TELECOMMUNICATIONS

DISTANCE, SPEED AND TIME $d = v\,t$

1. Complete the following table:

	SPEED	TIME	DISTANCE
a)	20 m s^{-1}	5 s	----------
b)	----------	6 s	36 m
c)	5 m s^{-1}	----------	40 m
d)	----------	3 min	720 m
e)	25 m s^{-1}	----------	3.5 km
f)	75 cm s^{-1}	2 min 30 s	----------
g)	----------	1 h	43.2 km

2. Sound travels at 340 m s^{-1} . How far does it travel in 5 s?

3. A girl standing 1330 m away from a lightning strike hears the thunder 4 s after she sees the lightning. What is the speed of sound?

4. If sound travels at 333 m s^{-1} , how long does it take to travel 3000 m?

5. The sound from an explosion reaches an observer 8 s after he sees the blast.
   a) How far away is the explosion if the speed of sound is 340 m s^{-1}?
   b) What assumption are you making in the above calculation?

6. A diver 4.5 km away from a diving bell hears the hooter to return 3 s after it is sounded. What value does this give for the speed of sound in water?

7. If the speed of sound in water is 1500 m s^{-1}, how far does it travel in 3 min 45 s?

8. Sound travels at 5050 m s^{-1} in railway tracks. A train is 4 km away. How long does the sound take to reach a man with his ear to the tracks?

9. Sound takes 3 x 10^{-3} s to travel through a copper bar which is 10.5 m long. What value does this give for the speed of sound in copper?

SPEED OF LIGHT ($c = 3 \times 10^8$ m s^{-1})

10. Calculate the distance that light travels in:
    a) 10 s,
    b) 5 min.

11. A boy hears the thunder 4 s after he sees the lightning.
    a) How far from the boy is the lightning strike?
    b) How long does it take the light to travel this distance?

12. Microwaves travel at the same speed as light. How long does the signal take to travel down a microwave link of 450 km between Inverness and Stranraer?

13. Radio waves travel at the same speed as light. A radio signal is sent 50 000 km up to a satellite from Edinburgh and has to travel the same distance down from the satellite to the receiving station in Washington. How long will it take to send a message and receive an answer (assume no delay in sending the answer)?

14. Twins, Carol and Peter, both want to hear a concert. Peter is at the open air arena but he is 250 m from the stage. Carol is 15 000 km away in South America. Carol has to listen on the radio but Peter hears the sound directly from the loudspeakers.
    a) How long does the sound take to reach Peter?
    b) How long does the radio wave take to reach Carol?
    c) Which of them hears the start of the concert first?

ECHO PROBLEMS

15. A boy is standing in front of a canyon wall. He shouts and hears the echo 0.24 s later. Take the speed of sound to be 340 m s^{-1}.
    a) Calculate the total distance which is travelled by the sound.
    b) How far from the wall is the boy standing?

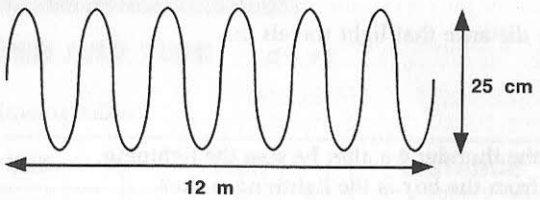
16. Sonar consists of sound waves which reflect from the sea bed or objects under the sea. A sonar pulse was sent down from a ship looking for a shoal of fish and two pulses were reflected back, the first after 0.85 s and the second after 2.3 s. Take the speed of sound in water to be 1500 m s^{-1}.
    a) Calculate the depth of the water.
    b) Calculate the depth at which the fish are swimming.

17. A girl standing in front of a tall building claps her hands four times every second. She hears the echo of one clap just as she makes the next one. If the speed of sound is 340 m s^{-1}, how far is she from the building?

18. A man shouts and hears the echo from a cliff 4 s later. Then he walks towards the cliff and tries again. This time he hears the echo after 2.5 s If the speed of sound is 340 m s^{-1}, how far has he walked?

