Simple Harmonic Motion

Question Paper
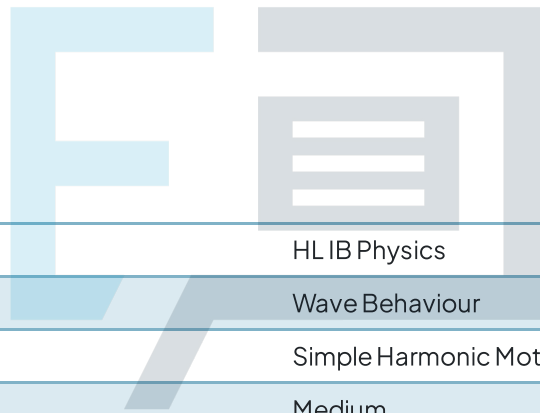
Course	HL IB Physics
Section	Wave Behaviour
Topic	Simple Harmonic Motion
Difficulty	Medium

To be used by all students preparing for HL IB Physics
Students of other boards may also find this useful

Question 1

A point on a guitar string S oscillates about its equilibrium position Z in simple harmonic motion.

```
         S
|_____●_____|_____
Y                 Z
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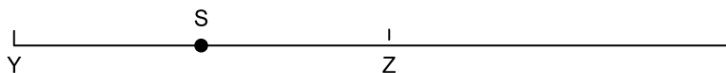
The amplitude of the oscillation is YZ.

Which positions show when the acceleration of point S is at a maximum and the velocity of point S is at zero?

	Acceleration	Velocity
A.	Z	Y
B.	Y	Y
C.	Z	Z
D.	Y	Z

[1 mark]

Question 2

A simple pendulum and a mass–spring system oscillate about their equilibrium positions with simple harmonic motion. On Earth, the period of the oscillations is T. The pendulum and the mass–spring system are taken to Mars where the acceleration of free fall is smaller than on Earth.

Which answer best describes the period of the pendulum and the mass–spring system on Mars?

	Simple Pendulum	Mass–spring System
A.	T	Greater than T
B.	T	T
C.	Greater than T	Greater than T
D.	Greater than T	T

[1 mark]

Exam Papers Practice

Question 3

Choose the correct statement describing the quantities that remain constant for an object in SHM.

   A. Frequency, *f.*

   B. Frequency, *f*, & period, *T.*

   C. Period, *T*, & the spring constant, *k.*

   D. Period, *T*, frequency, *f*, spring constant, *k*, & acceleration of freefall, *g.*

[1 mark]

Question 4

A mass-spring system oscillates with simple harmonic motion. The mass *m* has an amplitude *A* and the spring has a total energy *E*. The mass is increased by half and the amplitude increased to 4*A*.

What is the total energy in the spring?

   A. 24*E*

   B. 12*E*

   C. 8*E*

   D. 6*E*

[1 mark]

Question 5

A pendulum oscillating with simple harmonic motion has an amplitude x_0 and a maximum kinetic energy E_k.

What is the potential energy of the system when the pendulum bob is at a distance $0.4x_0$ from its maximum displacement?

   A. $0.36E_k$

   B. $0.4E_k$

   C. $0.6E_k$

   D. $0.64E_k$

[1 mark]

Question 6

Which of the following is a correct arrangement for the maximum displacement of a particle performing simple harmonic motion?

