

## Chapter 15. The electromagnetic spectrum

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- 15.2 Different types of EM waves and their uses
- 15.3 Electromagnetic hazards
- 15.4 Communications using EM waves

### **New word list:**

#### 3.3 Electromagnetic spectrum

##### Core

- 1 Know the main regions of the electromagnetic spectrum in order of frequency and in order of wavelength
- 2 Know that all electromagnetic waves travel at the same high speed in a vacuum
- 3 Describe typical uses of the different regions of the electromagnetic spectrum including:
  - (a) radio waves; radio and television transmissions, astronomy, radio frequency identification (RFID)
  - (b) microwaves; satellite television, mobile phones (cell phones), microwave ovens
  - (c) infrared; electric grills, short range communications such as remote controllers for televisions, intruder alarms, thermal imaging, optical fibres
  - (d) visible light; vision, photography, illumination
  - (e) ultraviolet; security marking, detecting fake bank notes, sterilising water
  - (f) X-rays; medical scanning, security scanners
  - (g) gamma rays; sterilising food and medical equipment, detection of cancer and its treatment
- 4 Describe the harmful effects on people of excessive exposure to electromagnetic radiation, including:
  - (a) microwaves; internal heating of body cells
  - (b) infrared; skin burns
  - (c) ultraviolet; damage to surface cells and eyes, leading to skin cancer and eye conditions
  - (d) X-rays and gamma rays; mutation or damage to cells in the body

##### Supplement

- 6 Know that the speed of electromagnetic waves in a vacuum is  $3.0 \times 10^8$  m/s and is approximately the same in air

*continued*

**3.3 Electromagnetic spectrum continued****Core**

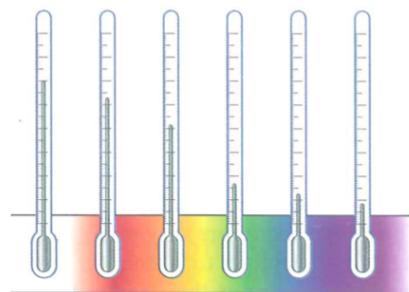
- 5 Know that communication with artificial satellites is mainly by microwaves:
- (a) some satellite phones use low orbit artificial satellites
  - (b) some satellite phones and direct broadcast satellite television use geostationary satellites

**Supplement**

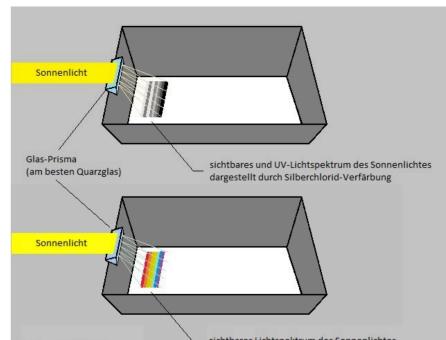
- 7 Know that many important systems of communications rely on electromagnetic radiation including:
- (a) mobile phones (cell phones) and wireless internet use microwaves because microwaves can penetrate some walls and only require a short aerial for transmission and reception
  - (b) Bluetooth uses radio waves because radio waves pass through walls but the signal is weakened on doing so
  - (c) optical fibres (visible light or infrared) are used for cable television and high-speed broadband because glass is transparent to visible light and some infrared; visible light and short wavelength infrared can carry high rates of data
- 8 Know the difference between a digital and analogue signal
- 9 Know that a sound can be transmitted as a digital or analogue signal
- 10 Explain the benefits of digital signaling including increased rate of transmission of data and increased range due to accurate signal regeneration

