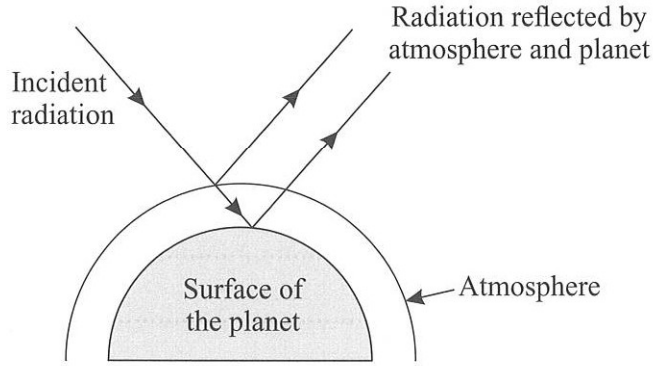
Electromagnetic Waves

1 A planet is orbiting a star. Radiation from the star is incident on the surface of the planet's atmosphere. The star transfers 400 J of energy per second to each square metre of the planet's atmosphere. **Figure 1** shows the paths taken by the incident radiation when it reaches the planet.

Figure 1



Of the radiation incident on the atmosphere, 10% is reflected back into space and 20% is absorbed by the atmosphere. The rest of the radiation passes through the atmosphere to the surface of the planet. The radiation that reaches the surface of the planet is either reflected or absorbed. The ratio of radiation absorbed by the surface of the planet to the radiation reflected by the planet is 5:2.

You may assume that each unit of radiation transfers the same amount of energy, and any energy radiated from the atmosphere towards the surface of the planet is negligible.

a) Calculate the amount of energy absorbed by 1 m^2 of the surface of the planet each second.

Energy = ... J

[2]

b) A moon that orbits the planet passes between the star and the planet, causing an eclipse. Suggest the effect this will have on the surface temperature of the planet. Explain your answer.

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[2]

[Total 4 marks]

2 A paint manufacturer has to ensure that each new batch of paint is the same as the other batches of the same colour of paint.

One way of checking this is by using a spectrophotometer on a sample of the paint, as shown in **Figure 2**. Spectrophotometers can record the percentage of light reflected by a sample across a range of wavelengths.

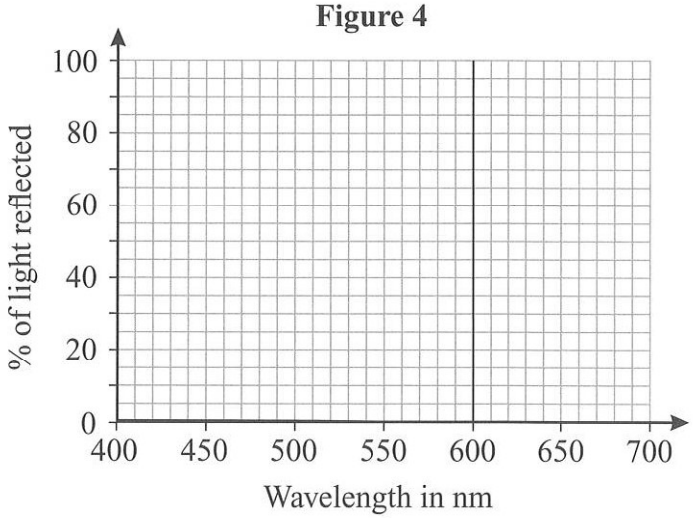
Figure 2

Figure 3 shows the frequencies of different colours of visible light. The spectrophotometer display for a particular paint is shown in **Figure 4**.

Figure 3

Colour	Frequency in THz
Violet	750
Indigo	670
Blue	640
Green	570
Yellow	520
Orange	500
Red	450

Figure 4



a) Determine the colour of the paint. Use a calculation to support your answer.
The speed of light is 3.0×10^8 m/s.

Colour = ...

[4]

b) Household paint consists of a solid, powdery pigment held together by a liquid binder. The binder becomes a smooth solid when it dries. Suggest why the ratio of binder to pigment is higher in glossy paints than in matte paints. Explain your answer.

