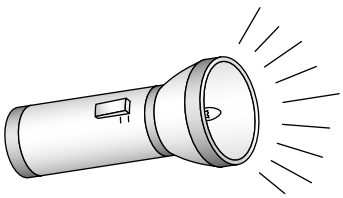
15 Light, Colours and Beyond

Part 1 Sectional Exercises

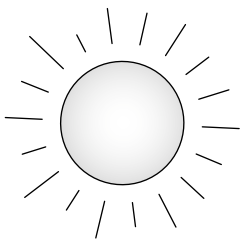
15.1 How do we See an Object?

A. Questions

Circle the number if the object shown is luminous.

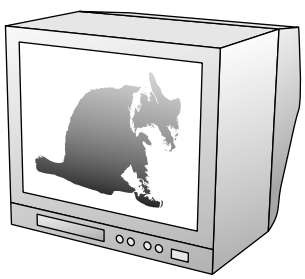


1. Torch



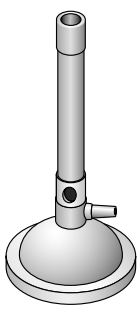
2. Sun

3. Earth

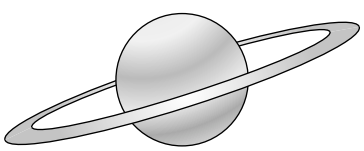


4. Television

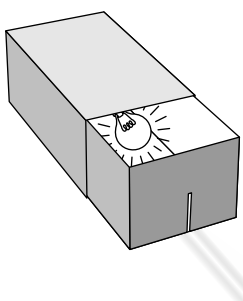
5. Pencil



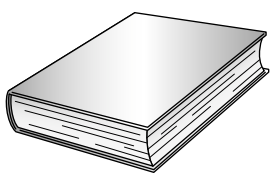
6. Bunsen burner



7. Saturn



8. Ray box



9. Book

B. Fill in the blanks

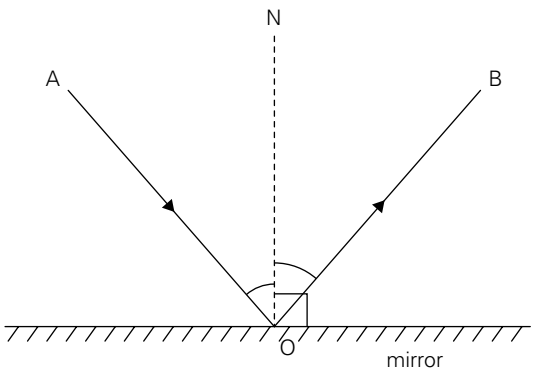
Complete the sentences below with suitable words.

1. Non-luminous objects are seen because they (a) reflect light to our eyes.
2. Light travels (b) faster than sound.
3. The speed of light is the fastest when it travels in a (c) vacuum .
4. Light travels in a (d) straight line.
5. When drawing diagrams, we can represent light rays with (e) straight lines and (f) arrows .

15.2 Reflection at Plane Surfaces

A. Label the diagram

A light ray is reflected from a mirror as shown in the diagram below.



Name the following.

Line OA : Incident ray

Line OB : Reflected ray

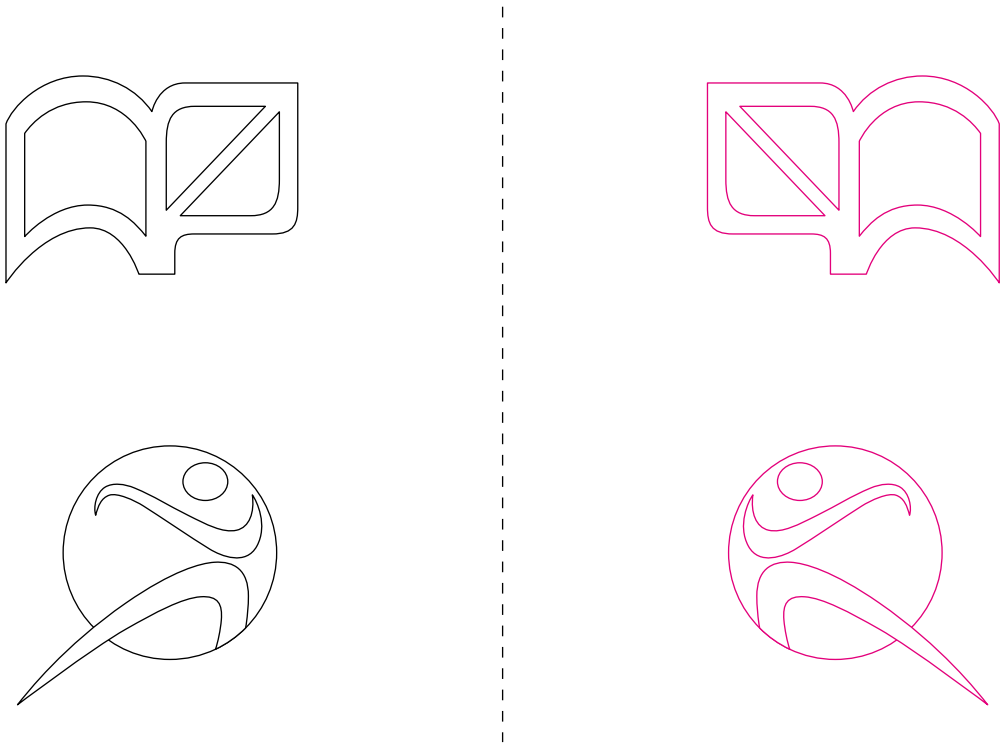
Line ON : Normal

Angle AON : Angle of incidence

Angle BON : Angle of reflection

B. Draw the images

Two objects are placed before a mirror (the dotted line) as shown in the diagram below. Draw the images formed by the mirror.



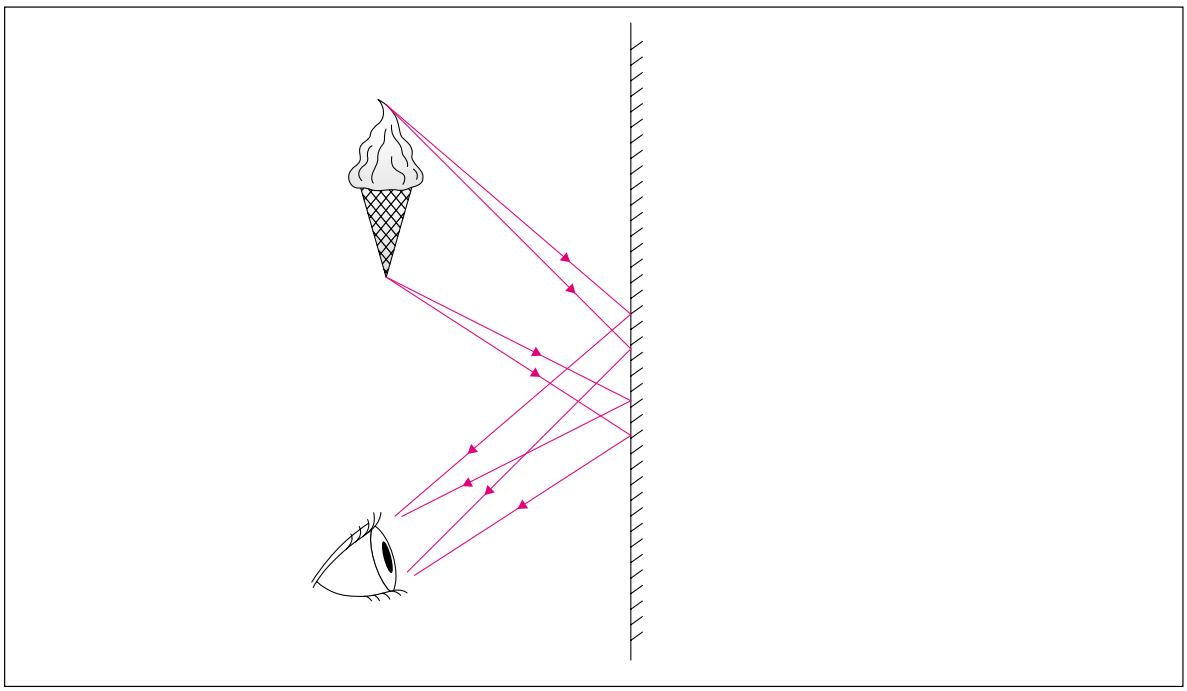
C. Fill in the blanks

Complete the sentences below with suitable words.

