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NEWTON'S LAW

Friction: Force that causes obj to slow down or stop.

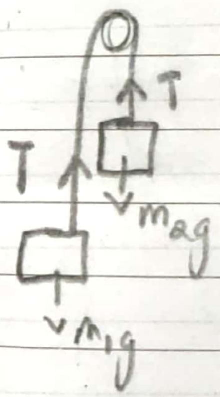
static prevents object from moving

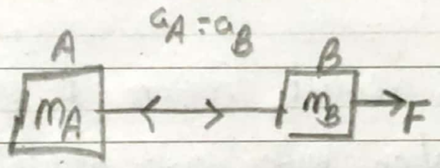
kinetic slows down moving obj

$$F = \mu R$$

Tension: Force transmitted through rope from one end to another.

Ideally, 0 mass, doesn't stretch, tension same throughout cord.



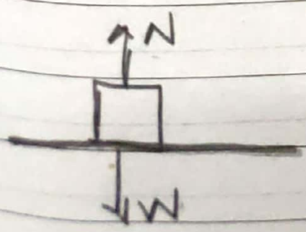


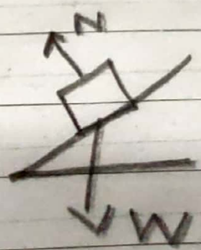
Spring Force: Force exerted by compressing or stretching a string.

$$\boxed{F = -kx}$$

$$\boxed{P.E = \tfrac{1}{2}kx^2}$$

Normal Force: Force acting perpendicullarly to contant surface





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Applied Force: Force applied in direction the obj is moving.

balanced equal forces in opp direction.
unbalanced unequal forces in opp direction.

LAWS of Motion:

→ An object moving with const. velocity requires no force to stay in motion.
→ If, net force = 0 then acc on obj = 0 and velocity constant.
→ when, net force ≠ 0, obj accelerates (+ or −)

★ N 1st LAW: Obj at rest remains at rest, obj in motion will stay in motion with const. velocity. Unless, acted upon by a force

Inertia: tendency of an obj to resist change.

Mass: scalar quantity, how much inertia the obj has.
comparing two masses, acceleration.
~~$m_1/m_2 = a_2/a_1$~~ $\boxed{\frac{m_1}{m_2} = \frac{a_2}{a_1}}$

Weight: $\boxed{W_F = mg}$
depends on gravity.

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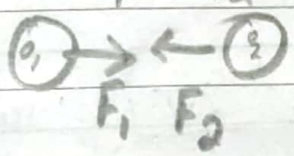
* N 2nd Law: Acceleration of an object is directly proportional to net force acting on it and inversely " to it's mass.

$$\boxed{F = ma}$$

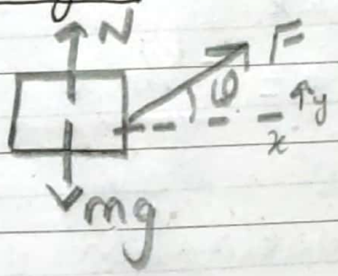
mass in kg, F in Newton, acc in m/s^2

* N 3rd Law: Two obj interact, F_1 exerted by Obj 1 on Obj 2 has equal magnitude but opp direction to F_2 exerted by Obj 2 ~~On~~ on Obj 1.

$$F_1 = -F_2$$



Free Body Diagram:



e.g: diagram.....

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OSCILLATION

Simple Harmonic Motion (SHM): oscillatory or wave like motion.

e.g: pendulum, guitar string.

$$\boxed{a = -\omega^2 x}$$

a = acc
ω = ang. speed
x = disp.

$F = 1/T$, T is time period, time it takes for one complete oscillation or wave

$\boxed{\omega = 2\pi f}$ or $\boxed{\omega = 2\pi/T}$ rad/s.

→ in spring: N's 2nd Law, $F_s = -kx$

as $F = ma$ ∴ $ma = -kx$, $a = -k/m\, x$

→ Condition for SHM: $a \propto -x$, acceleration is prop to disp from eq. position but opposite

→ formulas assuming disp is at extreme/max value = Amplitude.

$$\boxed{disp = A\cos(\omega t + \phi)}$$

Cos used when graph starts from extreme position.
Sin when ... mean position.

$$\boxed{velo = -\omega A\sin(\omega t + \phi)}$$

sin = extreme, cos = mean

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$$\boxed{acc = -\omega^2 A \cos(\omega t + \phi)}$$

cos = extreme , sin = equilibrium/mean.

