Name: ____

Optics

Questions

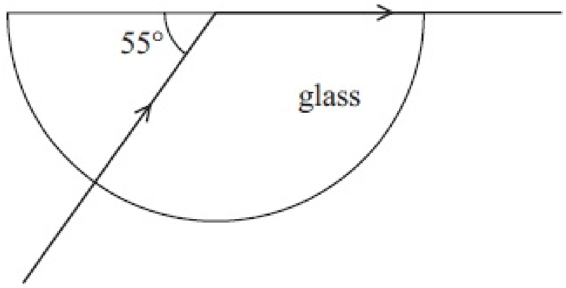
Date:

Time:

Total marks available:

Total marks achieved: ______

Q1.
A ray of monochromatic light passes into a glass block as shown
.



The refractive index of the glass for this light is

- **A** 0.57
- **B** 0.81
- **C** 1.22
- **D** 1.74

(Total for question = 1 marks)

Q2.

An object is placed 6.5 cm away from a lens of focal length 3.9 cm. An image is formed 9.8 cm from the lens.

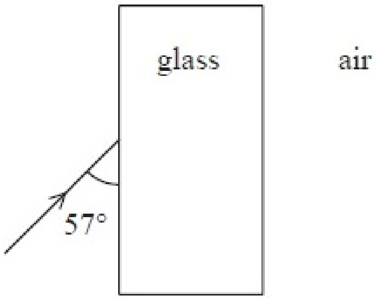
Which of the following is the magnification?

(1)

- **A** 0.60
- **B** 0.66
- **C** 1.5
- **D** 1.7

(Total for question = 1 mark)

Q3. The diagram shows a ray of light incident upon the surface of a glass block.



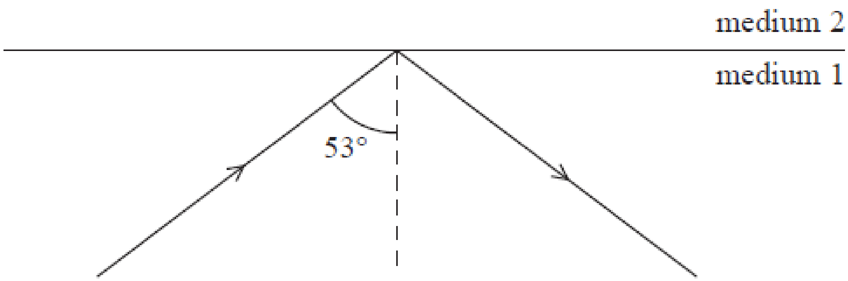
Which line could correctly show the angle of incidence and the angle of refraction?

	Angle of incidence	Angle of refraction
☒ **A**	33°	21°
☒ **B**	33°	55°
☒ **C**	57°	34°
☒ **D**	57°	38°

(Total for Question = 1 mark)

Q4.

Light in medium 1 strikes a boundary with medium 2 which is also transparent. The diagram shows what happens.



Which of the following can be deduced?

☒ **A** The critical angle for light travelling from medium 1 into medium 2 is 53°.

☒ **B** The refractive index of medium 1 is greater than the refractive index of medium 2.

☒ **C** The speed of light in medium 1 is greater than the speed of light in medium 2.

☒ **D** The frequency of light in medium 1 is less than the frequency of light in medium 2.

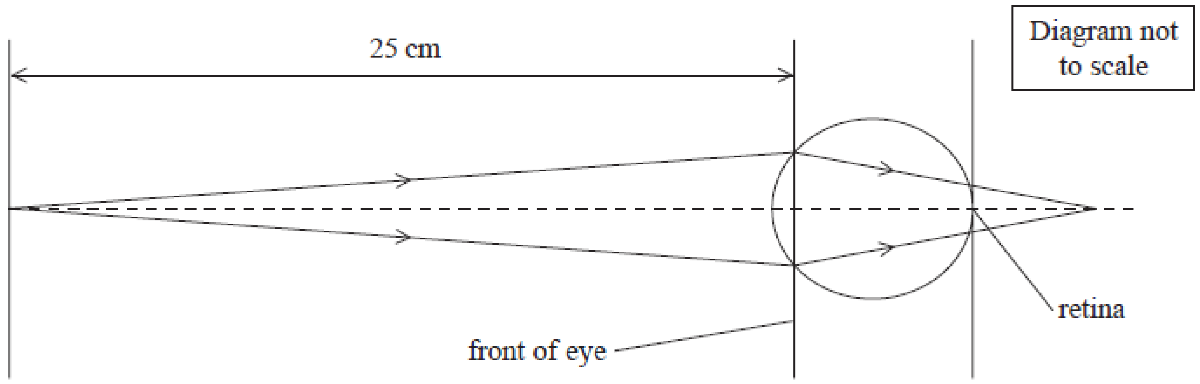
(Total for question = 1 mark)

Q5.

