Physics 201 Review

The principal idea of this course, and all of physics is:

$$\boxed{\begin{array}{l} \text{① Identify the type of problem} \\ \text{② Follow the recipe for that type of problem.} \end{array}}$$

Let's build a "Table of Contents" for our recipe book!

1. Kinematics
   - 1.1 Basic Ideas
   - → 1.2 1D Motion

1.3 2D Motion

1.3.1 Projectile Motion

1.3.2 Relative motion

1.3.3 Uniform Circular Motion

2. Dynamics

2.1 Basic Ideas / Newton's Laws

2.2 Single Object (Newton's 2nd law)

2.3 Multiple Objects (Newton's 3rd law)

3. Energy and Momentum.

3.1 Basic Ideas

3.2 Work - Energy Theorem.

Momentum /

3.3 Conservation of Momentum / Collisions

4. Rotational Motion.

4.1 Moment of Inertia

4.2 Kinematics

4.3 Dynamics / Torque

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1. Kinematics.

1.1 Basic ideas.

$\vec{x}(t)$ - position?

$\vec{v}(t)$ - how fast?

$\vec{a}(t)$ - how is $\vec{v}$ changing.

VECTOR

$$\boxed{\vec{v} = \frac{d\vec{x}}{dt} \qquad \vec{a} = \frac{d\vec{v}}{dt}}$$

INSTANTANEOUS

$\Delta\vec{x} \to$ displacement

$$\equiv \vec{x}(t_f) - \vec{x}(t_i)$$

$$\vec{v}_{avg} \equiv \frac{\Delta\vec{x}}{\Delta t} = \frac{\vec{x}_f - \vec{x}_i}{t_f - t_i}$$

$$S_{avg} \equiv \frac{\text{Total Distance}}{\text{Total time}}$$

INTERVA

1.2 1D Motion.

Motion in 1D with constant acceleration

① $v_f = v_i + at$

② $\Delta x = v_i t + \frac{1}{2} a t^2$

③ $\Delta x = v_f t - \frac{1}{2} a t^2$

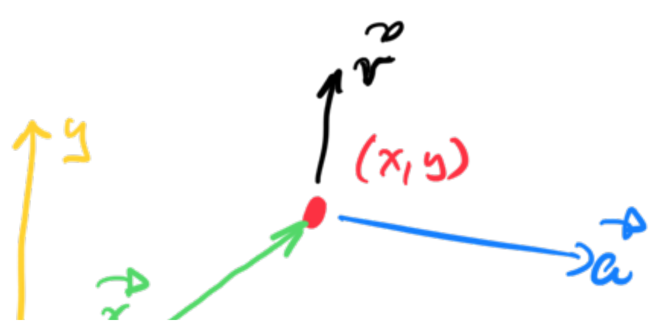
④ $\Delta x = \left(\frac{v_f + v_i}{2}\right) t$

⑤ $v_f^2 = v_i^2 + 2a\Delta x$

v_f
v_i
a
t
Δx

RULE OF THREE ✓✓

1.3 2D Motion (3D Motion)



