Question 1

(*b*) What is reflection? (3)

Spherical mirrors can be either convex or concave.

Draw a ray diagram to show the formation of an image in a convex mirror. (9)

A person looks at her image in a shiny spherical decoration when her face is 30 cm from the surface of the decoration. The diameter of the decoration is 20 cm. Find the position of the image. (12)

Concave mirrors, rather than convex mirrors, are used by dentists to examine teeth. Explain why. (4)

Question 2

(*e*) Draw a ray diagram to show the formation of an image in a convex mirror. (7)

Question 3

3. The following is part of a student's report on an experiment to measure the focal length of a concave mirror.

"I started with the object 6 cm from the mirror but couldn't get an image to form on the screen. I moved the object back a few centimetres and tried again, but I couldn't get an image to form on the screen until the object was 24 cm from the mirror. From then on I moved the object back 8 cm each time and measured the corresponding image distances. I wrote my results in the table."

u/cm	24.0	32.0	40.0	48.0
v/cm	72.5	40.3	33.0	27.9

Draw a labelled diagram of the apparatus used. (9)

Give two precautions that should be taken when measuring the image distance. (6)

Explain why the student was unable to form an image on the screen when the object was close to the mirror. (6)

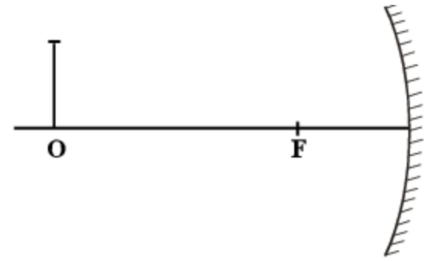
Use all of the data in the table to calculate a value for the focal length of the mirror. (15)

Describe how the student could have found an approximate value for the focal length of the mirror before starting the experiment. (4)

Question 4

(d) An object O is placed 30 cm in front of a concave mirror of focal length 10 cm.

How far from the mirror is the image formed? (7)



Question 5

3. In an experiment to measure the focal length of a concave mirror, an approximate value for the focal length was found. The image distance v was then found for a range of values of the object distance u. The following data was recorded.

u/cm	15.0	20.0	25.0	30.0	35.0	40.0
v/cm	60.5	30.0	23.0	20.5	18.0	16.5

How was an approximate value for the focal length found?

What was the advantage of finding the approximate value for the focal length? (10)

Describe, with the aid of a labelled diagram, how the position of the image was found. (12)

Calculate the focal length of the concave mirror by drawing a suitable graph based on the recorded data. (18)

Question 6

2. In an experiment to measure the refractive index of a substance, a student used a rectangular block of the substance to measure the angle of incidence i and the corresponding angle of refraction r for a ray of light as it passed from air into the substance. The student repeated the procedure for a series of different values of the angle of incidence and recorded the following data.

i (degrees)	20	30	40	50	60	70	80
r (degrees)	13	20	27	23	36	40	43

One of the recorded angles of refraction is inconsistent with the others. Which one? (4)

Describe, with the aid of a labelled diagram, how the student found the angle of refraction. (12)

Calculate a value for the refractive index of the substance by drawing a suitable graph based on the recorded data. (18)

Using a graph to calculate a value for the refractive index is a more accurate method than calculating the refractive index for each pair of angles and then finding the mean.
Give two reasons for this. (6)

Question 7

2. In an experiment to measure the focal length of a converging lens, a student measured the image distance v for each of four different values of the object distance u.

The table shows the data recorded by the student.

u/cm	12.0	18.0	23.6	30.0
v/cm	64.5	22.1	17.9	15.4

Describe, with the aid of a labelled diagram, how the student obtained the data. (15)

Why is it difficult to measure the image distance accurately? (4)

Using all the data in the table, find the value for the focal length of the lens. (15)

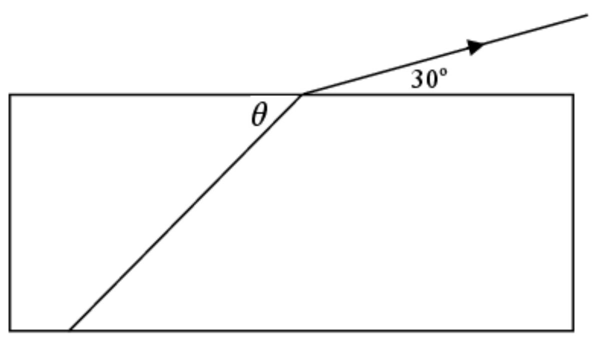
Why is it difficult to measure the image distance when the object distance is less than 10 cm? (6)

Question 8

(*e*) If a diamond has a refractive index of 2.42, what is the speed of light in the diamond?

