Oscillations & The Simple Harmonic Oscillator

Question Paper

Level	International A Level
Subject	Physics
Exam Board	Edexcel
Topic	Physics from Creation to Collaps
Sub Topic	Oscillations & The Simple Harmonic Oscillator
Booklet	Question Paper

Time Allowed: **68 minutes**

Score: **/56**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 A mass hanging from the end of a vertical spring is set into undamped simple harmonic motion with amplitude A. The total energy of the oscillating system is E.

When the amplitude of oscillation is increased to $2A$ the total energy of the oscillating system becomes

☒ **A** E

☒ **B** $2E$

☒ **C** $4E$

☒ **D** $4E^2$

(Total for Question 1 = 1 mark)

---

2 In earthquake-proof buildings, the amplitude of vibration of the building is prevented from becoming too large by using materials which deform as the buildings move.

Such materials should

☒ **A** be brittle.

☒ **B** be stiff.

☒ **C** deform elastically.

☒ **D** deform plastically.

(Total for Question 2 = 1 mark)

---

3 A mass is hung from a spring and set into vertical oscillation. The amplitude of oscillation halves after 10 cycles.

The ratio of the total energy of the system at the start to the total energy of the system after 10 cycles is

☒ **A** ¼

☒ **B** ½

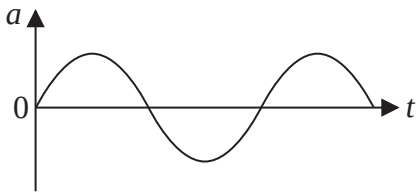
☒ **C** 2

☒ **D** 4

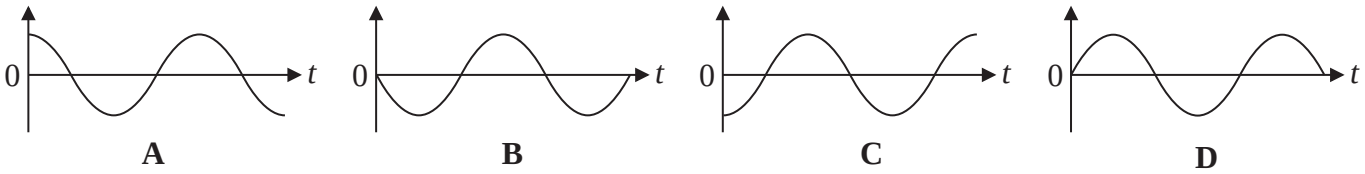
(Total for Question 3 = 1 mark)

Questions 4 and 5 refer to the graph below.

The graph shows how the acceleration *a* varies with time *t* for an object undergoing simple harmonic motion.



The following graphs show how other quantities for the object may vary over the same time period.



4 Choose the graph that shows the variation of displacement with time.

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 4 = 1 mark)

