Phy 4A 11/9

Wednesday, November 9, 2016 10:02 AM

Goals for the Lecture:

1) Review momentum (1-D and 2-D collisions), problems involving both momentum and energy, center of mass, work, and energy

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Power $P = \frac{\text{work}}{\text{time}}$ units $\frac{J}{s} = W$ ↑ watt

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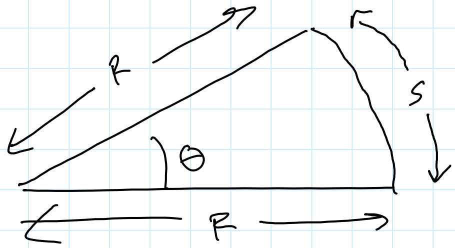
Overview:

		Translational Motion	Rotational Motion
Kinematics:	position	x	θ
	velocity	$v = \frac{dx}{dt}$	$\omega = \frac{d\theta}{dt}$
	acceleration	$a = \frac{dv}{dt}$	$\alpha = \frac{d\omega}{dt}$
	equations	$v_f = v_i + at$	$\omega_f = \omega_i + \alpha t$
		$x_f = x_i + v_i t + \frac{1}{2}at^2$ ⋮	$\theta_f = \theta_i + \omega_i t + \frac{1}{2}\alpha t^2$
Newton's Laws	Inertia:	m	$I = mr^2$ for a pt. object
	what changes motion:	$\vec{F}$	$\vec{\tau}$ torque
	2nd Law:	$\Sigma \vec{F} = m\vec{a}$	$\Sigma \vec{\tau} = I\vec{\alpha}$
Energy	Kinetic Energy:	$K = \frac{1}{2}mv^2$	$K_R = \frac{1}{2}I\omega^2$
Momentum:		$\vec{p} = m\vec{v}$	$\vec{L} = I\vec{\omega}$

Rotation

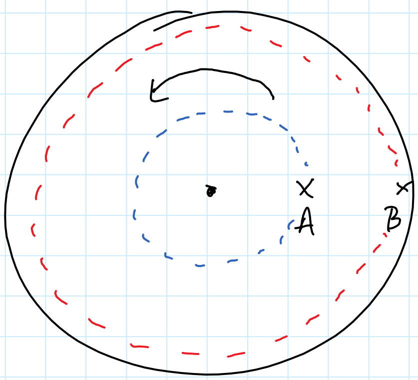
θ	ω	α
rad	$\frac{\text{rad}}{s}$	$\frac{\text{rad}}{s^2}$

rad	$\frac{rad}{s}$	$\frac{rad}{s^2}$
degrees	$\frac{degrees}{s}$	$\frac{degrees}{s^2}$
rev	$\frac{rev}{s}$	$\frac{rev}{s^2}$



$S = R\theta$

↑ if θ is in Radians



Who is going faster?

1) Linear or translational speed

B covers a larger circle in the same time

So,

$V_B > V_A$

2) Both complete a revolution in same time

So,

$\omega_A = \omega_B$

$S = R\,\theta$

$V = R\,\omega$

$a = R\,\alpha$

} must be in Rad, $\frac{Rad}{s}$, $\frac{Rad}{s^2}$

Prob 10-12

speeding up — slowing down

Prob 10-12

Spinning up

θ_i	0
θ_f	?
ω_i	0
ω_f	5 rev/s
α	?
t	8 s

Slowing down

θ_i	? (20 rev)
θ_f	?
ω_i	5 rev/s
ω_f	0
α	?
t	12 s

same (θ_f spinning up → θ_i slowing down)

same (ω_f spinning up → ω_i slowing down)

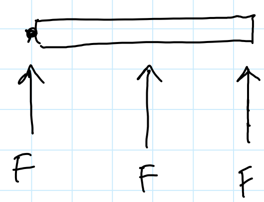
$$\theta_f = \theta_i + \frac{1}{2}(\omega_f + \omega_i)t$$
$$= 0 + \frac{1}{2}(5+0)\,8$$
$$= 20 \text{ rev}$$

$$\theta_f = \theta_i + \frac{1}{2}(\omega_f + \omega_i)t$$
$$= 20 + \frac{1}{2}(5+0)\,12$$
$$= 50 \text{ rev}$$

total of 50 revolutions

What causes Rotation: Torque

Top view of door:



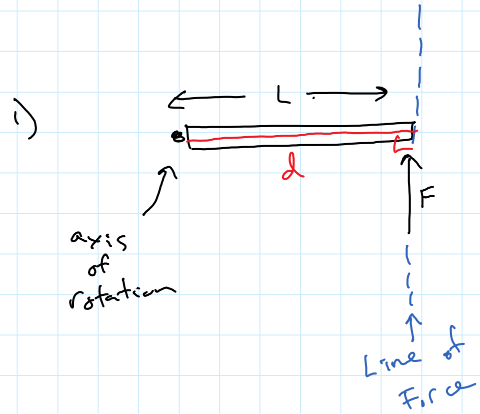
Torque: $\tau = F d$

d ← lever arm

The perpendicular distance from line of force to axis of rotation

... distance ... Line of force ... the axis of rotation

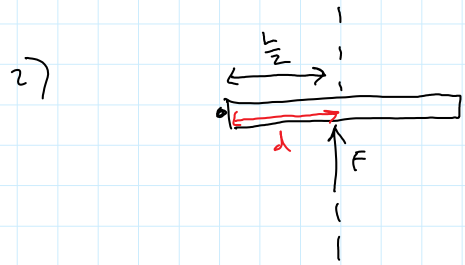
1)



$d = L$

$\tau = F L$

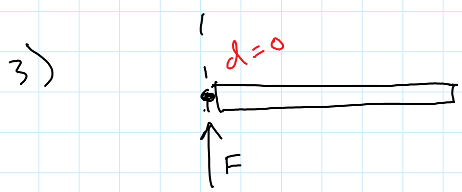
2)



$d = \frac{L}{2}$

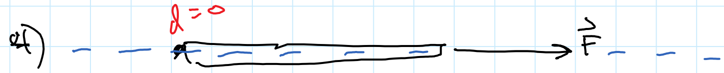
$\tau = F \frac{L}{2}$

3)



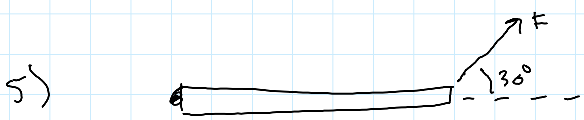
$\tau = 0$

4)



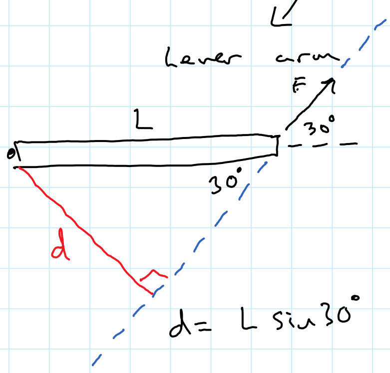
$\tau = 0$

5)



2 ways to look at this

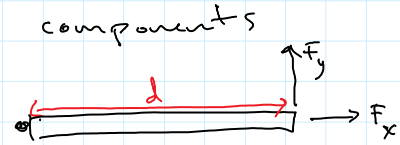
Lever arm



$d = L \sin 30°$

$\tau = F L \sin 30°$

components



$\tau = \tau_{F_x}^{\,0} + \tau_{F_y}$

$= F_y d$

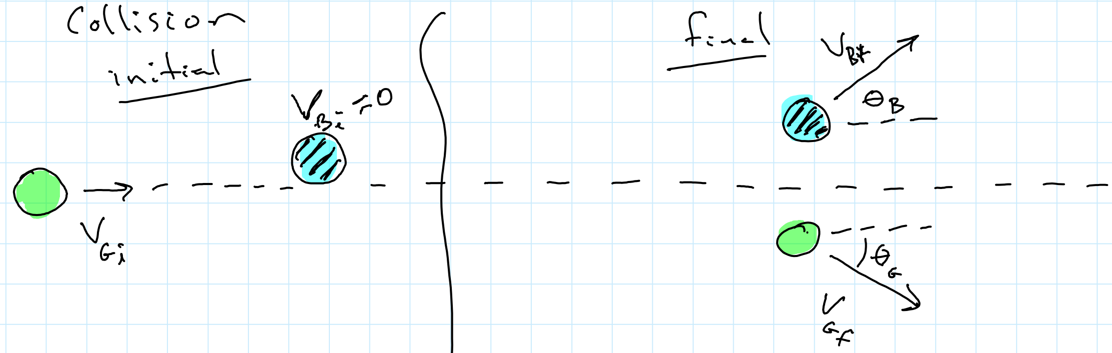
$= F \sin\theta \, L$

$= F L \sin 30^\circ$

Torque $\quad \tau = F d$

units: $N\,m$ [Not J (joules)]

2-D Collision



$M_G = M_B = m$

given everything except θ_B and θ_G, find θ_B and θ_G

$$\vec{P}_i = \vec{P}_f$$

$(P_x)_i = (P_x)_f \quad \rightarrow +$

$\cancel{m} V_{Gi} + 0 = \cancel{m} V_{Gf} \cos\theta_G + \cancel{m} V_{Bf} \cos\theta_B$

$$\boxed{V_{Gi} = V_{Gf} \cos\theta_G + V_{Bf} \cos\theta_B}$$

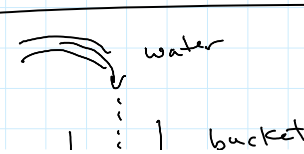
$(P_y)_i = (P_y)_f \quad \uparrow +$

$0 = m V_{Bf} \sin\theta_B - m V_{Gf} \sin\theta_G$

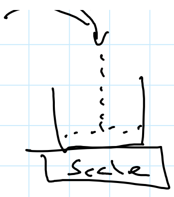
$$\boxed{V_{Bf} \sin\theta_B = V_{Gf} \sin\theta_G}$$

