reaches its destination and is **decoded**. The message is extracted from the code and presented in a form that the senses of the receiver can detect and understand. With speech and music, our ears detect the sound and the brain decodes it for us. If we send an image between computers, the electrical signals are decoded and the image appears on the computer screen.

Classifying Information Systems

There are a number of ways in which we can classify communication systems. **Verbal** communication involves the use of words, either spoken or as text. Nonverbal communication involves pictures, smell, touch and taste. Speaking on the phone is verbal communication. Sending photographs to another person involves nonverbal communication. However, there are occasions where more than one type of communication system may be possible. Communication systems like films have verbal parts such as the soundtrack, as well as the nonverbal pictures.

We might also classify communication systems according to the **distance** over which information can be transmitted. Short-distance communication occurs in the presence of the receiver or within the immediate area. When you speak to a person they need to hear your voice. Long-distance communication can locate people in other states or on different continents. Satellite communication is a good example. However, suppose you are talking using a mobile phone. The person may be only a short distance down the road or they may be in another country!

Finally, we can classify communication systems as **electronic** or non-electronic. Before the days of electronics, people spoke to each other. They may have sent smoke signals over longer distances or used message sticks or letters. Semaphore was a communication system that used flags to send messages. All of these are forms of non-electronic communication. The invention of vacuum tubes, transistors and integrated circuits has allowed a proliferation of electronic communication systems — mobile phones, DVD, the Internet and broadband cable TV are only a few.

Table 1.3 shows one way we might classify some communication systems.

For You To Do

1 People often send each other postcards. Which type of communication best classifies a postcard?
(A) electronic communication
(B) verbal communication
(C) nonverbal communication
(D) both verbal and nonverbal communication

2 Which communication system is used by most people daily?
(A) body language
(B) telegraph
(C) semaphore
(D) sign language

3 Which invention has allowed the recent rapid advances in communication?
(A) transistor
(B) integrated circuit
(C) electricity
(D) vacuum tube

4 Which is a code used to transmit information?
(A) sound
(B) telephone
(C) language
(D) light

5 Identify the communication system that could be classified as either short or long distance.
(A) touch
(B) taste
(C) radio
(D) sign language

6 Redraw Figure 1.2 to show how we communicate from person to person using the spoken word.

7 Use Table 1.2 to answer the questions.
(a) Describe how the two broadband communication systems differ.
(b) Both CDs and DVDs are the same diameter. Outline how CDs differ from DVDs.
(c) Identify the oldest electronic communication system listed.
(d) Identify the newest communication system.
(e) Name a communication system not found in Table 1.1.

8 You are talking on the telephone. Identify potential sources of 'noise' that can limit your ability to communicate.

9 Name a method of communication that is both electronic and non-electronic.

10 Complete the classification of communication systems shown in Table 1.4.

Table 1.3 Modern communication

System	Example	Verbal/nonverbal	Short distance/long distance	Electronic/non-electronic
Sound	Speech	Verbal	Short distance	Non-electronic
Body language	Wink, wave	Nonverbal	Short distance	Non-electronic
Scent/smell	Perfume	Nonverbal	Short distance	Non-electronic
Touch	Handshake	Nonverbal	Short distance	Non-electronic
Telephone	Speech	Verbal	Long distance	Electronic
Mobile phone	Speech	Verbal	Long distance	Electronic
Television	Speech/images	Verbal/nonverbal	Long distance	Electronic
VCR	Speech/images	Verbal/nonverbal	Long distance	Electronic
Fax	Text/images	Verbal/nonverbal	Long distance	Electronic
Email	Text/images	Verbal	Long distance	Electronic
Compact discs	Music	Verbal	Long distance	Electronic
Internet	Text/images	Verbal/nonverbal	Long distance	Electronic
Semaphore (flags)	Speech	Verbal	Short distance	Non-electronic
Smoke signals	Speech	Verbal	Short distance	Non-electronic

Table 1.4 Classifying communication systems

System	Example	Verbal/nonverbal	Short distance/long distance	Electronic/non-electronic
Cable broadband				
Digital video disc (DVD)				
Print media				
Public address systems (PA)				
Radio (FM)				
Satellite telephone				
Satellite communication				
Short message service (SMS)				
Multimedia message service (MMS)				
Sign language				
Wireless Application Protocol (WAP)				

2 Electromagnetic Spectrum

The existence of light has been known for thousands of years. One of the great advances in science came in the mid-1800s when James Clerk Maxwell was able to develop the electromagnetic theory that successfully explained the properties of light. However, his theory predicted that there would also be electromagnetic waves with much longer and shorter wavelengths than light. The first of these invisible waves was discovered by Heinrich Hertz in the late 1880s when he found radio waves. Since that time efforts have been made to send information using radio waves and other parts of the electromagnetic spectrum.

