Unit 1

*note

to find values in 2D, split into vector components - this will involve trig! (usually)

Kinematics eqs.

position : $X_f = X_i + V_0 t + \frac{1}{2} a t^2$ $(\Delta X = V_0 t + \frac{1}{2} a t^2)$

Velocity : $V_f = V_0 + at$ (no Δx) interchangable w/ y

Other formulas

when time doesn't matter → $V_f^2 = V_i^2 + 2a\Delta x$ (no t)

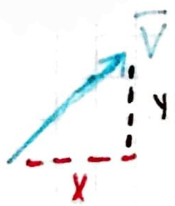
when acceleration doesn't matter → $\Delta x = \frac{1}{2}(V_i + V_f)t$ (no a)

Can be used in questions asking?

- Projectile motion in 1 & 2 dimensions (x & y)
- how far something moves / accelerates & calculating speed (if V = const, a = 0)
- how much time it takes for something to move

Vector Addition / Components

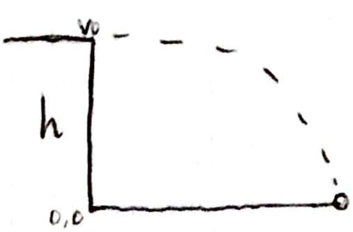
*



if $A + B = C$

then $A_x + B_x = C_x$ & $A_y + B_y = C_y$

Remember to change coordinate systems w/ angles below/above the horizontal if it makes life easier!!! :)



make a drawing!!

also write questions (if helpful) to find what you need

"What is ____ when ____ is ____?"

V_f	h	0
$X(t)$	$Y(t)$	0

Unit 2

Draw force diagrams!

See note on last page about vectors & cps

- Newton's 2nd → $\vec{F} = ma$
  - can break into components
    $\vec{F}_x$ & $\vec{F}_y$
  - Can include: Tension, Friction, Traction
  - Will include: F_N (normal force) & gravity (usually)

Can be used in questions asking?
- Calculating Static or Kinetic Friction → $\mu \cdot F_N = F_{Fric}$ in opposite direction of motion
- things sliding on surfaces in 1 or 2 D
- Vehicles "pulling" forward in 1 or 2D
- finding acceleration to insert into a kinematics eq.
- finding tension in ropes / pulley stetem

* Space & circles

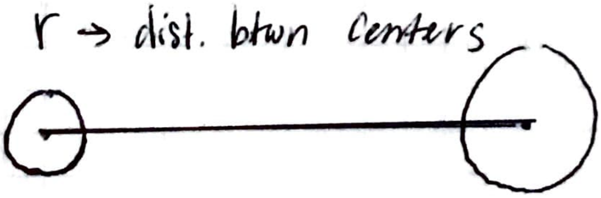
quick subsection!

$$\vec{F}_g = \frac{G M_1 M_2}{r^2}$$

$$G_{Earth} = 6.67 \cdot 10^{-11} \frac{N \cdot m^2}{kg^2}$$

where F_g: - diminishes over dist
- larger for more massive objects

r → dist. btwn centers



Unit 2 Con't

Circles & Space

position $\downarrow$ $\theta = \omega t$

use for conversions $\downarrow$ full rotation $\downarrow$

useful for sub. $\uparrow$

$\omega \rightarrow$ angular Velocity $\quad \omega = \frac{angle}{time} \; ; \; \frac{2\pi \, rad}{t} \; ; \; \frac{V}{r}$

$a_c \rightarrow$ Centripetal acceleration $\quad a_c = \omega^2 r \; ; \; \frac{V^2}{r}$

! always goes towards the center

This is derived from $S = \theta r$ & $V = \omega r$

dist. traveled = angle rotated · radius

$r \rightarrow$ radius, meters

Can be used in questions asking?

