A Level · OCR · Physics

36 mins   3 questions

Structured Questions

Simple Harmonic Oscillations

Describing Oscillations / Angular Frequency / Conditions for Simple Harmonic Motion / Time Period & Frequency / Acceleration & Displacement / Velocity / SHM Graphs

Medium (1 question)	/10
Hard (2 questions)	/26
Total Marks	**/36**

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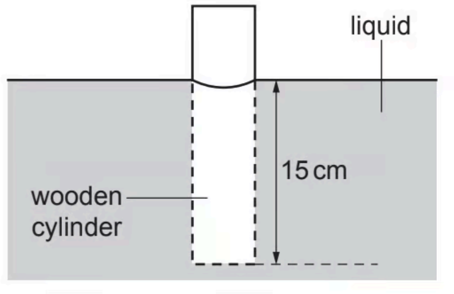
Medium Questions

1 (a) A long wooden cylinder is placed into a liquid and it floats as shown.



The length of the cylinder below the liquid level is 15 cm.

i) State **Archimedes' principle**.

[1]

ii) The pressure exerted by the liquid alone on the bottom of the cylinder is 1.9×10^3 Pa.

Calculate the density ρ of the liquid.

ρ = ... kg m^{-3} **[2]**

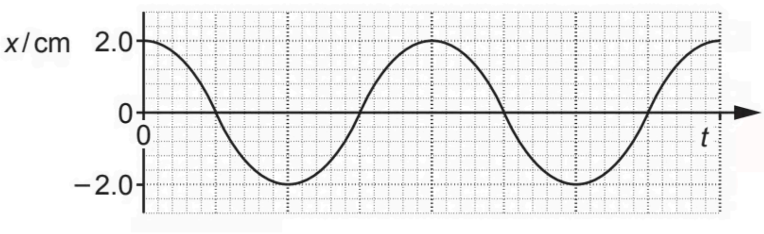
....

....

....

(3 marks)

(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

....

2 the period.

....

[2]

....

....

....

....

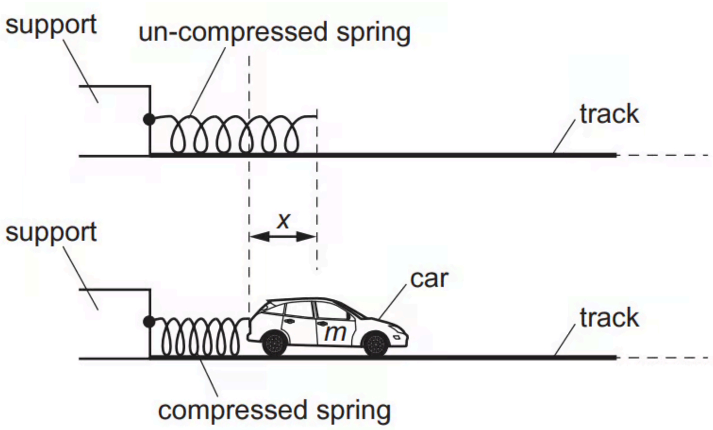
(7 marks)

Hard Questions

1 (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]**

(4 marks)

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

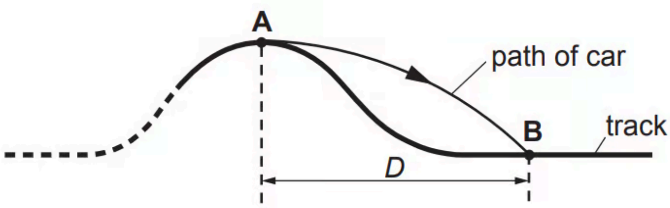
i) Point **A** is at the top of the track. The launch speed of the car is now adjusted until the car just reaches **A** with zero speed. The height of **A** is 0.20 m above the horizontal section of the track.

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 a 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**.

[2]

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

[2]

(7 marks)

2 (a) This question is about a simple pendulum made from a length of string attached to a mass (bob). For oscillations of small amplitude, the acceleration *a* of the pendulum bob is related to its displacement *x* by the expression

$$a = -\left(\frac{g}{L}\right)x$$

where *g* is the acceleration of free fall and *L* is the length of the pendulum. The pendulum bob oscillates with simple harmonic motion.

i) Show that the period *T* of the oscillations is given by the expression

$$T^2 = \frac{4\pi^2}{g}L.$$

[3]

ii) A student notices that the amplitude of each oscillation decreases over time.

Explain this observation and state what effect this may have on *T*.

[2]

(5 marks)

(b) Describe with the aid of a labelled diagram how an experiment can be conducted and how the data can be analysed to test the validity of the equation $T^2 = \frac{4\pi^2}{g}L$ for oscillations of small amplitude.

[6]

(6 marks)

(c) Another student conducts a similar experiment in the laboratory to investigate the small amplitude oscillations of a pendulum of a mechanical clock. Each 'tick' of the clock corresponds to **half** a period.

i) Show that the length of the pendulum required for a tick of 1.0 s is about 1 m.

[2]

ii) If the pendulum clock were to be used on the Moon, explain whether this clock would run on time compared with an identical clock on the Earth.

[2]

(4 marks)