Lecture 36: Announcements

Final in CBTF: Sign ups ongoing

* Double-check: Grainger or DCL (depends on time slot)

What to expect: Questions like HW/Quizzes
Some new, some repeats
About 3x longer

Energy Considerations

Recap: Kinetic Energy

$$T = \frac{1}{2} m v_c^2 + \frac{1}{2} I_c \omega^2 \quad \Big] \text{ center of mass } \underline{\text{always}} \text{ works}$$

$$= \frac{1}{2} I_O \omega^2 \quad \Big] \text{ If } O \text{ is always a fixed point (useful for pendulums)}$$

$$= \frac{1}{2} I_M \omega^2 \quad \Big] \text{ If } M \text{ is the instantaneous center (special cases where } M \text{ is known)}$$

Potential Energy (gravitational)

$$V = m g h_c \quad \Big] \text{ height of c.o.m.} \qquad ? \text{ Where should } h_c = 0 ?$$

Work-Energy Principle $\qquad \underbrace{W}_{\text{Work by external forces}} = \Delta E = \underbrace{E_f - E_i}_{\text{Change in energy}}$

$\boxed{\text{Scalar}}$

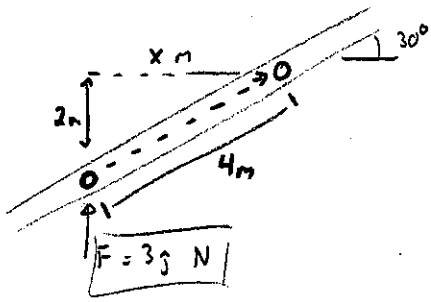
$$W = \int_{\vec{r}_0}^{\vec{r}_f} \underbrace{\vec{F} \cdot d\vec{r}}_{\text{dot product}} = \int_{t_0}^{t_f} \underbrace{\vec{F} \cdot \vec{v}}_{\text{Power}} \, dt \qquad \frac{\partial \vec{r}}{\partial t} = \vec{v}$$

"incremental work"

Special Case: Constant forces

$$W = \int_{\vec{r}_0}^{\vec{r}_f} \vec{F} \cdot d\vec{r} = \vec{F} \cdot \int_{\vec{r}_0}^{\vec{r}_f} d\vec{r} = \vec{F} \cdot (\vec{r}_f - \vec{r}_i)$$

<u>Example</u>



$$W = \int (3\hat{j}) \cdot d\vec{r}$$

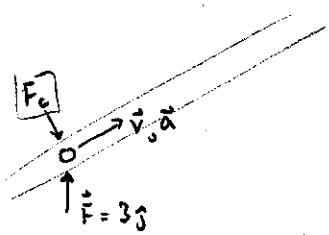
$$= (3\hat{j}) \cdot \int d\vec{r}$$

$$= (3\hat{j}) \cdot (x\hat{i} + 2\hat{j})$$

$$= 6 \text{ J}$$

What is the work done?

Special case: Constraint force



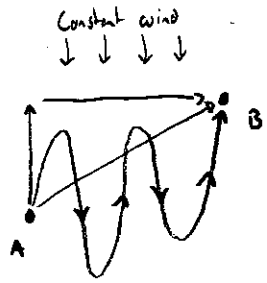
How much work does the constraint force do?

$\emptyset$

$\vec{F}_c \cdot d\vec{r} = 0$ $\boxed{\text{Perpendicular}}$

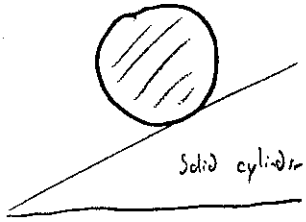
Take ME340 to learn about Lagrangian mechanics

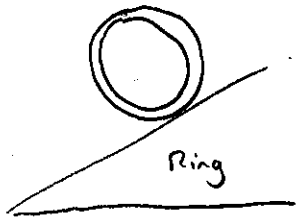
<u>Example</u> Bike in the wind



Which path results in most work done by wind?

Examples Rolling cylinders

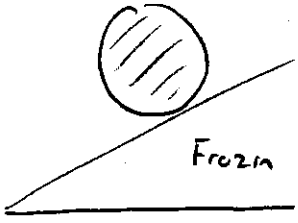


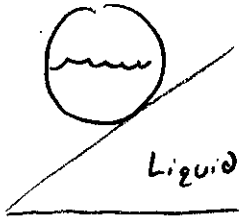


Same mass
Same starting height
Same ramp angle

Start at rest
Roll w/out slip

Which reaches the bottom first?





Which reaches the bottom first?

Which rolls the farthest after?