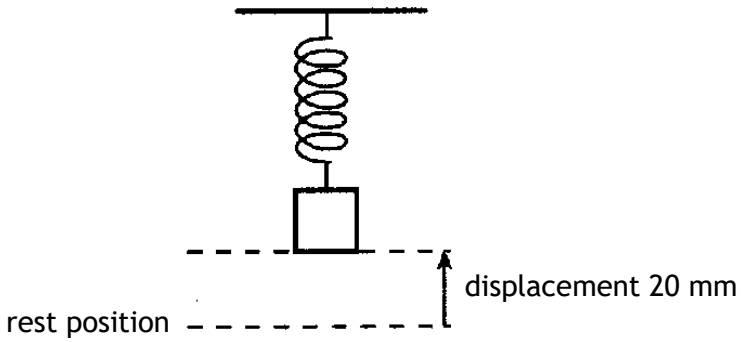
Homework – Simple Harmonic Motion

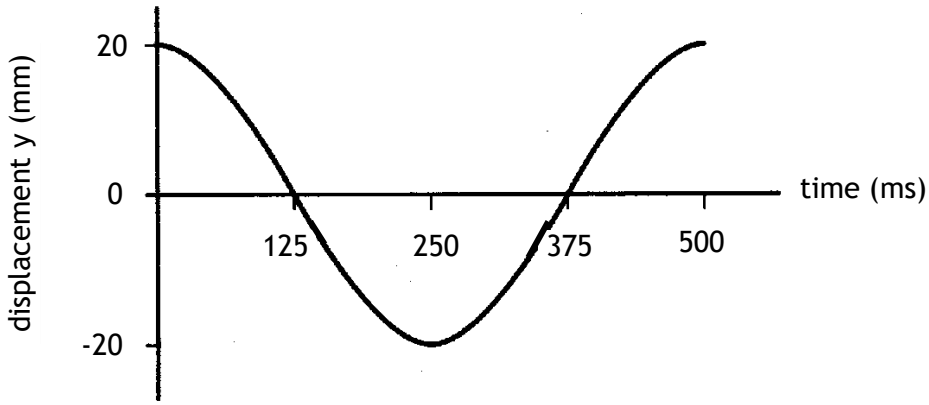
1. A mass is suspended from a spring and is at rest.

   The mass is displaced 20 mm above its rest position, as shown below.



   (a) The mass is released.

   A graph of the displacement y of the mass against time t shown in the graph below.

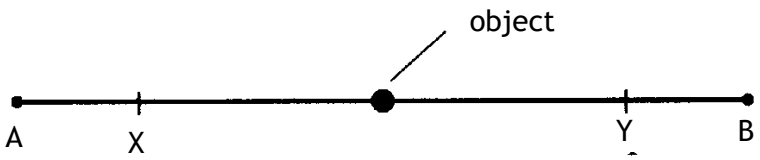


   (i) Show, by calculation, that

$$\frac{d^2y}{dt^2} = -158\,y$$

   (ii) Create a graph of the velocity of the mass against time for the first period of the oscillation. Numerical values are required on both axes.

   (b) An object has a periodic motion and oscillates between A and B as shown below.



   Between points X and Y the object moves with a constant speed.
   Explain why the motion of the object cannot be described as simple harmonic motion.

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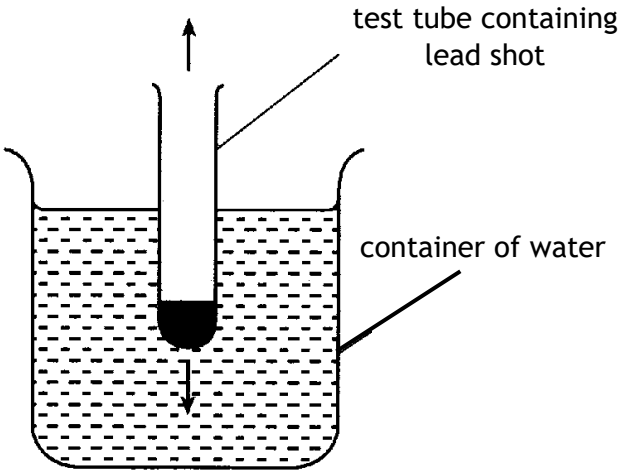
2. A test tube contains lead shot. The combined mass of the test tube and the lead shot is 0·250 kg.

   The test tube is gently dropped into a container of water and oscillates above and below its equilibrium position with simple harmonic motion as shown below.



   The displacement y of the test tube from equilibrium position is described by the equation

$$y = 0.05cos6t$$

   where y is in metres and t is in seconds.

   (a) Show that the kinetic energy of the test tube, in joules, is given by the equation.

$$E_K = 4.5(2.5 \times 10^{-3} - y^2)$$

   (b) Calculate the maximum value of the kinetic energy of the test tube.

   (c) Calculate the potential energy of the test tube when it is 40 mm above its equilibrium position.

