Teacher Resource Bank

GCE Physics B: Physics in Context

Additional Sample Questions (Specification B)

PHYB4 – Physics Inside and Out

ADDITIONAL SAMPLE QUESTIONS

This document provides a directory of past questions from the legacy AQA GCE Physics Specification B; these questions may prove relevant/useful to both the teaching of the new AQA GCE Physics B: Physics in Context specification and the preparation of candidates for examined units. It is advisable when using these questions that teachers consider how these questions could relate to the new specification. Teachers should be aware of the different treatment of the Quality of Written Communication between the specifications.

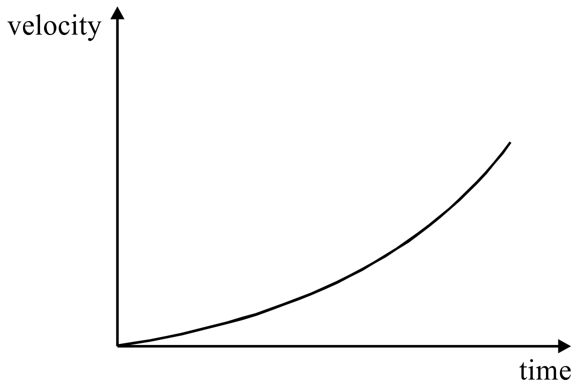
For specific examples of the style and flavour of the questions which may appear in the operational exams, teachers should also refer to the Specimen Assessment Materials which accompany the specification.

A mark scheme has been produced which accompanies this document.

1. (a) A rocket takes off from the Earth. Exhaust gases are discharged vertically downwards causing the rocket to accelerate vertically upwards.

Figure 1 is a sketch graph of the velocity of the rocket against time after lift off.

Figure 1



(i) Describe the acceleration of the rocket during the time shown in **Figure 1**.

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(1)

(ii) By referring to the graph in **Figure 1**, explain your answer to part (a)(i).

....

(1)

(iii) Suggest why the rocket accelerates as you have described.

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(1)

(b) A satellite has a mass of 3.9×10^3 kg. Initially, it is placed in an orbit of radius 1.0×10^7 m around the Earth.

(i) Show that the centripetal force provided by gravitational attraction is 1.6×10^4 N.

universal gravitational constant, $G = 6.7 \times 10^{-11}$ N m^2 kg^{-2}
mass of the Earth = 6.0×10^{24} kg

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(2)

(ii) **Figure 2** shows the variation of the gravitational force *F* on the satellite with orbital radius *R*.

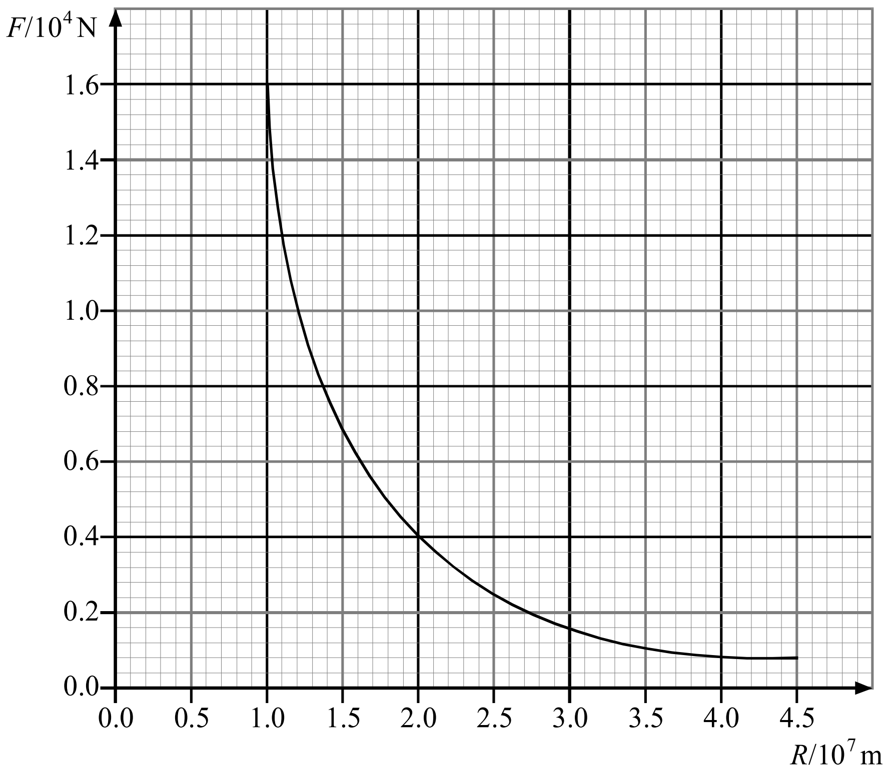

Figure 2

Show that the data given in **Figure 2** are consistent with the inverse square law for the variation of force with distance.

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(3)

(iii) Use data from **Figure 2** to find the change in potential energy which occurs when the satellite is raised from its orbit of radius 1.0×10^7 m to an orbit of radius 4.5×10^7 m.

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(3)

(iv) When the radius of the orbit is 4.0×10^7 m, the centripetal force on the satellite is 4.5×10^3 N. Calculate the speed of the satellite.

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(2)

(v) State and explain whether energy transformed from chemical energy as the fuel burns is equal to the change in potential energy which occurs when the radius of the orbit is increased.

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(3)
(Total 16 marks)

2. g is the strength of the gravitational field at the surface of the Earth; R is the radius of the Earth. The potential energy lost by a satellite of mass m falling to the Earth's surface from a height R above the surface is

A $4mgR$

B $2mgR$

C $\frac{mgR}{2}$

D $\frac{mgR}{4}$

(Total 1 mark)

3. (a) Define *gravitational field strength* at a point in a gravitational field.

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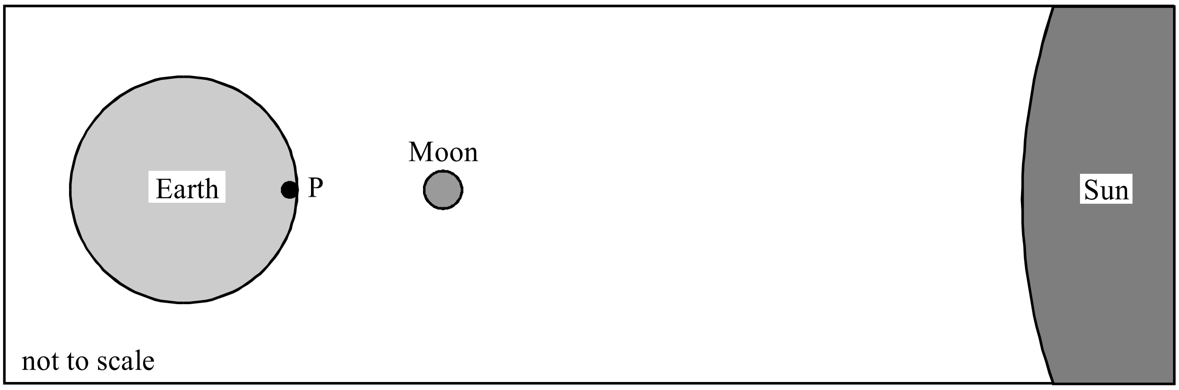
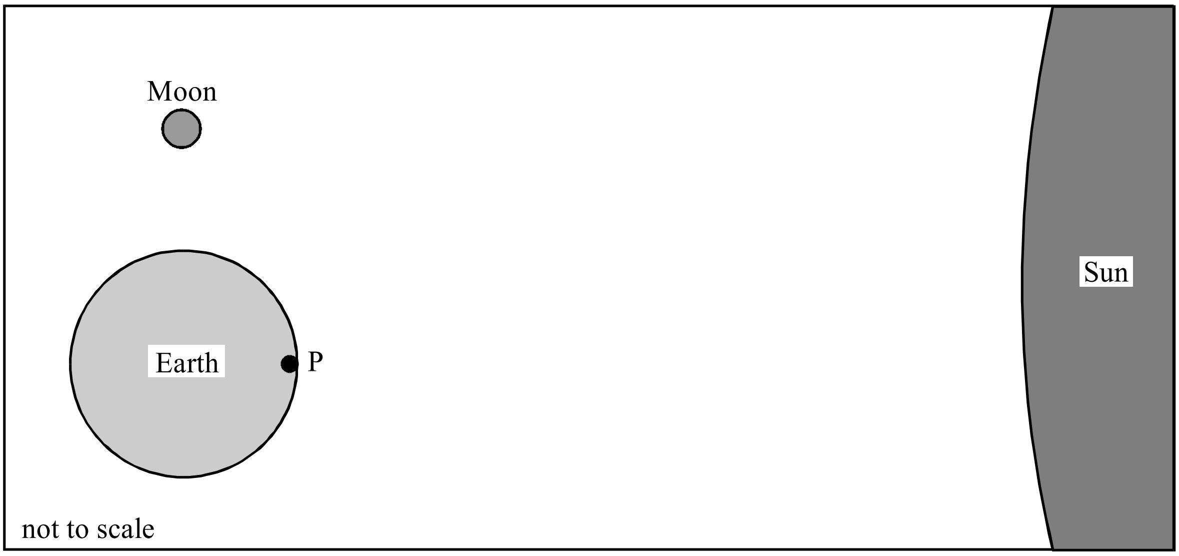
(1)

(b) Tides vary in height with the relative positions of the Earth, the Sun and the moon which change as the Earth and the Moon move in their orbits. Two possible configurations are shown in **Figure 1.**



Configuration A



Configuration B

Figure 1

Consider a 1 kg mass of sea water at position **P**. This mass experiences forces F_E, F_M and F_S due to its position in the gravitational fields of the Earth, the Moon and the Sun respectively.

(i) Draw labelled arrows on **both** diagrams in **Figure I** to indicate the three forces experienced by the mass of sea water at **P**.

(3)

(ii) State and explain which configuration, **A** or **B**, of the Sun, the Moon and the Earth will produce the higher tide at position **P**.

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(2)

(c) Calculate the magnitude of the gravitational force experienced by 1 kg of sea water on the Earth's surface at **P**, due to the **Sun's** gravitational field.

radius of the Earth's orbit $= 1.5 \times 10^{11}$ m

mass of the Sun $= 2.0 \times 10^{30}$ kg

universal gravitational constant, G $= 6.7 \times 10^{-11}$ Nm^2 kg^{-2}

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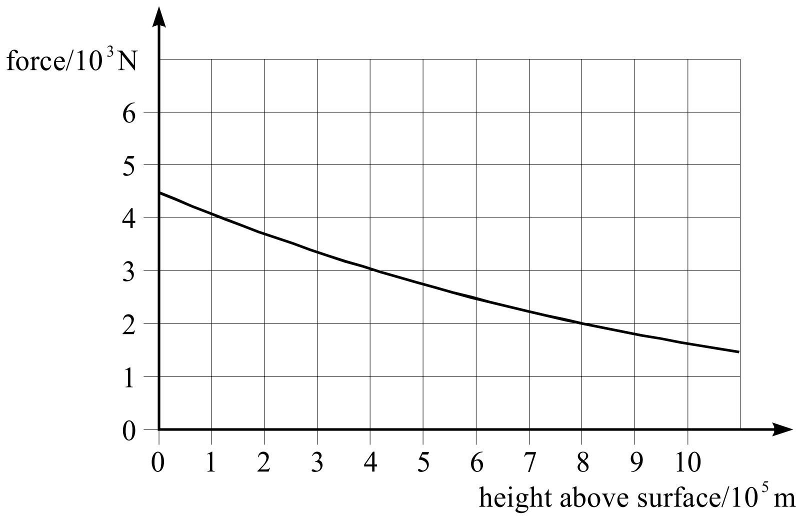
(3)
(Total 9 marks)

4. A lunar landing module and its parent craft are orbiting the Moon at a height above the surface of 6.0×10^5 m. The mass of the lunar module is 2.7×10^3 kg. The graph below shows the variation of the gravitational force on the module with height above the surface of the Moon.



(a) (i) Using data from the graph, find the gravitational force on the lunar module and hence find its speed when its orbital height is 6.0×10^5 m.

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(3)

(ii) Using data from the graph, find the change in gravitational potential energy of the lunar module as it descends from its orbit to the surface of the Moon.

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(3)

(b) The descent of the lunar module is controlled by a set of rockets. Describe how you would use the data which you have already calculated to determine the minimum fuel load which would enable the lunar module to land on the surface of the Moon and subsequently to rejoin its parent craft in orbit. State what additional information you would need to know.

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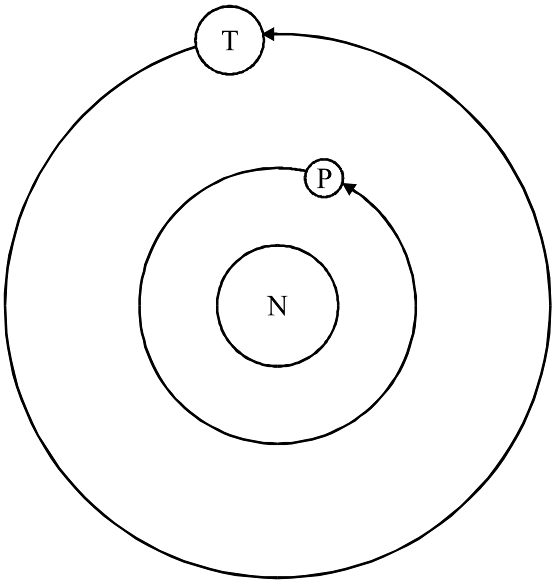
(3)
(Total 9 marks)

5. The diagram below (not to scale) shows the planet Neptune (N) with its two largest moons, Triton (**T**) and Proteus (**P**). Triton has an orbital radius of 3.55×10^8 m and that of Proteus is 1.18×10^8 m. The orbits are assumed to be circular.



(a) Explain why the velocity of each moon varies whilst its orbital speed remains constant.

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(1)

(b) Write down an equation that shows how Neptune's gravitational attraction provides the centripetal force required to hold Triton in its orbit. Hence show that it is unnecessary to know the mass of Triton in order to find its angular speed.

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(3)

(c) Show that $\frac{\text{the orbital period of Triton}}{\text{the orbital period of Proteus}}$ is approximately 5.2.

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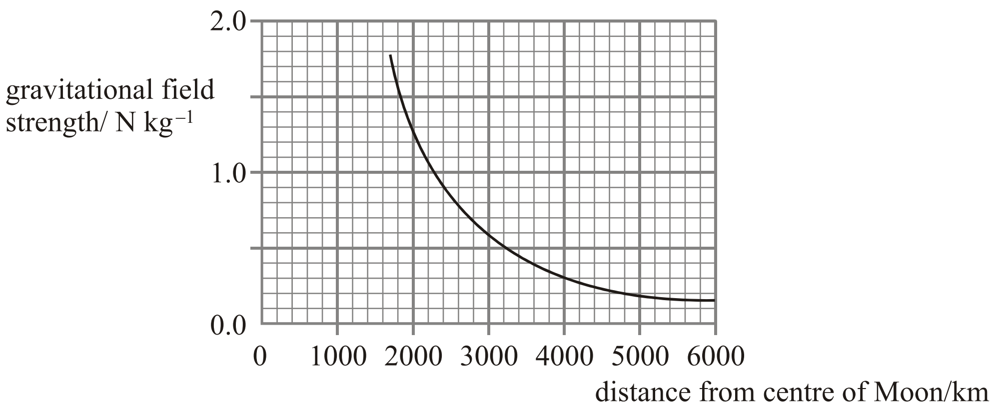
(4)
(Total 8 marks)

6. NASA wishes to recover a satellite, at present stranded on the Moon's surface, and to place it in orbit around the Moon.