A. $x_0 = -\dfrac{a_{max}\, f^2}{4\pi^2}$

B. $x_0 = -\dfrac{a_{max}}{2\pi f^2}$
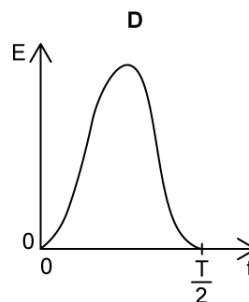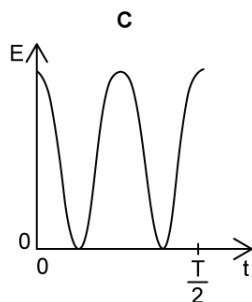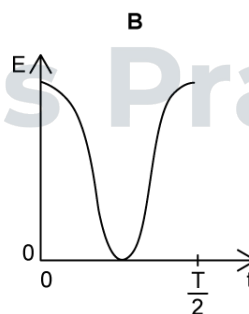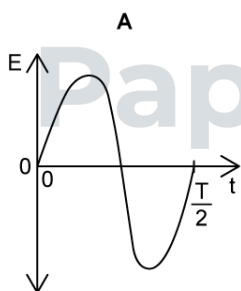
C. $x_0 = -\dfrac{a_{max}}{4\pi^2 T^2}$

D. $x_0 = -\dfrac{a_{max}\, T^2}{4\pi^2}$

[1 mark]

Question 7

An ion in a crystal lattice structure oscillates with simple harmonic motion. The period of the oscillation is T. T is measured from equilibrium.

Which graph shows the change in kinetic energy of the ion from time $t = 0$ to $t = \dfrac{T}{2}$?

[1 mark]

Question 8

A simple pendulum performs simple harmonic motion. The pendulum bob has a mass *m*, the string has a length *l*, and the pendulum has a period *T*.
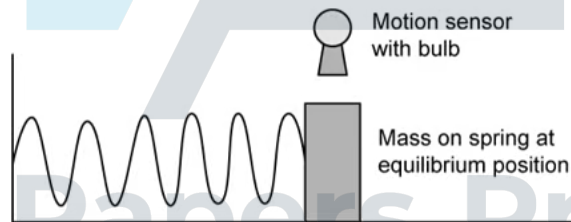
Which is the correct value for the period *T* if the mass of the pendulum bob is doubled and the length of the string is halved?

A. 1.4 *T*

B. 0.7 *T*

C. 0.5 *T*

D. 0.25 *T*

[1 mark]

Question 9

A mass-spring system oscillates about its equilibrium position in simple harmonic motion. A bulb on the motion sensor lights up each time the block passes the equilibrium position.

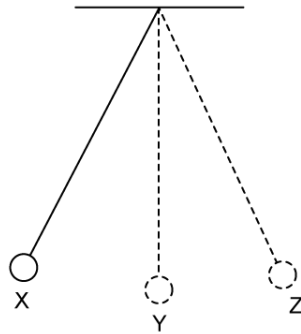
The block has a mass *m* and oscillates with a period *T*.

Select the new mass that would cause the period to double.

A. 0.5*m*

B. 1.4*m*

C. 2*m*

D. 4*m*

[1 mark]

Question 10

A simple pendulum oscillates with simple harmonic motion as shown.

At which positions are the acceleration at zero, the displacement at a negative maximum, and velocity at a maximum?

	Acceleration	Displacement	Velocity
A.	Z	Y	X
B.	Y	X	Y
C.	X	Z	Z
D.	Y	X	Z

[1 mark]

Question 11

A mass-spring system is oscillating with simple harmonic motion.

What is the total energy of the object proportional to?

A. The square of both the mass and the amplitude

B. Mass and displacement of the object

C. Angular frequency

D. Mass and the square of the amplitude

[1 mark]

Question 12

Which line identifies quantities which always have opposite directions during simple harmonic motion?