BREAK APART THE X- and Y- motions

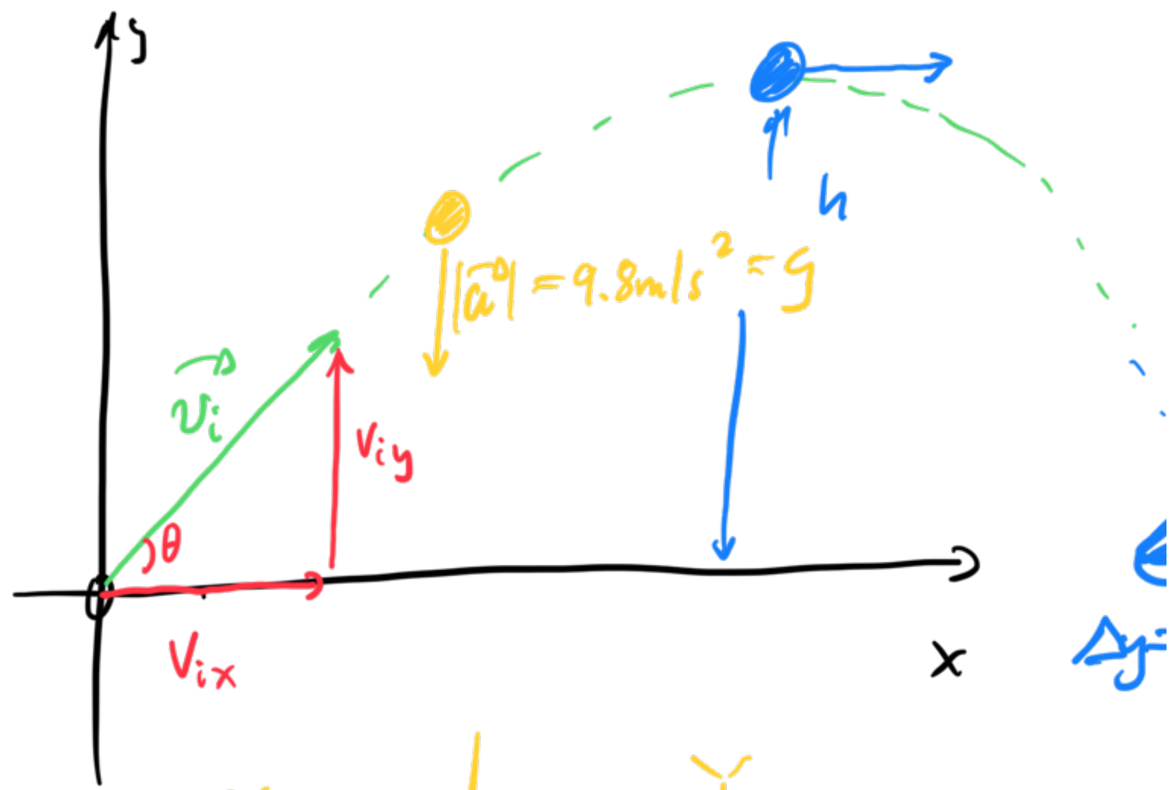
→ trig. sohcahtoa

X	Y
Δx	Δy
v_{ix}	v_{iy}
v_{fx}	v_{fy}
a_x	a_y
t	t

SAME

→ See section 1.2 !

1.3.1 Projectile Motion



X	Y
① $a_x = 0$	① $a_y = -g$
② $V_{ix} = V_i \cos\theta$	② $V_{iy} = V_i \sin\theta$
③ $\boxed{?}$	③ $\boxed{V_{fy} \overset{?}{=} 0}$

4 ✓

5 vt

4 ✓

5 t ✓

1.3.2 Relative Motion

IDENTIFY

→ three reference frames.

→ (boat, shore, water)

(plane, air, ground)

(rain, car, ground)

⋮

BOAT, SHORE, WATER

(B) (S) (W)

