**1** A student wants to carry out an experiment to determine the input power to a small electric motor without using electrical meters. The motor is used to lift light loads. The efficiency of the motor is 15%. Describe how this student can determine the input power to the motor. Your description should include:

- the measurements taken
- the instruments used to take the measurements
- how the measurements are used to determine the input power to the motor. *In your answer, you should use appropriate technical terms, spelled correctly.*

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..... **[4]**

**2** **(a)** A student conducts an experiment to estimate the acceleration $g$ of free fall by dropping a heavy metal ball from a high wall into a sandpit below. Describe how this student can estimate the acceleration $g$ of free fall. Your description should include:

- the measurements taken
- the instruments used to take the measurements
- how the measurements are used to estimate $g$
- an explanation of why the value for $g$ is only an estimate

*In your answer, you should use appropriate technical terms, spelled correctly.*

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**(b)** The global positioning system (GPS) is used to locate accurately the position of cars on the Earth's surface.

**(i)** Name the electromagnetic waves used by GPS.

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**(ii)** Explain how GPS determines the distance between the car and satellite.

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**(iii)** Briefly describe how the distances from two or more satellites are used to locate the position of a car.

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**[Total: 12]**

**3** You are provided with a small bottle of cooking oil and standard physics laboratory equipment. With the help of a **labelled** diagram, describe an electrical experiment to determine the specific heat capacity *c* of the oil.
State **two** sources of uncertainty in your measurements and discuss how these could be reduced.

*In your answer, you should use appropriate technical terms spelled correctly.*

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**[Total: 6]**

**4** **(a)** Fig. 2.1 shows a mass attached to the end of a spring. The mass is pulled down and then released. The mass performs vertical simple harmonic motion.

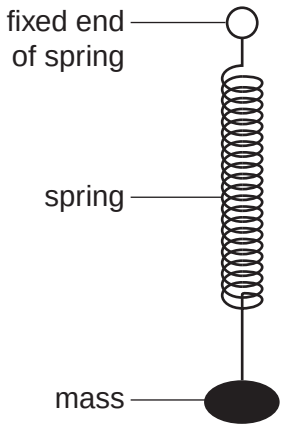


**Fig. 2.1**

**(i)** Define *simple harmonic motion*.

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**(ii)** Mark the following statements about the oscillating mass-spring system as *true* or *false*. **[2]**

| **statement** | **true/false** |
|---|---|
| The period of oscillation is constant. | |
| The net force on the mass is equal to its weight. | |
| The acceleration of the mass is a maximum at the mid-point of the oscillations. | |
| The velocity of the mass is proportional to the displacement. | |

**(b)** A student wishes to investigate whether the period of oscillation of a simple pendulum is constant for all angles of swing. Describe how the student should carry out the investigation. Include the following in your description:

- a sketch of the apparatus with angle of swing labelled
- details of how the measurements would be made
- how these results would be used to form a conclusion
- the major difficulty likely to be encountered and how this might be overcome.

Sketch:

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**[Total: 9]**

**5** **(a)** In experiments carried out to determine the nature of atoms, alpha particles were fired at thin metal foils. Describe how the alpha-particle scattering experiments provide evidence for the existence, charge and size of the nucleus.

*In your answer, you should make clear how your conclusions link with your observations.*

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**(b)** Describe the nature and range of the **three** forces acting on the protons and neutrons in the nucleus.

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**(c)** The radius of a $^{235}_{92}U$ nucleus is $8.8 \times 10^{-15}$ m. The average mass of a nucleon is $1.7 \times 10^{-27}$ kg.

**(i)** Estimate the average density of this nucleus.

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

**(ii)** State one assumption made in your calculation.

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**[Total: 14]**

**6** Fig. 4.1 shows slotted masses suspended from a spring. The spring is attached to a fixed support at its upper end.

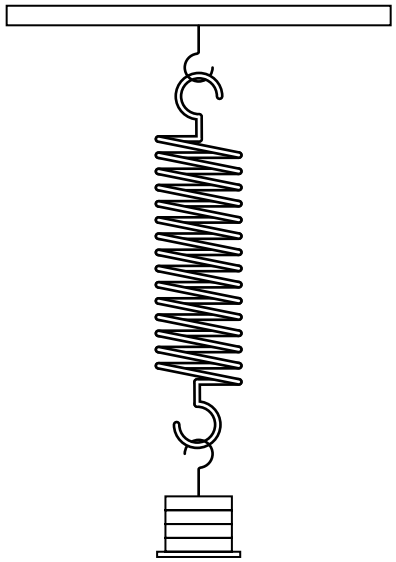

**Fig. 4.1**

When the masses are pulled down a short distance from the equilibrium position and released they oscillate vertically with simple harmonic motion. The frequency $f$ of these oscillations depends on the mass $m$ of the masses.
Two students make different predictions about the relationship between $f$ and $m$.
One suggests $f$ is proportional to $1/m$ and the other believes $f$ is proportional to $1/\sqrt{m}$.

**(a)** Describe how you would test experimentally which prediction is correct.
Include in your answer:

- the measurements you would take, and
- how you would use these measurements to test each prediction.

You should also discuss ways of making the test as reliable as possible.

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**(b)** When the masses hanging on the spring are 400 g in total, they oscillate with an amplitude of 36 mm and a period of 1.2 s. Calculate

**(i)** the maximum kinetic energy of the masses

maximum kinetic energy = ..... J **[3]**

**(ii)** the maximum acceleration of the masses.

maximum acceleration = ..... $m\,s^{-2}$ **[2]**

**(c)** List the different types of energy involved in the oscillations of this mass-spring system. Describe the energy changes when the masses move from the lowest point of the oscillation to the highest point.

*In your answer you should use appropriate technical terms spelled correctly.*

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**[Total: 13]**