9.1 Simple Harmonic Motion

Question Paper

Course	DP IB Physics
Section	9. Wave Phenomena (HL only)
Topic	9.1 Simple Harmonic Motion
Difficulty	Hard

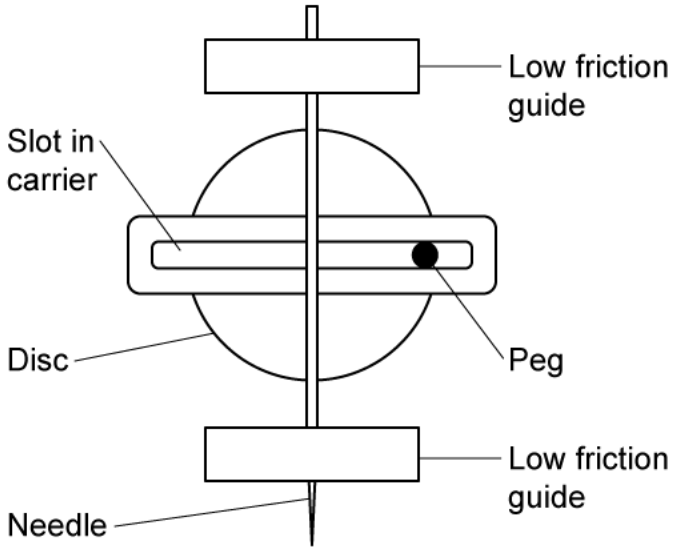
Time allowed: 50

Score: /37

Percentage: /100

Question 1a

The needle carrier of a sewing machine moves with simple harmonic motion. The needle carrier is constrained to move on a vertical line by low friction guides, whilst the disk and peg rotate in a circle. As the disk completes one oscillation, the needle completes one stitch.



(a)
The sewing machine completes 840 stitches in one minute. Calculate the angular speed of the peg.

[2]

[2 marks]

Question 1b

The needle carrier has a mass of 23.9 g, and the needle has a mass of 0.7 g. The needle moves a distance of 36 mm between its extremities of movement.

(b)
Assuming that the fabric requires a negligible force for the needle to penetrate it:

(i)
Calculate the maximum speed of the needle.

[1]

(ii)
Determine the kinetic energy of the needle at this point.

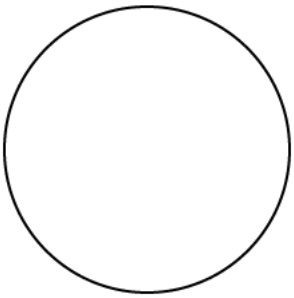
[1]

[2 marks]

Question 1c

(c)
For the needle-carrier system:

(i)
Label, on the diagram, the position of the peg at the point of maximum velocity, and the point of maximum contact force of the peg on the slot.



Disc front view

[2]

(ii)
Calculate the maximum force acting on the peg by the slot.

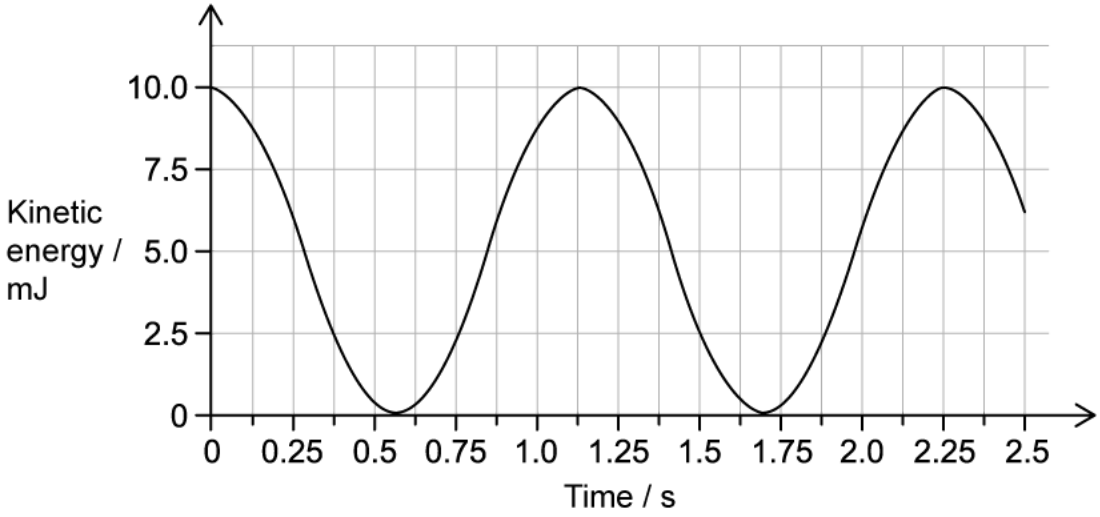
[1]

[1 mark]

Question 2a

A metal pendulum bob of mass 7.5 g is suspended from a fixed point by a length of thread with negligible mass. The pendulum is set in motion and oscillates with simple harmonic motion.

The graph shows the kinetic energy of the bob as a function of time.



(a)
Calculate the length of the thread.

[2]

[2 marks]

Question 2b

(b)
For the simple pendulum:

(i)
Label the graph from part a with an A at the point where the restoring force is acting at a maximum.

[1]

(ii)
Label the graph from part a with a B at the point where the speed of the pendulum is half of its initial speed.

[1]

[2 marks]

Question 2c

(c)
Show that the amplitude of the oscillation is around 0.6 m.

[2]

[2 marks]

Question 2d

An IB Physics class was discussing this experiment.

A student in the class said that increasing the mass of the pendulum bob would increase the period of the oscillation because increasing the mass would increase the inertia of the bob.

The teacher said the student was incorrect.

(d)
Discuss the teachers comments.

[6]

[6 marks]

Question 3a

A steel spring with an unstretched length of 33 cm is attached to a fixed point and a mass of 35 g is attached and gently lowered until equilibrium is reached and the spring has a length of 37.5 cm. The spring is then stretched elastically to a length of 42 cm and released.

(a)
Design a plan to investigate if the oscillation is simple harmonic motion.

[5]

[5 marks]

Question 3b

(b)
For the stretching of the spring:

(i)
Calculate the gravitational potential energy lost by the mass.

[1]

(ii)
Determine the elastic potential energy gained by the spring.

[2]

(iii)
Explain why the two answers are different.

[1]

[4 marks]

Question 3c

(c)
For the simple harmonic oscillation:

(i)
Determine the resultant force acting on the load at the lowest point of its movement.

[2]

(ii)
Calculate the maximum speed of the mass.

[2]

[4 marks]

Question 4a

A student with mass 68 kg hangs from a bungee cord with a spring constant, $k = 270$ N m^{-1}. The student is pulled down to a point where the cord is 4.0 m longer than its unstretched length, and then released. The student oscillates with SHM.

(a)
For the student:

(i)
Determine their position 15.7 s after being released.

[3]

(ii)
Calculate their velocity 15.7 s after being released.

[1]

(iii)
Explain where in the oscillation the student is at 15.7 s after being released. You may want to include a sketch diagram to aid your explanation.

[2]

[6 marks]

Question 4b

A second student wants to do the bungee jump, however, they would like a greater number of bounces in their five minute session.

(b)
Evaluate the possibilities for facilitating the student's wishes.

[2]

[1 mark]