WAVE DEFINITIONS

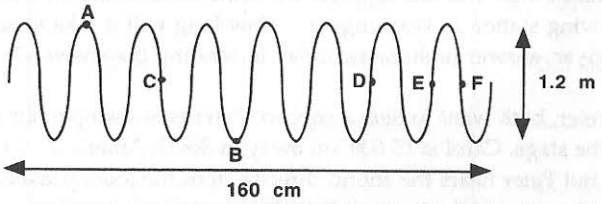
19.



a) What is the amplitude of the wave shown?
b) What is the wavelength of the wave?

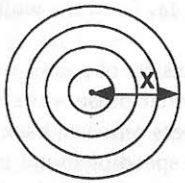
20. 20 waves pass a point in 4 s.
a) What is the frequency of the waves?
b) What is the period of the waves?

21.



All the waves shown were produced in 2 s.
a) Calculate the frequency of the waves.
b) Calculate the wavelength of the waves.
c) Calculate the period of the waves.
d) Calculate the amplitude of the waves.
e) Name the points: i) A , ii) B.
f) Calculate the distance separating the points: i) C and D, ii) E and F.

22. The circles shown represent wave fronts. The distance X is 50 m and the waves are produced in 10 s.



a) Calculate the wavelength of the wave.
b) Calculate the frequency of the waves.
c) Calculate the period of the waves.
d) Calculate the speed of the waves.

23. A generator producing waves vibrates 480 times every minute.
a) What is the frequency of the waves?
b) What is the period of the waves?

24. A boat is anchored in a bay and 10 waves pass it every minute. The average distance between the crests of the waves is 15 m.
a) What is the frequency of the waves?
b) What is the wavelength of the waves?
c) What is the speed of the waves?

WAVE EQUATION $v = f\lambda$, $f = \frac{1}{T}$

25. Complete the following table:

	WAVELENGTH	FREQUENCY	PERIOD	SPEED
a)	7 m	8 Hz	----i----	----ii----
b)	----i----	----ii----	0.25 s	36 m s^{-1}
c)	5 cm	----i----	----ii----	60 m s^{-1}
d)	----i----	----ii----	62.5 µs	320 m s^{-1}
e)	15 m	20 MHz	----i----	----ii----
f)	95 mm	----i----	----ii----	7.6 m s^{-1}
g)	----i---	375 kHz	----ii----	87.5 cm s^{-1}

26. A wave has a wavelength of 34 cm and a frequency of 75 Hz. Calculate its speed.

27. A wave travelling at 25 m s^{-1} has a wavelength of 7.5 mm. Calculate its frequency.

28. A wave has a velocity of 18 m s^{-1} and a frequency of 9 Hz.
a) Calculate the wavelength of the wave.
b) Calculate the period of the wave.

29. A light wave has a wavelength of 5×10^{-7} m. Calculate its frequency.

30. What is the wavelength of a microwave which has a frequency of 12 500 MHz?

31. Radio 1 has a wavelength of 285 m. What is its frequency?

32. Radio Clyde transmits at a frequency of 2927 kHz. Calculate its wavelength?

33. 96 waves arrive at a beach every minute. The speed of the waves is 4.8 m s^{-1}.
a) Calculate the frequency of the waves.
b) Calculate the wavelength of the waves.

34. A source produces 400 waves every minute. If the speed of the waves is 8 mm s^{-1}, find the distance between adjacent crests?

MIXED PROBLEMS $d = vt$, $v = f\lambda$, $f = \frac{1}{T}$

35. A wave has a wavelength of 12 m and a frequency of 6 Hz.
- **a)** Calculate the wave speed.
- **b)** How far does the wave travel in 1 min?

36. 256 waves pass a point in 32 s. They have a wavelength of 5 cm.
- **a)** Calculate the frequency and the period of the wave.
- **b)** Calculate the wave speed.
- **c)** How long does it take the waves to travel 48 m?

37. 1080 waves pass a point in 1 min and their wavelength is 15 cm.
- **a)** What is the wave speed in metres per second?
- **b)** What distance will the waves travel in 5 min?