- Force of objects moving in a circle (req: force diagram)
- Space Questions : objects orbiting → assume circular (even if its an ellipses)
  - force of objects affected by gravity and apparent weight
    - ↳ F_n exerted on object by surface below it.
- Finding Velocity or Centripetal acceleration (or Static friction) or Tension... anything really
- Find in terms of Variables

STEPS to keep in mind

1. Draw cartoons & force diagrams
   - better understanding of how systems move
   - Separate diagram for each interesting object
   - label all forces
2. Translate FD's into Newton's 2nd law
   - change coordinate system if needed (helps to align with $\vec{a}$)
   - ~~Solve~~ X & Y components separately
   - leave things in algebraic variables to make things easy

   write out rather

3. Construct System of Eq. – Solve for what you know

Then find what you need

(This is where formulas & relations come into play)

Unit 3 & 4

- Walter's notes on his website is pretty comprehensive so ill only have what I think is important to note

Momentum → $\vec{P} = mv$
(vector)

Conservation of momentum (can't be created or destroyed)

$$\boxed{\underbrace{m_a v_a + m_b v_b}_{\text{initial}} = \underbrace{m_a v_a + m_b v_b}_{\text{final}}}$$

involves 3rd law:

if A pushes on B, B pushes back on A

$$\boxed{F_{A \to B} = -F_{B \to A}}$$ (useful for substitution!)

Δ momentum → impulse delivered; $P_i - P_f = \vec{F}$ (when constant)

* angular momentum → Similar concept, but circular
ang. velocity = rotational mass / ang. momentum

* ↳ $L = I\omega$
I ↑ inertia, ω ↖ a. velocity

$$\underbrace{L_a + L_B}_{\text{initial}} = \underbrace{L_A + L_B}_{\text{final}}$$

Inertia can be... λMR^2 → general

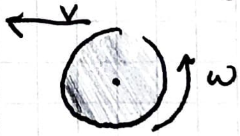
$\frac{1}{2}MR^2$ → circle, cylinder

! what we use most

MR^2 → ring

$\frac{2}{5}MR^2$ → sphere

* Can also be a combo



B:
$L_p = 0$
$L_w = CW$

A:
$L_p = ?$
$L_w = CCW$

Note: Think of before and after scenarios

is something sticking after collision? ($V_f(m_1 + m_2)$) or not?

Can be used in questions asking?

- Momentum in 1 & 2D (vectors are vital!)
- angular momentum: finding ang. velocity
- Momentum in Combination w/ kinematics

Unit 4 con't

Work-energy Theorem

use when there are/is

- clear initial & final states
- no need for time
- easy calculation of Σ Work

1D : $\underbrace{\frac{1}{2}mv_i^2}_{\text{Kinetic Energy (Scalar)}} + \Sigma \text{Work} = \frac{1}{2}mv_f^2$

↳ sum of all work done

2D : $\frac{1}{2}mv_i^2 + \Sigma \text{Work} = \frac{1}{2}mv_f^2$

↳ uses dot product

Work (in 1D) : $\Sigma \vec{F} \cdot \Delta x$

↳ size of force ↳ distance

Note:
- if $\vec{F}$ in direction of motion, $F \Delta x$ is + & speeds up
- if $\vec{F}$ is in opposite direction, vice versa.

Work (in 2D) : $\Sigma \vec{F}_{\parallel}(\Delta s)$ OR $\Sigma F(\Delta s_{\parallel})$ ← easy!

- Component of force $\parallel$ to displacement
- Component of displacement $\parallel$ to Force

* must ALWAYS follow (be parallel) to motion

What can do work? - Gravity, friction, tension, elasticity
Some of these can also be labeled as POTENTIAL ENERGY

Ex : PE gravity → $\frac{1}{2}mv_i^2 + (mg)h = \text{Final}$

↳ change in height

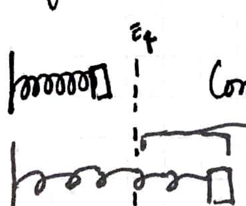
$$\Delta H = \frac{V_f^2 - V_i^2}{2g}$$

Friction, However... is nonconservative as PE forces do not! depend on the path whereas friction DOES depend.