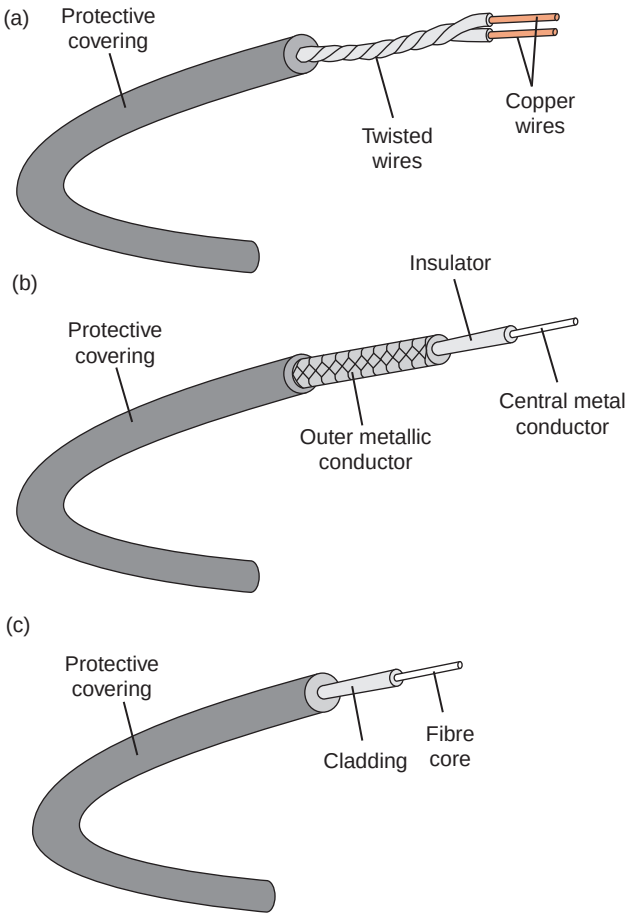

Figure 2.1 **Connecting with cable** (a) Twisted copper wire (b) Coaxial cable (c) Optical fibre.

How to Send Information

There has always been something of a competition between different communication methods. The discovery of electricity allowed the invention of the telegraph and then the telephone. Both depended on copper wires to send information from place to place (Figure 2.1 (a)). In the late 1800s radio was invented so that signals could be sent through the atmosphere. At first it was used to send morse code like the telegraph, but in the early 1920s radio broadcasts as we know them began. Television came in the 1940s.

Figure 2.2 **Microwave towers** Microwaves are beamed from tower to tower.

Initially cables were one or more pairs of copper wires, similar to those that connect telephones to our homes today. As communication needs increased, coaxial cables were invented (Figure 2.2 (b)). However, cable is always expensive to make and bury in the ground. It is even more expensive to lay across oceans as undersea coaxial cable. The problem was overcome in the 1950s and 1960s with the development of microwave links. On land, microwave towers were placed on hills and the signal beamed from tower to tower (Figure 2.2). To cross the oceans, geostationary satellites were placed in orbit. The signal was beamed from ground stations to satellite, which then retransmitted the signal to another continent.

Cable is now making a comeback. The invention of fibre optics has made many other communication systems redundant. Copper cable only connects to our homes because it is too expensive to replace it. Nearly all national and city communication links are fibre optics. Optical fibre brings cable TV near to our homes with coaxial cable making the final connection (Figure 2.1 (c)). Microwave links are kept ready as emergency backup systems, although they are still used in some remote areas. Satellite communication is still in use but undersea optical fibre cables are giving considerable competition.

Electromagnetic radiation through space is used in AM and FM radio as well as free-to-air TV. Electromagnetic radiation is also used for mobile communication. You cannot connect to a moving person using cable. Thus mobile phones can be used in most parts of Australia. In more remote regions, satellite phones must be used.

