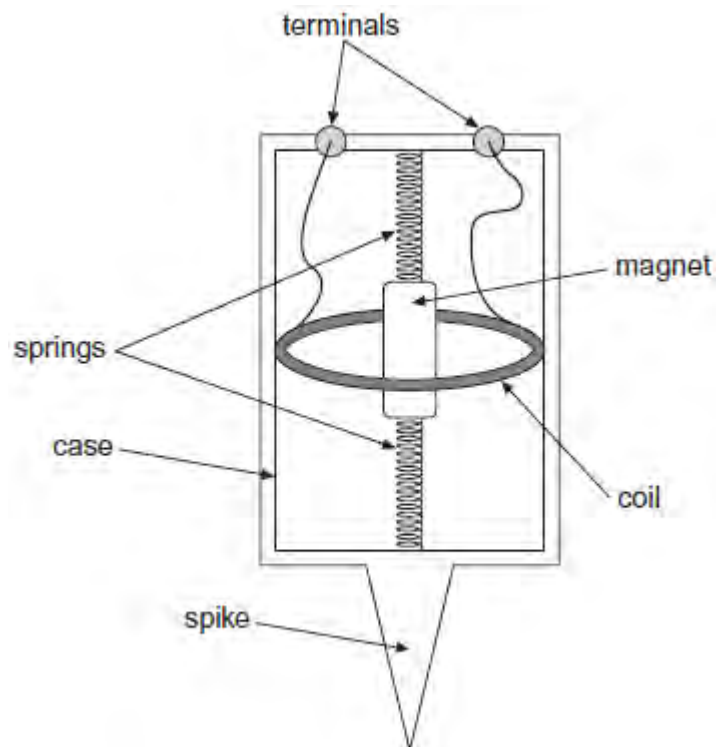**Q1.** A simple pendulum has a time period of 1.42 s on Earth. The gravitational field strength at the surface of Mars is 0.37 times that at the surface of the Earth.
What is the time period of the pendulum on Mars?

    A   0.53 s

    B   0.86 s

    C   2.33 s

    D   3.84 s

(Total 1 mark)

Q2. The diagram below shows the main parts of a geophone.

The spike attaches the geophone firmly to the ground. At the instant an earthquake occurs, the case and coil move upwards due to the Earth's movement. The magnet remains stationary due to its inertia. In 3.5 ms, the coil moves from a position where the flux density is 9.0 mT to a position where the flux density is 23.0 mT.

(a)   The geophone coil has 250 turns and an area of 12 cm^2.

Page 2

Calculate the average emf induced in the coil during the first 3.5 ms after the start of the earthquake.

emf V

(3)

(b)   Explain how the initial emf induced in the coil of the geophone would be affected:

if the stiffness of the springs were to be increased

....

....

if the number of turns on the coil were to be increased.

....

....

(2)

(c)   (i)   The geophone's magnet has a mass of 8.0×10^{-3} kg and the spring stiffness of the system is 2.6 N m^{-1}.

Show that the natural period of oscillation of the mass–spring system is approximately 0.35 s.

(2)

(ii) At the instant that the Earth stops moving after one earthquake, the emf in the coil is at its maximum value of +8 V. The magnet continues to oscillate.