(a) (i) The grid below shows a graph of gravitational field strength against distance from the **centre** of the Moon. Mark on the grid the area that corresponds to the energy needed to move 1 kg from the **surface** of the Moon to a vertical height of 4000 km **above the surface**.

radius of the Moon = 1700 km



(2)

(ii) The satellite has a mass of 450 kg. Estimate the change in gravitational potential energy of the satellite when it is moved from the surface of the Moon to a vertical height of 4000 km above the surface.

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(4)

(b) NASA now decides to bring the satellite back to Earth. Explain why the amount of fuel required to return the satellite to Earth will be **much** less than the amount required to send it to the Moon originally.

Two of the 6 marks for this question are available for the quality of your written communication.

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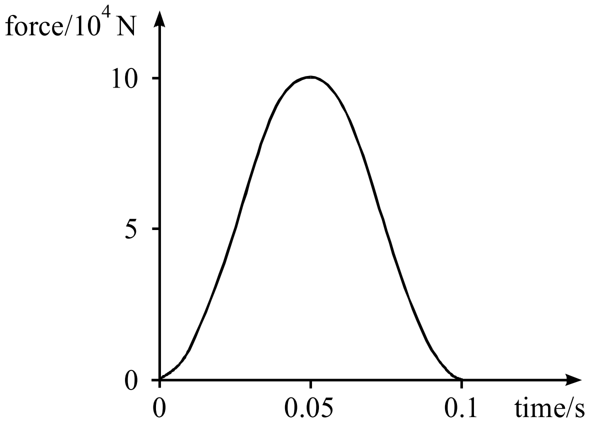
(6)
(Total 12 marks)

7. The diagram shows the graph of force on a car against time when the car of mass 500kg crashes into a wall without rebounding.



Which one of the following statements is correct?

A The area under the graph is equal to the initial momentum of the car

B Momentum is not conserved in the collision

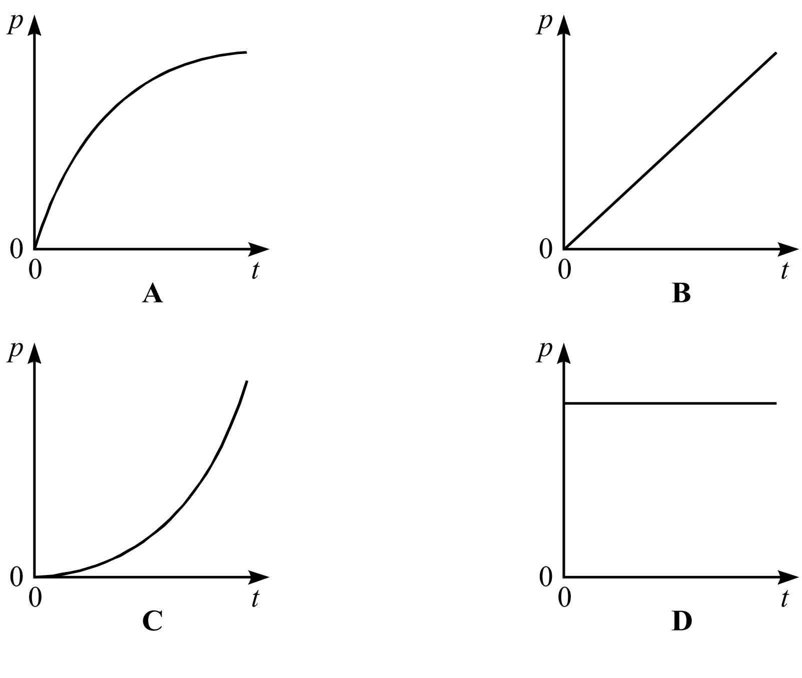
C Kinetic energy is conserved in the collision

D The average force exerted on the car is 10×10^4 N

(Total 1 mark)

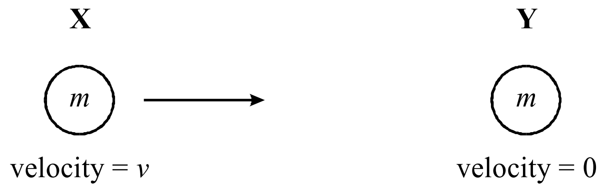
8. A body is accelerated from rest by a constant force.

Which one of the following graphs best represents the variation of the body's momentum p with time t?



(Total 1 mark)

9. A body **X**, moving with a velocity *v*, collides elastically with a stationary body **Y** of equal mass.



Which one of the following correctly describes the velocities of the two bodies after the collision?

	velocity of X	**velocity of Y**
A	$\frac{v}{2}$	$\frac{v}{2}$
B	$-\frac{v}{2}$	$\frac{v}{2}$
C	$-v$	0
D	0	v

10. (a) Starting with the relationship between impulse and the change in momentum, show clearly that the unit, N, is equivalent to kg m s^{-2}.

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(2)

(b) A rocket uses a liquid propellant in order to move.
Explain how the ejection of the waste gases in one direction makes the rocket move in the opposite direction.

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(3)

(c) A rocket ejects 1.5×10^4 kg of waste gas per second. The gas is ejected with a speed of 2.4 km s^{-1} relative to the rocket. Show that the average thrust on the rocket is about 40 MN.

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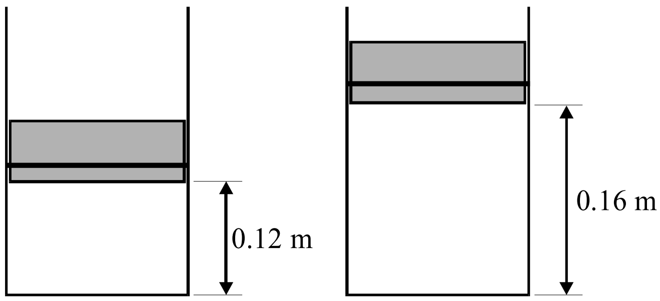
(2)
(Total 7 marks)

11. A fixed mass of gas is held in the cylinder shown below. It is heated at a constant pressure of 2.5×10^5 Pa. The initial temperature of the gas is 27 °C. The cylinder has a cross sectional area of 4.5×10^{-3} m^2.



(a) Calculate the final temperature of the gas.

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(2)

(b) Calculate the work done by the gas as it expands.

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(2)

(c) State and explain what would have happened to the gas had it been heated by the same amount at constant volume.

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(3)

(Total 7 marks)

12. (a) (i) The internal energy of a gas is the sum of the potential and kinetic energies of the molecules of the gas.

Explain why, for an ideal gas, only the kinetic energy changes when the internal energy of the gas is increased either at constant volume or at constant pressure.

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(3)

(ii) Calculate the total kinetic energy of the atoms in 0.025 mol of an ideal gas at a temperature of 290 K.

The Avogrado constant is 6.0×10^{23} mol^{-1}.
The Boltzmann constant is 1.38×10^{-23} J K^{-1}

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(2)

(b) The laws of football require the ball to have a circumference between 680 mm and 700 mm. Its pressure should be between 0.61×10^5 and 1.11×10^5 Pa above atmospheric pressure at sea level.

One ball has a circumference of 690 mm.

The molar mass of air is 0.028 kg mol^{-1}.
The universal gas constant R is 8.3 J mol^{-1} K^{-1}.

(i) The thickness of the material used for the ball is negligible. Show that the volume of air in the football is approximately 5.5×10^{-3} m^3.

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(2)

(ii) Assuming that the temperature is 17 °C and that the atmospheric pressure at sea level is 1.01×10^5 Pa, calculate the minimum mass of air inside the ball that satisfies the regulation.

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(3)

(iii) Calculate the pressure that would exist in the football if the temperature were to fall to 0 °C. Assume that the volume of the ball remains constant.

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(1)
(Total 11 marks)

13. (a) The first law of thermodynamics may be written as:

$$\Delta U = Q + W$$

State the meaning of positive values for each of the symbols in this equation.

ΔU ....

Q ....

W ....

(3)

(b) For an isothermal change in an ideal gas:

(i) explain why $\Delta U = 0$;

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(1)

(ii) explain the effects on Q and W.

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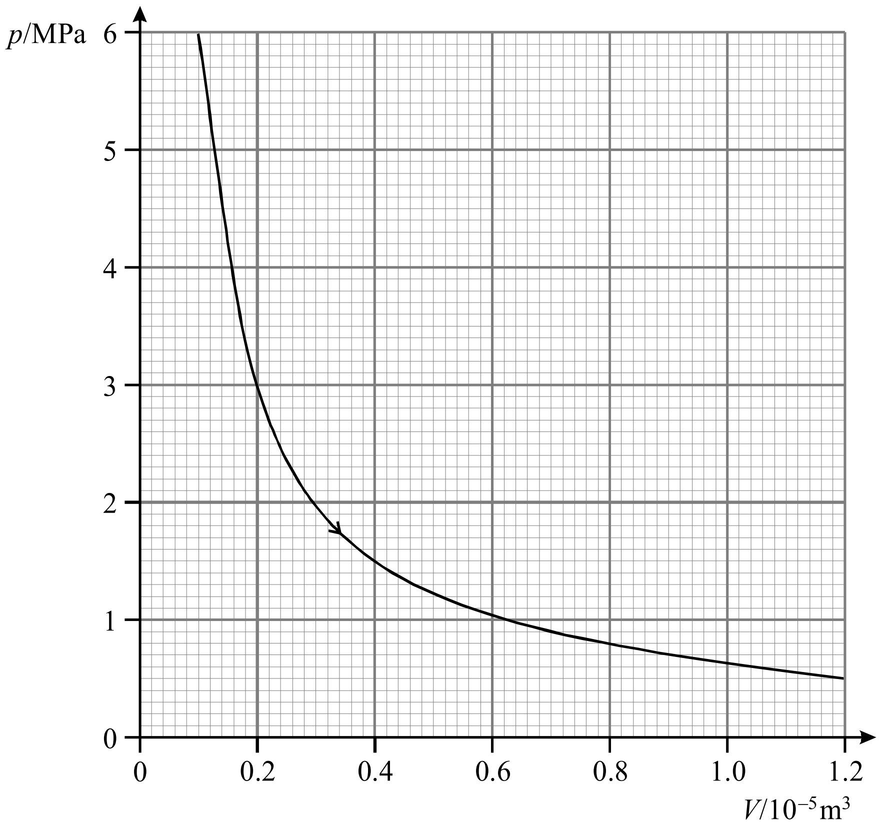
(2)

(c) The diagram below shows an isothermal expansion for 1.2×10^{-3} mol of an ideal gas.



(i) Show that the temperature at which this expansion occurs is approximately 600 K.

molar gas constant, $R = 8.3$ J mol^{-1} K^{-1}

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(2)

(ii) Add to the diagram above a second line to show the expansion of the ideal gas at a temperature of 400 K. Show how you have chosen your values.

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(4)

(Total 12 marks)

14. A meteorite of mass 1.2×10^4 kg enters the Earth's atmosphere at a speed of 2.5 km s^{-1}.

(a) Calculate the kinetic energy of the meteorite as it enters the atmosphere.

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(2)

(b) The meteorite is initially at a temperature of 25 °C. It is made of iron of specific heat capacity 110 J kg^{-1} K^{-1} and of melting point 1810 °C. As the meteorite travels through the Earth's atmosphere friction causes its temperature to rise. Calculate the energy needed to raise the temperature of the meteorite to its melting point. You should assume that the specific heat capacity of iron remains constant.

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(3)

(c) When it reaches the surface of the Earth the mass of the meteorite has fallen to 5.5×10^3 kg and its speed to 150 m s^{-1} so that its kinetic energy is only 6.2×10^7 J. On striking the Earth this mass penetrates the Earth's crust and is brought to rest in a distance of 25 m. Calculate:

(i) the average force acting on the meteorite as it penetrates the Earth's crust;

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(2)

(ii) the time it takes for the meteorite to be brought to rest by the Earth's crust;

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(2)

(iii) the rate at which the meteorite dissipates energy in this time.

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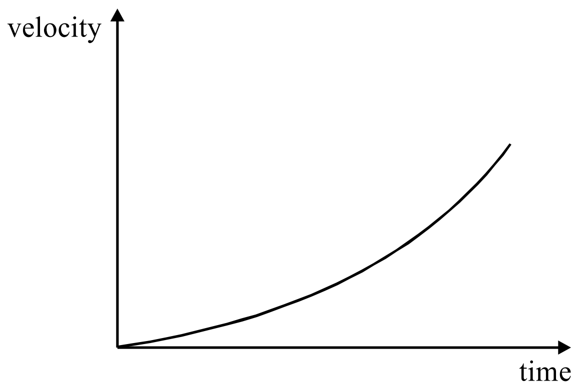
(2)
(Total 11 marks)

15. (a) A rocket takes off from the Earth. Exhaust gases are discharged vertically downwards causing the rocket to accelerate vertically upwards.

Figure 1 is a sketch graph of the velocity of the rocket against time after lift off.

Figure 1



(i) Describe the acceleration of the rocket during the time shown in **Figure 1**.

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(1)

(ii) By referring to the graph in **Figure 1**, explain your answer to (i).

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(1)

(iii) Suggest why the rocket accelerates as you have described.

....

(1)

(b) A satellite has a mass of 3.9×10^3 kg. Initially, it is placed in an orbit of radius 1.0×10^7 m around the Earth.

(i) Show that the centripetal force provided by gravitational attraction is 1.6×10^4 N.

universal gravitational constant, $G = 6.7 \times 10^{-11}$ N m^2 kg^{-2}
mass of the Earth = 6.0×10^{24} kg

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(2)

(ii) **Figure 2** shows the variation of the gravitational force *F* on the satellite with orbital radius *R*.

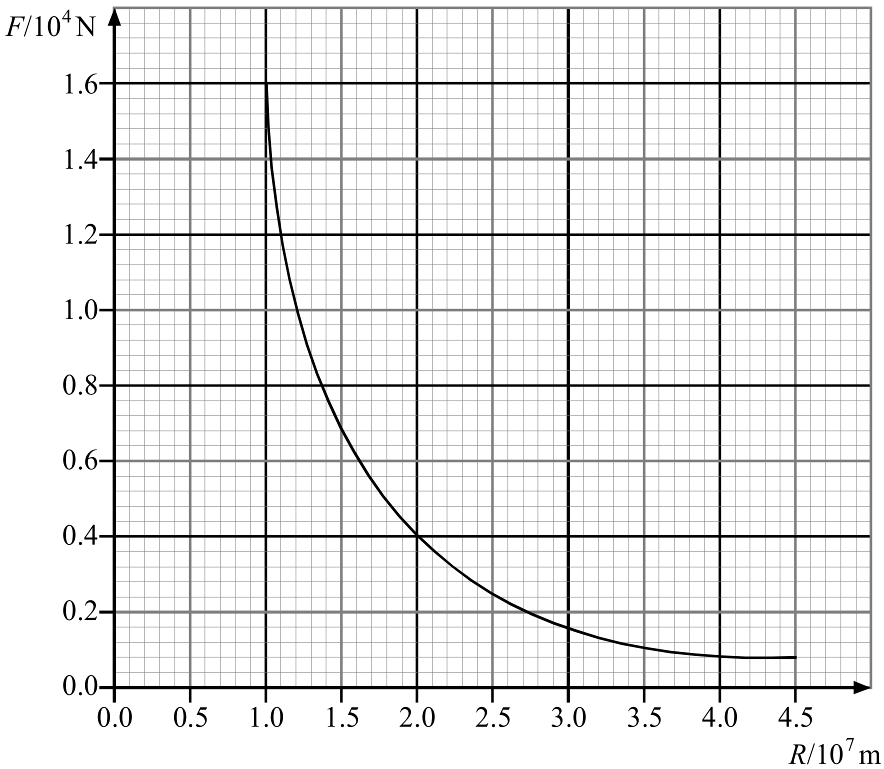

Figure 2

Show that the data given in **Figure 2** are consistent with the inverse square law for the variation of force with distance.