$\vec{v} \qquad \vec{v} + \vec{v}_{W/S}$

(1) $v_{B/S} = v_{B/W}$

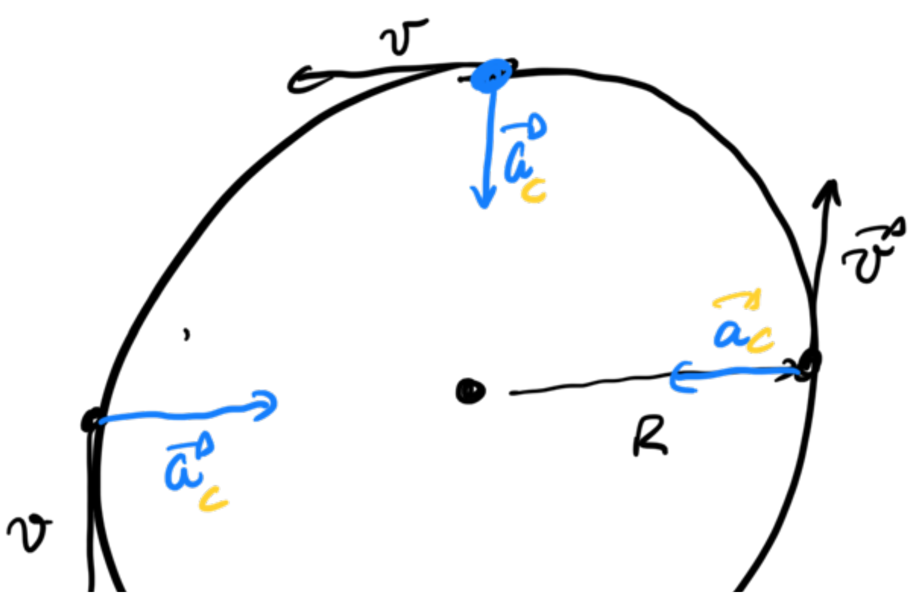
?

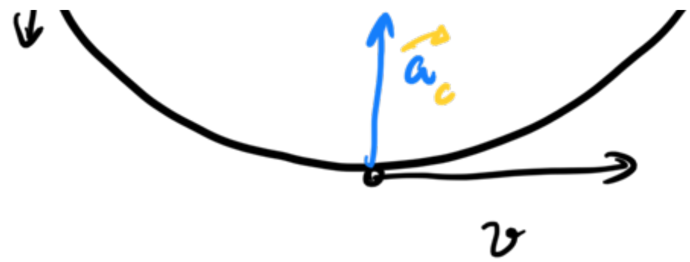
$$\vec{v}_{W/S} = \vec{v}_{W/B} + \vec{v}_{B/S}$$

(2)

$$\boxed{\vec{v}_{A/B} = -\vec{v}_{B/A}}$$

1.3.3 Uniform Circular Motion.





→ acceleration is directed to the centre of the circle!

$$|\vec{a}_c| = \frac{v^2}{R}$$

2. Dynamics

2.1 Basic Ideas

N2L
$$\boxed{\sum_i \vec{F}_i = \vec{F}_{NET} = m\vec{a}}$$

Single Object

2.2 (1) Identify all Forces!
(external)

→ gravity
→ contact forces

$\boxed{\text{FBD}}$ (normal force, friction, tension, ...

(2) Choose a coordinate system!
Such that $a_y = 0$, $a_x = \boxed{a}$

(3) Break all forces down into
x- and y- components.

(4) $\sum F_x = m a_x$ $\sum F_y = m a_y = 0$

⋮

Solve.

