Oscillations – 2021/20 GCE Physics A Component 01

1. Nov/2021/Paper_H556_01/No.6

For a simple harmonic oscillator, the maximum speed is v_{max} when the amplitude is A. The frequency of the oscillations is f.

Which expression is correct for this oscillator?

A $v_{max} = fA$

B $v_{max} = 2\pi fA$

C $v_{max} = f^2A$

D $v_{max} = 4\pi^2f^2A$

Your answer ☐ **[1]**

2. Nov/2021/Paper_H556_01/No.12

Oscillations of an object can either be **free** or **forced**.

Which of the following is an example of a **forced** oscillation?

A A ball rolling to-and-fro on a curved track.

B A loudspeaker oscillating and producing a continuous note.

C A mass oscillating from the end of a suspended spring.

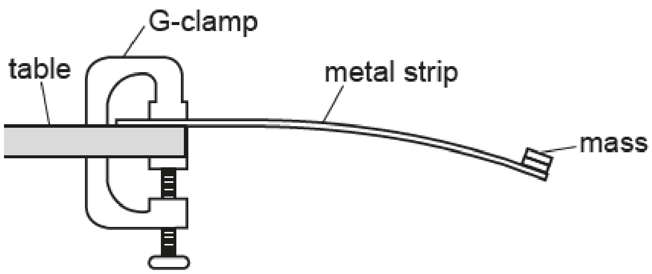
D A pendulum bob oscillating from the end of a fixed length of string.

Your answer ☐ **[1]**

3. Nov/2021/Paper_H556_01/No.17(b)

(b)* A student wants to determine the Young modulus *E* of the metal of the strip in **(a)**.

The student clamps the metal strip to the edge of a table using a G-clamp. A mass is **permanently** fixed to the end of the strip as shown.



The mass oscillates freely when it is moved away from its equilibrium position and then released.

The Young modulus *E* of the metal can be determined using the equation $E = \frac{16\pi^2 mL^3}{wt^3T^2}$, where *m* is the mass fixed to the end of the strip, *L* is the length of the strip from the end of the table to the centre of the mass, *w* is the width of the strip, *t* is the thickness of the strip, and *T* is the period of oscillations.

Describe how an experiment may be safely conducted, and how the data can be analysed to determine an accurate value for E. **[6]**

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Additional answer space if required.

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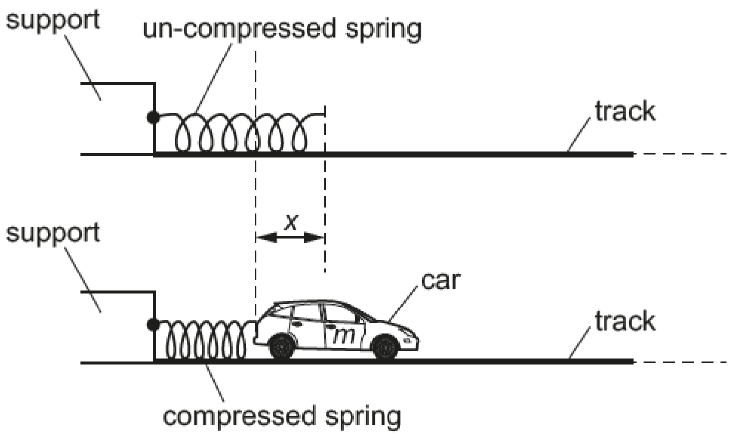
4. Nov/2021/Paper_H556_01/No.21

(a) One end of a spring is fixed to a support.
A toy car, which is on a smooth horizontal track, is pushed against the free end of the spring. The spring compresses. The car is then released. The car accelerates to the right until the spring returns back to its original length.



The car moves with **simple harmonic motion** as the spring returns to its original length.

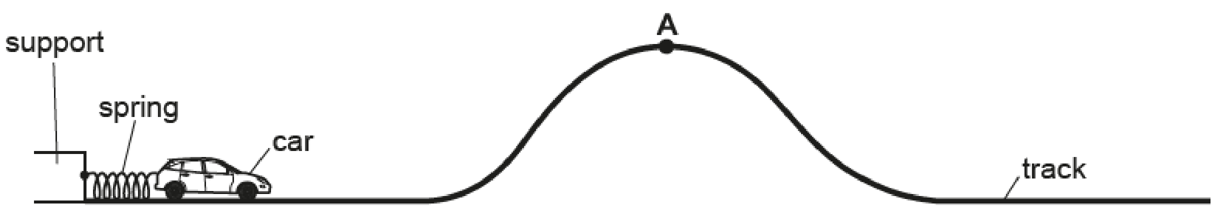
The acceleration of the car is given by the expression $a = -\left(\frac{k}{m}\right)x$, where m is the mass of the car, k is the force constant of the spring and x is the compression of the spring.

Use the data below to calculate the time t it takes for the spring to return to its original length after the car is released.

- mass of car m = 80 g
- force constant k of the spring = 60 N m^{-1}.

t = ... s **[4]**

(b) The arrangement in **(a)** is used to propel the toy car along a smooth track.