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(3)

(iii) Use data from **Figure 2** to find the change in potential energy which occurs when the satellite is raised from its orbit of radius 1.0×10^7 m to an orbit of radius
4.5×10^7 m.

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(3)

(iv) When the radius of the orbit is 4.0×10^7 m, the centripetal force on the satellite is 4.5×10^3 N. Calculate the speed of the satellite.

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(2)

(v) State and explain whether energy transformed from chemical energy as the fuel burns is equal to the change in potential energy which occurs when the radius of the orbit is increased.

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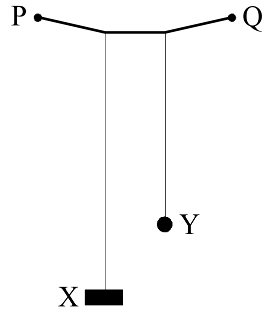
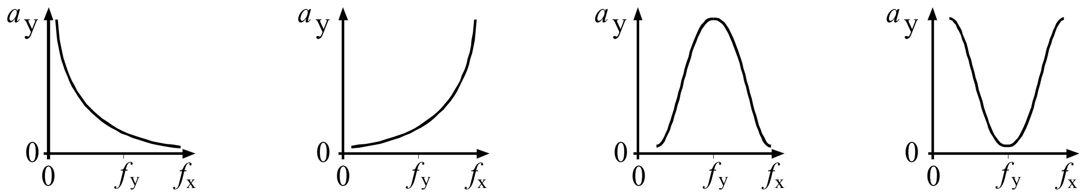
(3)
(Total 16 marks)

16. The diagram shows two pendulums suspended from fire same thread, **PQ**.



X is a heavy pendulum, the frequency f_x of which can be varied. **Y** is a lighter pendulum of fixed frequency f_y. As the frequency of oscillation of **X** is increased by shortening the thread, the amplitude of the oscillation of **Y** changes.

Which one of the following graphs best represents the relationship between the amplitude a_y of the oscillation of **Y** and the frequency f_x of **X**?



A B C D

(Total 1 mark)

17. **Figure 1** shows one cycle of the displacement-time graphs for two mass-spring systems **X** and **Y** that are performing simple harmonic motion.

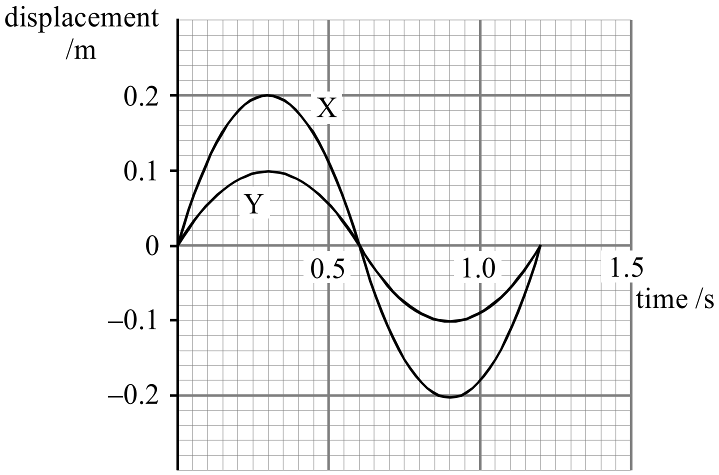


Figure 1

(a) (i) Determine the frequency of the oscillations.

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(2)

(ii) The springs used in oscillators **X** and **Y** have the same spring constant. Using information from **Figure 1**, show that the mass used in oscillator **Y** is equal to that in oscillator **X**.

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(2)

(iii) Explain briefly how you would use one of the graphs in **Figure 1** to confirm that the motion is simple harmonic.

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(2)

(b) **Figure 2** shows how the potential energy of oscillator **X** varies with displacement.

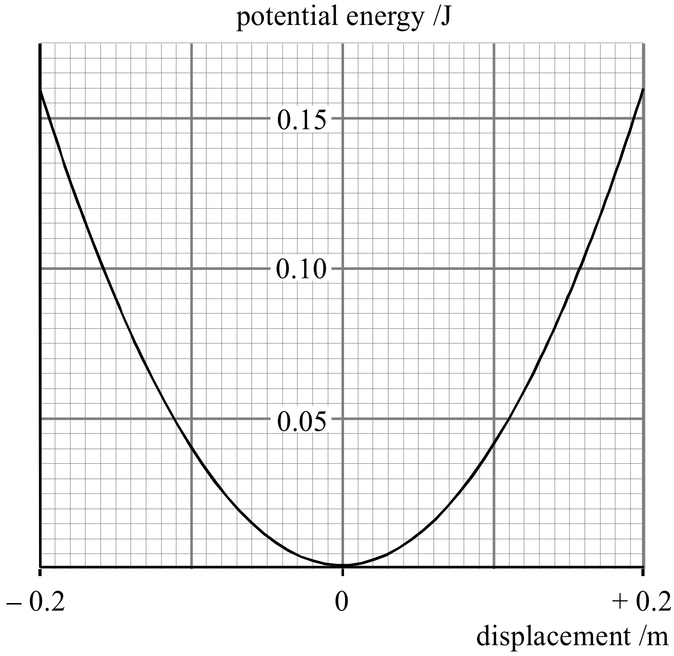

Figure 2

(i) Draw on **Figure 2** a graph to show how the kinetic energy of the mass used in oscillator **X** varies with its displacement. Label this **A**.

(1)

(ii) Draw on **Figure 2** a graph to show how the kinetic energy of the mass used in oscillator **Y** varies with its displacement. Label this **B**.

(2)

(c) Use data from the graphs to determine the spring constant of the springs used.

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(3)
(Total 12 marks)

18. One of the reasons why earthquakes can cause such devastation is that they can cause buildings to *resonate.* For a multi-storey building it is found that the *natural period of oscillation* is approximately 0.1 s multiplied by the number of storeys.

(a) Explain what is meant by the terms:

(i) *resonate;*..

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(2)

(ii) *natural period of oscillation* ....

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(2)

(b) A typical earthquake oscillation has a frequency of 2.5 Hz.

(i) Estimate the number of storeys that a building would have in order to resonate at this frequency.

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(2)

(ii) Sketch a graph of how the displacement of the building might be expected to change with time just after the earthquake had finished. Assume that the building was not damaged by the earthquake. Show **three** complete cycles.

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(2)

(iii) Explain why a building of one storey more than that in part (b)(i) would be less likely to be damaged by the earthquake.

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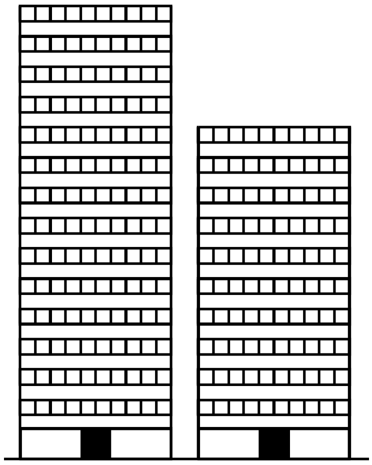
(1)

(iv) The diagram below shows two buildings of different heights situated close together. Explain why these two buildings are more likely to suffer damage than if they were built further away from each other.



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(2)

(c) When a tall building vibrates at 1.5 Hz, the amplitude of the horizontal oscillations at its top is 1.2 m. Assuming that the vibration is simple harmonic, calculate:

(i) the velocity of the top of the building as it passes the rest position;

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(3)

(ii) the acceleration of the top of the building as it reaches the maximum displacement.

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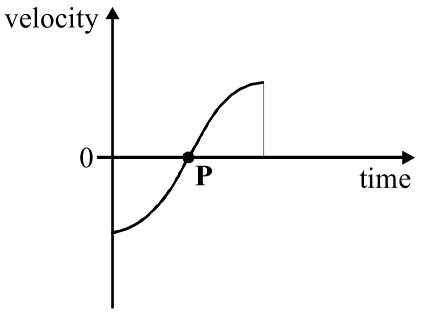
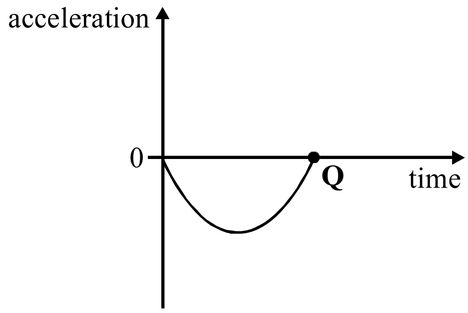
(2)

(Total 16 marks)

19. The diagrams show the variation of velocity and acceleration with time for a body undergoing simple harmonic motion.





Which one of the following is proportional to the change in momentum of the body during the time covered by the graphs?

A The area enclosed by the velocity-time graph and the time axis

B The gradient of the velocity-time graph at the point **P**

C The area enclosed by the acceleration-time graph and the time axis

D The gradient of the acceleration-time graph at the point **Q**

(Total 1 mark)

20. A particle is oscillating with simple harmonic motion described by the equation:

$$s = 5 \sin (20\pi t)$$

How long does it take the particle to travel from its position of maximum displacement to its mean position?

A $\frac{1}{40}$ s

B $\frac{1}{20}$ s

C $\frac{1}{10}$ s

D $\frac{1}{5}$ s

(Total 1 mark)

21. **Figure 1** shows an apparatus for investigating forced vibrations and resonance of a mass-spring system. **Figure 2** shows the displacement-time graph when the system is resonating.

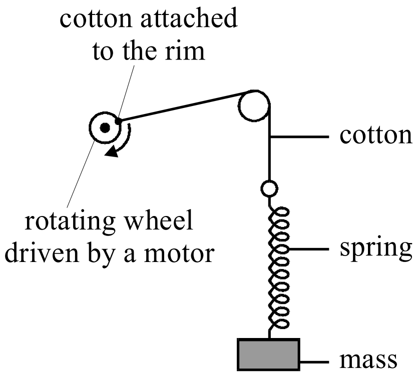


Figure 1

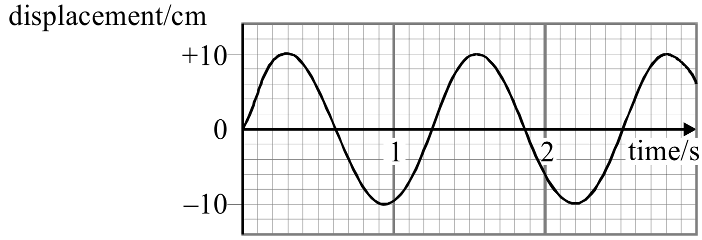


Figure 2

(a) (i) State what is meant by a forced vibration.

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(1)

(ii) Under what condition will resonance occur in the system shown in **Figure 1**?

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(1)

(b) The spring constant of the spring used in the experiment was 9.0 N m^{-1}. Using information from **Figure 2**, determine the value of the mass suspended from the spring.

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(3)

(c) When the rotating wheel stops, **Figure 3** shows how the amplitude of the oscillations of the mass subsequently varies with time.

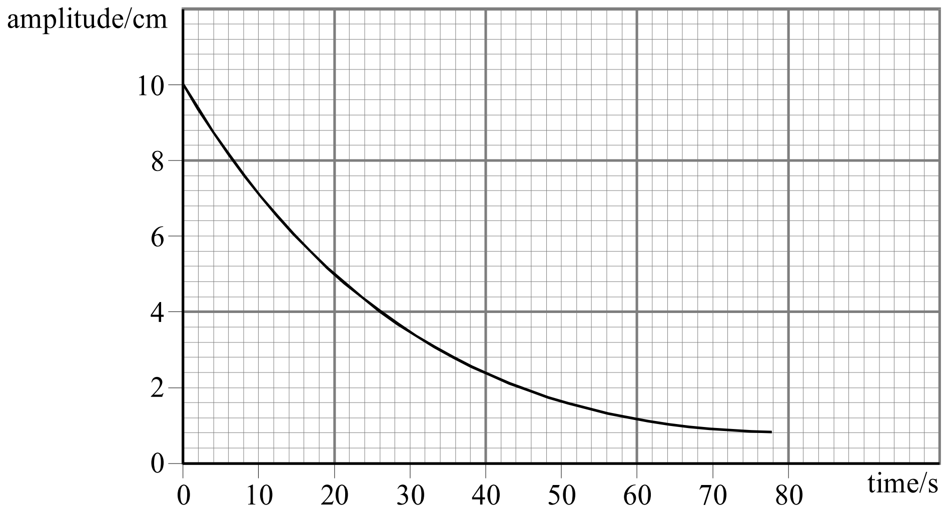

Figure 3

(i) Explain whether the graph supports the suggestion that the amplitude of the damped oscillations varies exponentially with time. Show your reasoning clearly.

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(3)

(ii) Determine the ratio:

$$\frac{\text{energy of the oscillator after twenty oscillations}}{\text{energy of the oscillator at time } t = 0}$$

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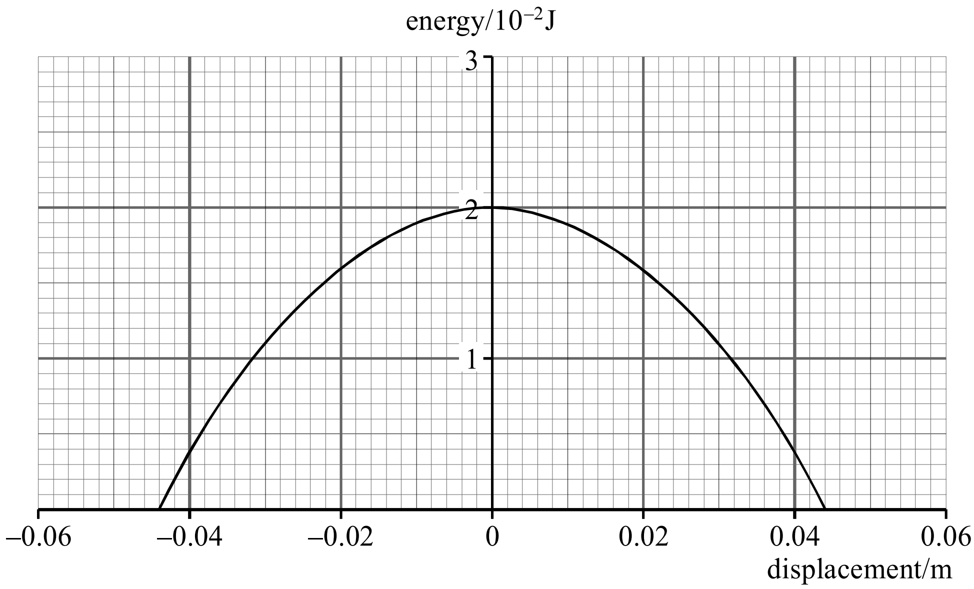
(2)
(Total 10 marks)

22. The diagram below shows how the kinetic energy of a simple pendulum varies with displacement.



(a) Sketch on the diagram above a graph to show how the potential energy of the pendulum varies with displacement.

