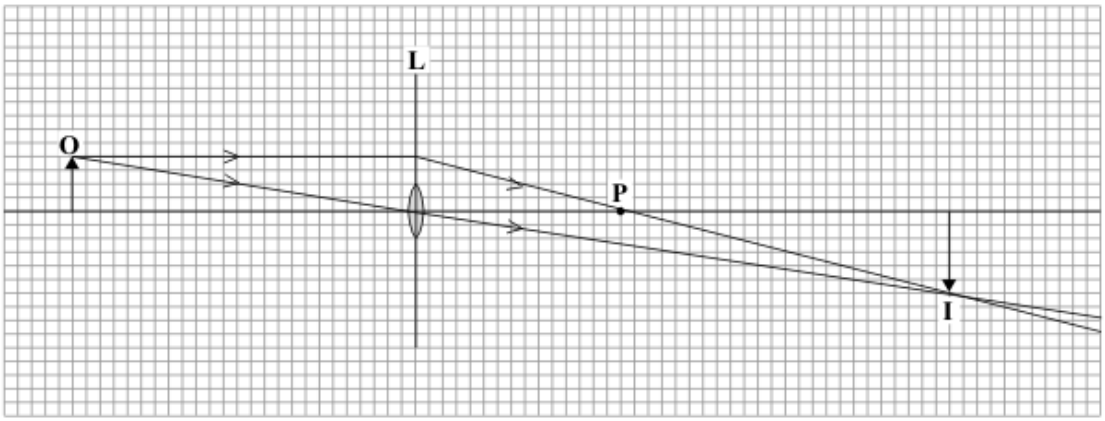
Medical Physics Revision

P3

160 minutes

160 marks

Q1. The ray diagram shows the position and size of the image, **I**, of an object, **O**, formed by a lens, **L**.



(a) What type of lens is shown in the ray diagram?

.....

(1)

(b) Name the point labelled **P**.

.....

(1)

(c) The ray diagram has been drawn to scale.

Use the equation in the box to calculate the magnification.

$$\text{magnification} = \frac{\text{image height}}{\text{object height}}$$

Show clearly how you work out your answer.

.....

.....

Magnification = ...

(2)

(d) How can you tell from this ray diagram that the image is a real image?

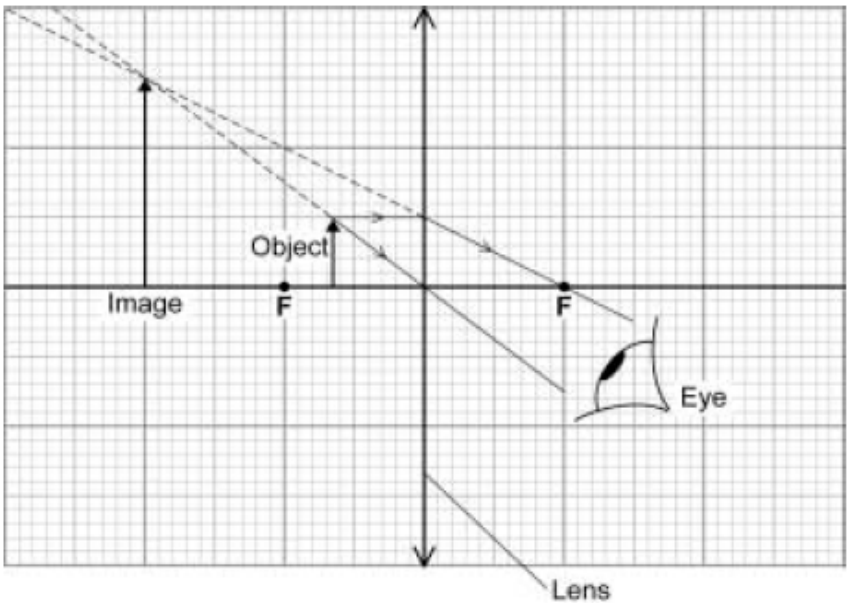
.....

.....

(1)

(Total 5 marks)

Q2. The ray diagram shows a converging lens being used as a magnifying glass. The diagram has been drawn to scale.



(a) What name is given to the type of lens used as a magnifying glass?

.....

(1)

(b) Calculate the magnification produced by the lens.

Write down the equation you use, and then show clearly how you work out your answer.

.....

.....

.....

.....

.....

.....

Magnification = ...

(2)

(c) Describe the image produced by a magnifying glass.

.....

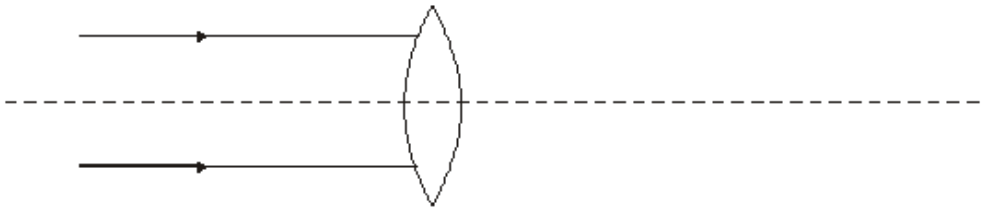
.....

.....

(3)
(Total 6 marks)

Q3. (a) The diagram shows two parallel rays of light, a lens and its axis.

(i) Complete the diagram to show what happens to the rays.



(2)

(ii) Name the point where the rays come together.

.....

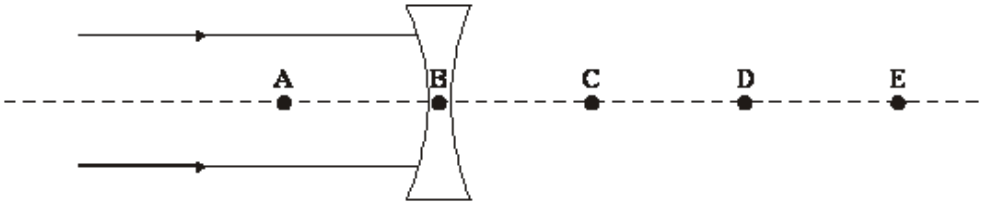
(1)

(iii) What word can be used to describe this type of lens?

.....

(1)

(b) The diagram shows two parallel rays of light, a lens and its axis.



(i) Which point **A**, **B**, **C**, **D** or **E** shows the focal point for this diagram?

Point .....

(1)

(ii) Explain your answer to part (b)(i).

.....

.....

(1)

(iii) What word can be used to describe this type of lens?

.....

(1)

(c) Complete the following **three** sentences by crossing out the **two** lines in each box which are wrong

In a camera a converging lens is used to produce an image on a

film
lens
screen

.

The image is

larger than
smaller than
the same size as

the object.

Compared to the distance of the image from the lens, the object is

further away from
nearer to
the same distance from

the lens.

(3)

(d) Explain the difference between a *real* image and a *virtual* image.

.....

.....

.....

.....

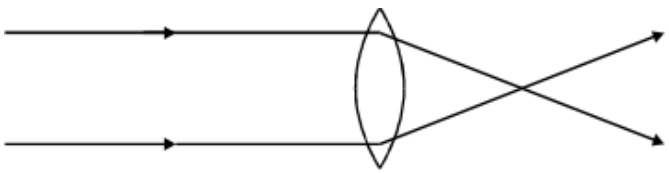
.....

.....

(3)
(Total 13 marks)

Q4. (a) The diagram shows how parallel rays of light pass through a convex lens.

(i) Mark the position of the focus.



(1)

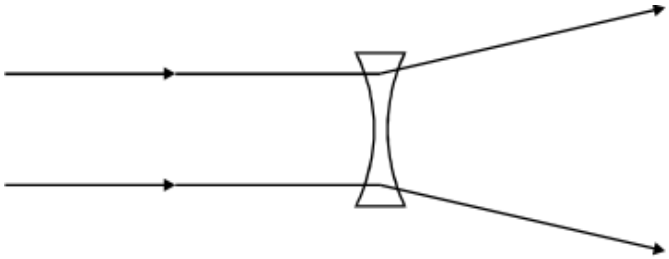
(ii) Is this a **converging** lens, a **diverging** lens, **both** or **neither**?

.....

(1)

(b) The diagram shows how parallel rays of light pass through a concave lens.

(i) Mark the position of the focus.



(1)

(ii) Is this a **converging** lens, a **diverging** lens, **both** or **neither**?

.....

(1)

(c) Complete these sentences by crossing out the **two** lines in each box that are wrong.

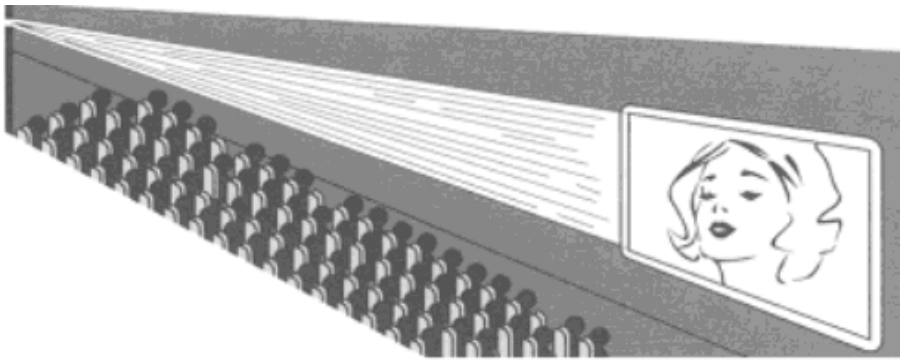
In a camera, a | converging
diverging
parallel | lens is used to produce an image of an object on a | film
lens
screen |.

The image is | larger than
smaller than
the same size as | the object.

The image is | further from
nearer to
the same disrtance from | the lens, compared to the distance of the object from the lens.

(4)

(d) In a cinema projector, a convex lens is used to produce a *magnified*, *real* image.



(i) What does *magnified* mean?

.....

.....

(1)

(ii) What is a *real* image?

.....

.....

(1)

(e) You are in a dark room. You have a box containing some lenses. Only **one** of them is a converging lens.

Describe how, by just feeling the lenses, you can pick out the converging lens.

