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Physics 140 – Fall 2007

30 October: lecture #16

Ch 9 + 10 topics:

- moment of inertia: parallel axis theorem
- torque
- Newton's second law of rotation

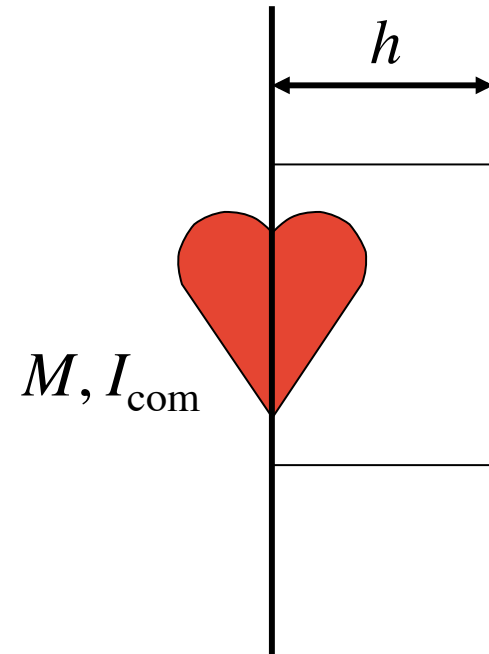
Midterm exam #2 is this Thursday, 1 Nov, 6-7:30 pm
bring two 3x5 notecards, calculator, #2 pencils

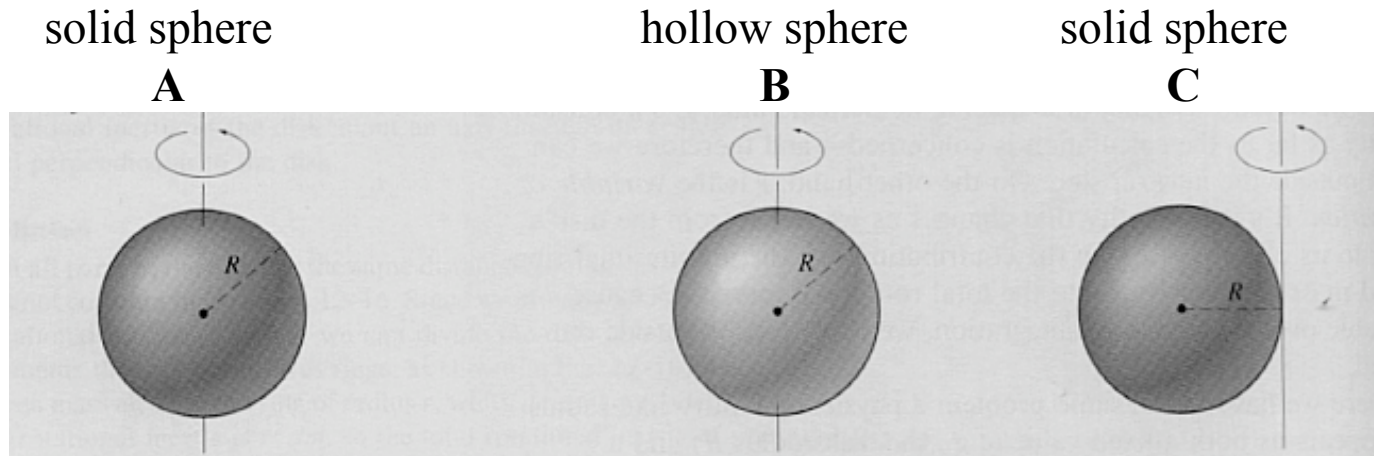
Parallel axis theorem

Given two parallel axes (lines), one passing through an object's center of mass and the other displaced by a distance h , the object's moment of inertia about the displaced axis is given by

$$I = I_{\text{com}} + Mh^2$$

where M is the object's mass and I_{com} is the moment of inertia measured about the axis that passes through the object's center of mass.





Source: Undetermined

The three spheres above have the same mass M and the same radius R . Sphere B is hollow, A and C are solid. Sphere C rotates about an axis adjacent to its edge while spheres A and B rotate about their centers. All rotate at the same angular velocity. Rank the spheres according to their rotational kinetic energy, largest to smallest.

