Problem of the week

Simple harmonic oscillations (SL&HL)

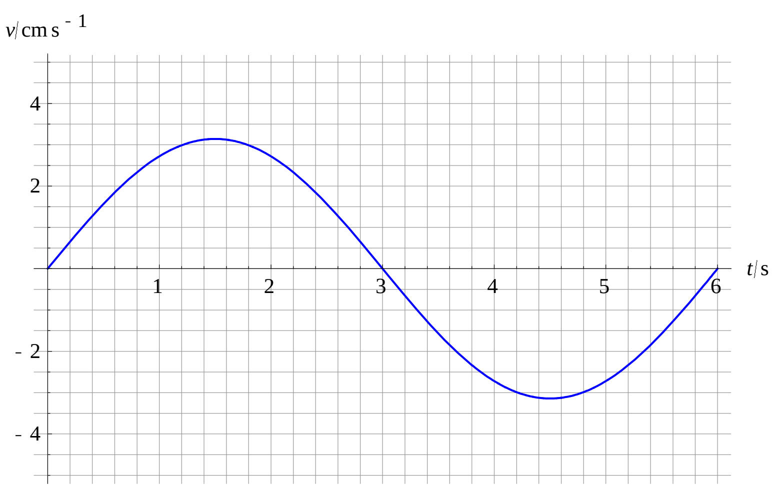
(a)

(i) The period of a simple pendulum on earth is 2.0 s. The mass of the bob is doubled. Determine the new period.

(ii) The period of mass-spring system is 3.0 s. Determine the period on a planet where the acceleration of free fall is half that of earth.

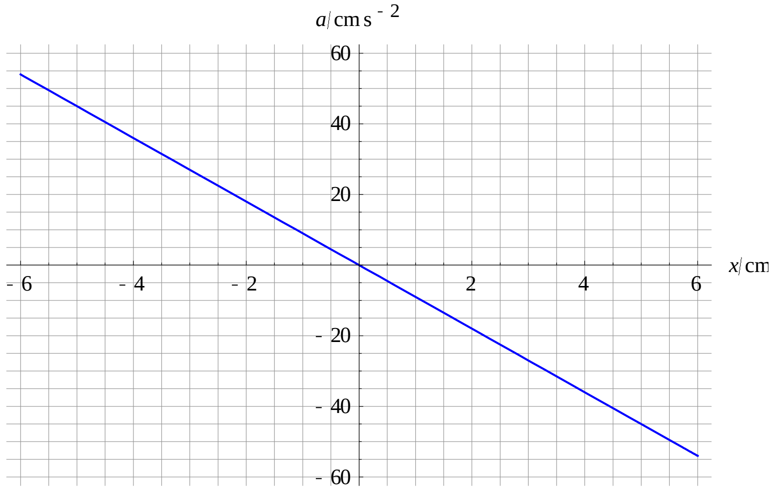
(iii) The period of a simple pendulum on earth is 1.0 s. The length of the string is doubled, and the pendulum is taken to a planet where the acceleration of free fall is half that on earth. Determine the new period.

(b) The graph shows the variation with time of the velocity of an object performing simple harmonic oscillations. The amplitude of the motion is 3.0 cm.



State the value of the area under the curve from t = 0 to t = 3.0 s.

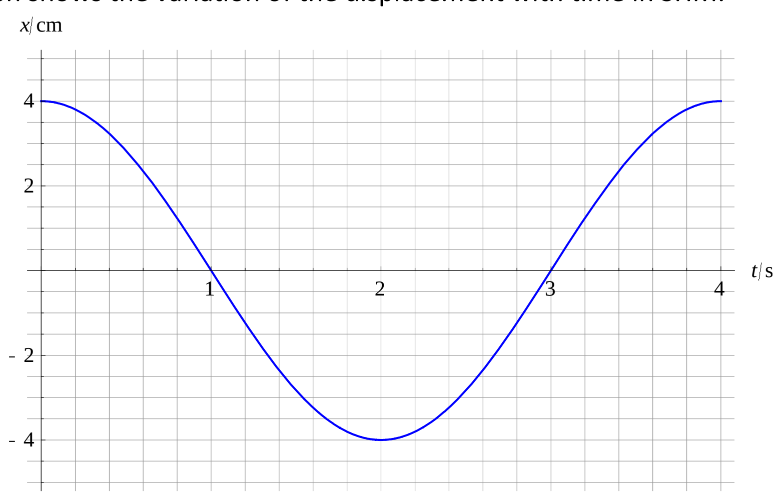
(c) The graph shows the variation with displacement of the acceleration of an object.