SPRINGS → $F_{elastic} = k(\Delta x)$

↑ Spring Constant, $\frac{N}{m}$

Equilibrium when $\vec{F} = 0$



Compressed (negative)

- distance used (Δx)

Stretched (positive)

- When PE ⇒ $F_{elas} = \frac{1}{2}k(\Delta x)^2$

Unit 5

- **POWER** is measured in Watts $\left(\frac{1\text{ Joule}}{\text{sec}}\right)$

$$P = \vec{F} \cdot \vec{V} \rightarrow \text{derived from Work-Energy}$$

rate of work done w/ watts — force of power — rate of distance

ROTATIONAL KE

$KE = \frac{1}{2}mv^2$

$\vec{V} = \omega r$ so $KE = \frac{1}{2}mr^2\omega^2 \rightarrow \frac{1}{2}\overbrace{\lambda m r^2}^{I}\omega^2$

we recognize this?

slow

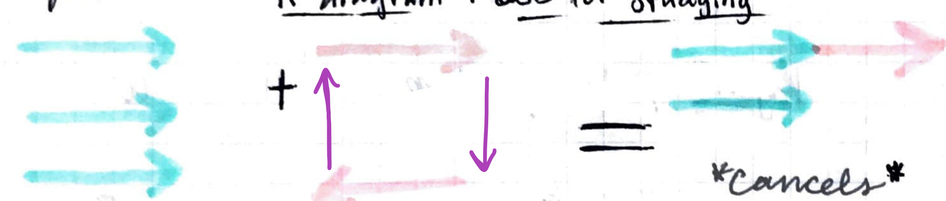
$\lambda =$
- 1 → ring
- 1/2 → cylinder
- 2/3 → hollow ball
- 2/5 → solid ball

fast

$\omega^2 = \frac{V_f^2}{r^2}$ where $V_f = \omega r$ (r → radius being rolled on)

is the rolling constant aka "no slip"

A diagram I use for studying



$V = \omega r$

$a = \alpha r$

Ex: $\underbrace{mgh}_{PE_i} = \underbrace{\frac{1}{2}mv_f^2}_{E_{Trans}} + \underbrace{\frac{1}{2}\left(\frac{1}{2}mr^2\right)\omega_f^2}_{E\text{ rolling}}$ or $\frac{1}{2}I\omega_f^2$

To find $V_f \rightarrow \sqrt{\frac{gh(2)}{1+\lambda}}$ which $= 1/2$ in ex.

NEW!

Torque $\tau = F_\perp r$ or $F r_\perp$ (RHR)

$\tau = I\alpha \rightarrow$ 2nd law of rotation

! Net torque = 0 at any point
Net force = 0
Torque due to $\vec{F}$ at pivot = 0

} static eq. (useful for ECS 221)

Base Quantities, Units & more!

Base Quantities	Unit	Sym
length	Meters (m), feet (ft)	L
mass	grams (g), pounds (lb)	m
time	Seconds (s)	t

↑ your best friends for life ↑ :)

Quantities		
Force	Newtons ($kg\frac{m}{s^2}$), $lb = \frac{slug\ ft}{s^2}$	F, Weight
Velocity	m/s , ft/s	V
Energy	$kg\frac{m^2}{s^2}$, N·m, w·s	joule, J
Power	$kg\frac{m^2}{s^3}$, J/s, N·$\frac{m}{s}$	Watts, w
Acceleration	m/s^2	a

Remember Some constants/values given can be unitless!

VECTOR vs SCALAR

VECTOR: has magnitude + direction
- displacement
- Velocity (except in energy problems)
- force
- notated w/ arrow ex: $\vec{V}$

SCALAR: specified with units, sometimes solved algebraically
- given base quantities (see above)
- no notation

K	H	D	W	D	C	M
3	2	1	Base	-1	-2	-3
kilo	Hecto	Deka		deci	centi	milli

use your conversions ~!

Other things to know + more

- Quadratic eq → useful in Kinematics (unit 1)

  $0 = ax^2 + bx + c \rightarrow x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

  if $\sqrt{\ }$ is negative / becomes imaginary

  there is no real answer!

- $F_{Friction}$ → Nonconservative force (see Work & Energy - Unit 4)

  $\leq \mu_s F_N$ Sticking

  $= \mu_k F_N$ Sliding

- Is momentum conserved in a portal? Is energy?

  (be prepared to answer questions like this)

  Ex: a) Always b) Sometimes c) Never

  Explain your reasoning

- Check out Walter's Final review notes & Sydney's Videos on the Website (main page & solutions)
- please do the final recitation packet that has helpful previous HW, exam & recitation questions.
- Come to the Clinic to ask us questions or ping us on discord

Lastly, take a deep breath. We made it to the end. You got this Good luck w/ finals week!

Best of luck,

Stay Hydrated PHY 211!

A. J & the PHY 211 Coaching Staff

Class of 2024