On the grid below, sketch a graph showing the variation of emf with time as the magnet's oscillation decays.
Show at least **three** oscillations.
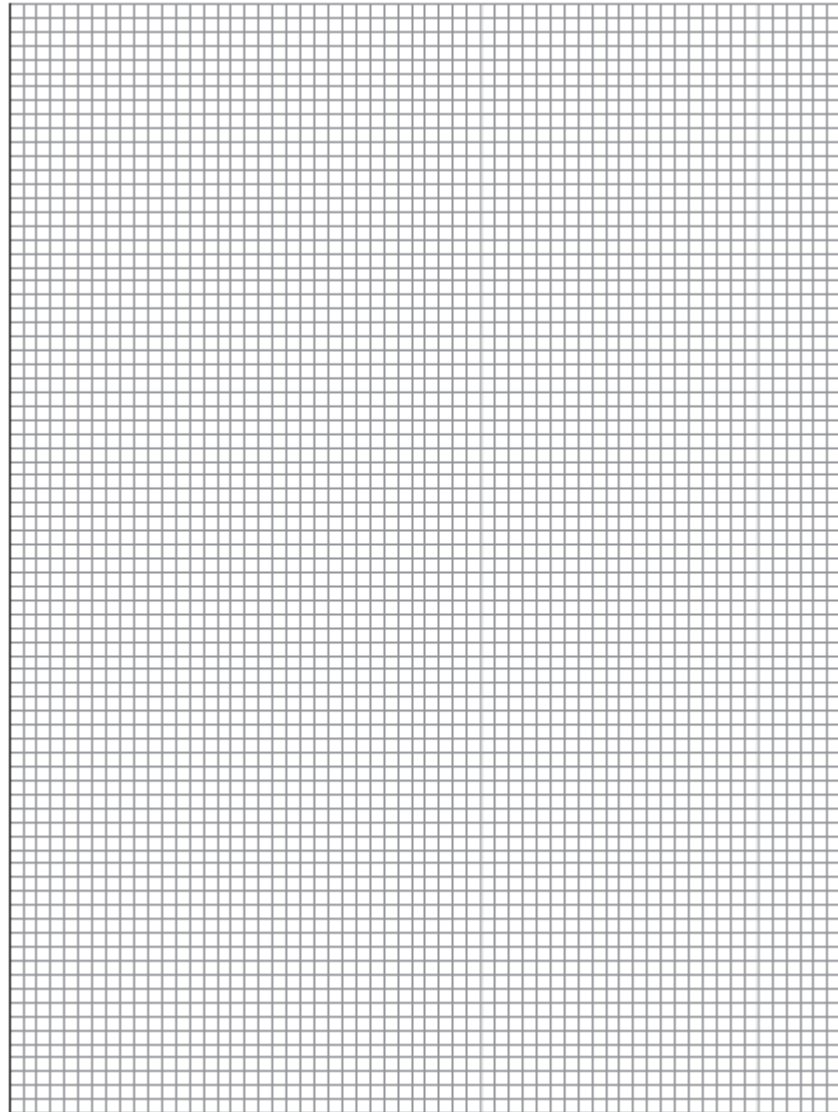
(3)
(Total 10 marks)

Q3. A simple pendulum and a mass-spring system have the same oscillation frequency f at the surface of the Earth. The pendulum and the mass-spring system are taken down a mine where the acceleration due to gravity is less than at the surface. What is the change in the frequency of the simple pendulum and the change in the frequency of the mass-spring system?

	simple pendulum	mass-spring	
A	f increases	f decreases	☐
B	f decreases	f decreases	☐
C	f increases	f stays unchanged	☐
D	f decreases	f stays unchanged	☐

(Total 1 mark)

Q4. The tip of each prong of a tuning fork emitting a note of 320 Hz vibrates in simple harmonic motion with an amplitude of 0.50 mm.
What is the speed of each tip when its displacement is zero?

A   zero

B 0.32π mm s^{-1}

C 160π mm s^{-1}

D 320π mm s^{-1}

(Total 1 mark)

Q5. (a)   (i)   Name the **two** types of potential energy involved when a mass–spring system performs vertical simple harmonic oscillations.

....

....

(1)

(ii)   Describe the energy changes which take place during one complete oscillation of a vertical mass-spring system, starting when the mass is at its lowest point.
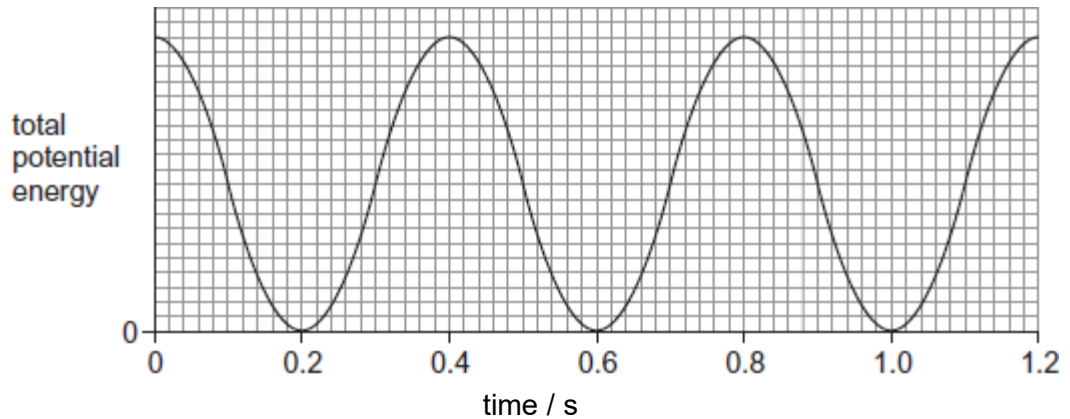
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Page 5

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(2)

(b)   **Figure 1** shows how the **total** potential energy due to the simple harmonic motion varies with time when a mass-spring system oscillates vertically.

