$$I = \sum_i m_i r_i^2$$

$$K_{\mathrm{rot}} = \frac{1}{2} I \omega^2$$

$$\tau = F_\perp r$$

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

$$x_{\mathrm{cm}} = \frac{1}{M} \sum_i x_i m_i$$

$$\tau = F r_\perp$$

$$I = I_{\mathrm{cm}} + M d^2$$

$$x_{\mathrm{cm}} = \frac{1}{M} \int x dm$$

$$I = \sum_i m_i r_i^2 \quad \boxed{6}$$

$$\boxed{7} \quad K_{\rm rot} = \frac{1}{2} I \omega^2$$

$$\tau = F_\perp r \quad \boxed{5}$$

$$I = \int r^2 dm \quad \boxed{4}$$

$$x_{\rm cm} = \frac{1}{M} \sum_i x_i m_i \quad \boxed{8}$$

$$\tau = F r_\perp \quad \boxed{1}$$

$$I = I_{\rm cm} + M d^2 \quad \boxed{2}$$

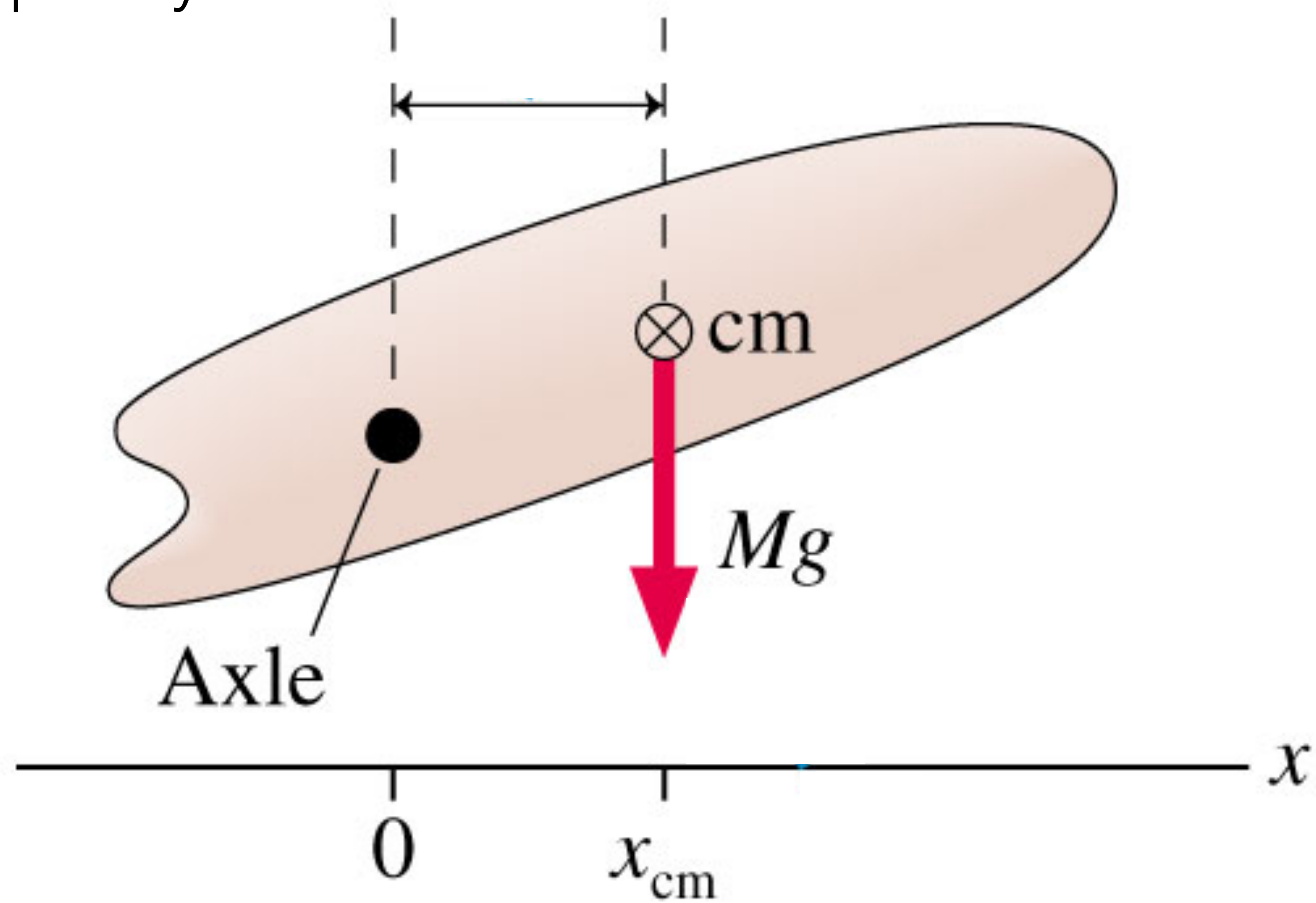
$$x_{\rm cm} = \frac{1}{M} \int x dm \quad \boxed{3}$$

