

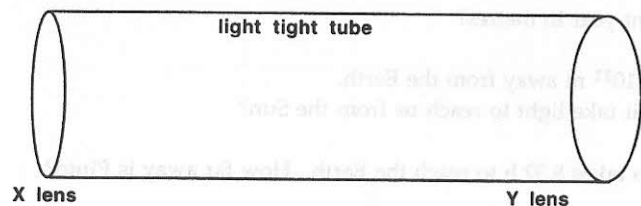
SPACE

DISTANCES IN SPACE

- How far is 1 light year in metres?
- The Sun is 1.5×10^{11} m away from the Earth.
How long does it take light to reach us from the Sun?
- Light from Pluto takes 5.32 h to reach the Earth. How far away is Pluto?
- Ursa Major is a collection of stars. Ursa Major is 1×10^7 light years away from the Earth.
 - How far is this in kilometres?
 - What name could be used to describe Ursa Major?
- The Andromeda Galaxy is 1.9×10^{19} m away from the Earth.
How far is this in light years?
- Uranus is 2.7×10^{12} m away from the Earth.
 - How long does it take light to reach the Earth from Uranus?
 - What percentage of a light year is this distance?
- The Moon is 3.84×10^8 m away from the Earth.
 - How long does it take light to reach the Earth from the Moon?
 - What percentage of a light year is this distance?
 - The Apollo spacecraft took 100 h to reach the Moon.
Calculate its average speed.
- It takes 9 years for light from Sirius to reach us on the Earth.
 - How far away is Sirius in metres?
 - How long would it take to reach Sirius travelling at 1200 m s^{-1} ?
- The nearest star, apart from the Sun, is 4.07×10^{16} m away from the Earth.
 - How long would it take to travel to the star at the speed of light?
 - How long would it take to travel to the star at 1200 m s^{-1} ?
 - How long would it take to travel to the star at 30 m s^{-1} (70 m.p.h.)?
- The nearest galaxy is 1.9×10^{19} m away.
 - How long would it take to travel to the galaxy at the speed of light?
 - How long would it take to travel to the galaxy at 1200 m s^{-1} ?
 - How long would it take to travel to the galaxy at 30 m s^{-1} (70 mph)?
- If there are 10 thousand million galaxies in the Universe and each galaxy contains 100 thousand million stars, calculate the number of stars in the Universe.

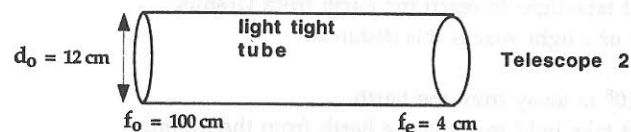
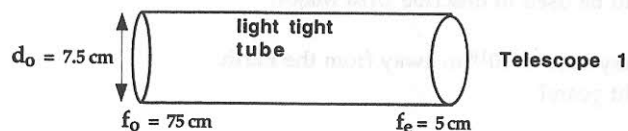
TELESCOPES

12. a) Copy and complete the following diagram to show the passage of two rays of light from a very distant object through the telescope:



- b) Name the two lenses, X and Y.

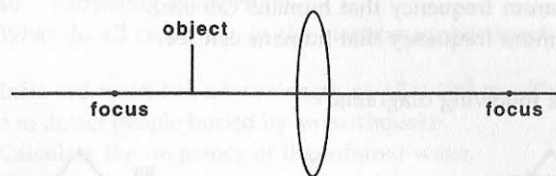
13.



- Which telescope collects most light?
 - Which telescope gives the brightest picture?
 - If the objective lens has a focal length f_o and the eyepiece lens a focal length f_e , the total length of the tube is $f_o + f_e$.
Which telescope is longer?
 - The overall magnification of the telescope is given by $\frac{f_o}{f_e}$.
 - Calculate the magnification for telescope 1.
 - Calculate the magnification for telescope 2.
14. A telescope has an objective lens with a focal length of 80 cm and an eyepiece lens of focal length 4 cm.
- What is the total length of the tube?
 - What is the overall magnification of the telescope?
15. A telescope has an objective lens with a focal length of 90 cm and an eyepiece lens of focal length 3.5 cm.
- What is the total length of the tube?
 - What is the overall magnification of the telescope?

RAY DIAGRAMS

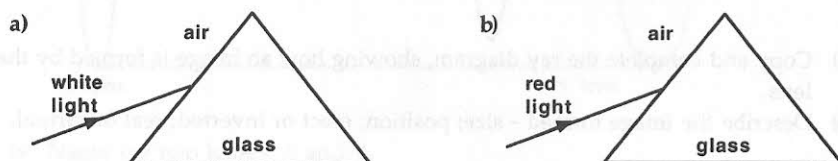
16. An object is placed in front of a convex lens as shown.



