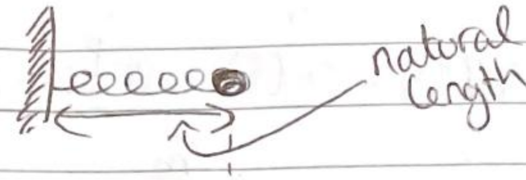
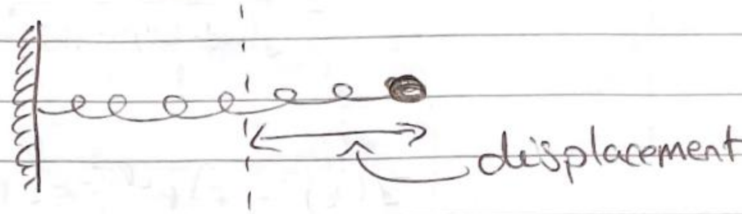
# Oscillations and Waves 1

Mass on spring:

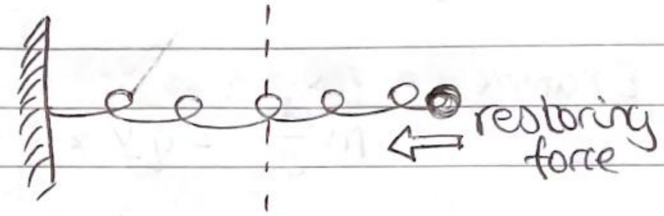
→ equalibrium



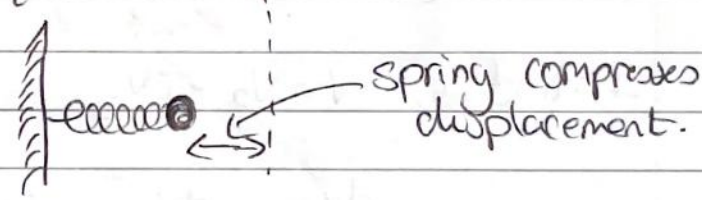

→ displace




→ release




→ mass moves to eqm, overshoots

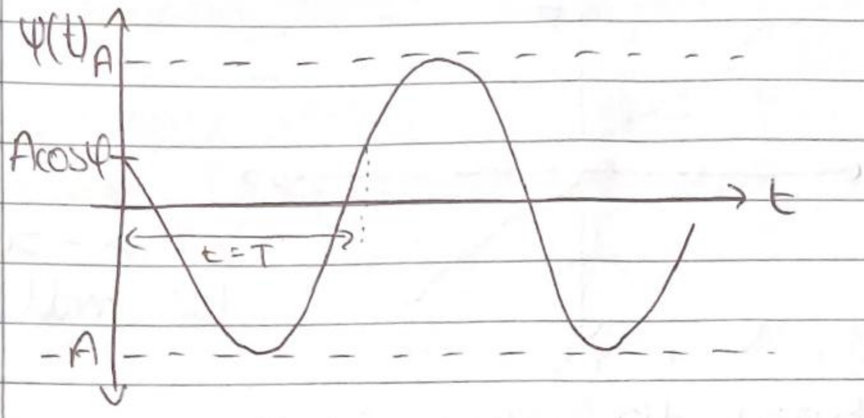



An oscillation has 3 components:

→ equalibrium
→ displacement
→ restoring force

A simple oscillation is when the displacement is a sinusoidal function of t.

$$\underset{\text{displacement}}{\psi(t)} = \underset{\text{amplitude}}{A}\cos(\underset{\text{angular frequency}}{\omega} t + \underset{\text{phase}}{\phi})$$




- $t = 0$ : $\psi = A\cos\varphi$
- $t = T$ : $\psi = A\cos(\omega T + \varphi)$

But $\psi(t = T) = \psi(t = 0)$

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

$f = \text{frequency} = \frac{1}{T} = \frac{\omega}{2\pi}$

no $\varphi$ (phase)

Alt form of SHM: $\psi(t) = B\cos(\omega t) + C\sin(\omega t)$

$B = A\cos\varphi \quad C = -A\sin\varphi$

Hooke's Law

For small displacements of a spring, the restoring force is given by Hooke's law.