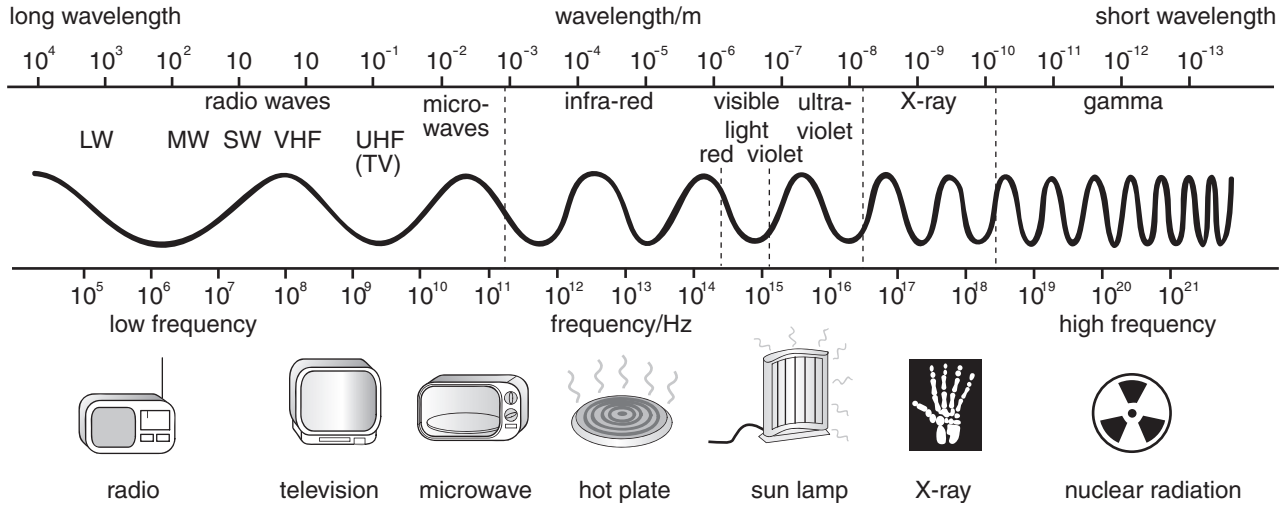

Figure 2.3 **Electromagnetic spectrum** Radio waves have the longest wavelengths while gamma rays have the shortest wavelengths.

Table 2.1 Electromagnetic spectrum

Frequency (Hz)	Wavelength (m)	Name	Source	Detection
10^{21} to 10^{22}	10^{-13}	Gamma rays	Atomic nuclei	Geiger counter
10^{16} to 10^{21}	10^{-10}	X-rays	Inner atomic electrons	Electronic counters and film
10^{15} to 10^{16}	10^{-7}	Ultraviolet light	Inner and outer atomic electrons	Fluorescence
10^{14} to 10^{15}	10^{-6}	Visible light	Outer atomic electrons	Eye, film and electronic detectors
10^{12} to 10^{14}	10^{-5}	Infra-red light	Molecular vibrations	Skin, thermopile and electronic detectors
10^{9} to 10^{12}	0.01	Microwaves	Electron and nuclear spin	Piezoelectric crystals
10^{8}	0.1	UHF TV	Electric currents	Electronic circuits
10^{7}	1	VHF TV and FM radio	Electric currents	Electronic circuits
10^{7}	100	AM radio	Electric currents	Electronic circuits
10^{5}	1000	Shortwave radio	Electric currents	Electronic circuits

Types of Electromagnetic Waves

The different parts of the electromagnetic spectrum all travel at the same speed — the speed of light. In air or vacuum this is around 300 000 kilometres per second. In denser transparent materials such as water and glass the speed of light is *less* than this. The way in which radio waves differ from the other parts of the electromagnetic spectrum is in their wavelength and frequency. Remember that these two quantities are related. The shorter the wavelength the higher the frequency; the longer the wavelength the lower the frequency. We will mainly use wavelength here as it is easier to visualise (Figure 2.3).

Making Use of EM Waves

At present it is the longer wavelengths of electromagnetic radiation that are used for communication — from visible light to radiowaves. We have not yet found it possible to make use of the more hazardous ultraviolet light, X-rays or gamma rays. Table 2.1 lists the parts of the electromagnetic spectrum and how they are produced and detected.