Figure 1

(i)   State the time period of the simple harmonic oscillations that produces the energy–time graph shown in **Figure 1**, explaining how you arrive at your answer.
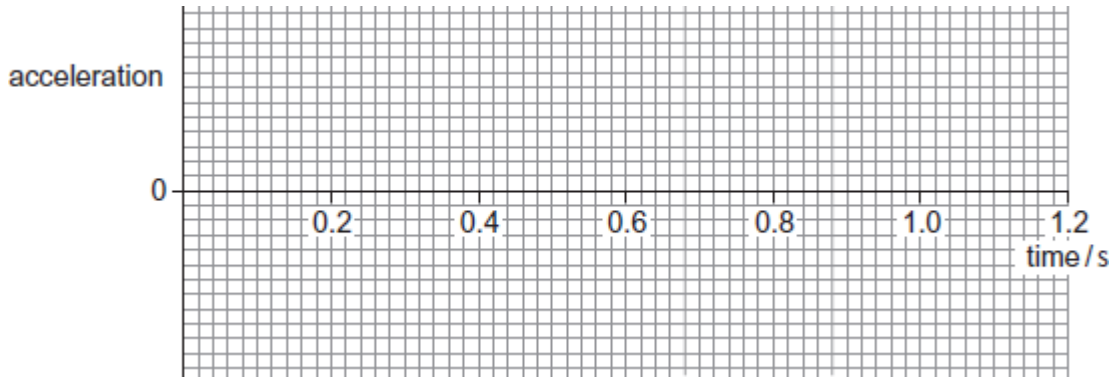
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(2)

(ii)   Sketch a graph on **Figure 2** to show how the acceleration of the mass varies with time over a period of 1.2 s, starting with the mass at the highest point of its oscillations. On your graph, upwards acceleration should be shown as positive and downwards acceleration as negative. Values are not required on the acceleration axis.

Figure 2

(2)

(c) (i) The mass of the object suspended from the spring in part (b) is 0.35 kg. Calculate the spring constant of the spring used to obtain **Figure 1**. State an appropriate unit for your answer.

spring constant .... unit ....

(3)

(ii) The maximum kinetic energy of the oscillating object is 2.0×10^{-2} J. Show that the amplitude of the oscillations of the object is about 40 mm.

(4)
(Total 14 marks)

Q6. When a mass suspended on a spring is displaced, the system oscillates with simple harmonic motion. Which one of the following statements regarding the energy of the system is **incorrect?**

A   The potential energy has a minimum value when the spring is fully compressed or fully extended.

B   The kinetic energy has a maximum value at the equilibrium position.

C The sum of the kinetic and potential energies at any time is constant.

D The potential energy has a maximum value when the mass is at rest.

(Total 1 mark)

Q7. When a mass M attached to a spring X, as shown in **Figure 1**, is displaced downwards and released it oscillates with time period T. An identical spring is connected in series and the same mass M is attached, as shown in **Figure 2**.

What is the new time period?

Figure 2

Figure 1
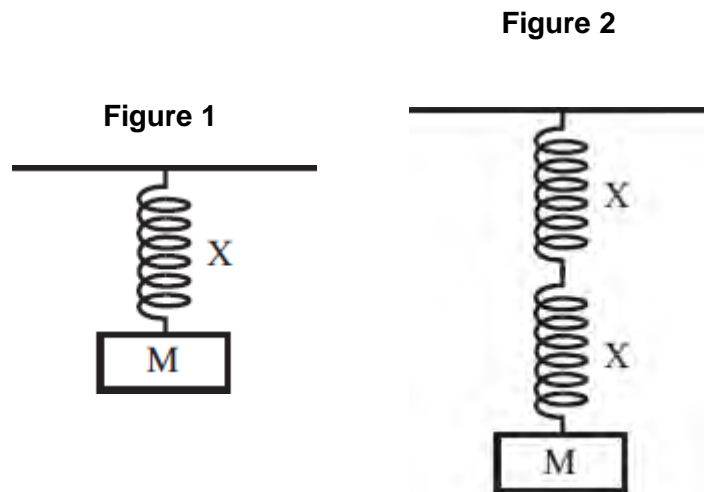
A $\dfrac{T}{2}$

B $\dfrac{T}{\sqrt{2}}$

C $\sqrt{2T}$

D $2T$

(Total 1 mark)

Q8.(a) A simple pendulum is given a small displacement from its equilibrium position and performs *simple harmonic motion*.