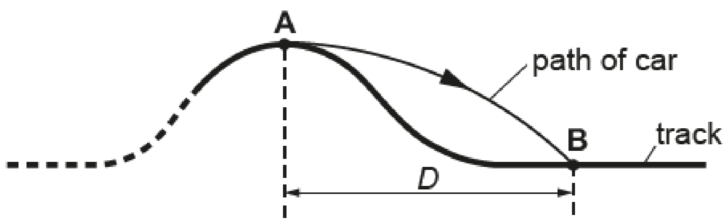
(i) Point **A** is at the top of the track.
The launch speed of the car is now adjusted until the car just reaches **A** with zero speed.
The height of **A** is 0.20 m above the horizontal section of the track.

All the elastic potential energy of the spring is transferred to gravitational potential energy of the car.

Calculate the initial compression x of the spring.

x = ... m **[3]**

(ii) At a specific speed, the car leaves point **A** horizontally and lands on the track at point **B**.
The horizontal distance between **A** and **B** is D.



Air resistance has negligible effect on the motion of the car between **A** and **B**.

1 Explain how the time of flight between **A** and **B** depends on the speed of the car at **A**.

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2 Explain how the distance D depends on the speed of the car at **A**.

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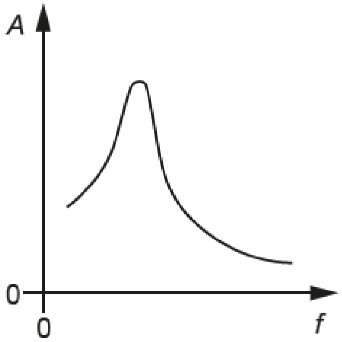
.... **[2]**

5. Nov/2020/Paper_H556_01/No.4

An oscillator is forced to oscillate at different frequencies.
The graph of amplitude A against driving frequency f for this oscillator is shown.



The damping on the oscillator is now **decreased**.

Which of the following statements is/are correct?

1 The amplitude of the oscillations at any frequency decreases.
2 The maximum amplitude occurs at a lower frequency.
3 The peak on the graph becomes thinner.

A Only 1

B Only 2

C Only 3

D 1, 2 and 3

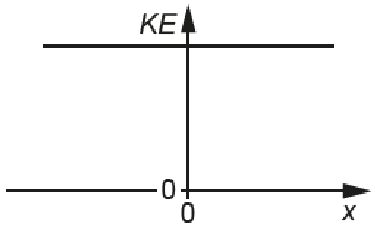
Your answer [1]

6. Nov/2020/Paper_H556_01/No.12

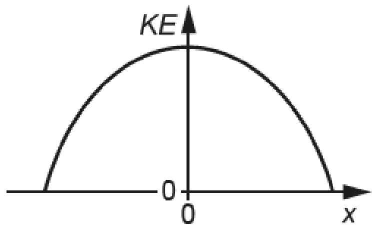
An oscillator is executing simple harmonic motion.

Which graph of kinetic energy *KE* against displacement *x* is correct for this oscillator?

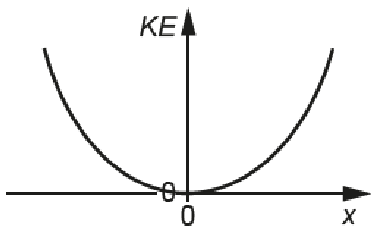
A



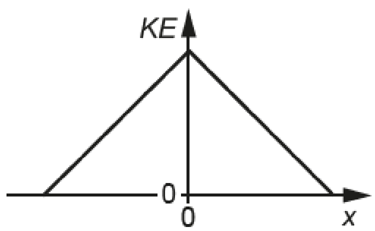
B



C



D

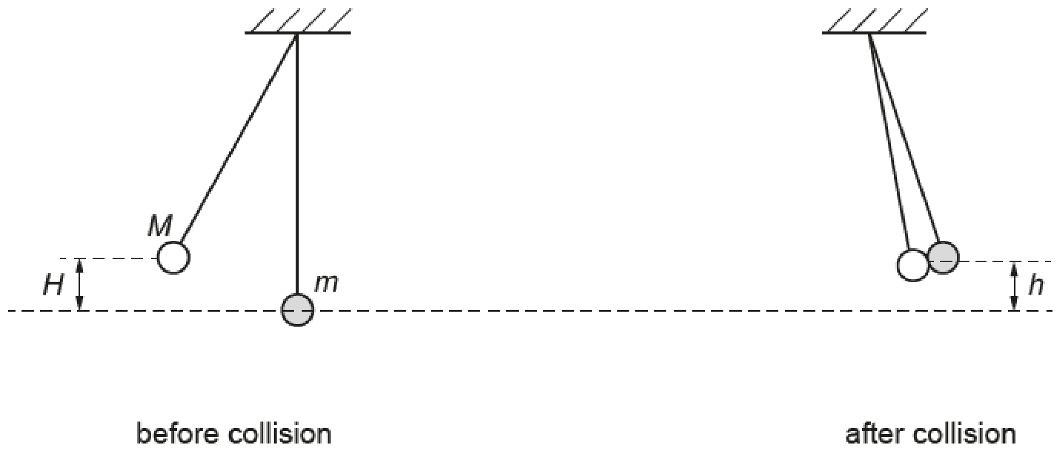


Your answer ☐ **[1]**

7. Nov/2020/Paper_H556_01/No.19

A student makes a pendulum using a length of string with a ball of adhesive putty which acts as a bob. The mass of this bob is M.
A similar second pendulum is constructed with the same length of string but with a bob of a smaller mass. The mass of this bob is m.