(2)

(b) (i) State the amplitude of the oscillation.

....

(1)

(ii) The frequency of vibration of the pendulum is 3.5 Hz. Write down the equation that models the variation of position with time for the simple harmonic motion of **this** pendulum.

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(1)

(iii) Calculate the maximum acceleration of the simple pendulum.

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(2)
(Total 6 marks)

23. **Figure 1** shows a mass suspended on a spring.

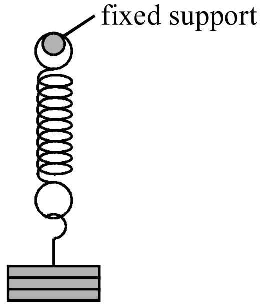

Figure 1

The mass is pulled down by a distance *A* below the equilibrium position and then released at time $t = 0$. It undergoes simple harmonic motion.

(a) Taking upward displacements as being positive, draw graphs on **Figure 2** to show the variation of displacement, velocity and the acceleration with time. Use the same time scale for each of the three graphs.

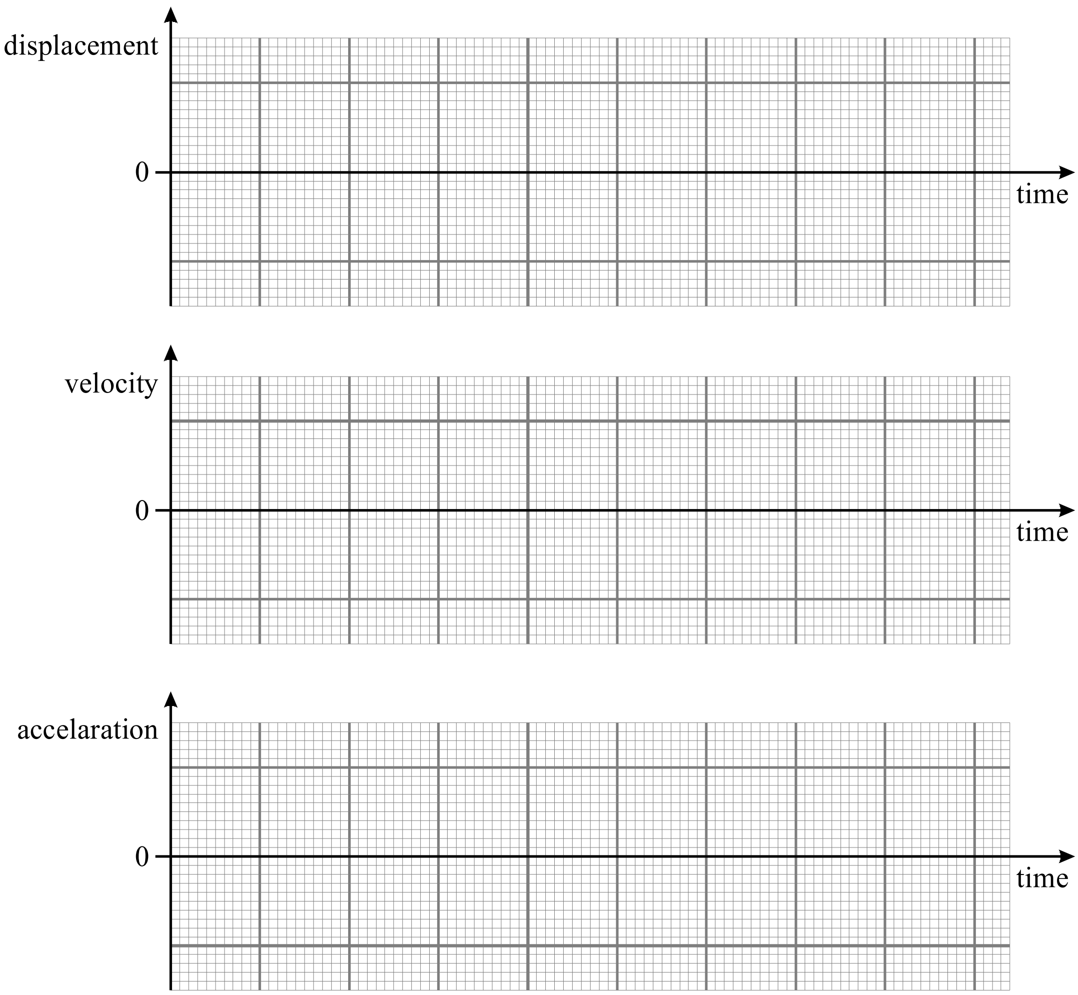

Figure 2

(4)

(b) The spring stiffness, *k*, is 32 N m^{-1}. The spring is loaded with a mass of 0.45 kg. Calculate the frequency of the oscillation.

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(3)
(Total 7 marks)

24. (a) State the conditions necessary for a mass to undergo simple harmonic motion.

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(2)

(b) A child on a swing oscillates with simple harmonic motion of period 3.2 s.

acceleration of free fall = 9.8ms^{-2}

(i) Calculate the distance between the point of support and the centre of mass of the system.

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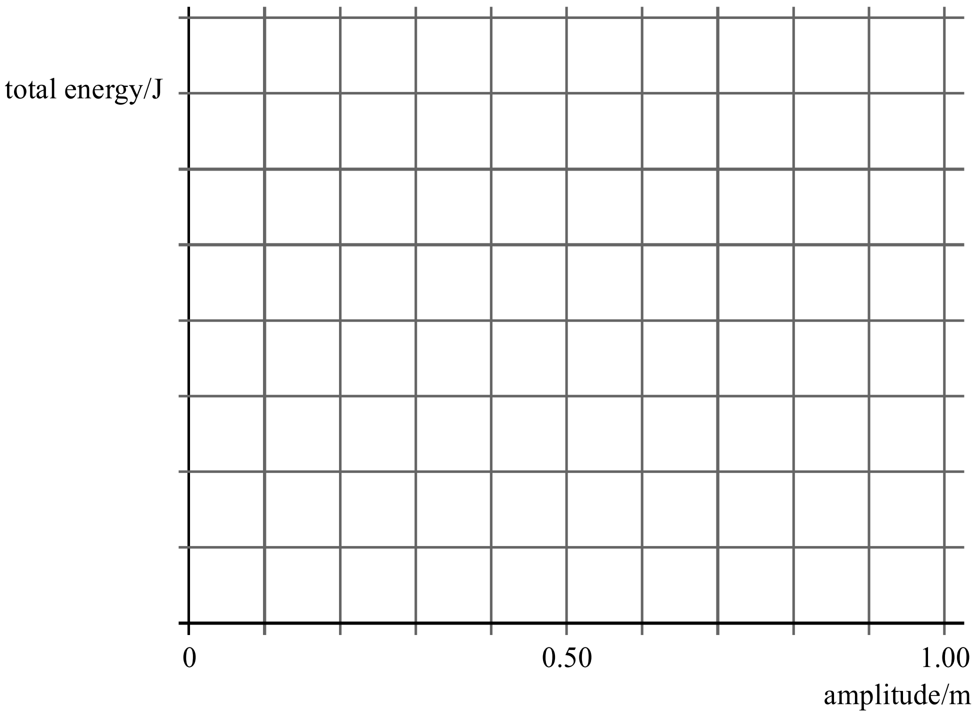
(2)

(ii) The total energy of the oscillations is 40 J when the amplitude of the oscillations is 0.50 m. Sketch a graph showing how the total energy of the child varies with the amplitude of the oscillations for amplitudes between 0 and 1.00 m. Include a suitable scale on the total energy axis.



(2)

25. (a) Simple harmonic motion may be represented by the equation

$$a = -(2\pi f)^2 x$$

(i) Explain the significance of the minus sign in this equation.

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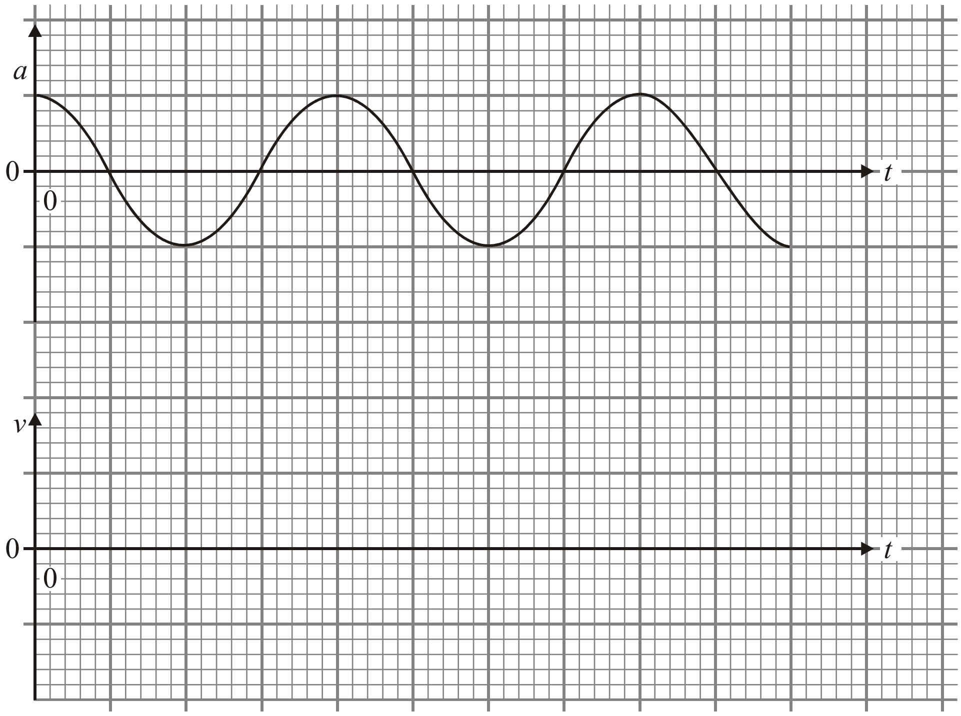
(1)

(ii) In **Figure 1** sketch the corresponding *v*-*t* graph to show how the **phase** of velocity *v* relates to that of the acceleration *a*.



(1)

(b) (i) A mass of 24 kg is attached to the end of a spring of spring constant 60 N m^{-1}. The mass is displaced 0.035 m vertically from its equilibrium position and released. Show that the maximum kinetic energy of the mass is about 40 mJ.

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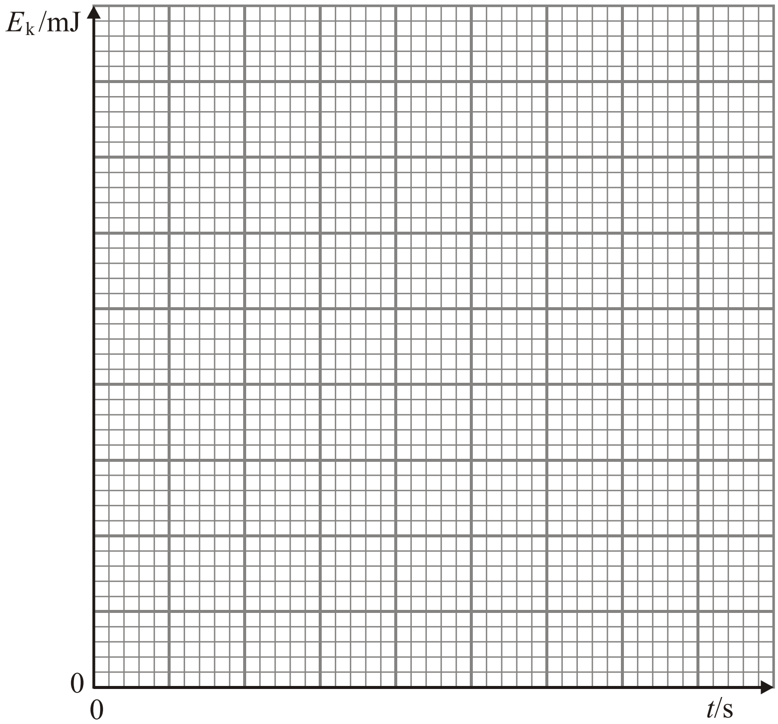
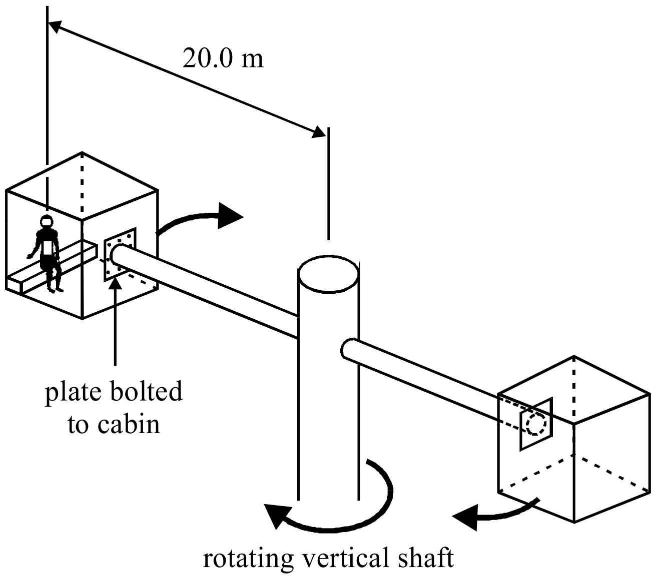
(5)

(ii) When the mass on the spring is quite heavily damped its amplitude halves by the end of each complete cycle. On the grid of **Figure 2** sketch a graph to show how the kinetic energy, E_k, of the mass on the spring varies with time over a single period. Start at time, $t = 0$, with your maximum kinetic energy. You should include suitable values on each of your scales.



(3)
(Total 10 marks)

26. To simulate the high accelerations experienced during take-off, astronauts are trained using a system similar to the one shown in the figure below.



The astronaut sits, as shown, and the system is accelerated to a high speed.

The centre of mass of the astronaut is 20.0 m from the axis of rotation.

(a) Explain why there is a horizontal force on the astronaut, even when the speed is constant.

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(3)

(b) Write down the formula for the horizontal force on the astronaut, defining all the terms used.

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(1)

(c) In one test the astronaut experiences a horizontal force 4.0 times that due to normal gravity. Determine the speed of the astronaut during this test.

acceleration due to gravity $g = 9.8 \text{ m s}^{-2}$

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(2)
(Total 6 marks)

27. A gymnast does a hand-stand on a horizontal bar. The gymnast then rotates in a vertical circle with the bar as a pivot. The gymnast and bar remain rigid during the rotation and when friction and air resistance are negligible the gymnast returns to the original stationary position.