Converging and diverging lenses may be used in glasses to correct problems with eyesight.

A person who is long-sighted cannot clearly see objects that are close to the eye.

Rays of light from an object 25 cm in front of the eye would converge to a point behind the retina as shown in the diagram.



This may be corrected by using an additional converging lens.

State how an additional converging lens would enable the light rays from an object 25 cm in front of the eye to converge at a point on the retina.

(1)

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(Total for question = 1 mark)

Q6. Which of the following is a base SI unit?

☐ **A** ampere

☐ **B** coulomb

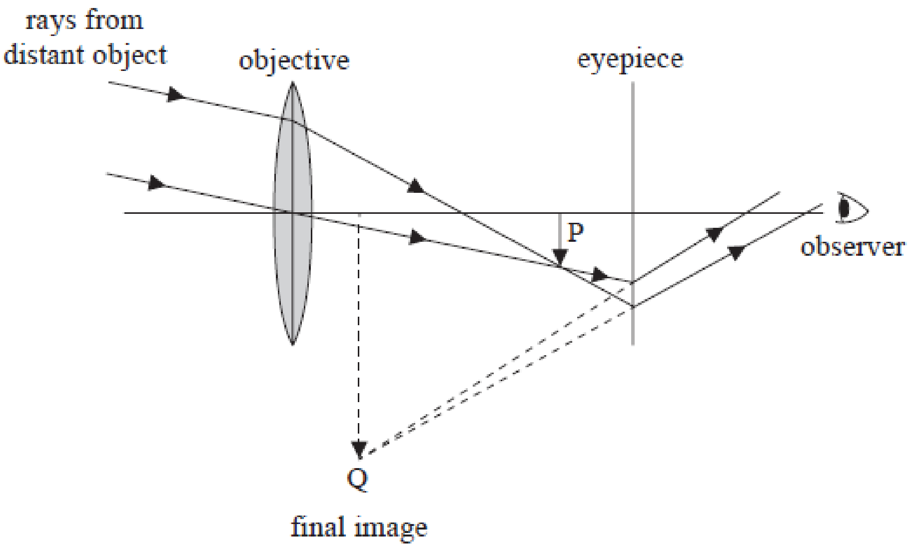
☐ **C** ohm

☐ **D** volt

(Total for question = 1 mark)

Q7.

A telescope consists of a convex lens (objective) of power 0.820 D and a second lens (eyepiece) as shown.



The objective produces an image at P. This image becomes the object of the eyepiece, which produces a final image at Q.

Show that the focal length of the objective lens is about 1200 mm.

(2)

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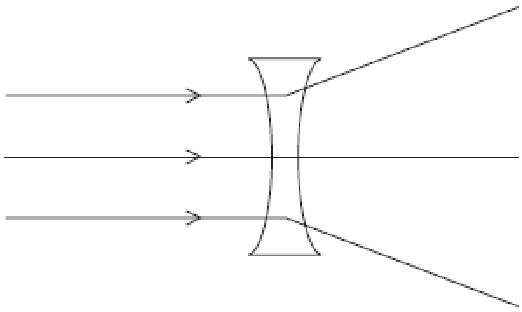
(Total for question = 2 marks)

Q8.

Converging and diverging lenses may be used in glasses to correct problems with eyesight.

The diagram shows three parallel rays of light incident on a diverging lens and the path of the rays after passing through the lens. The diagram is drawn to actual size.



Add to the diagram to determine the focal length of the lens.

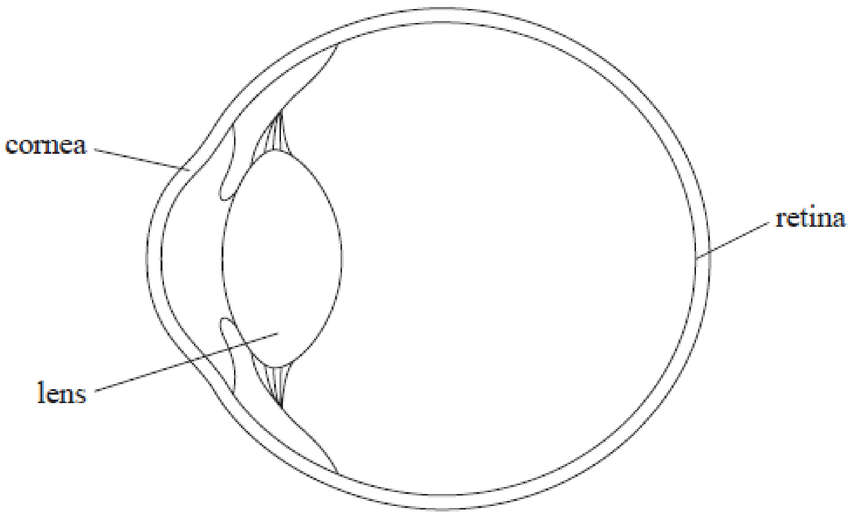
(2)

Focal length = ...

