# 4.1 Oscillations

## Question Paper

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|---|---|
| Course | DP IB Physics |
| Section | 4. Waves |
| Topic | 4.1 Oscillations |
| Difficulty | Medium |

**Time allowed:** 80

**Score:** /61

**Percentage:** /100

## Question 1a

A pendulum undergoes small-angle oscillations.

(a)
Outline the equation that defines simple harmonic motion.

**[3 marks]**

## Question 1b

(b)
Sketch a graph to represent the change in amplitude, $x_0$ against time for one swing of the pendulum. Start the time at zero seconds.

**[2 marks]**

## Question 1c

The time period of 10 oscillations is found to be 12.0 s.

(c)
Determine the frequency when the bob is 1.0 cm from its equilibrium position.

**[2 marks]**

## Question 1d

The student wants to double the frequency of the pendulum swing. The time period, *T* of a simple pendulum is given by the equation:

$$T = 2\pi\sqrt{\frac{L}{g}}$$

where *L* is the length of the string and *g* is the acceleration due to gravity

(d)
Deduce the change which would achieve this.

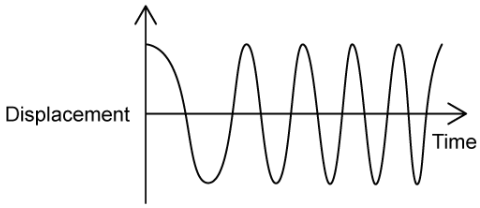
**[4 marks]**

## Question 2a

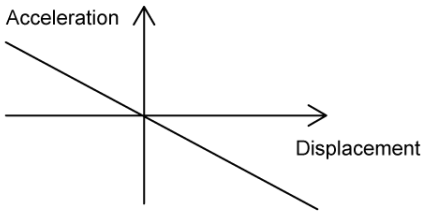
(a)

State and explain whether the motion of the objects in graphs I, II and III are simple harmonic oscillations

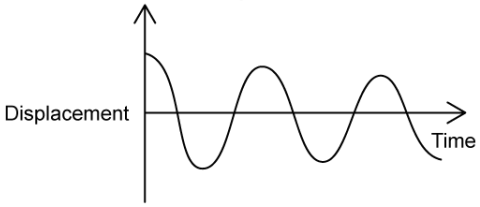
**Graph 1**




**Graph 2**




**Graph 3**




[6]

**[6 marks]**

## Question 2b

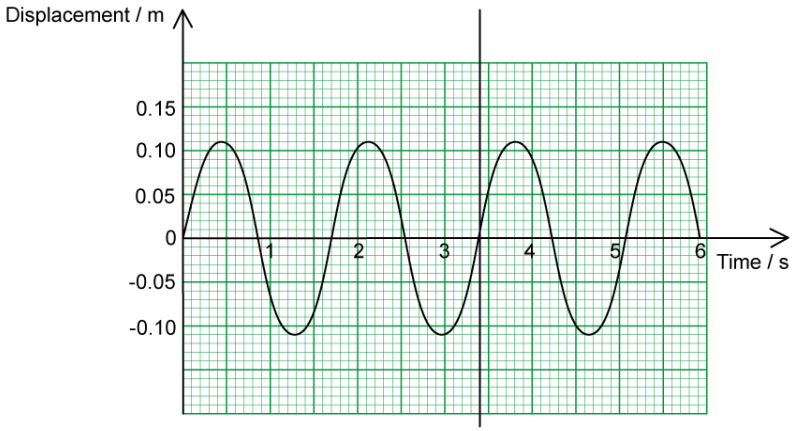
(b)
Explain why, in practice, a freely oscillating pendulum cannot maintain a constant amplitude.

[2]

**[2 marks]**

## Question 2c

The motion of an object undergoing SHM is shown in the graph below.




(c)
For this oscillator, determine:

(i)
The amplitude, *A*.

[1]

(ii)
The period, *T*.

[1]

(iii)
The frequency, *f*.

[1]

**[3 marks]**

## Question 2d

(d)
Using the graph from part (c), state a time in seconds when the object performing SHM has:

(i)
Maximum positive velocity.

[1]

(ii)
Maximum negative acceleration.

[1]

(iii)
Maximum potential energy.

