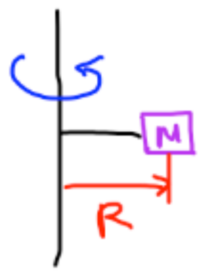
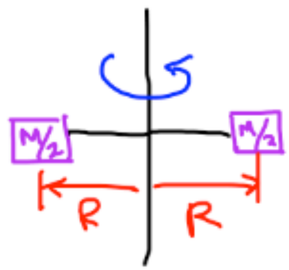
Which of these have $I = MR^2$?

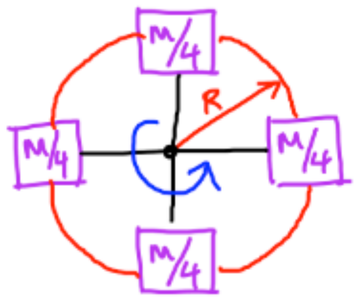
A. Single mass



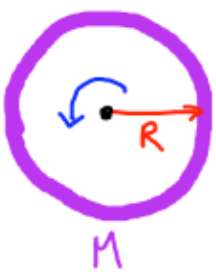
B. 2 masses



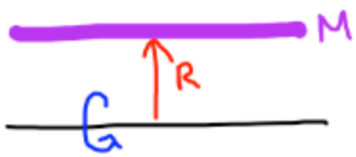
C. 4 masses



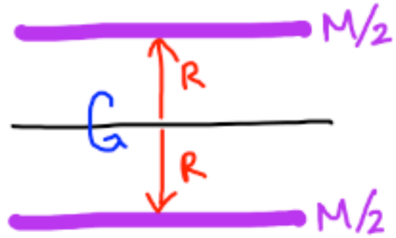
G. Hollow cylinder



D. Ring



E. Bar



F. 2 bars

Text ‘PHYSJC’ and your answer to 22333

Ch 9.5
Moment of Inertia

PHYS 1210 - Prof. Jang-Condell

Goals for Chapter 9

- To describe rotation in terms of angular coordinate, angular velocity, and angular acceleration
- To analyze rotation with constant angular acceleration
- To relate rotation to the linear velocity and linear acceleration of a point on a body
- To understand moment of inertia and how it relates to rotational kinetic energy
- To calculate moment of inertia

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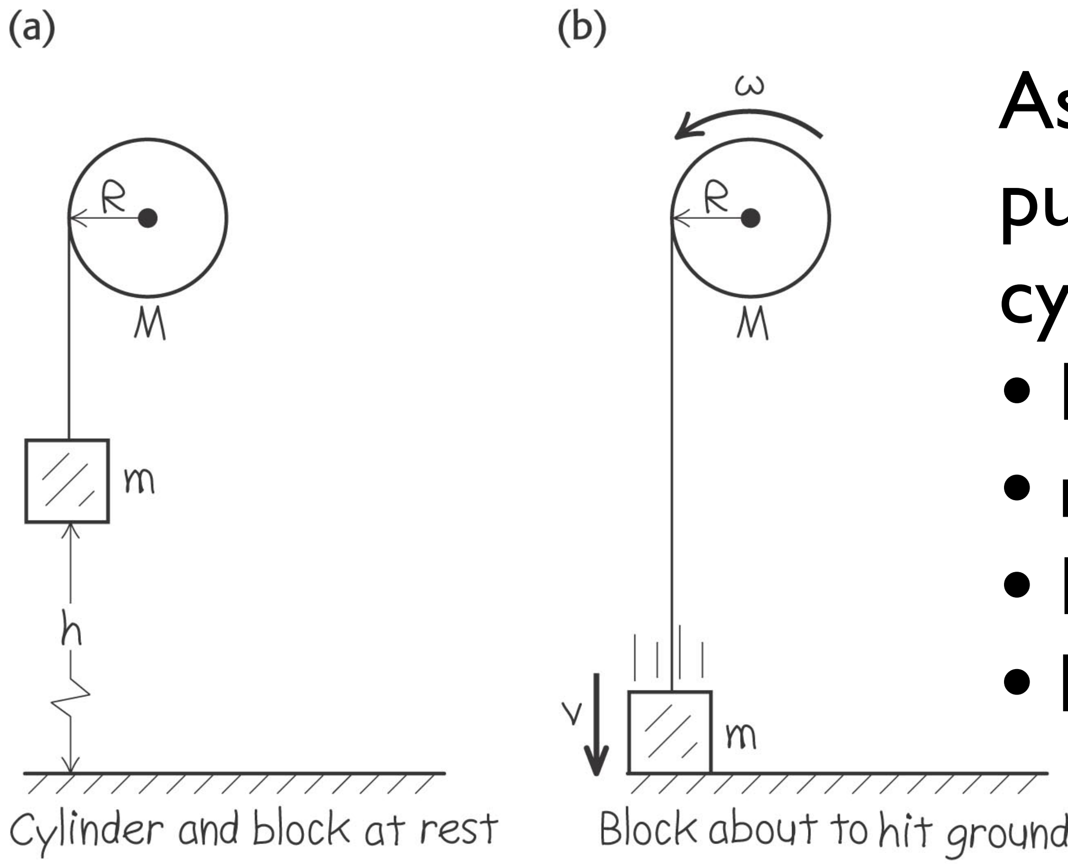
A pulley with mass