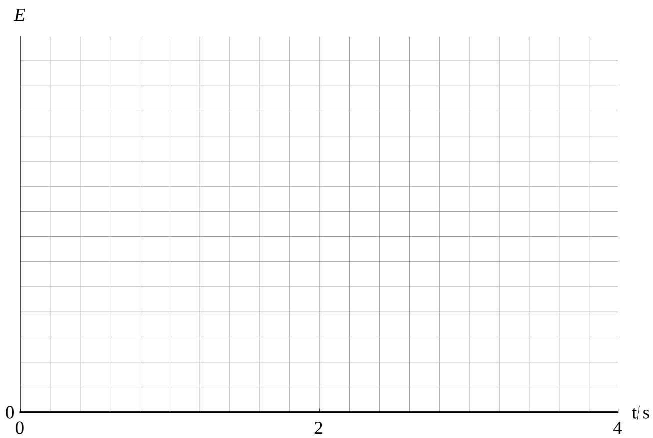
(i) Suggest why the graph implies that the motion of the object is simple harmonic.

(ii) Determine the period of oscillations.

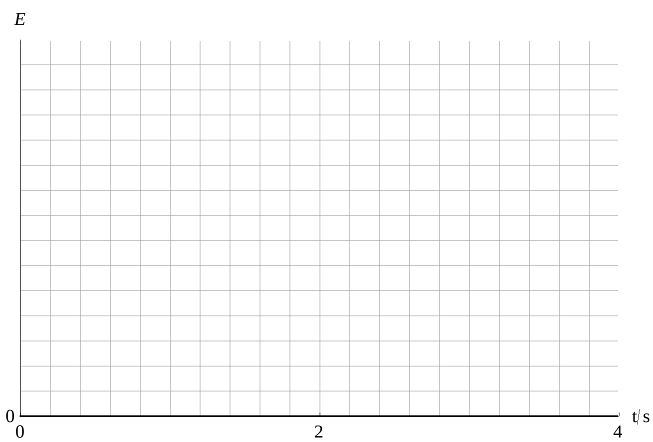
(d) The graph shows the variation of the displacement with time in SHM.



(i) Draw, on the same axes, graphs to show the variation with time of the kinetic energy and the potential energy of the object. No numbers are required on the vertical axis.



(ii) The period of the motion is doubled. Draw the new graphs of the variation of kinetic energy and potential energy with time.



Answers

(a)

(i) Period is independent of mass so no change.

(ii) Period is independent of g so no change.

(iii) $T' = 2\pi\sqrt{\frac{2L}{\frac{g}{2}}} = 2\pi\sqrt{4\frac{L}{g}} = 2T = 2.0\ \text{s}$

(b) The area is the distance from one extreme of the motion to the other i.e. a distance of twice the amplitude. The area is then 6.0 cm.

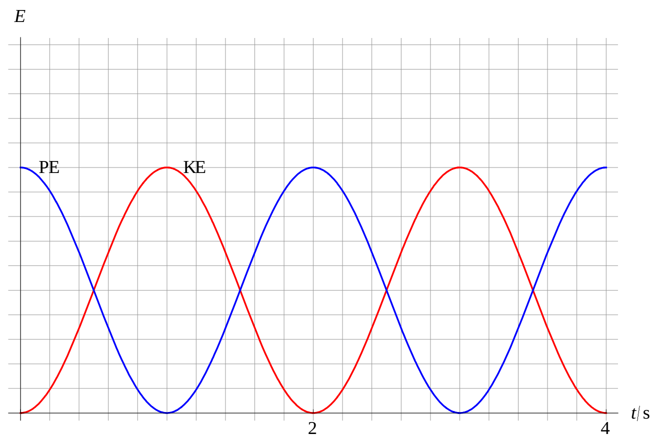
(c)

(i) Because the acceleration is opposite and proportional to displacement (straight line graph though origin with negative gradient).

(ii) The gradient is $-9.0\ \text{s}^{-2}$ and equals $-\omega^2$ so $\omega = 3.0\ \text{s}^{-1}$. Hence, $T = \frac{2\pi}{\omega} = 2.1\ \text{s}$.

(d)

(i)



(ii)