---

5 Choose the graph that shows the variation of velocity with time.

☒ **A**

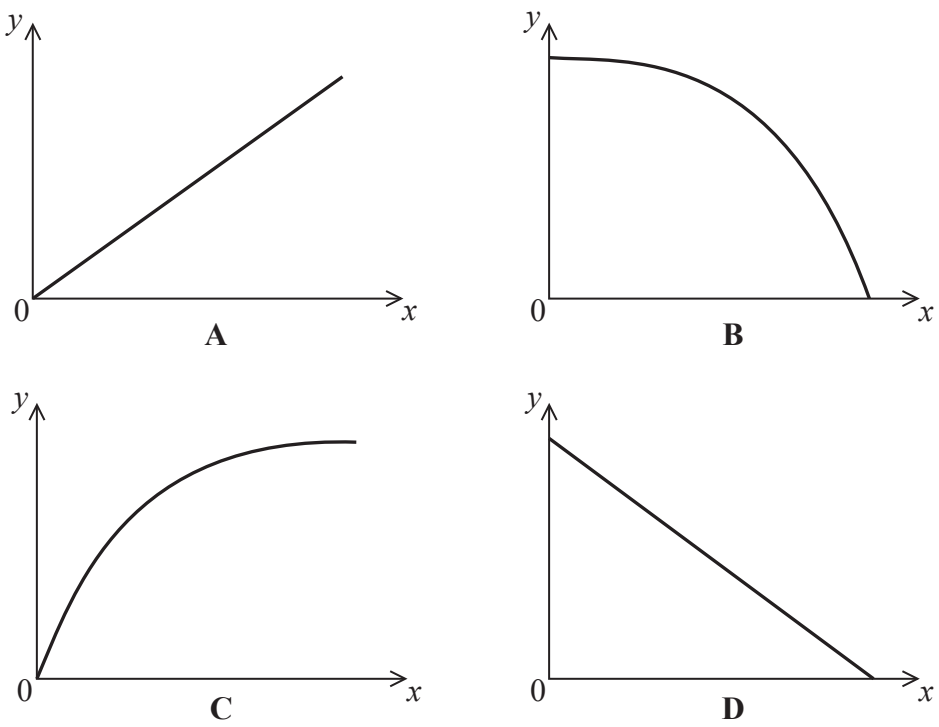
☒ **B**

☒ **C**

☒ **D**

(Total for Question 5 = 1 mark)

Questions 6 and 7 refer to the graphs below.



6 Which graph shows how the kinetic energy of a mass undergoing simple harmonic motion varies with its distance x from the equilibrium position?

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 6 = 1 mark)

---

7 Which graph shows how the magnitude of the resultant force on a mass undergoing simple harmonic motion varies with its distance x from the equilibrium position?

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 7 = 1 mark)

---

8 A mass is hung from a vertical spring and set into vertical oscillation.

The time period will

☒ **A** decrease as energy is lost from the system.

☒ **B** decrease as the amplitude decreases.

☒ **C** increase as the amplitude decreases.

☒ **D** stay constant provided the spring obeys Hooke's law.

(Total for Question 8 = 1 mark)

9 When a large number of people walk across a suspension bridge simultaneously the bridge may be set into oscillation.

This is an example of

☒ **A** forced oscillation.

☒ **B** free oscillation.

☒ **C** natural oscillation.

☒ **D** normal oscillation.

(Total for Question 9 = 1 mark)

10 A child of mass 35 kg is standing on a trampoline. At equilibrium the surface of the trampoline is displaced vertically by 22 cm from the unloaded position.

(a) Show that the force constant of the trampoline is about 1600 N m^{-1}.

(2)

(b) The child bounces up and down, always staying in contact with the trampoline. The motion is simple harmonic.

(i) Calculate the child's frequency of oscillation.

(3)

Frequency of oscillation = ...

(ii) The height of each bounce above the equilibrium position is 21 cm.

Calculate the maximum speed of the child and identify the position at which she has this speed.

(3)

.....

.....

.....

.....

Maximum speed of child = ...

Position = ...

(c) (i) The child bends her knees and pushes against the surface of the trampoline at each bounce. Her amplitude of oscillation gradually increases.

Name this effect and explain why there is an increase in amplitude.

(3)

Name of effect .....

Explanation .....

.....

.....

.....

*(ii) As her amplitude of oscillation increases she starts to lose contact with the surface of the trampoline.

Explain why the motion can no longer be described as simple harmonic.

(3)

(Total for Question 10 = 14 marks)

11 The photograph shows the Millennium Bridge in Salford. The bridge which is 91 m long straddles the Manchester Ship Canal.

When large numbers of people cross the bridge at the same time, the bridge begins to oscillate with large amplitude simple harmonic motion.

(a) Explain why there is large amplitude oscillation of the bridge under these conditions.

(3)

.....

.....

.....

.....

.....

.....

(b) The bridge oscillates with a frequency of 0.55 Hz. The amplitude of oscillation is greatest at the mid-point and falls gradually to zero at the ends.

Calculate the speed of transverse waves along the bridge.

(3)

.....

.....

.....

.....

Wave speed = ...

(Total for Question 11 = 6 marks)

12 A car suspension system can be thought of as a mass-spring system. The natural frequency of the system is determined by the force constant of the suspension k and the total mass of the system m.

(a) (i) A car is set into vertical oscillation by applying a momentary downwards force.