38. A wave travels 60 m in 30 s. It has a wavelength of 5 cm.
- **a)** Calculate the wave speed.
- **b)** Calculate the frequency of the wave.
- **c)** Calculate the period of the wave.

39. A wave travels 360 km in 4 min. It has a period of 7.5×10^{-4} s.
- **a)** Calculate the wave speed.
- **b)** Calculate the frequency of the wave.
- **c)** Calculate the wavelength.

40. A wave travels 12 km in 3 min and it has a wavelength of 25 cm.
- **a)** Calculate the wave speed.
- **b)** Calculate the frequency of the wave.
- **c)** Calculate the period of the wave.

41. A wave has a wavelength of 50 cm and a frequency of 2 kHz.
How long does it take the wave to travel a distance of 4 km?

42. A wave has a frequency of 25 kHz and a wavelength of 400 μm.
What distance does it travel in 14 min?

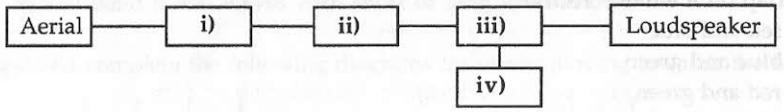
43. 1500 waves pass a point in 1 min with a wavelength of 6 cm.
- **a)** Calculate the wave speed.
- **b)** Calculate how far the wave travels in 3.25 min.

44. A pulse of light has a wavelength of 7×10^{-7} m. It travels through diamond for 8.2×10^{-12} s at a speed of 1.25×10^{8} m s^{-1}.
- **a)** Calculate the distance travelled by the light in the diamond.
- **b)** Calculate the frequency of the light.
- **c)** Calculate the distance the light would have travelled in air in the same time.

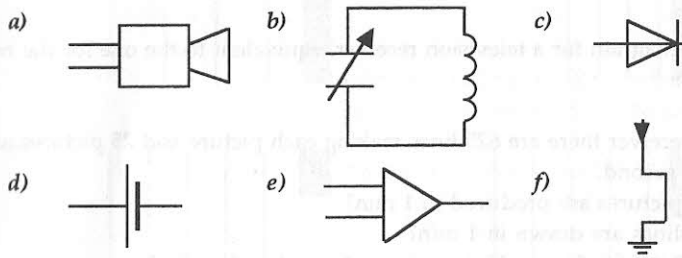
45. Show that $v = f\lambda$ and $v = \frac{d}{t}$ are equivalent.

RADIO AND TELEVISION

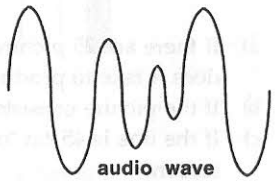
46. **a)** Name parts **i)** to **iv)** in the block diagram for a radio receiver.



47. *Which parts in a radio receiver do the following diagrams represent?*



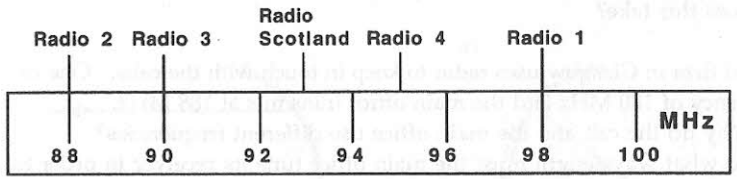
48. **a)** What is meant by modulation?
- **b)** Draw the wave that would be produced when the audio wave shown is added to a carrier wave:
  - **i)** to give an amplitude modulated wave,
  - **ii)** to give a frequency modulated wave.



49. How far does a radio wave travel in 1 min?

50. How long does it take a radio wave to travel from London to Edinburgh, a distance of 665 km?

51. The markings below are seen on the dial of a radio receiver.



- **a)** Draw a table to show the frequencies of the radio stations.
- **b)** Calculate the wavelength of Radio Scotland.
- **c)** What control would you adjust on your radio to change station?
- **d)** Classic F.M. has a wavelength of 2.97 m. What frequency does it have?