- Copy and complete the ray diagram, showing how an image is formed by the lens.
 - Describe the image formed - size; position; erect or inverted; real or virtual.
17. An object, 1 cm tall, is placed 3 cm in front of a convex lens with a focal length of 10 cm.
- Draw an accurate ray diagram to find the image produced.
 - Describe the image formed - size; position; erect or inverted; real or virtual.
18. An object, 1 cm tall, is placed 6 cm in front of a convex lens with a focal length of 10 cm.
- Draw an accurate ray diagram to find the image produced.
 - Describe the image formed - size; position; erect or inverted; real or virtual.
19. An object, 1 cm tall, is placed in front of a convex lens with a focal length of 4 cm.
- Draw a ray diagram to scale showing the formation of the image when the object is placed 2 cm from the lens.
 - Describe the image formed.
 - Draw a ray diagram to scale showing the formation of the image when the object is placed 8 cm from the lens.
 - Describe the image formed.
20. An object, 1 cm tall, is placed in front of a convex lens with a focal length of 5 cm.
- Draw a ray diagram to scale showing the formation of the image when the object is placed 4 cm from the lens.
 - Describe the image formed.
 - Draw a ray diagram to scale showing the formation of the image when the object is placed 10 cm from the lens.
 - Describe the image formed.
21. Consider your answers to Q.17 to Q.20.
- What can you say about the image formed when the object is placed at a distance which is twice the focal length away from the object.
 - What can you say about the image formed as the object is moved closer to the focus, from a distance less than the focal length or a distance more than the focal length.

VISIBLE SPECTRUM

22. The visible spectrum has a range of wavelengths from approximately 400 nm to 700 nm in air.
- Calculate the minimum frequency that humans can see.
 - Calculate the maximum frequency that humans can see.
23. Copy and complete the following diagrams:



24. The information in the following table compares other stars to our Sun.

Star	Temperature	Diameter	Brightness	Colour
Sun	5800 °C	1.0	1	yellow
B Centauri	19 000 °C	6.0	4000	white
Altair	8200 °C	1.9	15	blue
Cygni A	3900 °C	0.7	0.1	red
Vega	10 600 °C	2.6	100	bluish-white
Betelgeuse	4750 °C	600	0.4	orange-red

Another star has a temperature of 7000 °C.

- Suggest how bright the star may be.
 - What colour is it likely to have?
25. List the colours of the visible spectrum in order of:
- increasing wavelength,
 - increasing frequency.
26. The colour of a wave varies with the wavelength in nanometres as shown.

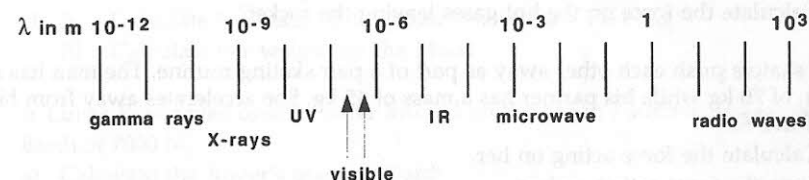
red	orange	yellow	green	blue	indigo	violet
700	650	600	550	500	450	400
λ in nm						

- What wavelength and colour of wave has a frequency of 6.25×10^{14} Hz?
- What wavelength and colour of wave has a frequency of 4.5×10^{14} Hz?
- What wavelength and colour of wave has a frequency of 5.1×10^{14} Hz?

ELECTROMAGNETIC SPECTRUM

27. a) List the radiations of the electromagnetic spectrum in order of:
- increasing frequency,
 - increasing wavelength.
- b) What do all radiations in the electromagnetic spectrum have in common?
28. An infra red wave has a wavelength of 2.7×10^{-5} m. This infrared radiation is used to detect people buried by an earthquake.
- Calculate the frequency of the infrared wave.
 - A series of pulses is sent out with a frequency of 2500 Hz. Calculate the period of the pulses.
 - The waves reflect back and are received after 8 ns. How deep is the person buried?
29. An ultra violet wave has a frequency of 1.1×10^{15} m.
- Calculate the wavelength of the ultraviolet wave.
 - The Sun is 1.5×10^8 km from the Earth. How long does it take for the ultraviolet rays to reach the Earth?

Use the diagram, which shows the approximate wavelengths in metres for the various parts of the electromagnetic spectrum, to answer Qs. 30 to 32.