→ Using N's 2nd Law: $F = ma = -(\omega^2 m)x = -kx$

$k = \omega^2/m$

$$\boxed{\omega = \sqrt{km}}$$

→ ϕ, phase difference: $2\pi\Delta t/T = 2\pi\Delta t f = \omega\Delta t$.

at a certain time. (Δt)

→ When acc and vel are max:

$\sin(\omega t + \phi) = 1$, so velocity is max, velo = ωA

$\cos(\omega t + \phi) = 1$, so acc is " , acc = $\omega^2 A$

→ ENERGY:

Potential energy = $\frac{1}{2}kx^2 = \frac{1}{2}kA^2\cos^2(\omega t + \phi)$

Kinetic $= \frac{1}{2}mv^2 = \frac{1}{2}m(\omega A\sin(\omega t + \phi))^2$

$= \frac{1}{2}m\omega^2 A^2 \sin^2(\omega t + \phi)$.

Total $= U + K = \frac{1}{2}kA^2$

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Angular SHM :

Torque associated with angular displacement

$$\tau = -\kappa\theta = I\, d^2\theta/dt^2$$

κ is torsion const; depends on length, diameter and material of suspension wire.

I is rotational inertia(?)

*mid-point.

$\boxed{\omega = \sqrt{\kappa/I}}$ $\boxed{T = 2\pi\sqrt{I/\kappa}}$ $\boxed{I = \frac{1}{2} m L^2}$

*example on page : 424.

Pendulums :

SHM when the centre mass is at a distance from the pivot, and has smol angular amplitudes.

$\boxed{T = 2\pi\sqrt{I/mgh}}$ $\boxed{\text{restoring torque } (\tau) = -L(F_g \sin\theta)}$

$\omega = \sqrt{I/mgh}$ * $F_g = ma$ $I\alpha$

$\boxed{\alpha = \left(-mgL/I\right)\theta}$ $\boxed{T = 2\pi\sqrt{L/g}}$ α = angular acc.

Damped Oscillations :

The oscillating objects motion is reduced by an external factor.

damping force (F_d) $\propto$ to the 1st power of velocity.

$\boxed{\cancel{F_d = -kv}}\ \boxed{F_d = -bv}$

$\boxed{disp = x_0 e^{-bt/2m} \cos(\omega' t + \phi)}$

x_0 = initial disp

ω' = derivative of ω

~~b = damping const~~

b = damping const.

$$\omega' = \sqrt{\frac{K}{m} - \frac{b^2}{4m^2}}$$ explaination.

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If, $b < 2m\omega_0$ under
$b > 2m\omega_0$ over
$b = 2m\omega_0$ critical damping.

N's 2nd Law:

$$\sum F_x = -kx - bv = ma_x$$

$$-kx - b\left(\frac{dx}{dt}\right) = m\left(\frac{d^2x}{dt^2}\right)$$

* as velocity is first derivative of x and acc is second.

$$x = A e^{-bt/2m} \cos(\omega' t + \phi)$$

$$\omega' = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$$

Forced oscillations and Resonance:

When a preodically oscillating object is subject to an external force, it exhibits forced oscillations.

Here two frequencies are involed:

ω_0 (natural frequency)

ω_e (freq due to external force)

$$\boxed{F_0 \cos(\omega_e t) = kx + b\left(\frac{dx}{dt}\right) + m\left(\frac{d^2x}{dt^2}\right)}$$

→ Resonance occurs when is disturbed by a periodic force which has frequency equal to the natural freq of the system.

The system oscillates with a LARGE amplitude.

$$\boxed{\omega_d = \omega_0,\ \text{Amplitude} \uparrow\uparrow}$$

WAVES

Mechanical waves:

Require : 1) a source of disturbance
2) a medium that can be disturbed.
3) a physical connection through which adj. portions of the medium can be influenced.

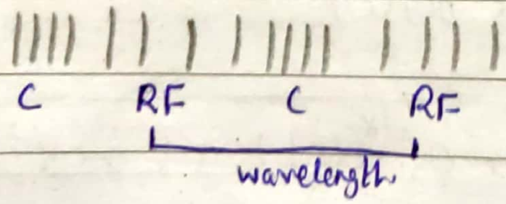
A wave is just energy travelling in a medium.

→ Types of M-waves:

TRANSVERSE: Vibration of the wave particles are perpendicular (normal/right angle) to the direction in which wave is travelling. 

Light is a transverse wave although it is not M-wave.

LONGITUDINAL: Vibrations of the wave particles are parallel to the direction of wave travel.



wavelength (λ) is from one RF to another or one C to another.