Assume the pulley is a solid cylinder, and

- $M = 0.50$ kg
- $m = 1.0$ kg
- $R = 10$ cm
- $h = 1.0$m

What is the speed of the block just before it hits the ground?

Two objects are at dropped from the same height at the same time. One of them is spinning as it falls, the other does not. Which object has more gravitational potential energy?

K. The spinning object.
L. The non-spinning object.
M. Both have the same potential energy.
N. Need more information

Gravitational potential energy of an extended body

- The gravitational potential energy of an extended body is the same as if all the mass were concentrated at its center of mass.

$$U_{\text{grav}} = Mgy_{\text{cm}}$$

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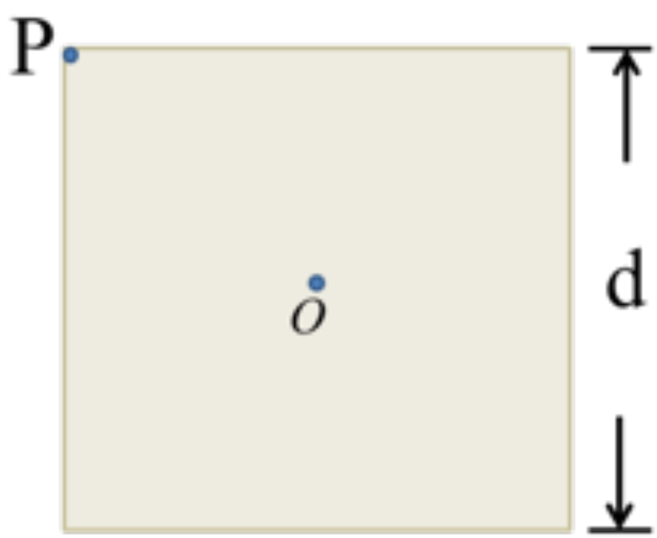
Diving video

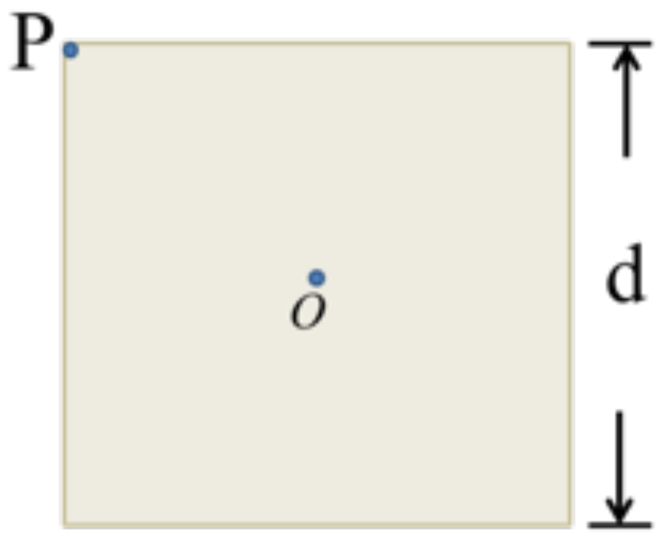
Parallel-axis Theorem

$$I_P = I_{\text{cm}} + Md^2$$

A square metal plate with length d on each side is pivoted about an axis through its center of mass (O) and perpendicular to the plate. The mass of the plate is M. What is the moment of inertia, I_{CM}?

