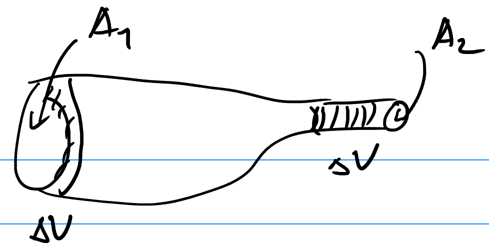
$$Q = \frac{\Delta V}{\Delta t}$$



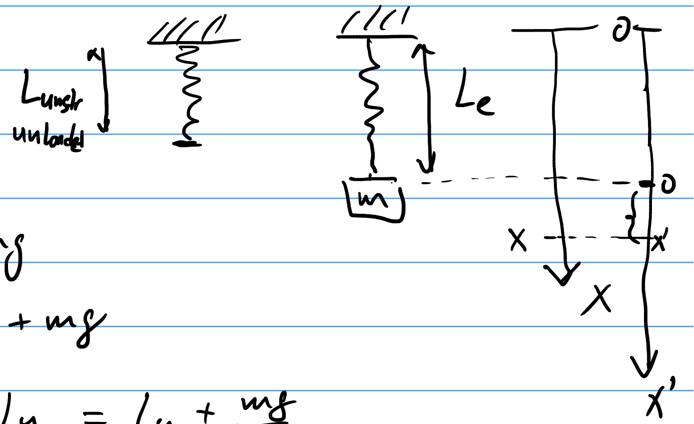
Oscillatory motion $\nearrow$ period $= T$ how long

$\uparrow$ repetative $\rightarrow$ frequency $= f = \frac{1}{T}$ how often, how many oscillation per unit of time

Simple harmonic motion

$$\ddot{x} = \frac{d^2x}{dt^2} = \frac{dv}{dt} = a = -\text{const.}\, x \implies \boxed{\ddot{x} = -\text{const.}\, x}$$

$$\ddot{x} = a = \frac{F}{m}$$



Hook's law
$$F_x = -k(x - L_u) + mg$$
$$F_x = 0 = -k(x_e - L_u) + mg$$
$$x_e = -\frac{mg}{-k} + L_u = L_u + \frac{mg}{k}$$
$$x = x' + x_e$$
$$F_x = -k(x' + x_e - L_u) + mg =$$
$$= -k\left(x' + \cancel{L_u} + \cancel{\frac{mg}{k}} - \cancel{L_u}\right) + \cancel{mg}$$

$$m\ddot{x} = m\ddot{x}' = -kx'$$
$$\ddot{x}' = -\frac{k}{m}x' \implies \text{drop the prime (')}$$

$$\ddot{x} = -\frac{k}{m}x = -\text{const}\, x$$
$$\boxed{\ddot{x} = -\omega^2 x} \qquad = \qquad \boxed{\omega = \sqrt{\frac{k}{m}}}$$

guess 1

$$x(t) = e^{c\cdot t} \qquad \dot{x} = \frac{dx}{dt} = c\cdot e^{ct} = c\cdot x$$

$$\ddot{x} = \frac{d}{dt}\left(c\cdot e^{ct}\right) = c\cdot c\, e^{ct} = c^2\cdot x$$

$$= -\omega^2\cdot x$$

$$c = \sqrt{-\omega^2} = i\omega$$

$$i = \sqrt{-1}$$

guess 2.

$$\boxed{x(t) = A\cos(\omega t+\varphi)}$$

$$\dot{x} = \frac{d}{dt}A\cos(\omega t+\varphi) = (A)(-)\sin(\omega t+\varphi)\cdot\frac{d(\omega t+\varphi)}{dt}$$

$$= A - \omega\sin(\omega t+\varphi)$$

$$\ddot{x} = A\frac{d}{dt}\left(-\omega\sin(\omega t+\varphi)\right) = -A\omega\cos(\omega t+\varphi)\frac{d(\omega t+\varphi)}{dt}$$

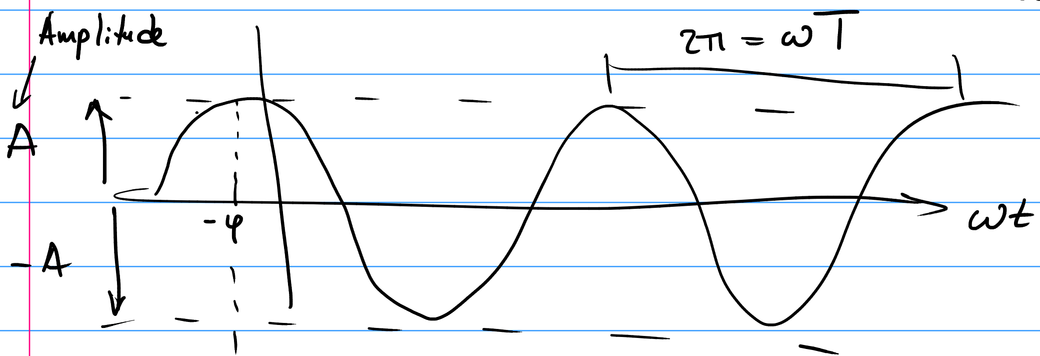
$$= -A\omega^2\cos(\omega t+\varphi) = -\omega^2 x$$

$$\cos(\theta) = \sin\left(\theta + \frac{\pi}{2}\right)$$

$$\boxed{x(t) = A\cos(\omega t+\varphi)}$$

angular frequency
not velocity

$$\omega = \frac{2\pi}{T}$$



max position
is when $\omega t + \varphi = 0$
$\omega t = -\varphi$

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

A, φ - ? from initial condition

$$x_0 = x(t=0) = A\cos(\omega t+\varphi) = A\cos\varphi$$

$$v_0 = v(t=0) = \dot{x}(t=0) = -A\omega\sin(\omega t+\varphi) = -A\omega\sin\varphi$$