1 **(a)** each of the following, tick [✓] one box to indicate whether the experimental technique would reduce random error, systematic error or neither. The first row has been completed as an example.

	random error	systematic error	neither
keeping your eye in line with the scale and the liquid level for a single reading of a thermometer		✓	
averaging many readings of the time taken for a ball to roll down a slope			
using a linear scale on an ammeter			
correcting for a non-zero reading when a micrometer screw gauge is closed			

[2]

(b) The measurement of a particular time interval is repeated many times. The readings are found to vary. The results are shown in Fig. 1.1.

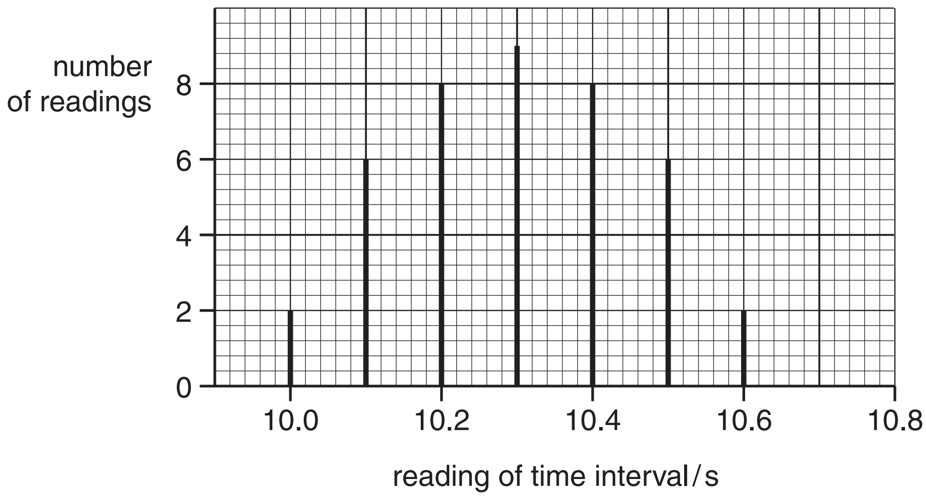

Fig. 1.1

The true value of the time interval is 10.1 s.

(i) State how the readings on Fig. 1.1 show the presence of

1. a systematic error,

....

....[1]

2. a random error.

....

....[1]

(ii) State the expected changes to Fig. 1.1 for experimental measurements that are

1. more accurate,

....

....[1]

2. more precise.

....

....[1]

2 A climber is supported by a rope on a vertical wall, as shown in Fig. 2.1.

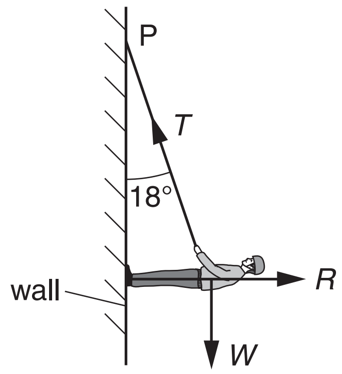

Fig. 2.1

The weight W of the climber is 520 N. The rope, of negligible weight, is attached to the climber and to a fixed point P where it makes an angle of 18° to the vertical. The reaction force R acts at right-angles to the wall.
The climber is in equilibrium.

(a) State the conditions necessary for the climber to be in equilibrium.

....

....

.... [2]

(b) Complete Fig. 2.2 by drawing a labelled vector triangle to represent the forces acting on the climber.

Fig. 2.2

[2]

(c) Resolve forces or use your vector triangle to calculate

(i) the tension *T* in the rope,

T = ... N [2]

(ii) the reaction force *R*.

R = ... N [1]

(d) The climber moves up the wall and the angle the rope makes with the vertical increases. Explain why the magnitude of the tension in the rope increases.

....

....

....[1]

3 A helicopter has a cable hanging from it towards the sea below, as shown in Fig. 3.1.

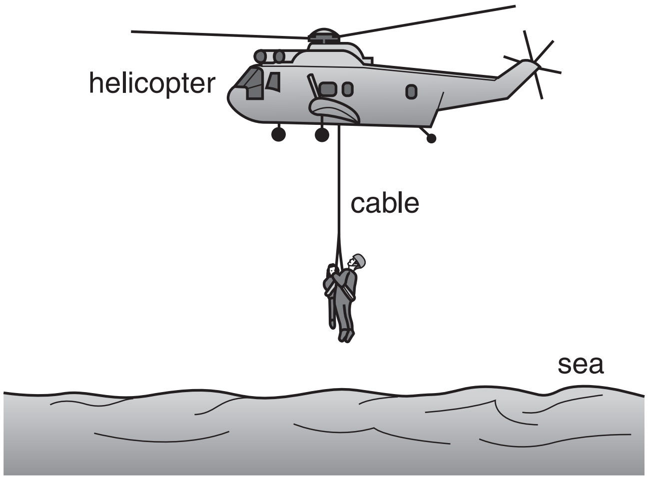

Fig. 3.1

A man of mass 80 kg rescues a child of mass 50.5 kg. The two are attached to the cable and are lifted from the sea to the helicopter. The lifting process consists of an initial uniform acceleration followed by a period of constant velocity and then completed by a final uniform deceleration.