1. A, B, C
2. B, A, C
3. A, C, B
4. C, B, A



Torque

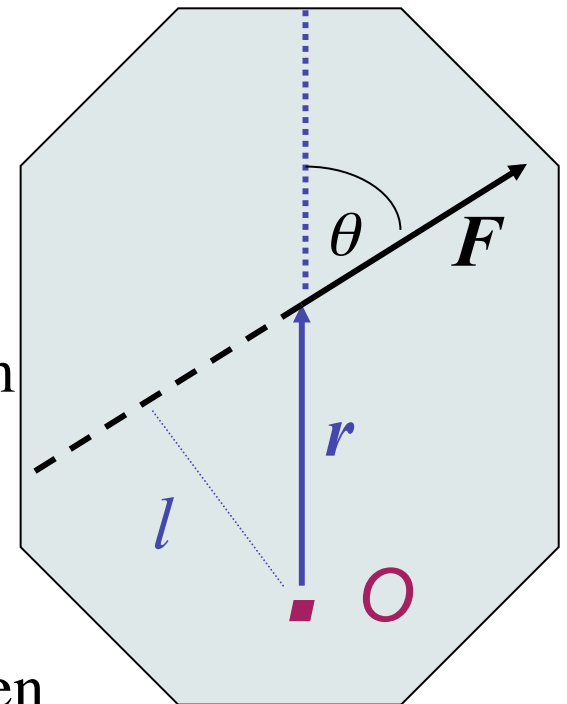
A force acting on an extended object will generally tend to make the object spin. When a force F is applied at some point displaced by r from a rotation axis O , the applied torque is

$$\vec{\tau} = \vec{r} \times \vec{F}$$

A convenient way to compute torque is in the form

$$\tau = F l = F (r \sin\theta)$$

where the distance l , known as the lever arm (or moment arm) is the perpendicular distance between the rotation axis and the line of action, the continuation of the direction of the applied force F .