(Total for question = 2 marks)

Q9.

Light entering a normal eye is refracted by both the cornea and the lens before a focused image is formed on the retina.



People swimming under water often wear goggles. The goggles enable them to see objects under water clearly whereas without goggles objects appear blurred.

Explain why wearing goggles has this effect.

speed of light in water = 2.25×10^{8} m s^{-1}

(3)

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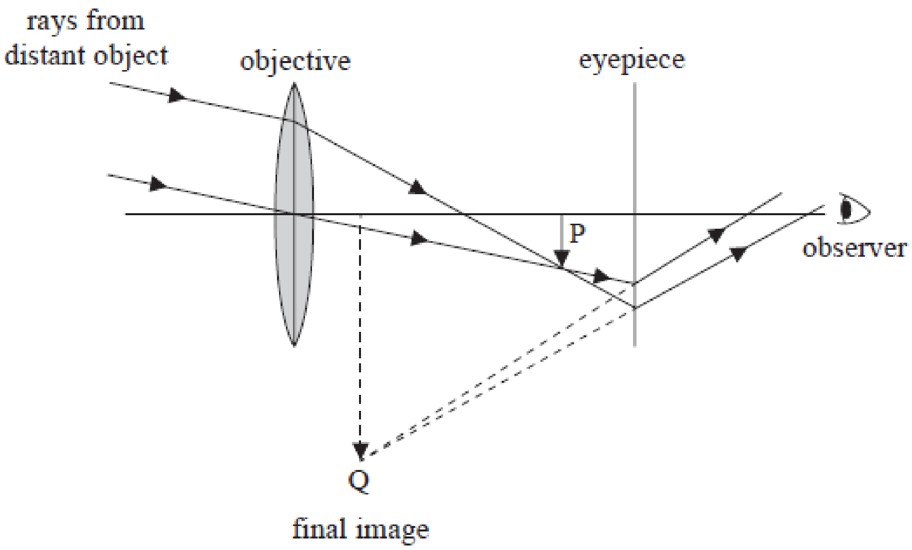
(Total for question = 3 marks)

Q10.

A telescope consists of a convex lens (objective) of power 0.820 D and a second lens (eyepiece) as shown.



The objective produces an image at P. This image becomes the object of the eyepiece, which produces a final image at Q.

The eyepiece is at a distance of 100 mm from the image at P. To give a reasonable magnification, the final image at Q should be a virtual image at a distance of 300 mm from the eyepiece.

The following lenses are available:

diverging lens focal length 150 mm,
converging lens focal length 150 mm,
diverging lens focal length 100 mm,
converging lens focal length 100 mm.

Deduce which lens should be used for the eyepiece.

(3)

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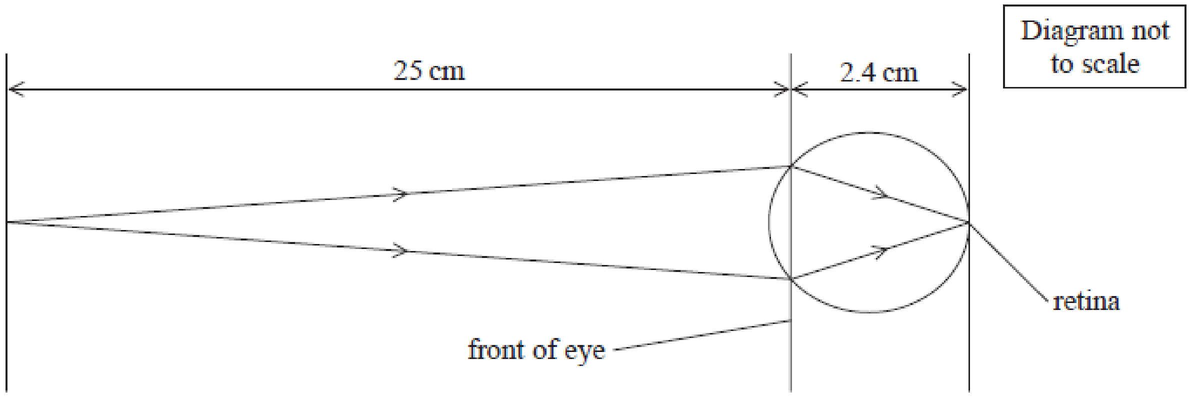
(Total for question = 3 marks)

Q11.

Converging and diverging lenses may be used in glasses to correct problems with eyesight.

The eye acts as a converging lens system.

