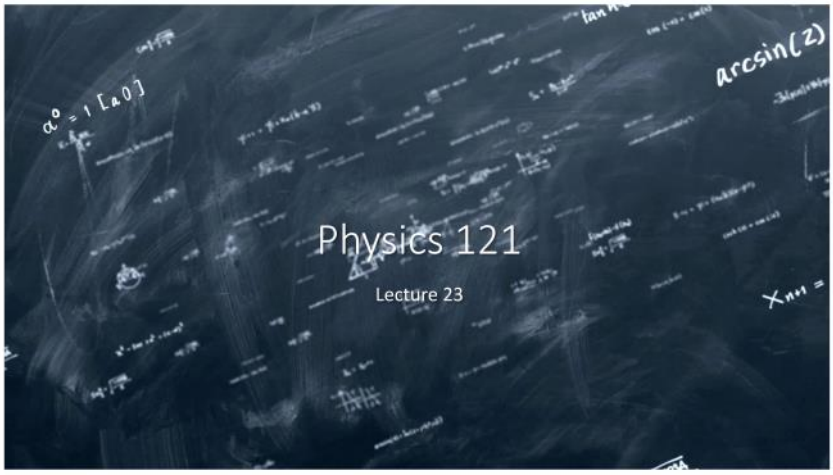
Lecture 23 - 3.30

Thursday, March 30, 2023 9:17 AM

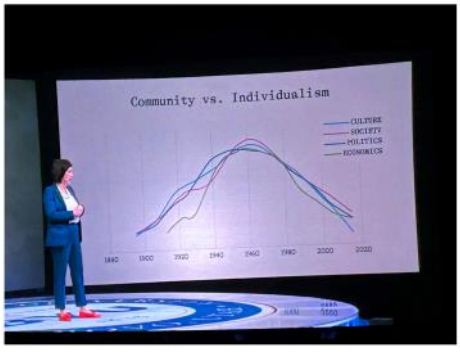


Forumtional Thought

SHAYLYN ROMNEY GARRETT
March 28, 2023

America's Upswing

James 5:16 The effectual fervent prayer of a righteous man/woman availeth much.



Review

Torque equals moment arm times force: $\tau = rF\sin\theta$

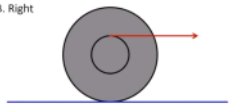
The direction of the torque is given by the right-hand rule: $\vec{\tau} = \vec{r} \times \vec{F}$

Unbalanced torques cause angular accelerations: $\tau = I\alpha$

Q3a: If I pull on this string, what way will the spool move?

A. Left

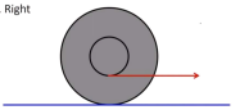
B. Right



Q3b: What about now? Which way will the spool move?

A. Left

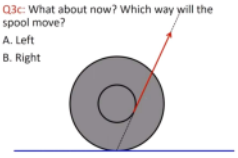
B. Right



Q3c: What about now? Which way will the spool move?

A. Left

B. Right



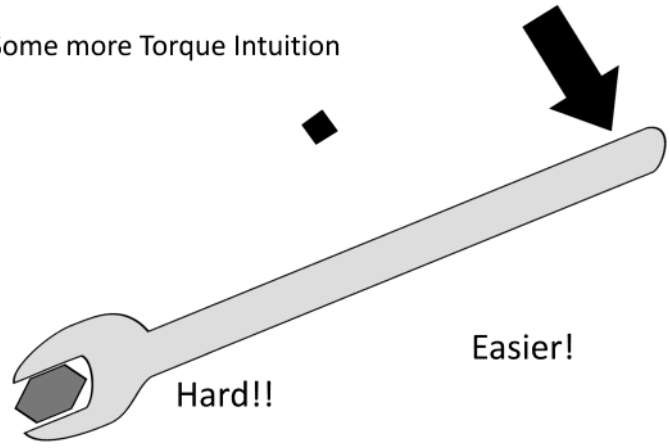
Consider the Pivot Points!

Proper Right Hand Rule for Cross Products

A = B x C

B = Thumb (Hitch-Hike)
C = Pointer (Gun)
A = Middle Finger (Wave)

Some more Torque Intuition

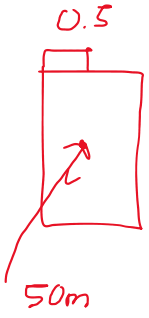


Motto for This Lecture – or Physics in General?

Course Objective – Explain This!

A force of 50 N is applied perpendicularly to the center of a door which is 1 m wide. The moment of inertia of the door about the hinge is 100 kg m^2. The angular acceleration of the door is

A. 0.10 rad/s^2
B. 0.25 rad/s^2
C. 0.50 rad/s^2
D. 0.75 rad/s^2
E. 1.00 rad/s^2



$T = r \cdot F$

$T = I \cdot \alpha$

$\alpha = \frac{rF}{I} = \frac{0.5 \cdot 50\,Nm}{100\,kg\,m^2}$

$= 0.25\,\frac{rad}{s^2}$

Some Discussion points…

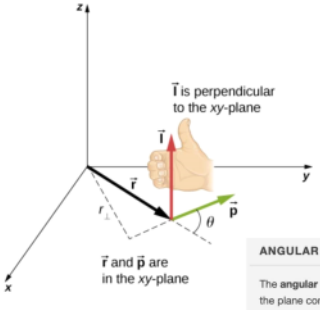
Why does Earth keep on spinning?

