



$$F = ma$$

$$-kx - bV = ma$$

$$a = \ddot{x}$$

$$m \ddot{x} + bV + kx = 0$$

$$\omega = \sqrt{\frac{k}{m}}$$

$$x(t) = A \sin(\omega t + \delta) \quad \leftarrow b=0$$

$$a e^{i\omega t} + b e^{-i\omega t}$$

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Handwritten notes in red ink, including a small circle and the text "B cos".

$$\propto \sin + \dots$$

$$x(t) = A e^{-\beta t} \sin(\omega_1 t + \delta)$$

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$b \neq 0$   
 $b$ : not big  
 underdamped

$$\beta = \frac{b}{2m}$$

$$\omega_1 = \sqrt{\frac{k}{m} - \left(\frac{b}{2m}\right)^2}$$

$$\omega_1 < \omega_0$$

$$\omega_0^2 = \frac{k}{m}$$

$\omega_0$ : natural frequency

$$\omega_1 = \sqrt{\omega_0^2 - \beta^2}$$

$\beta = 0$  undamped

$$\beta^2 \ll \omega_0^2$$

$$\omega_0 = 10 \text{ Hz}$$

$$\beta = 1 \rightarrow \omega_1 = \sqrt{99} \approx 10 \text{ Hz}$$

$$\beta = 8 \rightarrow \omega_1 = \sqrt{36} = 6 \text{ Hz} \neq \omega_0^2$$

X

$$\beta^2 < \omega_0^2$$

under damped

critically damped

$$\beta^2 > \omega_0^2$$

over damped

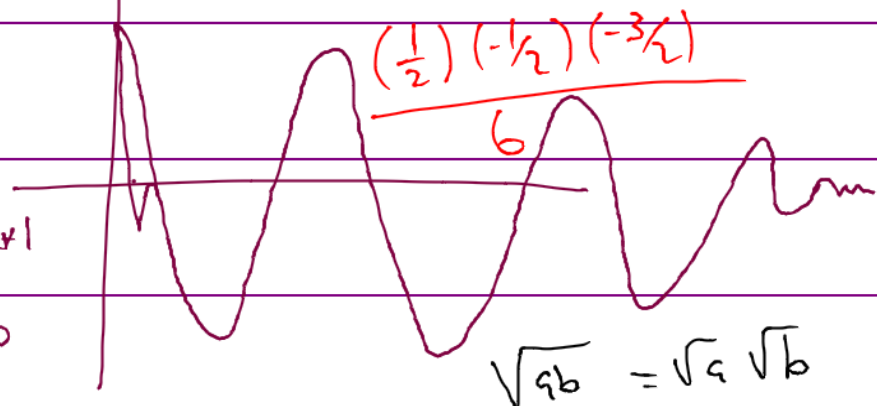
$$\frac{1}{8} = 0.125$$

$$\frac{3}{8} = 0.375$$

$$2! = 2$$

$$n! = n(n-1)(n-2) \dots \times 1$$

$$5! = 5 \times 4 \times 3 \times 2 \times 1 = 120$$



$$(1+x)^m \approx 1 + mX + \frac{m(m-1)X^2}{2!} + \frac{m(m-1)(m-2)X^3}{3!} + \dots$$

$$\sqrt{99} = (100 + (-1))^{1/2} = \left(100 \left(1 + \frac{-1}{100}\right)\right)^{1/2}$$

$$x = -0.01, m = 1/2 = 10 \left(1 + \frac{-1}{100}\right)^{1/2} = 10 \left\{ 1 + \frac{1}{2} \frac{(-0.01)}{1} + \frac{(-1/8) (-0.01)^2}{100} + \dots \right\}$$

$$\sqrt{99} = 10 \left\{ 1 - \frac{6.005}{100} - \frac{0.0000125}{100} \right\}$$

$$10 \times 0.995 = 9.95$$

$$\sqrt{99} \approx 9.94987$$

$$\begin{array}{r} 10.0 \\ 7.9 \end{array}$$

9.9  
9.3