[1]

**[3 marks]**

## Question 3a

A ball of mass 44 g on a 25 cm string oscillating in simple harmonic motion obeys the following equation:

$$a = -\omega^2 x$$

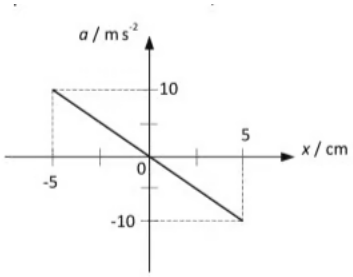
(a)
Demonstrate mathematically that the graph of this equation is a downward sloping straight line that goes through the origin.

[3]

**[3 marks]**

## Question 3b

The graph below shows the acceleration, *a*, as a function of displacement, *x*, of the ball on the string.




The angular speed, $\omega$, in rad $s^{-1}$, is related to the frequency, *f*, of the oscillation by the following equation:

$$\omega = 2\pi f$$

(b)

For the ball on the string, determine the period, *T*, of the oscillation.

[3]

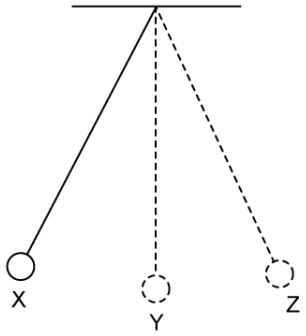
**[3 marks]**

## Question 3c

The ball is held in position X and then let go. The ball oscillates in simple harmonic motion.

(c)
Explain the change in acceleration as the ball on the string moves through half an oscillation from position X.
You can assume the ball is moving at position X.

[4]

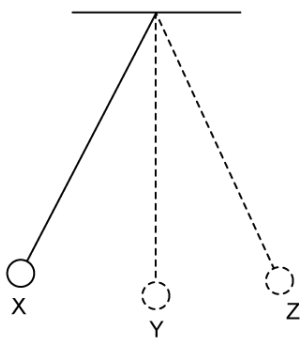



**[4 marks]**

## Question 3d

(d)
Describe the energy transfers occurring as the ball on the string completes half an oscillation from position X.

[3]



**[3 marks]**

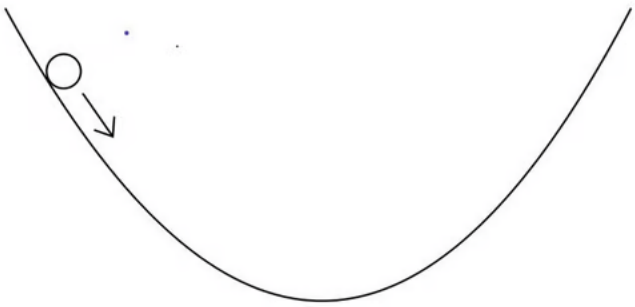
## Question 4a

A smooth glass marble is held at the edge of a bowl and released. The marble rolls up and down the sides of the bowl with simple harmonic motion.

The magnitude of the restoring force which returns the marble to equilibrium is given by:

$$F = \frac{mgx}{R}$$

Where $x$ is the displacement at a given time, and is the radius of the bowl.



(a)
Outline why the oscillations can be described as simple harmonic motion.

**[3 marks]**

## Question 4b

(b)
Describe the energy changes during the simple harmonic motion of the marble.

**[3 marks]**

## Question 4c

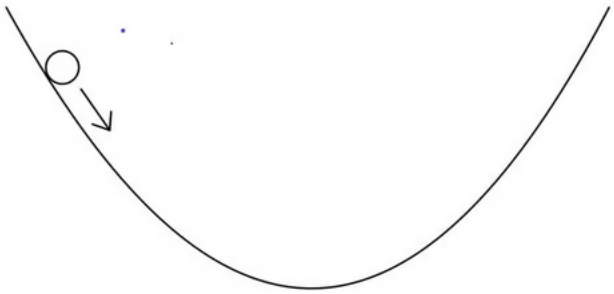
As the marble is released it has potential energy of 15 μJ. The mass of the marble is 3 g.

(c)
Calculate the velocity of the marble at the equilibrium position.

