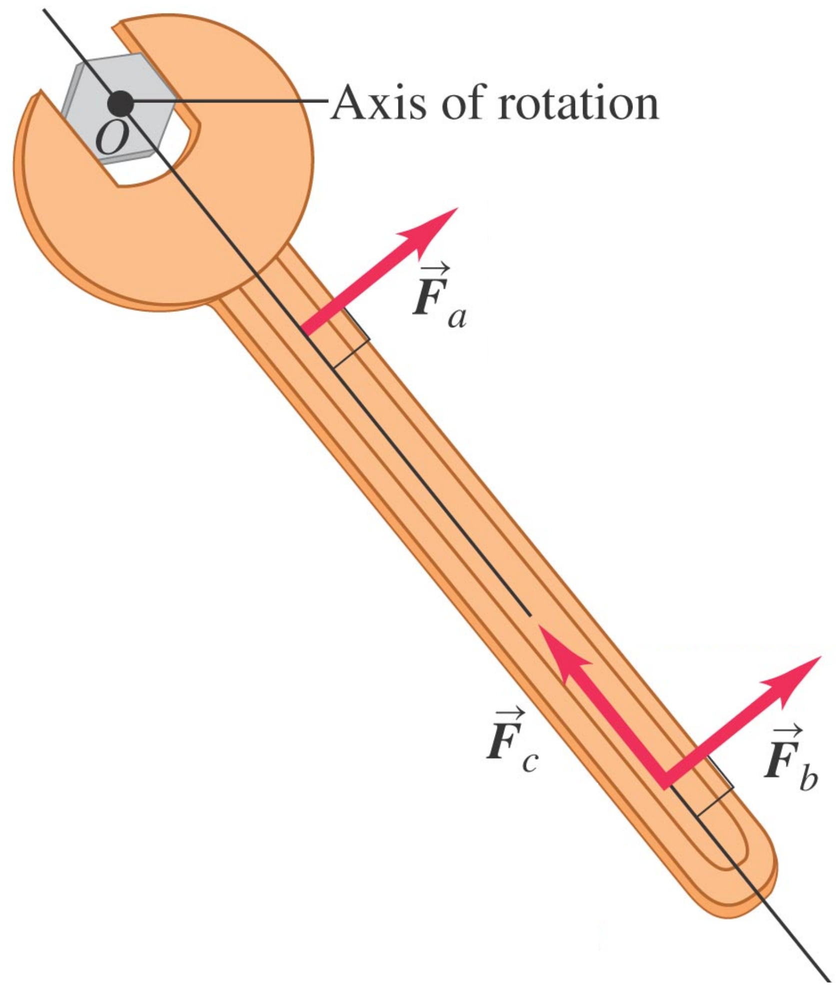
Loosen a bolt

- Which of the three equal-magnitude forces in the figure is most likely to loosen the bolt?
- A. $\boldsymbol{F}_{\mathrm{a}}$
- B. $\boldsymbol{F}_{\mathrm{b}}$
- C. $\boldsymbol{F}_{\mathrm{c}}$
- D. Not enough information to decide



Exam #2

- April 7, 5-7pm
- CR 214 (Wednesday Labs) & CR 222 (Thursday Labs)
- Chapters 6-9
- Closed book, closed notes. One page single-sided equation sheet allowed.

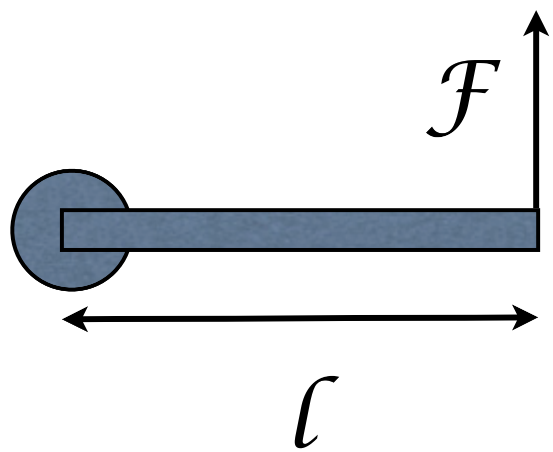
Ch 10.1-3
Torque

PHYS 1210 -- Prof. Jang-Condell

Goals for Chapter 10

- To learn what is meant by torque
- To see how torque affects rotational motion
- To analyze the motion of a body that rotates as it moves through space
- To use work and power to solve problems for rotating bodies
- To study angular momentum and how it changes with time
- To learn why a gyroscope precesses