Question 9

(*b*) The diagram shows a ray of light as it leaves a rectangular block of glass. As the ray of light leaves the block of glass, it makes an angle θ with the inside surface of the glass block and an angle of 30° when it is in the air, as shown.



(i) If the refractive index of the glass is 1.5, calculate the value of θ. (12)

(ii) What would be the value of the angle θ so that the ray of light emerges parallel to the side of the glass block? (9)

(iii) Calculate the speed of light as it passes through the glass. (7)

Question 10

3. In an experiment to verify Snell's law, a student recorded the following data.

$i/°$	30	40	50	55	60	65	70
$r/°$	19	26	30	33	36	38	40

Draw a labelled diagram of the apparatus used.
On your diagram, indicate an angle i and its corresponding angle r. (12)

Using the recorded data, draw a suitable graph and explain how your graph verifies Snell's law.

Using your graph, calculate the refractive index of the substance used in the experiment. (22)

The student did not record any values of the angle i below 30°. Give two reasons why. (6)

Question 11

2. A student was asked to measure the focal length of a converging lens. The student measured the image distance v for each of three different object distances u. The student recorded the following data.

u/cm	20.0	30.0	40.0
v/cm	65.2	33.3	25.1

Describe how the image distance was measured. (12)

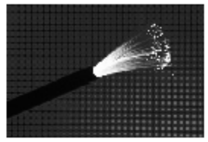
Give two precautions that should be taken when measuring the image distance. (6)

Use all of the data to calculate the focal length of the converging lens. (15)

What difficulty would arise if the student placed the object 10 cm from the lens? (7)

Question 12

(*c*) Information is transmitted over long distances using optical fibres in which a ray of light is guided along a fibre. Each fibre consists of a core of high quality glass with a refractive index of 1.55 and is coated with glass of a lower refractive index.



Explain, with the aid of a labelled diagram, how is a ray of light guided along a fibre. (9)

Why is each fibre coated with glass of lower refractive index? (6)

What is the speed of the light as it passes through the fibre? (7)

Light passing through optical fibres must travel through an enormous length of glass. Impurities in the glass reduce the power transmitted by half every 2 km. The initial power being transmitted by the light is 10 W.

What is the power being transmitted by the light after it has travelled 8 km through the fibre? (6)

(speed of light in air = 3.0×10^8 m s^{-1})

Question 13

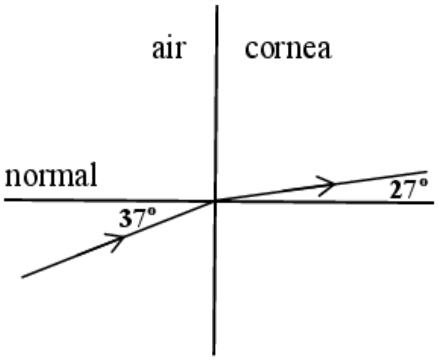
9. What is meant by refraction of light?
State Snell's law of refraction. (12)

An eye contains a lens system and a retina, which is 2.0 cm from the lens system.
The lens system consists of the cornea, which acts as a fixed lens of power 38 m^{-1}, and a variable internal lens just behind the cornea. The maximum power of the eye is 64 m^{-1}.

Calculate:

(i) how near an object can be placed in front of the eye and still be in focus;

(ii) the maximum power of the internal lens. (15)



Light is refracted as it enters the cornea from air as shown in the diagram.
Calculate the refractive index of the cornea. (6)

Draw a diagram to show the path of a ray of light as it passes from water of refractive index 1.33 into the cornea. (6)

A swimmer cannot see properly when she opens her eyes underwater.
When underwater:

(i) why does the cornea **not** act as a lens?

(ii) what is the maximum power of the eye?

(iii) why do objects appear blurred?

(iv) explain how wearing goggles allows objects to be seen clearly.

(17)

Question 14

7. What is meant by the refraction of light? (6)

A converging lens is used as a magnifying glass.
Draw a ray diagram to show how an erect image is formed by a magnifying glass. (12)

A diverging lens cannot be used as a magnifying glass.
Explain why. (5)

The converging lens has a focal length of 8 cm. Determine the two positions that an object can be placed to produce an image that is four times the size of the object? (15)

The power of an eye when looking at a distant object should be 60 m^{-1}. A person with defective vision has a minimum power of 64 m^{-1}.