Show that the frequency of oscillation f is given by

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

(4)

(ii) The car is displaced through a vertical distance of 27.5 mm when a man of mass 85.0 kg sits in the car.

Show that k is about 30 kN m^{-1}.

(2)

(iii) Calculate the natural frequency of oscillation of the car with the man sitting in it.

mass of car = 1130 kg

(2)

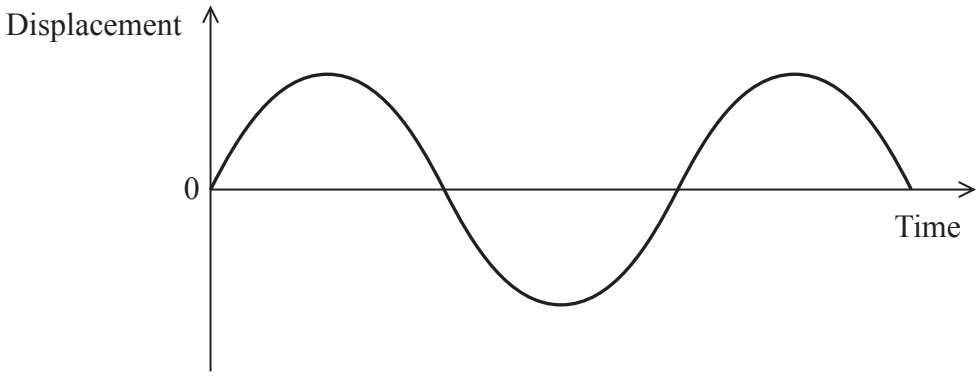
Natural frequency = ...

(b) Car suspension systems are examples of damped systems.

*(i) State what is meant by damping, and explain why this is desirable for a car suspension system.

(3)

(ii) The graph shows the way in which the displacement varies with time for an undamped mass-spring system.

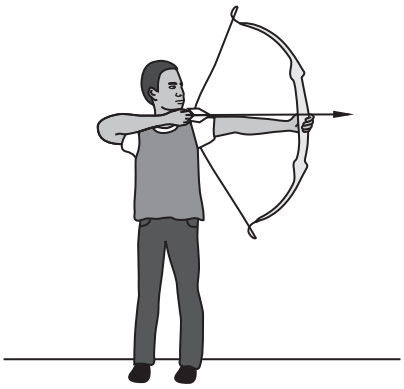


On the axes below draw a graph to show how the velocity varies with time for the damped system over the same time interval.

(2)

(Total for Question 12 = 13 marks)

13 An archer is carrying out some target practice with his bow and arrow.

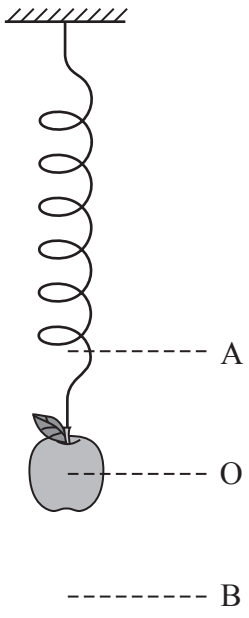


He attaches an apple to a spring hung from a fixed support and sets the apple into vertical oscillation of amplitude 10 cm. The apple performs simple harmonic motion with a frequency of 0.625 Hz.

(a) Describe the conditions required for an oscillation to be simple harmonic.

(2)

(b) The diagram shows the apple on the spring. A and B are the positions of maximum displacement and O is the equilibrium position of the apple.



Sketch a graph to show how the displacement of the apple varies with time.

(4)

(c) Calculate the maximum velocity of the apple as it oscillates.

(3)

Maximum velocity = ...

(d) The archer fires an arrow towards the apple as it is oscillating.

Explain at which position of the apple the archer has the best chance of scoring a direct hit.

(2)

.....

.....

.....

.....

*(e) Over time the amplitude of the apple's oscillation will decrease to zero.

Explain how the principle of conservation of energy applies to this situation.

(3)

.....

.....

.....

.....

.....

.....

(Total for Question 13 = 14 marks)