Figure 1 shows the gymnast's position at the start and **Figure 2** shows the position after completing half the circle.

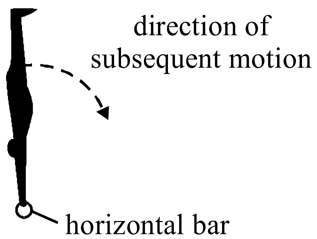

Figure 1

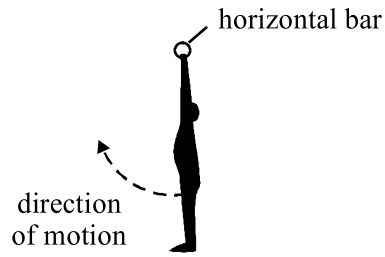

Figure 2

(a) The gymnast has a mass of 70 kg and the centre of mass of the gymnast is 1.20 m from the axis of rotation.

acceleration of free fall, $g = 9.8 \text{ m s}^{-2}$

(i) Show clearly how the principle of conservation of energy predicts a speed of 6.9 m s^{-1} for the centre of mass when in the position shown in **Figure 2**.

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(3)

(ii) The maximum force on the arms of the gymnast occurs when in the position shown in **Figure 2**.

Calculate the centripetal force required to produce circular motion of the gymnast when the centre of mass is moving at 6.9 m s^{-1}.

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(2)

(iii) Determine the maximum tension in the arms of the gymnast when in the position shown in **Figure 2.**

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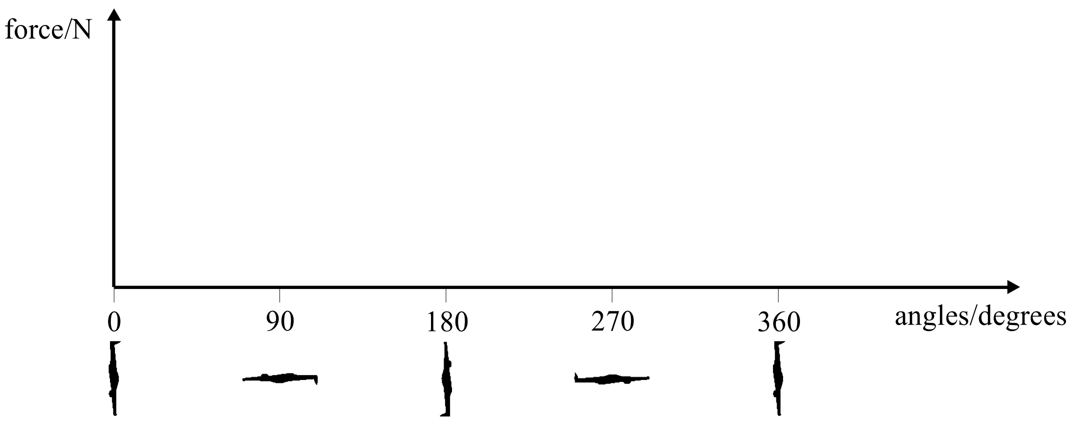
(1)

(iv) Sketch a graph to show how the **vertical** component of the force **on the bar** varies with the angle rotated through by the gymnast during the manoeuvre. Assume that a downward force is positive.

Include the values for the initial force and the maximum force on the bar.

Only show the general shape between these values.



(2)

(b) The bones in each forearm have a length of 0.25 m. The total cross-sectional area of the bones in both forearms is 1.2×10^{-3} m^2. The Young modulus of bone in compression is 1.6×10^{10} Pa.

Assuming that the bones carry all the weight of the gymnast, calculate the reduction in length of the forearm bones when the gymnast is in the start position shown in **Figure 1.**

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(3)
(Total 11 marks)

Use this information to answer questions 28/29/30

Mineral prospecting

Exploration for new ore deposits by drilling holes in the Earth can be a costly hit and miss exercise. The geophysicist employs physics to search for the location of ore deposits. The techniques used come from almost all branches of physics. Optical and infrared satellite photographs are first used to identify likely areas for further tests. Experiments are then carried out to investigate variations in one or usually several physical factors. For example, ores may produce local variations in the strength of the Earth's magnetic field, in the strength of the Earth's gravitational attraction, in the electrical resistivity of the Earth, in the speed of waves through the Earth (seismology) or, for radioactive ores, in the count rate measured using a radiation detector.

Voltage measurements to detect variation in resistivity

These measurements use the principle of the potential divider. Two methods are commonly used. In the method shown in **Figure 1**, a battery is connected to two electrodes **A** and **B** which are inserted in the ground some distance apart, ensuring good electrical contact between the electrodes and the soil.

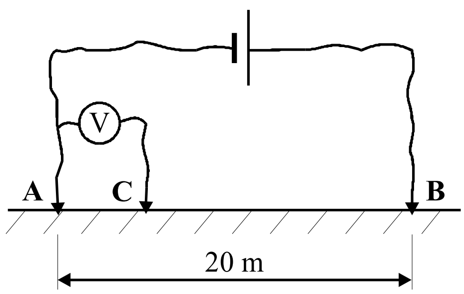


Figure 1

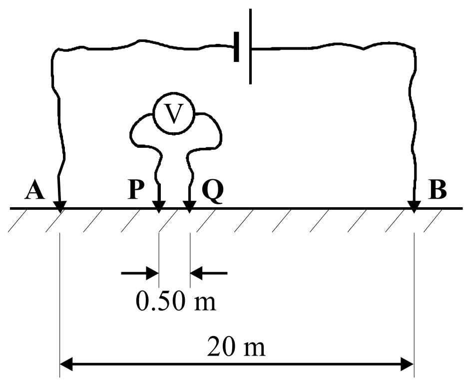


Figure 2

A test electrode **C** is then moved along the line joining the electrodes and the potential difference between **A** and **C** is measured. The geophysicist plots a graph of voltage against the distance. If the soil is of uniform resistivity the voltage increases linearly. Where there is an ore body, ions are released into the soil and this changes the gradient of the graph. The graph in **Figure 3** shows the results of one test using the method in **Figure 1**.

In the alternative approach, shown in **Figure 2**, two electrodes, **P** and **Q**, placed 0.50 m apart are moved along the line between the electrodes **A** and **B**, and the variation of the voltage with position is used to locate the ore deposit.

Seismology

In seismology a small explosion is produced at the surface (**X** in **Figure 4**) and the electric pulse which causes the explosion is used to start a clock. The explosion sends a shock wave through the ground to a geophone some distance away (at **Y**).

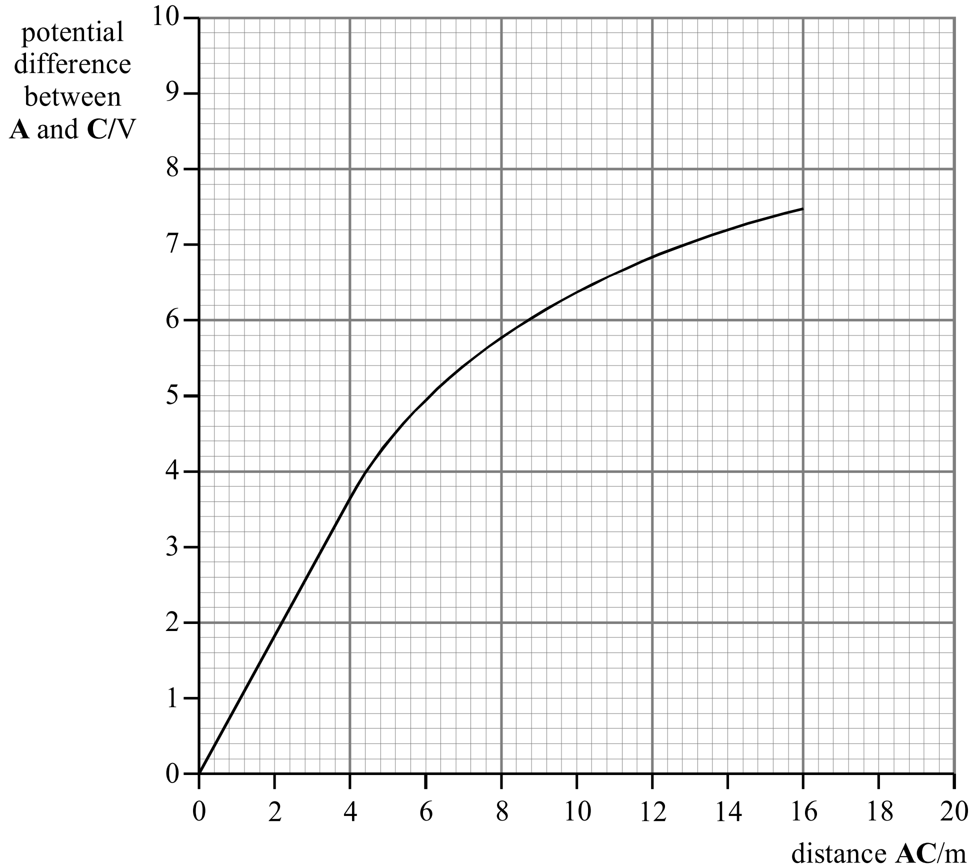
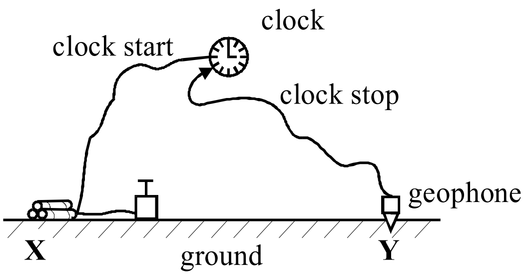


Figure 3



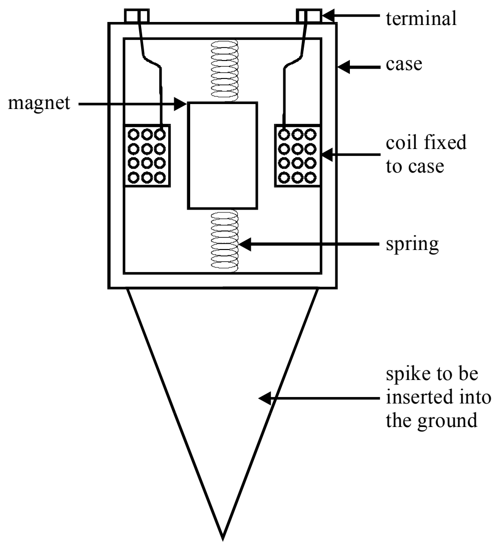


Figure 4 **Figure 5**

The structure of the geophone (simplified) is shown in **Figure 5**. The shock wave makes the coil in the geophone move up and down inducing a voltage which is used to stop the clock. The time taken for the wave to travel the distance **XY** is then known so that the speed of the shock wave between **X** and **Y** can be calculated. The speed of the shock wave changes from about 2000 m s^{-1} **in** soft soil to over 4000 m s^{-1} in ore deposits.

28. (a) State the factors that affect the gravitational field strength at the surface of a planet.

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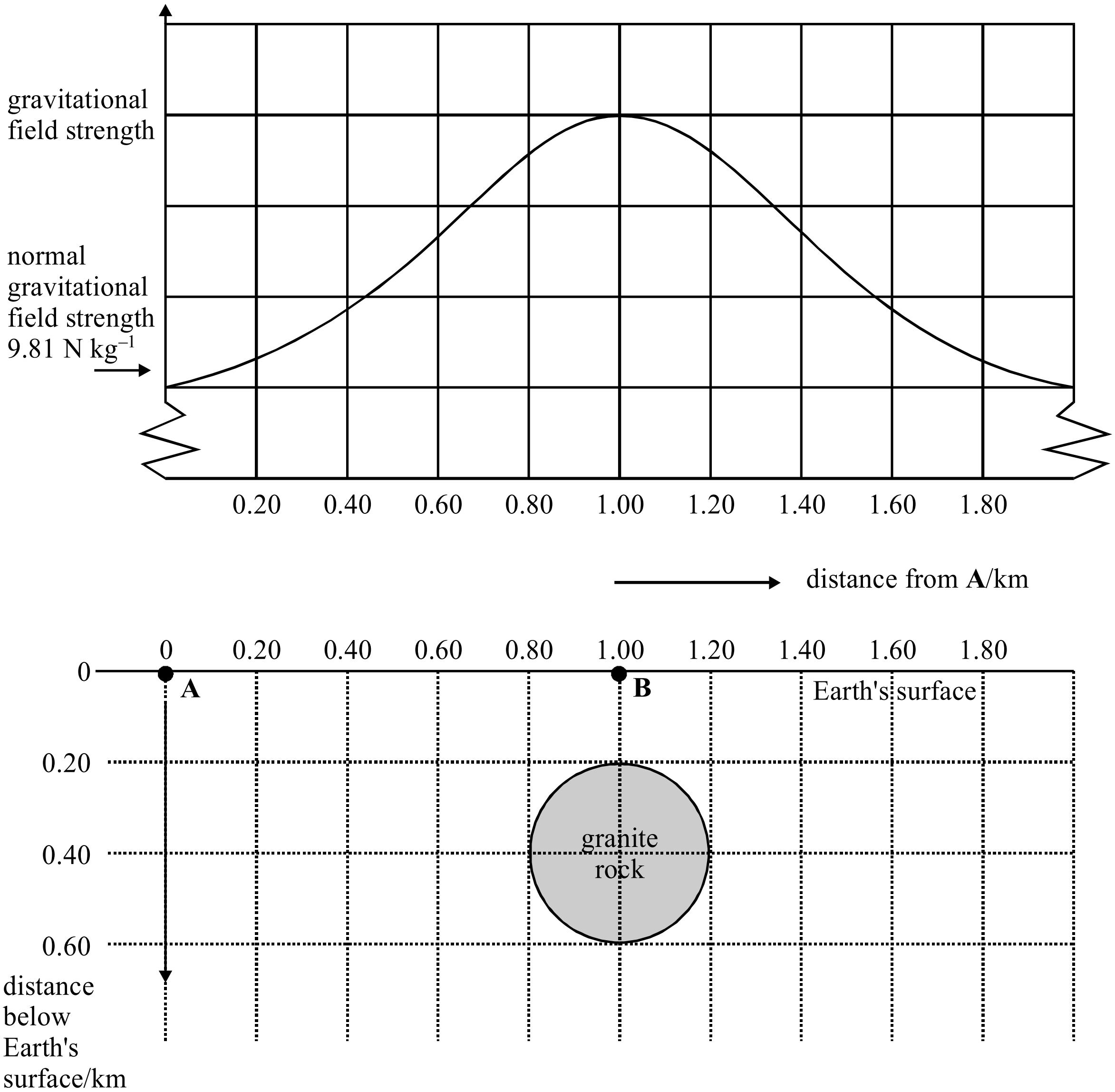
(2)

(b) The diagram below shows the variation, called an anomaly, of gravitational field strength at the Earth's surface in a region where there is a large spherical granite rock buried in the Earth's crust.



The density of the granite rock is 3700 kg m^{-3} and the mean density of the surrounding material is 2200 kg m^{-3}.

(i) Show that the difference between the mass of the granite rock and the mass of an equivalent volume of the surrounding material is 5.0×10^{10} kg.