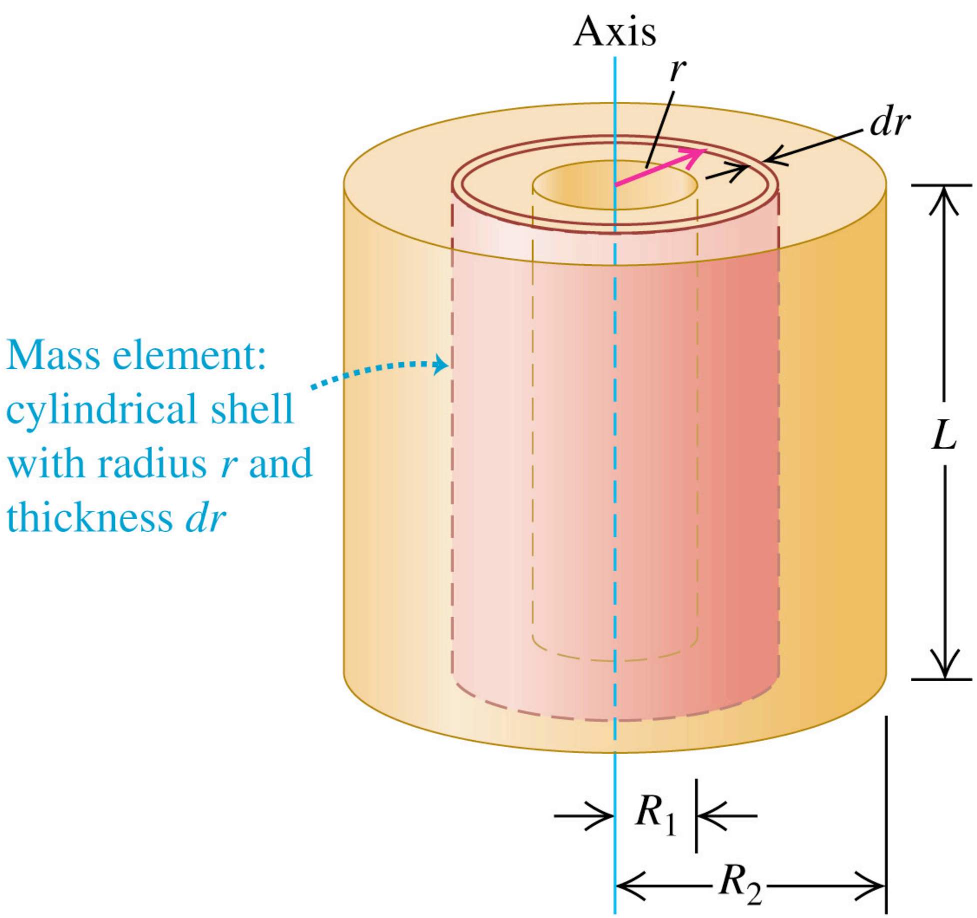


A square metal plate with length d on each side is pivoted about an axis through a corner (point P as indicated in the figure) and perpendicular to the plate. The mass of the plate is M, and the moment of inertia of the plate about an axis through its center of mass O and perpendicular to the plate is I_{CM}. What is the moment of inertia about the axis through point P?



A. $I_P = I_{CM} + Md^2$
B. $I_P = I_{CM} + M(d/2)^2$
C. $I_P = I_{CM} + (1/2)Md^2$
D. $I_P = (1/6)Md^2$
E. None of the above