.....

.....

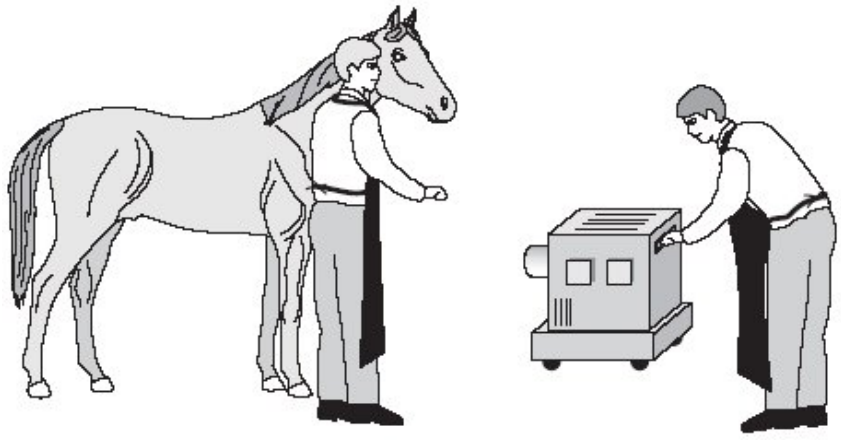
.....

.....

(2)

(Total 12 marks)

Q5. The picture shows a horse being prepared for an X-ray.



The person who will take the X-ray and the person holding the horse are wearing special aprons. These aprons have a lead lining.

Explain why the lead lining is important.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

.....

.....

.....

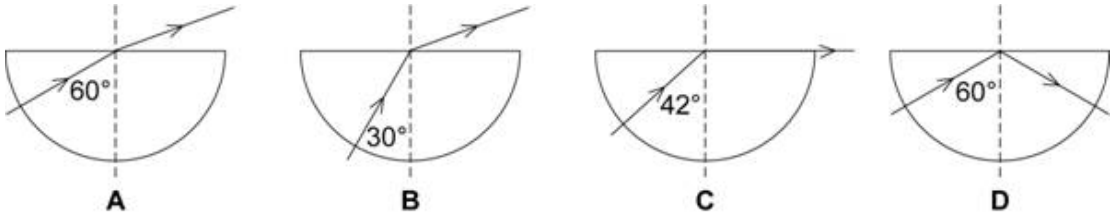
.....

.....

.....

(Total 3 marks)

Q6. (a) Each diagram shows a light ray incident on a glass-air boundary. The critical angle for glass is 42°.



Which **one** of the diagrams, **A**, **B**, **C** or **D**, shows total internal reflection?

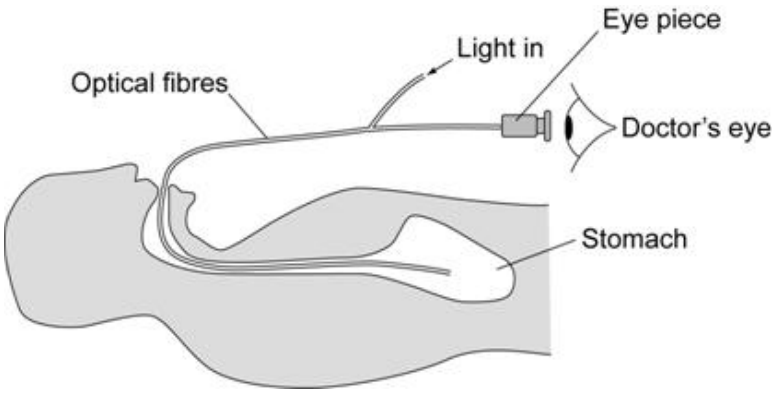
Write the correct letter in the box. ☐

(1)

(b) (i) Complete the diagram to show the path taken by the light ray as it travels through the optical fibre.

(2)

(ii) The diagram shows an endoscope being used by a doctor to look inside a patient's stomach. Light travels into the stomach through a bundle of optical fibres.



The following sentences describe how the endoscope allows the doctor to see inside the patient's stomach. The sentences are in the wrong order.

Q Light passes through a bundle of optical fibres into the patient's stomach.

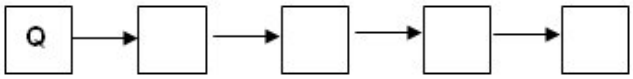
R The inside of the stomach reflects some of the light.

S The optical fibres take the light to an eyepiece.

T The doctor looks through the eyepiece to see inside the patient's stomach.

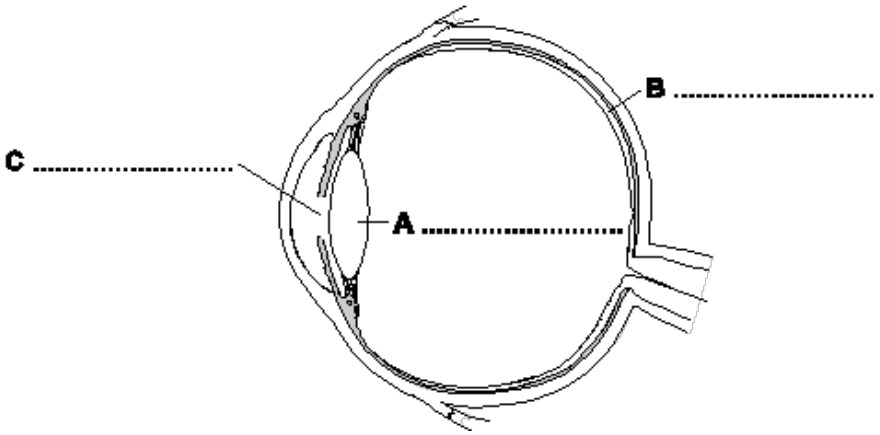
U The reflected light passes through a second bundle of optical fibres.

Arrange these sentences in the correct order. Start with letter **Q**.



(3)
(Total 6 marks)

Q7. (a) The diagram shows the cross-section of an eye.

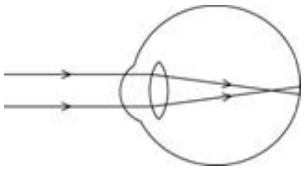


Use words from the box to label the parts, **A**, **B** and **C.**

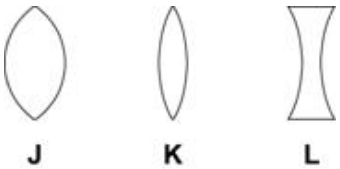
cornea	**iris**	**lens**	**pupil**	**retina**

(3)

(b) The diagram shows one of the eyes of a person who is short-sighted.



Which **one** of the following lenses, **J**, **K** or **L**, could be used to correct the person's eyesight?



Lens .....

Give a reason for your choice.

.....

.....

(2)
(Total 5 marks)

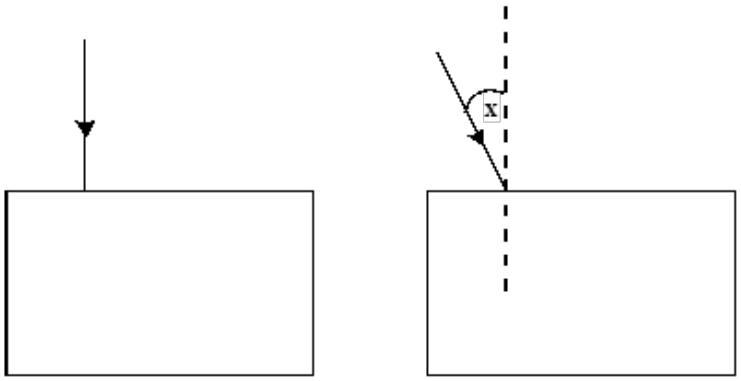
Q8. Lenses are used in many optical devices.

Complete the table below about the images formed by some optical devices.

OPTICAL DEVICE	NATURE OF IMAGE	SIZE OF IMAGE	POSITION OF IMAGE
Eye	real		
Projector		Magnified	
camera			Closer to lens than the object

(Total 6 marks)

Q9. (a) The diagrams show rays of light. Each ray strikes a surface of a glass block.

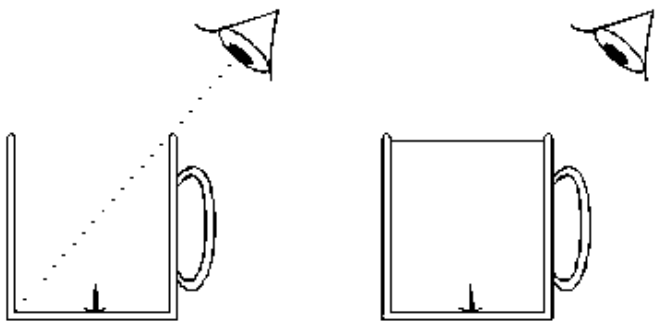


(i) On the diagram draw the path of each ray through the glass block and out into the air again.

(ii) Label another angle on the diagram which is equal to the angle marked **X**. Label this angle **Y**.

(4)

(b) The diagrams show two beakers. Both beakers have a drawing pin inside as shown.



The first beaker is empty. The eye cannot see the drawing pin.
The second beaker is full of water and the eye can see the drawing pin.

Explain how the eye is able to see the drawing pin in the second beaker. You may add to the diagram if it helps your answer.

.....

.....

.....

(3)
(Total 7 marks)

Q10. After a person is injured a doctor will sometimes ask for a photograph to be taken of the patient's bone structure, e.g. in the case of a suspected broken arm.

(i) Which type of electromagnetic radiation would be used to take the photograph?

.....

(1)

(ii) Describe the properties of this radiation which enable it to be used to photograph bone structure.

.....

