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2. MECHANICS.

2.1 MOTION.

2.1.1 UNIFORM MOTION.

↳ Graph of position against time is a straight line
↳ Slope of this graph is constant.
↳ The slope is the average velocity.
↳ Average velocity during an interval of time Δt is the ratio of the change in position Δs during that time interval to Δt.

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

↳ Increasing position — positive velocity.
Decreasing position — negative velocity.

↳ Displacement (vector) = change in position.
Distance (scalar) = length of the path followed.

↳ For constant velocity, graph of velocity v/s time is a straight horizontal line.

UNIFORMLY ACCELERATED MOTION

↳ Here, the graph of velocity v/s time is a non-horizontal straight line.
↳ The slope is constant.
↳ The slope is the acceleration.
↳ rate of change of velocity.

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

Positive acceleration – increasing velocity.
Negative acceleration – decreasing velocity.

The slope of the tangent to the graph of position v/s time is velocity.
↳ For a particular point, we get the instantaneous velocity.

$$V = \lim_{\Delta t \to 0} \frac{\Delta s}{\Delta t}$$

For uniformly accelerated motion, we use the SUVAT Equations:

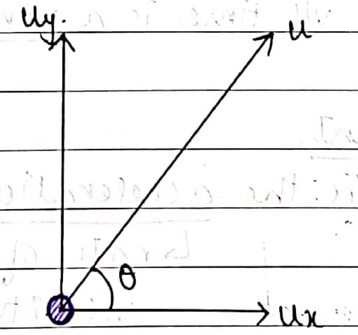
$$a = \frac{v-u}{t}$$

$$s = ut + \frac{1}{2}at^2$$

$$s = \left(\frac{u+v}{2}\right)t$$

$$v^2 = u^2 + 2as$$

PROJECTILE MOTION.



INITIAL VELOCITY:

$$u_x = u\cos\theta$$

$$u_y = u\sin\theta$$

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FINAL VELOCITIES:

$V_x = U_x = u\cos\theta$

$V_y = u\sin\theta - gt$

POSITION VECTORS.

$x = u_x t$

$x = ut\cos\theta$

$y = ut + \frac{1}{2}gt^2 ; g = -10ms^{-2}$

$y = ut\sin\theta - \frac{1}{2}gt^2$

$V_y^2 = u_y^2 - 2gy$

MAX HEIGHT @ $V_y = 0$.

$0 = u\sin\theta - gt$

$t = \frac{u\sin\theta}{g}$.

$y_{max} = u.\frac{u\sin\theta}{g}.\sin\theta - \frac{1}{2}g\left(\frac{u\sin\theta}{g}\right)^2$.

$y_{max} = \frac{u^2\sin^2\theta}{2g}$.

MAX HORIZONTAL DISPLACEMENT @ $y = 0$.

$0 = t(u\sin\theta - \frac{1}{2}gt)$

$t = 0$ or $t = \frac{2u\sin\theta}{g}$

$$x = \frac{u^2 \sin(2\theta)}{g}$$

FLUID RESISTANCE

↳ One of the drag forces.

Whenever a body moves through a fluid (gas or liquid), it experiences a <u>fluid resistance.</u>

↓ directed opp to the velocity.

$F = kv$ (low speeds)

$F = kv^2$ (high speeds)

During free fall, when the fluid or the air <u>resistance equals the weight</u> of the body, its <u>acceleration becomes zero</u> & it attains <u>terminal velocity</u> (V_T).

$$mg = kV_T$$

2.2 FORCES

↳ Force is a <u>vector</u>.

WEIGHT

↳ Force as a result of gravitational attraction.

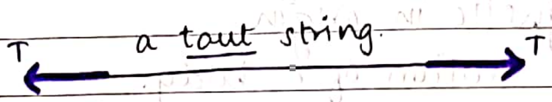
$$W = mg$$

g → gravitational feild strength of the planet.

TENSION

↳ Force that arises in any body when it is stretched.

The tension force is the result of electromagnetic interactions between the molecules of the string.



A tension force is created when 2 forces are applied in opposite direction. These 2 forces act on all any arbitrary point on the string.

In a massless string, the tension is the same at all points on the string.

FORCES IN SPRINGS

When a spring is pulled or compressed, tension is developed inside the spring that will tend to bring the length back to its original value.

Hooke's Law:

Tension force in a spring is proportional to the extension.

$$T = kx$$

→ spring constant.

NORMAL REACTION FORCE

↳ The force of reaction or contact force between 2 bodies.

↳ Perpendicular to the surface of the body exerting the force.

↳ The origin of this force is electromagnetic.