30. An electromagnetic wave has a frequency of 4.3×10^{12} Hz.
- Calculate the wavelength.
 - State which part of the electromagnetic spectrum it belongs to.
 - Suggest a suitable detector for the wave.
 - How long would it take for a signal of this frequency to arrive from a comet 9×10^{13} m away?
31. An electromagnetic wave has a frequency of 5×10^{18} Hz.
- Calculate the wavelength.
 - State which part of the electromagnetic spectrum it belongs to.
 - Suggest a suitable detector for the wave.
 - How far away is a star if a signal of this frequency takes 7×10^{18} s to arrive at Earth?
32. An electromagnetic wave has a frequency of 250 kHz.
- Calculate the wavelength.
 - State which part of the electromagnetic spectrum it belongs to.
 - Suggest a suitable detector for the wave.

NEWTON'S THIRD LAW

33. Draw a diagram showing the forces acting, and state all the 'Newton Pair' forces acting, in the following situations:
- a rocket at the instant it leaves the Earth
 - an Olympic swimmer on the final length of a race
 - two skaters pushing each other away on an ice rink
34. A man is playing golf. His club has a mass of 575 g and the ball has a mass of 45 g.
- The ball accelerates at 600 m s^{-2} . Calculate the force acting on the ball.
 - The force acts for $2 \times 10^{-2} \text{ s}$. Calculate the final speed of the ball.
35. A rugby ball has a mass of 400 g. The kicker gives it a momentary acceleration of 500 m s^{-2} .
- Calculate the force acting on the ball.
 - What is the force acting on the kicker's foot?
 - What is the direction of the force in part b)?
36. A rocket accelerates away from the Earth at 8 m s^{-2} . It has a mass of 1200 kg.
- Draw a diagram showing all the forces acting on the rocket.
 - Calculate the weight of the rocket.
 - Calculate the resultant force acting on the rocket.
 - Calculate the force on the hot gases leaving the rocket?
37. Two skaters push each other away as part of a pair skating routine. The man has a mass of 70 kg while his partner has a mass of 45 kg. She accelerates away from him at 2.5 m s^{-2} .
- Calculate the force acting on her.
 - State the force acting on him.
 - Calculate his acceleration.
38. A girl steps out of a stationary rowing boat onto the shore. She has a mass of 65 kg and the boat has a mass of 25 kg. She pushes herself onto the shore with a force of 375 N.
- What is the force acting on the boat?
 - What is the acceleration of the boat?
 - If the force acts for 0.16 s, what is the final speed of the boat?
 - How much kinetic energy does the boat gain?
 - How much work is done by friction in stopping the boat?
 - If the boat stops in a distance of 2.5 m, what is the average force due to friction with the water?

GRAVITATIONAL FIELD STRENGTH

39. The acceleration due to gravity on Earth is 10 m s^{-2} .
- What is the gravitational field strength on Earth in newtons per kilogram?
 - What is the weight of a 45 kg boy on Earth?
40. The acceleration due to gravity on the Moon is 1.6 m s^{-2} .
- What is the gravitational field strength on the Moon in newtons per kilogram?
 - What is the weight of a 65 kg astronaut on the Moon?
41. The gravitational field strength on Venus is 8.9 N kg^{-1} .
- What is the acceleration due to gravity on Venus?
 - What would be the weight of a 2000 kg spacecraft on Venus?
42. The gravitational field strength on Mars is 3.7 N kg^{-1} .
- What is the acceleration due to gravity on Mars?
 - What would be the weight of a 2000 kg spacecraft on Mars?
43. An astronaut has a mass of 550 N on Earth, where $g = 10 \text{ N kg}^{-1}$.
- Calculate her mass on Earth.
 - Calculate her mass on Mars, where $g = 3.7 \text{ N kg}^{-1}$.
 - Calculate her weight on Mars.
 - Calculate her mass on the Moon, where $g = 1.6 \text{ N kg}^{-1}$.
 - Calculate her weight on the Moon.
44. A Lunar Rover was used to move around on the Moon's surface. It has a weight on Earth of 7000 N.
- Calculate the Rover's mass on Earth.
 - Calculate the Rover's mass on the Moon, where $g = 1.6 \text{ N kg}^{-1}$.
 - Calculate the Rover's weight on the Moon.
 - Calculate the Rover's mass on Mars, where $g = 3.7 \text{ N kg}^{-1}$.
 - Calculate the Rover's weight on Mars.
45. The gravitational field strength at 36 000 km above Earth is 0.22 N kg^{-1} .
- Calculate the weight of a satellite with a mass of 350 kg?
 - How long would the satellite take to orbit the Earth at this height?
 - What name is given to such a satellite?
 - What is particularly important about the orbit of such a satellite?
46. The gravitational field strength at a height of 7000 km above Earth is 2.14 N kg^{-1} .
- What would be the weight of an astronaut of mass 65 kg, when in a spacecraft orbiting at this height?
 - In fact the astronaut experiences weightlessness. Explain why this happens.