(a) What is the equation used for?
(b) What do each of the variables mean?
(c) Make up a physical situation to illustrate.

Gravitational Torque

When I release the object what will happen?

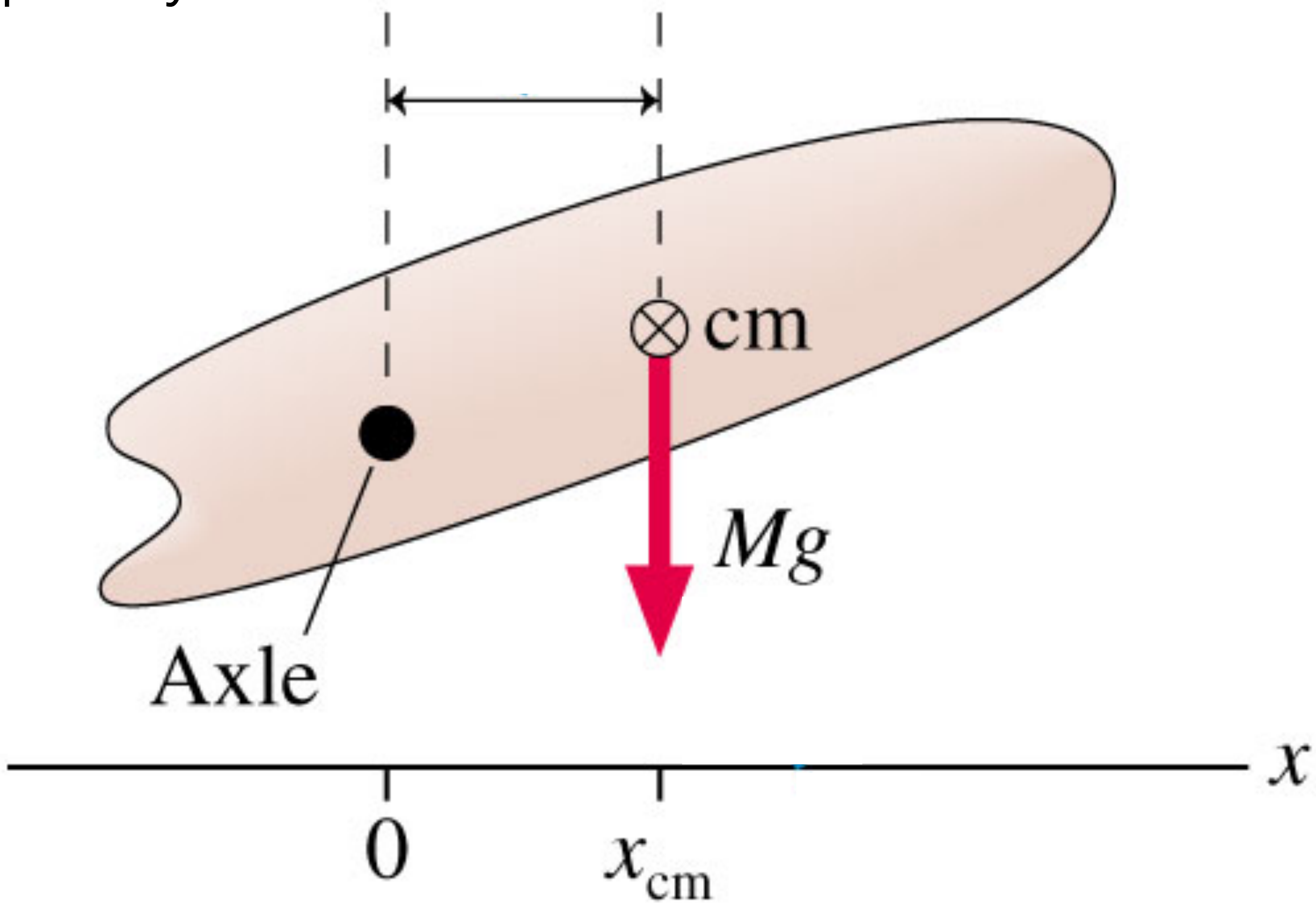
A) It will oscillate back and forth.
B) Nothing. It will stay where you put it.
C) It will first rotate and the quickly come to rest.