Sound waves are longitudinal.

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→ WATER:
Combination of transverse and ~~tr~~ longitudinal.

→ Sound waves:
Longitudinal waves.
Sound travels differently in different media.
Fastest in solids, slowest in gas.
The denser the medium the faster it travels.
Higher temperature means particle move faster...
Air = 347 m/s   WATER = 1500 m/s
Aluminium = 4,877 m/s.

Infrasonic and Ultrasonic:
frequencies below 20 Hz = Infrasonic
" above 20,000 Hz = Ultrasonic
Normal human hearing range: 20 – 20,000 Hz

WAVE ON A STRING:

$\boxed{y = h(x, t)}$ y = disp   h = sin/cos func of time and position.

→ Variables:

$\boxed{y(x, t) = y_m \sin(kx - \omega t)}$ k = angular wave no.
x = position.

OR

$\boxed{disp = A \sin(kx - \omega t)}$

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y_m = Amplitude of the wave, max displacement
phase of the wave : $(kx - wt)$
angular wave no. = related to λ $\boxed{2\pi/\lambda} = k$
period of oscillation = One full oscillation

$$w = 2\pi/T$$

frequency = no. of waves in one second

$\boxed{f = 1/T}$ $\boxed{f = w/2\pi}$

→ Wave speed :

as $(kx - wt)$ is a const

$$k\,dx/dt - w = 0$$

$$dx/dt = v$$

$$kv - w = 0$$

$$\boxed{v = w/k}$$

$\boxed{v = w/k}$
$\boxed{v = \lambda f}$

→ Wave Equation :

travelling wave in the following form

$$\boxed{y(x,t) = f(x \pm vt)}$$

???

these func. are solutions of wave equation

$$\boxed{\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 y}{\partial t^2}}$$ wave eq.

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→ Superposition of waves:

$$\boxed{y'(x,t) = y_1(x,t) + y_2(x,t)}$$

y' = disp of net / resultant wave

y_1 = " of wave 1

y_2 = " of wave 2.

Overlapping waves always produce a net wave

Interfere but don't interact.

IF two sinosoidal wave of SAME amp and λ travel in same direction, resultant wave:

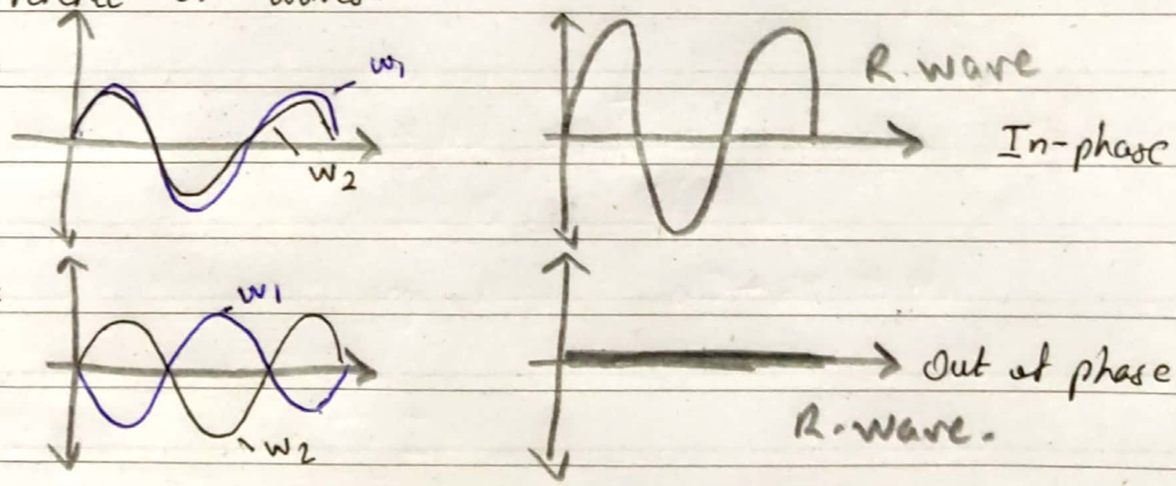
$$\cancel{y'(x,t) = [2y_m \cos(\tfrac{1}{2}\phi)}$$

$$y'(x,t) = [(2y_m \cos \tfrac{1}{2}\phi)] \sin(kx - \omega t + \tfrac{1}{2}\phi)$$

→ Interference of waves:

e.g 1:

e.g 2:



WHEN, resultant wave amplitude $= 0$ fully destructive

$= 2y_m$ " constructive

else Intermediate