AP PHYSICS 1 NOTES Sem 1 & 2

02A KINEMATICS

How to calculate percent error:

Distance:
the amount of space inbetween

Uncertainty (in Distance & Time) +/-:
best estimate of how far an experimental quantity might be from the "true value"; *Range* — ± (estimation)

Time:
How long something has taken place

Max Speed:
$\frac{\text{maximum distance}}{\text{minimum Time}}$

Minimum Speed:
$\frac{\text{minimum distance}}{\text{maximum time}}$

Accepted / Median Speed:
averaged out speed $((s_1 + s_2 + s_3) \div 3) \Rightarrow \bar{s}$ *not proper variables*

% ERROR: $\frac{|\text{experimental} - \text{theoretical}|}{\text{theoretical}}$; $\frac{|\text{experimental} - \text{accepted}|}{\text{accepted}}$

Motion Variables:

name	Definition	Variable	Units	Vector or Scalar?
Distance	How far feet traveled	x	m	Scalar
Displacement	Final position − start position	Δx	m	vector
Position	location @ 1 moment in time	x_1	@ meter mark	X
Velocity	displacement / time	v	m/s	vector
Average Velocity	$\bar{v} = \frac{v_1 + v_2}{2}$ if constant acceleration	$\bar{v}$	m/s	X
Speed	distance / time	s	m/s	Scalar
Acceleration		a	m/s/s	

Vector: has magnatude (size) & direction

Scalar: only has magnatude

Average vs Overtime

Instantaneous: @ one moment in time / speedometer

5 Equations of Motion:

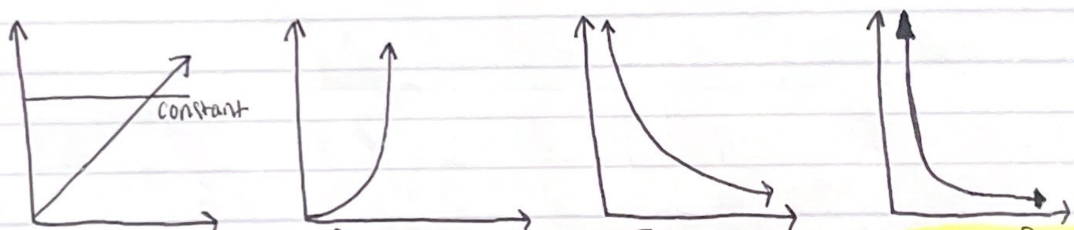
1) $X_f = X_0 + \overline{V}t$ $\quad \Delta X = \overline{V}t$
2) $V_f = V_0 + at$ $\quad \Delta V = at$
3) $X_f = X_0 + V_0 t + \frac{1}{2}at^2$ $\quad \Delta X = V_0 t + \frac{1}{2}at^2$
4) $V_f^2 = V_0^2 + 2a\Delta X$
5) $\overline{V} = \frac{V_0 + V_f}{2}$ (when acceleration is constant)

Original	final	Change in
X_0	X_f	ΔX
V_0	V_f	ΔV

X = position
a = acceleration
t = time
$\overline{V}$ = average v.

4 Mathematical Relation Ships

ONLY ONES EVER USED IN THIS CLASS



Linear	Quadratic	Inverse	Inverse Squared
$y = kx$	$y = kx^2$	$y = k(\frac{1}{x})$	$y = k(\frac{1}{x^2})$

k → constant of proportionality

Degree	1	2	-1	-2

2B & 2C — ACCELERATED MOTION

Problem Solving Steps:

1) Draw picture
2) Write given information
3) Formulan in Letters
4) Substitute in given information
5) Do Algebra
6) Answer with units in BOX

example) "a vehicle travels at 10 m/s. It accelerates at 5 m/s/s for 3 seconds. What is the final velocity?