PROJECTILES

47. A ball is thrown vertically upwards. It leaves the hand at 25 m s^{-1} .
- How long does it take to reach the top of the flight where its final speed is zero?
 - How long will it take to fall back down to the hand?
 - What speed will it be travelling at when it reaches the hand?
 - Sketch a speed - time graph for the ball's flight.
 - Calculate the total distance travelled by the ball.
48. A ball is dropped out of a window. At the moment it is released the initial speed is zero. It takes 3 s to reach the ground.
- Calculate the final speed of the ball just before it touches the ground.
 - Sketch a speed - time graph for the ball's flight.
 - Calculate the total distance travelled by the ball.
49. A package is dropped from a helicopter which is hovering at rest. The package takes 8 s to reach the ground.
- Describe the forces acting on the helicopter as it hovers.
 - Calculate the final speed of the package just before it touches the ground.
 - Calculate the total distance travelled by the package.
50. A ball is thrown out of a window with a horizontal speed of 10 m s^{-1} . At the moment it is released out of the window the initial vertical speed is zero. It takes 4 s to reach the ground.
- What is the value of the horizontal acceleration of the ball?
 - State the final horizontal speed of the ball just before it touches the ground.
 - Sketch a speed - time graph for the ball's horizontal motion.
 - Calculate the total horizontal distance travelled by the ball.
 - What is the value of the vertical acceleration of the ball?
 - Calculate the final vertical speed of the ball just before it touches the ground.
 - Sketch a speed - time graph for the ball's vertical motion.
 - Calculate the total vertical distance travelled by the ball.
51. A cat jumps horizontally out of a window with a speed of 5 m s^{-1} . It takes 1.5 s to reach the ground.
- State the final horizontal speed of the cat.
 - Calculate the final vertical speed of the cat.
 - Sketch a speed - time graph for the cat's horizontal motion.
 - Calculate the total horizontal distance travelled by the cat.
 - Sketch a speed - time graph for the cat's vertical motion.
 - Calculate the total vertical distance travelled by the cat.
52. A plane is flying horizontally at 180 m s^{-1} when it drops a bomb. The bomb hits the ground 9 s later.
- State the final horizontal speed of the bomb just before it touches the ground.
 - Calculate the final vertical speed of the bomb just before it touches the ground.
 - Calculate the total horizontal distance travelled by the bomb.
 - Sketch a speed - time graph for the bomb's vertical motion.
 - Calculate the total vertical distance travelled by the bomb.
 - Where is the plane, compared to the bomb, at the moment that the bomb hits the ground, provided it does not alter course?
53. A plane is flying horizontally at 400 m s^{-1} when it drops a bomb. The bomb hits the ground 20 s later.
- State the final horizontal speed of the bomb just before it touches the ground.
 - Calculate the final vertical speed of the bomb just before it touches the ground.
 - Calculate the total horizontal distance travelled by the bomb.
 - Sketch a speed - time graph for the bomb's vertical motion.
 - Calculate the total vertical distance travelled by the bomb.
 - Where is the plane, compared to the bomb, at the moment that the bomb hits the ground, provided it does not alter course?
54. A ball rolls across a table at 5 m s^{-1} then reaches the edge and rolls off. The ball lands 2.5 m from the table.
- State the final horizontal speed of the ball just before it touches the ground.
 - Calculate the time it takes for the ball to land.
 - What is the initial vertical speed of the ball?
 - What is the vertical acceleration of the ball?
 - Calculate the final vertical speed of the ball just before it touches the ground.
 - Sketch a speed - time graph for the ball's vertical motion.
 - Calculate the total vertical distance travelled by the ball.
55. A package leaves a helicopter with a horizontal speed of 25 m s^{-1} . The package lands 125 m in front of the point where it left the helicopter.
- Calculate the time it takes for the package to land.
 - What is the initial vertical speed?
 - What is the vertical acceleration?
 - Calculate the final vertical speed of the package just before it touches the ground.
 - Sketch a speed - time graph for the package's vertical motion.
 - Calculate the height of the helicopter.