1. The law of reflection states that the angle of reflection is equal to the (a) angle of incidence .
2. All images formed in a piece of plane mirror are (b) laterally inverted and have the same size as the (c) objects .
3. Periscopes can be found on (d) tanks and in (e) submarines to help the crew view the outside area.
4. Plane mirrors can be used to increase the (f) spatial feel of a room.
5. In regular reflection, all parallel light rays are reflected in the (g) same direction.
6. The word at the front of an ambulance is laterally inverted because it helps the driver see the word through the (h) rear-view mirror .

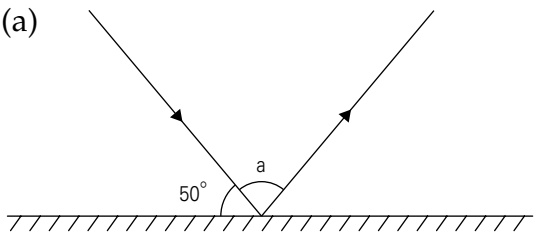
D. Questions

1. Complete the following diagram to show how the light rays from the object reach our eyes.



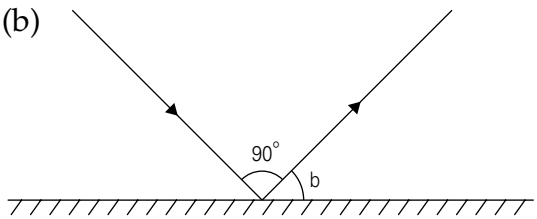
2. Calculate the marked angle.

(a)



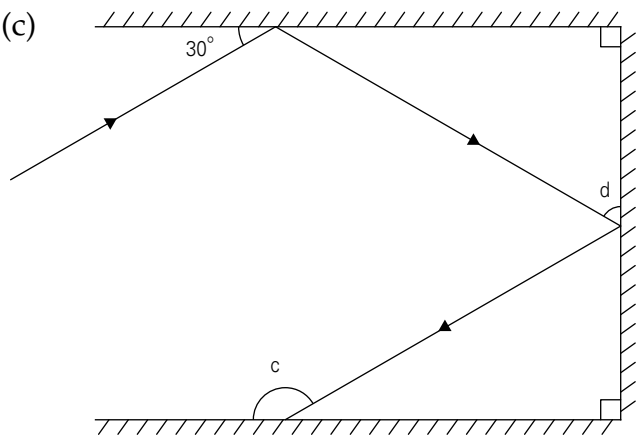
a = 80°

(b)



b = 45°

(c)



c = 150°

d = 60°

15.3 Colour

A. Word searching

Circle the seven colours dispersed by white light. The word may be in any orientation.

B	S	Y	S	R	A	I	B	U
O	L	Z	E	D	Q	R	N	I
G	F	U	L	L	O	E	N	K
R	W	X	E	W	L	D	L	V
E	P	I	N	K	I	O	C	I
E	T	T	L	G	U	H	W	O
N	E	V	O	R	N	A	B	L
H	Y	U	R	W	H	I	T	E
M	O	R	A	N	G	E	B	T

B. True or False

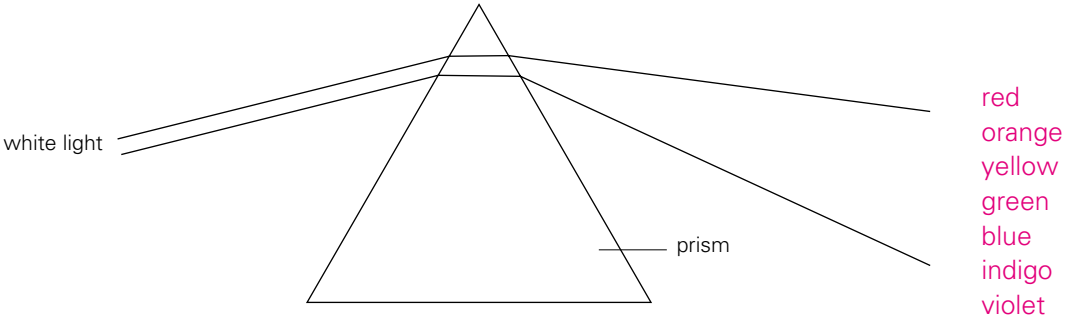
Study each of the following statements. Put a '√' in the box against a true statement and a '×' against a false statement.

1. Rainbow is the result of dispersion of white light by water droplets in the air. [√]
2. The three primary colours are red, yellow and green. [×]
3. Rod cells in our retina are responsible for distinguishing between different colours. [×]
4. Statistics have shown that women have a higher chance of colour-blindness. [×]
5. The surface of the television screen is coated with phosphor. [√]
6. A colour filter is a transparent object which allows only light of a particular colour to pass through. [√]
7. Pure green objects only reflect green light. [√]

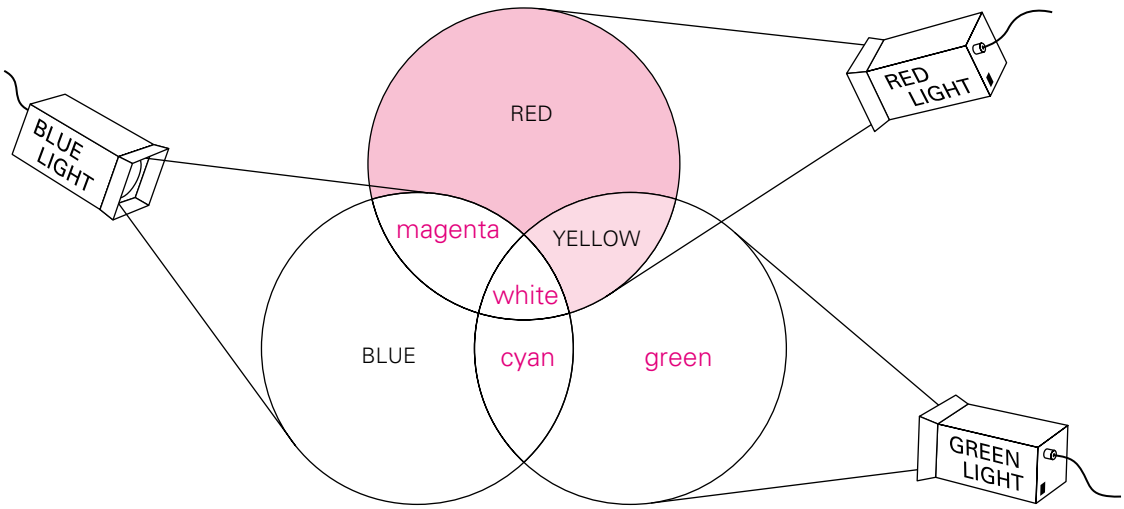
C. Complete the diagrams

Complete the following diagrams with suitable colours.

