WAVES AND OPTICS PROBLEMS

Speed of waves

1. Thunder is heard 20 seconds after a lightning flash. If the speed of sound is 340 m/s, how far away is the storm?

2. Explain why, during a thunder storm, you see the lightning before you hear the thunder.

3. On a day when the speed of sound in air is 330 m/s, how long would sound take to travel a distance of 1.6 km?

4. During a thunder storm it is noticed that the time interval between the flash of lightning and the clap of thunder gets less. What does this tell you about the storm?

5. Describe a method of measuring the speed of sound in air giving:
   a) the apparatus used
   b) the measurements taken
   c) any equations used in the calculation.

6. Ten pupils are standing on Calton Hill, looking at Edinburgh Castle. They measure the time difference between seeing the smoke from the one o'clock gun and hearing the bang. The measured times are 3.8 s, 4.2 s, 4.0 s, 3.8 s, 4.4 s, 3.8 s, 4.0 s, 4.2 s, 3.6 s, and 4.2 s.
   a) Calculate the average time for the group.
   b) Calculate the distance from the Castle to Calton Hill if the speed of sound is 330 m/s.

7. An explosion in Grangemouth could be heard in South Queensferry one minute later . Given they are 20 km apart, calculate the speed of sound in air.

8. On a day when the speed of sound is 330 m/s, how long would the sound take to travel a distance of 19.8 km?

9. In a race the runners are at different distances away from the starter. They will hear the starting horn at different times. Using the speed of sound as 340 m/s, calculate the time difference in hearing the horn for two runners who are 5 m and 15 m from the starter.

10. Calculate how long it would take light to travel from the sun to the earth, a distance of 1.49×10^8 km.

11. How long will it take a radio signal to travel from Britain to Australia, a distance of 1.8×10^4 km.

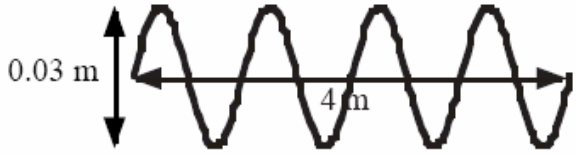
12. a) Explain, using a diagram, the difference between a transverse and longitudinal wave.
    b) What type of waves are the following:
       i) sound waves
       ii) water waves
       iii) light waves.

13. Explain, using the particle model, why sound travels quicker in metals than gases.

14. Explain why sound cannot travel through a vacuum.

Speed, frequency, wavelength and period

15. The diagram below represents a wave 0.2 s after it has started.



Calculate the following quantities for this wave:

a) wavelength
b) amplitude
c) frequency
d) speed.

16. A swimming pool is to have a wave-making machine installed. The time taken for a wave to travel the length of the 50 m pool has to be 20 s and the wavelength has to be 4 m.

a) Calculate the speed of the waves.
b) Calculate the required frequency of the waves.

17. Wave A has a wavelength of 6 cm and a frequency of 50 Hz. Wave B travels 250 m in 1 minute 40 s. Which wave travels faster - and by how much?

18. 40 waves are found to pass a point in 20 s. If the waves have a wavelength of 0.015 m, calculate their speed.

19. Calculate the wavelength of a wave of frequency 0.1 Hz and speed 5 m/s.

20. State what is meant by the period of a wave.

21. If the speed of a water wave is 0.6 m/s and the wavelength of each wave is 6 cm, calculate

a) the frequency
b) the period of the wave.

22. Waves of wavelength 5 cm travel 120 cm in one minute.
Find their

a) speed
b) frequency
c) period.

23. A sound generator produces 25 waves every 0.1 s. If the speed of sound is 330 m/s, find:

a) the wavelength of the sound
b) the period of the waves.

24. a) List the members of the electromagnetic spectrum in order with the largest wavelength first.
    b) What do all the members have in common?

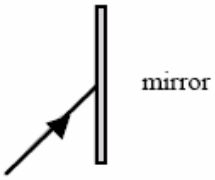
25. How far will radio waves travel in a) 2 m s b) 0.25 m s c) 1 m s.

26. Calculate the wavelength of waves of frequency a) 5 GHz b) 4 MHz c) 200 GHz.

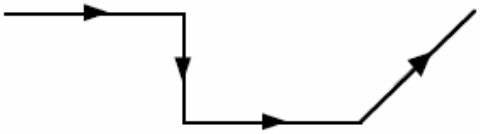
27. Calculate the transmission frequency of Radio Scotland broadcasting on 370 m on the Medium waveband. Give your answer in MHz.

Reflection

28. Copy and complete the diagram below labelling clearly
    a) the angle of incidence
    b) the angle of reflection
    c) the normal.



29. The diagram shows the path of a ray of light . The ray was made to change direction using mirrors, but these have been left out.



Copy the ray of light and complete the diagram by placing the mirrors in exactly the correct position.

30. If you were given a semicircular glass block, a ray box and single slit, describe how you would demonstrate total internal reflection. Include a diagram in your explanation.

31. Copy the following diagrams, showing the path of the rays when their direction is reversed.

a) b)

32. Explain, using a diagram, how a curved reflector is used in a torch to produce a beam of light.

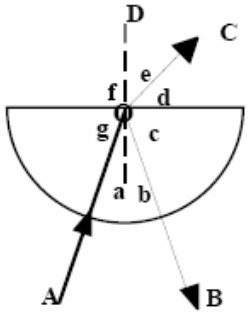
3. An outside broadcast unit at a football game beams television signals by means of a satellite dish to a receiver unit. Show by means of a diagram how
   a) the beam is sent
   b) the beam is received.

34. How can a curved reflector be used to ensure heat is directed more efficiently from an electric fire.

35. a) Optical fibre systems use repeater stations. What is the purpose of repeater stations?
   b) Light signals travel through glass at a speed of 2×10^8 m/s. How long would it take to travel between two repeater stations which were 100 km apart?

Refraction

36. Identify the following from the diagram shown below.
   i) the incident ray ii) the reflected ray iii) the refracted ray
   iv) the normal v) the angle of incidence vi) the angle of refraction
   vii) the angle of reflection.



37. Copy and complete the following diagrams.

a) b) c) d)

38. By constructing accurate ray diagrams, describe the images produced using a converging lens of focal length 5 cm for the following object distances,
   a) 15 cm b) 8 cm c) 2 cm.

39. A projector can be used to produce a magnified image on a screen.
   a) Describe where the slide would have to be positioned, relative to the converging lens, to form this image.
   b) To ensure seeing the image the right way up what would have to be done to the slide?

40. A slide viewer produces a virtual, magnified image. Where would the object (the slide) have to be placed, relative to the lens, to produce this type of image?

41. Describe how the power of a lens could be found experimentally. This should include :
    a) a list of apparatus used
    b) a description of the procedure
    c) how the measurement(s) was used to find the power of the lens.

42. Find the power of the following lenses :
    a) f = 25 cm b) f = 10 cm c) f = 20 cm

43. Calculate the focal length of the following lenses :
    a) P = +2 D b) P = +2.5 D c) P = -8 D d) P = -5 D

44. a) Explain how being
        i) short sighted
        ii) long sighted would affect a person.
    b) Show how rays would pass through an eye resulting in
        i) short sight ii) long sight
    c) Explain which type of lens would be used to correct the above conditions.