(a) Calculate the combined weight of the man and child.

weight = ... N [1]

(b) Calculate the tension in the cable during

(i) the initial acceleration of $0.570\,\text{m}\,\text{s}^{-2}$,

tension = ... N [2]

(ii) the period of constant velocity of $2.00\,\text{m}\,\text{s}^{-1}$.

tension = ... N [1]

(c) During the final deceleration the tension in the cable is 1240 N. Calculate this deceleration.

deceleration = ... m s^{-2} [2]

(d) **(i)** Calculate the time over which the man and child are

1. moving with uniform acceleration,

time = ... s [1]

2. moving with uniform deceleration.

time = ... s [1]

(ii) The time over which the man and child are moving with constant velocity is 20 s. On Fig. 3.2, sketch a graph to show the variation with time of the velocity of the man and child for the complete lifting process.

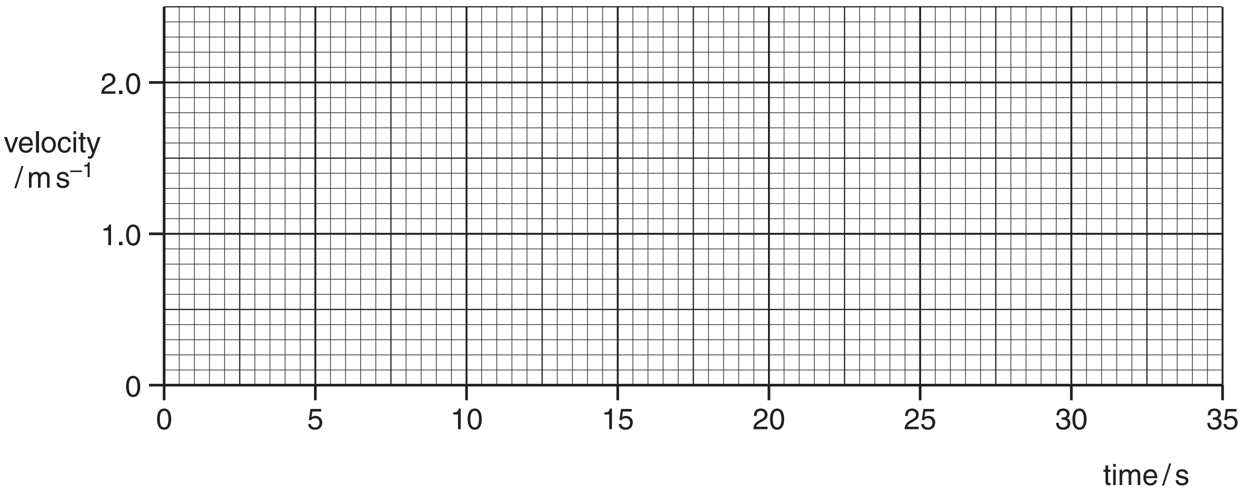

Fig. 3.2

[2]

4 **(a)** State Hooke's Law.

....

....[1]

(b) A spring is compressed by applying a force. The variation with compression x of the force F is shown in Fig. 4.1.

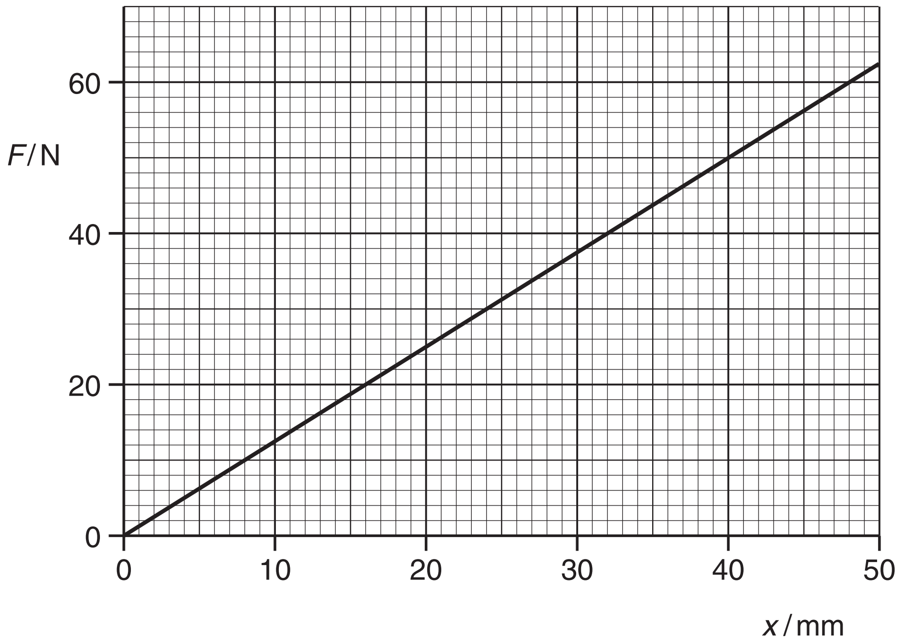

Fig. 4.1

(i) Calculate the spring constant.