The diagram shows light rays from an object 25 cm in front of an eye converging to a point on the retina at the back of the eye. The eye has a depth of 2.4 cm.



Calculate the optical power of the eye.

(3)

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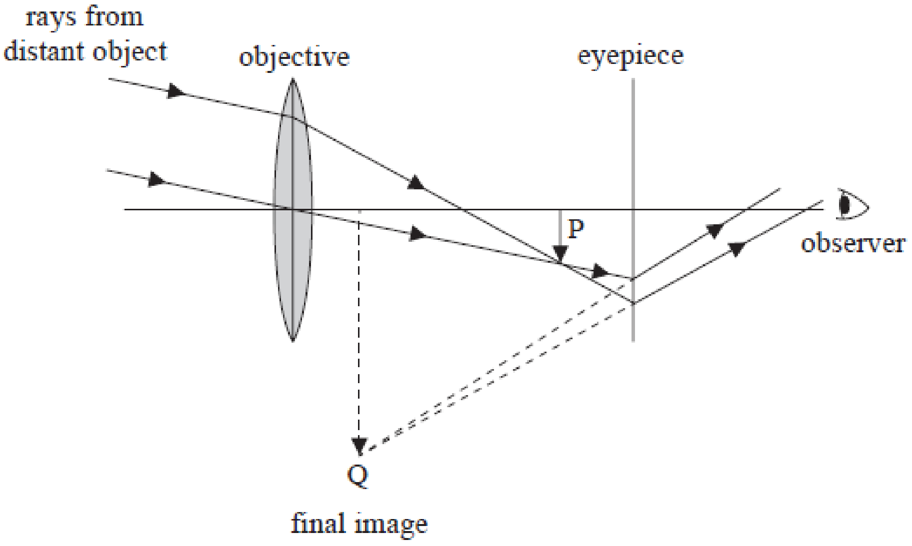
Power = ...

(Total for question = 3 marks)

Q12.

A telescope consists of a convex lens (objective) of power 0.820 D and a second lens (eyepiece) as shown.



The objective produces an image at P. This image becomes the object of the eyepiece, which produces a final image at Q.

Telescopes can be used to observe distant objects such as the Moon.

(i) Explain why the image of the Moon produced at P by the objective lens will be at a distance of about 1200 mm from this lens.

(2)

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(ii) State the properties of the image at P.

(2)

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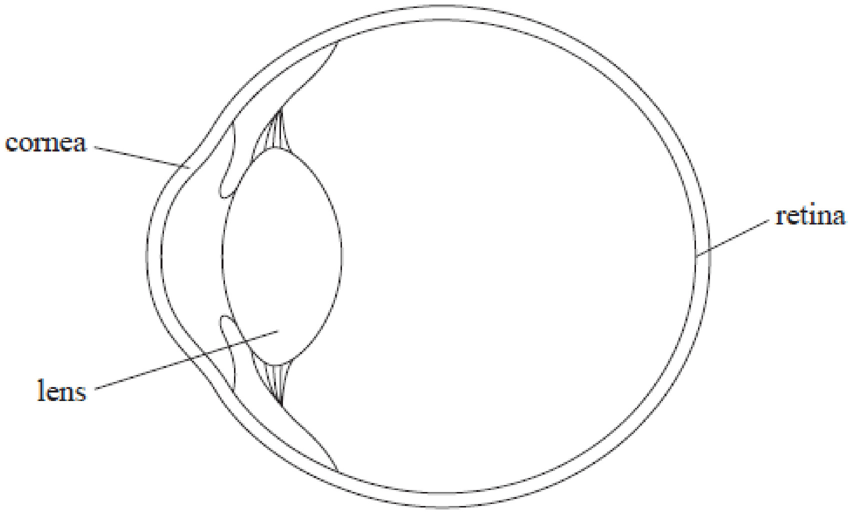
(Total for question = 4 marks)

Q13.

Light entering a normal eye is refracted by both the cornea and the lens before a focused image is formed on the retina.



It is suggested that the cornea provides 80% of the focusing power of the eye.

Determine whether this is correct.

focal length of cornea = 2.23 cm

focal length of lens for near object = 5.27 cm

(4)

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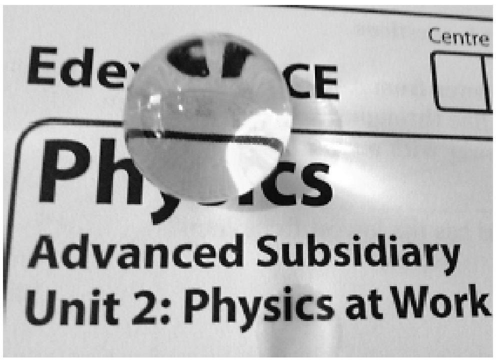
(Total for question = 4 marks)

Q14.

Flower arrangers sometimes use gel balls instead of water to fill vases.