$V_0 = 10 \frac{m}{s}$ $V_f = V_0 + at$ +1 formula letters

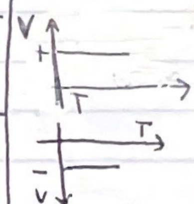
$a = 5$ m/s/s $V_f = 10 + 5(3)$ + plug

$t = 3$ sec $V_f = 25 \frac{m}{s}$ +1 answer

$V_f = ?$ +1 units

Velocity & Acceleration

Velocity	Acceleration	is this accelerated motion?	Describe Motion	
POS →	none	NO	Constant Positive Velocity	
← NEG	none	NO	Constant Negative Velocity	
POS →	POS →	YES	Constant Positive Acceleration Speeding up	
POS →	← NEG	YES	Constant Negative Acceleration Slowing down	driving forward breaking
← NEG	POS →		Constant positive acceleration Slowing down	backing up breaking
← NEG	← NEG		Constant negative acceleration speeding up	backing up gassing up



3 Accelerating forces:

1) Speeding up
2) Slowing down
3) turning / changing direction

Multiplicitive Factor Part 1

"An object starts at Rest and accelerates at a, reaching a velocity, V_f, over a displacement, Δx"

What equation relates these 4 variables? $V_f^2 = \cancel{V_0^2} + 2a\Delta x$ (→ 0)

Equation with the "Zero" term eliminated: $\boxed{V_f^2 = 2a\Delta x}$

* Multiplicitive factor can only have 2 terms (NOT 3 or 4)
If a variable "stays the same", replace with a 1 (bc 1 times as much) *

Ex) "If the acceleration doubled over the same displacement, by what factor is velocity affected?"

$V_f^2 = 2a\Delta x$ $\qquad V_f^2 = 2$

$V_f^2 = (1)(2)(1)$ $\qquad \boxed{V_f = \sqrt{2} \text{ larger}}$

No units

Multiplicitive Factor Part 2 → $V_0 = 0$

"An object starts from rest and accelerates at a, for a time, t, over a displacement, Δx

3 terms

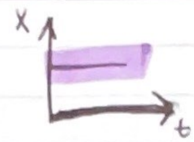
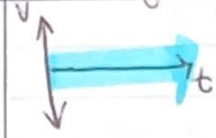
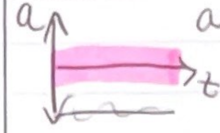
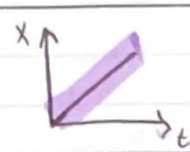
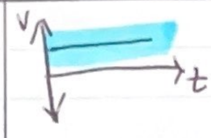
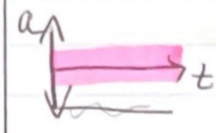
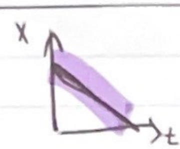
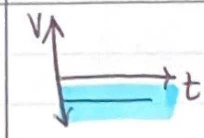
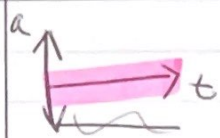
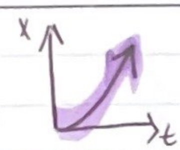
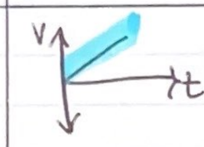
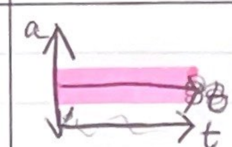
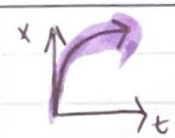
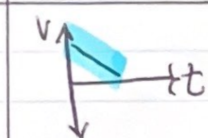
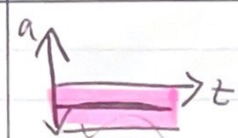
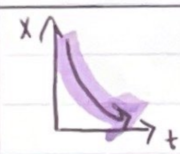
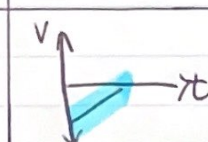
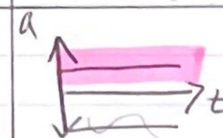
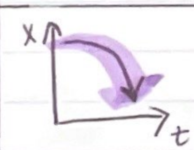
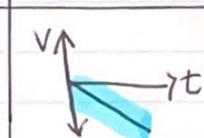
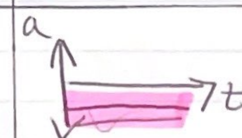
What equation relates these 4 variables? $\Delta x = \cancel{V_0 t}^{\,0} + \frac{1}{2}at^2$

Equation with the "Zero" term eliminated: $\boxed{\Delta x = \frac{1}{2}at^2}$

Multiplicitive Factor Part 3 "Comes to rest" ⇒ $\boxed{V_f = 0}$

$\cancel{V_f}^{\,0} = V_0 + at \rightarrow \boxed{0 = V_0 + at}$

time can NEVER NEGATIVE

	Position	Velocity	Acceleration
Not moving		 V=0	 a=0
constant positive velocity			
constant negative velocity			
Positive velocity with Constant positive Acceleration			
Positive velocity with Constant negative Acceleration			
Negative velocity with constant positive Acceleration			
Negative velocity with constant negative Acceleration			

Slowing down (the last two rows)

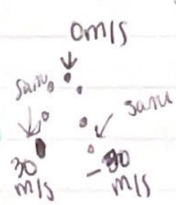
acceleration? → needs curve on P vs. T graph
→ needs slant on V vs. T graph

+V & −A
−V & +A = slowing down

pos Acceleration? → going up
neg Acceleration? → going down

Acceleration for gravity $= -9.8\,m/s^2$ (can be + if freefall only down)

@ Top of hight, velocity = 0



→ if thrown straight up.