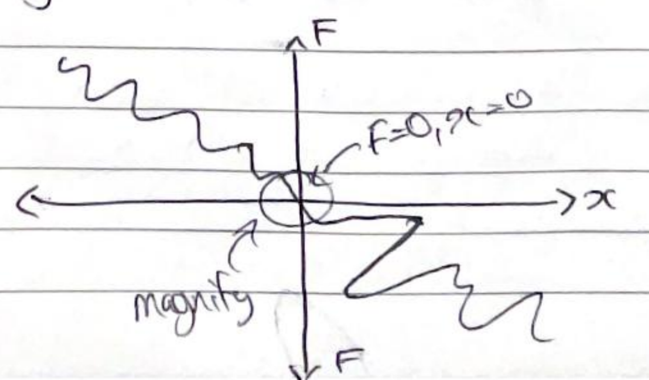
$F = -kx$ ← displacement

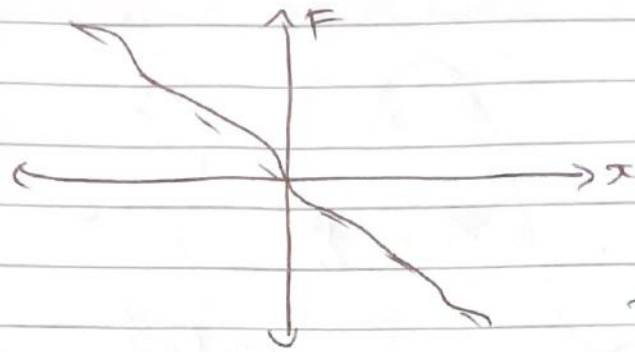
restoring force, opposite to displacement

spring constant

Hooke's law is usually valid for small displacements of any system with an equalibrium and restoring force.

Example





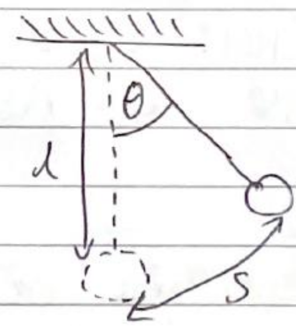

$F \propto -x$
for small $x$.

<u>Taylor Expand f(x) about origin</u>

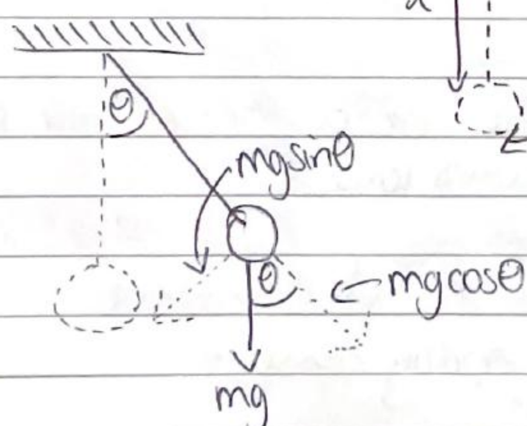
$$F(x) = \underbrace{F(0)}_{=0} + \underbrace{x\left(\frac{dF}{dx}\right)}_{\frac{dF}{dx}=-k} + \underbrace{\frac{x^2}{2!}\left(\frac{d^2F}{dx^2}\right)}_{\substack{x^2 \ll x \\ \text{ignore}}} + \dots$$

$$F = -kx$$

<u>Example</u>




displacement $= s = l\theta$




$F = mg\sin\theta$

Small angle approx. $\sin\theta = \theta$

$$F = -mg\theta = -mg\frac{s}{l} = -\left(\frac{mg}{l}\right)s$$

$\therefore$ pendulum follows hooke's law.