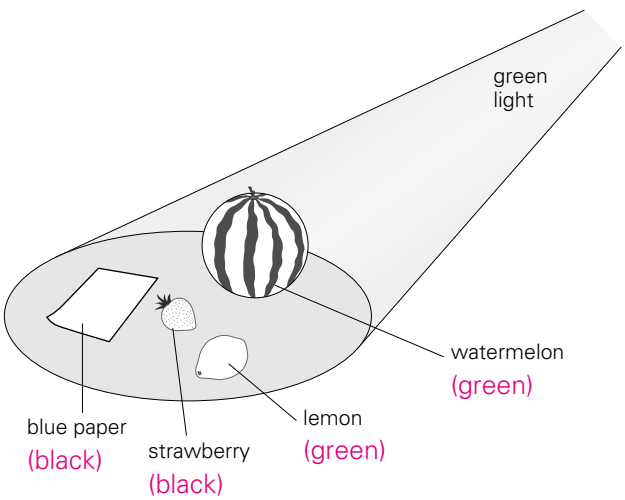
1.



2.



Ⓔ 3.



D. Fill in the blanks

Complete the sentences below with suitable words.

1. A (a) _____colour spectrum_____ is produced from the dispersion of white light by a prism.
2. Blue light is complementary to (b) _____yellow light_____ . Mixing light of these two colours will give (c) _____white_____ light.
3. Cone cells are distributed around the (d) _____centre_____ of the retina which are responsible for distinguishing between (e) _____different_____ colours.
4. Colour-blindness is due to defects of (f) _____cone cells_____ in the retina.
5. There are many (g) _____phosphor_____ dots on the screen of a colour television. When they are hit by an (h) _____electron beam_____ , the dots glow.
6. A green filter absorbs light of all colours except (i) _____green_____ light.

E. Complete the table

Complete the following table.

Colour of the light used	Colour of the mixed light produced
Red and blue	magenta
Blue and green	cyan
Magenta and blue	violet
Red and yellow	orange
Red, blue and green	white

F. Comprehension

Read the following passage and answer the questions.

> Light is important in photography. Almost all forms of photography will make use of silver-halide crystals because of their light-sensitive property. When a photographic film is exposed to light, silver-halide crystals contained in the emulsion of the film will undergo chemical changes. A latent image will be formed on the film. When the film is processed in a chemical reagent called a developer, particles of metallic silver will form in areas that have been exposed to light. More particles will form if there was an intense exposure. Fewer particles will form for weaker exposure to light. The image produced in this way is called 'negative' because the tonal values of the subject photographed are reversed. The tonal values will be changed into the opposite again in the photographic printing process.

1. What is the essential ingredient in photographic film?

   silver halide

2. What is the light-sensitive property of silver-halide crystals?

   When a photographic film is exposed to light, silver-halides crystals in the emulsion of the film will undergo chemical changes. A latent image will be formed on the film.

3. What will happen when the film is put in the developer?

   Particles of metallic silver will form in areas that have been exposed to light.

4. Why is the name 'negative' so called?

   That is because the tonal values of the subject photographed are reversed.

15.4 Beyond the Visible Spectrum

A. True or False

Study each of the following statements. Put a '√' in the box against a true statement and a '×' against a false statement.

1. Objects at room temperature do not emit infrared radiation. ×
2. Infrared radiation is invisible to the naked eye and so it is used in security systems. √
3. The laser pointer produces an invisible ray and emits a red spot when it hits the wall. The ray produced is infrared radiation. ×
4. The ozone layer absorbs excessive ultraviolet radiation in the sunlight. √

Ⓔ 5. Since ultraviolet radiation helps our bodies to produce vitamin D, the more we are exposed to ultraviolet radiation, the healthier we are. ×

Ⓔ 6. In 1997, a treaty was signed by nations all over the world to stop the use of CFCs which are harmful to the ozone layer. ×

B. Fill in the blanks

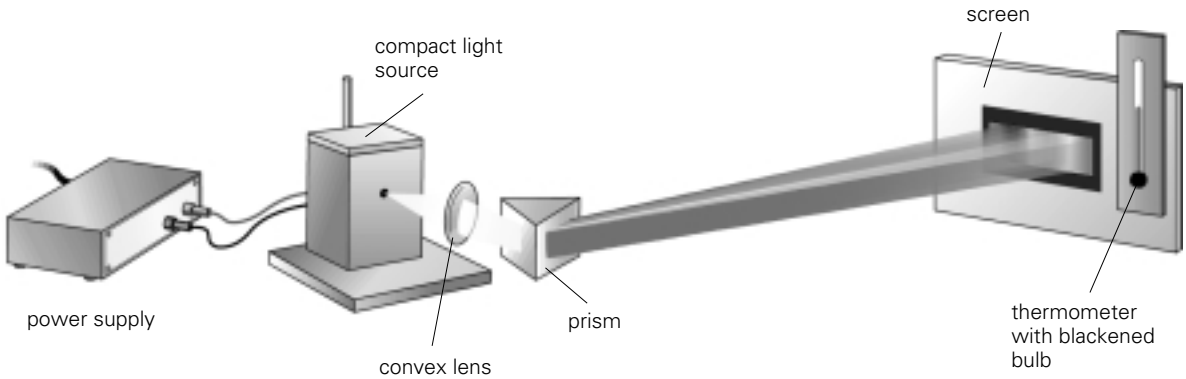
Complete the sentences below with suitable words.

1. (a) _____Frequency_____ refers to the number of recurrences of an event in a second. It determines the (b) _____colour_____ of light.
2. (c) _____Infrared radiation_____ , the radiation just beyond the visible spectrum, can be detected by a blackened thermometer.
3. One of the applications of infrared radiation is (d) _____IR photography_____ . It is useful to investigations in astronomy.
4. The frequency of ultraviolet radiation is (e) _____higher_____ than that of visible light.

Ⓔ 5. Overexposure to the sun will cause (f) _____skin burn_____ or even (g) _____skin cancer_____ .

C. Questions

The following experiment shows an investigation on the visible spectrum using a prism.



1. What is the name of the radiation just beyond the violet light of the spectrum?

   ultraviolet radiation

2. Name a substance which can help to detect the radiation.

   fluorescent materials/petroleum/paint

3. Name two uses of the radiation.

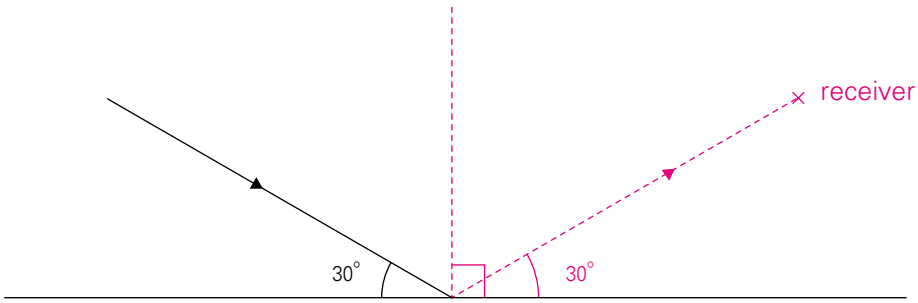
   sterilisation of drinking water

   checking of banknotes

15.5 Beyond Infrared and Ultraviolet

A. Questions

1. The following set-up shows a beam of microwave falling on a metal plate.

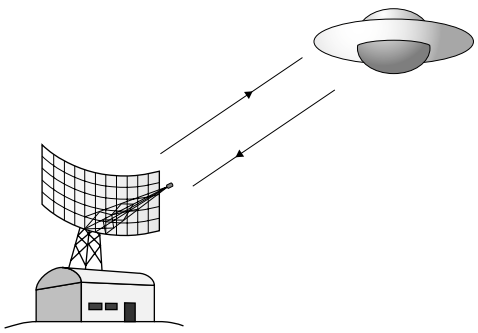


(a) Draw a dotted line to show the position where the receiver should be placed to detect the microwave.