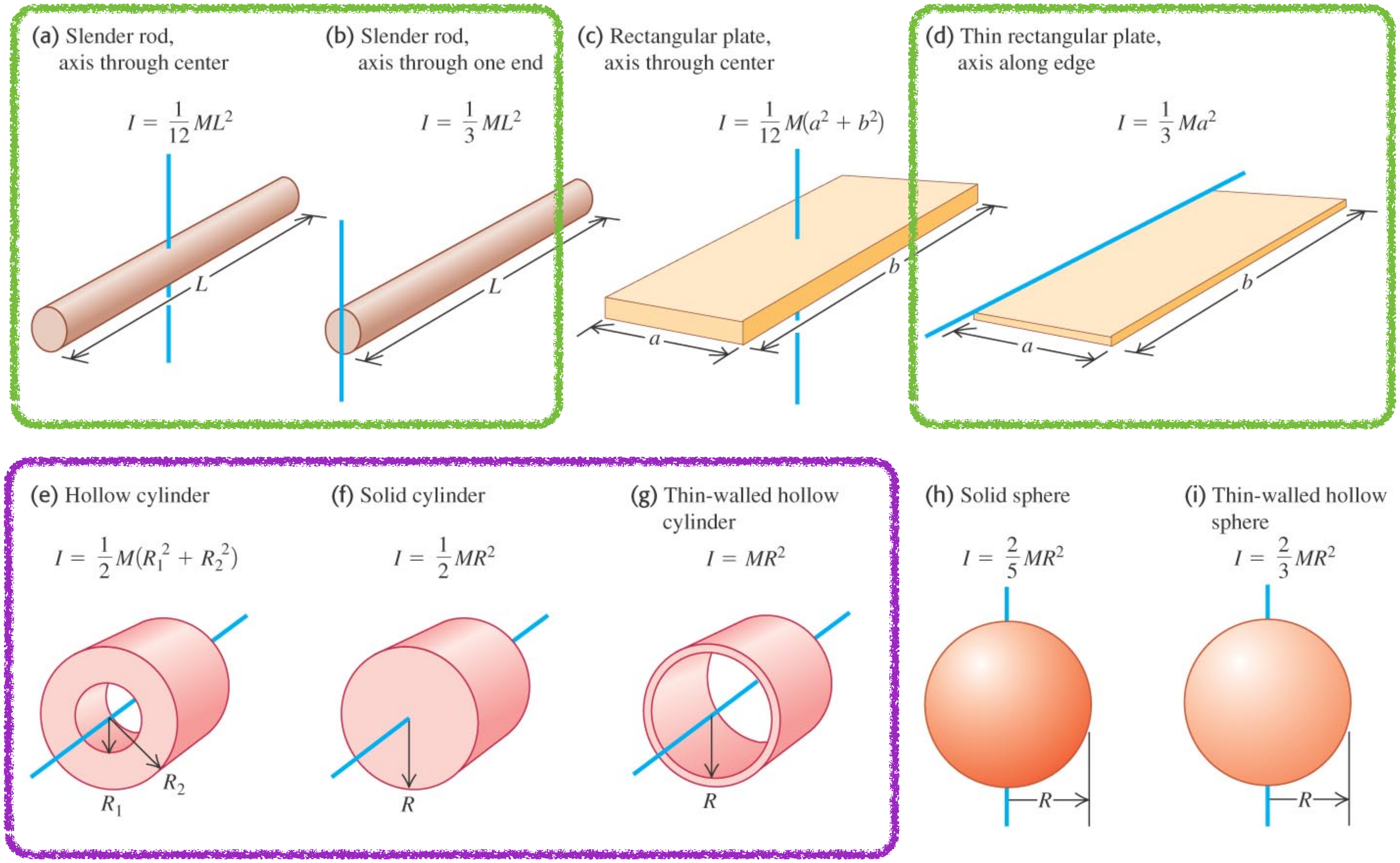
Moment of Inertia Calculations



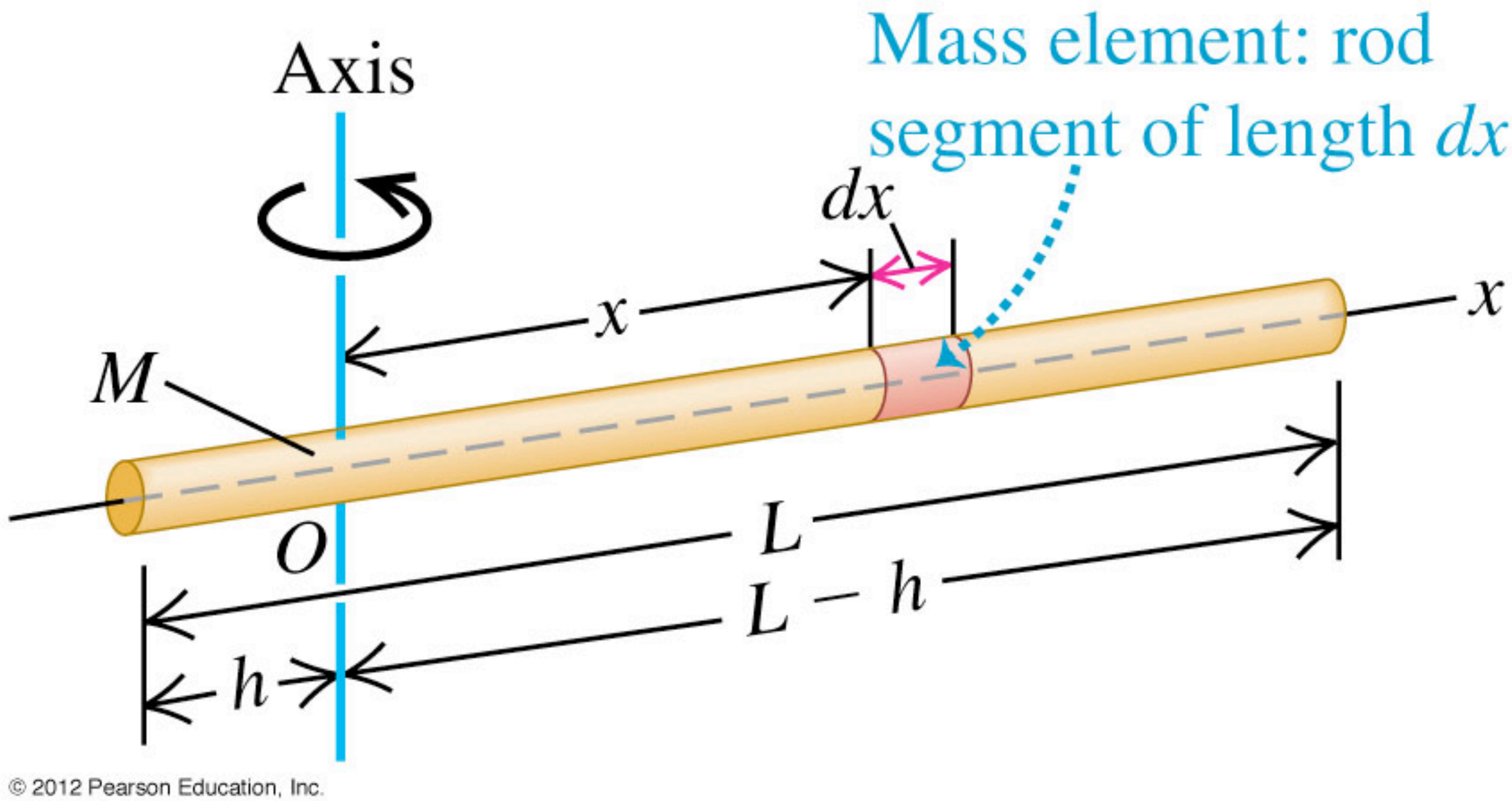
$$I = \int r^2 \, dm$$

$$dm = \rho \, dV$$

$$I = \int \rho r^2 \, dV$$

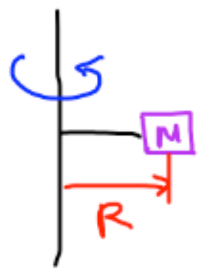

(a) Slender rod, axis through center
$I = \frac{1}{12}ML^2$
L
(b) Slender rod, axis through one end
$I = \frac{1}{3}ML^2$
L
(c) Rectangular plate, axis through center
$I = \frac{1}{12}M(a^2 + b^2)$
a
b
(d) Thin rectangular plate, axis along edge
$I = \frac{1}{3}Ma^2$
a
b
(e) Hollow cylinder
$I = \frac{1}{2}M(R_1{}^2 + R_2{}^2)$
R_1
R_2
(f) Solid cylinder
$I = \frac{1}{2}MR^2$
R
(g) Thin-walled hollow cylinder
$I = MR^2$
R
(h) Solid sphere
$I = \frac{2}{5}MR^2$
R
(i) Thin-walled hollow sphere
$I = \frac{2}{3}MR^2$
R

Simplest case: 1D

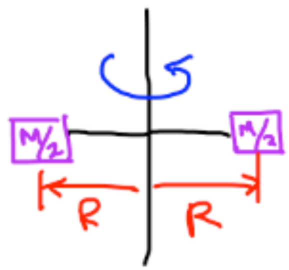


Which of these have $I = MR^2$?