**[2 marks]**

## Question 4d

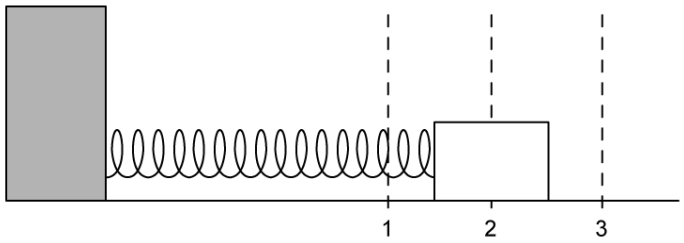
(d)
Sketch a graph to represent the kinetic, potential and total energy of the motion of the marble, assuming no energy is dissipated as heat. Clearly label any important values on the graph.



**[3 marks]**

## Question 5a

An object is attached to a light spring and set on a frictionless surface. It is allowed to oscillate horizontally. Position 2 shows the equilibrium point.




a)

(i) Sketch a graph of acceleration against displacement for this motion.

[2]

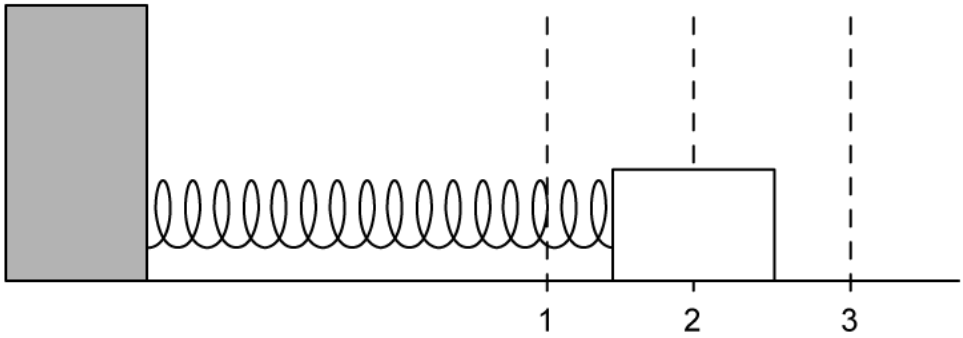
(ii) On your graph, mark positions 1, 2 and 3 according to the diagram.

[1]

**[3 marks]**

## Question 5b

The mass begins its motion from position 1 and completes a full oscillation.




(b)

(i) Sketch a graph of velocity against time to show this.

[2]

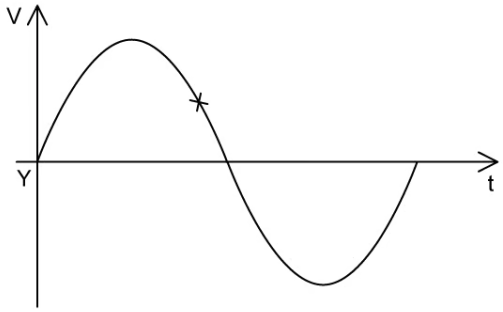
(ii) On your graph, add labels to show points 1, 2 and 3

[2]

**[4 marks]**

## Question 5c

At the point marked **Y** on the graph, the potential energy of the block is $E_P$. The block has mass $m$, and the maximum velocity it achieves is $v_{max}$.




(c)

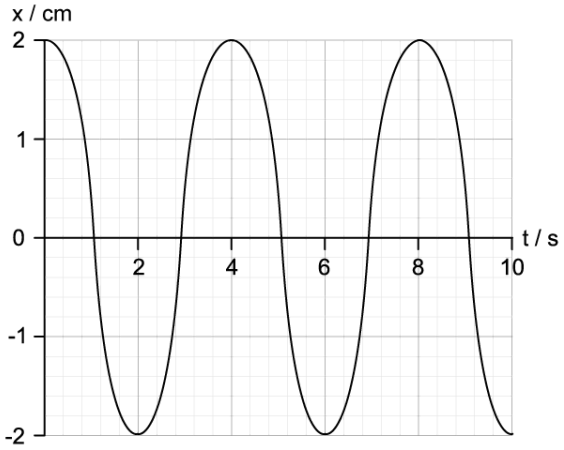
Determine an equation for the potential energy at the point marked X.

Give your answer in terms of $v_{max}$, $v_x$ and $m$.

**[3 marks]**

## Question 5d

The graph shows how the displacement $x$ of the mass varies with time $t$.




(d)

Determine the frequency of the oscillations.

**[2 marks]**