03 VECTORS & PROJECTILES

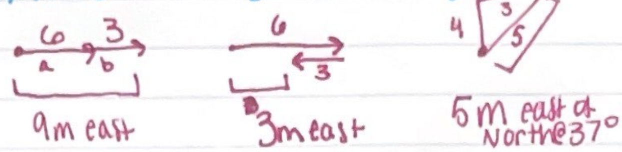
Vectors: quantity that has magnatude (size) and direction

ALWAYS Tip to Tail

examples: - displacement
- velocity
- acceleration

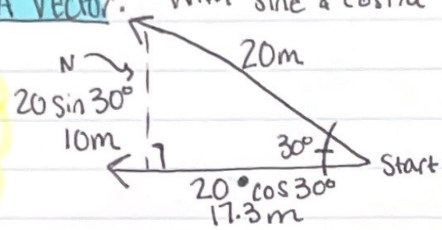
Vector A = 6, vector B = 3, Vector C = 4

ex1) $\vec{A} + \vec{B}$ ex2) $\vec{A} - \vec{B}$ ex3) $\vec{C} + \vec{B}$



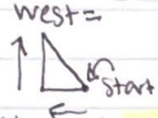
Orthogonal is another name for ⊥ (perpendicular)

Componetizing A Vector: with sine & cosine SOH CAH TOA



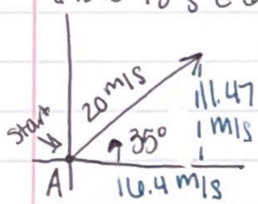
$\sin(30°) = \frac{N}{20} \cdot 20$
$\cdot 20$
$20\sin(30°) = N$

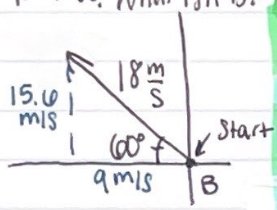
* Direction: 2nd, 1st *
ex) North of west =



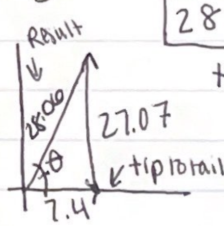
Adding Non-Perpendicular Vectors: use chart to calculate x & y for result

"A is @35° N of E 20m/s,
& B is 18 m/s @60° N of W. What is A+B?"





	x	y
A	16.4	11.47
B	-9	15.6
result	7.4	27.07



magnatude: $\sqrt{7.4^2 + 27.07^2}$

28.06m/s @ 74.7°

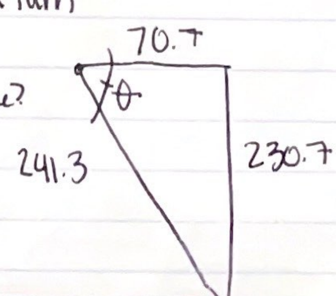
$\tan^{-1}\left(\frac{27.07}{7.4}\right) =$
$\theta = 74.7°$

What 3rd Vector should be added to above so Net Vector is Zero?

	x	y
A	0	160
B	-70.7	70.7
C	+70.7	-230.7
Result	0 m	0 m

Nature walk 160 m North, you turn around @ 45° west of North.
What is 3rd leg to return home?
What are components?