The photograph below shows some writing seen through one of these gel balls. The writing is distorted because the gel ball refracts light.



(a) Explain what is meant by refraction.

(2)

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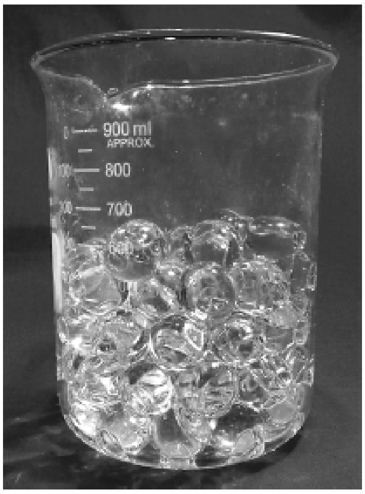
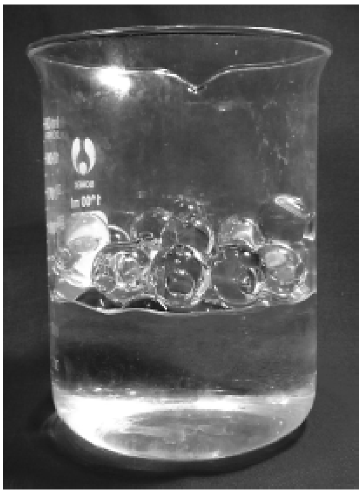
(b) The photographs below show a beaker containing gel balls. When water is added to the beaker, the gel balls below the water surface are no longer visible.





Explain how this shows that the gel has the same refractive index as water.

(2)

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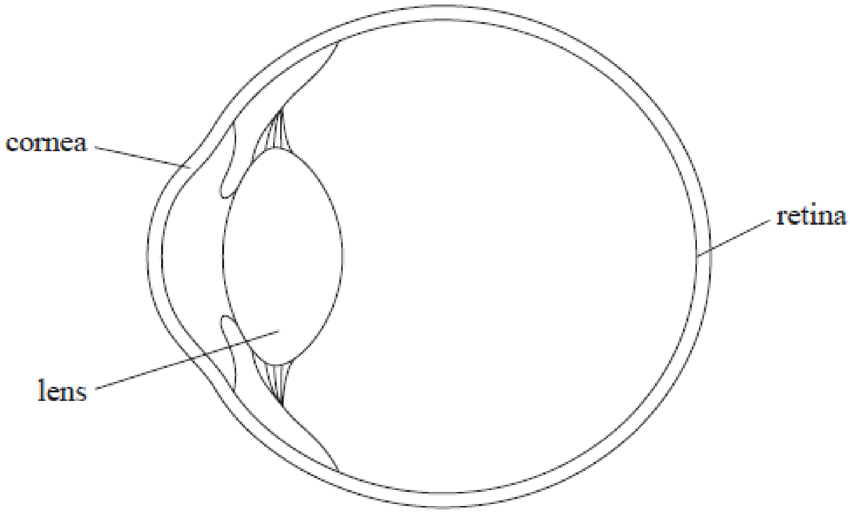
Q15.

Light entering a normal eye is refracted by both the cornea and the lens before a focused image is formed on the retina.



Light from a point object forms a focused image on the retina.

The cornea and lens may be treated as a single lens of focal length 1.6 cm that is 2.4 cm from the retina.

(i) Calculate the distance from the point object to this single lens when a focused image is formed on the retina.

(2)

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Distance = ...

(ii) A ray of light strikes the front of the cornea at an angle to the normal in air of 15°.

Calculate the angle of the ray to the normal in the cornea.

speed of light in air = 3.00×10^{8} m s^{-1}

speed of light in cornea = 2.18×10^{8} m s^{-1}

(3)

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Angle to normal in cornea = ...

(Total for question = 5 marks)

Q16.

A simple optical fibre consists of a core surrounded by cladding. The refractive index of the core is 1.56 and the refractive index of the cladding is 1.20.

(a) Show that the critical angle for light between these two media is about 50°.

(3)

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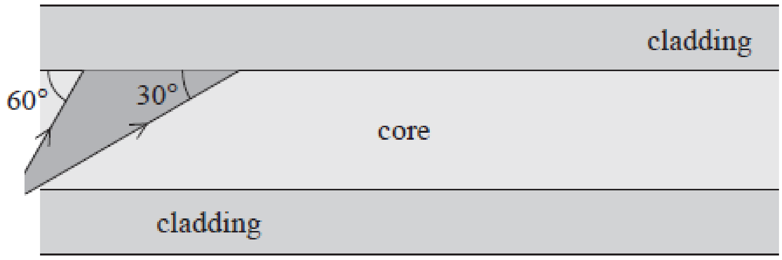
(b) The diagram shows a diverging beam of light incident on the boundary between the core and the cladding. One side of the beam strikes the boundary at 60° and the other side at 30° as shown.