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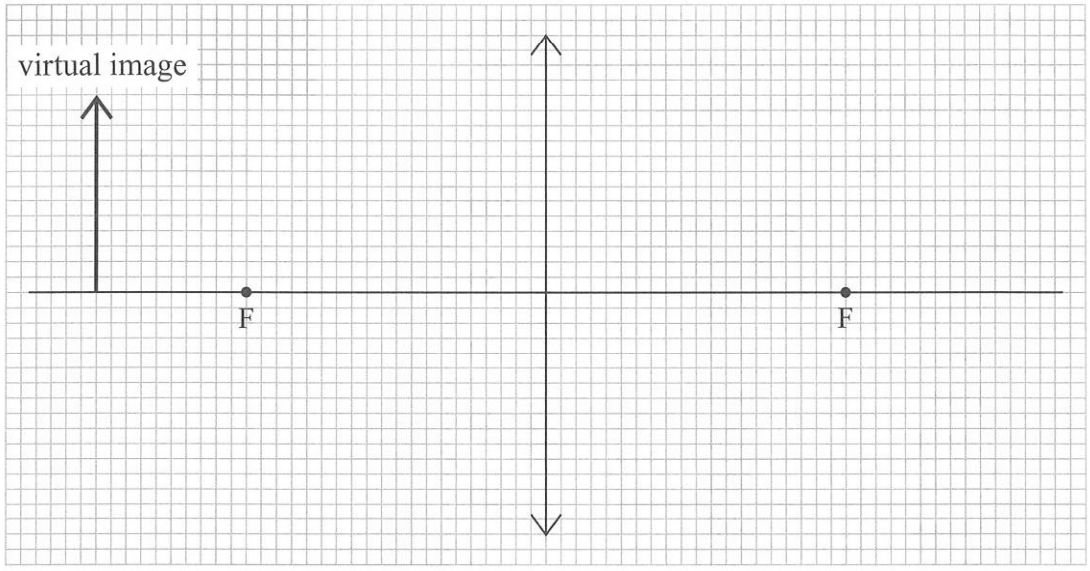
[3]

[Total 7 marks]

3 An object is placed on the left-hand side of a convex lens. The lens has a focal length of 40 mm.

a) i) A 26 mm tall virtual image is formed on the same side of the lens as the object, 60 mm from the lens. Complete **Figure 5** by constructing an accurate ray diagram showing the size and location of the object. The lens, the axis of the lens, the principal focus points and the virtual image have been drawn for you.

Figure 5



[4]

ii) The object is moved so that it is 80 mm from the lens.
Which option describes the image produced by the lens? Tick **one** box.

☐ **A** The image is real and upright.

☐ **B** The image is real and upside down.

☐ **C** The image is virtual and upright.

☐ **D** The image is virtual and upside down.

[1]

iii) The object is returned to its original position and the convex lens is replaced by a concave lens with the same focal length. Compare and contrast the image produced by the concave lens with that produced by the convex lens.

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[2]

b) Lenses alter the path of light rays by refraction. Inside the lens, light travels at a speed of 2.0×10^8 m/s. Red light with a wavelength of 640 nm in air is incident on the lens.
Calculate the wavelength of the red light inside the lens. The speed of light in air is 3.0×10^8 m/s.

Wavelength = ... m

[5]

c) When a real image is produced on a screen using a convex lens and white light, a violet fringe is seen around the edge of the image. Explain using wave properties why this fringe occurs.

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[3]

[Total 15 marks]

4 Radio waves are commonly used in communications on Earth.

a) Gamma radiation can pass through most obstacles, which would be useful in communications. Suggest **one** reason why gamma radiation isn't used in communications.

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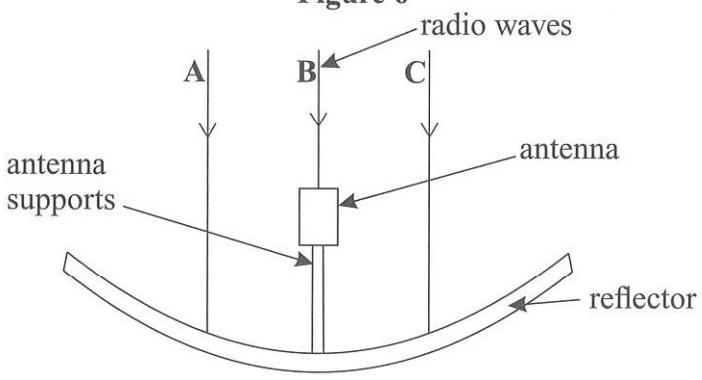
[1]

b) **Figure 6** shows a type of receiver used to detect radio waves.
A beam of radio waves is incident on the receiver, represented by rays **A**, **B** and **C**.

Figure 6



i) Any radio waves that hit the reflector's surface are reflected towards the antenna.
Complete **Figure 6** to show the paths of the rays labelled **A** and **C** after striking the reflector.

[1]

ii) Explain why there is a delay between the waves represented by rays **A** and **B** reaching the antenna.

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[2]

[Total 4 marks]

Exam Practice Tip

If you get a question asking you about an unfamiliar application, don't panic. Read it through carefully and work out which ideas you actually need to apply — it'll always be stuff you should know.
Don't just speak in general terms though — make sure you relate everything back to the question.

Score: ____ / **30**