Question #21 Gravitational Torque

When I release the object what will happen?

A) It will oscillate back and forth.
B) Nothing. It will stay where you put it.
C) It will first rotate and the quickly come to rest.



Moment of Inertia

12.11

12.49

12.51

12.52 ← Parallel-axis theorem

12.53 ← Calculus

12.54 ← Calculus (more challenging)

Torque

12.18

12.19

12.8

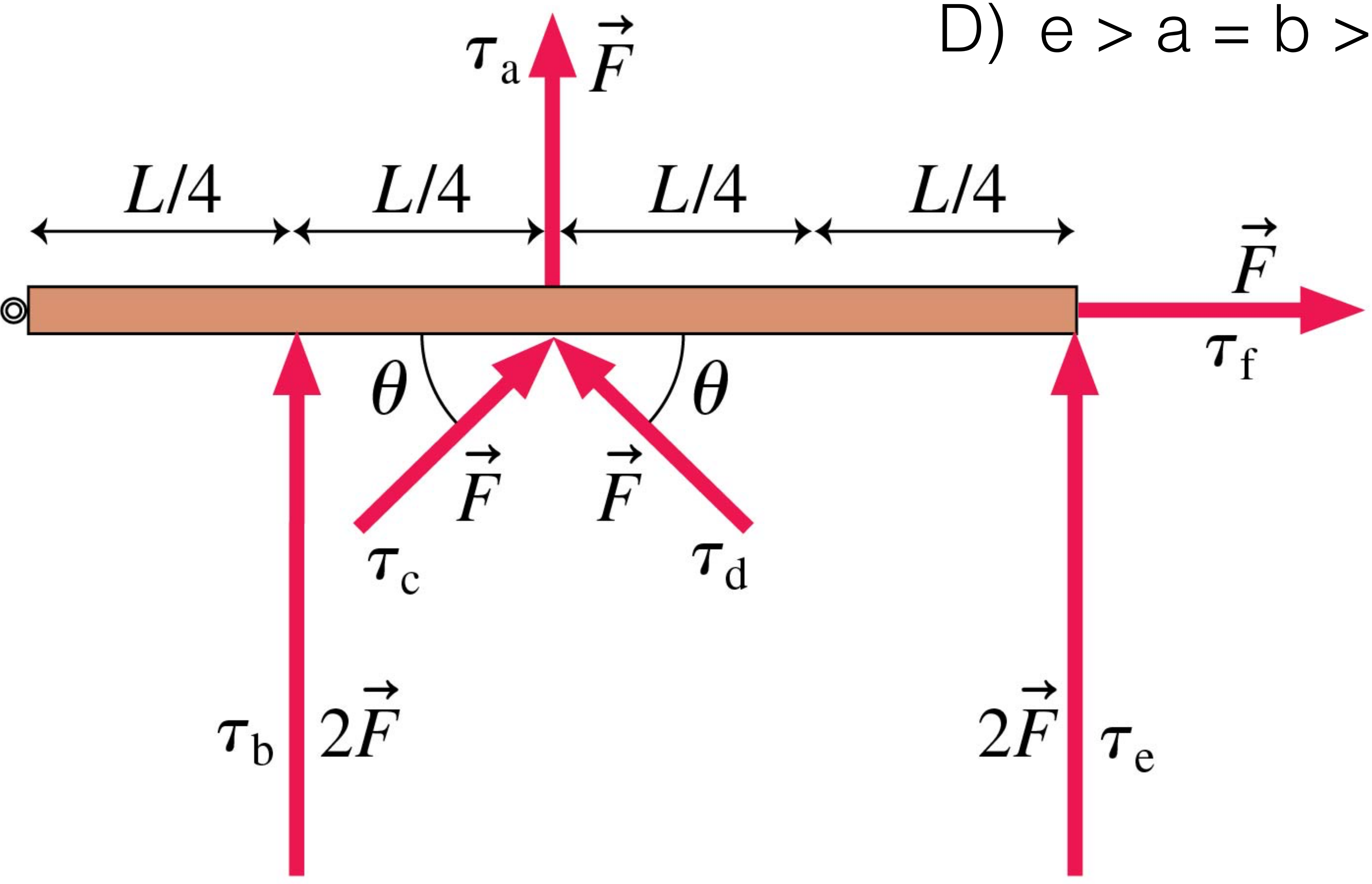
12.20 12.22

12.23

Question #22

Rank the torques

A) e = a > b > c > d > f
B) a > e > d > f = d > c
C) e > b > a > d = c > f
D) e > a = b > c = d > f



Question #23

Video question

A) 10 cm from left end
B) 25 cm from right end
C) 10 cm from right end
D) In the middle