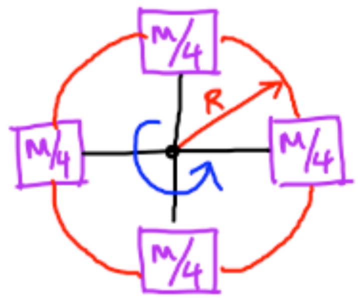
A. Single mass



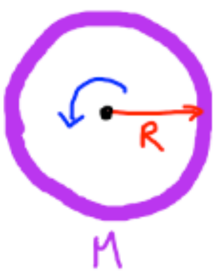
B. 2 masses



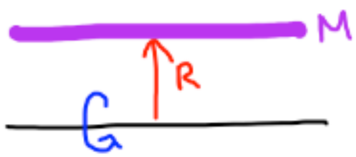
C. 4 masses



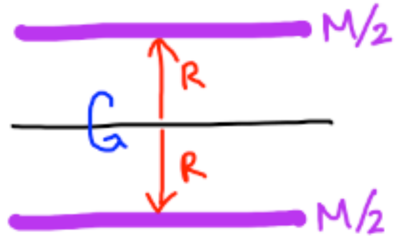
G. Hollow cylinder



D. Ring

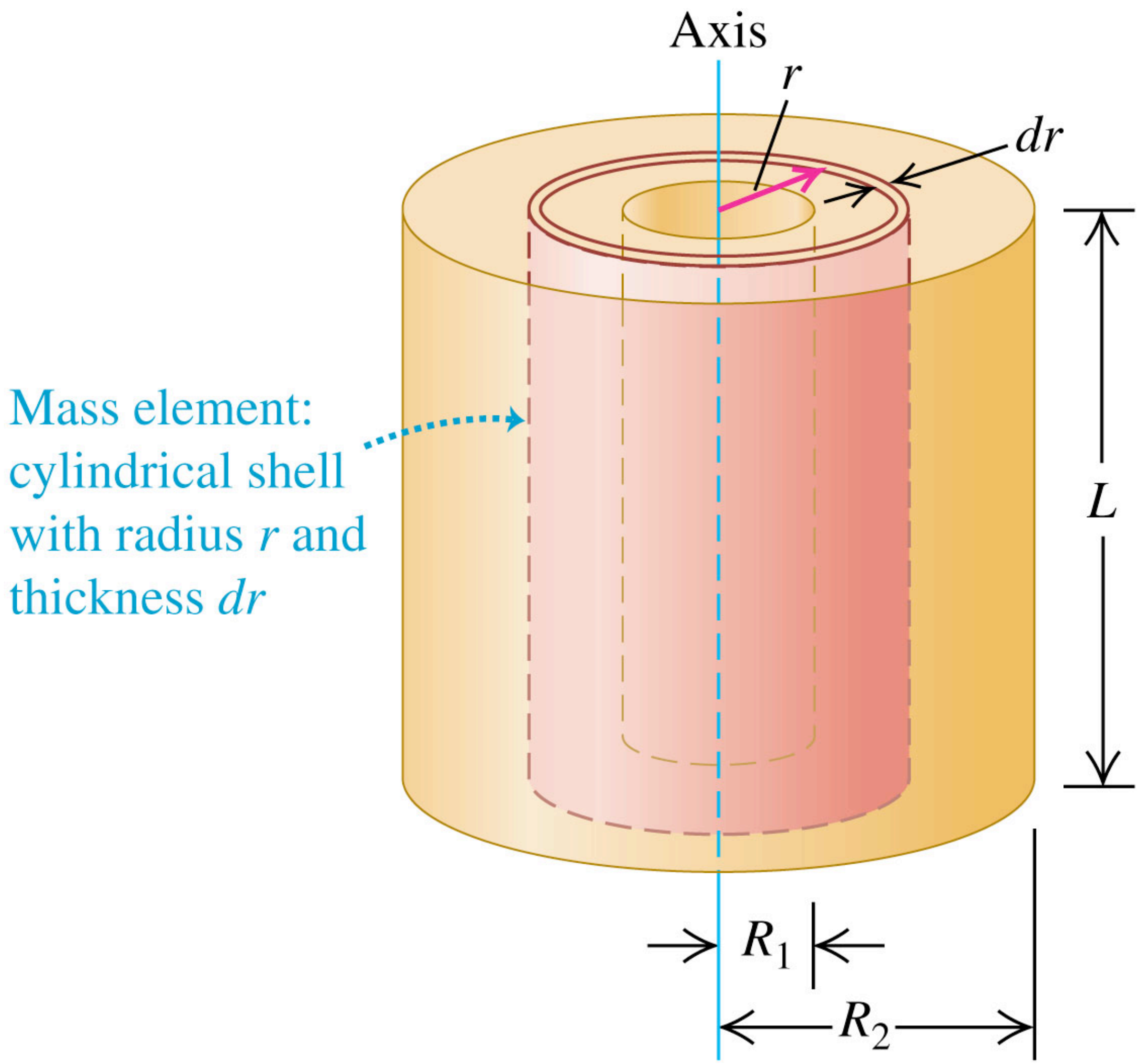