What started it spinning to begin with?

Why doesn't Earth's gravitational attraction not bring the Moon crashing in toward Earth?

And how does an ice skater manage to spin faster and faster simply by pulling her arms in?

Angular Momentum Definition



Anything that rotates about an axis carries angular momentum!

For a rigid body: $L = I\omega$

p = m*v

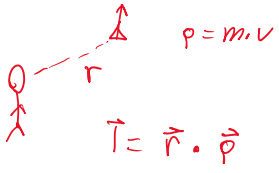
ANGULAR MOMENTUM OF A PARTICLE

The **angular momentum** $\vec{l}$ of a particle is defined as the cross-product of $\vec{r}$ and $\vec{p}$, and is perpendicular to the plane containing $\vec{r}$ and $\vec{p}$:

$$\vec{l} = \vec{r} \times \vec{p}. \qquad l = rp \sin\theta. \qquad (11.5)$$

Big L = rigid body (bowling ball)

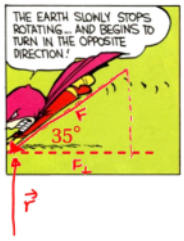
Little l = particles need to sum them up.



Story Problem!

Calculate the earth's angular momentum $\vec{\mathbf{L}}$. Assume that the earth has uniform density, so that $I = \frac{2}{5}Mr^2$, with $M = 6 \times 10^{24}$ kg and $r = 6 \times 10^{6}$ m.

If Stupendous Man exerted a constant force and stopped the earth's rotation completely in 100 s, how much force was he exerting? HINT: Remember $\sum \vec{\tau} = \frac{d\vec{L}}{dt}$ and that the torque is constant.



Rotational Symmetry results in…

LAW OF CONSERVATION OF ANGULAR MOMENTUM

The angular momentum of a system of particles around a point in a fixed inertial reference frame is conserved if there is no net external torque around that point:

$$\frac{d\vec{\mathbf{L}}}{dt} = 0 \qquad \boxed{11.10}$$

or

$$\vec{\mathbf{L}} = \vec{\mathbf{l}}_1 + \vec{\mathbf{l}}_2 + \cdots + \vec{\mathbf{l}}_N = \text{constant.} \qquad \boxed{11.11}$$

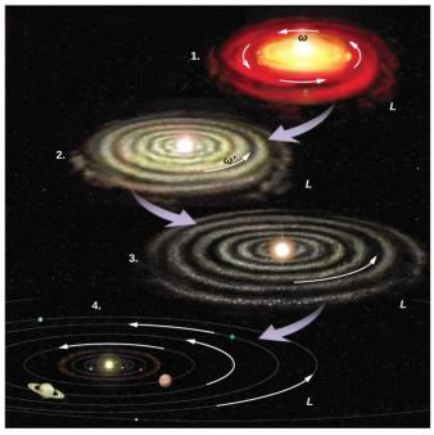
Changing Moment of Inertia causes Acceleration!

https://www.youtube.com/watch?v=GBWLP-iDUqg

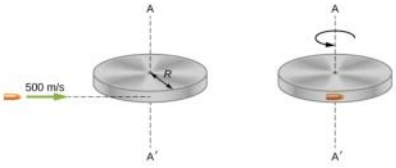
A pair of ice skaters of equal mass are spinning about a point on the ice at 1 rad/sec. Their centers of mass are 1.5 m apart. They then pull themselves into a close embrace (0.3 m separation between their centers of mass). What is their new spin frequency? Approximate the ice skaters as point masses.

A. about 0.25 rad/sec
B. about 2.5 rad/sec
C. about 25 rad/sec
D. about 250 rad/sec

Earth spins because Angular Momentum is conserved!



A bullet of mass $m = 2.0\ \text{g}$ is moving horizontally with a speed of $500.0\ \text{m/s}$. The bullet strikes and becomes embedded in the edge of a solid disk of mass $M = 3.2\ \text{kg}$ and radius $R = 0.5\ \text{m}$. The cylinder is free to rotate around its axis and is initially at rest (Figure 11.18). What is the angular velocity of the disk immediately after the bullet is embedded?



Angular momentum

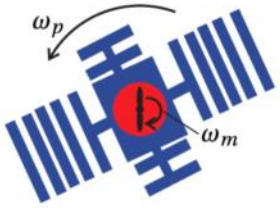
- It is a conserved quantity when there are no external torques
- It is good for random masses
- It is good for systems of masses
- It is good for orbiting masses
- It is good for spinning masses
- You can use this principle to solve physics problems.

$$\vec{L} = \vec{r} \times \vec{p}$$
$$L = I\omega$$
$$\vec{L} = I\vec{\omega}$$

Homework Hint

What is the same for a small motor moving a larger object?

I * theta_1 = I_2 * theta_2!



So, what is going on with that bike wheel?

https://www.youtube.com/watch?v=ty9QSiVC2g0

Exit Poll

- Please provide a letter grade for todays lecture:

A. A
B. B
C. C
D. D
E. Fail