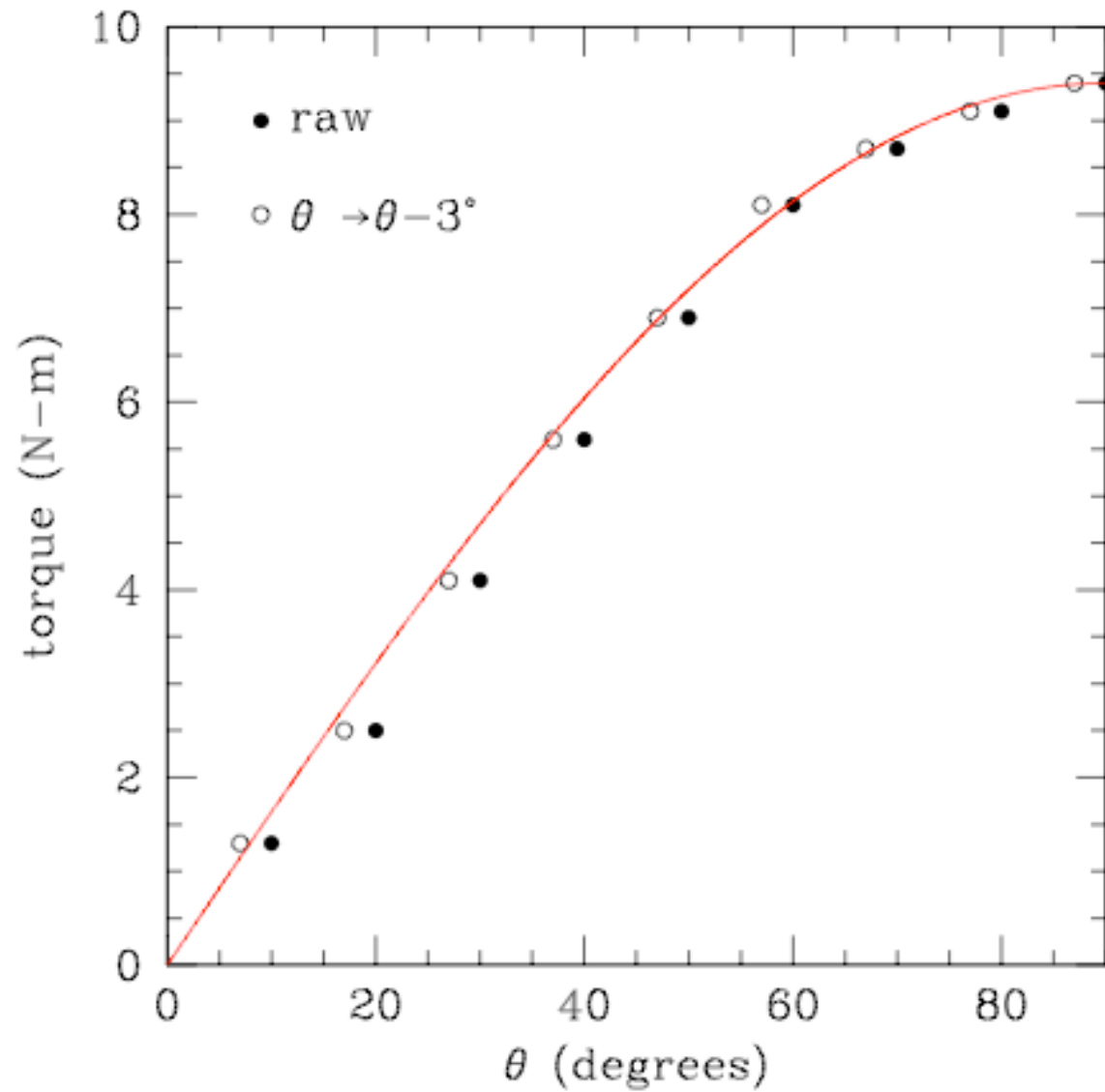


Torque (cont'd)

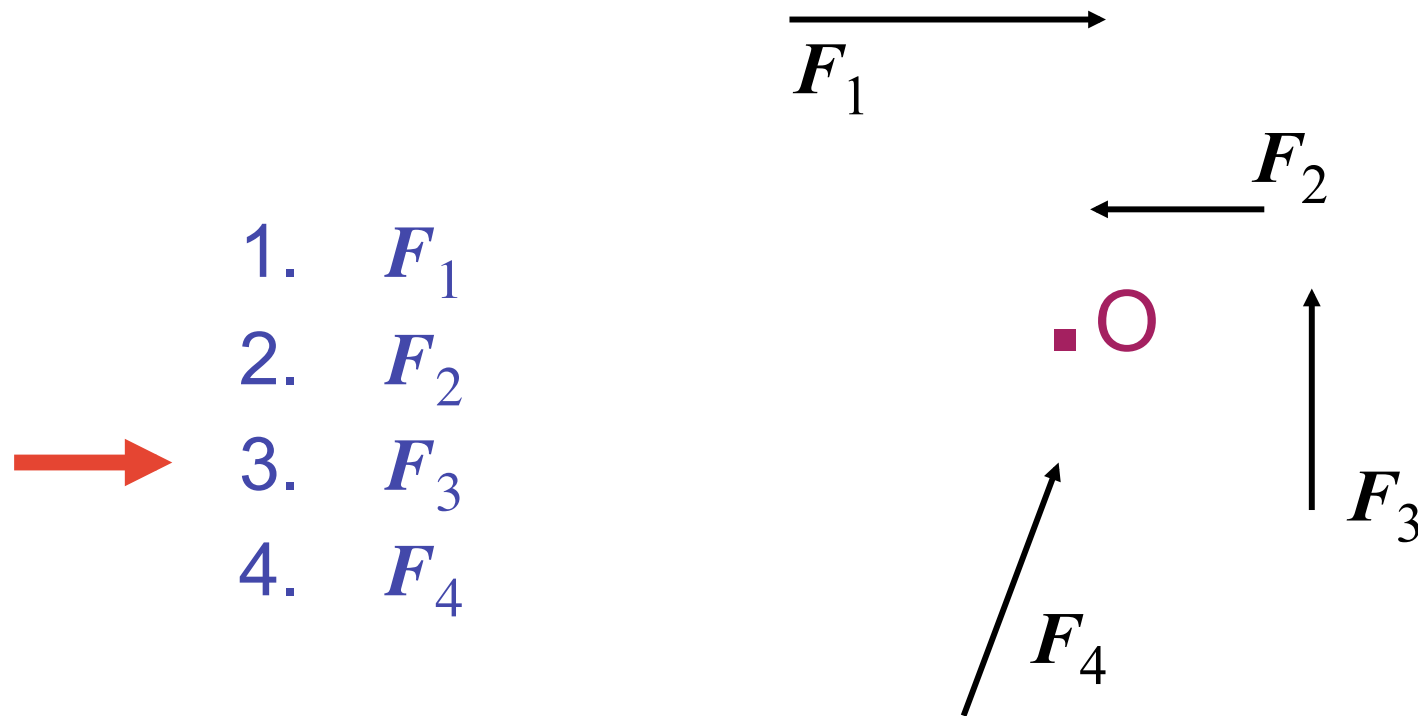
- sign convention of applied torque (use RH rule)
 - + for counterclockwise rotation
 - for clockwise rotation
- for a single force F , many different torques τ can result, depending on the location of the rotation axis O .