Calculate the focal length of the lens required to correct this defect. (12)

What type of lens is used? Name the defect. (6)

Question 15

3. In an experiment to verify Snell's law, a student measured the angle of incidence *i* and the angle of refraction *r* for a ray of light entering a substance. This was repeated for different values of the angle of incidence. The following data was recorded.

i/degrees	20	30	40	50	60	70
r/degrees	14	19	26	30	36	40

Describe, with the aid of a diagram, how the student obtained the angle of refraction. (9)

Draw a suitable graph on graph paper and explain how your graph verifies Snell's law. (18)

From your graph, calculate the refractive index of the substance. (9)

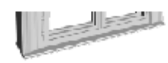
The smallest angle of incidence chosen was 20°. Why would smaller values lead to a less accurate result? (4)

Question 16

(e) The refractive index of a liquid is 1.35, what is the critical angle of the liquid? (7)

Question 17

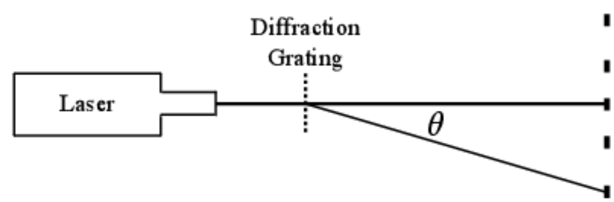
(*e*) List a pair of complementary colours of light.



Question 18

7. What is meant by the terms (*i*) diffraction and (*ii*) interference? (9)

A laser produces a beam of red light with a wavelength of 709 nm. The beam is incident on a diffraction grating, as shown in the diagram. A diffraction pattern is formed on a screen. A second order image is detected at an angle of 34.6° from the central image.



Calculate the energy of each photon in the laser beam. (9)

Sensors in the eye can respond to single photons. Where in the eye are these sensors located? (3)

State two differences between the electromagnetic radiation emitted from a laser and the electromagnetic radiation emitted from a vapour lamp. (6)

Derive, with the aid of a labelled diagram, the diffraction grating formula. (15)

Calculate the number of lines per millimetre on the grating used in the experiment. (9)

What would be observed on the screen if the laser was replaced by a ray of white light? (5)

Question 19

(*b*) A narrow beam of light undergoes dispersion when it passes through either a prism or a diffraction grating.

What is meant by dispersion? (6)

Give two differences between what is observed when a narrow beam of light undergoes dispersion as it passes through a prism, and what is observed when a narrow beam of light undergoes dispersion as it passes through a diffraction grating. (6)

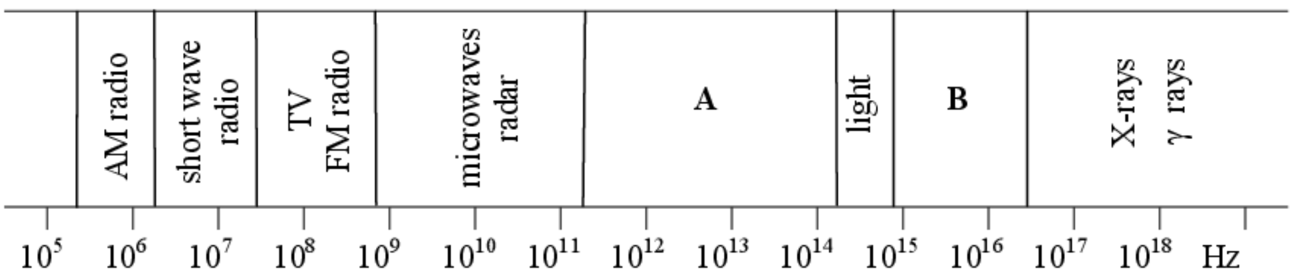
Give another example of light undergoing dispersion. (4)

Yellow light of wavelength 589 nm is produced in a low-pressure sodium vapour lamp. What causes the sodium atoms to emit this light? (3)

Calculate the highest order image that could be produced when a beam of light of this wavelength is incident perpendicularly on a diffraction grating that has 300 lines per mm. (9)

Question 20

7.



The diagram shows a simplified version of the electromagnetic spectrum.
Name the sections labelled **A** and **B** in the diagram.
Describe how to detect each of these radiations. (15)

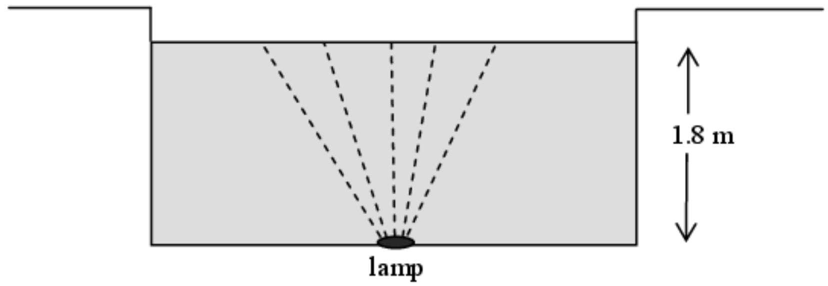
An electromagnetic radiation has a wavelength of 4 m.
Name the section of the electromagnetic spectrum in which this radiation is located. (9)