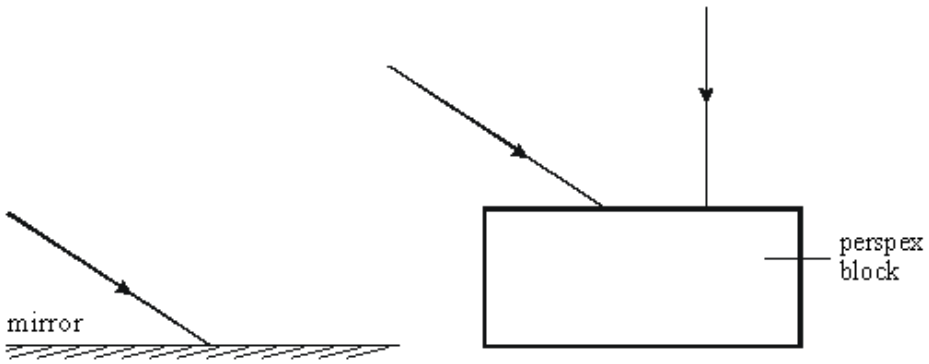
.....

.....

.....

(2)
(Total 3 marks)

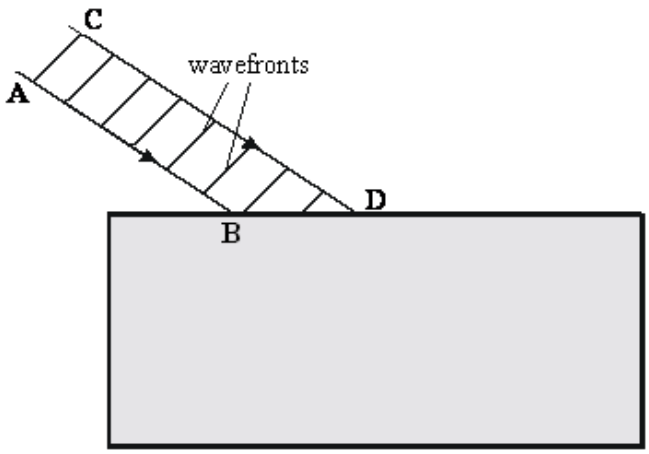
Q11. (a) The diagrams below show rays of light striking a mirror and a perspex block.



Complete the paths of the three rays of light on the diagrams to show the rays leaving the mirror and the perspex block.

(4)

(b) The diagram below shows a beam of light striking a perspex block.



(i) Continue the paths of the rays AB and CD inside the perspex block.

(ii) Draw the wavefronts of the beam of light in the perspex.

(iii) Explain why the beam behaves in the way you have shown.

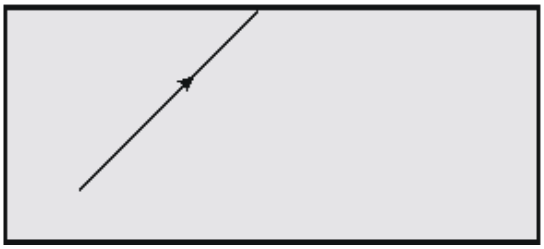
.....

.....

.....

(7)

(c) The diagram below shows a ray of light striking a perspex-air surface from inside the perspex. The critical angle is 45º.



Draw the path of the ray after it reaches the perspex-air boundary.

(2)
(Total 13 marks)

Q12. (a) Sound travels through air, water and glass at different speeds. Through which of these materials does sound travel:

the fastest; .....

the slowest? .....

(2)

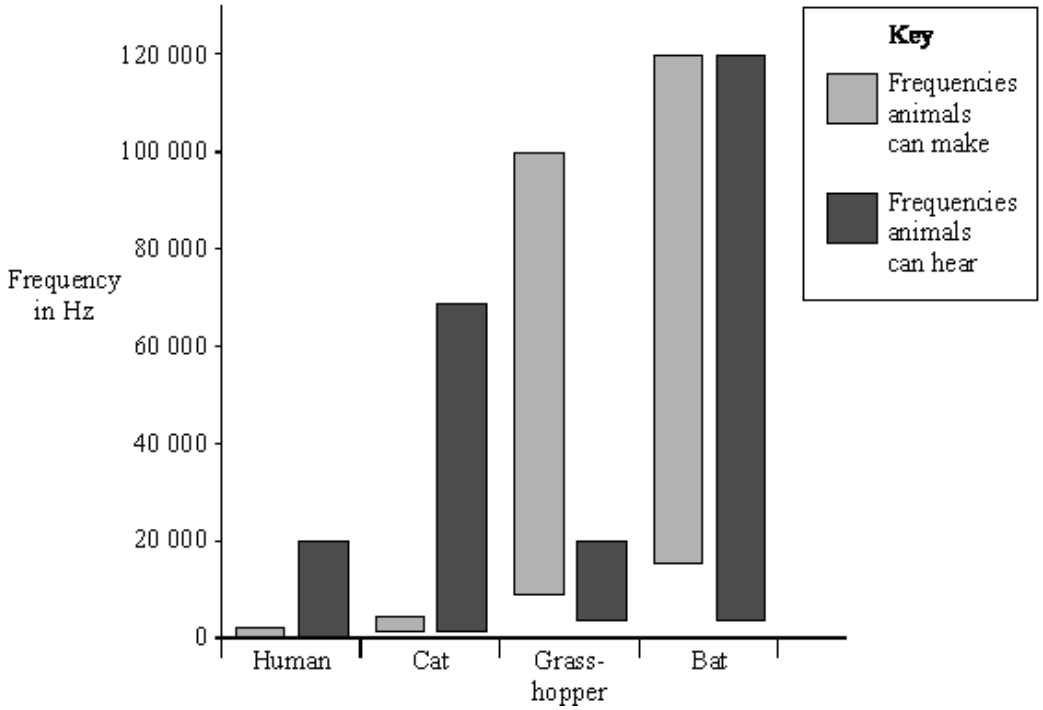
Give a reason for your choice of answers.

.....

.....

(1)

(b) The bar chart shows the frequencies of sound which different animals can make and can hear.



(i) Which of the animals can make sounds which are beyond their own hearing range?

.....

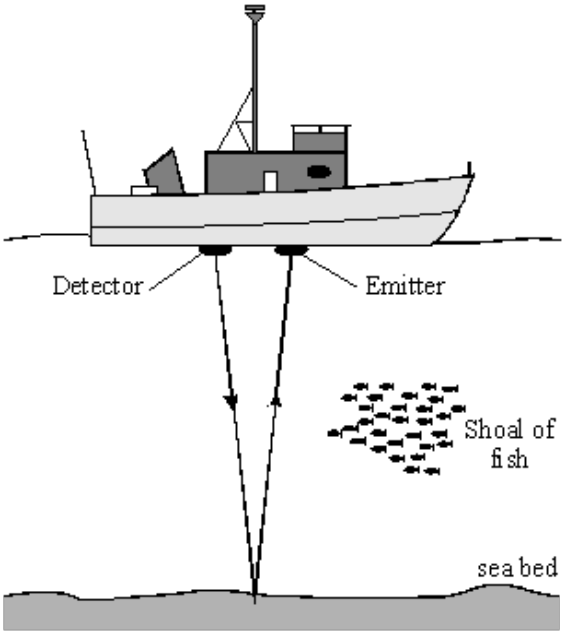
(1)

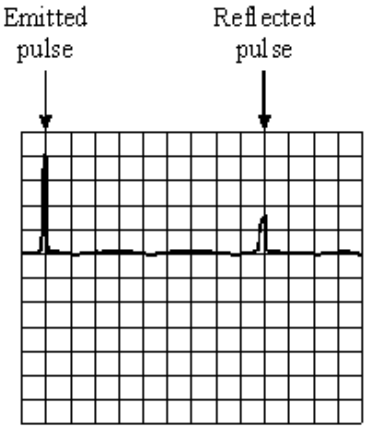
(ii) What name is given to the sounds which a cat can hear but a human cannot?

.....

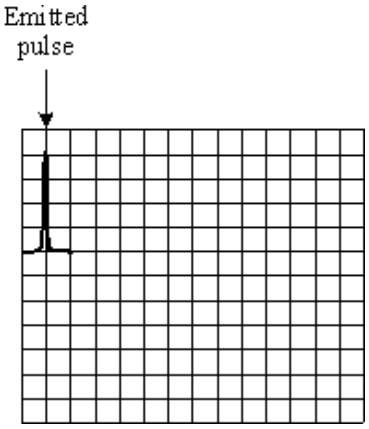
(1)

(c) The diagram shows a trawler searching for a shoal of fish. Pulses of high frequency sound emitted from the trawler are reflected back to the trawler. The pulses are displayed on a cathode ray oscilloscope.



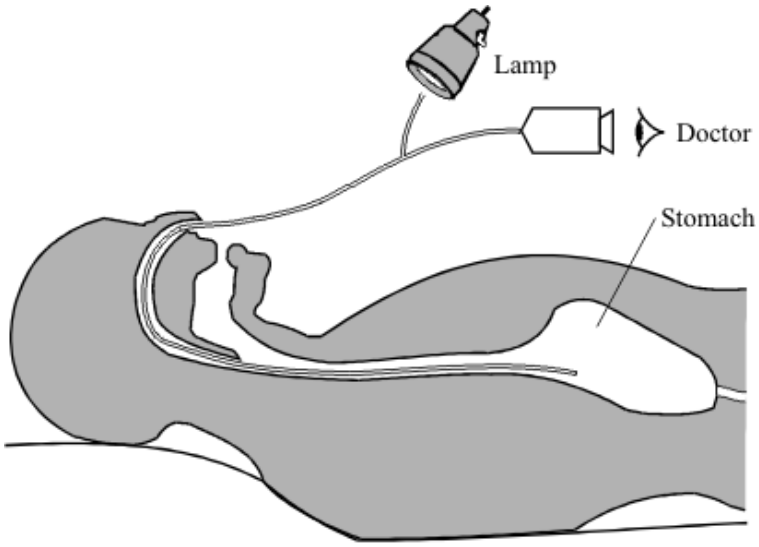


Complete the diagram below to show the pattern seen on the cathode ray oscilloscope as the trawler passes over the shoal of fish.



(2)
(Total 7 marks)

Q13. (a) An endoscope is an instrument used by doctors for looking inside patients. A bundle of thin optical fibres pass light into the patient's body, a second bundle of fibres carry reflected light back to the doctor.



(i) Complete the diagram below to show how an optical fibre is able to pass light into a patient's body.