Three students each suggest a different outcome for the beam of light at the boundary.

Student A says "all the beam will totally internally reflect".

Student B says "all the beam will refract".

Student C says "some of the beam will totally internally reflect and some will refract".

State which student is correct, adding to the diagram to illustrate your answer.

(3)

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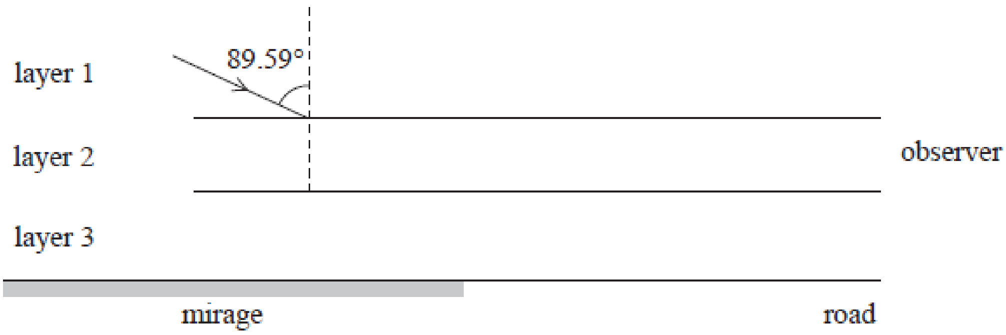
(Total for question = 6 marks)

Q17.

On sunny days a mirage can sometimes be observed when a virtual image of the sky is seen on the surface of a road.

The Sun's rays heat up the surface of the road. The heated road then heats the surrounding air so that the layer of air just above the road is at a higher temperature than the air above it. Warm air has a lower refractive index than cool air.

The diagram represents a simple model which is sometimes used to explain how a mirage is formed. The three layers, each with a different refractive index, represent air at three different temperatures. Layer 3 represents the air at the highest temperature closest to the road. A light ray is shown incident at the interface between layer 1 and layer 2.



	refractive index
layer 1	1.00032
layer 2	1.00030
layer 3	1.00028

critical angle for light travelling from layer 1 to layer 2 = 89.64°
critical angle for light travelling from layer 2 to layer 3 = 89.64°

Use the information to discuss whether the observer sees a mirage on the road in the position shown.

(6)

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(Total for question = 6 marks)

Q18. (a) You are asked to find the refractive index for light passing from air to glass by tracing the path of a ray of light through a glass block.

State the measurements you would take, the graph you would plot and how you would use the graph to determine a value for the refractive index.

(3)

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(b) (i) State what is meant by critical angle.

(2)

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(ii) Calculate the critical angle for light passing from water to air.

refractive index of water = 1.33

(2)

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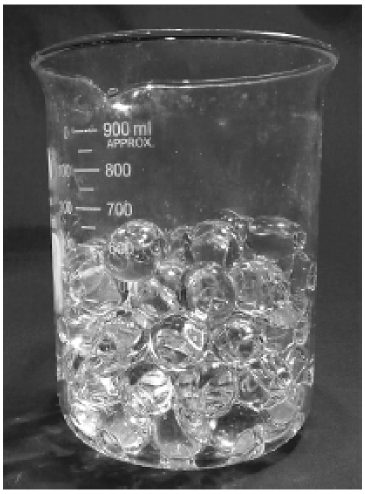
Critical angle = ...

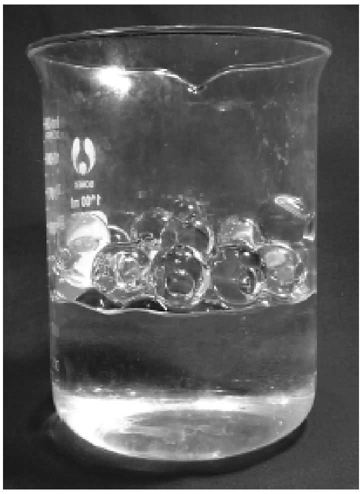
(Total for Question = 7 marks)

Q19.

Flower arrangers sometimes use gel balls instead of water to fill vases.

The photographs below show a beaker containing gel balls. When water is added to the beaker, the gel balls below the water surface are no longer visible.





(a) A student decides to use a gel ball to model the formation of a rainbow by raindrops. He wants to see if total internal reflection occurs.

Explain what is meant by total internal reflection.