E) 25 cm from left end

Rotational Dynamics

- What does a torque do?
- For linear motion, a net force causes an object to accelerate.
- For rotation, **a net torque causes an object to have angular acceleration.**

$$\alpha = \frac{\tau_{\rm net}}{I}$$

In the absence of a net torque ($\tau_{net} = 0$), the object either does not rotate ($\omega = 0$) or rotates with *constant* angular velocity (ω = constant).

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Torque applet

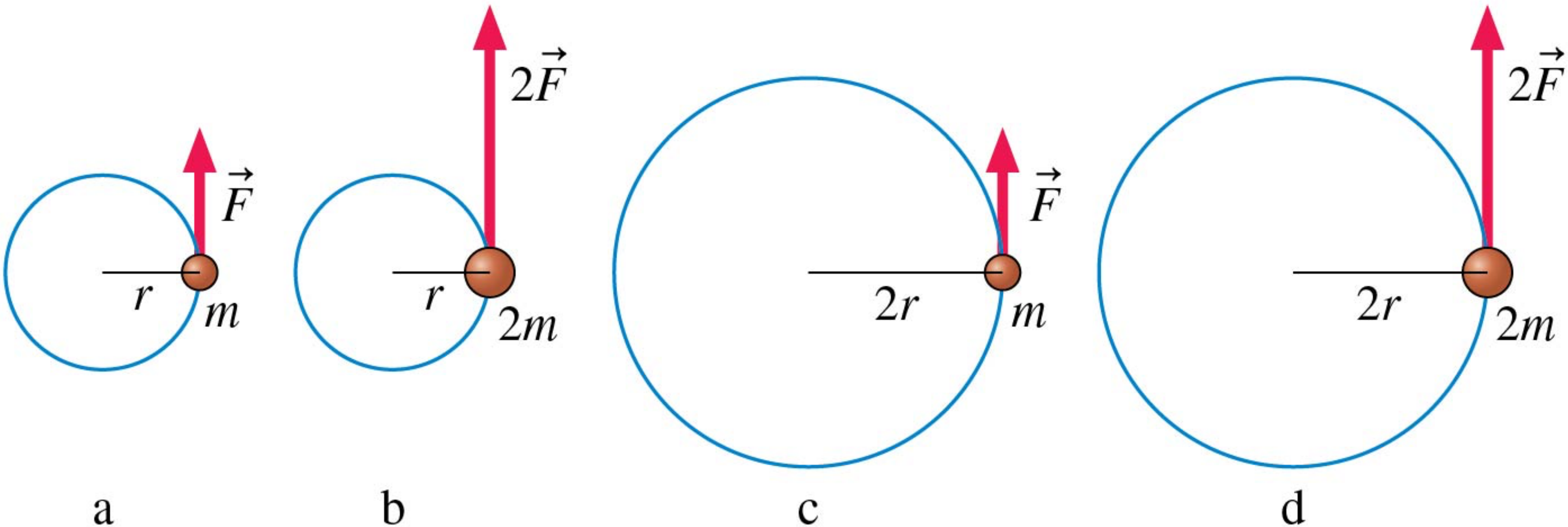
In the absence of a net torque ($\tau_{net} = 0$), the object either does not rotate ($\omega = 0$) or rotates with *constant* angular velocity (ω = constant).