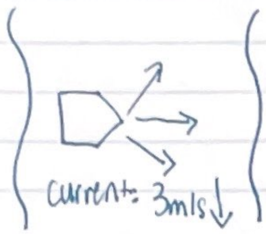
$\tan^{-1}\left(\frac{230.7}{70.7}\right) = 72°$



Relative Velocity

* **Horizontal & Vertical displacement are INDEPENDENT of Eachother** *

ex)



q: what direction would the boat need to be pointed for the boat to reach the shore *the quickest?

answer: straight, because independent of the vertical speed, the horizontal speed is quickest when pointed due east

q: what direction do I aim the boat if I want to move fastest with respect to shore (downshore)?

answer: downstream angle (speed + current, overall speed is greatest)

Horizontal Projectiles: $= \frac{1}{2}$ projectiles

From the base equation $\Delta y = V_0 t + \frac{1}{2}at$ comes the two INDEPENDENT EQUATIONS

Time → round 3 dec. places

Horizontal equation

$\Delta x = V_{ox} t$

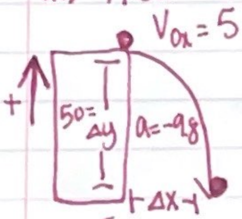
Vertical equation

$\Delta y = \frac{1}{2}at^2$

Tip: Start with Δy, find t, plug in *usually* for Δx or V_{ox}

ex) A ball is rolling off a cliff 50m high @ 5m/s what is

1) time in air?
2) calc. range (Δx)
3) final vel (V_i, H, & total)



1) $\Delta y = \frac{1}{2}at^2$

$50 = \frac{1}{2}(-9.8)($

$t = 3.194$ sec

2) $\Delta x = V_{ox} t$

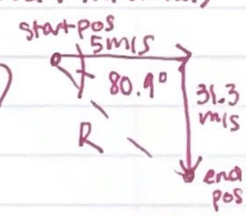
$\Delta x = 5(3.194)$

$\Delta x = 15.97$ m

3) $V_{fy} = V_{oy} + a_y t$

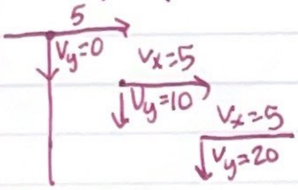
$V_{fy} = 0 + (-9.8)(3.194)$

$V_{fy} = -31.3$ m/s



R: $\tan^{-1}\left(\frac{31.3}{5}\right) = 80.9°$

result: 31.7 $\frac{m}{s}$ @ 80.9° South of East Below Positive X-axis



HORIZONTAL VELOCITY STAYS THE SAME!

Multiplicitive factor with half projectiles:

Verticle eq: $\Delta y = \frac{1}{2}at^2$ Horiz eq: $\Delta x = V_{0x}t$

ex) Imagine a half projectile. If the height of the cliff is doubled what happens to..

time in air?

depends on height

$\Delta y = \frac{1}{2}at^2$

$2 = (1)(1)(t^2)$

$\sqrt{2} = t \approx$ **1.41x s**

V_{0x}?

$\Delta x = V_{0x}t$

but Δy not in eq.

so No Effect

Range (Δx)?

$\Delta x = V_{0x}t$

$\Delta x = (1)(\sqrt{2})$

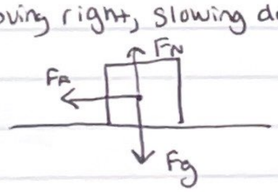
$\Delta x = \sqrt{2}$

04 Newtons Laws:

Five forces:
- F_g → gravity; always points down; unique to each object
- F_N → normal force (⊥ to plane of support)
- F_T → tension (rope, cable, chaine, string; one way)
- F_f → friction (opposes direction of motion)
- F_a → applied force (hand touching it)

Free Body diagram: a display SEPERATE from diagram

ex) moving right, slowing down



If the sum of forces is = 0, either:
1) constant velocity
2) No forces acting on it
3) Sums add to 0

F = MA
(force mass acceleration)

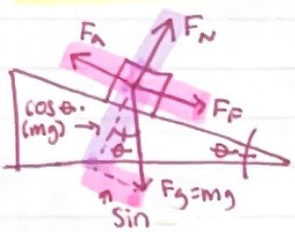
*If 2 objects are connected through **common tension**, the **tension is equal** *

Elevator Senarios:

Velocity:	acceleration	Speeding up or slowing down?	Normal force ___ Force of Gravity
↑	↑	S.U.	>
↑	↓	S.D.	<
↓	↓	S.U.	<
↓	↑	S.D.	>

* constant velocity $F_g = F_N$ *

Componetizing forces:



$m = 25\,kg$ $F_a = 120N$ $\theta: 40°$ $\mu = .18$

$F_\perp = 0$ → not floating $F_{\parallel} = ma_{\parallel}$

$F_F = \mu mg$

$F_F = \mu mg\cos\theta$ → $F_a - F_F - mg\sin\theta = ma_{\parallel}$

$F_a - \mu mg\cos\theta - mg\sin\theta = ma_{\parallel}$

$120 - (.18)(25)(9.8)(\cos 40°) - (25)(9.8)(\sin 40°) = 25a_{\parallel}$

$-2.85 = a_{\parallel}$

↑ neg means down ramp

2 types of friction: relative roughness between 2 objects

static = μ_s kinetic: μ_K

$\mu_s \geq \mu_K$

$0 \leq \mu \leq 1$
(0 ↑ frictionless, 1 ↑ Rough)

$\mu F_n = F_F$

Static friction - the force that keeps an object at rest

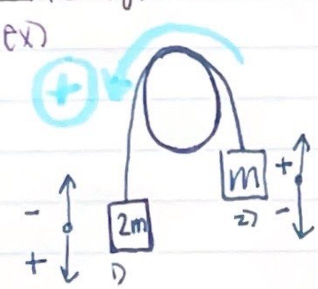
Kinetic friction - the friction that exists between 2 objects moving relative to eachother

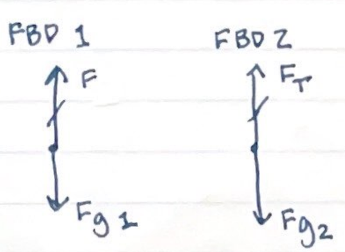
ex) Static → cars tires @ rest → movement

Kinetic → cars tires when skidding

multiple objects with the same tension: Same rope → Same tension

ex)





Solving:

$F_{g_1} = 2ma$

$F_{g_1} - F_{g_2} = (2m + m)a$

* chose + direction *

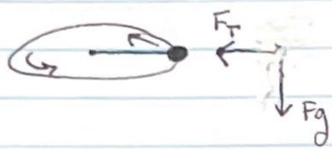
05 Circular Motion

3 categories of acceleration:
1) Straight line acceleration motion

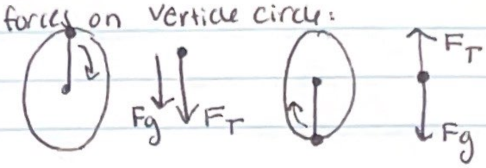
CH5 {
2) horizontal circular motion
3) vertical circular motion

Variables:
- Period (T) = (seconds) time for 1 revolution
- Circumference = $2\pi r$
- Speed (around outer edge) = $\frac{\text{circumference}}{\text{time}} \rightarrow V = \frac{2\pi r}{T}$
- radial force : force pointing towards center of circle
- $F_r = ma_r$
- a_r (radial acceleration) $\Rightarrow$ $a_r = \frac{v^2}{r}$

forces of horizontal circle:



forces on verticle circle:



"what's the slowest speed the rock can go before the rope goes SLACK (verticle)"?

→ Slack ⇒ at top, when does $F_T = 0$ (speed?)

Circular mechanics:

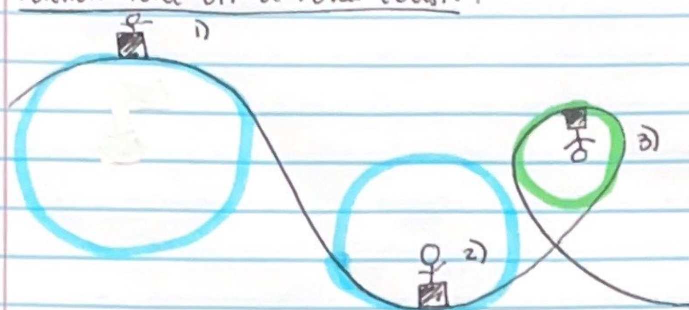
Frequency : (H_z) $\frac{\text{cycles}}{\text{second}}$ f
v.
Period: (T)(sec) $\frac{\text{seconds}}{\text{1 cycle}}$

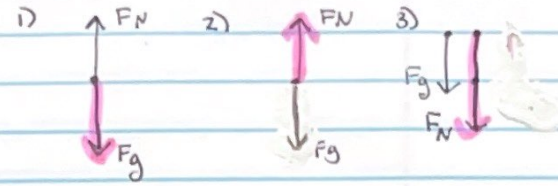
Rotation: on internal axis $\left(\frac{\text{24 hrs in}}{\text{1 day}}\right)$
v.
Revolution: on external axis $\left(\frac{\text{earth around}}{\text{sun}}\right)$