## 15.1 Electromagnetic waves

1. Who discovered infrared light and how?

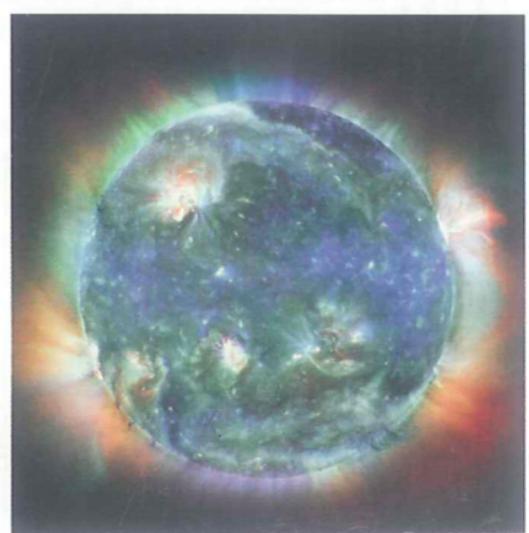
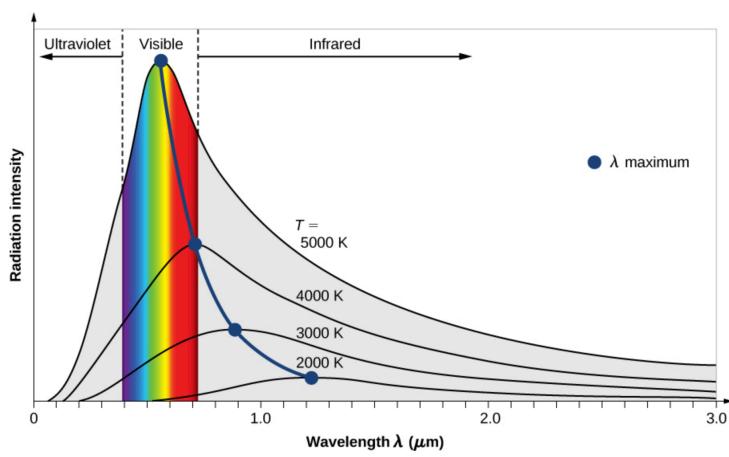


2. Who discovered ultraviolet light and how?



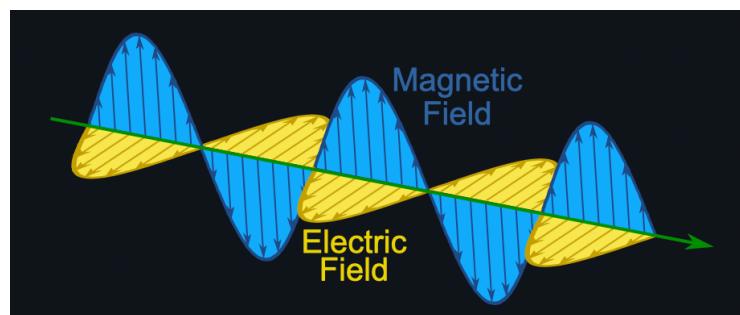
3. Which experiment suggest there is a connection between infrared, visible and ultraviolet light?

4. Radiation spectrum from the Sun and black body radiat



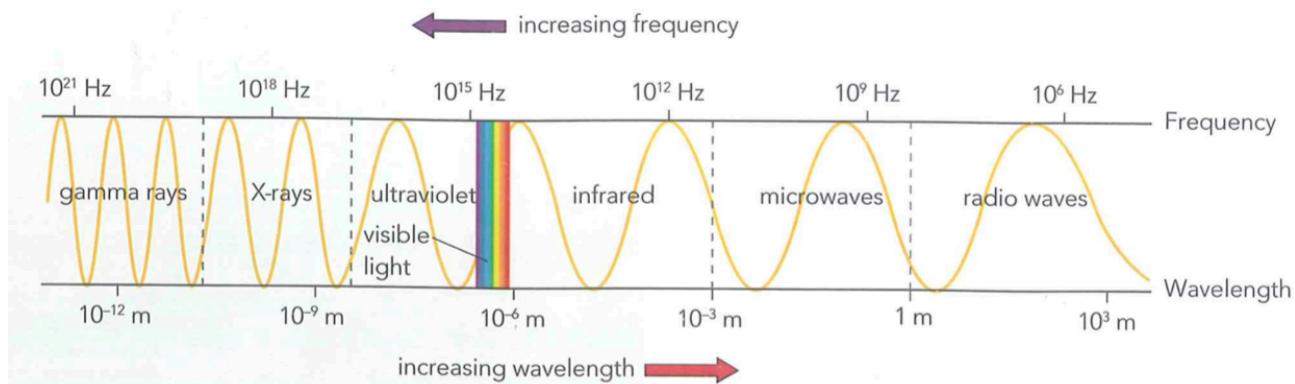
## 5. EM Wave model of light — James Clerk Maxwell

Description:



**Light is a  
transverse  
wave!!!**

Prediction of Maxwell's EM wave model:



### Exercise 15.1

Draw and label two waves to show the difference between red light and violet light.