52. Describe how a moving television picture is formed. Include: where the light energy comes from, the production of one picture, the number of pictures every second, changes between them and remanence of vision.

53. What are the three primary colours for light?

54. State the colour which is obtained when the following beams of equally bright light overlap on a white screen:
    a) red and blue
    b) blue and green
    c) red and green
    d) cyan and red
    e) yellow and blue
    f) red, green and blue

55. Draw the block diagram for a television receiver, equivalent to the one for the radio receiver in Q.45.

56. In a television receiver there are 625 lines making each picture and 25 pictures are produced every second.
    a) How many pictures are produced in 1 min?
    b) How many lines are drawn in 1 min?
    c) A man dozes off for 5 min. How many pictures does he miss?

57. a) If there are 25 pictures produced in 1 s on a television receiver, how long does it take to produce 1 picture?
    b) If the picture consists of 625 lines, how long does it take to produce 1 line?
    c) If the line is 45 cm long, how fast is the electron beam travelling across the screen?

58. a) BBC1 uses 623 to 631 MHz for transmission.
    To what wavelength range does this correspond?
    b) Why does television need such a wide range for one channel?

59. A television station uses 0.371 m to 0.375 m for transmission.
    a) What frequency range does this correspond to?
    b) If the signal has to travel 120 km from the transmitter to the receiver, how long does this take?

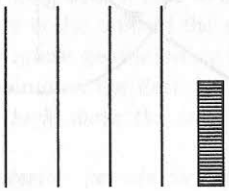
60. A taxi firm in Glasgow uses radio to keep in touch with the cabs. One cab uses a frequency of 180 MHz and the main office transmits at 188 MHz.
    a) Why do the cab and the main office use different frequencies?
    b) To what wavelength must the main office tune its receiver in order to get messages from the cab?
    c) In order to receive radio messages inside the cab, a receiver and one other piece of equipment are needed.
        i) What is the name of the other piece of equipment?
        ii) Why is it needed?
    d) A second firm in Edinburgh also uses 188 MHz.
    Why does this not cause problems?

REFLECTION AND DIFFRACTION

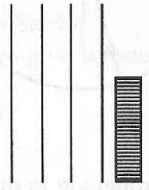
61. a) What term is given to the bending of waves round an obstacle?
    b) Which bend more, waves with short or long wavelengths?

62. Copy and complete the following diagrams for waves moving towards the barriers:

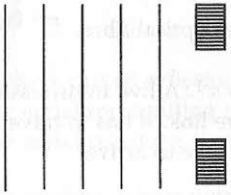
a)



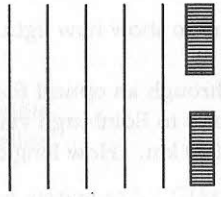
b)



c)



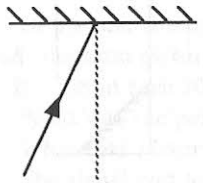
d)



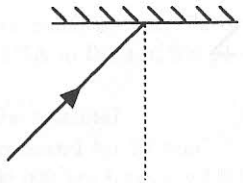
63. Which property of light allows you to see yourself in a mirror?

64. Copy and complete the following diagrams for light rays meeting mirrors:

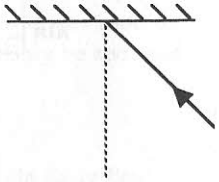
a)



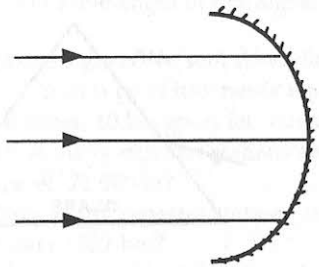
b)



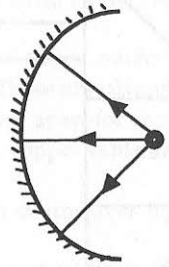
c)



d)



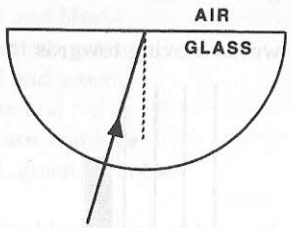
e)



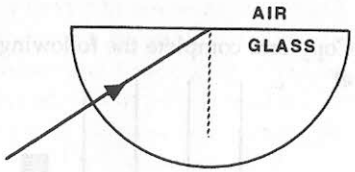
65. Explain what is meant by 'total internal reflection'.