E. Bar

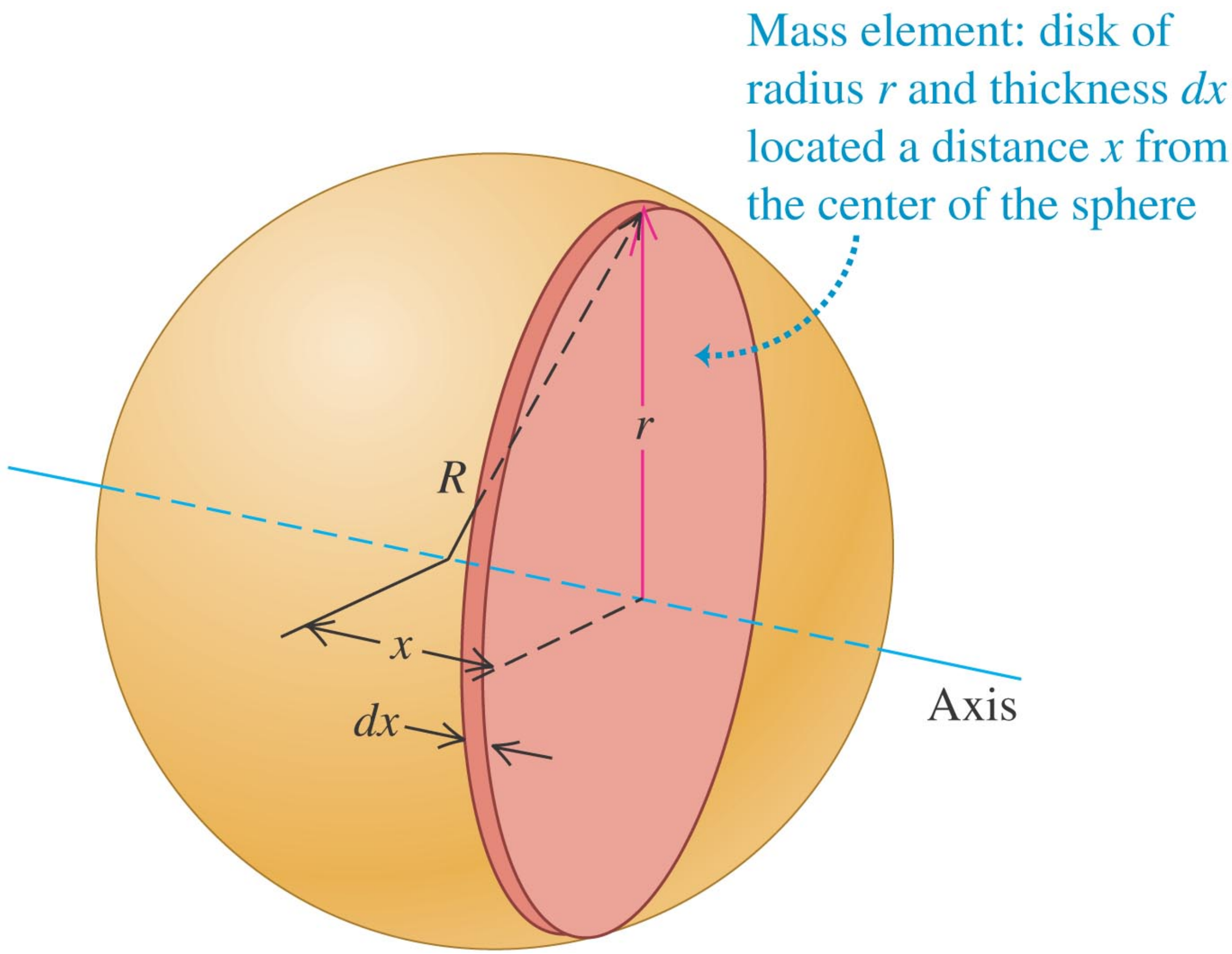


F. 2 bars

Harder case: 2D



Harder still: 3D



Torque

Loosen a bolt

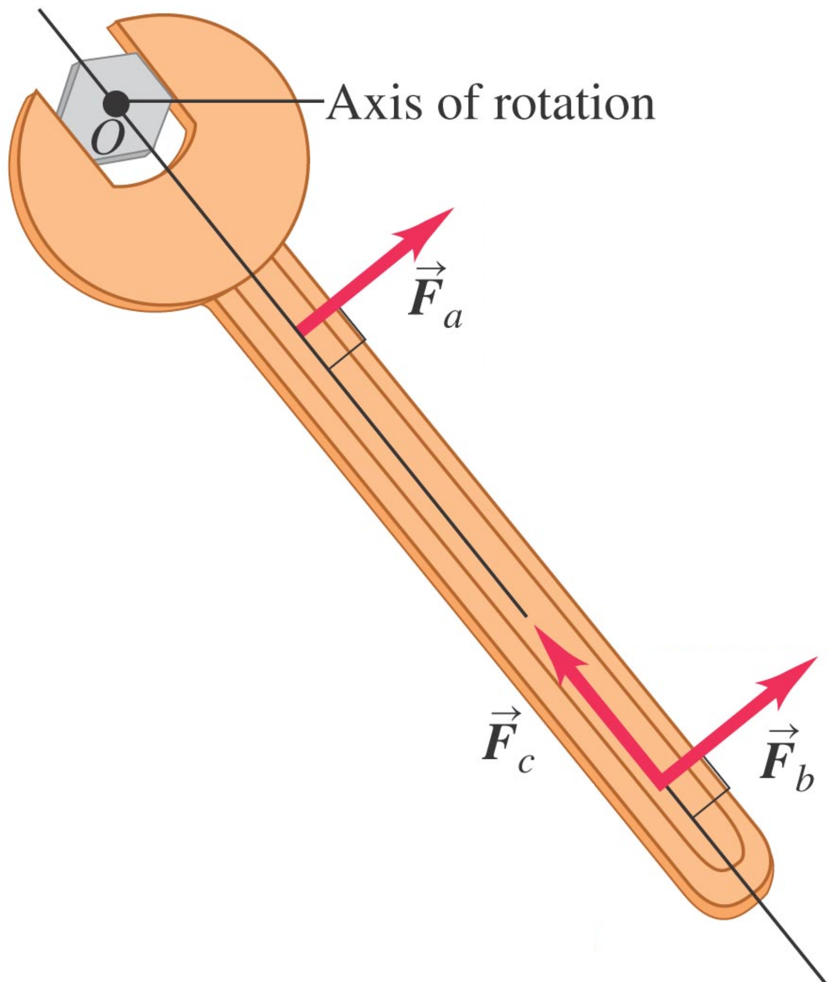
- Which of the three equal-magnitude forces in the figure is most likely to loosen the bolt?