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(4)

(ii) The universal gravitational constant $G = 6.7 \times 10^{-11}$ N m^2 kg^{-2}. Calculate the difference between the gravitational field strength at **B** and that at point **A** on the Earth's surface that is a long way from the granite rock.

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(4)

(iii) Add to the diagram above a graph to show how the variation in gravitational field strength would change if the granite rock were buried deeper in the Earth's crust.

(1)
(Total 11 marks)

29. The following questions refer to the paragraphs on '*Resistance or voltage measurements*'.

(a) State what is meant by the phrase '*good electrical contact*'.

....

(1)

(b) The graph in **Figure 3** shows the results of one test using the method in **Figure 1**.

(i) State and explain whether you would recommend drilling nearer to **A** or nearer to **B**.

....

....

....

(2)

(ii) Determine the approximate distance of the edge of the ore body from **A**.

....

(1)

(iii) Determine the terminal potential difference of the supply used in the test that produced the data in **Figure 3**.

....

(1)

(iv) The current through the battery was 5.0 mA. Calculate the resistance between the terminals **A** and **B**.

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....

....

(2)

(c) Sketch the graph that would be obtained for the region between **AB** when the circuit in **Figure 2** is used. Include a suitable scale on the axes.

(3)
(Total 10 marks)

30. The following questions refer to the paragraphs on '*Seismology*'.

Explain:

(a) why movement of the Earth's surface makes the magnet in **Figure 5** move relative to the coil;

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(3)

(b) why relative movement between the magnet and the coil produces a voltage;

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(2)

(c) how energy is transmitted by a '*shock wave*' and suggest why the speed of the shock wave is different in soft soil and in ore deposits You can gain up to 2 marks in this question for good written communication

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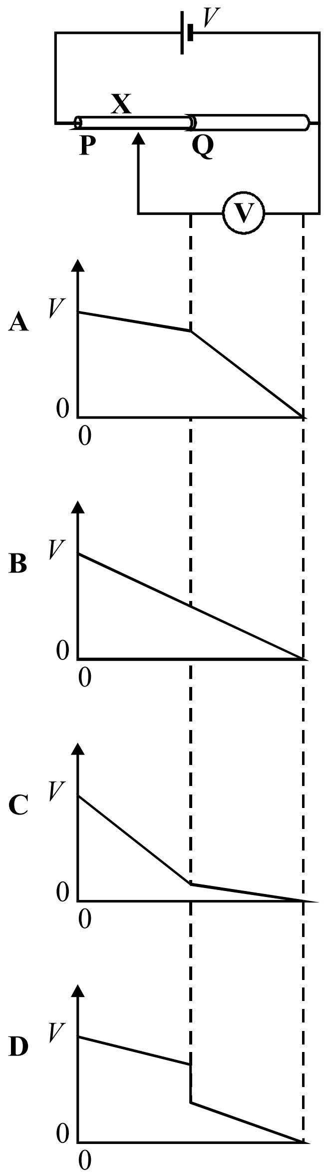
(6)
(Total 11 marks)

31. The diagram shows two wires, **P** and **Q**, of equal length, joined in series with a cell. A voltmeter is connected between the end of **Q** and a point **X** on the wires. The pd across the cell is *V*. Wire **Q** has twice the area of cross-section and twice the resistivity of wire **P**. The variation of the voltmeter reading as the point **X** is moved along the wires is best shown by



(Total 1 marks)

32. A strip of aluminium foil of uniform thickness is cut to the shape shown in **Figure 1**. Current flows through the foil when a potential difference is applied between its ends.

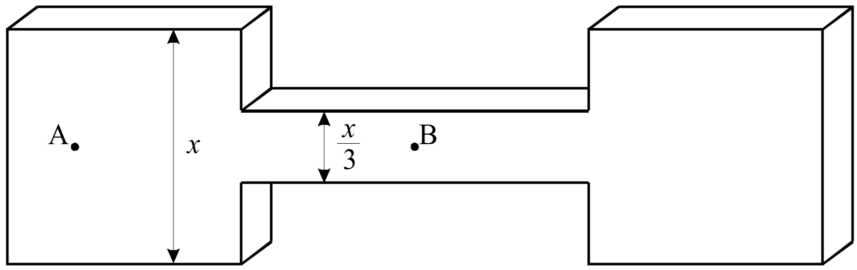


Figure 1

(a) Name the charge carriers responsible for the electrical conduction in aluminium.

....

(1)

(b) **Figure 1** shows two points **A** and **B** in the regions of different width. The width at **B** is one-third of the width at **A**. v_A is the charge carrier drift speed at point **A** and v_B is the charge carrier drift speed at point **B**.

(i) State the relationship between the current at point **A** and the current at point **B**.

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(1)

(ii) Calculate the ratio of charge carrier drift speeds, v_B/v_A.

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(2)

(c) The foil is connected into an electrical circuit as shown in **Figure 2**. The power supply has a negligible internal resistance and a constant emf

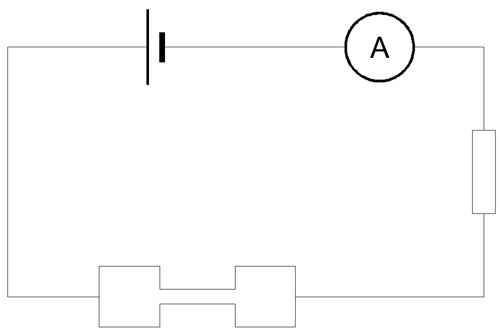

Figure 2

State and explain how the current measured by the ammeter will change when the temperature of the foil increases.
Two of the 7 marks in this question are available for the quality of your written communication.

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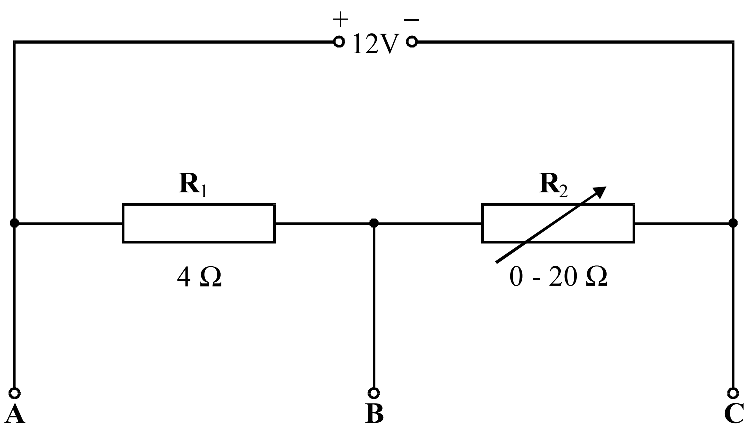
(7)
(Total 11 marks)

33. The figure below shows a circuit from which different potential differences can be obtained by making connections to any two of the terminals **A**, **B** and **C**, and by changing the value of the variable resistor (**R_2**). You may assume that the supply has no internal resistance.



(a) What is the name given to this type of circuit?

....

(1)

(b) What is the value of the potential difference across **AC**?

....

(1)

(c) Calculate the range of potential differences that can be obtained across **AB**.

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(2)

(d) Calculate the range of potential differences that can be obtained across **BC**.

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(2)
(Total 6 marks)

34. The magnetic flux threading a coil of 100 turns drops from 5×10^{-3} Wb to zero in 0.1 s. The average induced emf, in V, is

A 0.05

B 0.5

C 5

D 20

(Total 1 mark)

35. (a) Explain what is meant by a flux density of 1 tesla (T).

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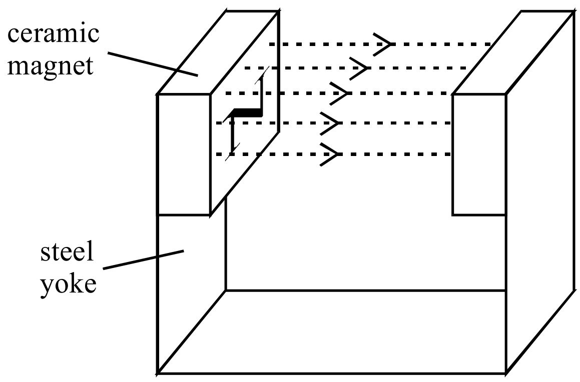
(1)

(b) Complete the diagram below to show a current balance, which may be used to measure the magnetic flux density between the poles of the ceramic magnets. Clearly label the directions of the current and the magnetic force acting on the conductor in the field.



(3)

(c) (i) The armature of a simple motor consists of a square coil of 20 turns and carries a current of 0.55 A just before it starts to move. The lengths of the sides of the coil are 0.15 m and they are positioned perpendicular to a magnetic field of flux density 40 mT. Calculate the force on each side of the coil.

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(2)

(ii) Explain why the current falls below 0.55 A once the coil of the motor is rotating.

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(2)

(iii) The resistance of the coil is 0.50 Ω. When the coil is rotating at a constant rate the minimum current in the coil is found to be 0.14 A. Calculate the maximum rate at which the flux is cut by the coil.

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(4)
(Total 12 marks)

36. Faraday's law of electromagnetic induction predicts that the induced emf, E, in a coil is given
by $E = \dfrac{\Delta(N\phi)}{t}$.

(a) (i) What quantity does the symbol ϕ represent?

....

(1)

(ii) State the SI unit for ϕ.

....

(1)

(b) In **Figure 1** the magnet forms the bob of a simple pendulum. The magnet oscillates with a small amplitude along the axis of a 240 turn coil that has a cross-sectional area of
2.5×10^{-4} m^2.

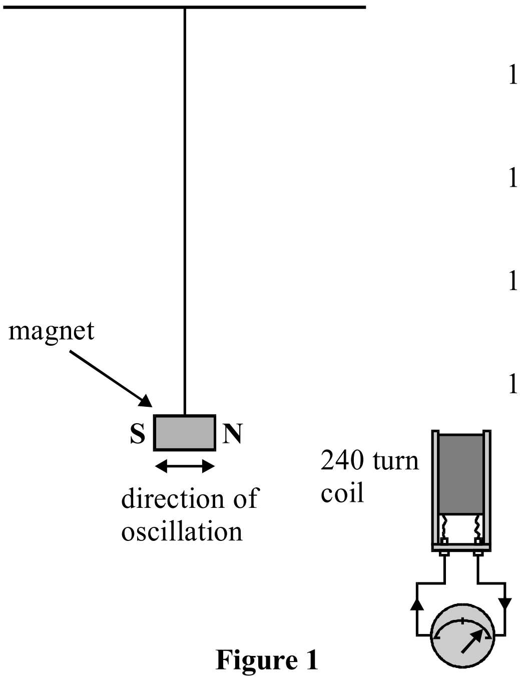

Figure 1

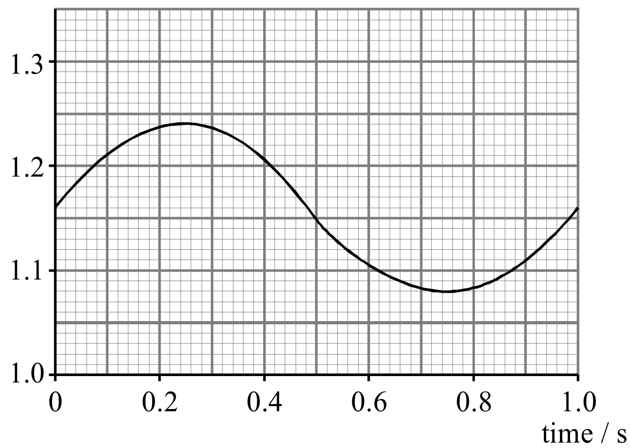

Figure 2

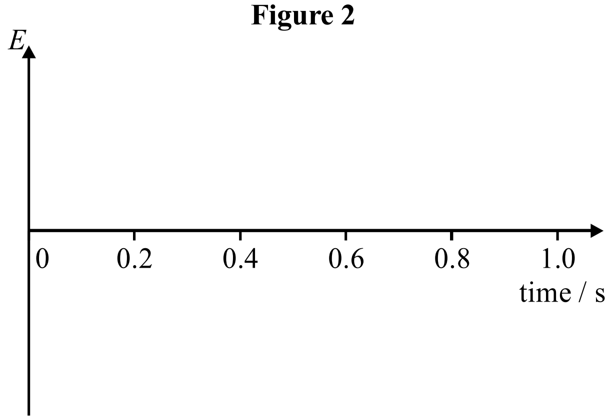

Figure 3

Figure 2 shows how the magnetic flux density, B, through the coil varies with time, t, for one complete oscillation of the magnet. The magnetic flux density through the coil can be assumed to be uniform.

(i) Calculate the maximum emf induced in the coil.

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....

(3)

(ii) Sketch on **Figure 3** a graph to show how the induced emf in the coil varies during the same time interval.

(2)

(iii) Explain how the pendulum may be modified to double the frequency of oscillation of the magnet.

....

....

(2)

(iv) The frequency of oscillation of the magnet is increased without changing the amplitude. Explain why this increases the maximum induced emf.

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(2)

(v) State **two** other ways of increasing the maximum induced emf.

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(2)

(vi) Explain how the output from the coil would have to be processed in order to store the information in a computer memory.

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(2)
(Total 15 marks)

37. Bone can be distinguished from soft tissue on a medical X-ray photograph of the human body. Explain how the bones and soft tissues affect the X-rays to cause this effect.

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(Total 2 marks)

38. (a) State and explain the benefits and drawbacks of X-rays compared with other technologies when used for medical diagnosis.

Two of the 7 marks in this question are available for the quality of your written communication.

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(b) (i) State a medical diagnostic technique that overcomes one of the limitations of X-rays that you mentioned.

Diagnostic technique... **(1)**

(ii) Explain how the diagnostic technique you stated in part (b)(i) overcomes the limitation of X-rays.

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.... **(1)**

38. Figures **1a** and **1b** each show a ray of light incident on a water-air boundary. **A, B, C** and **D** show ray directions at the interface.

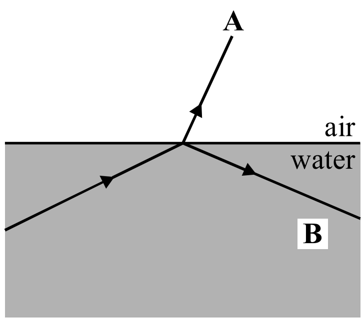


Figure 1a

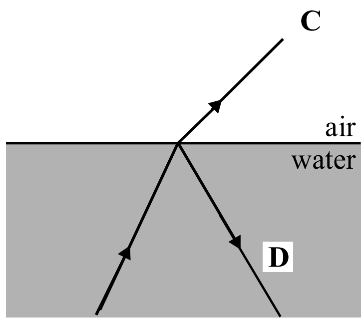


Figure 1b

(a) Circle the letter below that corresponds to a direction in which a ray cannot occur.

A **B** **C** **D**

(1)

(b) Circle the letter below that corresponds to the direction of the faintest ray.