To calculate torque on a body of mass m due to near-Earth gravity, use the fact that the gravitational force acts downward at the body's center of mass/gravity with magnitude mg .

torque wrench measurements



Which force below produces the largest positive torque about an axis passing through point O?



Newton's Second Law for rotation

The net torque $\Sigma\tau$ exerted on an extended object that is able to rotate about an axis O causes angular acceleration α about that axis with magnitude given by

$$\Sigma\tau = I\alpha$$

where I is the moment of inertia about axis O .

Note the similarity to NSL for translation in one dimension,

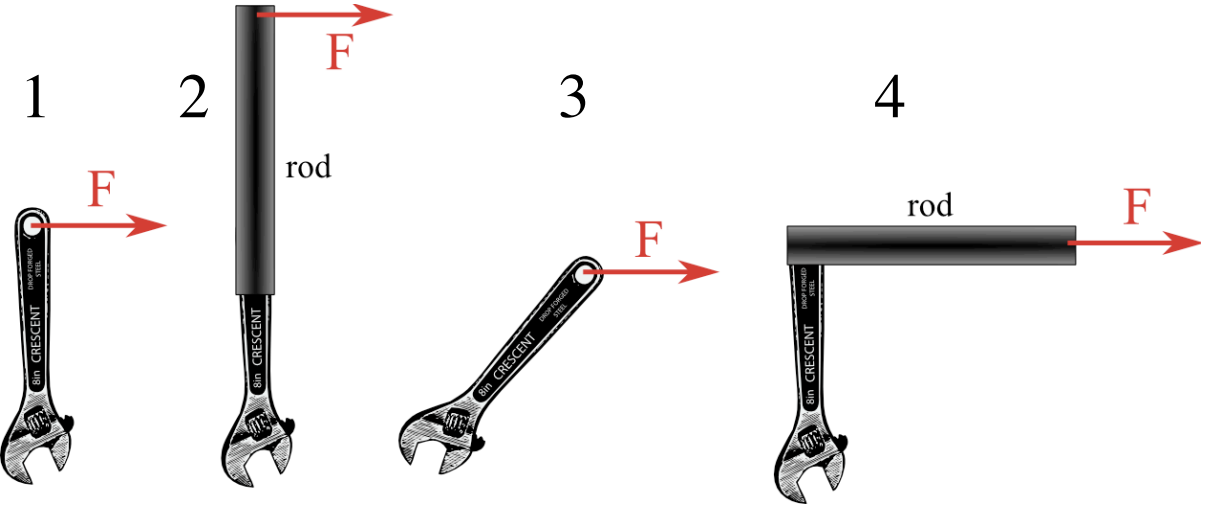
$$\Sigma F = ma$$

Can torque due to gravity ever produce a downward linear acceleration with magnitude $>g$?



1. Yes
2. No
3. Maybe?

You are using a wrench to try to loosen a rusty nut. Shown below are possible arrangements for the wrench and your applied force F . List the arrangements in order of decreasing torque.



- 1. $2 > 1 > 3 > 4$
- 2. $2 > 1 = 4 > 3$
- 3. $4 > 2 > 1 > 3$
- 4. $2 > 1 = 3 = 4$