Solve for θ_B and θ_G

Book Prob 9-21



Book Prob 9-21



$$N_{scale} = (\text{Weight of bucket}) + (\text{Weight of water}) + \frac{\text{impulse}}{\text{time}}$$

$$I = F\Delta t = \Delta P$$

flow rate

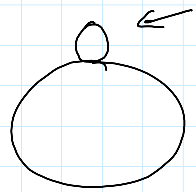
$$F = \frac{\Delta P}{\Delta t} = \frac{\Delta(mv)}{\Delta t} = \frac{m}{\Delta t}\Delta v$$

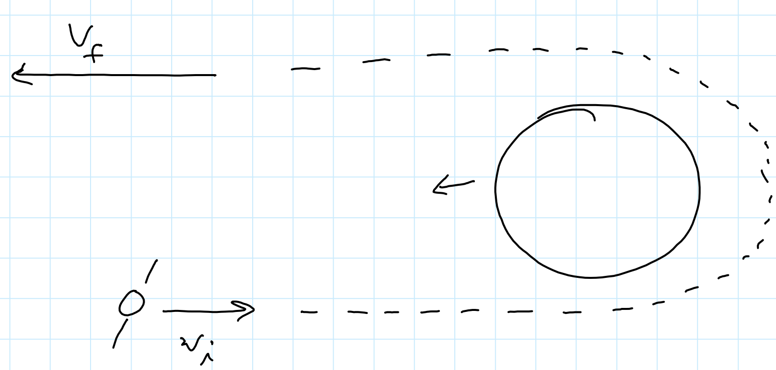
$$= \left(0.25\ \frac{L}{s}\right)\left(\rho\ \frac{kg}{L}\right)\ \Delta v$$

density of water

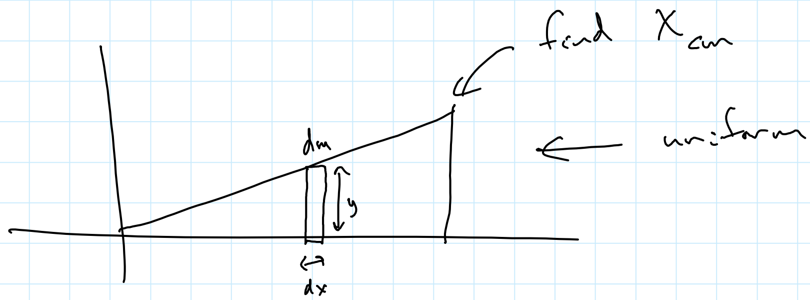
use kinematics

$$\rho = 1\ \frac{kg}{L}$$



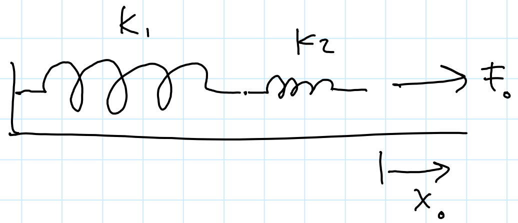


$$|\vec{V}_f| > |\vec{V}_i|$$



$$dm = \sigma\, dA = \sigma\, y\, dx$$

$$= \sigma\,(mx+b)\,dx$$



Spring 1 stretches x_1
Spring 2 stretches x_2
} $x_1 + x_2 = x_0$

$$(F_{sp})_1 = (F_{sp})_2 = F_0$$

$$k_1 x_1 = k_2 x_2 = k_{eq}\, x_0$$

$$F = (\quad)\, x_0$$

↑ eq. spring constant

$$x_1 + x_2 = x_0$$

$$\frac{k_2}{k_1} x_2 + x_2 = x_0$$

$$\left(\frac{k_2}{k_1} + 1\right) x_2 = x_0$$

$$\left(\frac{k_2}{k_1} + 1\right) x_2 = x_0$$

$$x_2 = \frac{1}{\left(\frac{k_2}{k_1} + 1\right)} x_0$$

$$k_2 x_2 = \frac{k_2}{\left(\frac{k_2}{k_1} + 1\right)} x_0$$

$$F = \frac{k_2}{\frac{k_2}{k_1} + 1} x_0$$

$$F = \underbrace{\frac{k_1 k_2}{k_1 + k_2}}_{K_{eq}} x_0$$