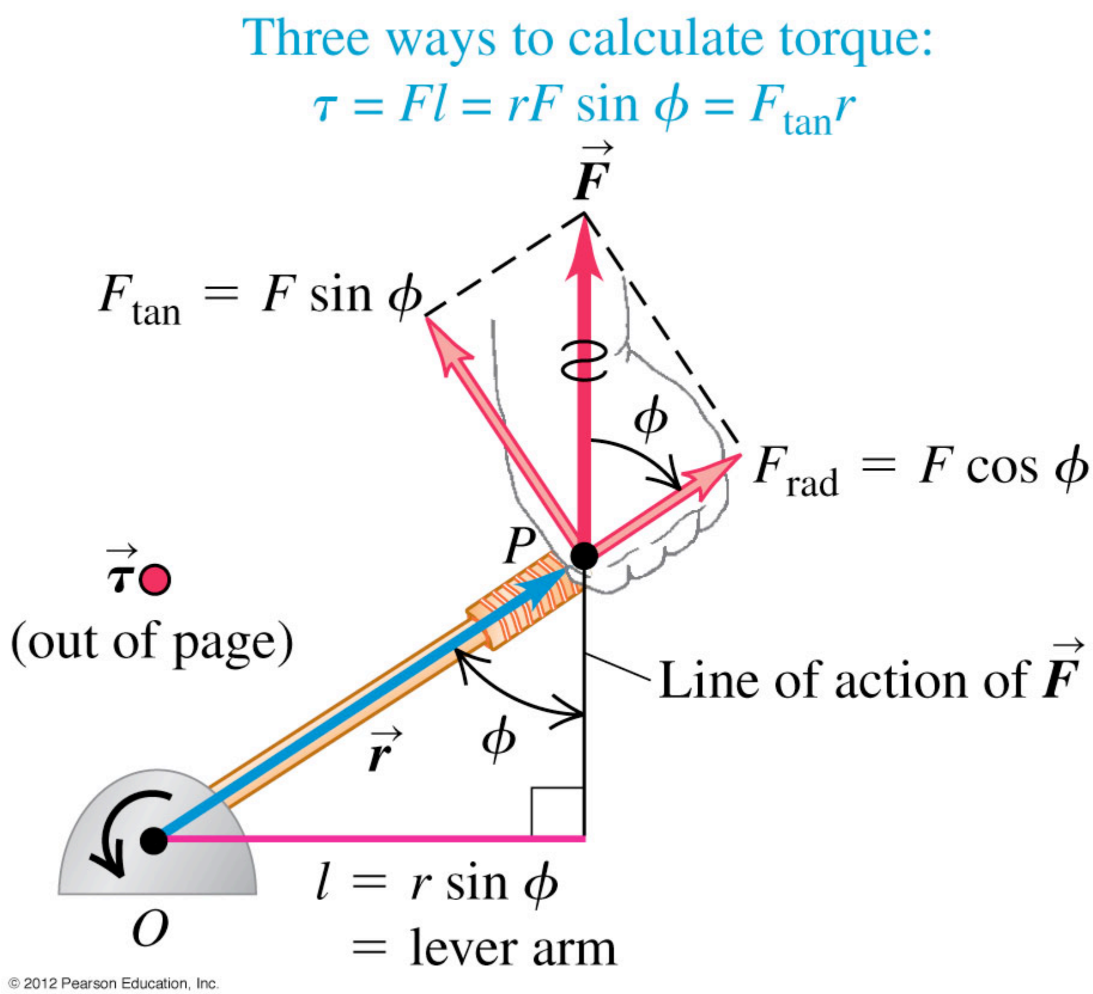
Torque



When $F \perp l$, then

$$\tau = F\, l$$

Torque



Three ways to calculate torque:
$\tau = Fl = rF \sin\phi = F_{tan} r$
$\vec{F}$
$F_{tan} = F \sin\phi$
ϕ
