Connecting Kinematics and Energy for Simple Harmonic Motion

A student connects a 0.200 kg object on a spring, sets it into oscillation on a frictionless surface, and obtains the data for the position of the object as a function of time shown in the graph above.

1. Determine the maximum displacement from the graph.
   \[ x_{\text{max}} = 0.3 \, \text{m} \]

2. Determine the period from the graph.
   \[ T = 0.7 \, \text{s} \]

3. Calculate the frequency:
   \[ f = \frac{1}{T} = \frac{1}{0.7 \, \text{s}} = 1.43 \, \text{Hz} \]

4. Calculate the spring constant.
   \[ T = \frac{T^2}{4\pi^2} = \frac{M}{K} \]
   \[ k = \frac{0.2 \left(4\pi^2\right)}{(0.7)^2} = 16.1 \, \text{N/m} \]

5. Calculate the maximum acceleration of the mass.
   \[ F = ma \quad F = kmx \]
   \[ m a_{\text{max}} = kx_{\text{max}} \]
   \[ a = \frac{(16.1)(0.3)}{0.2} \]
   \[ a = 24.2 \, \text{m/s}^2 \]
6. Calculate the total energy of the spring-mass system.

\[ E_{\text{total}} = U_{\text{max}} = \frac{1}{2} k \chi^2 \]
\[ = \frac{1}{2} (16.1)(0.3)^2 \]
\[ = 0.735 \]

7. Calculate the maximum velocity of the mass.

\[ E_{\text{Total}} = K_{\text{max}} \]
\[ 0.735 = \frac{1}{2} (1.2) v^2 \]
\[ v = 2.7 \text{ m/s} \]

8. On the axis below, sketch the velocity of the object as a function of time. Explicitly label any intercepts, asymptotes, maxima, or minima with numerical values, as appropriate.

9. On the axis below, sketch the acceleration of the object as a function of time. Explicitly label any intercepts, asymptotes, maxima, or minima with numerical values, as appropriate.
10. On the grid below, sketch the total energy of the block-spring system as a function of time. Explicitly label any intercepts, asymptotes, maxima, or minima with numeric values, as appropriate.

![Energy is conserved](image)

11. On the grid below, sketch the potential energy of the block-spring system as a function of time. Explicitly label any intercepts, asymptotes, maxima, or minima with numeric values, as appropriate.

![Potential Energy](image)

12. On the grid below, sketch the kinetic energy of the block-spring system as a function of time. Explicitly label any intercepts, asymptotes, maxima, or minima with numeric values, as appropriate.

![Kinetic Energy](image)