(2)

(ii) Give **one** advantage of using lots of thin fibres to make the bundles, rather than a few thick fibres.

.....

.....

(1)

(iii) Give **one** further example of the practical use of an optical fibre.

.....

.....

(1)

(b) The diagram shows a wave travelling through a stretched spring.

In what way is this wave the same as a sound wave?

.....

(1)

(c) Sound waves travel faster in liquids than in gases. Why?

.....

.....

(1)

(d) A bat uses ultrasound to find its way around. Explain how.

.....

.....

.....

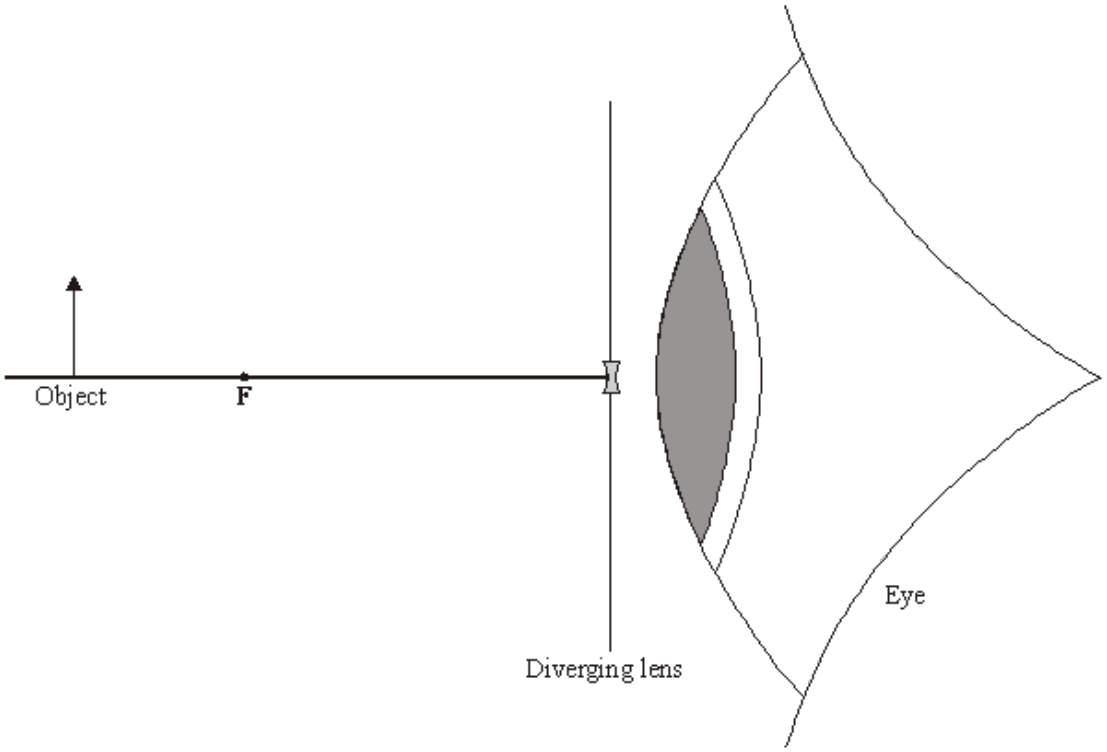
.....

(2)

(Total 8 marks)

Q14. The diagram shows an object located vertically on the principal axis of a diverging lens. A student looks through the lens and can see an image of the object.

(a) Using a pencil and ruler to draw construction lines on the diagram, show how light from the object enters the student's eye and the size and position of the image.



(3)

(b) Describe the nature of the image by comparing it to the object.

.....

.....

.....

.....

(2)

(Total 5 marks)

Q15. (a) What is ultrasound?

.....

.....

(1)

(b) The picture shows a pregnant woman having an ultrasound scan and the image produced by the scan.

To produce the image, a very narrow beam of ultrasound pulses is fired into the mother's body. The reflected pulses are used to build up the image of the unborn baby.

(i) Why is it important to have a very narrow beam of ultrasound waves?

.....

.....

(1)

(ii) Why is it possible to produce a very narrow beam with ultrasound but not with normal sound waves?

.....

.....

(1)

(iii) The image produced by ultrasound is not as clear as an image produced by X-rays. Why is ultrasound used for looking at unborn babies rather than X-rays?

.....

.....

(1)

(iv) Give **two** important pieces of information about an unborn baby which can be gained from the image produced by an ultrasound scan.

1 .....

.....

2 .....

.....

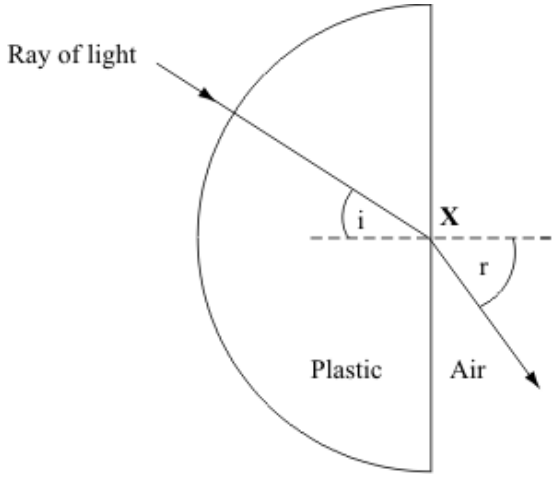
(2)

(Total 6 marks)

Q16. (a) A student investigated the refraction of light as it passes out of a transparent plastic block.

She aimed a ray of light at point **X**. She marked the position of the ray as it passed through the transparent plastic block and into the air.

The angle *i* is the angle of incidence.



(i) What is the name of angle **r**?

.....

(1)

(ii) What is the name of the dashed line?

.....

(1)

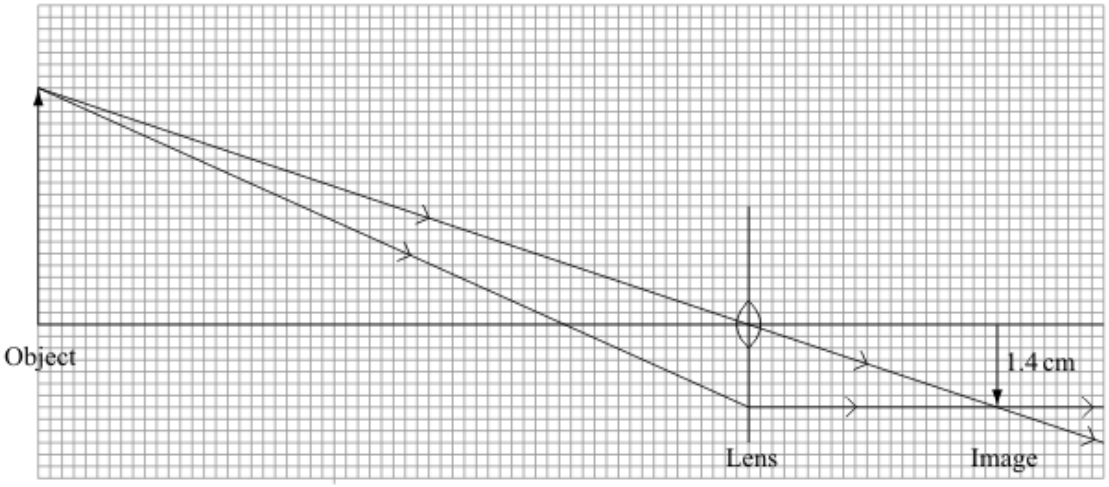
(b) A camera uses a lens to produce an image which falls on a light detector.

Name a light detecting device which may be used in a camera.

.....

(1)

(c) The diagram shows the position of an image formed in a camera.



(i) What type of lens is shown in the diagram?

.....

(1)

(ii) Use the equation in the box to calculate the magnification.

$$\text{magnification} = \frac{\text{image height}}{\text{object height}}$$

Show clearly how you work out your answer.

.....

.....

Magnification = ...

(2)

(d) Why does the image formed in a camera have to be a real image?

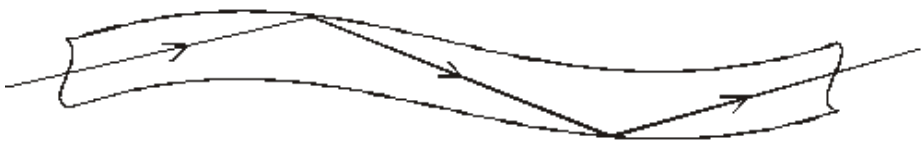
.....

.....

(1)

(Total 7 marks)

Q17. The diagram shows the path of a light ray through part of an optical fibre.



(i) Give **one** practical use for optical fibres.

.....

.....

(1)

(ii) Explain, as fully as you can, why the light ray stays inside the optical fibre.

.....

.....

.....

.....

(2)

(Total 3 marks)

Q18. (a) This information is from a science magazine.

Electronic systems can be used to produce ultrasonic waves. These waves have a frequency higher than the upper limit for hearing in humans.

Complete the sentence by choosing the correct number from the box.

20	**2000**	**20 000**	**200 000**

The upper limit for hearing in humans is a frequency of ..... Hz.

(1)

(b) An electronic system produces ultrasound with a frequency of 500 kHz.

What does the symbol kHz stand for?

.....

(1)

(c) (i) State **one** industrial use for ultrasound.

.....

(1)

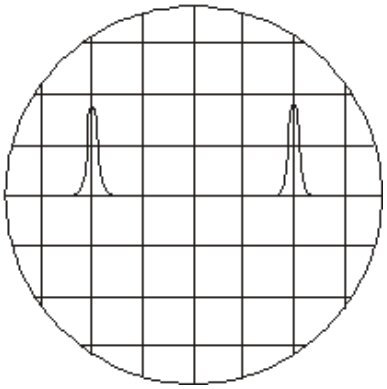
(ii) State **one** medical use for ultrasound.

.....

(1)

(d) An ultrasound detector is connected to an oscilloscope.

The diagram shows centimetre squares on an oscilloscope screen. Each horizontal division represents 2 microseconds.