$F_{rad} = F \cos\phi$
P
$\vec{\tau}$
(out of page)
Line of action of $\vec{F}$
$\vec{r}$
ϕ
O
$l = r \sin\phi$
$= $ lever arm
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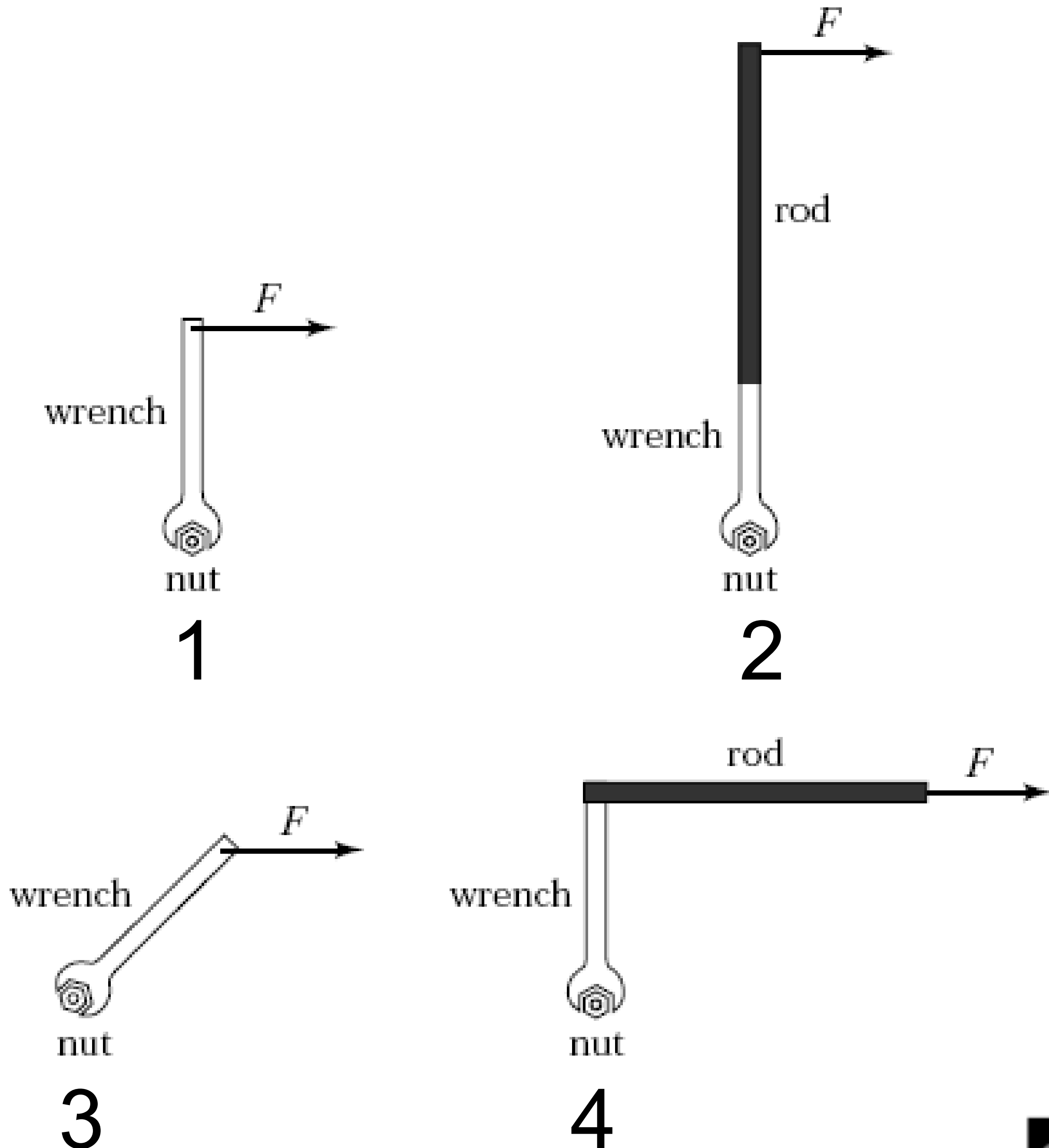
Torque

