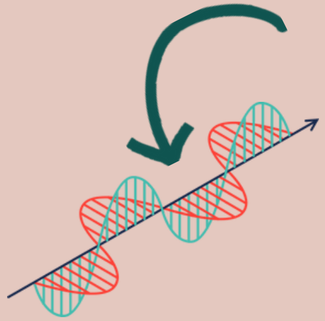
CIE IGCSE PHYSICS for board 0625 and 0972
(For exam 2025+)



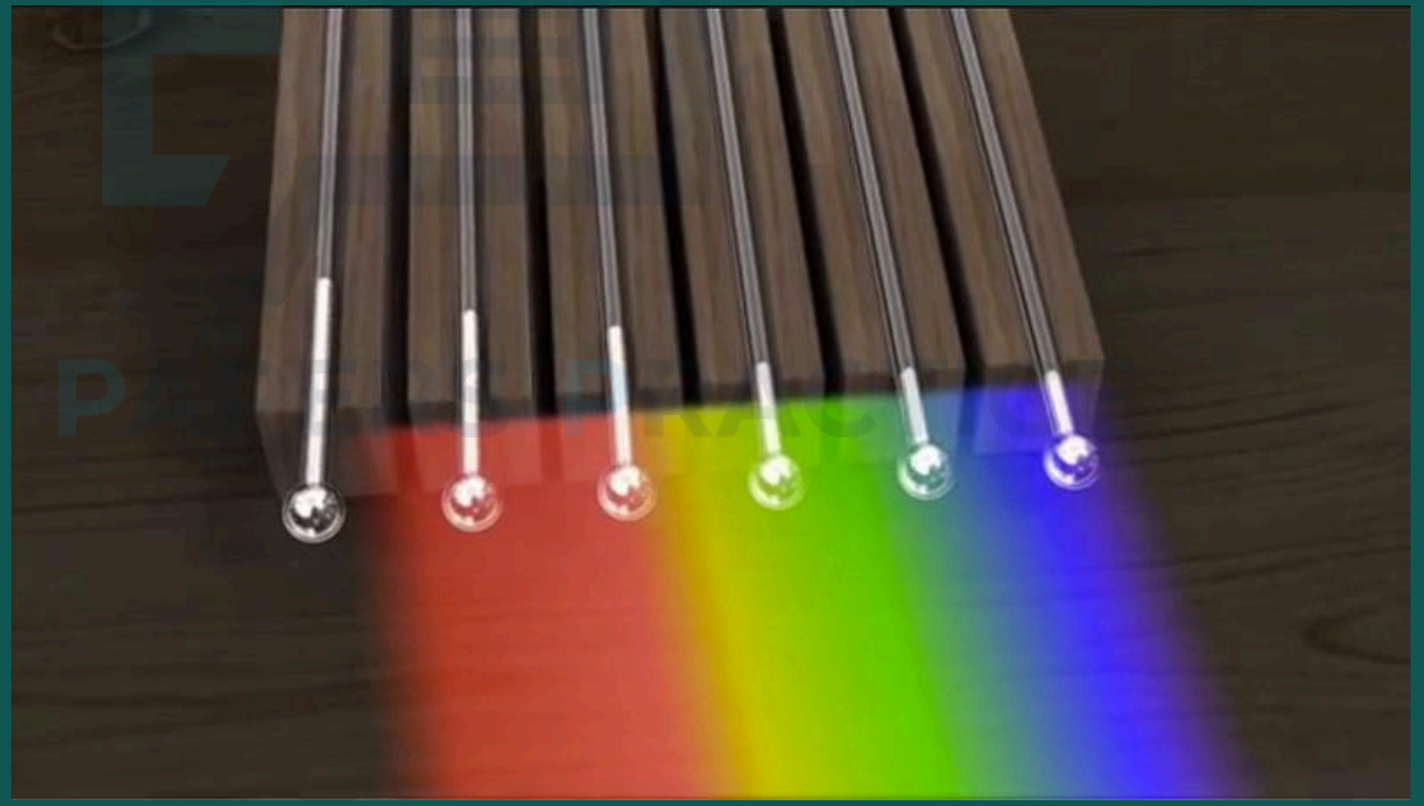
ELECTROMAGNETIC WAVES

chapter 15

15.1

INTRODUCTION

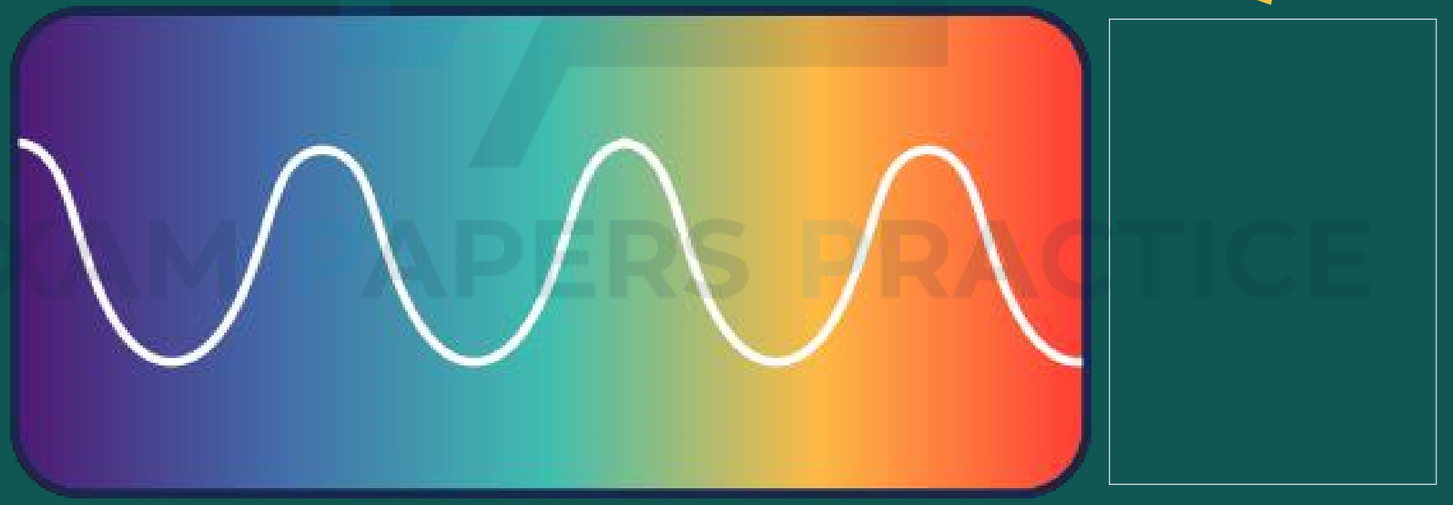
In 1800, William Herschel was studying the sun's light when he passed it through a prism and measured the temperature of each color.



15.1

INTRODUCTION

Williams Herschel discovered from there is a type of radiation, invisible to the human eye, beyond the red end of the spectrum, which Herschel named infrared radiation (infra means below).



