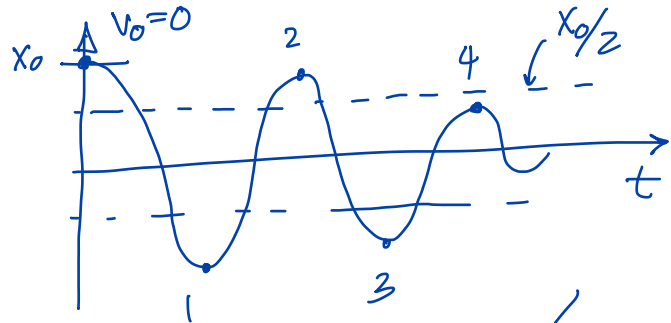
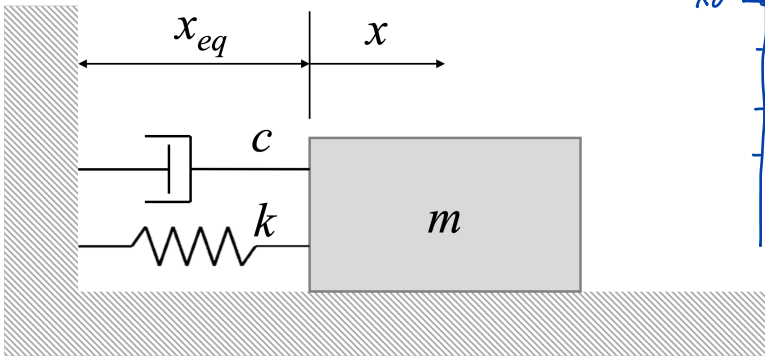


A 20 kg block on a frictionless surface is attached to a spring ($k = 700 \text{ N/m}$) and a damper ($c = 35 \text{ N-s/m}$). If the initial perturbation, x_0 , is 0.2 m ($v_0 = 0$), how many half-cycles will it take for the amplitude of the oscillation to peak at half the original displacement or less (i.e. $|x_{\text{peak}}| \leq |x_0/2|$)?

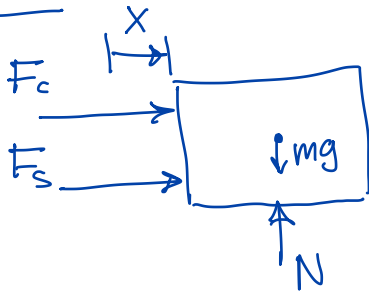


underdamped? ✓
 $c^2 < 4mk$

$$(35 \frac{\text{N}\cdot\text{s}}{\text{m}})^2 < 4(20\text{kg})(700\text{N/m})$$

$$1225 < 56000$$

FBD



$$F_s = -kx$$

$$F_c = -c\dot{x}$$

$$\sum F_x: F_c + F_s = m\ddot{x} = m\ddot{x}$$

$$\Rightarrow -c\dot{x} - kx = m\ddot{x}$$

$$\Rightarrow \underbrace{m\ddot{x} + c\dot{x} + kx}_{\text{must all be positive}} = 0$$

$$\Rightarrow \ddot{x} + \underbrace{\frac{c}{m}}_{2\omega_n \xi} \dot{x} + \underbrace{\frac{k}{m}}_{\omega_n^2} x = 0$$

$$\omega_n = \sqrt{\frac{k}{m}} = 5.92 \text{ rad/s}$$

$$\xi = \frac{c}{2m\omega_n} = 0.148 \text{ (no unit)}$$

$$\omega_d = \sqrt{1 - \xi^2} \omega_n = 5.85 \frac{\text{rad}}{\text{s}}$$

$$\text{or } t_n = \frac{n\pi}{\omega_d}$$