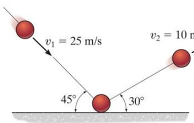
15.1 Impulse & Momentum

- Take Newton's 2nd Law: $\vec{F}_{\text{net}} = m\vec{a}$
- Integrate over time:

$$\underbrace{\int_{t_1}^{t_2} \vec{F}_{\text{net}}\, dt}_{\text{impulse}} = \int m\vec{a}\, dt = \int m\frac{d\vec{v}}{dt}\, dt = m\int_{\vec{v}_i}^{\vec{v}_f} d\vec{v} = \underbrace{m\Delta\vec{v}}_{\text{momentum change}}$$

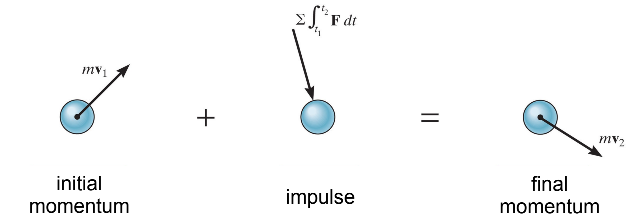


$$\vec{I} = \Delta\vec{L}$$

"Principle of Impulse and Momentum"

15.1 Impulse & Momentum

$$\int_{t_1}^{t_2} \vec{F}_{\text{net}}\, dt = \Delta(m\vec{v}) \qquad \text{or} \qquad m\vec{v}_1 + \int_{t_1}^{t_2} \vec{F}_{\text{net}}\, dt = m\vec{v}_2$$

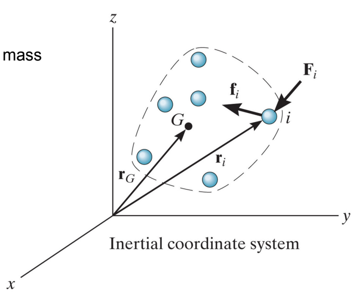


15.2 Impulse & Momentum

For a system of particles:

$$\underbrace{\int_{t_1}^{t_2} \vec{F}_{\text{net,ext}}\, dt}_{\text{impulse from external forces only}} = \Delta(m\vec{v}_G)$$

(total mass)



15.2 Impulse & Momentum

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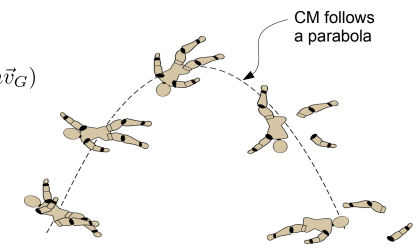

15.1-2 Compare Work and Impulse

compare:	Work, U	Impulse, $\vec{I}$
	$\int_{s_1}^{s_2} \vec{F}\cdot d\vec{r}$	$\int_{t_1}^{t_2} \vec{F}\, dt$
units:	$1\ \text{N}\cdot\text{m} = 1\ \text{J}$	$1\ \text{N}\cdot\text{s} = 1\ \text{kg}\frac{\text{m}}{\text{s}}$
problems:	Find object speed after force F is applied over distance d. $\int F_t\, ds = \Delta T$	Find object velocity after force F is applied for time t. $\int_{t_1}^{t_2} \vec{F}_{\text{net}}\, dt = \Delta(m\vec{v})$

15.1-2 Compare Work and Impulse

compare:	Work, U	Impulse, $\vec{I}$
	$\int_{s_1}^{s_2} \vec{F}\cdot d\vec{r}$	$\int_{t_1}^{t_2} \vec{F}\, dt$
	scalar ΔT	vector $\Delta(m\vec{v})$
	Simpler.	Full Newton's 2nd Law.
	For analysis only along the path of motion.	For analysis in all three dimensions.
	Some forces do zero work.	Any unbalanced force will change momentum.

15.1-2 Compare Work and Impulse

compare:	Work, U	Impulse, $\vec{I}$
	$\int_{s_1}^{s_2} \vec{F} \cdot d\vec{r}$	$\int_{t_1}^{t_2} \vec{F}\ dt$
relation to kinematics:	$a\ ds = v\ dv$	$a\ dt = dv$
	$\int ma\ ds = \frac{1}{2}m\left(v^2 - v_0^2\right)$	$\int ma\ dt = m\left(v - v_0\right)$
	$\int F_t\ ds = \Delta T$	$\int \vec{F}\ dt = \Delta\left(m\vec{v}\right)$

15.1-2 Compare Work and Impulse

compare:	Work, U	Impulse, $\vec{I}$
	$\int_{s_1}^{s_2} \vec{F} \cdot d\vec{r}$	$\int_{t_1}^{t_2} \vec{F}\ dt$
internal forces:	do no work for rigid bodies; deform non-rigid bodies	do not change momentum of CM
external forces:	change energy $U = \Delta T$ (for rigid bodies)	change momentum $\vec{I} = \Delta\vec{L}$