# PHYS 195 : OSCILLATIONS AND WAVES REVIEW

MOSTLY IN 1 SPATIAL DIMENSION. FOR ANY 1D SYSTEM AROUND EQUILIBRIUM

$$U(x) = \underbrace{U(x_0)}_{\text{NO PHYS}} + \cancel{\left.\frac{dU}{dx}\right|_{x_0}}^{=0} x + \frac{1}{2} \underbrace{\boxed{\left.\frac{d^2U}{dx^2}\right|_{x_0}}}_{K_{eff}} (x-x_0)^2 + \cdots \qquad \text{TAYLOR EXP.}$$

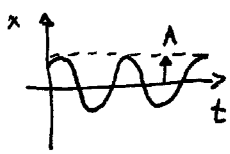
AND $U(x) = \frac{1}{2} k_{eff} (x-x_0)^2$


RESULTS IN

- **SIMPLE HARMONIC MOTION:**

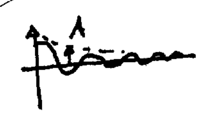
$E = \frac{1}{2}kA^2 = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$

EOM: $\boxed{\frac{d^2x}{dt^2} + \omega_0^2 x = 0}$ $\left\{ \begin{array}{l} \text{2ND ORDER} \\ \text{LINEAR} \\ \text{HOMOGENEOUS} \end{array} \right.$

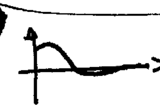



SOLUTIONS $x = A\cos(\omega t + \varphi)$ INITIAL CONDITIONS SET $(A, \varphi)$.

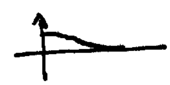
- **ADD DAMPING** : $F_d = -b\frac{dx}{dt}$ $\rightsquigarrow$ 3 CASES :




UNDERDAMPED



CRITICAL DAMPED



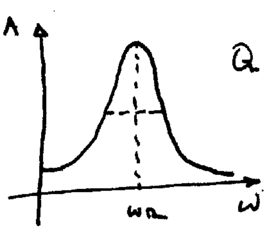
OVERDAMPED

SOLUTIONS $x(t) = Ae^{-\alpha t}\cos(\omega t + \varphi)$.

- **ADD DRIVING** : EOM $\frac{d^2x}{dt^2} + \frac{b}{m}\frac{dx}{dt} + \omega_0^2 x = \frac{F_0}{m}\cos(\omega t)$

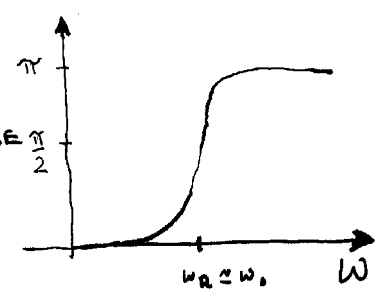
STEADY STATE SOL'N HAS $x(t) = A(\omega)\cos(\omega t - \delta)$

AMPLITUDE




$Q \sim \frac{\omega_R}{\Delta\omega} \sim \frac{m\omega}{b}$

PHASE $\delta$

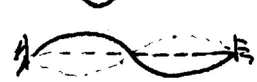



- MANY SYSTEMS INTERACT WITH ENVIRONMENT AND **WAVES**

EOM: $\boxed{\frac{\partial^2 D}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 D}{\partial t}}$ $v = \sqrt{\frac{F_T}{\mu}}$ FOR STRINGS PHASE VELOCITY OF WAVE

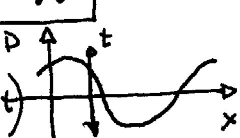
SUPERPOSITION :


STANDING WAVES :



$\lambda = L$

SOL'NS $D(x,t) = D_0 \sin(kx \pm \omega t)$




AVE. ENERGY TRANSPORT : $\bar{P} \propto f^2 D_0^2$