spring constant = ... $N m^{-1}$ [1]

(ii) Show that the work done in compressing the spring by 36 mm is 0.81 J.

[2]

(c) A child's toy uses the spring in **(b)** to shoot a small ball vertically upwards. The ball has a mass of 25 g. The toy is shown in Fig. 4.2.

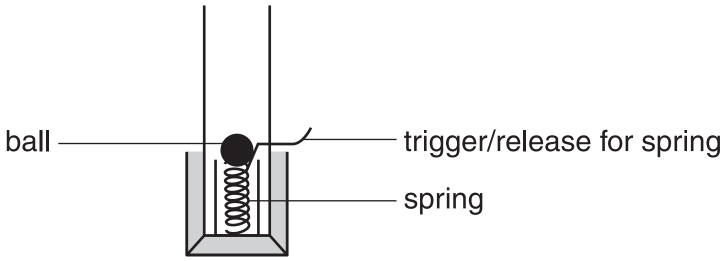

Fig. 4.2

(i) The spring in the toy is compressed by 36 mm. The spring is released.
Assume all the strain energy in the spring is converted to kinetic energy of the ball.
Using the result in **(b)(ii)**, calculate the speed with which the ball leaves the spring.

speed = ... $m\,s^{-1}$ [2]

(ii) Determine the compression of the spring required for the ball to leave the spring with twice the speed determined in **(i)**.

compression = ... mm [2]

(iii) Determine the ratio

$$\frac{\text{maximum possible height for compression in } \textbf{(i)}}{\text{maximum possible height for compression in } \textbf{(ii)}} .$$

ratio = ... [2]

5 **(a)** **(i)** On Fig. 5.1, sketch the I – V characteristic for a filament lamp.

Fig. 5.1

[2]

(ii) Explain how the resistance of the lamp may be calculated for any voltage from its I – V characteristic.

....

.... [1]

(b) Two identical filament lamps are connected first in series, and then in parallel, to a 12 V power supply that has negligible internal resistance. The circuits are shown in Fig. 5.2 and Fig. 5.3 respectively.

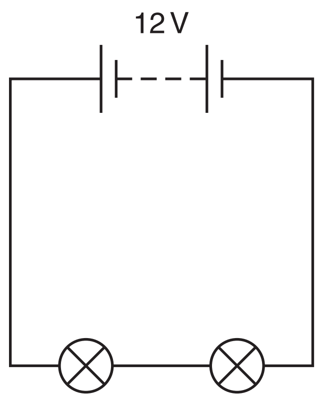

Fig. 5.2

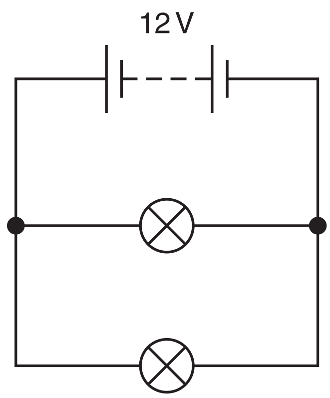

Fig. 5.3

(i) State and explain why the resistance of each lamp when they are connected in series is different from the resistance of each lamp when they are connected in parallel.

....

....

....

....

....[3]

(ii) Each lamp is marked with a rating '12 V, 50 W'. Calculate the total resistance of the circuit for the two lamps connected such that each lamp uses this power.

total resistance = ... Ω [3]

6 **(a)** A transverse progressive wave travels along a stretched string from left to right. The shape of part of the string at a particular instant is shown in Fig. 6.1.