(b) Calculate the angle of reflection of the microwave.

Angle of reflection = 90° – 30° = 60°

(c) The reflection property of microwave is applied in radar. A microwave pulse is emitted by an emitter and reflected back, after 7.5×10^{-5} s, to a receiver placed close to the emitter. How far is the object from the radar? (Assume that the velocity of wave is 3×10^{8} m s^{-1}.)



Let 'd' be the distance between the object and radar.

$2d = 7.5 \times 10^{-5} \times 3 \times 10^{8}$

d = 11 250 m

2. It is known that microwave, visible light and X-rays belong to a family of waves called electromagnetic waves. State three common features of these waves.

- They all travel in a vacuum with a speed of 3×10^{8} m s^{-1}.
- All EM waves can be reflected and refracted.
- All waves transmit energy.

B. Matching

Match the items in column I with those in column II.

Column I		Column II	
1. visible light	C	A.	 TV broadcast
2. X-rays	G	B.	 remote control
3. ultraviolet radiation	D	C.	 illumination
4. microwaves	F	D.	 checking banknotes
5. radio waves	A	E.	 killing cancer cells
6. gamma rays	E	F.	 radar
7. infrared radiation	B	G.	 medical diagnosis

C. Fill in the blanks

Complete the sentences below with suitable words.

1. The different types of electromagnetic waves, in descending order of frequency, include (a) gamma rays , X-rays, (b) ultraviolet radiation , visible light, (c) infrared radiation , (d) microwaves and radio waves.
2. X-rays are produced by the collision of high-speed electrons with (e) tungsten . Its major application is in (f) medical diagnosis .
3. Gamma rays have a (g) higher energy than that of X-rays. They can be used in radiotherapy to kill (h) cancer cells .
4. Short wave and microwave are both used in (i) long-distance communications . However, microwave is reflected by a (j) satellite while short wave is reflected by the (k) ionosphere .
5. We use (l) antennae to transmit and receive radio waves.
6. There are two kinds of radio broadcasting, (m) FM (Frequency Modulation) and AM (Amplitude Modulation).

D. Multiple-Choice Questions

Write the correct answer to each question in the box provided.

1. Which of the following electromagnetic waves has energy higher than X-rays?

   A. radio waves
   B. ultraviolet radiation
   C. infrared radiation
   D. gamma rays

   D

2. All electromagnetic waves

   (1) can be reflected.
   (2) can be refracted.
   (3) travel with the same speed in vacuum.
   (4) cannot be detected by human eyes.

   A. (1) only
   B. (2) only
   C. (1), (2) and (3) only
   D. (1), (2) and (4) only

   C

3. P is an EM wave with a frequency in between that of visible light and radio waves. P is often used in live broadcasting. What may P be?

   A. infrared radiation
   B. microwaves
   C. X-rays
   D ultraviolet radiation

   B

4. Radioactivity refers to

   A. medical treatment involving the use of gamma rays to kill cancer cells.
   B. the use of radio waves in transmission of signals.
   C. the emission of penetrating radiation from an element.
   D. a group of amateurs interested in using radio waves for communications.

   C

5. Which of the following is NOT a use of microwaves?

   A. in microwave oven
   B. in radio broadcasting
   C. in satellite transmission
   D. in radar

   B

6. Which of the following is NOT a use of radio waves?

   A. in radiotherapy
   B. in TV broadcasting
   C. in radio broadcasting
   D. in mobile communication

   A

Ⓔ 15.6 Refraction and its Practical Uses

A. Fill in the blanks

Complete the sentences below with suitable words.

1. When light enters glass from air, it changes its (a) direction and (b) velocity . This phenomenon is called (c) refraction .
2. The apparent depth of a swimming pool is (d) less than its real depth.
3. For a light beam travelling from air into water, the smaller the angle of incidence, the (e) smaller the angle of refraction will be.
4. Parallel light rays passing through a (f) convex lens converge to a fixed point.
5. We use a (g) microscope to observe very small objects, such as cells and small insects.
6. Hand lens is made from a (h) convex lens.

B. True or False

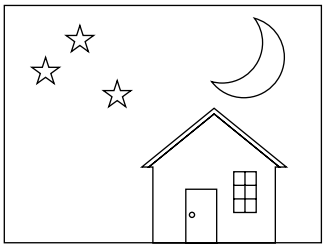
Study each of the following statements. Put a '√' in the box against a true statement and a '×' against a false statement.

1. When light enters water from the air, its speed decreases. [√]
2. When light enters air from water, it bends towards the normal. [×]
3. Refraction occurs only when light enters from an optically less dense medium to an optically denser medium. [×]
4. Images formed by a convex lens are always erect and diminished in size. [×]
5. When an image is diminished in size, its magnification is less than unity. [√]
6. Images formed by a microscope are inverted. [√]

C. Questions

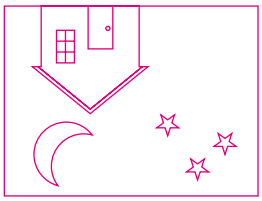
Answer the following questions in the spaces provided.

1.



Draw the image observed when the above picture is placed

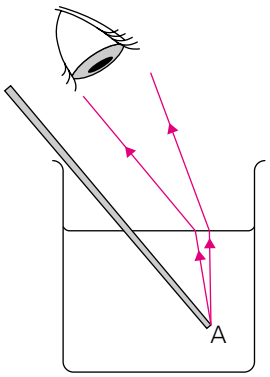
(a) very far away from a converging lens.



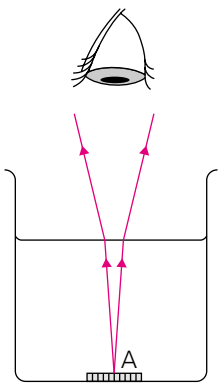
(b) very close to a converging lens.

2. Draw two lines in each of the following cases to show how the rays from point A will reach the eye.

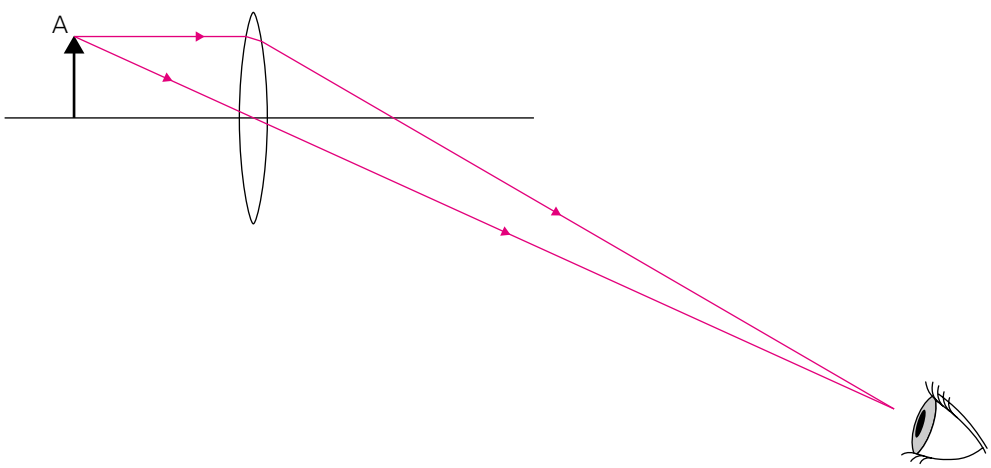
(a) bent chopstick



(b) real depth



(c) formation of image



Ⓔ 15.7 Total Internal Reflection and Optical Fibres

A. Fill in the blanks

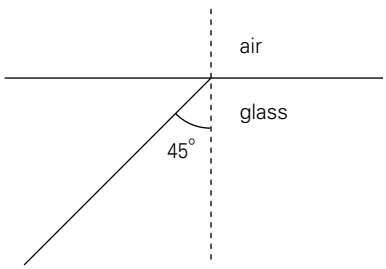
Complete the sentences below with suitable words.