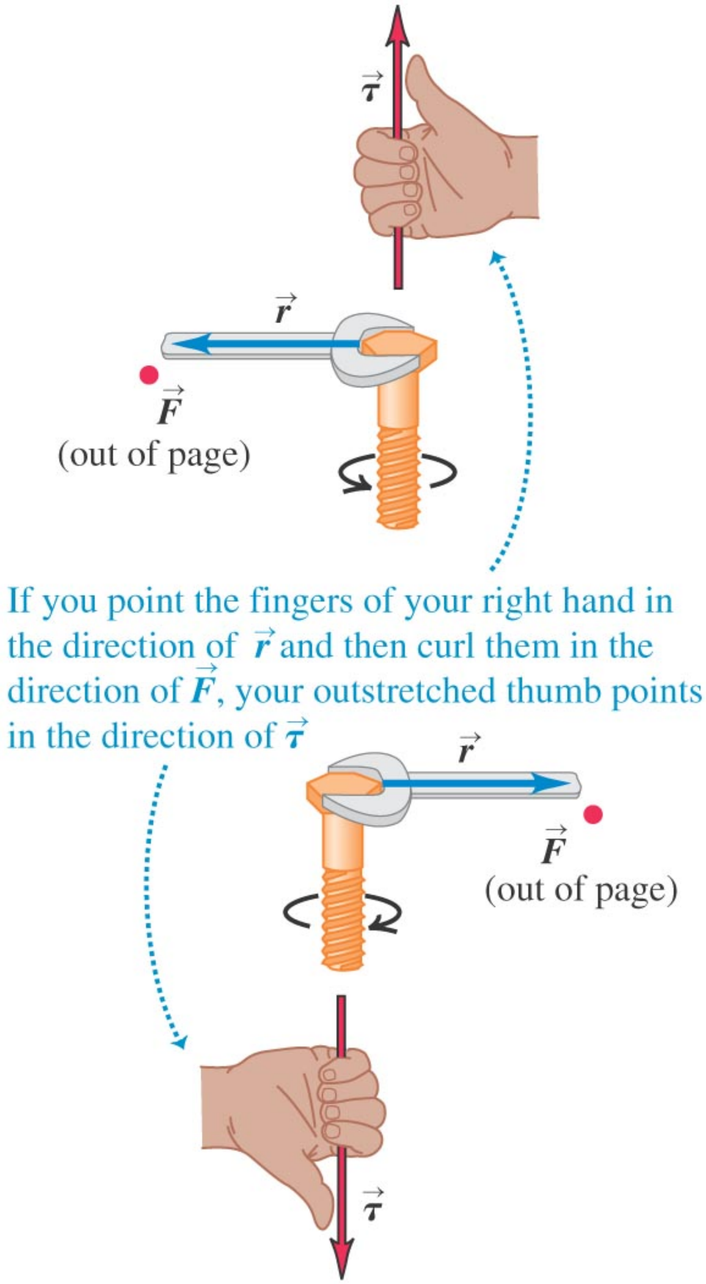
$$\vec{\boldsymbol{\tau}} = \vec{\boldsymbol{r}} \times \vec{\boldsymbol{F}}$$

You are using a wrench and trying to loosen a rusty nut. Which of the arrangements shown is most effective in loosening the nut? List in order of descending efficiency the following arrangements:



Torque as a vector

- Torque can be expressed as a vector using the vector product.
- Figure 10.4 at the right shows how to find the direction of torque using a right hand rule.