A **B** **C** **D**

(1)

Teacher Resource Bank

GCE Physics B: Physics in Context

Additional Sample Questions (Specification B)

Mark Scheme

PHYB4 – Physics Inside and Out

1.	(a)	(i)	acceleration is increasing	B1	1
		(ii)	slope increases with time	B1	1
		(iii)	the gravitational field strength is reducing / the mass is reducing	B1	1
	(b)	(i)	$F = \dfrac{GMm}{R^2}$	B1	
			correct substitution $\dfrac{6.7\times10^{-11}\times3.9\times10^{3}\times6.0\times10^{24}}{1.0\times10^{14}}$	B1	2
		(ii)	makes appropriate calculation from one data set eg FR^2	M1	
			makes appropriate calculation from another data set	M1	
			shows that the two are equal	A1	3
		(iii)	determines area under curve	C1	
			approximately 12 cm squares **or** 1 cm square is 10^{10} J	C1	
			1.2×10^{11} J	A1	3
		(iv)	$F = mv^2/r$	C1	
			3.2×10^3 m s^{-1}	A1	2
		(v)	potential energy is increased	B1	
			there is a change in KE too	B1	
			KE is reduced	B1	
			chemical change not equal to PE change because of KE change	B1	
			relevant, correct comment about energy losses	B1	Max 3
					[16]

2.	C	1	
			[1]

3.	(a)	force acting per unit mass **or** $g = F / m$ **or** $g = \dfrac{GM}{R^2}$ with terms defined		1		
	(b)	(i)	direction of F_E correct in each diagram	B1	1	
			direction of F_M correct in each diagram	B1	1	
			direction of F_S correct in each diagram	B1	1	
			Fs must be distinguished from F_M			
			penalty of 1 mark for any missing labelling			3
		(ii)	sun and moon pulling in same direction / resultant of F_M and F_s is greatest / clear response including summation of F_M and F_s	M1	1	
			configuration A	A1	1	2

(c) $F = GMm/R^2$ C1 1

correct substitution $\dfrac{6.7\times10^{-11}\times2.0\times10^{30}}{\left(1.5\times10^{11}\right)^2}$ C1 1

(5.95 **or** 5.96 **or** 5.9 **or** 6.0) × 10^{-3} N kg^{-1} A1 1 3

[9]

4. (a) (i) F = 2500 or 2600 N B1

$F = mv^2/r$ B1

1500 m s^{-1} / 1480 m s^{-1}

or any further progress towards a solution such as
attempting to use: $F=GMm/r^2$
or $½\, mv^2 = mgh$
or equations of motion
or r= 6 ×′10^5
or $F = mv^2/(r+h)$

or evidence of time wasted, for example, repeated attempts at a solution
no unit penalty or s.f. penalty B1 3

(ii) using the area under the graph between 0 and 6.0 × 10^5 m

or use of $V_G = GM/r$ or $PE = GMm/r$ C1

between 20 and 22 squares

or 1 square = 10^8 J

or uses the trapezium rule or rectangle and triangle
(allow if they fail with powers of ten)

or attempts to find the difference between the 2 values of PE C1

2.0 × 10^9 J to 2.2 × 10^9 J

or attempt to complete the calculation
(may be confounded by lack of r) A1 3

(b) (work done by motors) relates to change in PE or (PE + KE) B1

2 × (PE + KE) condone 2 × (PE) B1

need to know energy value of fuel / fuel density / energy density of fuel / fuel economy / efficiency of engines B1 3

[9]

5. (a) direction changing, velocity vector B1 1

(b) Newton's law equation M1
centripetal force equation M1
cancel mass of Triton A1 3

(c) $\omega = 2\pi f$ or $\omega = 2\pi/T$ M1

$\omega^2 r^3$ = constant or $\omega^2 = \dfrac{GM}{r^3}$ M1

		$\frac{T_T^2}{T_P^2} = \frac{r_T^3}{r_P^3}$ **or** statement of Kepler III for B3	M1	4
		$\frac{T_T}{T_P} = \sqrt{\frac{(3.55\times10^8)^3}{(1.18\times10^8)^3}}$		
				[8]
6.	(a) (i)	Endpoint 1700	B1	
		Endpoint 5700	B1	2
	(ii)	counts squares [100 ± 10]	B1	
		evaluates energy/kg of one square [20 000 J/kg]	B1	
		computes total energy for 1 kg	C1	
		multiplies by 450 accept range 7×10^8 J $\rightarrow 10 \times 10^8$ J	A1	4
		or		
		Combines correct equations	B1	
		Read off from graph correct for *g* or quotes correct value	B1	
		Calculation correct	C1	
		Multiplies by 450 [ans: 9.2×10^8 J]	A1	
	(b)	Compares correctly **up to 3** of Gravitational potential (energy) Grav field (strength)/*g*/force of gravity/gravitational attraction Escape velocity Kinetic energy *not energy bald* Distance to neutral point OWTTE Fuel weight at launch/launch vehicle size (large first stage at Earth)	B3	
		Plus States earth mass > moon mass	B2	
		Quotes both values of g_{earth} (9.8 N/kg) and g_{moon} (1.7 N/kg) to 2sf or 6:1 ratio expressed unambiguously		Max 4
		Use of Physics terms is accurate, the answer is fluent/well argued with few errors in spelling, punctuation and grammar **And gains at least 2 marks for Physics**	B2	
		Use of Physics terms is accurate but the answer lacks coherence or the spelling, punctuation and grammar are poor **and gains at least 1 mark for Physics**	B1	
		Use of Physics terms is inaccurate, the answer is disjointed with significant errors in spelling, punctuation and grammar	B0	
				[12]
7.	A			**[1]**
8.	B			**[1]**
9.	D			**[1]**

10.	(a)	$F = \frac{\Delta(mv)}{t}$ or $Ft = mv - mu$ etc.		M1	
		substitute units		A1	2
	(b)	conservation of momentum mentioned		B1	
		ejected gas has momentum or velocity in one direction		B1	
		rocket must have equal momentum in the opposite direction		B1	3
		or			
		force = rate of change of momentum		(B1)	
		ejected gas has momentum or velocity in one direction		(B1)	
		rocket must have equal and opposite force		(B1)	
	(c)	equation seen ($F = m/t \times v$ but not $F= ma$)		B1	
		substitution into any sensible equation leading to 3.6×10^7 (N)		B1	2
					[7]
11.	(a)	use of V/T = constant		C1	
		127 °C		A1	2
	(b)	W = $p\Delta V$		C1	
		45 J		A1	2
	(c)	higher temperature		B1	
		greater pressure		B1	
		internal energy greater as no work done by the gas		B1	3
					[7]
12	(a)	(i)	the molecules of an ideal gas are assumed not to attract one another or negligible attractive force	B1	
			molecules of an ideal gas have no internal potential energy	B1	
			no work is done in separating molecules at constant pressure	B1	
			KE increases as the molecules move faster increasing the KE	B1	
			Max 3		
		(ii)	$3/2\ kT$ seen in a calculation ($3/2 \times 1.38 \times 10^{-23} \times 290$) or energy of 1 molecule = 6.0×10^{-21} J or $6 \times 10^{23} \times 0.025$ seen in calculation or number of molecules = 1.5×10^{22}	C1	1
			90 J	A1	1
	(b)	(i)	calculation of radius using circumference = $2\pi r$ (110 mm) $r = 0.690/2\pi$ seen in calculation	B1	1
			calculation of volume using $4/3\ \pi r^3$ (must see evidence: either substitution of radius in equation or a calculated value to 3 sf)	B1	1
		(ii)	use of T = 290 K or pressure = 1.62×10^5 Pa in pV $=nRT$	C1	1
			number of moles $=PV/RT=$ 0.37- 0.38 mol (0.23 mol common)	A1	1
			mass = 0.37 × 28 = 10.4 - 10.5 g (ecf common incorrect answer is 6.5)	B1	1
			$p\ V = \frac{m}{28}\ 8.3T$ with correct p *or* T gets 2		
		(iii)	1.53×10^5 Pa (ecf common answer with ecf is 0.95×10^5 Pa)	B1	1
					[11]

13.	(a)		**increase** in internal energy	B1	1
			heat / thermal energy supplied to the system or energy supplied to system by heating	B1	1
			work done **on** the system	B1	1
	(b)	(i)	constant temperature	B1	1
		(ii)	heat supplied to system = work done by system (or on surroundings)	B1	1
			work done on the system = heat transferred to surroundings (or from system)	B1	1
	(c)	(i)	$pV = nRT$	M1	1
			choice of point on curve and correct substitution giving e.g., 602(K) or 581(K) (all half a small square tolerance)	A1	1
		(ii)	**smooth** curve below first curve not touching curve of axes	B1	1
			correct point (need not be marked as dot provided curve passes through correct point – e.g. (0.2, 2))	B1	1
			2^{nd} correct point e.g. (0.4.,1)	B1	1
			supporting evidence – e.g., p_1V_1 or $pV = 4$ (=3.98)	B1	1
					[12]

14.	(a)		½ mv^2 or substitution ignoring powers of 10	C1	1
			3.75×10^{10} J	A	1
	(b)		$Q = mc\Delta\theta$	C1	1
			1785 seen	C1	1
			2.36×10^{9} J	A1	1
	(c)	(i)	$W = Fs$ or correctly substituted values	C1	1
			2.48×10^{6} N	A1	1
			condone effect of change of g.p.e.		
		(ii)	force = rate of change of momentum or use of an equation of motion	C1	1
			0.33 s	A1	1
		(iii)	$P = W/t$ or $P = Fv$ or substitution ignoring powers of 10	C1	1
			1.88 (or 1.86) × 10^{8} W e.c.f. from (c)(ii)	A1	1
					[11]

15.	(a)	(i)	acceleration is increasing	B1	1
		(ii)	slope increases with time	B1	1
		(iii)	the gravitational field strength is reducing / the mass is reducing	B1	1
	(b)	(i)	$F = \dfrac{GMm}{R^2}$	B1	
			correct substitution $\dfrac{6.7\times10^{-11}\times3.9\times10^{3}\times6.0\times10^{24}}{1.0\times10^{14}}$	B1	2
		(ii)	makes appropriate calculation from one data set eg FR^2	M1	
			makes appropriate calculation from another data set	M1	
			shows that the two are equal	A1	3
		(iii)	determines area under curve	C1	

			approximately 12 cm squares **or** 1 cm square is 10^{10} J	C1	
			1.2×10^{11} J	A1	3
		(iv)	$F = mv^2/r$	C1	
			3.2×10^3 m s^{-1}	A1	2
		(v)	potential energy is increased	B1	
			there is a change in KE too	B1	
			KE is reduced	B1	
			chemical change not equal to PE change because of KE change	B1	
			relevant, correct comment about energy losses	B1	Max 3
					[16]
16.	C				
					[1]
17.	(a)	(i)	period = 1.2 s or $T = l/f$	C1	
			0.83 Hz or 0.833	A1	2
		(ii)	period /frequency is the same or $T_1 = T_2$	B1	
			since T depends on $\frac{m}{k}$ – **or** $T = 2\pi\sqrt{\frac{m}{k}}$ and k *is* constant	B1	2
		(iii)	waveform sinusoidal or fits $x = A \sin \omega t$ (accept cos waveform)	M1	
			A after 1/8 cycle should be $A/\sqrt{2}$		
			or find ω (= $2\pi f$) and A; calculate x at any time and compare	A1	
			or use gradients to plot $v - t$ then $a - t$ graphs	M1	
			check whether $\frac{a}{s}$ for all t is constant	A1	2
	(b)	(i)	correct curvature with values at ends and centre correct and crossing at 0.08 ± 1 small square both sides	B1	1
		(ii)	correct curvature	M0	
			end displacements correct (1/2 that for **X** i.e. 0.1)	A1	
			maximum correct (1/4 that for **X** i.e. 0.04 ± 1 small square)	A1	2
	(c)		reads maximum energy and displacement correctly 0.16 J and 0.20 m (allow e.c.f. for (b)(i) and (b)(ii))	C1	
			quotes $E = \frac{1}{2}k\Delta\chi^2$ *or* $E = \frac{1}{2}$ *Fx and F= kx*	C1	
			correct substitution leading to a value for k (8.0 N m^{-1})	A1	
			or maximum speed of oscillator **X** = ωA (using maximum gradient ≈ 0.2/0.15 or $27\pi fA$ (1.04 ms^{-1}))	C1	
			mass of oscillator from $E_m = ½ mv^2$ gives 0.189 kg (v = 1.04 gives 0.296 kg)	C1	
			$T = 2\pi\sqrt{\frac{m}{k}}$ leading to a value for k (k = 5.2 Nm^{-1}) (v = 1.04 gives 8.1 N m^{-1})	A1	

			(discrepancy due to difficulty of measuring gradient)		3 **[12]**
18.	(a)	(i)	mention of large amplitude **or** maximum energy	B1	
			mention of applied frequency being matched to natural frequency of building	B1	2
		(ii)	time for one oscillation **or** $T = \frac{1}{f_n}$	B1	
			T_n or f_n when no forcing frequency applied consistently	B1	2
	(b)	(i)	0.4 or use of $f = 1/T$	C1	
			4 storeys	A1	2
		(ii)	3 cycles shown, constant period, $T = 0.4$ s **or** T shown on graph	B1	
			decay in amplitude	B1	2
		(iii)	applied frequency no longer = natural frequency	B1	
			not just 'no longer resonates'; allow 'now $T = 0.5$ s'		1
		(iv)	2 possible resonant frequencies	B1	
			collisions between two buildings **or** one collapses on other	B1	2
	(c)	(i)	$\omega = 2\pi f$ **or** $\omega = \frac{2\pi}{T}$ **or** $\omega = 9.4(2)$	C1	
			$v = \omega A$ or equivalent	C1	
			11.3 m s^{-1}	A1	3
		(ii)	$a = \omega^2 A$	C1	
			107(106) m s^{-2} (e.c.f. for ω from (c)(i))	A1	2 **[16]**
19.	C				**[1]**
20.	A				**[1]**
21.	(a)	(i)	system made to oscillate by a periodic external force / energy source **or** system made to oscillate by another oscillator it is connected to **or** another oscillator forcing the system to vibrate **or** an oscillator forcing another oscillator to vibrate due to its own vibrations	B1	1
			not made to oscillate by an external force **not** when its vibrations are not at its natural frequency **not** when it is made to oscillate by another system		
		(ii)	frequency of wheel (motor)= natural frequency of system condone 'fundamental or resonant frequency' of the system **or** rotating wheel rotates at the resonant / fundamental frequency of the system	B1	1
			must be reference to the wheel or motor or driver oscillator **not** just when it vibrates at its natural frequency		