UPTHRUST

↳ Upward force experienced by a body in fluid
↳ If this force equals the weight, the body will float.
↳

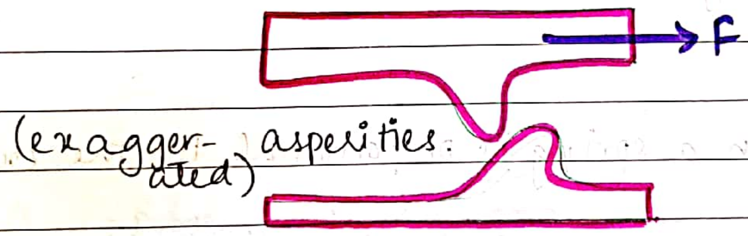
FRICTIONAL FORCES

↳ Electromagnetic in origin.
↳ Oppose the motion of a body.

DYNAMIC FRICTION
↳ arises when one body moves or slides over another
↳ also called the kinetic friction.

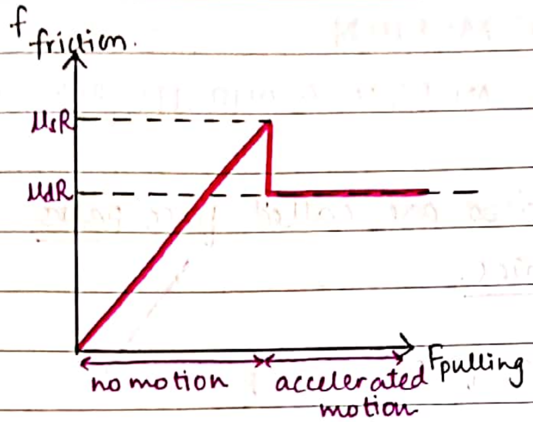
STATIC FRICTION
↳ arises when there is a 'tendency' for motion, not necessarily motion ~~itself~~ itself

The surfaces of bodies have irregularities (called asperities) which interlock & oppose sliding.



FRICTION LAWS:

1. The area of contact between two surfaces does NOT affect the frictional forces.
2. The force of dynamic friction is: $f_d = \mu_d R$
3. The force of dynamic friction does NOT depend on the speed of sliding
4. The MAXIMUM force of static friction that can develop between two surfaces is: $\mu_s R = f_s$



- Initially, the stractic friction force matches the pulling force. The negate each other & hence, there is no motion.
- When the pulling force exceeds the maximum possible static frictional force ($\mu_s R$), the frictional force drops abruptly to the dynamic friction value.
- This value stays constant & the body accelerates.

NEWTON'S FIRST LAW OF MOTION (law of inertia)

WHEN THE NET FORCE ON A BODY IS ZERO, THE BODY WILL MOVE WITH CONSTANT VELOCITY (WHICH MAY BE ZERO).

★ A force is what changes a body's velocity. A force is NOT what is required to keep something moving.

Inertia is what keeps the body in the same state of motion when no force is acting on it.

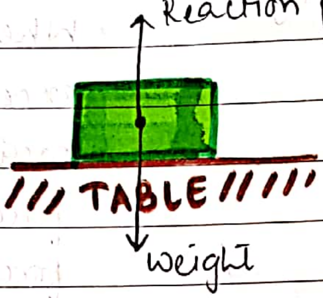
The reaction of a body to a change in its state of motion (acceleration) is inertia.

NEWTON'S THIRD LAW OF MOTION.

FOR EVERY ACTION, THERE IS AN EQUAL & OPPOSITE REACTION.

These action & reaction forces are called force pairs.
They act on different bodies.

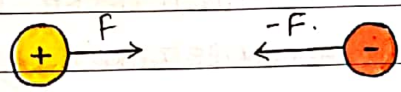
Eg:



$W = R$

These are equal & opposite forces, but they aren't force pairs because they act on the same body.

The 3rd law applies to cases where there is no contact between the bodies.
Eg. electric or gravitational forces.



NEWTON'S SECOND LAW OF MOTION:

THE NET FORCE ON A BODY OF CONSTANT MASS IS PROPORTIONAL TO THAT BODY'S ACCELERATION & IS IN THE SAME DIRECTION AS THE ACCELERATION.

$$F = ma$$

One Newton is the force required to accelerate a mass of 1 kg by $1 ms^{-2}$ in the direction of the force.

2.3 WORK, ENERGY & POWER.

PRINCIPLE OF CONSERVATION OF ENERGY:
Energy cannot be created or destroyed but is only transformed from one form into another.

→ Therefore, any change in the energy of a system must be accompanied by a change in the energy of the surroundings.

$$\boxed{\Delta E_{system} + \Delta E_{surroundings} = 0}$$

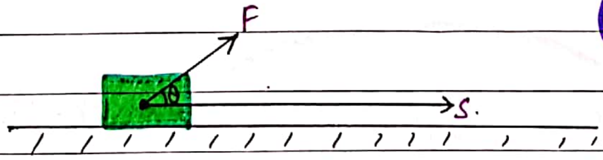
Energy changes occur when the system interacts with its surroundings.
→ These interactions involve work + transfer of thermal energy (Q)