### Exercise 15.2

Describe and explain what happens when monochromatic green light of wavelength 540 nm passes through a prism. And calculate the frequency of the green light.

## 15.2 Different types of EM waves and their uses

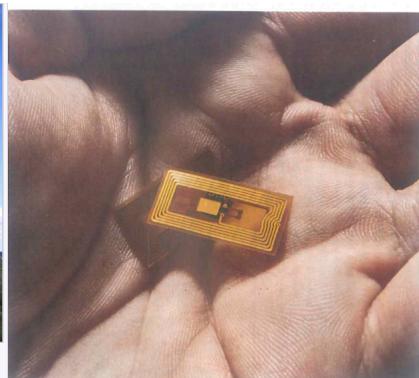
**1. Radio waves:** (long wavelength, transfer in long distance)

- a. Radio, television and microphone transmission
- b. Radio astronomy
- c. RFID

|              | Frequency / Hz                     |
|--------------|------------------------------------|
| Broadcast    | AM: 500 – 1600 K<br>FM: 80 – 110 M |
| TV           | 10-1000 M                          |
| Mobile phone | 1000 - 3000 M                      |

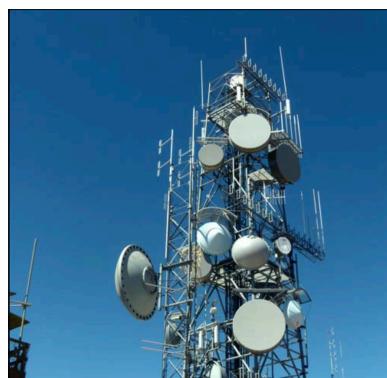


The Karl G. Jansky Very Large Array, a radio interferometer in New Mexico, United States



**2. Microwave:** (slightly shorter wavelength)

- a. Satellite TV
- b. Transfer mobile phone signal between masts
- c. microwave oven

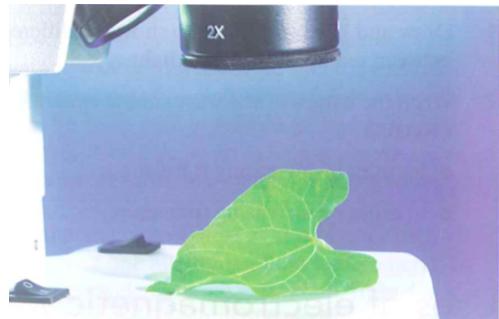


**3. Infrared radiation**

- a. Remote controller
- b. Grills or toasters
- c. Intruder alarm



e. Infrared imaging f. Optical fibre(endoscope) g. Infrared scanner



#### 4. Visible light

a. vision b. Illumination c. photography d. photosynthesis

#### 5. Ultraviolet(UV) light

a. Security marking/detecting fake banknote b. Sterilising water



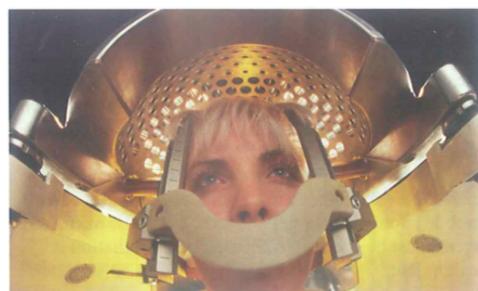
#### 6. X-rays

a. Medical scanning b. Security scanners



#### 7. Gamma rays

a. Sterilising food and medical equipment b. Detection of cancer and its treatment



**Exercise 15.3**

Name two types of electromagnetic radiation that are used to cook food

**Exercise 15.4**

Name three types of electromagnetic radiation that have medical uses

**Exercise 15.5**

A girl phones her friend on her mobile phone while watching TV by a log fire. Explain how infrared radiation, microwave, visible light and radio waves are involved in this.