Newton's Second Law

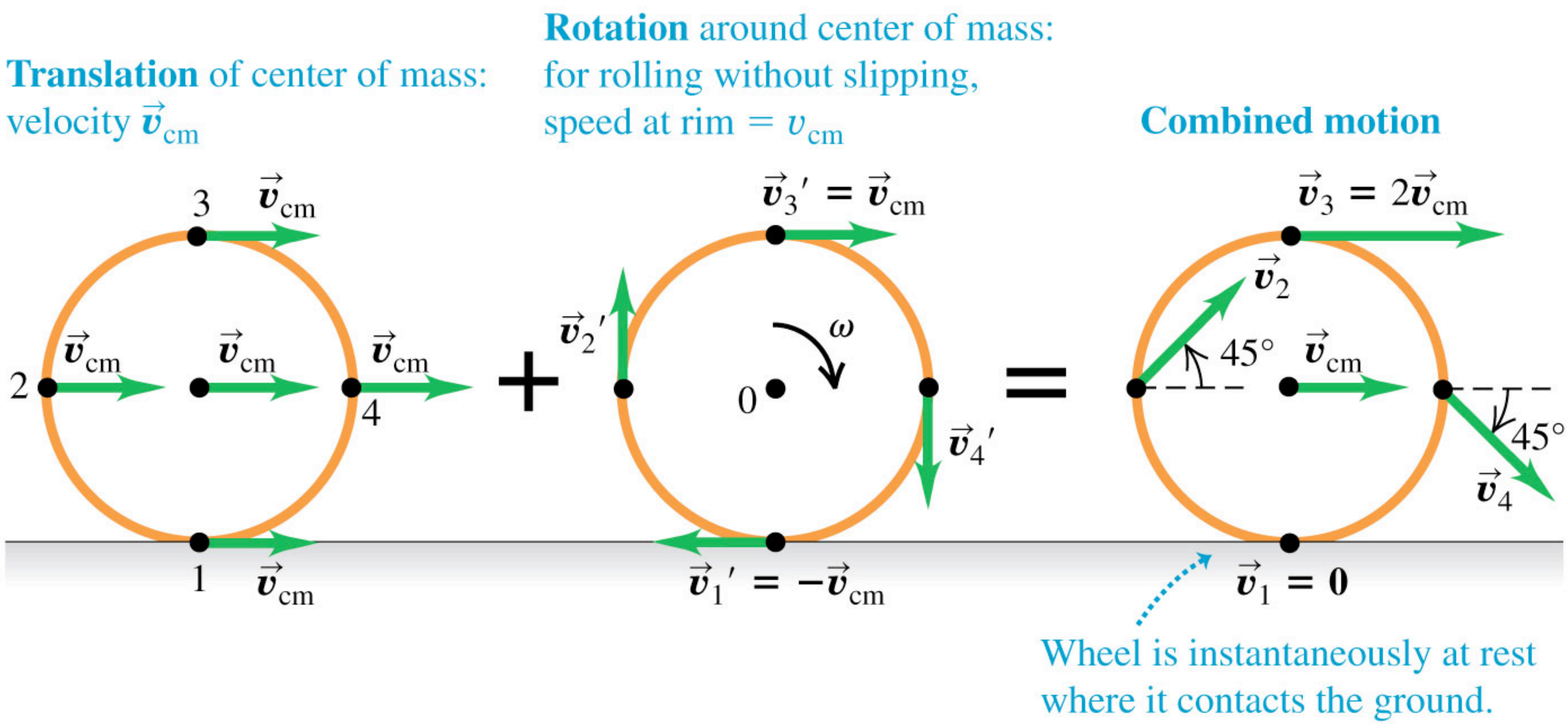
$$\sum \vec{\boldsymbol{\tau}} = I\vec{\boldsymbol{\alpha}}$$

Linear vs. Rotational Motion

Linear	**Rotational**
r	θ
v	ω
a	α
m	I
$K = (1/2)\ mv^2$	$K = (1/2)\ I\omega^2$
$\sum F = ma$	$\sum \tau = I\alpha$