Distinguish between interference and diffraction.
Can a diffraction grating which diffracts light also diffract X-rays? Justify your answer. (21)

Light travels as a transverse wave. Name another type of wave motion and give two differences between these two types of wave motion. (11)

Question 21

(*b*) State the laws of refraction of light. (6)



A lamp is located centrally at the bottom of a large swimming pool, 1.8 m deep.

Draw a ray diagram to show where the lamp appears to be, as seen by an observer standing at the edge of the pool. (7)

At night, when the lamp is switched on, a disc of light is seen at the surface of the swimming pool. Explain why the area of water surrounding the disc of light appears dark.

Calculate the area of the illuminated disc of water. (15)

(refractive index of water = 1.33)

Question 22

7. When light shines on a compact disc it acts as a diffraction grating causing <u>diffraction</u> and <u>dispersion</u> of the light. Explain the underlined terms. (12)

Derive the diffraction grating formula. . (12)

An interference pattern is formed on a screen when green light from a laser passes normally through a diffraction grating. The grating has 80 lines per mm and the distance from the grating to the screen is 90 cm. The distance between the third order images is 23.8 cm.

Calculate

(i) the wavelength of the green light;

(ii) the maximum number of images that are formed on the screen. (21)

The laser is replaced with a source of white light and a series of spectra are formed on the screen.

Explain

(iii) how the diffraction grating produces a spectrum;

(iv) why a spectrum is **not** formed at the central (zero order) image. (11)

Question 23

3. In an experiment to measure the wavelength of monochromatic light, a diffraction pattern was produced using a diffraction grating with 500 lines per mm.
The angle between the first order images was measured.
This was repeated for the second and the third order images.

The table shows the recorded data.

Angle between first order images	Angle between second order images	Angle between third order images
34.2°	71.6°	121.6°

Draw a labelled diagram of the apparatus used in the experiment. (12)

Explain how the first order images were identified.
Describe how the angle between the first order images was measured. (12)

Use the data to calculate the wavelength of the monochromatic light. (16)

Question 24

(*d*) Why does diffraction **not** occur when light passes through a window? (7)

Question 25

(*e*) Why is a fluorescent tube an efficient source of light? (7)

Question 26

2. In an experiment to measure the wavelength of monochromatic light, a narrow beam of the light fell normally on a diffraction grating. The grating had 300 lines per millimetre. A diffraction pattern was produced. The angle between the second order image to the left and the second order image to the right of the central bright image in the pattern was measured. The angle measured was 40.6°.

Describe, with the aid of a labelled diagram, how the data was obtained. (9)

How was a narrow beam of light produced? (6)

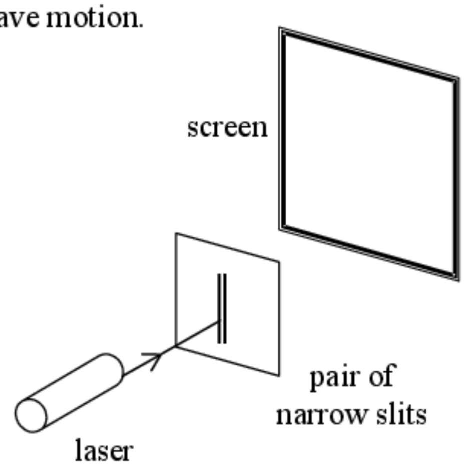
Use the data to calculate the wavelength of the monochromatic light. (15)

Explain how using a diffraction grating of 500 lines per mm leads to a more accurate result. (6)

Give another way of improving the accuracy of this experiment. (4)

Question 27

7. A student used a laser, as shown, to demonstrate that light is a wave motion.



(i) Name the two phenomena that occur when the light passes through the pair of narrow slits. (6)

(ii) A pattern is formed on the screen. Explain how the pattern is formed. (12)

(iii) What is the effect on the pattern when

(a) the wavelength of the light is increased.

(b) the distance between the slits is increased. (8)

Describe an experiment to demonstrate that sound is also a wave motion. (12)

Sound travels as longitudinal waves while light travels as transverse waves. Explain the difference between longitudinal and transverse waves. (9)

Describe an experiment to demonstrate that light waves are transverse waves. (9)