Calculate the time, in microseconds, between one peak of one ultrasound pulse and the peak of the next.

.....

Time = ... microseconds

(1)

(e) Ultrasounds are partially reflected when they reach a boundary between two different media.

The time taken for the reflection from the boundary to reach the detector can be seen from the screen.

What can be calculated from this time interval?

.....

.....

(2)

(f) Explain what action scientists should take if they find evidence that ultrasonic waves may be harmful to human health.

.....

.....

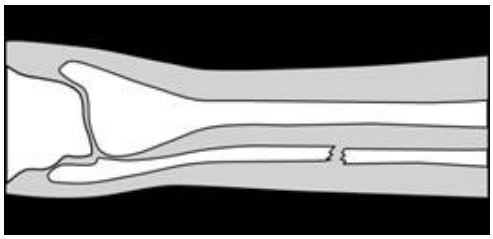
.....

(2)

(Total 9 marks)

Q19. Both X-ray machines and CT scanners are used to produce images of the body.

(a) The diagram shows an X-ray photograph of a broken leg.



Before switching on the X-ray machine, the radiographer goes behind a screen.

Explain why the radiographer does this.

.....

.....

.....

.....

.....

.....

.....

(3)

(b) The following is an extract from a newspaper article.

> **X-rays cause 700 new cancers each year in the U.K.**
>
> Each year there are about 125 000 new cancer cases in the UK, of which, about 700 may be due to the use of X-rays to diagnose illness.

The article was reporting on a scientific research project first published in a medical journal.

What evidence would the scientists have collected to come to the conclusion that X-rays can cause cancer?

.....

.....

.....

.....

.....

(2)

(c) Explain the advantage of a CT scan compared to an X-ray.

.....

.....

.....

.....

.....

(2)
(Total 7 marks)

Q20. Ultrasound can be used in industry for detecting internal cracks in metals.

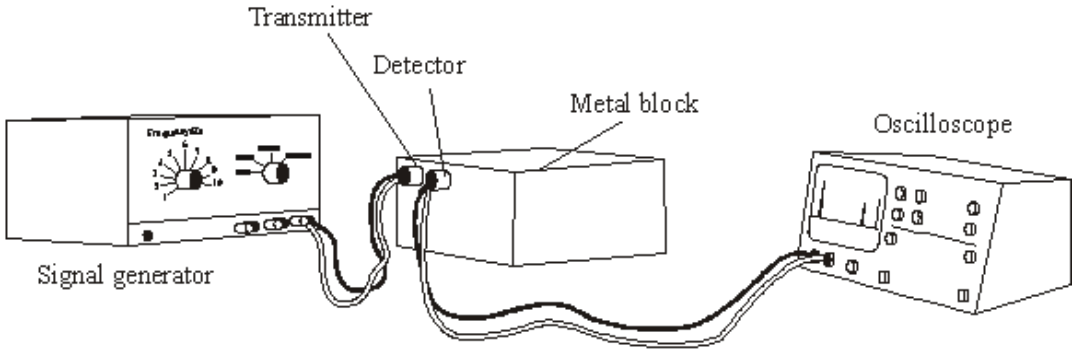
(a) State **two** features of ultrasound.

1 .....

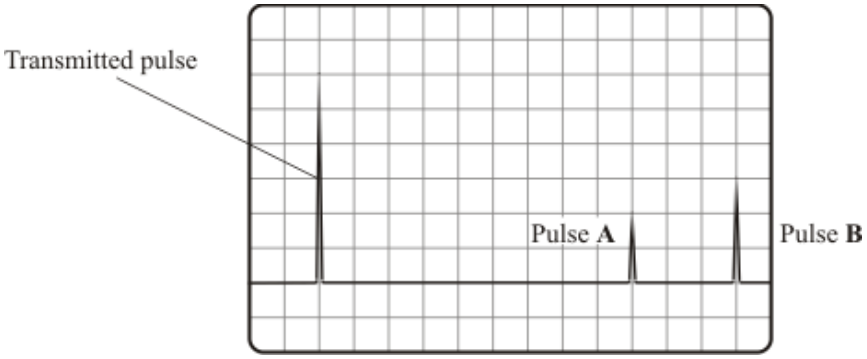
2 .....

(2)

(b) The diagram shows an ultrasound transmitter and detector fixed to the front of a metal block. The block has an internal crack.



The diagram below shows the screen of the oscilloscope connected to the detector.



(i) Explain why pulse **A** and pulse **B** occur.

.....

.....

.....

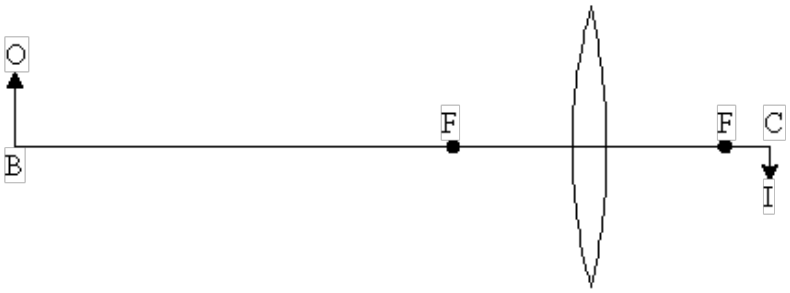
(2)

(ii) The metal block is 120 mm from front to back. What is the distance, in mm, from the front of the block to the internal crack?

Distance = ... mm

(1)
(Total 5 marks)

Q21. The diagram shows the image IC formed by a lens, of an object OB a long way from it. The points F mark the focal points of the lens.



(a) Describe, either by writing below or drawing on the diagram, how the size and position of the image changes:

(i) when the object OB is moved towards the focal point F.

.....

.....

(ii) when the object OB is moved past F to a point nearer the lens than the focal point.

.....

.....

(4)

(b) Explain how a converging lens in a camera is used to produce sharp images on the film when the object is a long distance away from the camera, and when it is close to the camera.

.....

.....

.....

.....

.....

(3)
(Total 7 marks)

Q22. (a) The diagram shows a lens used as a magnifying glass. The position of the eye is shown and the size and position of an object standing at point **O**.

(i) What type of lens is shown in the diagram?

.....

(1)

(ii) Two points are marked as **F**. What are these points?

.....

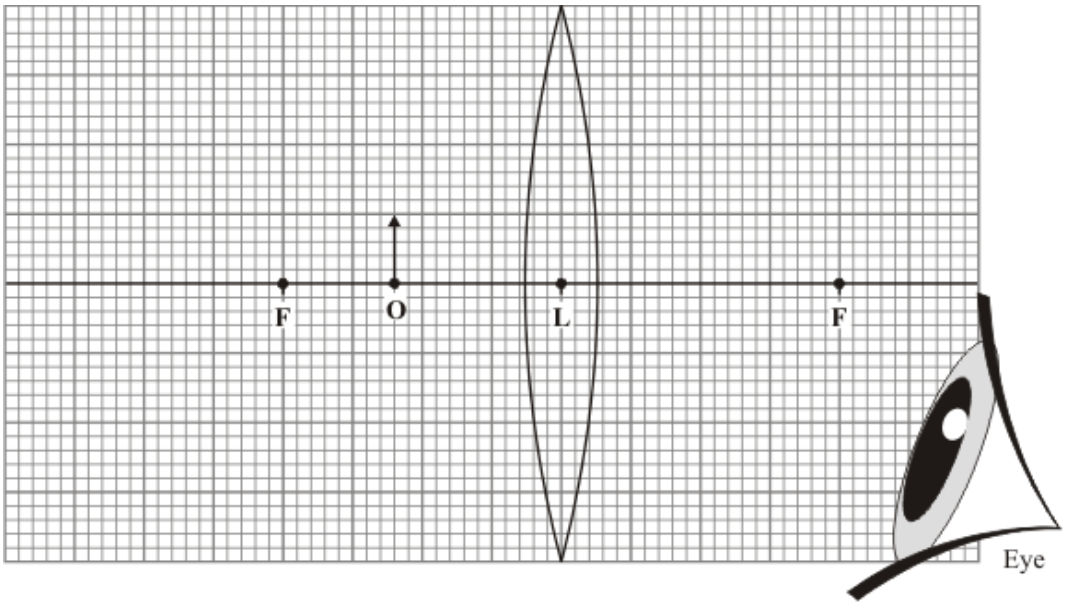
(1)

(iii) What is the name of the straight line which goes through the point **F**, through the point **L** at the centre of the lens, and through the point **F** on the other side?

.....

(1)

(iv) On the diagram, use a ruler to construct accurately the position of the image. You should show how you construct your ray diagram and how light appears to come from this image to enter the eye.



(5)

(v) The image is *virtual*. What is a *virtual* image?

.....

.....

(1)

(b) The lens shown in the diagram in part (a)(iv) can be used in a camera to produce a *real* image.

Explain why a *real* image must be produced in a camera and how the object and the lens are positioned to produce a *real* image which is **smaller** than the object.

Do **not** draw a ray diagram as part of your answer.

.....

.....

.....

.....

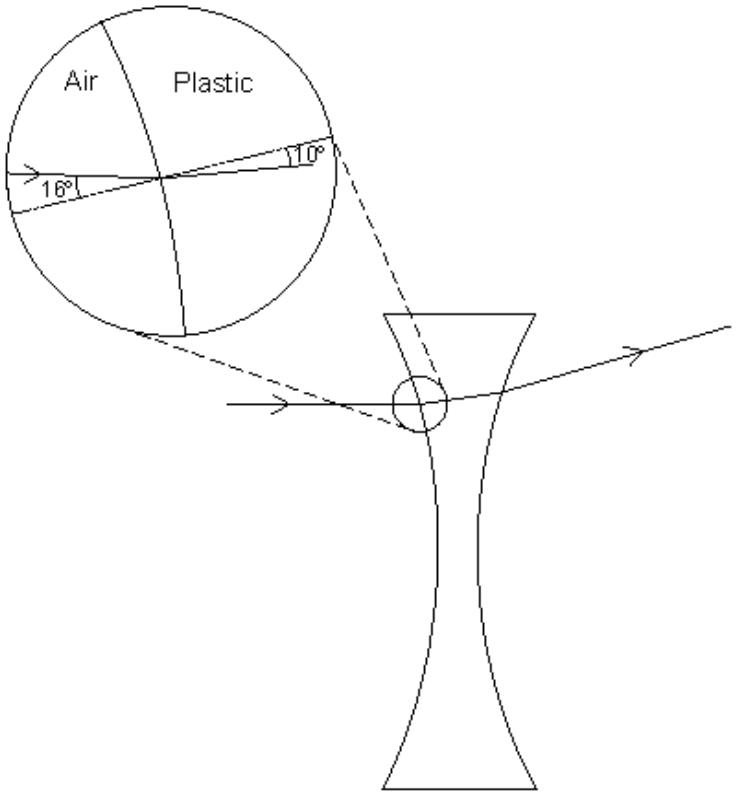
.....

