Data and Formulae

The speed of sound in air is 340 m/s

The speed of light in air and in a vacuum is 3×10^8 m/s

1 light-year is the distance light travels in one year.

1 mile = 1.6 km

The density of water is $1 g/cm^3$ or $1,000 kg/m^3$

The acceleration due to gravity = $10 m/s^2$

$$\text{pressure (N/m}^2\text{)} = \frac{\text{force (N)}}{\text{area (m}^2\text{)}}$$

$$\text{average speed (m/s)} = \frac{\text{total distance travelled (m)}}{\text{time taken (s)}}$$

$$\text{acceleration (m/s}^2\text{)} = \frac{\text{change in velocity (m/s)}}{\text{time taken (s)}}$$

$$\text{Force (N)} = \text{mass (kg)} \times \text{acceleration (m/s}^2\text{)}$$

$$\text{power (W)} = \frac{\text{change in energy (J)}}{\text{time taken (s)}}$$ (1 watt is equal to 1 J/s)

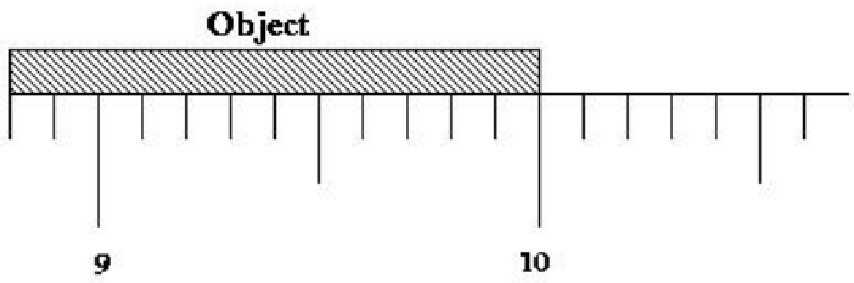
$$\text{density (kg/m}^3\text{)} = \frac{\text{Mass (kg)}}{\text{Volume (m}^3\text{)}}$$

$$\text{Area of a sphere} = 4\pi \times \text{radius}^2$$

$$\text{Volume of a sphere} = \frac{4}{3}\pi \times \text{radius}^3$$

Part A *Multiple Choice - circle your answer– 1 mark each*.

1. A standard centimetre ruler is shown. Which recorded value is the most correct for the location of the shaded object’s right end?

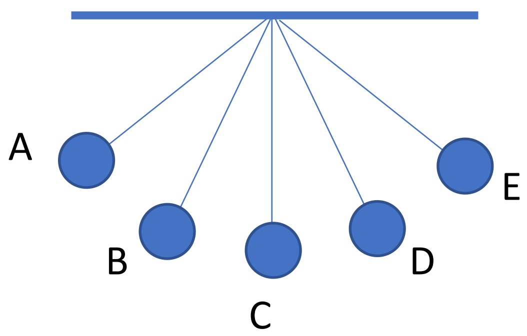


10 cm 10.0 cm 10.00 cm $10.\bar{0}$ cm

2. Two motorbikes are 150 km apart at 12:00 and are travelling towards each other. Motorbike A travels East at 60 km/h and motorbike B travels West at 40 km/h. At what time will they meet?

13:30 13:45 14:00 14:30 15:00

3. A mass on a string forms a pendulum which swings as shown.



Friction is negligible. Which statement is correct about the pendulum-Earth system?

A The total energy in the system is maximum at A and E.

B The total energy in the system is maximum at C.

C The gravitational store of energy at A is less than that at C.

D The ratio of energy in a kinetic store at positions D and C is the same as the ratio of energy in a kinetic store at positions E and D.

E The total energy in the system is constant

4. A student stands on a balance inside an elevator (lift). The balance reads 500 N and then quickly increases to a steady 520 N reading. The elevator must be

A accelerating upwards

B accelerating downwards

C moving upwards at a constant speed

D moving downwards at a constant speed

E at rest

5. The volume of a tennis ball is approximately equal to

10 cm^3 150 cm^3 500 cm^3 1000 cm^3 1500 cm^3

6. The specific heat capacity of a material is the energy required to raise 1 kg of the material by 1 ^{o}C. This value varies between different materials.

   A block of metal is heated (with no heat losses) until its temperature rises by 12 ^{o}C. The same quantity of heat is given to a different block. This block has half the mass of the first block and is made of a material with four times the specific heat capacity of that of the first block. Its maximum temperature rise is

   3 ^{o}C 6 ^{o}C 12 ^{o}C 24 ^{o}C 48 ^{o}C

7. A student is investigating lightbulb filaments. The filament length, diameter and material can be varied. Different materials have different resistivities (which is a measure of the material's opposition to the follow of electrical current). How should the filament be modified to make a lightbulb produce more light at a given voltage?