	(b)		$T = 1.25$ s	B1	
			$T = 2\pi(m/k)^{1/2}$ **or** numerical substitution	C1	
			0.36 kg allow e.c.f. for T; 0.6 s gives 0.82 kg	A1	3
	(c)	(i)	correct process using ratios (eg times to halve marked on the graph)	B1	
			three amplitudes read correctly **or** two times to halve read correctly	B1	
			ratios determined and conclusion drawn that it is exponential **or** a clear statement that the time to halve is the same for points indicated and conclusion that it is exponential	B1	3
		(ii)	amplitude correct for 25 s , i.e. 4 to 4.2 cm **or** energy proportional to A^2 (allow $0.5\ kA^2$ or $0.5\ kx^2$)	C1	
			allow e.c.f. from (b); $T = 0.6$ s leads to amplitude = 6.8 cm ; ratio = 0.46		
			0.16-0.19 **or** 17/100 (2 s.f. only)	A1	2
					[10]
22.	(a)		Max to zero to max with zero at 0 displacement and correct amplitude	M1	
			correct shape drawn with reasonable attempt to keep total energy constant, crossing at 1×10^{-2}J	A1	2
	(b)	(i)	0.044 m	B1	1
		(ii)	$x = 0.044 \cos 2\pi 3.5t$ (0.044 cos 22t) or $x = 0.044 \sin 2\pi 3.5t$ etc ecf for A	B1	1
		(iii)	$\alpha_{max} = (2\ \pi\ 3.5)^2\ 0.044$	C1	
			21 (21.3) m s^{-2} ecf for A and incorrect $2\pi f$ from (ii) (0.042 gives 20.3; 0.04 gives 19.4)	A1	2
					[6]
23.	(a)		displacement negative cosine	B1	1
			velocity consistent with first graph	B1	1
			acceleration consistent with first or second graph	B1	1
			at least one cycle, constant amplitude (condone small decay), include A for displacement, reasonably drafted	B1	1
	(b)		use of $T = 2\pi\sqrt{\frac{m}{k}}$ i.e. substituted values or 0.74 seen	C1	1
			use or implied use of $T = \frac{1}{f}$	C1	1
			1.34 Hz	A1	1
					[7]

24.	(a)		acceleration/force is directed toward a (fixed) point/the centre/the equilibrium position **or** $a = -kx$ + '–' means that a is opposite direction to x	B1	
			acceleration/force is proportional to the distance from the point/displacement **or** $a = -kx$ where a = acceleration; x = displacement and k is constant	B1	2
	(b)	(i)	$3.2 = 2\pi\sqrt{l/9.8}$ (condone use of $g = 10$ m s^{-2} for C mark) (use of $a = -\omega^2 x$ is a PE so no marks)	C1	
			2.5(4) m	A1	2
		(ii)	Correct value at 0.5 m and correct curvature	M1	
			Energy at 1 m = 160 J	A1	2
					[6]
25.	(a)	(i)	acceleration (not a) and displacement (not x) are in opposite directions OR restoring force/acceleration always acts toward rest position	B1	1
		(ii)	(+) sine curve consistent with a graph	B1	1
	(b)	(i)	statement that $E_K = E_P$	B1	
			statement of max values considered	B1	
			$E_P = ½\, k(\Delta l)^2$ or $E_{Pmax} = ½\, kA^2$	B1	
			correctly substituted values	B1	
			$E_K = 3.7 \times 10^{-2}$ J	B1	
			OR		
			$f = 1/T$ or $T = 3.97$ s or period equation	B1	
			leading to $f = 0.252$ Hz	B1	
			$\omega_{max} = 1.58$ rad s^{-1} or $v_{max} = 0.055$ms^{-1} (seen or used)	B1	
			substituted values into $E_K = ½mA^2\omega^2$ or $E_K = ½mv^2$	B1	
			$E_K = 3.7 \times 10^{-2}$ J	B1	5
		(ii)	any attenuation from t=0 seen	M1	
			10 mJ or $E_0/4$ at either 4s or third hump	M1	
			consistent period values minima at 1 and 3s maxima at 0 and 4s	A1	3
					[10]
26.	(a)		velocity is vector	B1	
			velocity is changing	B1	
			there is an acceleration **or** mention of centripetal force	B1	3
	(b)		$F = mv^2 / r$ with terms defined	B1	1
	(c)		acceleration = v^2/ r	C1	
			28 m s^{-1}	A1	2
					[6]

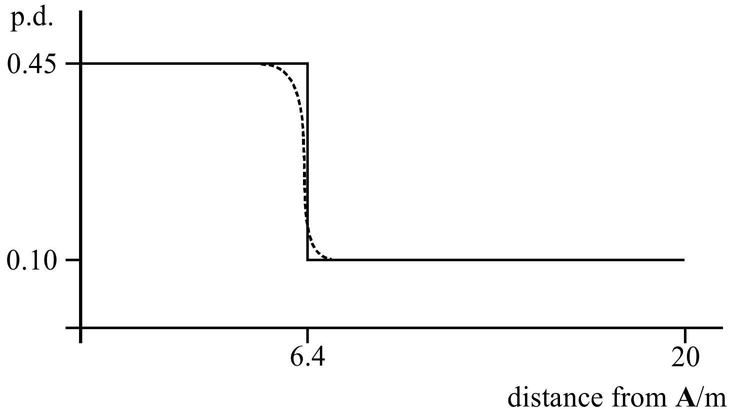
27.	(a)	(i)	loss of PE = gain of KE **or** $mgh = ½mv^2$ allow for statement of conservation of energy (energy can not be destroyed but can be converted from one form to another)	B1	
			correct height used (2.4 m or 2 × 1.2 seen in an equation)	B1	
			correct substitution including values for h and g (no u.p.)	B1	3
		(ii)	$F = mv^2/r$ (allow $mr\omega^2$)	C1	
			2800 N (2780 N) **or**		
			2700 N (2740 N) if using $v = 6.86$ m s^{-1}	A1	2
		(iii)	(ii) + 690 (3500 N or 3460 N)	B1	1
			(3400 N or 3430 N if using $v = 6.86$ m s^{-1})		
		(iv)	graph shape down up down up (condone linear); minima at 90° and 270°	M1	
			graph starts at 690 (N); this point labelled; maximum labelled consistent with answer to (a)(iii), zero at 90 and 270 (allow any shape between these points)	A1	2
	(b)		stress = F/A **and** strain = extension /original length **and** E = stress / strain **or** $E = Fl/Ae$	C1	
			correct substitution using 690 N (condone 700 N) **or** substitution with e.c.f. from graph allow e.c.f. for use of g without substitution if penalised in (a)(i)	C1	
			$8.9 \times 10^{-6} – 9.1 \times 10^{-6}$ m	A1	
			allow only 1 mark if candidate divides by 2 at any stage		3 **[11]**
28.	(a)		the radius/diameter of the planet **not** 'size'	B1	
			the mass (or density) of the planet	B1	2
	(b)	(i)	volume of the granite = $4/3\ \pi\ r^3$ **or** radius of the granite = 0.2 km (may be seen in an incorrect equation)	B1	
			200^3 or $4/3\ \pi\ 0.2^3$ or 3.35×10^7 m^3	B1	
			Mass = density × volume used with any density and their volume (Volume may be in formula form) If they use correct volume then either 1.24×10^{11} or 7.37×10^{10} gets the mark)	B1	
			(3700-2200) × 3.35×10^7 **or** 1500 × 3.35×10^7 kg **or** ($1.24 \times 10^{11} – 7.37 \times 10^{10}$) **or** 5.025×10^{10} **or** 5.03×10^{10} seen Condone rounding off early leading to 4.6×10^{10} kg	B1	4
			NB 1)the fourth mark is not for 5.0×10^{10} – all working must be shown 2)those who do not show conversion of radius from km to m in the calculation but otherwise correct will get 3		
		(ii)	Gravitation field strength $g = GM/r^2$		

			or uses distance of 0.4 km for *r*	C1	
			Substitution for extra field strength = $6.7 \times 10^{-11} \times 5.0 \times 10^{10}/(0.4\times10^{3})^{2}$ Condone $r = 0.4$ for this mark	C1	
			Correct substitution for the extra field strength with **correct** powers of 10	C1	
			2.1×10^{-5} N kg^{-1} (condone m s^{-2}) **or** 1.9×10^{-5} if 4.6×10^{10} carried forward from (i)	A1	4
		(iii)	Correct general shape always below original curve	B1	1
					[11]

Alternative scheme for different approach to (ii)

		(ii)	Gravitation field strength = GM/r^2 or uses distance of 0.4 km for *r*	C1	
			Correct substitution for field strength for granite (or soil) $6.7 \times 10^{-11} \times 1.24 \times 10^{11}/(0.4\times10^{3})^{2}$ or $6.7 \times 10^{-11} \times 7.37 \times 10^{10}/(0.4\times10^{3})^{2}$ Condone r = 0.4 for this mark	C1	
			Correct substitution for field strength for soil (or granite)	C1	
			2.1×10^{-5} N kg^{-1} (condone m s^{-2})	A1	4

29.	(a)		low (no) resistance between contacts	B1	1
	(b)	(i)	nearer to **B**	M0	
			resistance of soil is lower	A1	
			ions present to enable conduction / pd changes less with distance from **A**	A1	2
		(ii)	6.2 - 6.6 m	B1	1
		(iii)	8.2 – 8.4 V	B1	1
		(iv)	$R = V/I$ or (b)(iii) / 5.0 mA	C1	
			1700 Ω	A1	2
	(c)		resistance near A = 0.45 V per half metre	B1	
			resistance near B = 0.10 V per half metre	B1	
			may be calculated separately or shown on graph.		



		graph as shown with discontinuity (may be curved or stepped) at value consistent with their (b)(iii)	B1	3
				[10]
30.	(a)	Earth movement makes case, and hence the coil, move (immediately)	B1	
		the magnet has large mass (inertia) and accelerates slowly as springs exert a force	B1	
		the mass spring system oscillates following the initial movement of the case (appreciation of simple harmonic oscillations)	B1	3
	(b)	flux linking coil changes **or** coil cuts flux	B1	
		an emf is induced in the coil	B1	2
	(c)	movement of particles in vicinity of explosion pass energy to nearby particles	B1	
		these in turn pass on energy to particles further away	B1	
		the energy may travel as a longitudinal or transverse wave	B1	
		molecules in ore deposits are held bonded lattice so energy passed on quickly to nearby particles **or** elasticity of ore deposits is higher than that of loose soil **or** particles have to move further in loose soil to pass on energy to neighbouring particles	B1	4
		the use of Physics terms is accurate, the answer is fluent / well argued with few errors in spelling, punctuation and grammar	2	
		the use of Physics terms is accurate, but the answer lacks coherence or the spelling, punctuation and grammar are poor	1	
		the use of Physics terms is inaccurate, the answer is disjointed, with significant errors in spelling, punctuation and grammar	0	
		Max 2		
				[11]
31.	B			
				[1]
32.	(a)	electrons	B1	1

	(b)	(i)	the same	B1	1
		(ii)	$nA_A v_A q = nA_B v_B q$ **or** $v_B/v_A = A_A/A_B$	B1	
			= 3	B1	2
	(c)		current decrease	B1	
			(because) resistance increases with temperature	B1	
			[temperature rise leads to] increased collisions of electrons with lattice	B1	
			slower drift speed/impedes electron flow	B1	
			pd constant	B1	
			therefore I proportional to l/R (so current drops)	B1	max 5
			the use of Physics terms is accurate; the answer is fluent/well argued with few errors in spelling, punctuation and grammar, and candidate obtains at least 4 for Physics	2	
			the use of Physics terms is accurate but the answer lacks coherence or the spelling, punctuation and grammar are poor, and candidate obtains at least 2 for Physics	1	
			the use of Physics terms is inaccurate; the answer is disjointed with significant errors in spelling, punctuation and grammar	0	
			max 2		
					[11]

33.	(a)	potential / voltage divider		B1	1
	(b)	12 V		B1	1
	(c)	when $R_2 = 0$,	$V_{AB} = 12$ V	B1	
		when $R_2 = 20\ \Omega$,	$V_{AB} = 2$ V $\left(\frac{12\text{ V}}{24\Omega}\times 4\Omega\right)$	B1	2
	(d)	when $R_2 = 0$,	$V_{BC} = 0$	B1	
		when $R_2 = 20\ \Omega$,	$V_{BC} = 10$ V	B1	2
					[6]

34. C

[1]

35.	(a)		the flux density when a conductor carrying a current of 1 A experiences a force of 1 N per metre (condone $NA^{-1}\ m^{-1}$ and $Wb\ m^{-2}$)	B1	1
	(b)		apparatus that would work: coil, pivot, balancing weight	B1	1
			current direction consistent with arrangement	B1	1
			direction of force on conductor consistent	B1	1
	(c)	(i)	use of $F = BIl$ *or* F = $BIlN$ or substituted values	C1	1
			6.6×10^{-2} N	A1	1
		(ii)	induced back emf	B1	1
			as conductor cuts the magnetic field	B1	1
		(iii)	difference in current = 0.41 A or two correct voltages	C1	1
			back emf = 0.205 V or $V = IR$ used appropriately	C1	1

			attempted use of E = $\Delta(N\Phi)/\Delta t$	C1	1
			$1.02(5) \times 10^{-2}$ Wbs^{-1}	A1	1
					[12]
36.	(a)	(i)	(magnetic) flux Not flux linkage	B1	1
		(ii)	weber or tesla-metre^2 or Wb or T m^2	B1	1
	(b)	(i)	max dB/dt determined using tangent drawn at t = 0, 0.5 s or 1.0 s (value should be in range 0.5 to 0.8 ($\times 10^{-2}$ T s^{-1}) or coordinates in an equation) (condone powers of 10)	B1	
			Attempt to apply Δ(BAN)/t e.g. induced emf = 240 × 2.5 × 10^{-4} × dB/dt (ignore powers of 10 here) (any B divided by any t is sufficient evidence e.g. 0.24 s or 1 s)	C1	
			Answer **using correct method** in range 0.30 – 0.50 mV (allow 1, 2 or 3 sf answers)	A1	3
		(ii)	Graph showing positive and negative values	M0	
			zero emf at approximately correct times (0.20 to 0.26 s and 0.70 to 0.76 s)	A1	
			maximum at correct times **and** correct shape Ignore phase; Must show positive and negative emfs	A1	2
		(iii)	Pendulum has to be shorter	C1	
			Length reduced to ¼ original length	A1	2
		(iv)	the (maximum) speed of the magnet increases (condone angular speed)	B1	
			the (maximum) rate of change of flux increases **or** wires/coil cuts flux at a higher rate	B1	2
		(v)	**ANY 2 from**		
			use a stronger/more powerful magnet	B1	
			use a coil with more turns (allow more coils)	B1	
			(use a coil with) greater area (**Not** magnet with greater area)	B1	
			use a soft iron core in the coil	B1	
			use a larger amplitude of oscillation of the magnet	B1	Max 2
		(vi)	output/voltage would be sampled **or** sample at a frequency (much) higher than that of the pendulum	B1	
			changed to digital/binary form **or** processed by an A – D converter	B1	2
					[15]
37.	(a)		X - rays are absorbed	B1	
			Bones absorb more **OR** absorption depends on density	B1	
			[NOT 'bones stop X-rays' or 'X-rays reflect from bone']		
					[2]

38.	(a)	One benefit Second benefit One drawback Second drawback states physical principle of one of above [notate ✓[p]]	B1 B1 B1 B1 B1	
	(b)	Use of physics terms is accurate, the answer is fluent/well argued with few errors in spelling, punctuation and grammar **And gains at least** 3 **marks for physics** Use of physics terms is accurate but the answer lacks coherence or the spelling, punctuation and grammar are poor **and gains at least** 1 **mark for physics** Use of physics terms is inaccurate, the answer is disjointed with significant errors in spelling, punctuation and grammar	B2 B1 B0	7
		(i) Stated technique (e.g. ultrasound)	B1	
		(ii) Explanation of how technique overcomes limitation B2	B1	2
				[9]

38.	(a)	A	B1	
	(b)	D	B1	
				[2]