15.1

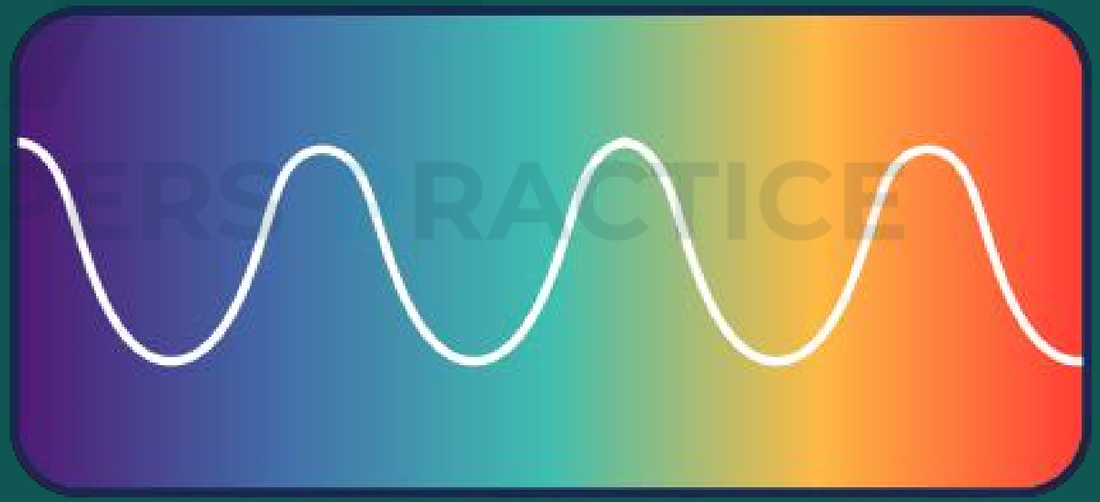
INTRODUCTION

In 1801, Johann Ritter discovered ultraviolet light while experimenting with the effect of various light sources on silver chloride paper. He observed that the paper darkened more quickly under sunlight than under other light sources, leading him to hypothesize the existence of an invisible form of light.

15.1

INTRODUCTION

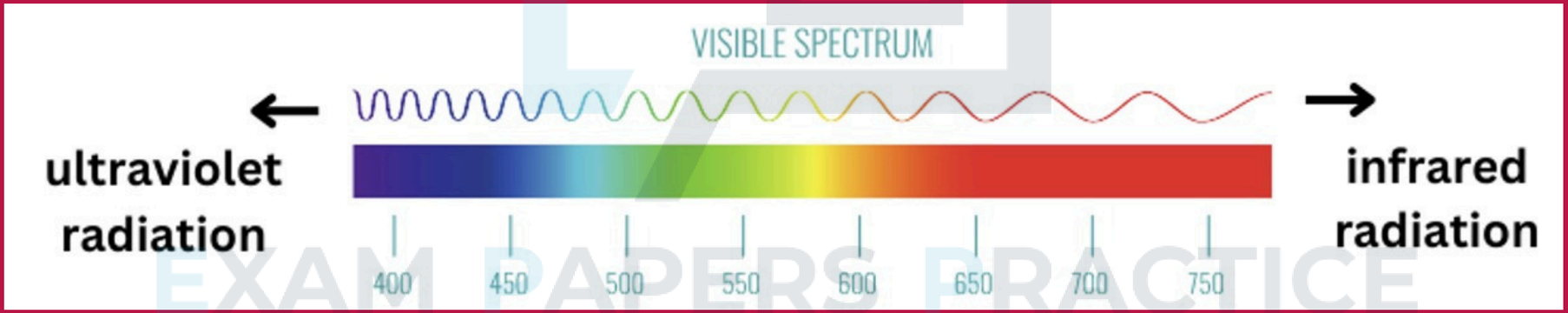
Ritter explored beyond the violet end of the spectrum and discovered ultraviolet radiation(ultra means beyond).



15.2

ELECTROMAGNETIC WAVES

Sound can have different pitches -the higher the frequency, the higher the pitch. As for light, it can have different colours, according toits frequency.