(2)

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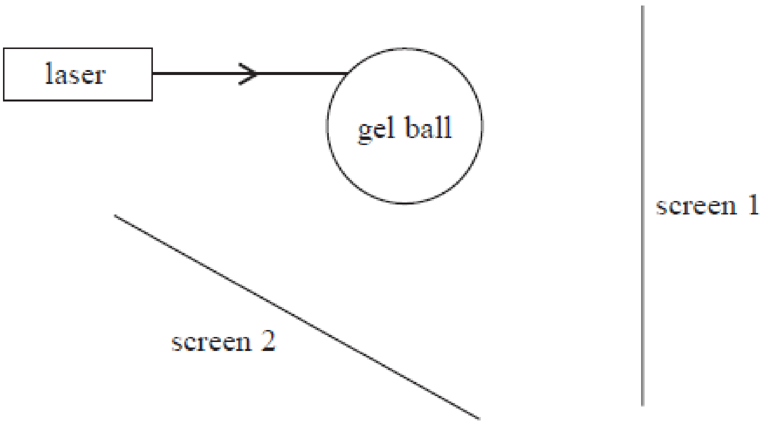
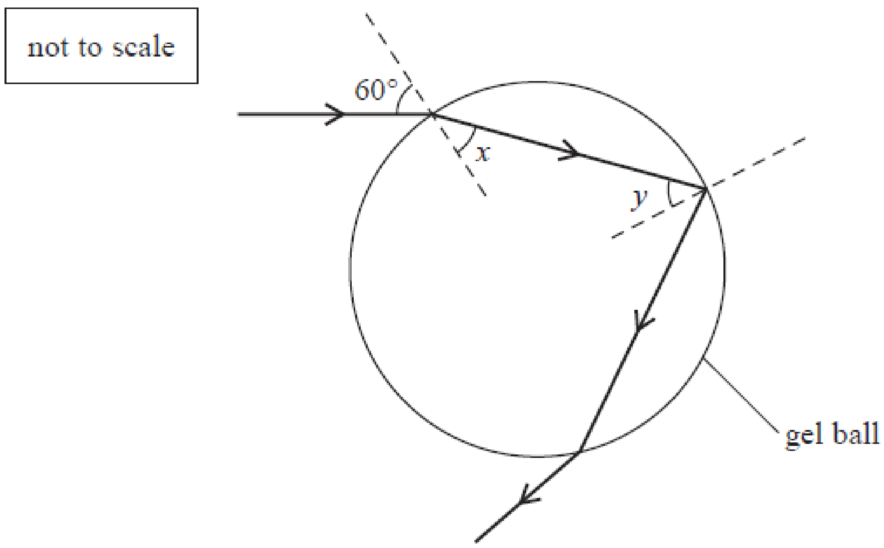
(b) The student shines a narrow laser beam at a gel ball using the arrangement shown.



When the angle of incidence of the laser beam with the gel ball is 60°, light from the laser illuminates screen 2 following the path shown.



(i) Show that the angle x is about 40°.

refractive index of gel = 1.33

(2)

(ii) Show that the critical angle for light striking the boundary of gel with air is about 50°.

(2)

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(iii) Angle *x* has the same value as angle *y*.
Explain whether light from the laser will be observed on screen 1.

(2)

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Q20.

A student has the equipment shown in Figure 1:

- protractor
- 15 cm ruler
- laser light source
- pencil
- sheet of paper
- rectangular block of plastic.

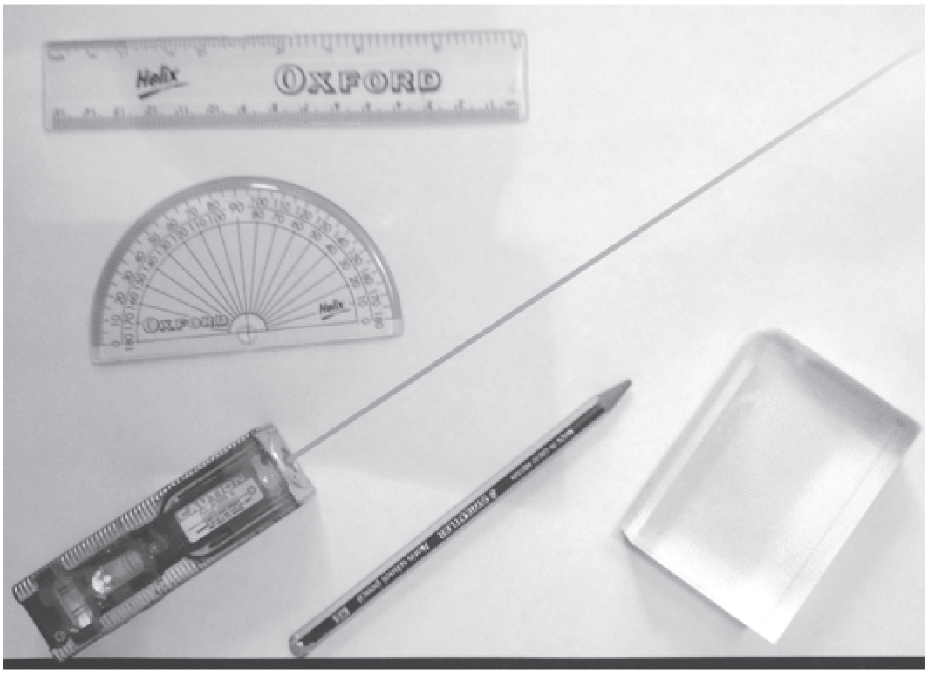

Figure 1

(a) The student uses the equipment shown in Figure 1 to take the measurements needed to determine the refractive index for light travelling from air into the plastic.

