Oscillations: SHM, Damping and Resonance

Further mechanics · 4 questions · step-by-step answers at the end

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USEFUL EQUATIONS

$a = -\omega^2 x$ $x = x_0 \cos \omega t$ $v = \pm\omega\sqrt{(x_0^2 - x^2)}$ $T = 2\pi\sqrt{(m / k)}$, $T = 2\pi\sqrt{(l / g)}$ $E = \frac{1}{2}m\omega^2 x_0^2$

Questions

Show your working in the space under each question.

1. A 0.20 kg mass on a spring oscillates with period 0.50 s. Find the spring constant.

2. An object moves with x = 0.050 cos(4πt), with x in metres and t in seconds. Find the frequency, the maximum speed and the maximum acceleration.

3. The mass on a spring is doubled. What happens to the period?

4. Why are soldiers told to break step when crossing a footbridge?

Step-by-step answers

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1. $k = 4\pi^2 m/T^2 = 4\pi^2 \times 0.20/0.25 =$ **$32\ \text{N m}^{-1}$**.

2. 1. $\omega = 4\pi\ \text{rad s}^{-1}$, so $f = \omega/2\pi =$ **2.0 Hz**.
2. $v_{max} = \omega x_0 = 4\pi \times 0.050 =$ **$0.63\ \text{m s}^{-1}$**.
3. $a_{max} = \omega^2 x_0 = (4\pi)^2 \times 0.050 =$ **$7.9\ \text{m s}^{-2}$**.
Answer: 2.0 Hz; $0.63\ \text{m s}^{-1}$; $7.9\ \text{m s}^{-2}$

3. $T \propto \sqrt{m}$, so it increases by a factor of **$\sqrt{2}$**.

4. Marching in step could drive the bridge at its **natural frequency**, causing resonance and a large amplitude.