The arrangement of the pendulums is shown below.



The bob of mass M is pulled back to a vertical height of H from its rest position. It is released and collides with the bob of mass m. The two bobs then stick together and reach a maximum vertical height h from the rest position.

The height h is given by the equation $h = \left(\frac{M}{M+m}\right)^2 H$.

Describe how to perform an experiment to test the validity of this equation and how the data can be analysed. **[6]**

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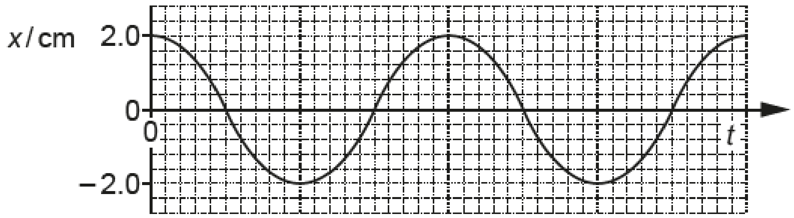
8. Nov/2020/Paper_H556_01/No.22(b)

(b) The cylinder is pushed down into the liquid and then allowed to oscillate freely.
The graph of displacement *x* against time *t* is shown below.



The cylinder oscillates with simple harmonic motion with frequency of 1.4 Hz.

(i) Calculate the displacement, in cm, at time $t = 0.60$ s.

displacement = ... cm **[3]**

(ii) Calculate the maximum speed of the oscillating cylinder.

maximum speed = ... m s^{-1} **[2]**

(iii) The cylinder is now pushed down further into the liquid before being released.
As before, the cylinder oscillates with simple harmonic motion.

State the effect this has on

1 the amplitude

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2 the period.

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[2]

9. Nov/2020/Paper_H556_03/No.1(c)

A ball coated with conducting paint has weight 0.030 N and radius 1.0 cm. The ball is suspended from an insulating thread. The distance between the pivot and the centre of the ball is 120 cm.

The ball is placed between two vertical metal plates. The separation between the plates is 8.0 cm. The plates are connected to a 4.0 kV power supply.

(c) When the ball oscillates between the plates, the current in the external circuit is 3.2×10^{-8} A.

A charge of 9.0 nC moves across the gap between the plates each time the ball makes one complete oscillation.

Calculate the frequency *f* of the oscillations of the ball.

f = ... Hz **[2]**

10. Nov/2020/Paper_H556_03/No.5(b)

This question is about investigations involving an electromagnetic wave.

A vertical transmitter aerial emits a **vertically polarised** electromagnetic wave which travels towards a vertical receiver aerial. The wavelength of the wave is 0.60 m.

Fig. 5.1 shows a short section of the oscillating electric field of the electromagnetic wave.

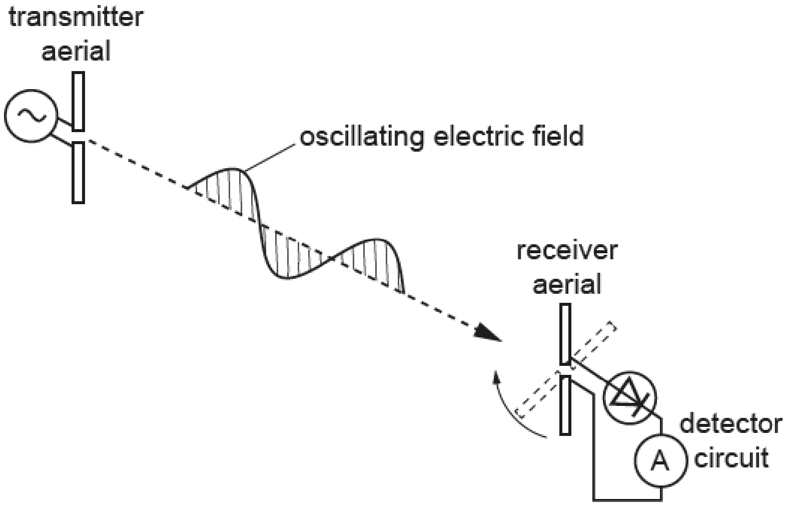

Fig. 5.1

(b) The electromagnetic wave is caused by electrons oscillating in the transmitter aerial. Each electron oscillates with simple harmonic motion.

Calculate the maximum acceleration a_{max} of an electron which oscillates with an amplitude of 4.0×10^{-6} m.

a_{max} = ... m s^{-2} **[3]**