.....

(3)

(Total 12 marks)

Q23. The diagram shows a ray of light passing through a diverging lens.



(a) Use the information in the diagram to calculate the refractive index of the plastic used to make the lens.

Write down the equation you use, and then show clearly how you work out your answer.

.....

.....

.....

.....

.....

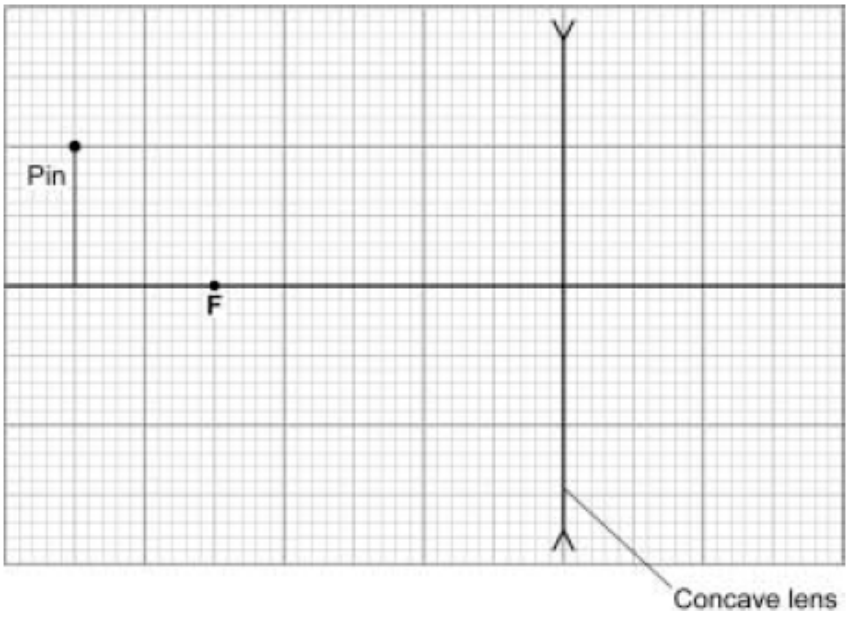
.....

Refractive index = ...

(2)

(b) The focal length of the lens is 5 cm. A student looking through the lens sees the image of a pin.

Complete the ray diagram below to show how the image of the pin is formed.



(3)
(Total 5 marks)

M1. (a) converging

or convex

1

(b) (principal) focus

or focal point

1

(c) **either** (×)1.5 **or** (×)1½ **or** 150%

*unambiguous evidence of appropriate measurements for **1** mark only eg 4 and 6 **or** 8 and 12 **or** 0.8 and 1.2*

2

(d) real rays cross to form it / formed at the intersection of real rays

accept 'image on the opposite side of the lens to the object'
accept 'can be put onto a screen'

1

[5]

M2. (a) converging

accept convex

1

(b) 3

*allow **1** mark for substitution into the correct equation*

ie $\frac{3}{1}$ *or* $\frac{15}{5}$

2

(c) bigger

accept magnified

1

upright

1

virtual

1

[6]

##

(a) (i) rays continued to meet on the right hand side of the lens and beyond

must be straight lines from the right hand side of the lens
ignore details through the lens
allow if no arrows

1

meet exactly on the axis

negate mark if contradictory arrow(s) added
do not need to go beyond the focus for this mark

1

(ii) (principal) focus

or *focal (point)*

1

(iii) converging

or *convex*

1

(b) (i) **A**

1

(ii) rays seem to come from this point

or *words to this effect*
or *shows this on the diagram*

1

(iii) diverging

or *concave*

1

(c) film

accept any unambiguous method of showing the correct response

1

smaller than

1

further away from

1

(d) any **three** from:

- real image can be put on a screen
  allow film
- virtual image cannot be put on a screen / film
- virtual image is imaginary
- real image is formed where (real) rays cross / converge
  allow real image has light travelling through it
- virtual image is where virtual / imaginary rays (seem to) come from
  or *virtual image is where rays seem to come from*
- virtual image formed where virtual rays intersect / cross

3

[13]

M4. (a) (i) point where the rays cross
do not credit if ambiguous

1

(ii) converging (lens)
*do **not** accept convex*

1

(b) (i) point where the rays appear to diverge from
this should appear to be within 10mm in front of the back of the arrows on the approximate centre line
need not be accurately constructed using a ruler

1

(ii) diverging (lens)
*do **not** accept concave*

1

(c) converging

1

film

1

smaller than

nearer to
accept any clear indication of the response e.g. ticking, ringing, writing in after a mistake

1

(d) (i) (image) bigger than object enlarge
accept just 'made bigger'

1

(ii) it / real image can be put on a screen **or** real image on the opposite side of the lens to the object

accept 'not an imaginary or virtual image'

assume 'it' refers to a real image

*do **not** credit 'it can be seen'*

1

(e) **either** (the converging lens is) thick in the middle thin(ner) at the edge

1

*thick<u>est</u> in the middle gains **2** marks*

1

or (both) sides bend outwards (1) in the middle (1)

*convex gains **2** marks*

*suitable diagrams gains **2** marks*

or one side bends in the middle (1) more than the other side bends inwards (in the middle) (1)

1

[12]

M5. Quality of written communication

*award for a sensible sequence of **two** points*

1

X-rays do not go through lead

accept lead protects them from the X-rays
accept not exposed to X-rays

1

lead stops / reduces risk of X-rays harming / damaging / killing (persons) <u>cells</u>

accept X-rays (may) cause cancer

accept organs for cell
*do **not** accept references to electric shock*
*do **not** accept stops bones of people showing on X-ray*
answers involving the horse wearing an apron are incorrect

references to gamma rays are incorrect

1

[3]

M6. (a) **D**

1

(b) (i) total internal reflection shown

1

2 or 3 reflections only

1

(ii) **R U S T**

correct order

*allow **2** marks for two in correct place*

*allow **1** mark for one in correct place*

3

[6]

M7. (a) **A** – lens

1

B – retina

1

C – pupil

1

(b) **L**

1

it diverges the light (before entering the eye)
or
it will make the light focus on the retina

accept spreads for diverges

1

[5]

M8. **Eye –** Diminished/smaller than object
Nearer the lens than object or on the retina

for 1 mark each

2

Projector – real
Further from lens than object

for 1 mark each

2

Camera – real
Smaller (than object)

for 1 mark each

2

[6]

M9. (a) (i) Ignore arrows on rays
perpendicular rays goes straight in and out
other ray refracts towards normal (not along)
emerges parallel incident ray (by sight) if refraction correct (ignore reflections)
for 1 mark each

3

(ii) emergent angle marked Y if emerges parallel to right of normal
for 1 mark

1

(b) straight ray to water surface refracts/bends
straight to eye/towards surface on right image correctly shown
or states the same mark prose only of diagram incomplete
any 3 for 1 mark each

3

[7]

M10. (i) X-rays or gamma rays
for 1 mark

1

(ii) passes through flesh;
stopped by bone/absorbed
for 1 mark each

2

[3]

M11. (a) Reflection correct
Normal incidence correct in and out
Correct refraction in
Parallel ray out
each for 1 mark

4

(b) (i) Each ray correctly refracted in
1 + 1 = 2

7

(ii) Wavefronts perp sides
Wavefronts closer
(Cannot score wavefront marks if refracted rays clearly wrong)

(iii) Speed reduces
Starting at B
Then D
each for 1 mark

(c) TIR correct

gets 2 marks

Else rough reflection

gets 1 mark

2

[13]

M12. (a) glass

1

air

must be in correct order

1

closer the particles faster the speed

answer must show a comparison

or

particles in glass closest in air furthest apart

accept the denser the material the faster the sound travels

or

sound travels faster in solids than gases

incorrect explanation negates credit

1

(b) (i) grasshopper

(ii) ultrasound

accept ultrasonic

1

(c) all of reflected pulse closer than given in original diagram

accept a cluster of pulses ignore a reflected pulse in original position any pulse drawn to right of original negates credit

1

reflected pulse smaller than emitted but greater than 1 square high

accept cluster of pulses provided one part fulfils height criteria

2

[7]

M13. (a) (i) total internal reflection shown (2 – 8 reflections)

1

angles look correct (by eye) (2 – 5 reflections)

1

(ii) can be bent more (without loss of light)

accept easier to get into patient or more flexible
accept more detailed or better image
accept if some fibres broke system would not fail
*do **not** accept to pass more light - neutral*

1

(iii) any **one** of the following:

*do **not** accept any further endoscopy uses*

(telephone) communications (carry (laser) light) for surgery
or operations
torches
guides in cars
table lamps **or** ornamental lights

*do **not** accept telephone wires*

1

carry TV signals
carry computer data **or** information
cable TV **or** cable telephone

*do **not** accept TV **or** telephone **or** computers without qualification*

*do **not** accept bomb disposal unless qualified*
accept to stimulate children with learning difficulties

(b) (both) longitudinal

accept both have compressions or rarefactions
accept both have high or low pressure regions
accept both transfer energy
*do **not** accept 'need a medium'*

1

(c) liquids have a greater density

or

molecular spacing in gases is greater

1

(d) (bat) transmits **or** emits ultrasound **or** pulses **or** signals **or** sound **or** waves