1. Total internal reflection occurs only if a light ray travels from an optically (a) denser medium to an optically (b) less dense medium.
2. (c) Cat's eyes serve as a guide for drivers travelling on roads at night.
3. In a desert, where the temperature is very high, the air forms layers with varying (d) densities and (e) temperatures .
4. (f) Optical fibres can guide light to travel along a curved path with a little loss of energy.
5. An (g) endoscope helps doctors to examine the interior of human bodies.

B. Questions

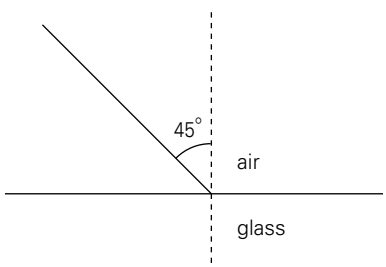
It is known that for light travelling from glass into air and from water into air, total internal reflection will occur when the angle of incidence is larger than 42° and 48° respectively. Find out in which of the following cases total internal reflection will occur and put a '√' in the correct boxes.

(a)



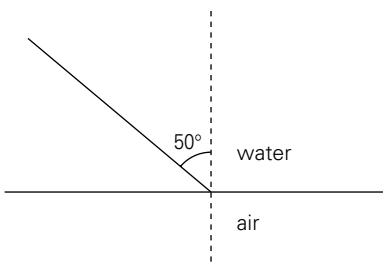
√

(b)



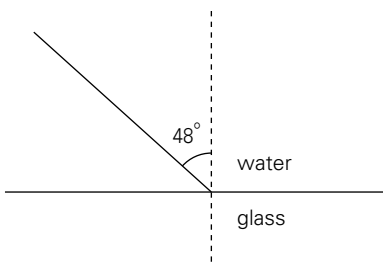
☐

(c)



√

(d)



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Part 2 Integrated Exercises

A. True or False

Study each of the following statements. Put a '√' in the box against a true statement and a '×' against a false statement.

1. Among the EM waves, only visible light is a form of energy. [×]
2. The images formed by plane mirrors are laterally inverted. [√]
3. A red colour filter absorbs colours other than red. [√]
Ⓔ 4. Ultraviolet radiation facilitates the production of vitamin E in our bodies. [×]
5. Not all members of the EM spectrum can travel in vacuum. [×]
6. Short waves are mainly used in long-distance communications because they can pass through the ionosphere and be reflected by the satellites in space. [×]
Ⓔ 7. The apparent depth of a trough of water is less than the real depth because light rays are refracted at the boundary between water and air. [√]
Ⓔ 8. An ordinary microscope is made up of two concave lenses. [×]
9. A periscope can be made from two isosceles right-angled triangular prisms. [√]
Ⓔ 10. If a hand lens is placed far away from an object, an inverted image will be formed. [√]

B. Multiple-Choice Questions

Write the correct answer to each question in the box provided.

1. Which of the following items is/are luminous object(s)?

(1) Pluto
(2) fluorescent paper
(3) the Sun
(4) optical fibres

A. (1) only
B. (3) only
C. (1), (2) and (4) only
D. (2), (3) and (4) only

[B]

2. The speed of light in vacuum is

   A. 3.00×10^{6} m s^{-1}.
   B. 2.25×10^{8} m s^{-1}.
   C. 3.00×10^{8} m s^{-1}.
   D. 3.00×10^{9} m s^{-1}.

   C

Ⓔ 3. When light travelling in air enters a piece of glass at an oblique angle, which of the following properties will change?

   (1) speed of the light ray
   (2) colour of the light ray
   (3) direction of travel of the light ray
   (4) colour of the piece of glass

   A. (1) only
   B. (1) and (3) only
   C. (2) and (3) only
   D. (1), (2) and (4) only

   B

4. Which of the following description(s) about cone cells is/are CORRECT?

   (1) They are cone-shaped.
   (2) They contain a kind of pigment called visual purple.
   (3) They can distinguish between different colours.
   (4) There are four types of cone cells in our retina.

   A. (1) only
   B. (1) and (3) only
   C. (2) and (3) only
   D. (1), (2), (3) and (4)

   B

5. Colour-blindness

   A. is caused by bacteria infecting the retina.
   B. can be cured by wearing glasses.
   C. is a genetic disease.
   D. is more common in women than in men.

   C

6. Green light can pass through

   A. a red filter.
   B. a green filter.
   C. a red and a green filter.
   D. a blue filter.

   B

7. Which of the following is NOT an application of infrared radiation?

   A. heating
   B. remote control system
   C. remote sensing
   D. radiotherapy

   D

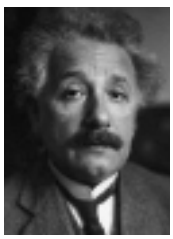
8. All members of the EM spectrum have the same

   A. frequency.
   B. wavelength.
   C. penetrability.
   D. speed in vacuum.

D

9. Radioactivity was discovered by

A. 
Isaac Newton

B. 
Albert Einstein

C. 
Becquerel

D. 
J. C. Maxwell

C

10. Which of the following is NOT an application of X-rays?

    A. checking the foetus of a pregnant woman
    B. detecting bone fractures
    C. detecting cracks in metal objects
    D. identifying the contents of luggage

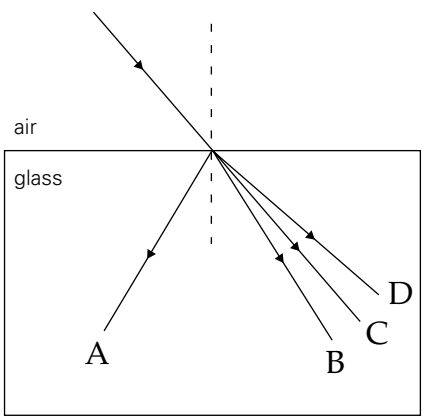
A

11. Which of the following statements about microwaves is INCORRECT?

    A. They can be reflected by the ionosphere.
    B. They are used to detect distant objects.
    C. Their frequencies are lower than that of infrared radiation.
    D. They can be used to heat up food.

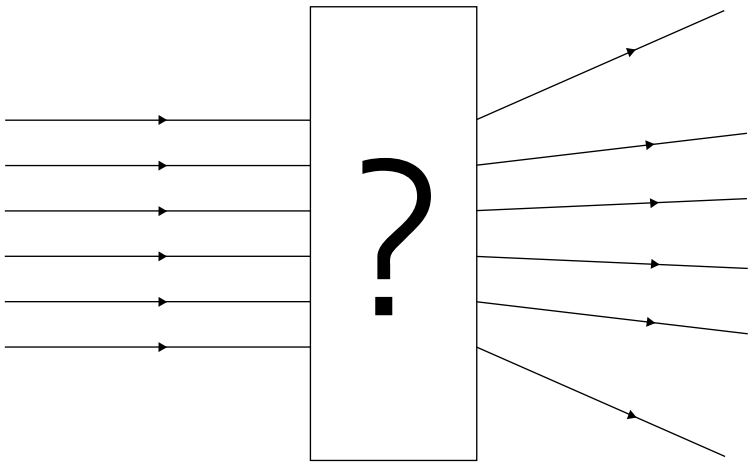
A

Ⓔ 12. Which of the following correctly represents refracted rays in this case?



B

Ⓔ 13. What may be the missing optical instrument?