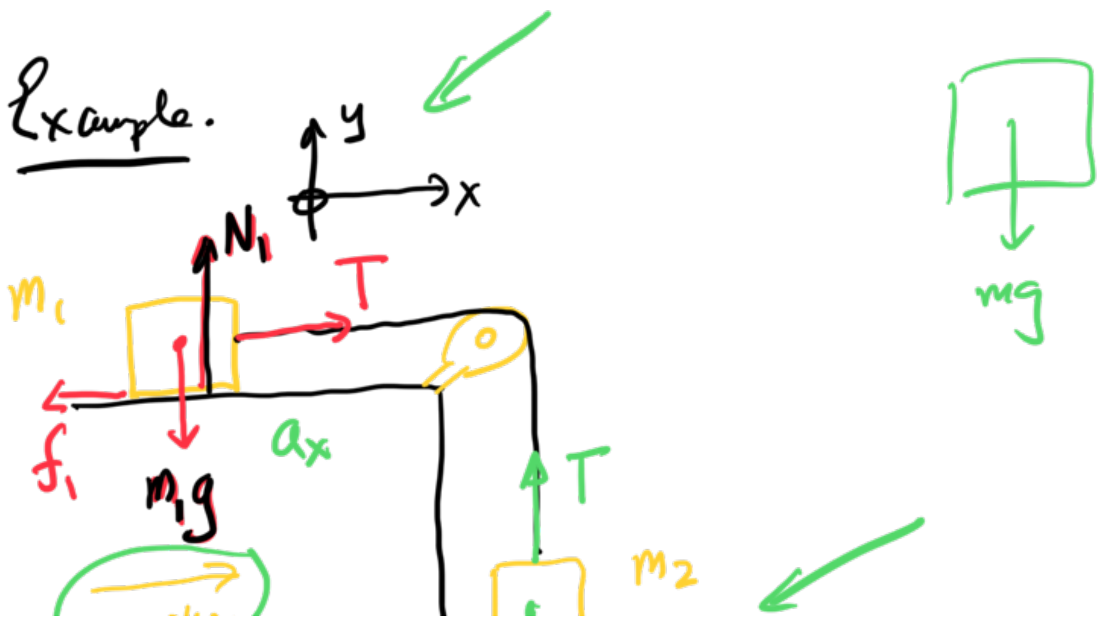
2.3 Multiple Objects

1 → FBD for <u>each</u> object, in isolation

2 → Think carefully about using <u>consistent</u> coordinates systems between the different objects.

3 → label the masses, forces, etc. appropriately for the different objects.

<u>Example.</u>



Object 1 $\quad x$: $\quad T - f_1 = m_1 a_x$

y: $\quad N - m_1 g = m_1 a_y = 0$

$\therefore \quad N = m_1 g$ ✓

$f_1 = \mu_K N = \mu_K m_1 g$

+ve

$$\boxed{T - \mu_K m_1 g = m_1 a_x}$$

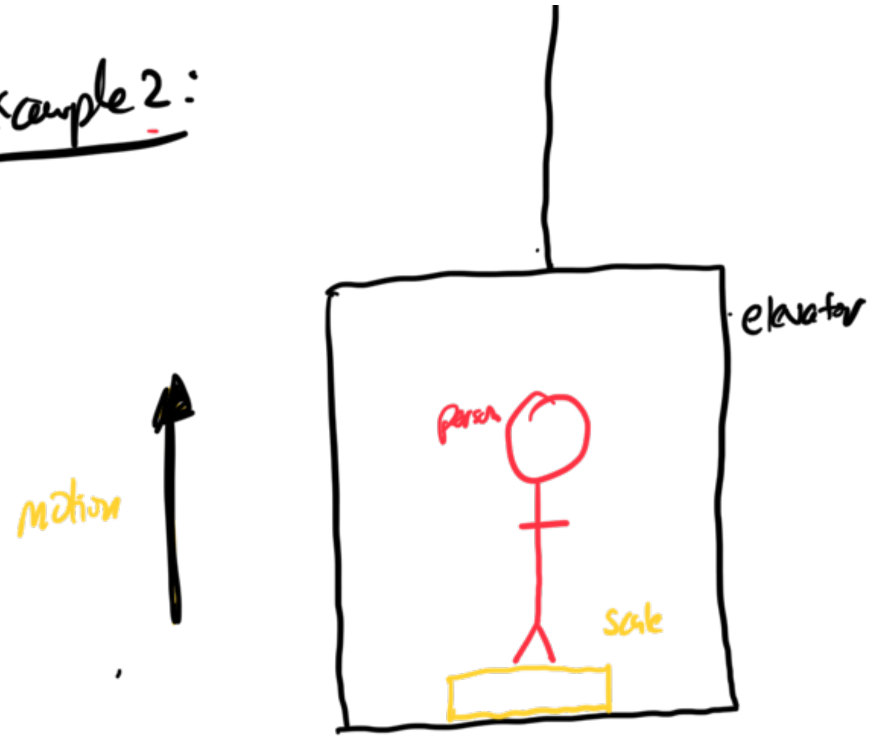
Object 2 $\quad x$:

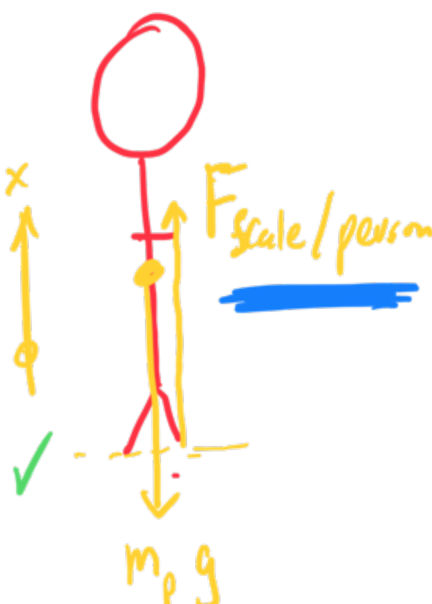
$$\boxed{m_2 g - \underset{-ve}{T} = m_2 a_x}$$

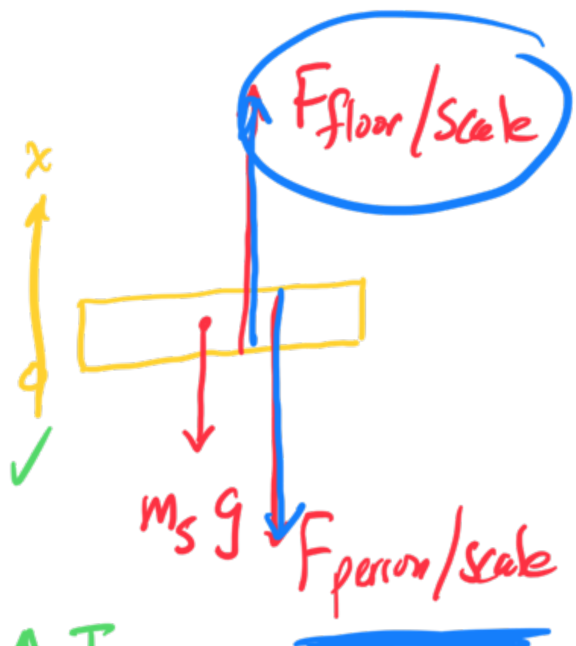
Add: $\quad m_2 g - \mu_K m_1 g = (m_1 + m_2)($

$$\boxed{a_x = \left(\frac{m_2 - \mu_K m_1}{m_2 + m_1}\right) g}$$

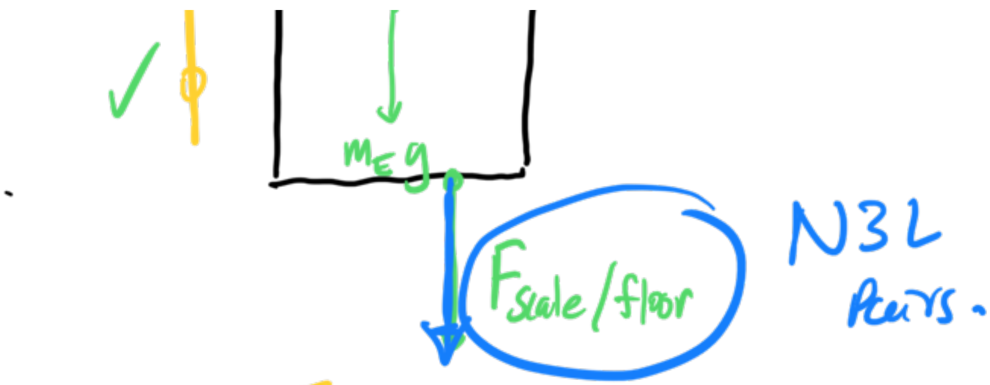
Example 2:







Newton's 3rd law Pairs



$$① \quad \overset{F_1}{\boxed{F_{scale/person}}} - m_p g = m_p a_x$$

equal!

$$② \quad \underset{F_2}{\boxed{F_{floor/scale}}} - \overset{F_1}{\boxed{F_{person/scale}}} - m_s g = m_s a$$

equal!

$$③ \quad T - m_E g - \overset{F_2}{\boxed{F_{scale/floor}}} = M_E a$$

3 Energy and Momentum.

3.1 Basic Ideas.

Kinetic Energy (scalar!) $\quad K = \frac{1}{2} m v^2$

Work (scalar)

$$W_F = \vec{F} \cdot \vec{\Delta x}$$

$$= |\vec{F}||\vec{\Delta x}| \cos \theta$$

3 cases:

$\theta = 0^\circ$

$$W_F = F \cdot \Delta x$$

$\boxed{+ve}$

$\theta = 180^\circ$

$$W_F = -F \cdot \Delta x$$

$\theta = 90^\circ$

$$W_F = 0$$

Momentum exists

Momentum

$$P = mV$$

(vector)

Impulse Exists

$$\Delta \vec{p} = \vec{p}_f - \vec{p}_i$$
$$= m\vec{v}_f - m\vec{v}_i$$

Multiple Objects

$$\vec{P}_{system} = \vec{P}_1 + \vec{P}_2 + \vec{P}_3 + \ldots$$

3.2 Work Energy Theorem.

Scalars!

$$W_{\substack{all \\ forces}} = \Delta K$$

$$= \Delta K$$

$W_1 + W_2 + W_3 + \ldots\ldots$

$(+) \quad (-) \quad \cdots \longrightarrow$

Gravitational Potential Energy.

$$U_g = mg\,y$$

$\uparrow$ y-coordinate.

$$\Delta U_g = mg\,\Delta y$$

$$= -W_g$$

$y = h$

$h \quad \Delta y = +h$

$m \quad y = 0$

$W_g = -mgh$

$\Delta U = +mgh$

$W_{nc} = \Delta K$

if V all this

$$\cancel{W_g} + W_{\substack{\text{not}\\\text{gravity}}} = \Delta K - W_g$$

Modified W-E Theorem

$$\boxed{W_{\substack{\text{not}\\\text{gravity}}} = \Delta K + \Delta U_g}$$

3.3 Collisions and conservation of momentum.

$$\vec{F}_{net} = \frac{\Delta \vec{p}}{\Delta t} = m\frac{\Delta \vec{v}}{\Delta t} = m\vec{a}$$