*allow **one** mark if response is in terms of distance and time*

1

picks up reflected ultrasound **or** signals **or** waves **or** sound **or** echo

*allow **1** mark for echo location*

1

[8]

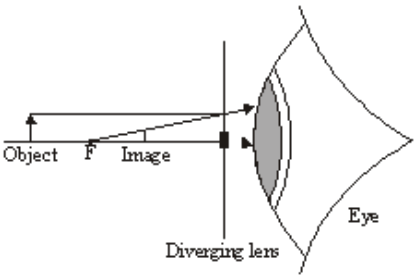
M14. (a) straight line from the tip of the object

… straight through the centre of the lens (1)

… parallel to the axis, then diverges from the lens as if from F (1)

image drawn from where **these** lines intersect, vertically to the axis (1)

example



3

(b) any **two** from:

- smaller (than the object)
- (both) upright
- image is virtual / imaginary (whereas object is real)

no errors carried forward from the candidate's diagram

*mark first **two** points given*

2

[5]

M15. (a) sound with a frequency above audible

do not accept answer in terms of λ

do not accept sound which cannot be heard unless obvious from context

accept above 20 kHz

1

(b) (i) to show detail **or** to give a clear image/picture

*accept the generators **or** transducers can be small*

accept so the beam does not spread out/beam in focus

***not** 'good picture'*

1

(ii) (much) smaller wavelength

allow higher frequency/pitch

1

(iii) no damage to living cells (provided low power)

accept the converse

*accept no damage to baby **or** not dangerous to baby*

1

(iv) any **two** forms

sex

stage of development
or specific examples

abnormalities

general health

potential problems (at birth)
accept specific examples e.g. umbilical cord around neck

size of head
accept multiple births

2

[6]

M16. (a) (i) (angle of) refraction
*take care **not** to credit 'angle of reflection'*

1

(ii) normal
*do **not** credit 'horizontal'*

1

(b) **either**

(photographic) film

or CCD(s) (charge-coupled device(s)) / CMOS(s) (sensor(s)) / (active) pixel sensor(s)
accept 'LDR(s)' / 'light dependent resistor(s)'
***not** lux meter*
*do **not** accept light sensor(s)*

1

(c) (i) converging
***or** 'convex'*

1

(ii) **either**

(0).35

or (0).4(1...)
*do **not** give any credit for an answer greater than 1*
or
*7 ÷ 20 for **1** mark*
or
*clear evidence that appropriate measuring / counting, has been made for **1** mark*

2

(d) otherwise it will have no effect on the light detector

or otherwise no (real) light will fall on the light detector

or *'a virtual / imaginary image will have no effect on the light detector'*

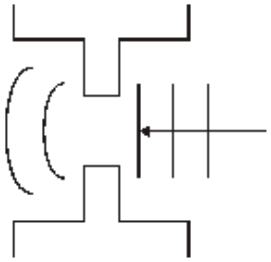
allow error carried forwards for 'light detector'

allow so it can be formed on the film

1

[7]

M17. (i) waves shown diffracting in the correct direction



ignore wavelength

1

(ii) diffraction

accept diffract / diffracted

2

[3]

M18. (a) 20000

accept any unambiguous indication

1

(b) kilohertz

credit misspellings

credit '1000 hertz' or '1000 Hz'

accept 1000 oscillations/beats/waves <u>per second</u>

1

(c) (i) cleaning (e.g. something delicate such as a watch)

or *quality control/flaw detection*

credit any appropriate extra Specification response e.g. sonar

1

(ii) pre-natal (scanning)

*do **not** credit just 'scanning'/medical scanning/ scanning a baby*

credit any appropriate extra Specification response e.g. destruction of (kidney) stones or cleaning teeth

1

(d) 8 (μs)

1

(e) distance (1)

between the boundary and the detector (1)

accept 'between the boundary and the source'

accept any correct use of speed = distance/time

2

(f) examples

publish/tell doctors/the public (1) ... their evidence/results/research/data (1)

carry out more research/tests (1) ... to make sure/check reliability (1)

allow a wide variety of appropriate responses
valid point (1) appropriate example/qualification/expansion/etc. (1)
allow just 'stop using them/ultrasonic waves' (1)
allow using them (only) for industrial purposes (1)

2

[9]

M19. (a) X-rays are ionising

or

X-rays kill / damage cells

accept cause cancer

1

any stray X-rays are absorbed by screen

1

which reduces the radiation dose to the radiographer

1

(b) medical records / X-ray records

1

of people with cancer

1

(c) a CT scan gives a 3D image

1

therefore the image can be observed from different directions

1

[7]

M20. (a) any **two** points:

*do **not** credit features which are true of sound in general eg longitudinal waves*

- humans cannot hear ultrasound
- it has a very high frequency / pitch

  *do **not** credit just 'has a high frequency / pitch'*
- above the (upper) limit for humans / above 20 000 Hz

2

(b) (i) ultrasound / waves are reflected

...are bounced is insufficient, but ...echo is acceptable

1

Pulse **A** indicates / is the crack

Pulse **B** *i*ndicates / is the back (of the block or crack)

need to mention both A and B to get this mark

1

(ii) 90 (mm)

accept any answer in the range 88 – 92 (mm)

1

[5]

M21. (a) (i) Image distance increases
Image size increases
Remains inverted
Remains real

for 1 mark each

2

(ii) Image distance decreases
Image size decreases
Becomes upright
Becomes virtual

for 1 mark each

2

(b) Move lens with respect to film
Closer for distant objects
Further for near objects

for 1 mark each

3

[7]

M22. (a) (i) converging / convex / biconvex

1

(ii) focal (points) **or** foci

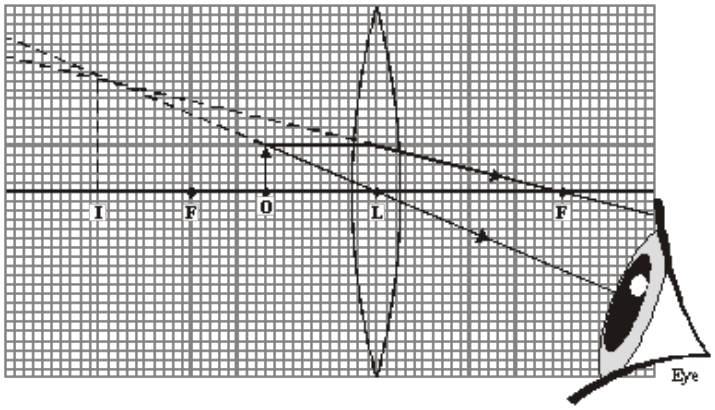
*accept focuses **or** focus (point)*

1

(iii) (principal) axis

1

(iv)



all lines drawn with a ruler for full marks

no ruler, penalise **1** mark from first four

last mark can still be awarded

double refraction drawn could get **4** out of 5 marks

ray that continues from the top of the object through L to the eye

1

horizontal ray from the top of the object, refracted by the lens and continued through F on the r.h.s. to the eye

1

back projections of these rays (shown as dotted lines)

1

image 25 mm high at 61 mm left of L
(tolerance 1 mm ± vertically, 2 mm ± horizontally)

1

*at least one arrow shown on real ray and towards the eye but do **not** credit if contradicted by other arrow(s)*

1

(v) formed where imaginary rays intersect / cross **or** not formed by real rays

accept (virtual image) is imaginary
accept cannot be put on screen
*do **not** credit just '… is not real'*

1

(b) (the image) needs to fall on film / sensors / LDRs / CCDs

accept just 'charged couples'
*do **not** credit '… solar cells'*
*do **not** accept virtual image cannot be stored*

1

either to cause a (chemical) reaction **or** to be digitalised

for credit response must be appropriate to camera type

1

object (should be) on the far side of F / the focus (from the lens)

***or** … more than the focal length (away from the lens)*
allow 'beyond the focus'

or object should be more than twice the distance / 2F (from the lens) (2 marks)

***or** … more than twice the focal length (away from the lens)*
*(**2** marks)*

1

[12]

M23. (a) 1.59

accept an answer that rounds to this
*allow **1** mark for correct substitution into correct equation*

ie refractive index = $\frac{\sin 16^\circ}{\sin 10^\circ}$

2

(b) 2 lines correctly drawn from the top of the pin through the lens

*allow **1** mark for each*

2

position of image correct

image must be upright

1

[5]

E1. (a) Usually the lens was incorrectly identified as a diverging or concave lens rather than as a converging or convex lens.

(b) Only about a quarter of candidates recognised that the point is a principal focus or a (focal) point.

(c) More able candidates were able to take appropriate values from the diagram and to calculate the magnification.

(d) A very small minority of candidates gained the mark because they stated that the image could be put on a screen. No one referred to a correct diagram and stated that the image is real because it is formed where real rays cross.

E3. In part (a)(i) most candidates gained at least one mark. The most common mistakes were either to not continue the lines once the focus had been reached or to not have the focus on the axis. About half were able to name the point where the rays come together and the majority were able to name the type of lens. In (b) parts (i) and (ii) were rarely correct but most were able to name the type of lens.

In part (c) it is likely that some answers were guessed as it was rare to see a set of three correct answers.

Few candidates gained any credit in part (d). The minority who did usually knew that real images can be formed on a screen or a film whilst virtual images cannot.

E4. (a) In part (a)(i) most candidates were able to identify this as a converging lens and to indicate the position of the focus.

(b) Though most candidates identified this as a diverging lens, only a small minority were able to indicate the position of the focus. Many made no effort to do so and this may indicate that some candidates did not think that a diverging lens has a focus.

(c) Nearly all candidates attempted this part and followed the instructions. Some gained all four marks.

(d) Attempts at explaining the word *magnified* were much more successful than attempts at *real*. The many, wildly incorrect responses indicated that few had been able to find any clues in the artwork.

(e) Only a minority of candidates had the confidence to simply state that the converging lens would be convex. However, ‘thicker in the middle and thinner at the edges’ was a fairly popular correct answer. Some candidates were not assisted by their limited ability to communicate clearly. A minority claimed that if only one lens was a converging lens then all the others would be the same. This is not correct; each lens in the box might be a different shape.