A. a convex lens
B. a concave lens
C. a plane mirror
D. a prism

B

Ⓔ 14. Magnification

A. $= \frac{\text{image size}}{\text{object size}}$

B. is the ratio between the thickness of the concave lens and its diameter.

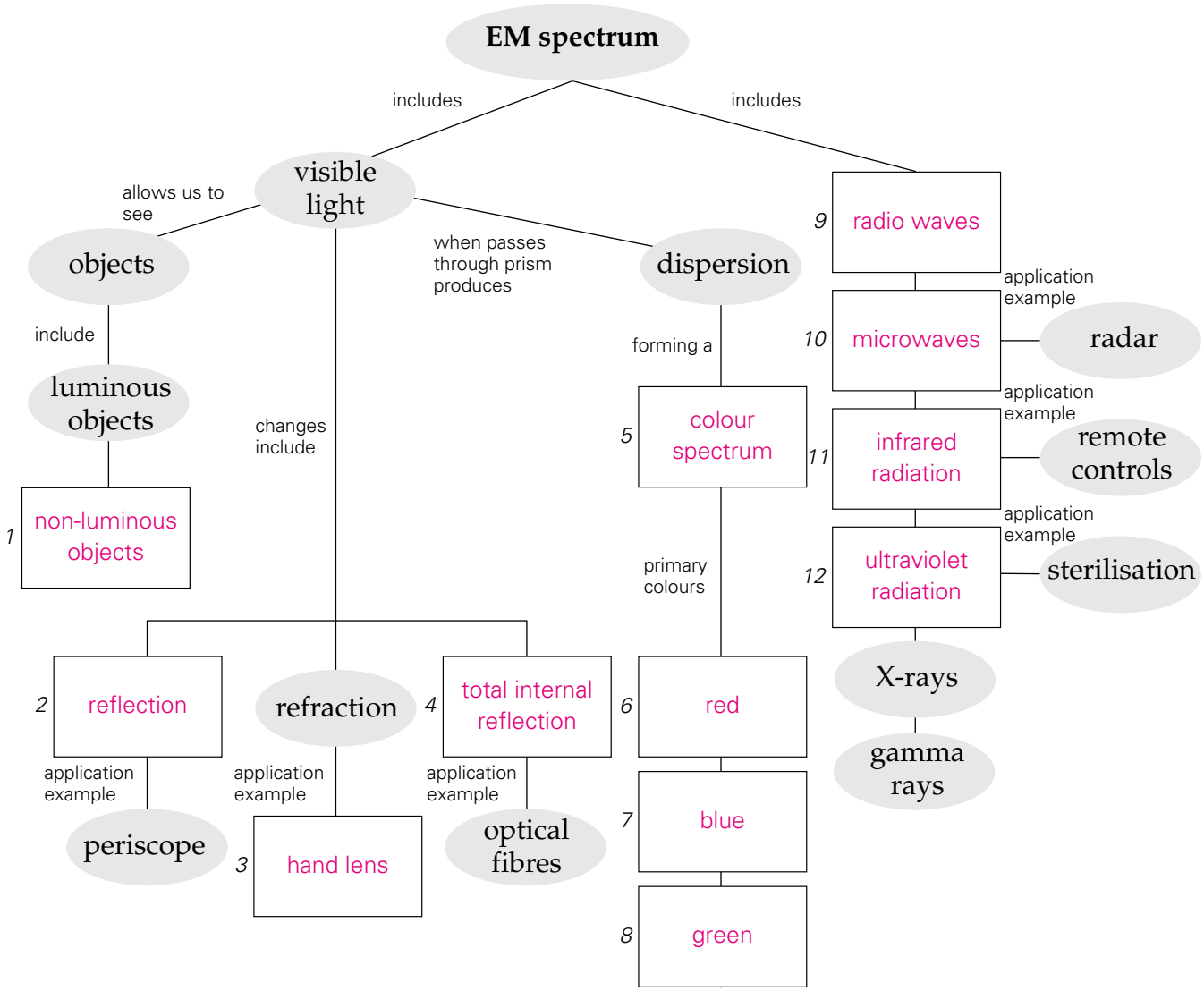
C. $= \frac{\text{object size}}{\text{image size}}$

D. is an optical instrument used to magnify objects.

A

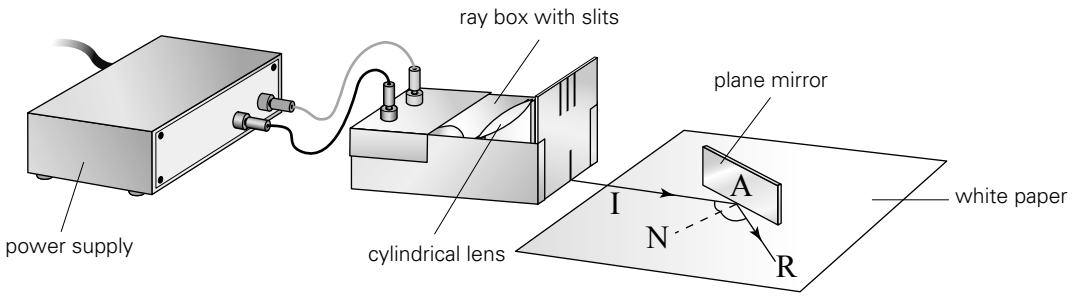
C. Concept map

The following is the concept diagram of Unit 15. Fill in the blanks with suitable words.



D. Questions

1. Study the diagram below.



The above set-up is used to investigate the law of reflection. ∠IAN will be adjusted and the corresponding ∠NAR measured.

(a) What are the names of ∠IAN, ∠NAR and line NA respectively? (3)

∠IAN: angle of incidence

∠NAR: angle of reflection

NA: normal

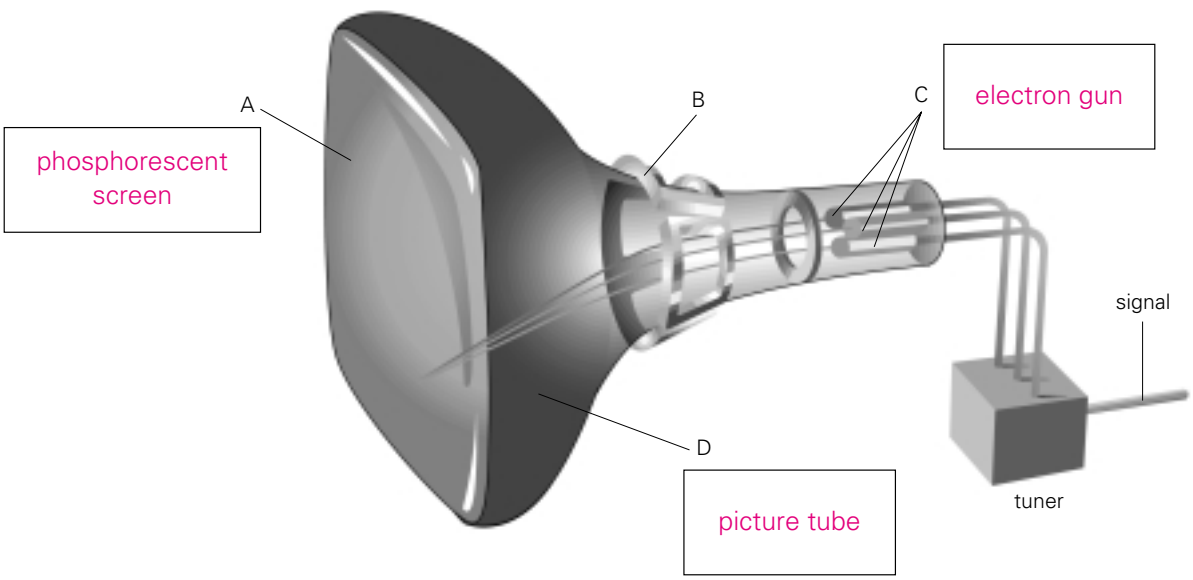
(b) State the law of reflection. (1)

The angle of incidence equals the angle of reflection.