15.2 ELECTROMAGNETIC WAVES →

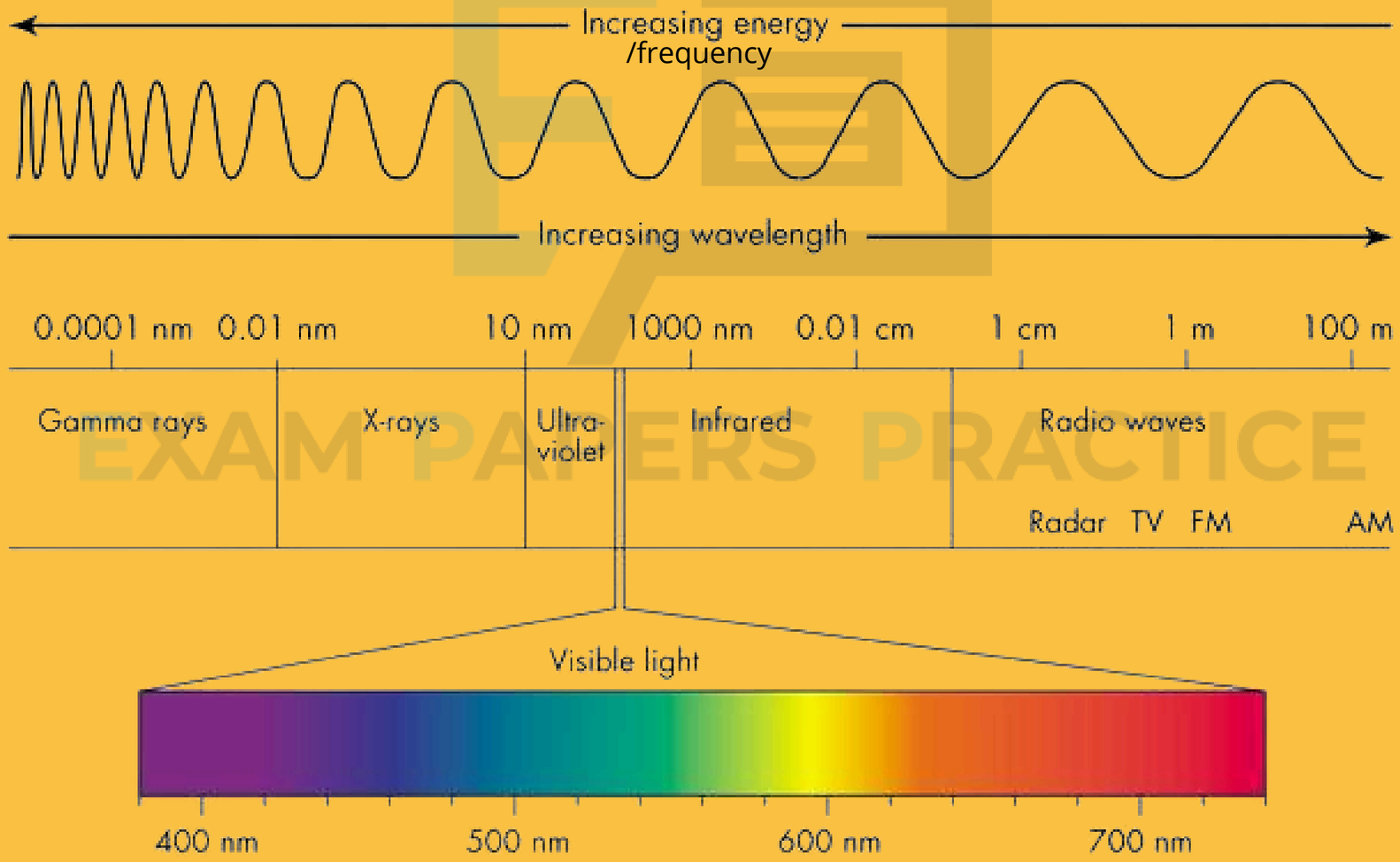
Electromagnetic waves travel at the speed of light (3×10^8 m/s). It is a transverse wave.

James Clerk Maxwell described light as small oscillations in electric and magnetic fields.