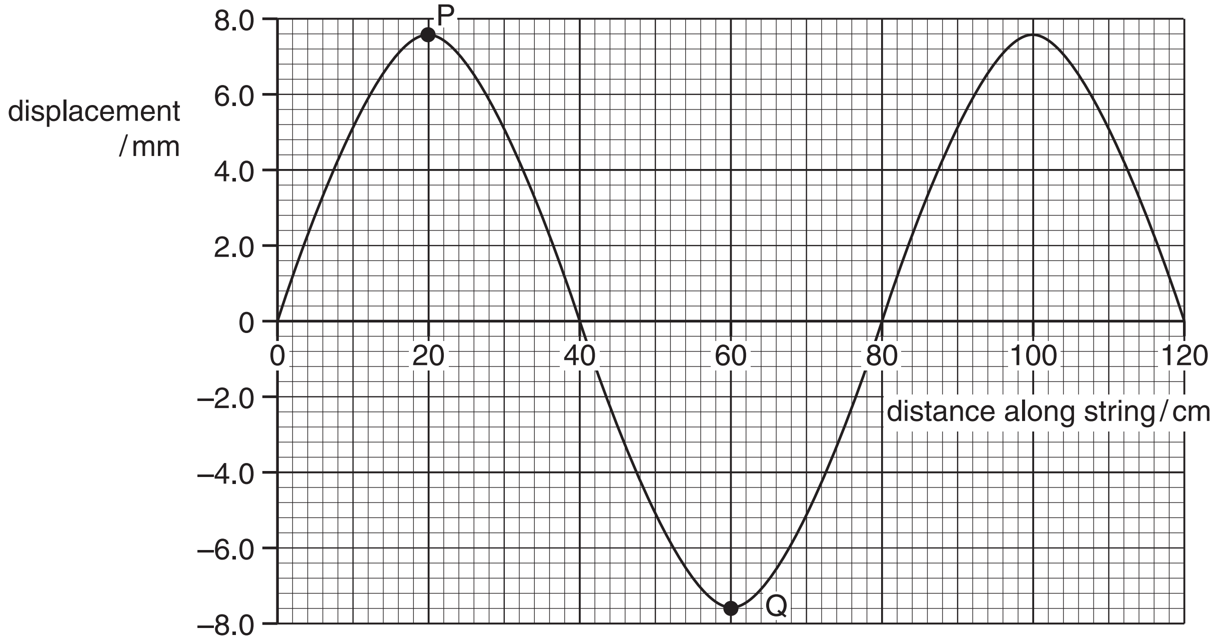

Fig. 6.1

The frequency of the wave is 15 Hz.
this wave, use Fig. 6.1 to determine

(i) the amplitude,

amplitude = ... mm [1]

(ii) the phase difference between the points P and Q on the string,

phase difference = ... [1]

(iii) the speed of the wave.

speed = ... m s^{-1} [2]

(b) The period of vibration of the wave is T. The wave moves forward from the position shown in Fig 6.1 for a time 0.25 T. On Fig. 6.1, sketch the new position of the wave. [2]

(c) Another stretched string is used to form a stationary wave. Part of this wave, at a particular instant, is shown in Fig. 6.2.

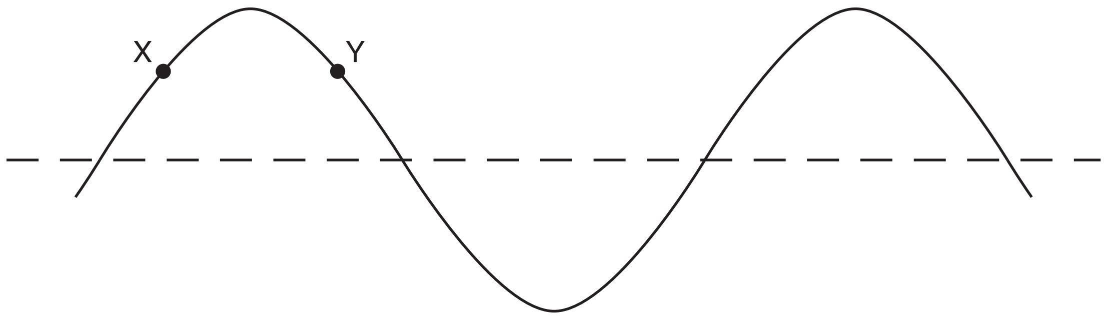

Fig. 6.2

The points on the string are at their maximum displacement.

(i) State the phase difference between the particles labelled X and Y.

phase difference = ... [1]

(ii) Explain the following terms used to describe stationary waves on a string:

antinode: ....

node: ....

[1]

(iii) State the number of antinodes shown on Fig. 6.2 for this wave.

number of antinodes = ... [1]

(iv) The period of vibration of this wave is τ. On Fig. 6.2, sketch the stationary wave 0.25τ after the instant shown in Fig. 6.2. [1]

7 **(a)** Explain the difference in densities in solids, liquids and gases using ideas of the spacing between molecules.

....

....

....

....

....

....

.... [3]

(b) A hydrogen nucleus (proton) may be assumed to be a sphere of radius 1×10^{-15} m. Calculate the density of a hydrogen nucleus.

density = ... $kg\,m^{-3}$ [3]

(c) The density of hydrogen gas in a pressurised cylinder is $4\,kg\,m^{-3}$. Suggest a reason why this density is much less than your answer in **(b)**.

....

....

.... [1]