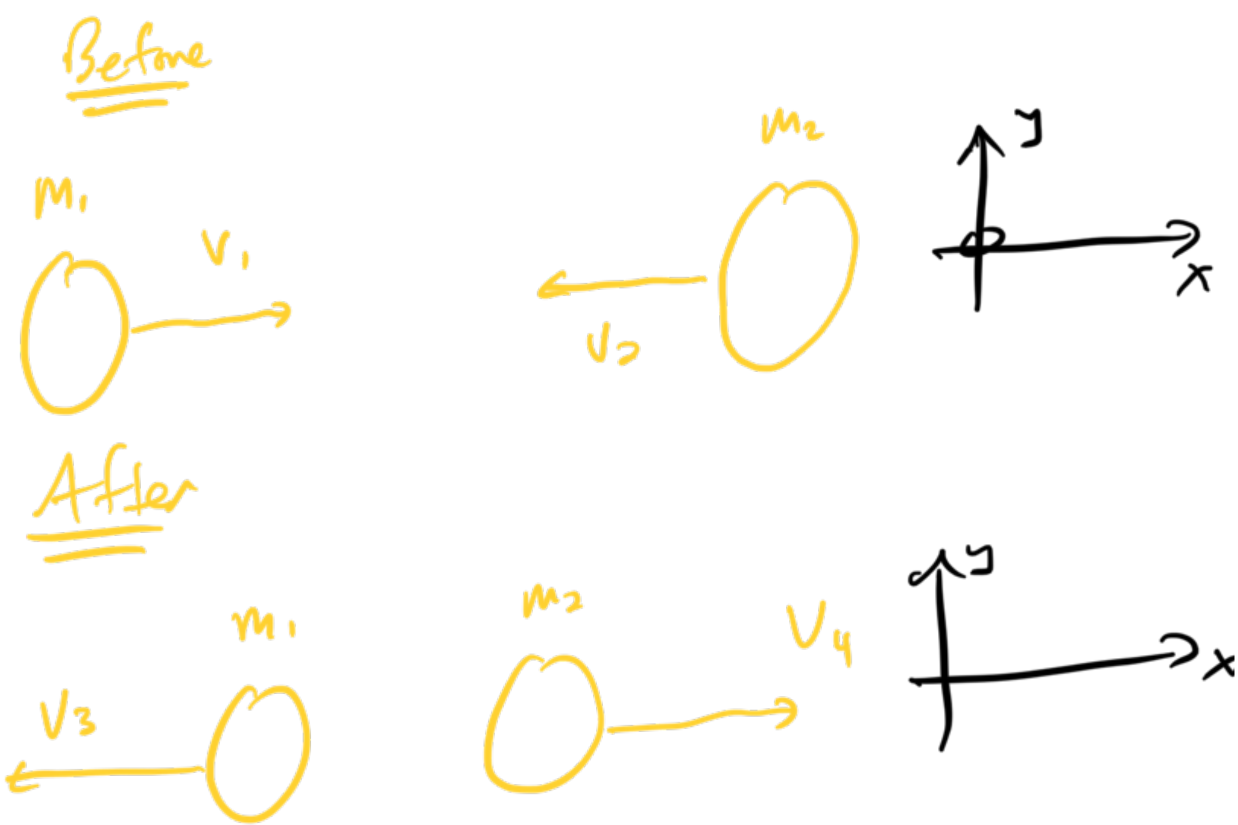
If $\vec{F}^{\,system}_{NET} = 0$, then

$$\Delta \vec{p}_{sys} = 0$$

sys

Conservation of momentum

$$\boxed{\vec{P}^{\,before}_{System} = P^{after}_{System}}$$



x: $\boxed{m_1 v_1 - m_2 v_2 = m_2 v_4 - m_1 V}$

after

$$P_{sys}^{before} = P_{sys}$$

4 Rotational Motion.

4.2 Kinematics

Linear	Rotational
$\vec{x}$	θ
$\vec{v}$	ω
$\vec{a}$	α
$\Delta\vec{x}$	$\Delta\theta$
$\vec{F}$	$\boxed{\vec{\tau}}$
m	$\boxed{I}$

Vectors! (linear)

Vectors! 1D (rotational)