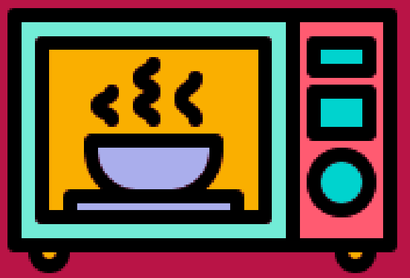
15.3

ELECTROMAGNETIC SPECTRUM

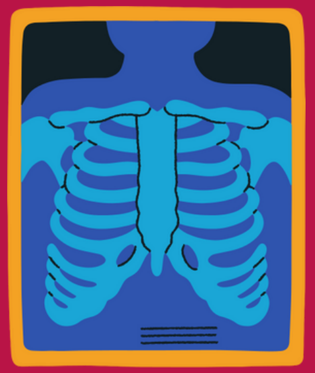
By the close of the 20th century, physicists had identified or created various other forms of electromagnetic waves, thereby completing the electromagnetic spectrum.



15.3 USES OF ELECTROMAGNETIC WAVES

Electromagnetic Wave	Wavelength	Uses
Radio waves	1mm -100km	•Broadcast radio and television signals •Wireless data transfer such as Radio Frequency Identification (RFID) 
Microwaves	1mm -100cm	•Microwave oven. Microwaves are absorbed by molecules in food, causing heating •Satellite television broadcasting. It can pass through the Earth's atmosphere •Transmit mobile phone signals 

Electromagnetic Wave	Wavelength	Uses
Infrared radiation	700nm -1mm	• Remote controls for television • Grills and toasters • Security alarms • Vein scanner 
Visible light	400 nm (violet) - 700nm (red)	• Photography •Optical instruments such as cameras, telescopes, and microscopes • Photosynthesis 
Ultraviolet light	180 nm -420 nm	•Used by forensic scientists to find evidence at crime scenes which is invisible to the human eye •Sterilise water / medical equipment ○UV radiation destroys DNA within any bacteria and viruses contained in the water 

Electromagnetic Wave	Wavelength	Uses
X-rays	0.01 nm -10 nm	• Medical imaging ○ Bone absorbs X-rays more strongly than flesh, so bones appear as a shadow in the image • Security scanners 
Gamma rays	Less than 10μm	• Kill cancerous cells • Sterilise medical equipment • Used by engineers to look for cracks in pipes 