RPM: revolutions per minute → $\frac{\text{Rev}}{\text{1 min}}$

radial force:
- merry go round F_f ← ↓ F_g → Friction
- anti-gravity ride F_N ← ↑ F_f ↓ F_g → Normal
- rock on string F_T ← ↓ F_g → Tension

radial force on a roller coaster:





what does negative normal force: 1) the normal force was drawn opposite direction than reality

or

2) fallen out of seat

Slowest speed possible to prevent the man from falling out of his seat?

radial force = 0

$F_r = ma_r$

$F_N^{\nearrow 0} + F_g = \frac{mv^2}{r}$

universal law of gravitation: $F = \frac{Gm_1m_2}{r^2}$

{G is constant 6.67×10^{-11}}

Five equations for deriving:

$F = \frac{Gm_1m_2}{r^2}$	$a_r = \frac{V^2}{r}$	$V = \frac{2\pi r}{T}$	$F_r = ma_r$	$F_g = mg$

equations you can derive: $g = \frac{Gm_{planet}}{r^2_{planet}}$

orbital velocity: $V = \sqrt{\frac{Gm_{planet}}{r}}$ ← from center to satalite

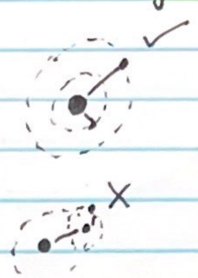
T = time to orbit?

Newtons synthesis: $\frac{4\pi^2}{Gm} = \frac{T^2}{r^3}$

Keplers 3rd Law: when 2 objects orbit the same 3rd object

$\frac{T^2}{r^3} = \frac{T^2}{r^3}$

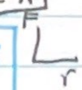
↑ one planet ↑ different planet



Astronomical unit (AU): distance from earth to sun

finding relationships between variables in equations:
- plug in 1 for all other variables & get on opposite sides

ex) $F = \frac{Gm_1m_2}{r^2}$ $F \propto \frac{1}{r^2}$ $F = \frac{(1)(1)(1)}{r^2} \rightarrow F = \frac{1}{r^2} \rightarrow$ square inverse (go off of x)



06 WORK, ENERGY, & POWER

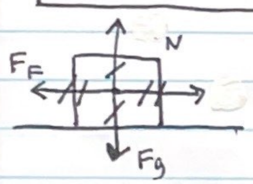
Work - A force is applied to an object
when I "do work", I change energy an object has

NET Work - Change in Kinetic Energy
Work = $F \Delta x \cos\theta$ in the same direction → x & y independent!
units of work: Joules (J) or Nm

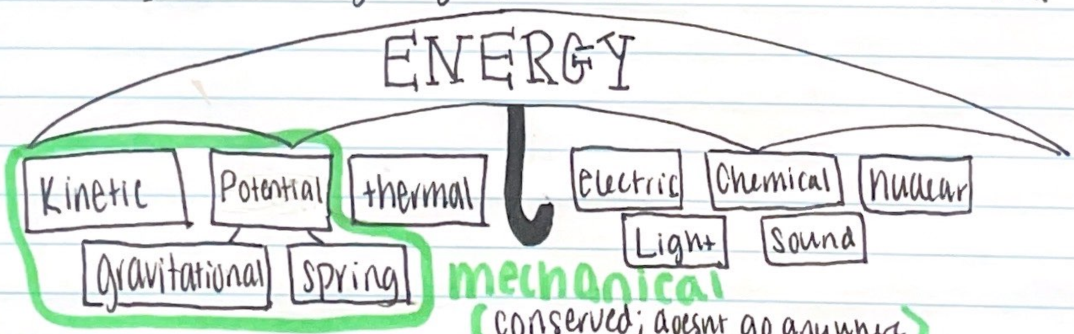
$\Delta KE = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_0^2$ $KE = \frac{1}{2}mv^2$ $\Delta KE = W_{Net}$

$W = F \Delta x \cos\theta$

* REMEMBER * work cannot be done by forces opp of Δx (4 Force has no work on Δx if in x plane)



work done by...
normal? 0 applied? (+) $F\Delta x(\cos 0°) = +F\Delta x$
gravity? 0 Friction? (-) $F\Delta x(\cos 180°) = -F\Delta x$



type of mechanical	abreviation	abreviation	Formula	units
Gravitational Potential	GPE	U_g	mgh	Joules
Spring Potential	SPE	U_e	$\frac{1}{2}kx^2$	Joules
Kinetic	KE	U_k	$\frac{1}{2}mv^2$	Joules or NM