Useful Properties

A number of properties of the electromagnetic spectrum make it useful for communication.

Speed of travel

As we have seen, light travels at 300 000 kilometres per second. That means communication is almost instantaneous. When the distances are very large there is a slight time delay. You may have noticed a slight delay on TV when satellite communication is being used. This is the time it takes for the signal to travel 36 000 kilometres up to the satellite and then 36 000 kilometres down to another state or continent (Figure 2.4 (b)). We will study satellite communication in Unit 4.

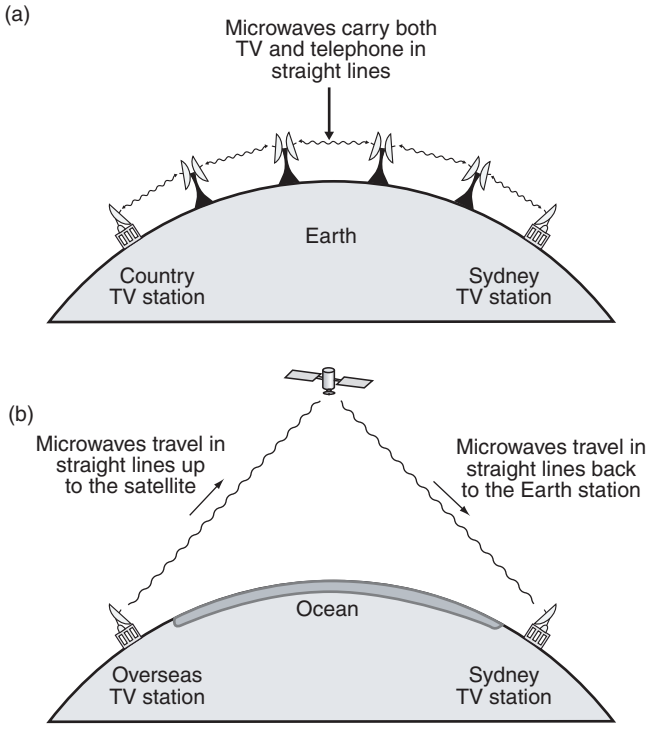

Figure 2.4 **Straight-line travel** (a) Microwaves travel in straight lines from tower to tower (b) Microwaves travel in straight lines between ground station and satellite.

Ability to travel in a straight line

Unless there is a change in medium, electromagnetic waves travel in straight lines. Thus microwaves travel in straight lines from dish to dish on microwave towers (Figure 2.4). Microwaves also travel in straight lines from ground station up to the satellite and then from satellite back to ground. FM radio and TV signals also travel in straight lines, but this presents a problem. If your house is behind a hill or large building then reception can be a problem. It is not such a problem for AM radio. This is because the longer waves can **diffract** (bend) around large objects.

Ability to be reflected

Electromagnetic waves can be reflected (Figure 2.5). You make use of this when you look into a mirror. Microwave antennas have a dish behind them that reflects microwaves so that they can more efficiently transmit and receive signals.

Short-wave radio communications make use of this property when they reflect waves from the ionosphere (Figure 2.6). You can also detect this effect when listening to radio. At night, the ionosphere descends to lower altitudes so that even normal AM radio is reflected. Reflection can also be a problem. When aeroplanes fly over, you can sometimes see 'ghosting' on your TV. When it is raining, you may notice the quality of UHF TV declines. This is because the very short wavelength TV waves used are reflected or **scattered** off the rain droplets. For the same reason, microwave transmission has problems when rain or snow falls between microwave towers.