   A increase the resistivity only

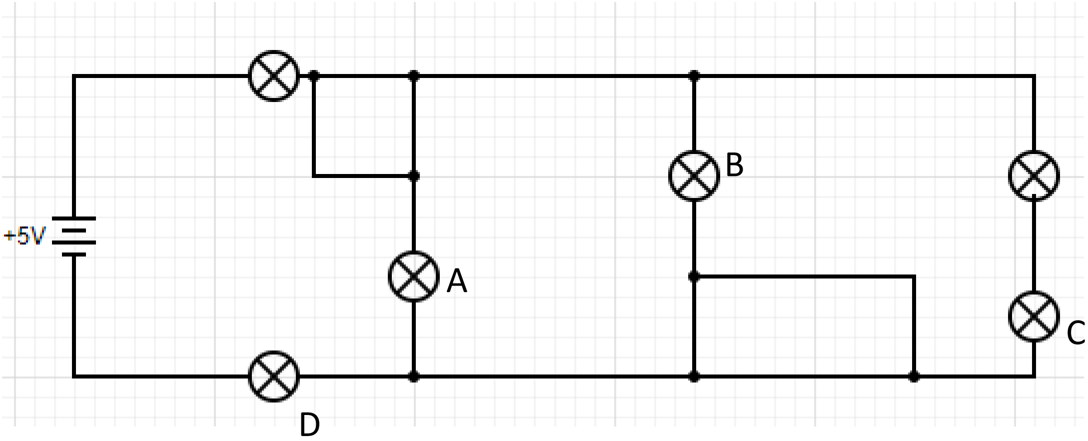
   B increase the diameter only

   C decrease the diameter only

   D decrease the diameter and increase the resistivity

   E increase the length only

8. Which of the bulbs, if any, in the following circuit diagram will not light?



A B C D they all light

Part B *Short Answer Questions*

9. A long, heavy rope hangs down from a bridge. Each part of the rope is stretched as a result of the weight of the rope hanging below it.

   The top of the rope is quickly moved sideways, back and forth, two times, sending two pulses down the string. The pulses move more quickly in regions of greater tension.

   State and explain happens to the spacing of the pulses as they travel downward the rope.

[3]

10. Kepler's third law of planetary motion states that the orbital period *T* of a planet around a star is related to its average orbital radius *R* as follows:

$$T^2 \propto R^3$$

a) If the average Earth-Sun distance is 1.495×10^{11} m and the average Mars-Sun distance is 2.278×10^{11} m, what is the orbital periods of Mars in seconds?

b) It is often said that the Sun is 8 light-minutes from Earth. How many light-minutes is Mars ***from Earth***?

[4]

11. About 100 years ago, Chester Wentworth attempted to quantify rock fragment shapes in order to investigate correlations between rock shape and origin. He defined three radii of interest:
    - R is the average radius of the rock
    - r_1 is the radius of curvature on the sharpest edge (ignoring chips and cracks)
    - r_2 is the sharpest radius of curvature of the rock on its flattest face.

    The figure illustrates these measurements on a particular rock. r_1 refers to the curve seen in the top right corner and r_2 refers to a curve coming out of the page on the top surface.

$\frac{r_1}{R}$ is the roundness ratio; $\frac{r_2}{R}$ is the flatness ratio.

You will not have seen these equations before.

Using the measurements in this table, rank rocks A, B and C in terms of their roundness and flatness.

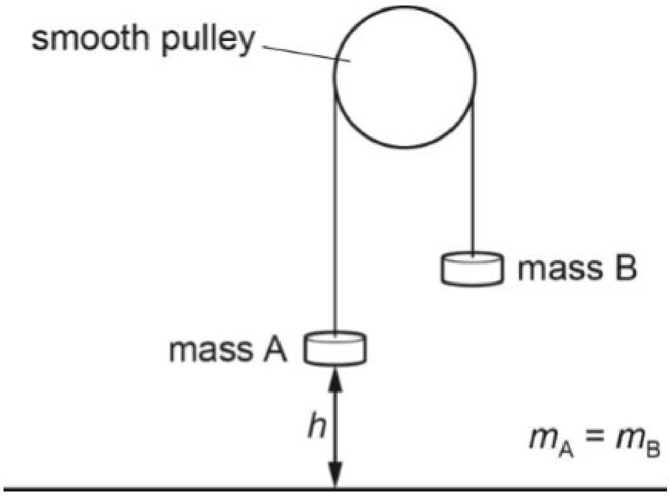
	r_1	r_2	R
A	8mm.	50mm.	18mm.
B	3mm.	500mm	15mm.
C	2mm.	250mm	17mm.

(most round) ……………… ………………… ……………… (least round)

(most flat) ……………… ………………… ……………… (least flat)

[4]

12. A simple experiment to measure and verify the value of g, the acceleration due to gravity, is shown in the figure. Mass A (m_A) and mass B (m_B) are connected by a string over a smooth pulley and each begins with five 10 g slotted masses. One 10 g mass is transferred from B to A and the time taken t for A to fall through a constant height h is measured.



a) **State** two additional measuring devices that will be needed:

1. ……

2. ……

[2]

b) Compare the acceleration of mass A with that of mass B.

[2]

c) They obtain the following data:

m_A in g	m_B in g	$(m_A - m_B)$ in g	t in s	$(1/t^2)$ in _______
60	40	20	0.52	
			0.41	
			0.32	
			0.30	
			0.26	

(i) Complete the first three columns.

(ii) Add a suitable unit in the last column title.

(iii) Complete the final column. Choose an appropriate number of significant figures.

[5]

d) It is suggested that the relationship between $(m_A - m_B)$ and t is $(m_A - m_B) = \frac{k}{t^2}$ where k is a constant that is related to g. This means that $(m_A - m_B)$ should be proportional to $\frac{1}{t^2}$.

(i) Plot a graph of $\frac{1}{t^2}$ on the y-axis against $(m_A - m_B)$ on the x-axis.

[5]

(ii) State and explain whether your graph supports the suggested relationship.

[2]

13. State and explain the factors that affect the rate at which an ice-cream melts. You should state any assumptions and include any time-related effects. Diagrams are encouraged to illustrate your points.

[8]