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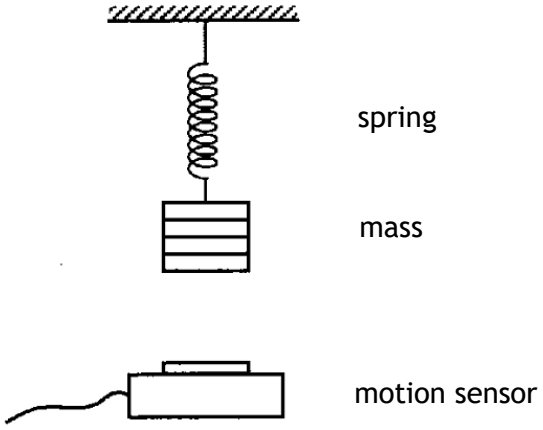
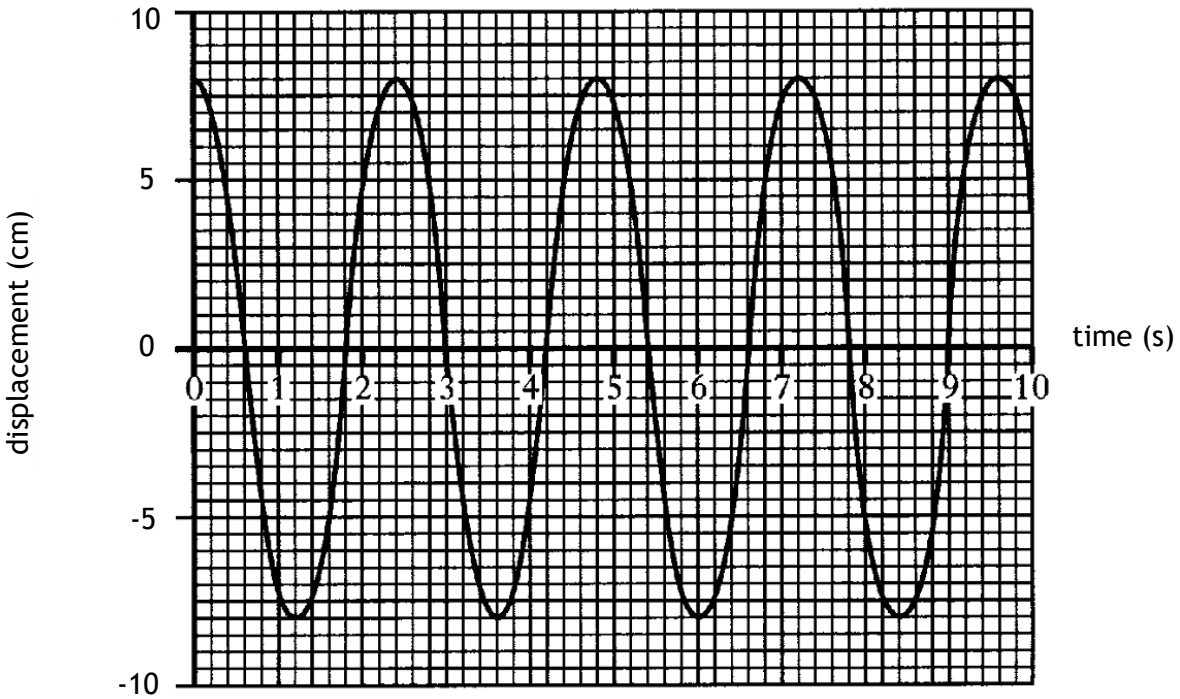
3. A mass of 0·40 kg is suspended from a spring as shown below. The mass is then displaced vertically and released. Its subsequent motion is recorded using a motion sensor linked to computer.



The mass moves with simple harmonic motion. The displacement-time graph of the mass is shown below.



(a) State the amplitude of the oscillation.

(b) State the period of the oscillation.

(c) Using the value from part (a) and (b) create an expression in form $y = A\cos\omega t$, for the vertical displacement y of the mass.

(d) Using the expression created in part (c), derive an expression which gives the relationship between the acceleration a of the mass and the time t.

(e) Calculate the maximum kinetic energy of the mass.

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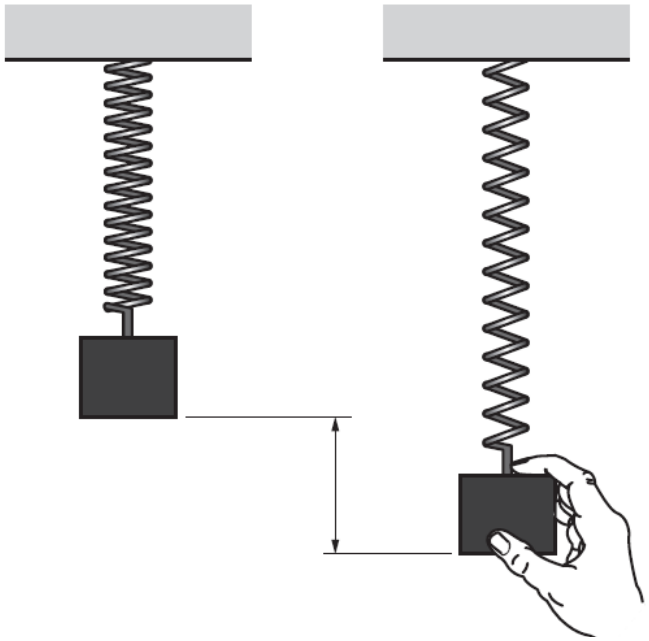
4. A group of pupils were evaluating an experiment to investigate the relationship between the mass on a spring and its period of oscillation. The diagram below shows some of the apparatus used.



Student A stated
"I think we should use a balance that reads to 0·001 g instead of 0·1 g. This will give us a more accurate answer."

Student B stated
"I think we should repeat the time measurement and calculate a mean value."

Student C stated
"I think we should time the pendulum for 10 oscillations and divide this value by 10 to get the time for one complete oscillation. This will give us a more precise answer."

Student D stated
"I think it would be good to check the mass on another balance."

Using your knowledge of experimental physics, comment on these statements.