1] Daniel Kondratov - Today's substitute

SHO: $\boxed{\frac{d^2x}{dt^2}} = -\boxed{w_0^2}\, x$ ~~sx~~ ⇐ spring

$= -w_0^2 \sin x$ ⇐ pendulum

acceleration frequency

Damping: An effect that decreases the magnitude of oscillations

$x(t) = A\cos(wT)$

$F_{drag} = -Dv - \cancel{Dv^2}$ ⇐ quadratic damping

coefficient of Damping

X Dampening: To make a cloth wet

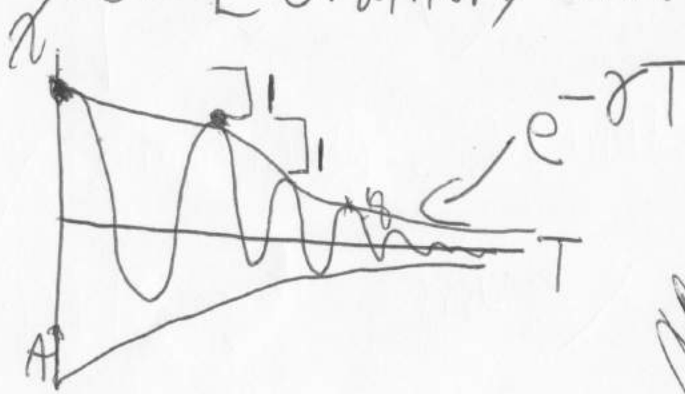
DHO: $F = ma \Rightarrow -kx - Dv = ma$; $k = m w_0^2$

$a = \frac{d^2x}{dT}$, $v = \frac{dx}{dT}$

decay factor

$\frac{d^2x}{dT^2} + 2\gamma \frac{dx}{dT} + w_0^2 x = 0$; $\gamma = \frac{D}{2m}$

ODE [ordinary differential equation]



$\gamma << W_0$

$x(T) = Ae^{-\gamma T} \cos(WT)$

$W = \sqrt{w_0^2 - \gamma^2}$

3)

$E(T) = \cancel{\tfrac{1}{2}mv^2}\ KE + PE$

$= \frac{1}{2} m v^2 + \frac{1}{2} m \omega_0^2 x^2$

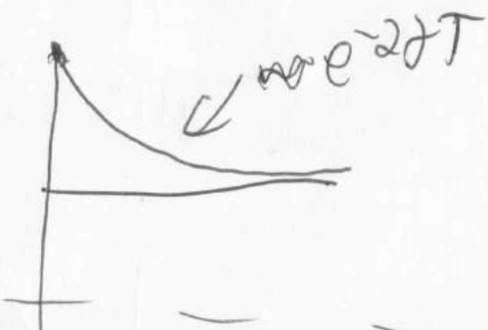
$x(T) = A e^{-\gamma T} \cdot \cos(\omega T)$

$v(T) = \frac{dx}{dT} = -\gamma A e^{-\gamma T} \cos(\omega T) - A\omega e^{-\gamma T} \sin(\omega T)$

$E(T) \cong \frac{1}{2} m A^2 \omega_0^2 e^{-2\gamma T} \sin^2(\omega T) + \frac{1}{2} m \omega_0^2 A^2 e^{-2\gamma T} \cos^2(\omega T)$

$\cos^2(x) + \sin^2(x) = 1$

$E(T) = \boxed{\frac{1}{2} m A^2 \omega_0^2 e^{-2\gamma T}}$



Quality Factor: Measure of Energy dissipation in a weakly damped oscillator.

$$Q = \frac{E}{\Delta E} \cdot 2\pi = \frac{\cancel{\frac{1}{2} m \omega_0^2 A^2} \cdot 2\pi}{\cancel{\frac{1}{2} m \omega_0^2 A^2} - \cancel{\frac{1}{2} m \omega_0^2 A^2}\, e^{[-\gamma \frac{2\pi}{\omega} \cdot 2]}}$$

4]

$$Q = \frac{2\pi}{1 - e^{-2\gamma\frac{2\pi}{w}}}$$

$$(1+x)^n \cong 1+nx$$

$$e^{-x} \cong 1 - x$$

$$Q \cong \frac{2\pi}{\cancel{1} - \left[\cancel{1} + 2\gamma\frac{2\pi}{w}\right]}$$

$$Q \cong \frac{w}{2\gamma} \Rightarrow Q = \frac{w_0}{2\gamma}$$

$\frac{E}{\Delta E} \cong$ # of oscillations a system will complete

$Q_{bell} \cong 1,000$

$Q_{guitar} \cong 30$

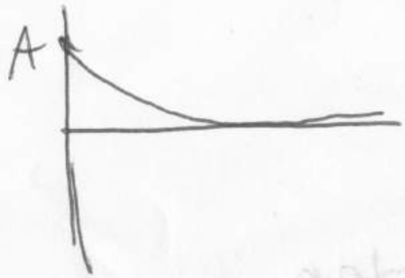
$Q_{earthquake} \cong 400 - 4,000$

5

Critical damping

$$x(T) = A e^{-\gamma T} \cos(\omega T) \rightarrow 1$$

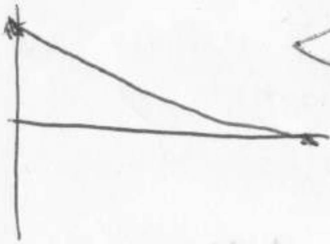
$$\omega = \sqrt{\omega_0^2 - \gamma^2}$$



$$\boxed{\omega_0 = \gamma}$$

overdamping

$$\gamma > \omega_0$$



very slow decay