   A. Acceleration and displacement

   B. Acceleration and velocity

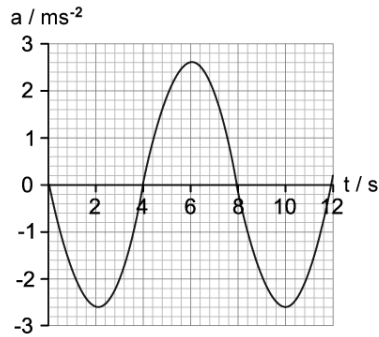   C. Velocity and restoring force

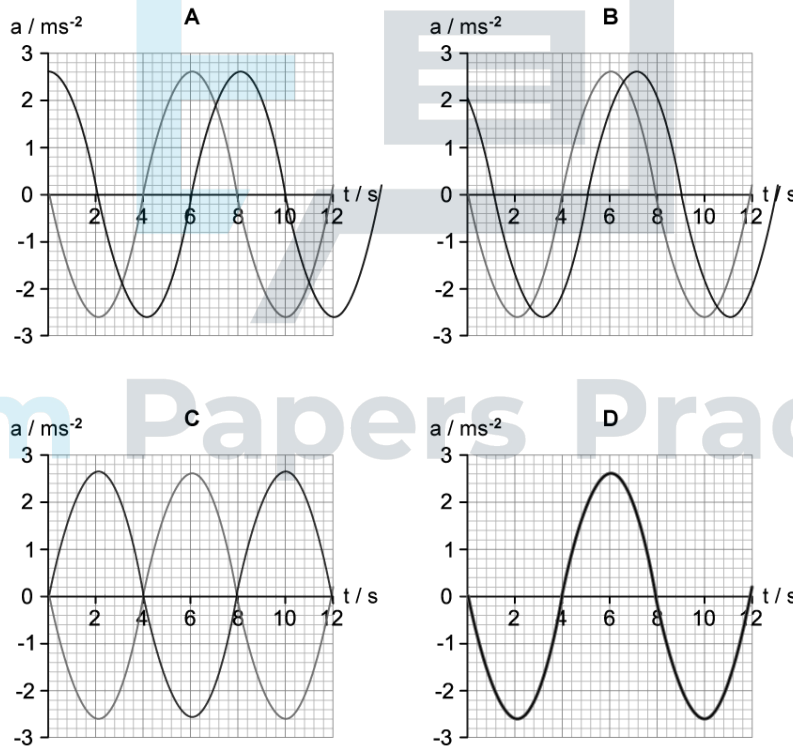   D. Acceleration and restoring force

[1 mark]

Question 13

The graph shows the variation with time *t* of the acceleration *a* of an object X undergoing simple harmonic motion (SHM).

A second object Y oscillates with the same frequency as X but with a phase difference of $\frac{\pi}{4}$.

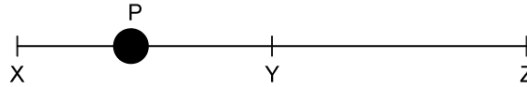Which graph shows how the acceleration of object Y varies with *t*?

[1 mark]

Question 14

A particle, **P**, oscillates on the line **XZ** about its equilibrium point **Y**, in simple harmonic motion.

At the point shown, which statement could be correct about the motion of the particle?

   A. It has maximum kinetic energy and minimum potential energy

   B. The total energy is equal to the kinetic energy at **X**

   C. The restoring force is towards **Z** and the particle is accelerating

   D. The restoring force is towards **X** and the particle is accelerating

[1 mark]

Question 15

A pendulum is undergoing simple harmonic motion with a time period T and angular frequency ω.

A student makes a change to the set up so that the pendulum has a new time period $3T$.

What is the new angular frequency?

   A. 6ω

   B. 3ω

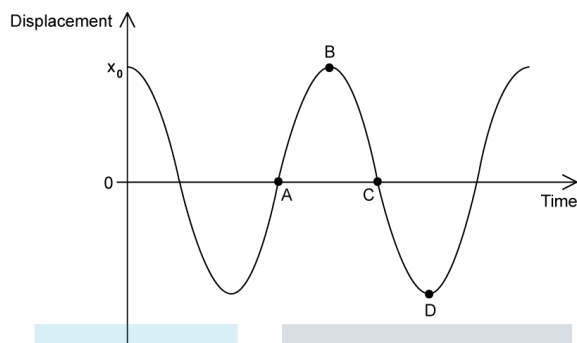   C. $\dfrac{\omega}{3}$

   D. $\dfrac{\omega}{6}$

[1 mark]

Question 16

A pendulum is made to swing by a student pulling the bob to the left and releasing it. The student is careful to displace the bob by only a small amount.

After two full oscillations, the motion of the pendulum is plotted on a graph.

At which point is the velocity of the bob towards the right?

[1 mark]

Question 17

A mass is attached to a vertical spring and allowed to reach equilibrium. It is then displaced by a distance d and released. The total energy and time period are E_T and T respectively.