State what is meant by simple harmonic motion.

....

Page 8

....

....

....

(2)

(b) (i) Calculate the frequency of the oscillations of a simple pendulum of length 984 mm. Give your answer to an appropriate number of significant figures.

frequency .... Hz

(3)

(ii) Calculate the acceleration of the bob of the simple pendulum when the displacement from the equilibrium position is 42 mm.

acceleration .... ms^{-2}

(2)

(c) A simple pendulum of time period 1.90 s is set up alongside another pendulum of time period 2.00 s. The pendulums are displaced in the same direction and released at the same time.

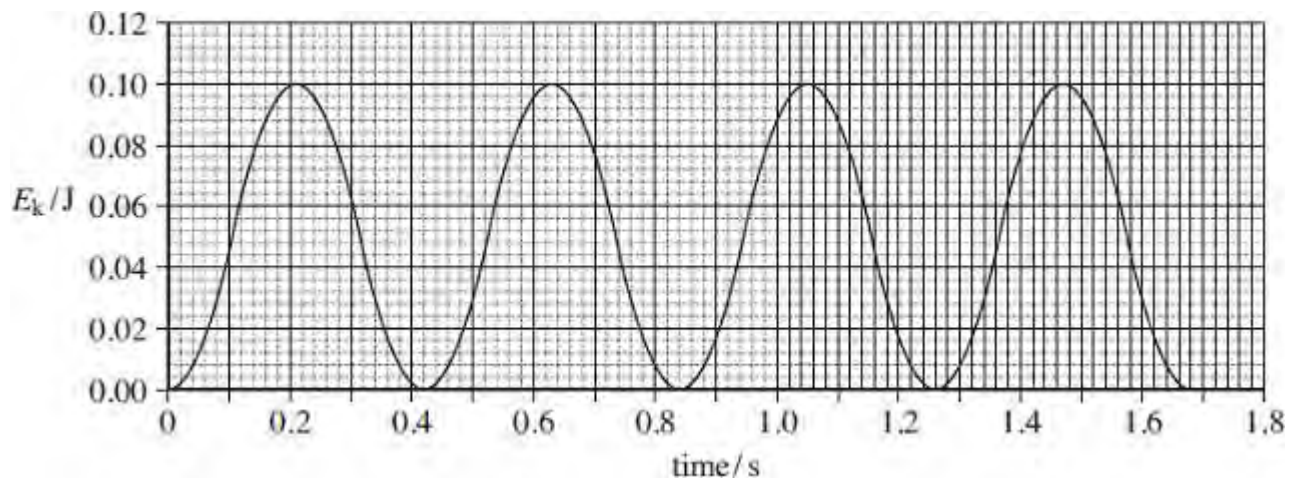Calculate the time interval until they next move in phase. Explain how you arrive at your answer.

....

....

....

....

time interval .... s

(3)
(Total 10 marks)

Q9.(a) **Figure 1** shows how the kinetic energy, E_k, of an oscillating mass varies with time when it moves with simple harmonic motion.