(c) Usually ∠IAN cannot be adjusted to a value larger than 70°, can you suggest one reason for this observation? (1)

The law of reflection does not hold well when the angle of incidence is too large.

2. The diagram below shows the internal structure of a television.



(a) Label the structures A, C and D in the diagram. (3)

(b) Structure A is coated with a certain substance X so that it can glow when hit by electrons, what is X? (1)

phosphor

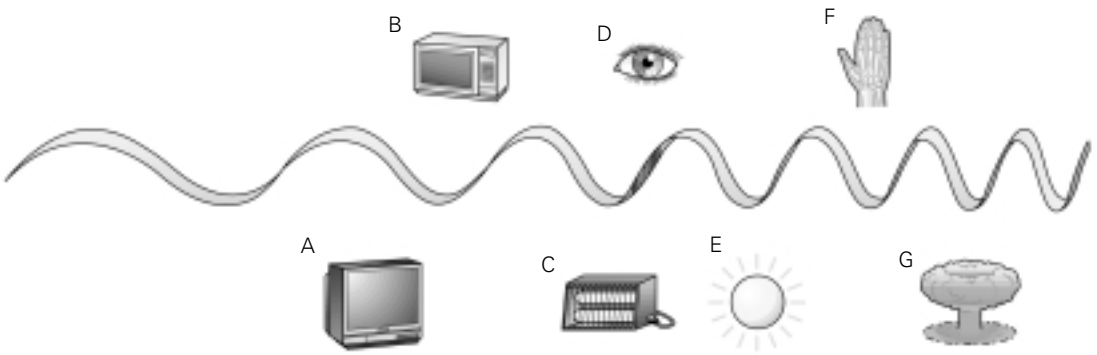
(c) Describe briefly how a colourful picture is formed on structure A. (3)

There are numerous dots on the screen. They are arranged in groups of three. These dots can emit red, blue or green light when hit by an electron beam. Thus a colourful picture can be formed by combining these dots.

(d) Part of the signal is transmitted to structure B. Explain the function of structure B. (1)

B is responsible for deflecting the electron beam to a suitable position on the screen.

3. The diagram below shows the different members of the EM spectrum.



(a) State two applications of EM wave A. (2)

radar, long distance communications

(b) B can be used to heat up food. State one precaution when using it in heating. (1)

DO NOT use metal containers to hold the food.

(c) Suggest one way to detect C. (1)

use a thermometer with a blackened bulb

(d) Suggest one way to detect E. (1)

fluorescent paper

(e) G can be used to kill cancer cells during the process of radiotherapy. Explain why G is used instead of other members in the EM spectrum. (2)

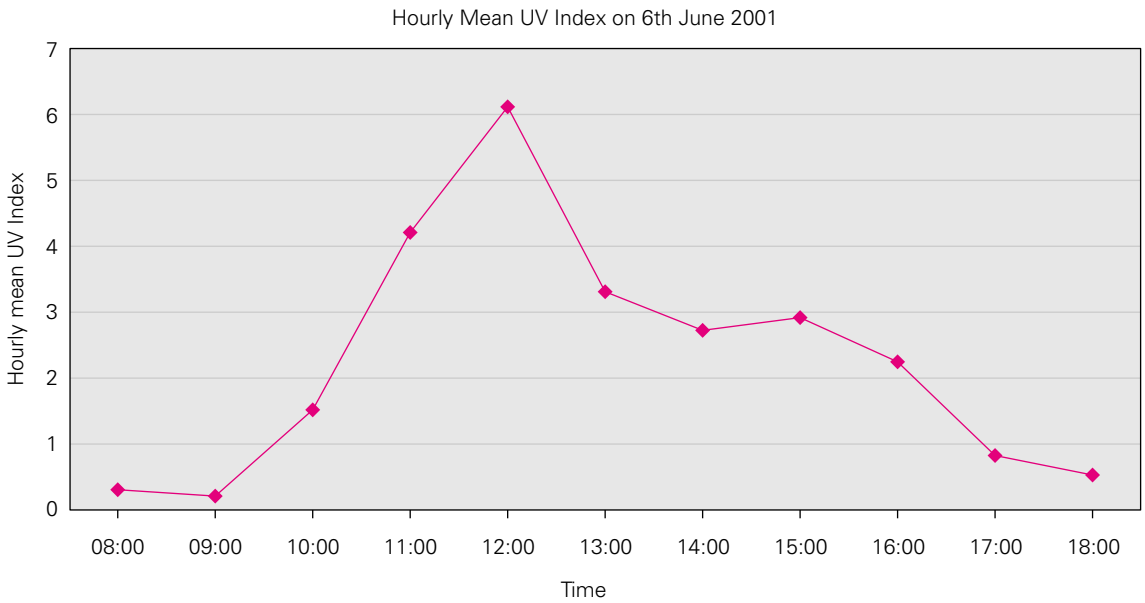
G is the most energetic EM wave and has the highest penetrating power, thus it can pass through a cancerous tissue and destroy cancer cells.

Part 3 'Take Up the Challenge'

Ⓔ 1. Recorded below is the Ultraviolet Index (UV Index) on 6th June 2001 in Hong Kong.

Hong Kong Time	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00
Hourly mean UV Index	0.3	0.2	1.5	4.2	6.1	3.3	2.7	2.9	2.2	0.8	0.5

(a) Use the data above to draw a broken line graph.



(b) How did the hourly mean UV Index on 6th June 2001 change throughout the day? Explain this change.

The UV Index was low in the morning, increased to its peak at noon and dropped in the afternoon. It was because there was brighter sunlight in the afternoon.

(c) What was the highest hourly mean UV Index on 6th June 2001? When did it occur?

6.1. At 12:00.

(d) The mean value of daily highest UV Index in Hong Kong is 12-13. Can you use the answer in (c) to deduce the weather of Hong Kong on 6th June 2001? Explain your answer.

It should have been a cloudy or rainy day because the highest UV Index on that day was lower than the mean value, it means there were clouds which hid the sunlight.

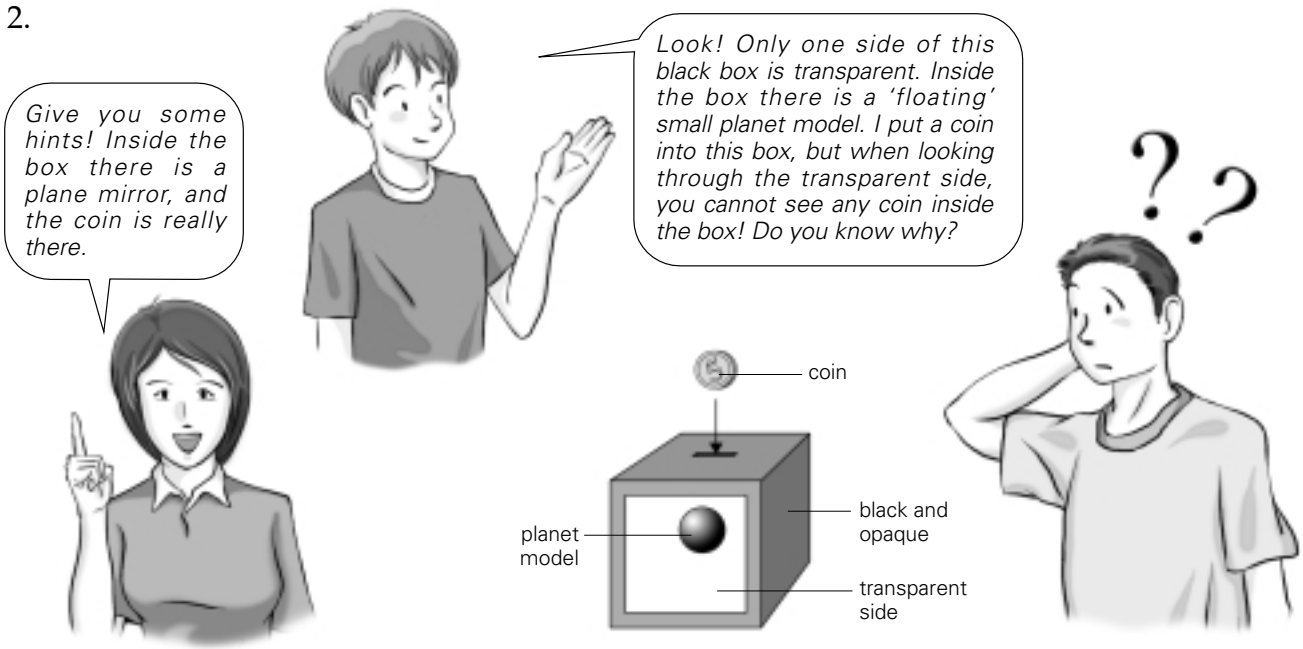
(e) Recorded below are the highest UV Index in different countries:

Location	Typically observed maximum UV Index
Alishan (about 2.4 km above mean sea level) in Taiwan	14
Mexico city (about 2.2 km above mean sea level) in Mexico	13
Mauna Loa (about 3.4 km above mean sea level) in Hawaii, U.S.A.	20

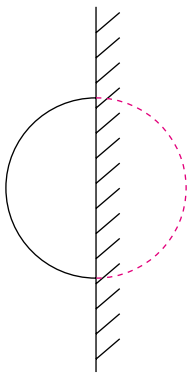
From the table above, which factor may be related to the values of UV Index? Why?

The altitude above the sea level. The higher the altitude, the higher the UV intensity as the amount of ozone available to absorb UV radiation is reduced.

2.

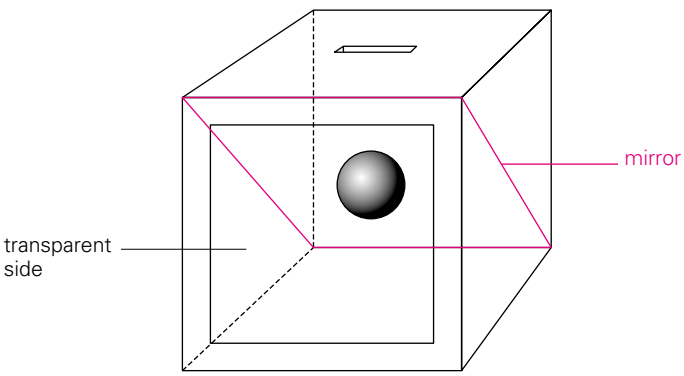


(a) The diagram below shows a plane mirror with a hemisphere attached at its centre. Draw the image of the hemisphere in the diagram.



(b) In fact, the black box makes use of the above phenomenon so that the planet model 'floats' in the air and the coin 'disappears' once it was inserted into the box.

In the following figure, draw the plane mirror in a suitable place in the black box.



(c) By making use of the answer in (b), explain why the planet model 'floats' in the air and the coin 'disappears' once being inserted into the box.

As half of the planet model is attached at the centre of the plane mirror, an image is formed. The planet model together with its image form a sphere which looks like a complete planet model floating in air. On the other hand, the coin inserted is actually behind the mirror, that is why we cannot see it when looking through the transparent side of the box.

3. In Hong Kong, the number of cellular phone users has grown to over 3 million. Sunday Times (12 March 2000) quoted a Swiss study on cellular phone radiation. The following figures are the radiation dosages of some of the mobile phones. The radiation is measured as specific absorption rate (SAR). The FCC (Federal Communications Commission) limit for radiation exposure is an SAR level of 1.6 W/kg.

Nokia 3310	Nokia 8210	Nokia 8850	Ericsson R310s
			
0.75	0.72	0.22	0.94
Ericsson T28s	**Panasonic GD92**	**Sony CMD-Z5**	**Motorola V3690**
			
1.27	1.07	1.06	1.13

Note: SAR is the relative amount of radiation energy absorbed in the head of a user of a wireless handset.

(a) (i) Do you use a cellular phone? Which model is it?

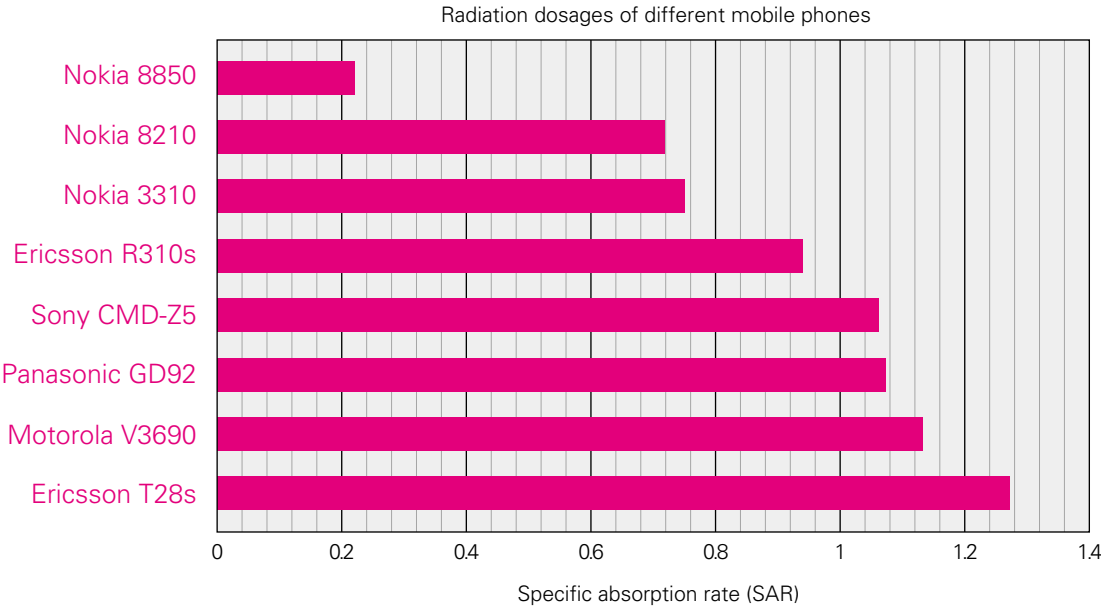
_____

(ii) Which electromagnetic waves do mobile phones transmit?

radio waves

_____

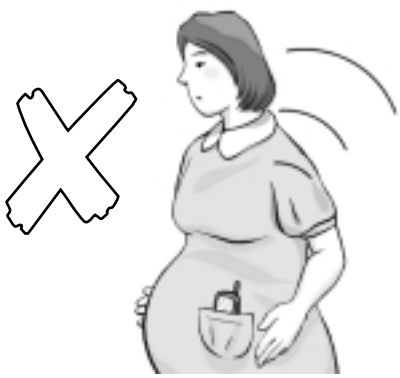
(iii) Draw a bar chart to indicate the radiation dosages of different phone models in ascending order.



(b) No reports have yet shown that radiation from cellular phones is harmful to humans. But there are some public warnings already, e.g. mobile phones should be used for less than half an hour per day to lower the radiation exposure. Do you know what the following posters indicate?

A.

B.



- Use hand-free headphones to reduce direct exposure of our brains to radiation.
- Pregnant women should avoid putting phones near their abdomens in order to reduce exposure of their foetuses to radiation.