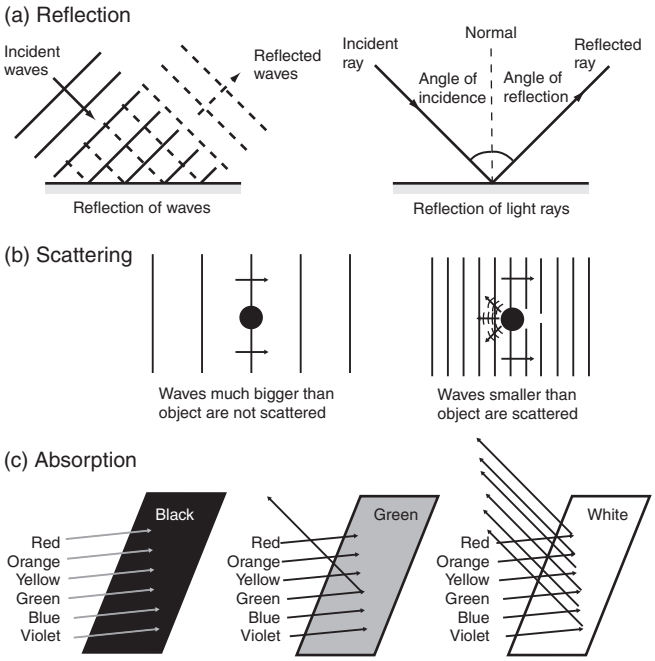

Figure 2.5 **Reflection, scattering and absorption** (a) When waves are reflected, the angle of incidence equals the angle of reflection (b) Scattering of waves (c) Absorption of light.

As we progress through this topic we will find other properties are important. **Refraction** of light is important in fibre optics. The shorter the **wavelength** the more information that can be carried per unit of time.

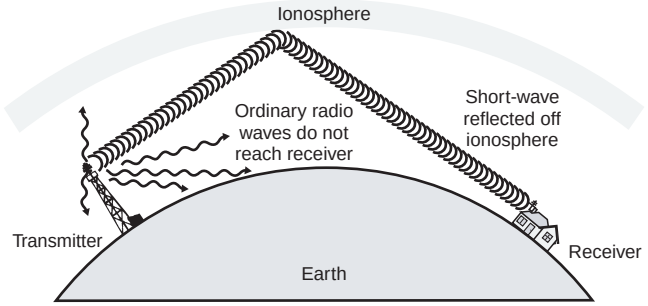

Figure 2.6 **Short-wave radio** The radio waves are reflected off the ionosphere.

Not So Useful Properties

When electromagnetic waves are produced, they spread out from the source and the **intensity** decreases (Figure 2.7). This is most obvious with a normal incandescent light globe. The further the light travels, the weaker it becomes. In fact, if you double the distance the intensity is reduced to one quarter. There are a number of ways to overcome this problem. We can increase the transmission power — in the case of our lamp, we can choose a light with a higher wattage. We can also direct the electromagnetic radiation. We usually achieve this with a curved mirror, such as the mirror behind the lamp in a torch. Microwave communication uses the same technique. A curved reflector behind the source produces a beam that is pointed directly at another reflector. As the beam arrives, the energy is reflected onto the antenna.