E5. Providing of a copy of the Electromagnetic Spectrum enabled many candidates to correctly identify the types of waves utilised in various applications, but few candidates chose radio as the answer to part (a)(i). In part (b) few candidates realised the commonality of the speed of these waves.

E8. Optical devices were not well known with few candidates gaining full marks. There was no pattern amongst the many wrong answers offered by the candidates. There was some hedging of bets, e.g. for size “magnified/smaller”. Demagnified image was a not uncommon incorrect answer. The description of the image position was often unclear. Although not anticipated when the mark scheme was written, the position of the eye image when given as “on the retina” was credited.

E9. This question proved to be quite demanding with few candidates gaining full marks. In part (a)(i) most candidates drew the ray continuing along the straight line into and out of the block to gain the mark. A few candidates finished their ray on the lower surface, thus losing the mark, the question having asked for the ray “out into the air again”. In (ii) many again drew the correct ray path for both marks, several had the ray refracting away from the normal in the glass to lose the marks. A few had the ray refracting down the normal which again lost both marks. In part (b) the prose answers tended to be vague and although some candidates scored full marks most could only gain part marks. Many written answers attributed the effect to reflection rather than refraction. Fortunately all three marks could be gained for a correct ray diagram and the majority of candidates doing so gained their marks in this way. A few candidates lost marks for rays which “clipped” the side of the mug and could clearly not refract out of the water surface. Some candidates experienced trouble drawing ray diagrams without the aid of a ruler.

E10. Generally well answered.

E12. Foundation Tier

In part (a) the majority of candidates incorrectly gave ‘air’ and then ‘glass’. Many erroneous explanations were given in terms of ‘sound particles’ travelling easily through a gas. Part (b) was generally answered well, although a significant number of candidates could not recall the term ‘ultrasound’. In part (c) few of the responses were correct for both pulse size and position.

Higher Tier

In part (a) a significant number of candidates incorrectly gave ‘air’ and then ‘glass’. Many gave an erroneous explanation in terms of ‘sound particles’ travelling easily through a gas. Those candidates correctly giving ‘glass’ then ‘air’ usually gave a correct reason for their choice. Part (b) was generally answered well, although a significant number of candidates could not recall the term ‘ultrasound’. In part (c) only the most able candidates saw the significance of both amplitude and position. Many candidates also included the reflected pulse from the original graph which was unnecessary and, unless clearly labelled, often spoilt their answer.

E13. Foundation Tier

Large numbers of candidates were able to demonstrate a working knowledge of the ray diagram for an optical fibre and many understood the reasons for thin fibre bundles being employed. Many correct applications were given in part (a)(iii) but rather too many employed a similar medical application to that already given. In part (b) candidates generally described the diagram, rather than mentioning ‘longitudinal’. Many answers to part (c) suggested ‘more particles’ but fewer inferred particle concentration. In part (d) many candidates identified that the bat listened to sounds, but many answers implied that the objects in its path produced signals rather than the bat itself. Few candidates understood that both the emission and detection of ultrasound involved the bat.

Higher Tier

Most candidates were able to demonstrate a working knowledge of the ray diagram for an optical fibre and understood the reasons for thin fibre bundles being employed. Many correct applications were given in part (a)(iii) but rather too many employed a similar medical application to that already given. In part (b) candidates generally described the diagram, rather than mentioning ‘longitudinal’. Many answers to part (c) suggested ‘more particles’ but fewer inferred particle concentration or proximity of particles. In part (d) many candidates identified that the bat listened to sounds, but many answers implied that the objects in its path produced signals rather than the bat itself. Few candidates understood that both the emission and detection of ultrasound involved the bat.

E14. (a) There were many examples of incorrect constructions. Only a minority of candidates drew two straight lines; one from the top of the object which continued through the centre of the lens and the other parallel to the principal axis which continued as if from **F** when it reached the lens. However, some of those candidates who got this far went on to secure their third mark by showing the image located vertically with the intersection of these lines marking the top of the image.

(b) Adjectives and features which may be used to describe images were employed fairly randomly. Diminished/smaller, erect/upright, and virtual/imaginary are correct but only about one quarter of the candidates secured two marks.

E15. Foundation Tier

Part (a) was poorly answered with very few candidates being able to give a reasonable definition of ultrasound. In part (b) most candidates thought that a wider beam would cause problems for both the mother and baby. Few considered that a narrow beam would give more detail. Most candidates were able to give sensible answers in part (b)(iv).

Higher tier

Part (a) was answered poorly with very few candidates being able to give a reasonable definition of ultrasound. In part (b) most candidates thought that a wider beam would cause problems for both the mother and baby. Few considered that a narrow beam would give more detail. Most candidates were able to give sensible answers in both part (b)(iii) and part (b)(iv).

E16. Foundation Tier

(a) (i) A third of candidates identified the angle of refraction correctly.

(ii) A quarter of candidates could name the dash line as the normal.

(b) A small minority of candidates answered in terms of a digital camera. Only a few of the candidates identified any king of light detecting device eg film.

(c) (i) About half of candidates recognised that this is a converging or convex lens.

(ii) The diagram had been reduced to fit the page but, regrettably, the dimension 1.4cm had not been altered. However no candidate was disadvantaged. This question was answered well with 50 % of candidates gaining at least 1 mark. Numerically correct answers obtained by measuring or by counting or by using the dimension in some appropriate combination were awarded both marks. Where, for example, a correct method and calculation had been employed but a small mistake had been made, eg the object had been miscounted as 21 small squares rather than 20, then one mark was scored.

(d) Very few candidates related the formation of a real image to the necessity for light to fall on a light detector.

Higher Tier

(a) (i)(ii) Most candidates knew that the angle is the angle of refraction and that the dotted line is the normal.

(b) About a half of candidates suggested photographic film though some had it as photographic paper; LDRs were sometimes proposed but there were few correct references to the light sensors in digital cameras.

(c) (i) A high percentage of candidates recognised that this is a converging or convex lens.

(ii) The diagram had been reduced to fit the page but, regrettably, the dimensions 1.4cm had not been altered. However no candidate was disadvantaged. Numerically correct answers obtained by measuring or by counting or by using the dimension in some appropriate combination were awarded both marks. Where, for example, a correct method and calculation had been used but a minor mistake had been made, eg the object had been miscounted as 21 small squares rather than 20, then one mark was scored.

(d) Few candidates seemed to understand that, in order to have an effect on the light sensor; light must fall on it.

E17. Foundation tier

This question was poorly answered. While most candidates could give a use for an optical fibre, few understood the principle of total internal reflection.

Higher Tier

Whilst most candidates could give a use for an optical fibre few could give an explanation in terms of critical angle and total internal reflection. A common misconception was that the fibres are lined with tiny mirrors.

E18. Foundation Tier

(a)(b) The majority of candidates chose the correct response and nearly all knew that the symbol kHz stands for kilohertz.

(c) (i)(ii) A significant minority of candidates could give an industrial use for ultrasound and a majority could give a medical use. It should be noted that vague responses such as 'scanning organs' did not gain a mark.
Candidates needed to be more precise eg 'scanning the kidneys' or 'scanning an unborn baby'.

(d) Many candidates were able to interpret the diagram, and the information given about the scale, and correctly deduce that the time interval is 8 microseconds.

(e) Few candidates were able to deduce that if the time interval is known then the distance travelled can be calculated.

(f) Most candidates obtained a mark for the suggestion that, in this imaginary event, we should stop using ultrasonic waves but few had any sensible qualification to make and seemed unaware to the harm this reaction could cause.

Higher Tier

(a) Most candidates answered this correctly.

(b) Nearly all candidates gained the mark for this question.

(c) (i)(ii) Most candidates could give an industrial use and a medical use for ultrasound. It should be noted that vague answers such as 'scanning organs' or 'scanning babies' did not gain credit.
Candidates needed to be more precise eg 'scanning the kidneys' or 'scanning an unborn baby'.

(d) Most candidates were able to interpret the diagram, and the information given about the scale, and correctly deduce that the time interval is 8 microseconds.

(e) Over half the candidates gained one mark by deducing that if the time interval is known then the distance can be calculated but few of these candidates were able to state what the distance is in this case.

(f) Nearly all candidates obtained a mark for the suggestion that, in this event, we should stop using ultrasonic waves and about half of these candidates had a sensible qualification to make such as the need for further research.

E20. (a) Most candidates secured both marks by writing that ultrasound has a frequency greater than 20 000 Hz and so cannot be heard by humans. However, some candidates offered responses which are true for sound in general, 'It's not as fast as light' for example, and did not gain any credit.

(b) (i) Most candidates realised that the pulses are caused by ultrasound being reflected, though some candidates did not secure the mark because they offered 'rebounded' or 'bounced'. Most candidates thought that pulse A indicates the crack and pulse B indicates the back of the block, or the back of the crack. Either interpretation gained credit provided that both pulses were identified.

(ii) Most candidates correctly offered an answer in the range 88 – 92 (mm).

E22. (a) (i) Nearly all candidates correctly recognised the lens as convex or converging.

(ii) Most candidates identified **F** as a focal point or focus.

(iii) Only a small minority of candidates were able to name the central horizontal line as the axis.

(iv) Some candidates seemed quite unfamiliar with the process of optical construction. Those who made a fair attempt generally secured at least three marks. The most common errors were failure to show correctly the direction of at least one ray with any contradiction, lack of accuracy and failure to show the position of the image from the point of intersection of the virtual rays to the axis.

(v) Few candidates mentioned that a virtual image was formed as a result of the intersection of virtual rays. Many correctly noted that a virtual image cannot be projected onto a screen. Some contented themselves, but not their examiners, by simply stating 'a virtual image is not real'.

(b) Some candidates were confident that it needed to be a real image because it needed to fall on the exposed film, but many answers were vague and generally poorly expressed. A very small minority of responses in terms of digital cameras, and similar answers, were usually worthy of credit. Many candidates knew that the object would need to be beyond the focal length, but few had sufficient understanding to state that the object would need to be at more than twice the focal length from the lens.