F. $\boldsymbol{F}_a$

G. $\boldsymbol{F}_b$

H. $\boldsymbol{F}_c$

I. Not enough information to decide



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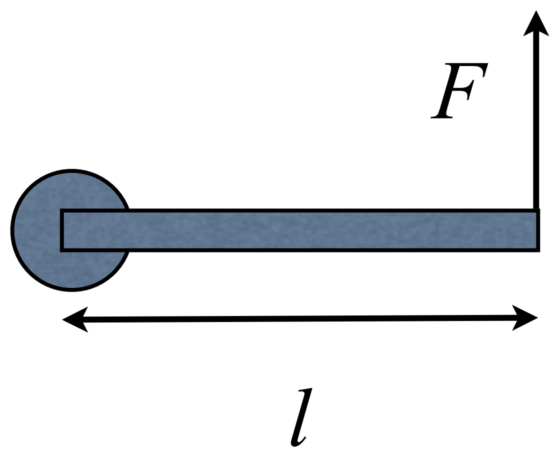
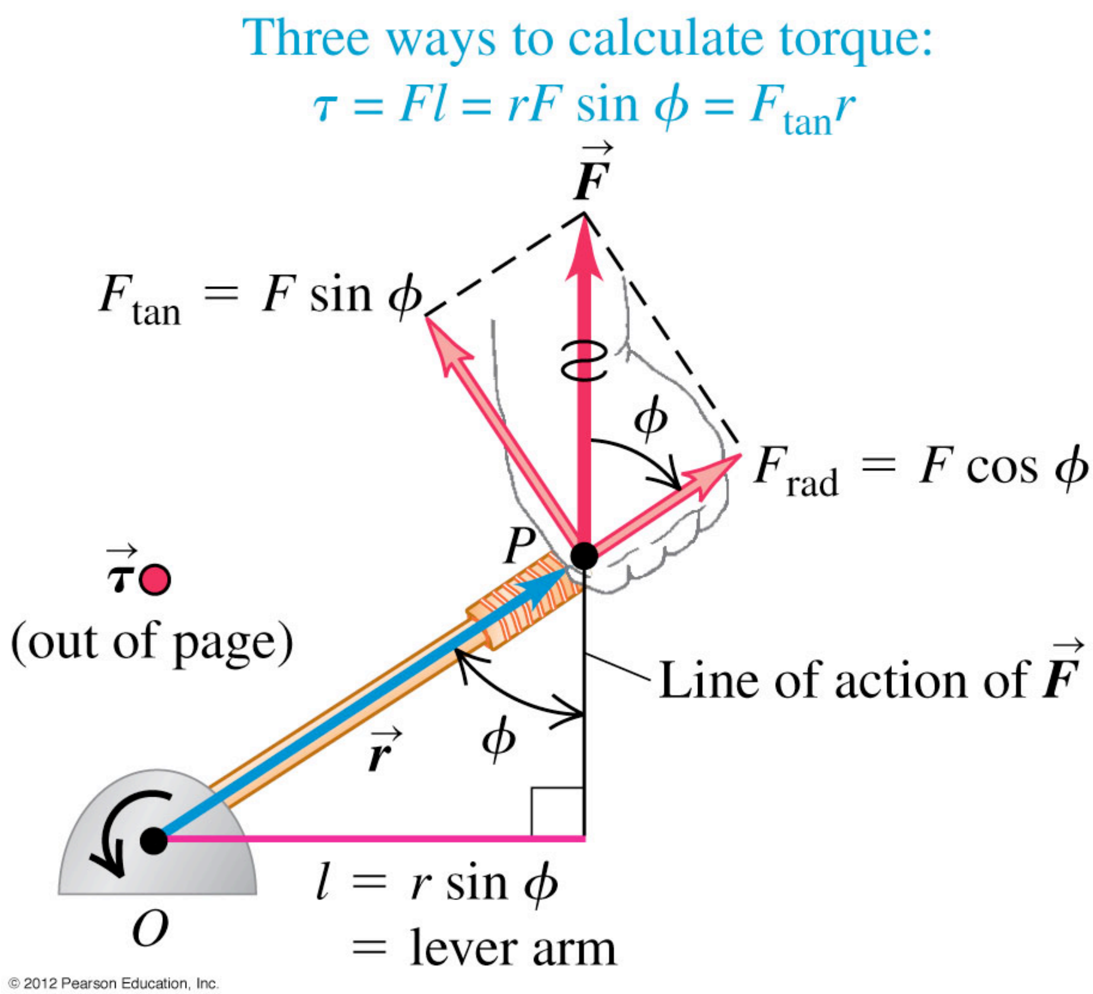
Torque



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

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