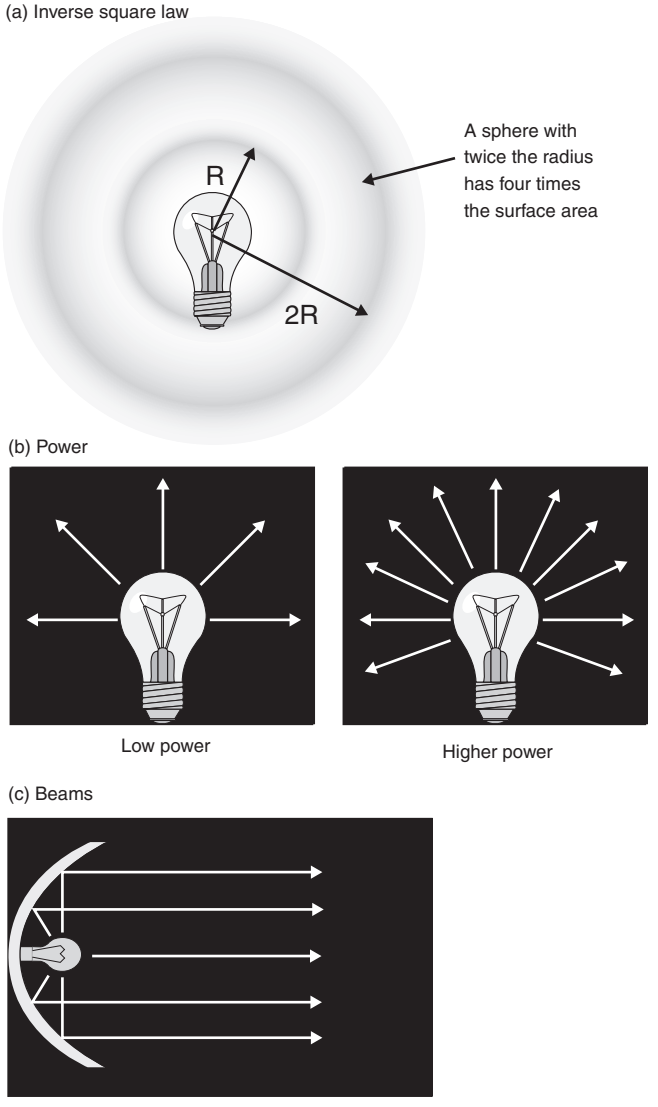

Figure 2.7 **Intensity of light** (a) Intensity decreases rapidly away from a light source (b) Power can be increased so that the light at a given distance is more intense (c) Curved reflectors concentrate the light into beams.

The other less useful property is that radiation is **absorbed** by many materials (Figure 2.5). Black materials are black because they absorb most of the light that reaches them. This is a particular problem with fibre optics as the light is travelling through glass. Ultrapure glass must be used to reduce the problem to a minimum. As well, repeaters are located at appropriate distances to strengthen the signal. We will study more about fibre optics later in this book.

Radio Waves or Microwaves?

We can see how the properties of electromagnetic waves influence their use in communication by comparing radio waves with microwaves. Radio waves have a much longer wavelength than microwaves. When the microwave links were established, why didn't they use the well-developed technology of radio?

Microwaves have a number of **advantages** over radio for communicating between cities.

- Microwaves are more directional than radio waves so that several microwave links can be run side by side. With radio, each frequency can only be used once in an area.
- Not as much power is needed to transmit microwaves over the same distance (they have high 'gain').
- Microwaves need smaller dishes to transmit signals than radio waves. Because of their long wavelength, radio waves diffract around the edges of small dishes.

Microwaves also have a number of **disadvantages** when compared to radio for communicating between cities.

- The short wavelength of microwaves means that scattering can be caused by rain, snow, flocks of birds and insect swarms. This is because the wavelength of the microwaves is about the same as the cause of the interference.
- Extreme heat can cause expansion in towers that puts the parabolic reflectors out of alignment.

On balance, the lower energy needs and the ability to reuse frequencies several times led to the adoption of microwave links. In turn, microwave links have been superseded by fibre optics.

For You To Do

1 Which is an example of an electromagnetic wave?
(A) sound wave
(B) water wave
(C) light wave
(D) earthquake wave

2 Which is an example of electromagnetic waves used for electronic communication?
(A) gamma rays
(B) X-rays
(C) ultraviolet rays
(D) infra-red light

3 Which pairs of electromagnetic waves have the shortest and longest wavelengths?

	Shortest	*Longest*
(A)	microwaves	AM radio
(B)	FM radio	TV
(C)	infra-red	visible light
(D)	radio waves	microwaves

4 Which technologies use energies from the electromagnetic spectrum for communication purposes?
(A) coaxial cable
(B) fibre optics
(C) copper wires
(D) speech

5 A helicopter flies over your house while you are watching TV and you see a double image or 'ghosting'. What is the most likely cause?
(A) Some TV waves travel at a different speed from the others to produce two images.
(B) TV waves are scattered by the air particles disturbed by the moving helicopter.
(C) TV waves have reflected off the helicopter.
(D) TV waves are absorbed by the helicopter.

6 Identify why the speed of travel of electromagnetic waves make them useful in communication technologies.

7 Identify why the ability to travel in a straight line makes electromagnetic waves useful in communication technologies.

8 Identify why the ability to be reflected makes electromagnetic waves useful in communication technologies.

9 Use Table 2.1 to answer the questions below.
(a) What is the frequency of UHF TV?
(b) What is the wavelength of ultraviolet light?
(c) Which part of the electromagnetic spectrum has wavelength of around 1 kilometre?
(d) Which part of the electromagnetic spectrum has frequency of 1000 million Hertz?
(e) Which part of the electromagnetic spectrum can be detected by the skin?

10 Explain why parts of the electromagnetic spectrum are used to transmit information through the atmosphere rather than through cables.

11 Microwaves were chosen over radio waves for transmitting information between cities. Do you think microwaves should also replace radio waves for the transmission of music to our homes? Justify your answer.

12 Predict if radio waves or microwaves would be used to communicate with spacecraft travelling between the planets. Justify your answer.