66. Copy and complete the following diagrams:

a)



b)



c) What is happening in diagram (b)?

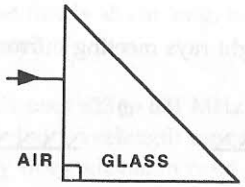
d) What is the name of the smallest angle at which this occurs?

67. Draw a diagram to show how light passes along an optical fibre.

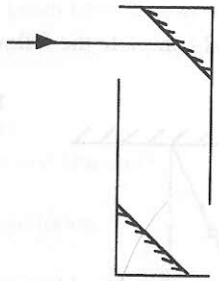
68. Light travels through an optical fibre at 2×10^8 m s^{-1}. A live transmission is sent from Los Angeles to Edinburgh via an optical fibre link. It has to travel a total distance of 10 000 km. How long does the signal take to arrive?

69. Copy and complete the following diagrams:

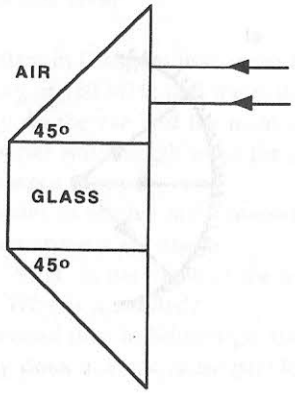
a)



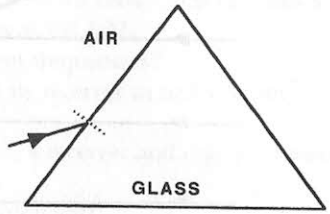
b)



c)



d)



SATELLITES

70. What determines the period of a satellite?

71. One of the most useful types of satellites is a 'geostationary' satellite.
   a) What is meant by a geostationary satellite?
   b) How long does it take to orbit the Earth?
   c) Where is the orbit of the satellite relative to the Earth?
   d) How many geostationary satellites are needed to give communication between all points on the Earth?
   e) *How high above the earth is the satellite placed?*

72. *Suggest possible periods for satellites orbiting at:*
   a) 10 000 km,
   b) 36 000 km,
   c) 50 000 km.

73. Explain why a curved reflector is needed:
   a) at the aerial transmitting signals to a satellite,
   b) at the aerial receiving signals from a satellite.

74. A satellite receives information from a ground station at 5.2 GHz and transmits information to the Earth at 5.6 GHz (1 GHz = 1×10^9 Hz).
   a) Why are two frequencies used?
   b) Calculate the two wavelengths which are used.
   c) What else is done to the signal at the satellite apart from the change of frequency?

75. One of the first communications satellites was 'Early Bird'. When it was used to send television pictures from USA to Britain, the pictures could only be received for 20 min in each 90 min.
   a) What was the period of the satellite?
   b) Why were pictures only received for 20 min?
   c) The signal had to travel 80 000 km from the USA to Britain via Early Bird. Calculate how long this took.
   d) If the wavelength of one signal was 15 cm, calculate its frequency.

76. Telephone signals are sent down links using optical fibres, microwaves or copper cable. Each type of link needs repeater stations. These are placed 100 km apart for optical fibres, 40 km apart for microwaves and 4 km apart for copper cable.
   a) How many repeater stations are required with copper cable if the signal has to travel 72 000 m?
   b) How many repeater stations are required with microwaves if the signal has to travel 1200 km?
   c) How many repeater stations are required with optical fibres for a signal travelling 5×10^5 m?
   d) How many extra repeater stations are required with copper cable instead of optical fibres if the signal has to travel 13 400 km?