Coordinate System →

+ve −ve

Coordinate system

Vector

Rotational Motion in 1D with constant angular acceleration (α,

$$\omega_f = \omega_i + \alpha t$$

$$\Delta\theta = \omega_i t + \frac{1}{2}\alpha t^2$$

$$\Delta\theta = \omega_f t - \frac{1}{2}\alpha t^2$$

$$\Delta\theta = \left(\frac{\omega_i + \omega_f}{2}\right)t$$

$$\omega_f^2 = \omega_i^2 + 2\alpha\Delta\theta$$

ω_i

ω_f

α

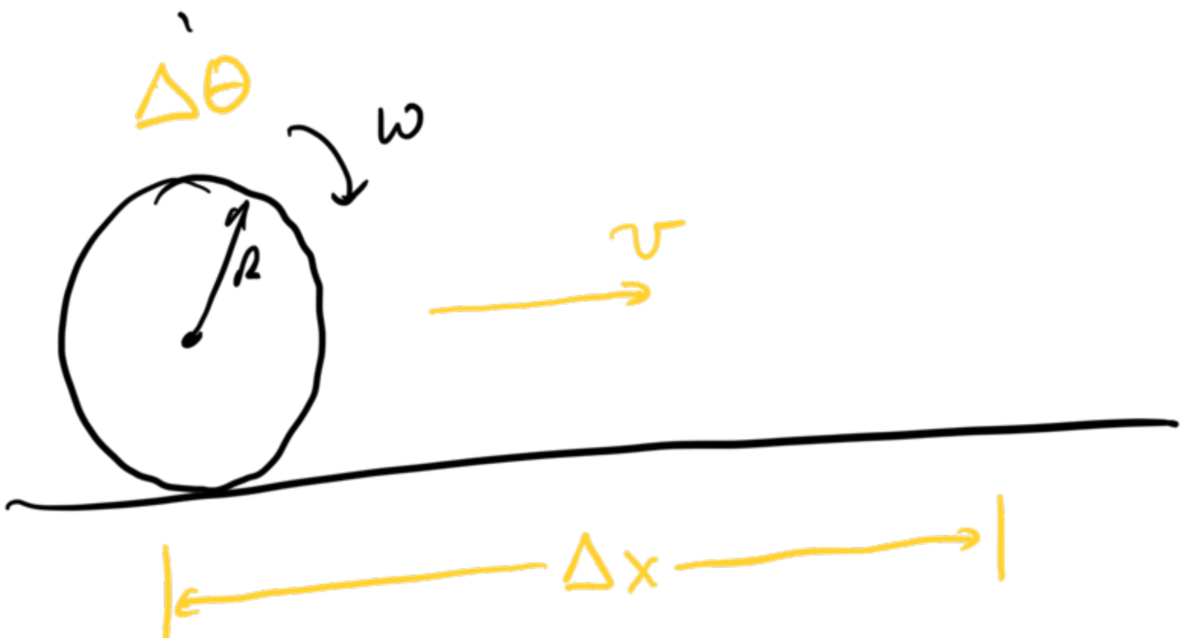
t

$\Delta\theta$

RULE OF THREE

1. $\theta, \Delta\theta$ in radians!
2. ω in rad/s (rpm?)
3. α in rad/s^2

Things that are rolling!



Rolling Conditions.

$$\boxed{\begin{aligned} \Delta x &= R\,\Delta\theta \\ v &= R\,\omega \\ a &= R\,\alpha \end{aligned}}$$

Linear variables

Rotational Variables

Rotational Kinematics

4.1 Moment of Inertia.

- what is the rotational equivalent of mass?

$$I = \int r^2\,dm$$

① I is given

② ~~Calculate using calculus / sections / ...~~

③ Known shape

cylinder, wheel, sphere, ...

$I = \frac{1}{2}MR^2$ $\boxed{=\frac{1}{2}MR^2}$ $\frac{2}{5}MR^2$, ...

give.

4.3 Rotational Dynamics

... the equivalent of

What is the

$$\sum_{i=1}^{N} \vec{F}_i = \vec{F}_{net} = m\vec{a} \quad ?$$

$$\sum_{i=1}^{N} \vec{\tau}_i = \boxed{\vec{\tau}_{NET} = I\vec{\alpha}}$$

Vector.

$$\boxed{\tau_{NET} = I\alpha}$$

$$\tau_F = |\vec{r} \times \vec{F}|$$

$$= |\vec{r}|\,|\vec{F}| \sin\theta$$

$$\tau_F = +|\vec{r}||\vec{F}|\sin(90^\circ)$$

Final Exam:

① Friday at 11:00 am

② WebAssign 10:55 am (2.5 h

→ 5 attempts per question part

→ "Show your work"

$\boxed{\text{Full Solutions!}}$ camera / photo / . .

↳ equations / diagrams / words / thoughts / numbers / smiley faces,