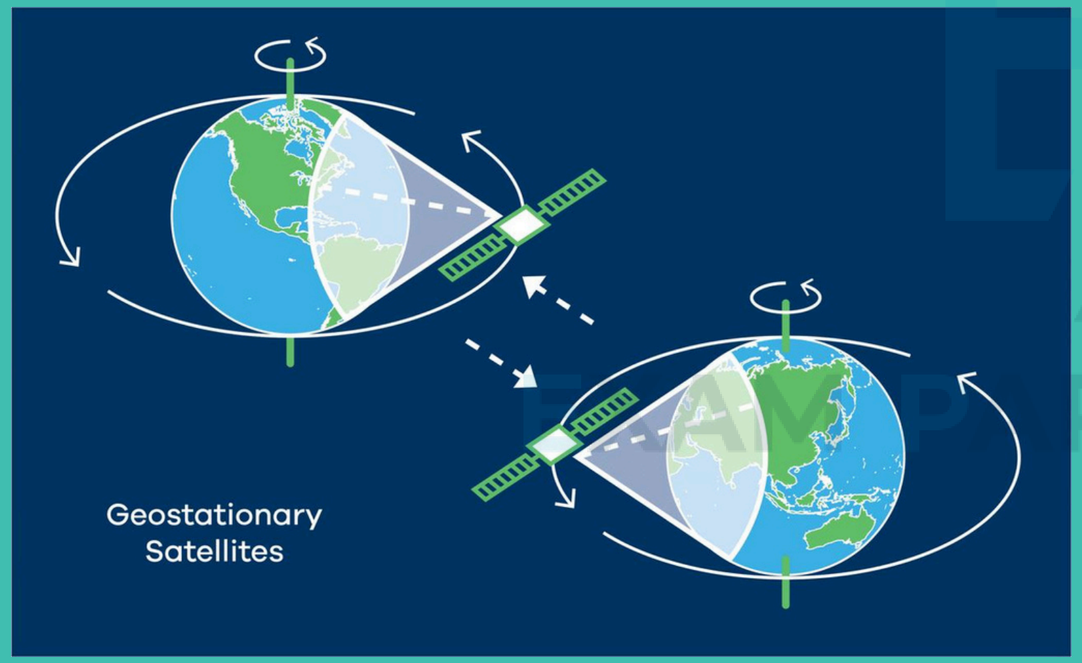
15.4

ELECTROMAGNETIC HAZARDS

Electromagnetic waves	Harms
Infrared radiation	Prolonged exposure to high levels of infrared radiation can cause thermal injuries, such as burns, due to the heating effect on tissues.
Ultraviolet light	Ultraviolet light can damage the DNA in skin cells, leading to sunburn, premature aging, and an increased risk of skin cancer.
X-rays and Gamma rays	Both X-rays and gamma rays are highly penetrating and can damage or destroy cells and DNA, potentially causing cancer and other radiation-induced illnesses.
Microwaves	Exposure to high levels of microwaves can result in thermal injuries, including burns and cataracts, due to the heating of body tissues.

15.5

COMMUNICATION USING ELECTROMAGNETIC WAVES



GEOSTATIONARY SATELLITES

a.	They rotate at the same rate as the Earth, maintaining a fixed position above a specific point on the Earth's surface.
b.	These satellites are robust and can handle large volumes of data transmission.
c.	This capability makes them ideal for satellite television and satellite phone services.
d.	Although they move quickly, the long distance to the satellite can complicate real-time conversations.

15.5

COMMUNICATION USING ELECTROMAGNETIC WAVES

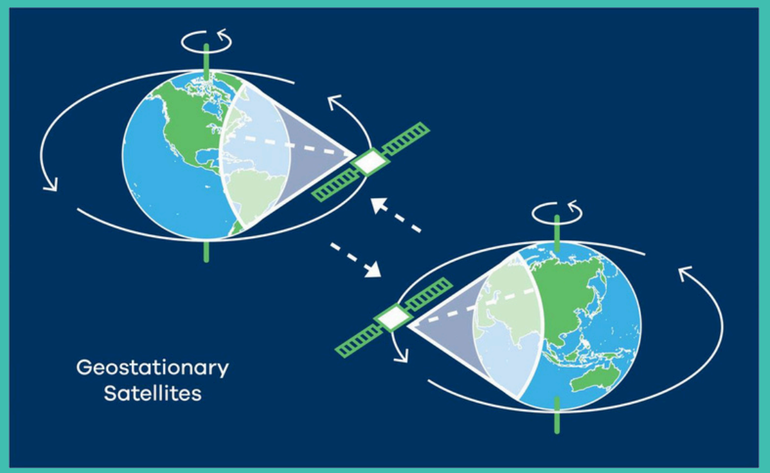
LOW EARTH ORBIT SATELLITE

a.	They offer immediate communication with no delay.
b.	However, they cannot transmit data as quickly as geostationary satellites and are not suitable for television broadcasting.

15.5

DIFFERENCES

Geostationary satellites orbit at a high altitude, providing continuous coverage over a specific region. They are suitable for uninterrupted communication but have higher latency.



Low Earth orbit (LEO) satellites orbit at lower altitudes, offering lower latency and faster data transmission. LEO satellites are ideal for real-time applications like internet connectivity but require more satellitesfor global coverage and frequent handoffs for continuous coverage.