Rolling without slipping

$$v_{cm} = R\omega$$



(f) Solid cylinder

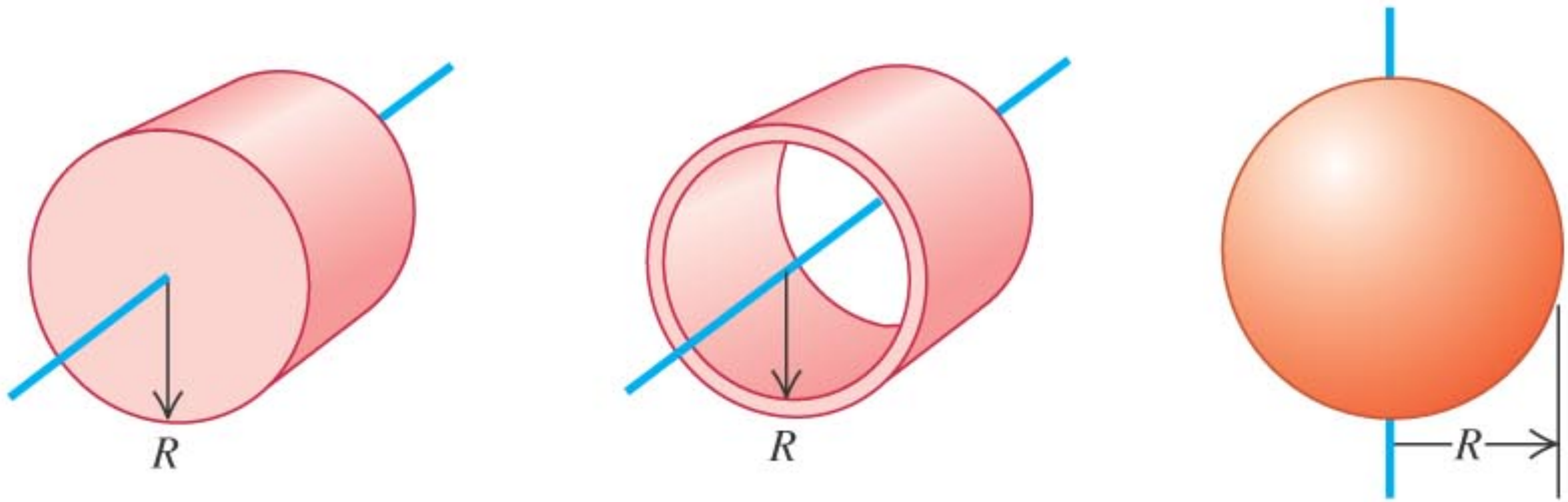
$$I = \frac{1}{2}MR^2$$

(g) Thin-walled hollow cylinder

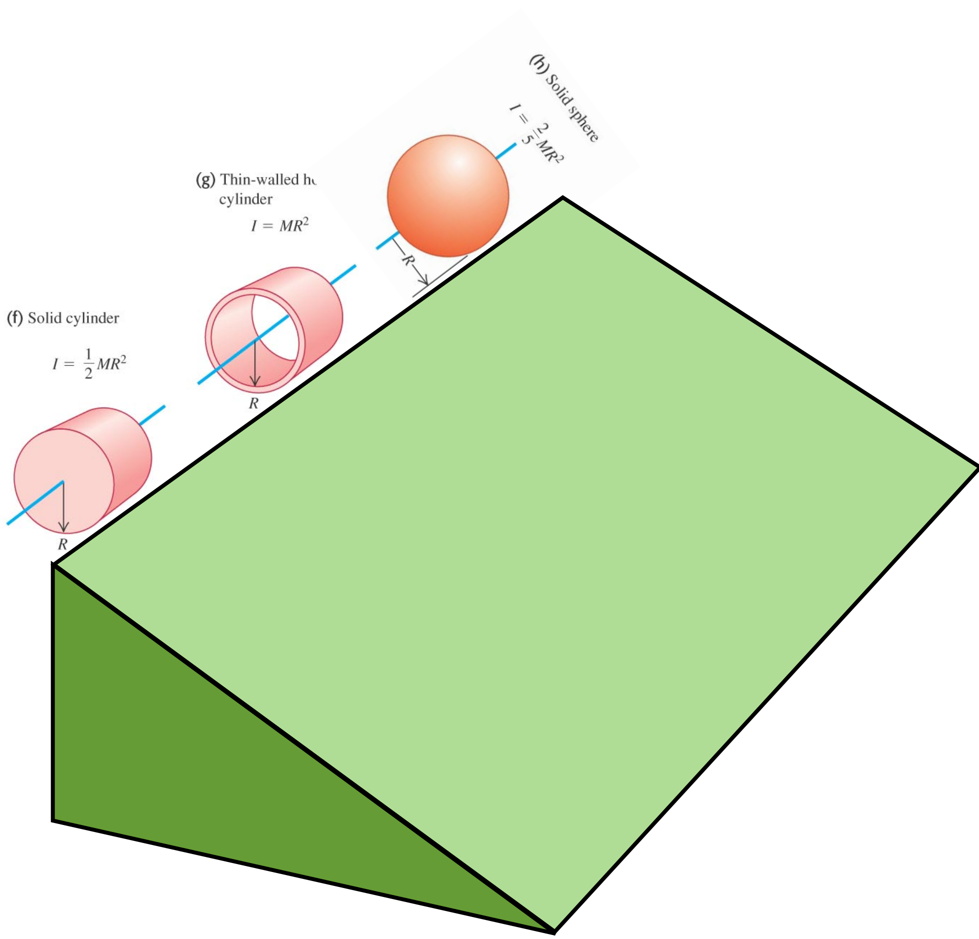
$$I = MR^2$$

(h) Solid sphere

$$I = \frac{2}{5}MR^2$$



Ramp Race

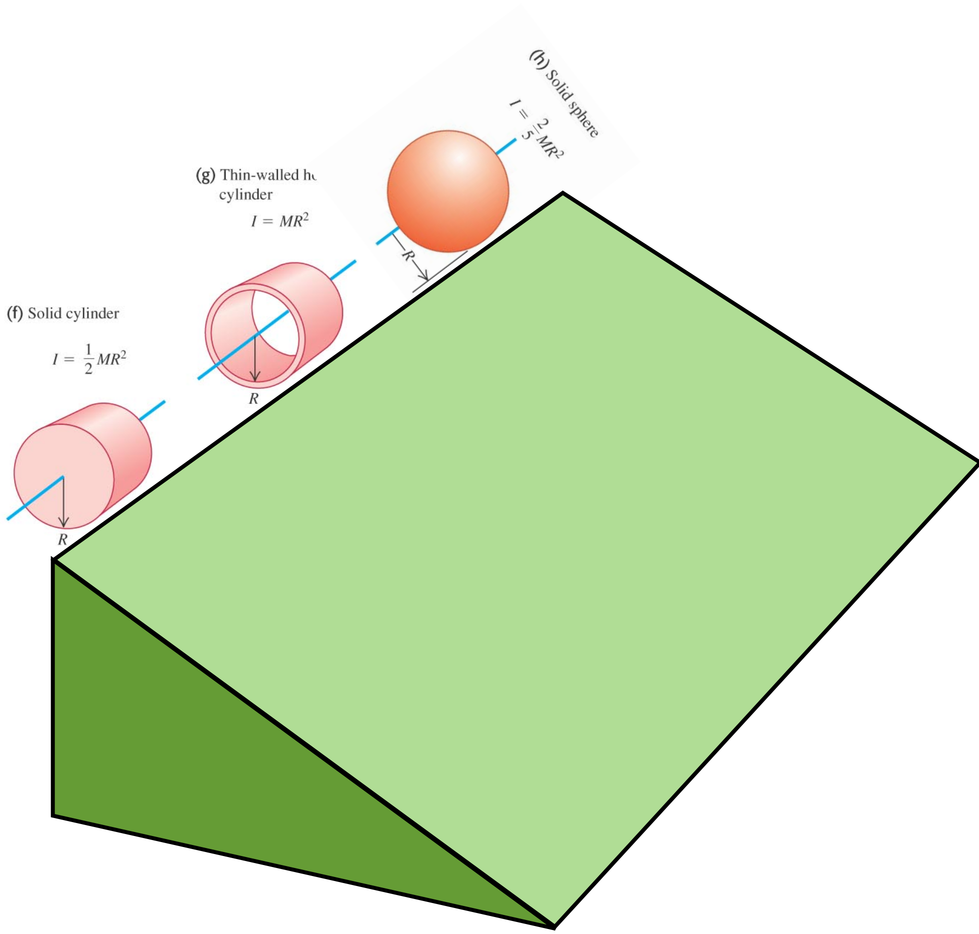


You roll a solid cylinder, a hollow cylinder, and a solid sphere down a ramp. The have equal mass and radii. Which has the greatest **total kinetic energy** at the bottom of the ramp?

F. Solid cylinder
G. Hollow cylinder
H. Sphere
I. All have the same kinetic energy
J. Need more information

Solid cylinder: $I = (1/2)MR^2$
Hollow cylinder: $I = MR^2$
Solid sphere: $I = (2/5)MR^2$

Ramp Race



Solid cylinder (SC): $I = (1/2)MR^2$
Hollow cylinder (HC): $I = MR^2$
Solid sphere (SS): $I = (2/5)MR^2$

You roll a solid cylinder, a hollow cylinder, and a solid sphere down a ramp. The have equal mass and radii. **In what order** will the objects reach the bottom of the ramp?

1. SC, HC, SS
2. SC, SS, HC
3. HC, SC, SS
4. HC, SS, SC
5. SS, SC, HC
6. SS, HC, SC
7. Two-way tie
8. Three-way tie

A solid disk and a ring roll down an incline. The ring is slower than the disk if

K. $m_{ring} = m_{disk}$, where m is the mass.

L. $r_{ring} = r_{disk}$, where r is the radius.

M. $m_{ring} = m_{disk}$ and $r_{ring} = r_{disk}$.

N. The ring is always slower regardless of the relative values of m and r.

Q10.5

A glider of mass m_1 on a frictionless horizontal track is connected to an object of mass m_2 by a massless string. The glider accelerates to the right, the object accelerates downward, and the string rotates the pulley. What is the relationship among T_1 (the tension in the horizontal part of the string), T_2 (the tension in the vertical part of the string), and the weight m_2g of the object?

Q. $m_2g = T_2 = T_1$

R. $m_2g > T_2 = T_1$

S. $m_2g > T_2 > T_1$

T. $m_2g = T_2 > T_1$

U. none of the above