

Simple Harmonic Motion

displacement, x - distance from oscillator to equilibrium

Amplitude, A - maximum displacement to equilibrium

Time period, T - time it takes to complete 1 full oscillation

Frequency, f - number of oscillations per unit time

Angular frequency, ω - rate of change of angular displacement

$$\omega = \frac{\Delta \theta}{\Delta t} = \frac{2\pi}{T} = 2\pi f$$

- the acceleration is proportional to the displacement
- the acceleration is always directed towards the equilibrium position

$$a = -\omega^2 x + c$$

gradient, $m = -\omega^2$

$$m = -(2\pi f)^2$$

$$m = -\left(\frac{2\pi}{T}\right)^2$$

• Straight line through origin

a is proportional to x

• negative gradient: a is towards the equilibrium

How to determine T and f

- displace the mass to initiate the SHM
- measure $10T$ from the equilibrium position with the use of a fiducial marker

Take all measurement from eye level to reduce parallax error

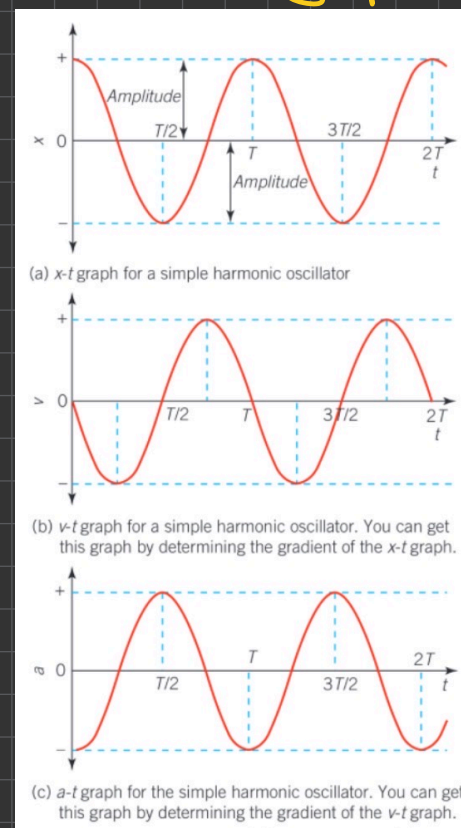
- Divide measurements by 10 for Time period

- Take multiple measurements and then find the mean to improve accuracy

- Calculate frequency using $f = \frac{1}{T}$

$$\omega = 2\pi f$$

SHM graphs

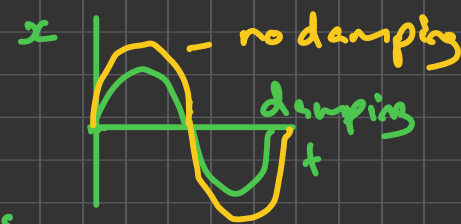


$$v = \frac{\Delta x}{\Delta t}$$

$$a = \frac{\Delta v}{\Delta t}$$

Damping effects:

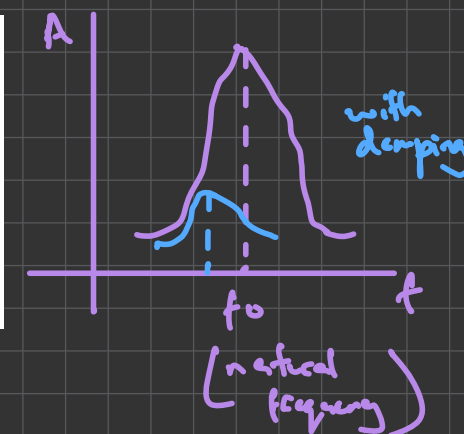
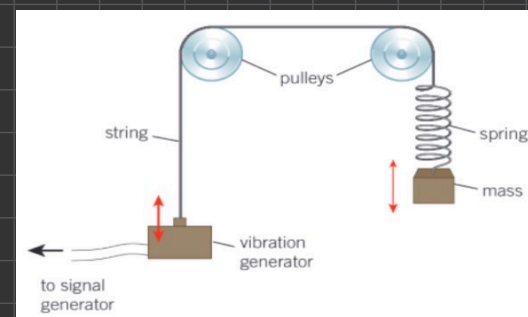
- Amplitude decreases
- Time period remains the same
- in SHM time period is independent of the amplitude



Free and forced collisions

In a free oscillation, the system is disturbed initially and then it oscillates with no external force

In a forced oscillation, a driving force is applied during the oscillation



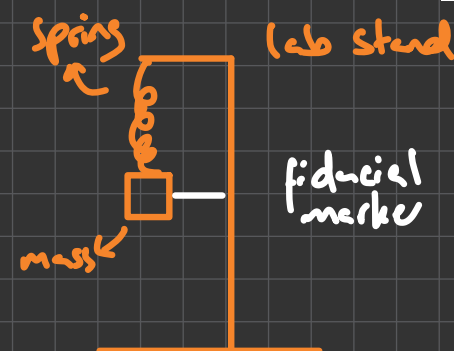
- A decreases

- peak occurs at a lower frequency

Natural frequency:

The frequency at which an object will oscillate after an initial disturbance

If the frequency of the driving force matches the natural frequency, resonance occurs. The amplitude increases considerably



Resonance examples:

Microwave oven: The driving frequency is the frequency of the EM radiation, which matches the natural frequency of the water molecules. This causes resonance. It increases the amplitude and the kinetic energy of the molecules of food

An oscillating bridge: The driving force from the wind matches the natural frequency of the bridge. This causes resonance and an increase in the amplitude of vibration of the bridge

Displacement equations

$x = A \cos(\omega t) \rightarrow$ use when $t=0$, oscillator is at amplitude

$x = A \sin(\omega t) \rightarrow$ use at $t=0$, oscillator is at equilibrium