Figure 1

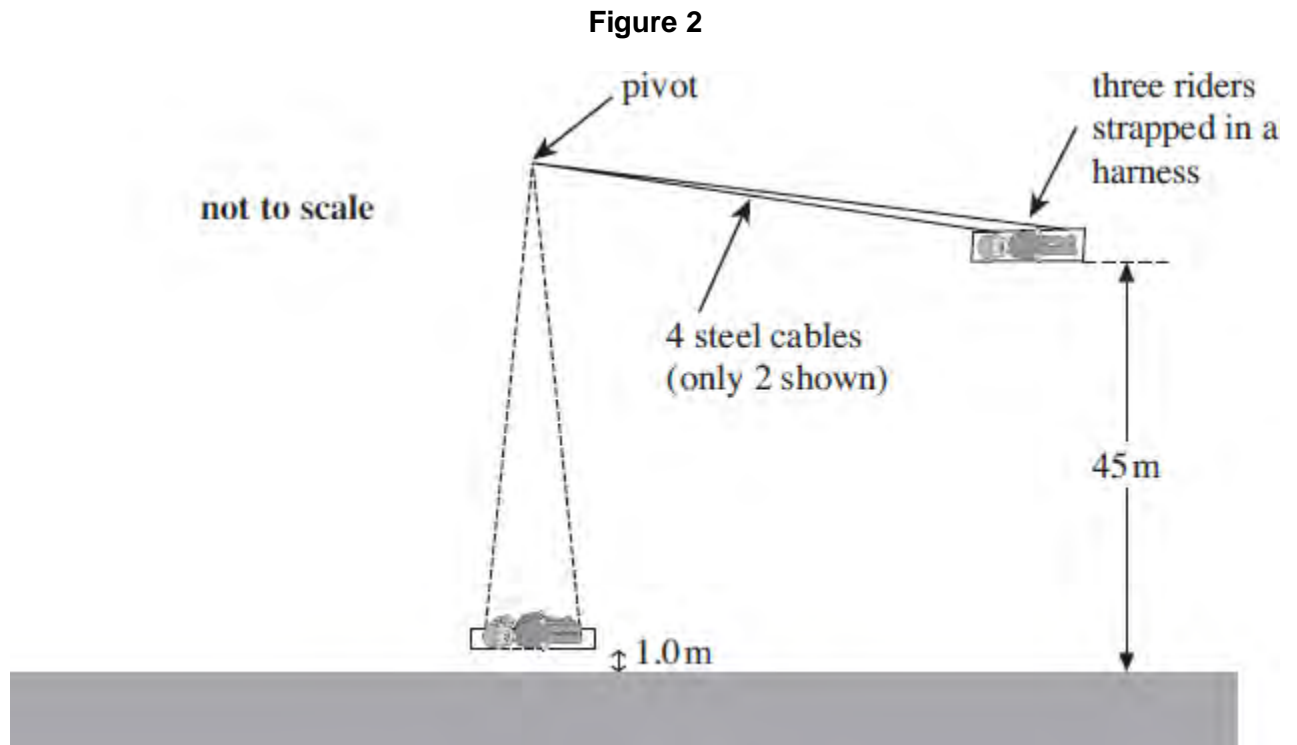(i) Determine the frequency of the oscillations of the mass.

frequency of oscillation .... Hz

(2)

(ii) Sketch, on **Figure 1**, a graph showing how the potential energy of the mass varies with time during the first second.

(2)

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(b) **Figure 2** shows a ride called a 'jungle swing'.

Figure 2

The harness in which three riders are strapped is supported by 4 steel cables. An advert for the ride states that the riders will be released from a height of 45 m above the ground and will then swing with a period of 14.0 s. It states that they will be 1.0 m above the ground at the lowest point and that they will travel at speeds of 'up to 120 km per hour'.

(i) Treating the ride as a simple pendulum, show that the distance between the pivot and the centre of mass of the riders is about 49 m.

(2)

(ii) The riders and their harness have a total mass of 280 kg.
Calculate the tension in each cable at the lowest point of the ride, assuming that the riders pass through this point at a speed of 120 km h^{-1}. Assume that

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the cables have negligible mass and are vertical at this point in the ride.

tension in each cable .... N

(4)

(iii) Show that the maximum speed stated in the advert is an exaggerated claim. Assume that the riders are released from rest and neglect any effects of air resistance.

(4)

(iv) The riders lose 50% of the energy of the oscillation during each half oscillation. After one swing, the speed of the riders as they pass the lowest point is 20 m s^{-1}.

Calculate the speed of the riders when they pass the lowest point, travelling in the same direction after two further complete oscillations.

speed of riders .... ms^{-1}

(3)
(Total 17 marks)

Q10. A simple pendulum and a mass-spring system are taken to the Moon, where the gravitational field strength is less than on Earth. Which line, **A** to **D**, in the table correctly describes the change, if any, in the period when compared with its value on Earth?

	period of pendulum	period of mass-spring system
A	increase	no change
B	increase	increase
C	no change	decrease
D	decrease	decrease

(Total 1 mark)

Q11. Two pendulums, P and Q, are set up alongside each other. The period of P is 1.90 s and the period of Q is 1.95 s.

How many oscillations are made by pendulum Q between two consecutive instants when P and Q move in phase with each other?

A   19

B   38

C   39

D   78

(Total 1 mark)

Q12.   A mass on the end of a spring undergoes vertical simple harmonic motion. At which point(s) is the magnitude of the resultant force on the mass a minimum?

A   at the centre of the oscillation

B   only at the top of the oscillation

C   only at the bottom of the oscillation

D   at both the top and bottom of the oscillation

(Total 1 mark)

Q13. A baby bouncer consisting of a harness and elastic ropes is suspended from a doorway. When a baby of mass 10 kg is placed in the harness, the ropes stretch by 0.25 m. When the baby bounces, she starts to move with vertical simple harmonic motion. What is the time period of her motion?

A   1.0 s

B   2.1 s

C   2.3 s

D   3.1 s

(Total 1 mark)