When $Q = 0$ & there are no other energy transfers,

$$\Delta E = W.$$

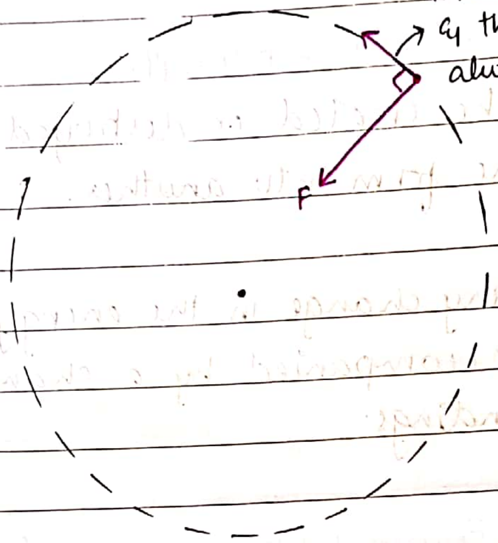
WORK DONE BY A FORCE:
The work done by a force is the product of the force in the direction of the displacement times the distance travelled.

$$W = F\cos\theta$$



One joule is the work done by a force of 1 N when it moves a body a distance of 1 m in the direction of the force.

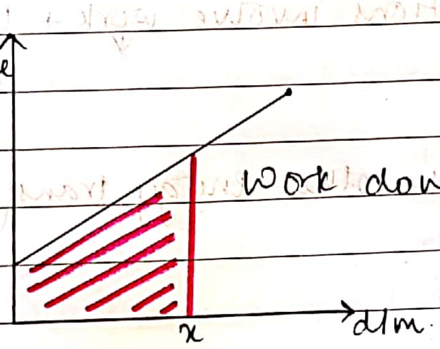
FORCE & CURVED PATH.



In a circle, the force & the line segments are always at right angles.
since $\cos 90 = 0$,
For circular motion, ~~the total work done~~ by the centripetal force is zero!

In circular motion there must be a force acting towards the centre of the circle. This is called the centripetal force.

(changing magnitude same direction)



Work done is area under the graph.

WORK DONE BY A FORCE ON A PARTICLE:

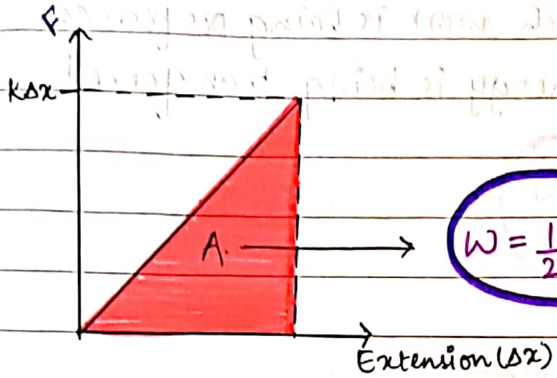
$$v^2 = u^2 + 2as.$$

$$v^2 = u^2 + 2\frac{F}{m}s$$

$$Fs = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

→ work-kinetic energy relation.

WORK DONE IN STRETCHING A SPRING:



$$W = \frac{1}{2}kx^2$$

This work done in extending the spring goes into its potential energy stored in the spring.

The elastic potential energy of a spring with extension equal to x is:

$$E_{el} = \frac{1}{2}kx^2$$

WORK DONE BY GRAVITY.

The work done by gravity is independent of the path followed & depends only on the vertical distance between the initial & final positions.
This makes weight a conservative force.

MECHANICAL ENERGY

The total mechanical energy (of a system consisting a particle, a spring & the Earth is:

$$E = \frac{1}{2}mv^2 + mgh + \frac{1}{2}kx^2$$

Potential energy is the energy of a system due to its position or shape & represents the work done by an external agent in bringing that system to that position or shape.

POWER

Power is the rate at which work is being performed or the rate at which energy is being transferred.

$$P = \frac{\Delta W}{\Delta t}$$

Also,

$$P = \frac{F \Delta x}{\Delta t} \longrightarrow P = Fv.$$

EFFICIENCY $= \frac{\text{useful energy out}}{\text{actual energy in}} = \frac{\text{useful power out}}{\text{actual power in}}$.

2.4 MOMENTUM & IMPULSE:

$$p = mv.$$

In terms of momentum, Newton's second law is:

$$F_{net} = \frac{\Delta p}{\Delta t}.$$

The average net force on a system is equal to the rate of change of momentum of the system.

$$\Delta p = F_{net} \Delta t = J$$

Area under the force v/s time graph

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CONSERVATION OF MOMENTUM:

WHEN THE NET FORCE ON A SYSTEM IS 0, THE MOMENTUM DOES NOT CHANGE ie. IT STAYS THE SAME. IT IS CONSERVED.

When kinetic energy is conserved, the collision is said to be elastic.

When kinetic energy is lost, the collision is inelastic. When the bodies stick together after collision, the collision is said to be plastic (totally inelastic)

$$E_K = \frac{1}{2}mv^2 = \frac{1}{2m}m^2v^2$$

$$E_K = \frac{p^2}{2m}$$

✓ Just Ask