## 15.3 Electromagnetic hazards

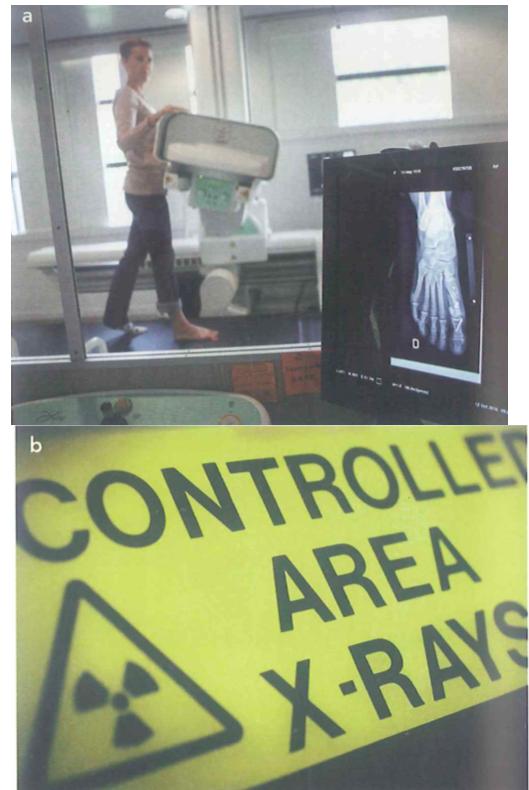
**Shorter wavelength, more dangerous**

Microwaves:

Infrared:

Ultraviolet:

X-ray and gamma ray:

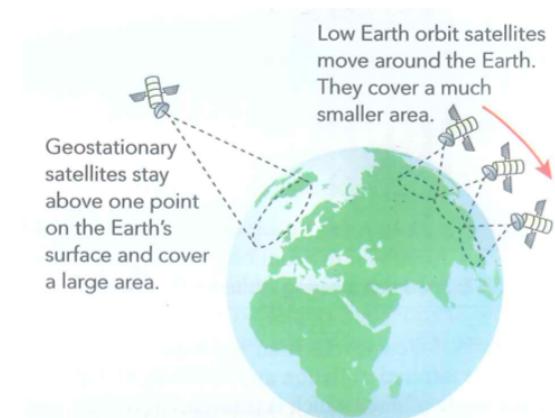


## 15.4 Communications using EM waves

**Artificial satellite**

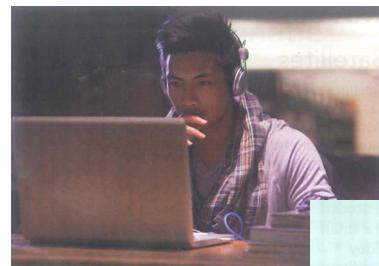
1. Geostationary satellite

2. Low Earth satellite



**The right wave for the job**

1. Mobile phone/wireless internet



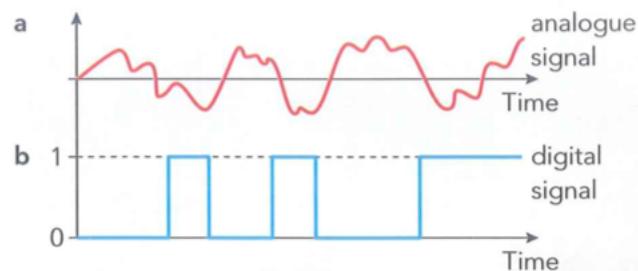
2. Bluetooth



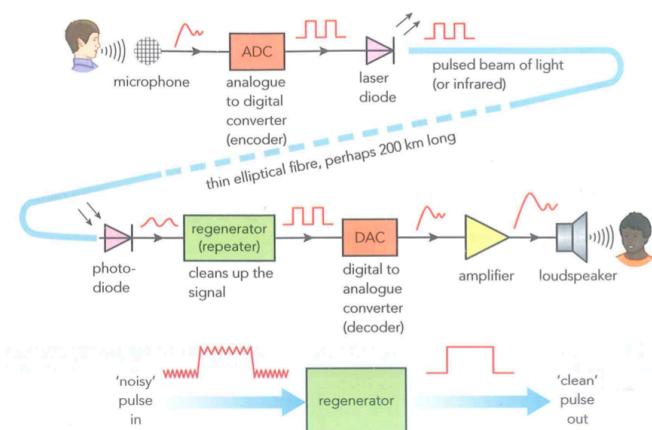
3. Optical fibre

**Analogue and digital signals**

1. Difference



2. Making a digital phone call



3. Benefits of digital signaling