Explain **one** limitation of this equipment when used to obtain the measurements.

(2)

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(b) The value of refractive index obtained by the student was 1.52.

(i) Calculate the speed of light in the plastic.

(2)

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Speed of light in the plastic = ...

(ii) Calculate the critical angle for the plastic.

(2)

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Critical angle = ...

*(c) The student was given the shape shown in Figure 2 made from the same plastic.

Figure 3 shows what happens when light from a laser was directed at one end of the shape.

Figure 2

Figure 3

Explain the path of the laser light through the plastic as shown in Figure 3.

(4)

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(Total for question = 10 marks)

Q21. When light rays enter the Earth's atmosphere from space they undergo refraction. This can lead to a star appearing to be in a different position from its actual position.

(a) Explain what is meant by refraction and why it occurs for light entering the Earth's atmosphere.

(3)

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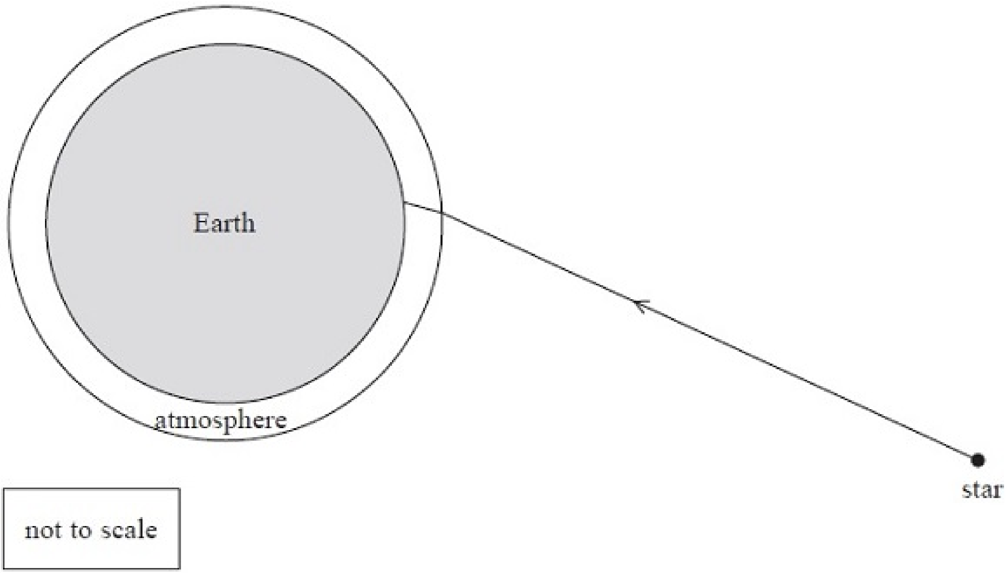
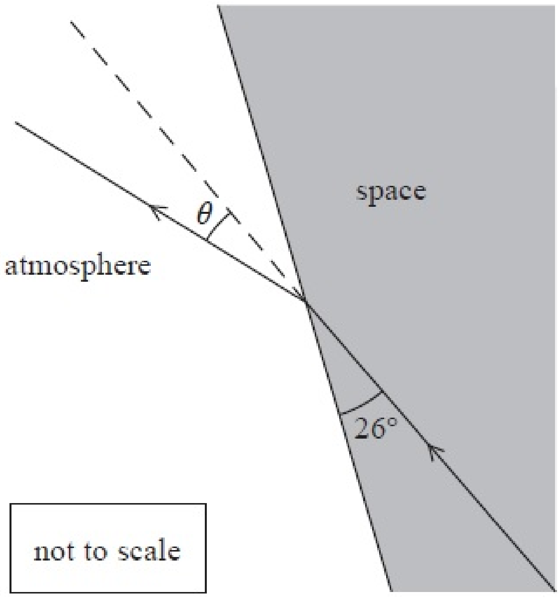
(b) The diagram shows a ray of light from a star reaching the Earth's surface.



The diagram shows in more detail the ray of light as it enters the atmosphere.



Calculate the change in direction θ of the ray.

refractive index of atmosphere = 1.001

(4)

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θ = ...

(Total for Question = 7 marks)