15.5

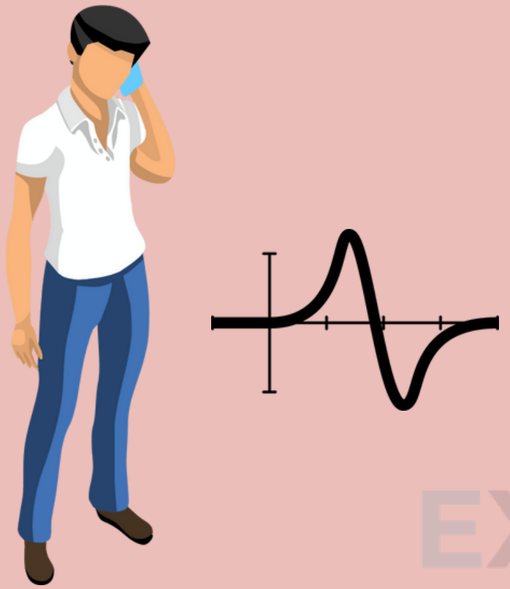
COMMUNICATION USING ELECTROMAGNETIC WAVES

OTHER FORMS OF COMMUNICATION THAT USES ELECTROMAGNETIC WAVES

Communication tools	Types of waves involved
Mobile phones and wireless internet 	Microwaves(because they can pass through most walls)
Bluetooth 	Radio waves(signal weakened when it passes through walls)
Optical fibers (for cable television and high-speed internet) 	Infrared radiationandvisible light

15.5

HOW ELECTROMAGNETIC WAVES ALLOW MOBILE PHONES TO WORK



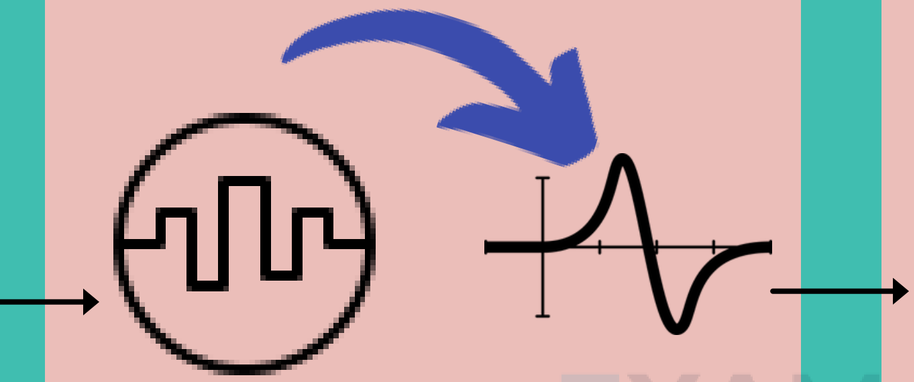
In telephone communication, the transmitted signal begins as a sound wave, which is an analog signal.

A sound wave is converted by a microphone into an electrical signal using an analog-to-digital converter, which produces a digital signal that varies in the same way as the original sound wave.

The digital signal is transmitted along optical fibers, sometimes over distances exceeding 200 km, using visible light pulses or infrared waves. The signal is processed through one or more regenerators that clean up the signal, eliminating any distortion.

15.5

HOW ELECTROMAGNETIC WAVES ALLOW MOBILE PHONES TO WORK



A second converter, the digital-to-analog converter, switches the signal back to an analog form, which can then be converted back into a sound wave.

The amplified sound wave is then played through the receiver's phone speaker.

Why convert analogue data to digital?

Digital signals can transmit data much more rapidly and accurately than analogue signals.

The table below shows the entire electromagnetic spectrum. It runs in order of increasing frequency.

Three parts of the spectrum are missing.

radio waves	**X**	infrared	visible light	**Y**	x-rays	**Z**

What are parts **X**, **Y** and **Z**?

	X	**Y**	**Z**
A	ultraviolet	microwaves	gamma rays
B	microwaves	gamma rays	microwaves
C	gamma rays	ultraviolet	microwaves
D	microwaves	ultraviolet	gamma rays

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Which of the following sentences about infrared waves is true?

A They can be used to treat cancerous tumours.

B They can be used to make images of bones, through the skin.

C They can be used for cooking.

D They are used to send communication signals to satellites.

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Which of the following options shows the correct speed for electromagnetic waves in a vacuum?

A. 3.0×10^{4} cm / s

B. 3.0×10^{8} cm / s

C. 3.0×10^{10} cm / s

D. 3.0×10^{8} km / s

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