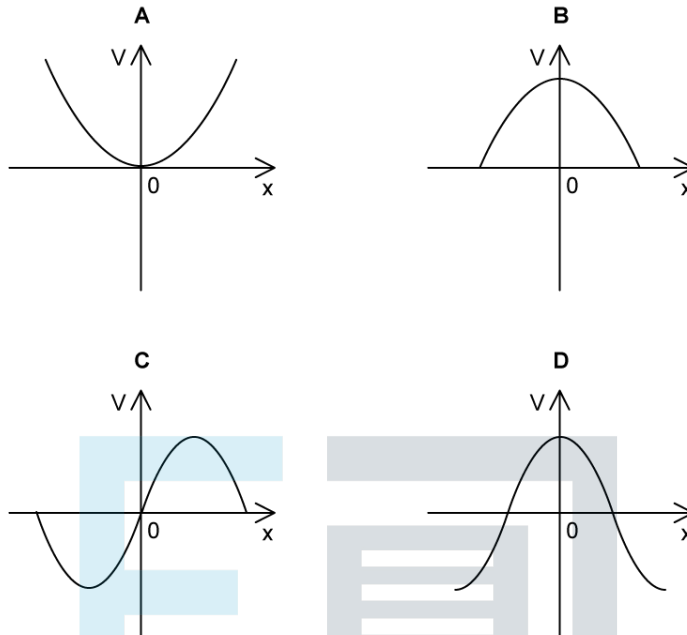In a second investigation the same mass–spring system travels twice as fast.

Which line correctly identifies the total energy and time period of the second oscillations?

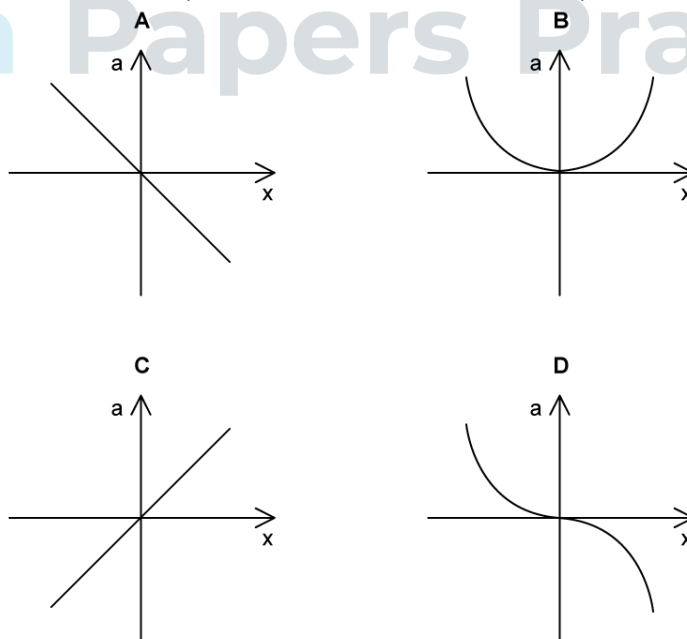|	E_T	T
A.	2E	$\dfrac{T}{2}$
B.	4E	$\dfrac{T}{2}$
C.	2E	2T
D.	4E	T

[1 mark]

Question 18

Which of the following graphs shows the variation with displacement x of the speed v of a particle performing simple harmonic motion?

[1 mark]

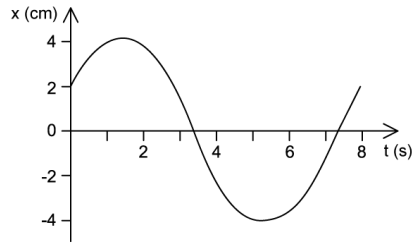## Question 19

Which graph correctly represents the relationship between acceleration, a, and displacement, x, in simple harmonic motion?

[1 mark]

Question 20

The graph shows the motion of an oscillating body.

What is the frequency of the oscillation?

A. $\dfrac{1}{3.5}$ Hz

B. 7.5 Hz

C. $\dfrac{1}{7.5}$ Hz

D. 3.5 Hz

[1 mark]