Analogies between linear and rotational dynamics

Rotational dynamics		**Linear dynamics**	
torque	τ_{net}	force	$\vec{F}_{\text{net}}$
moment of inertia	I	mass	m
angular acceleration	α	acceleration	$\vec{a}$
second law	$\alpha = \tau_{\text{net}}/I$	second law	$\vec{a} = \vec{F}_{\text{net}}/m$

Question #24

Rank the angular accelerations!



B) a > b = c > d

D) c > d = a > c

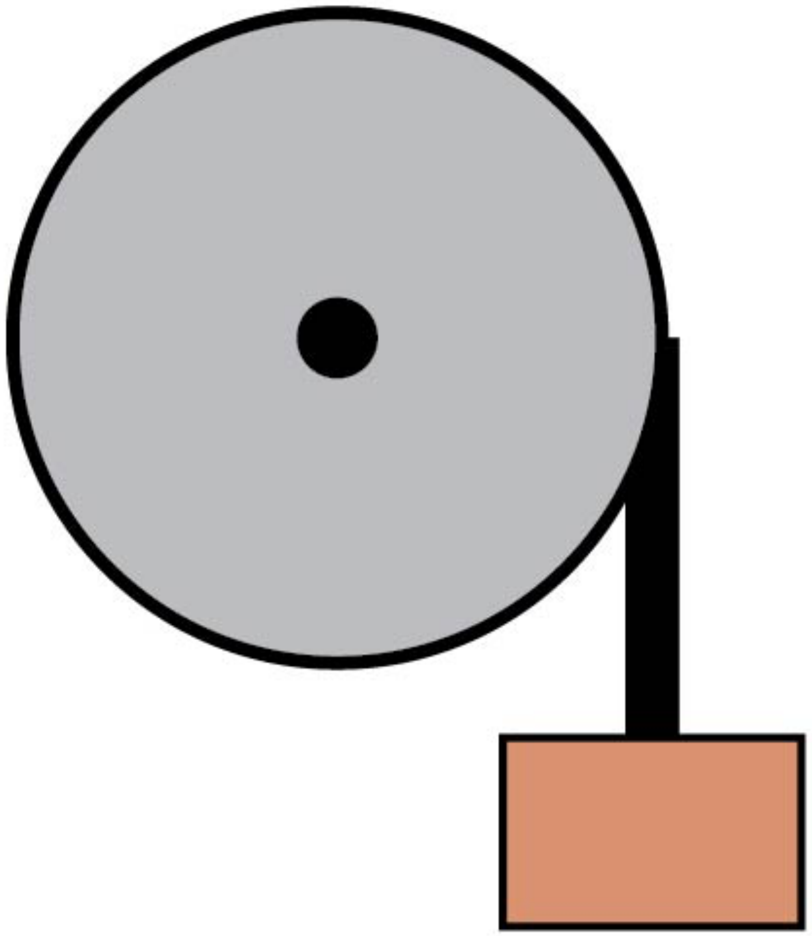
C) a = b > c = d

E) b > d = a > c

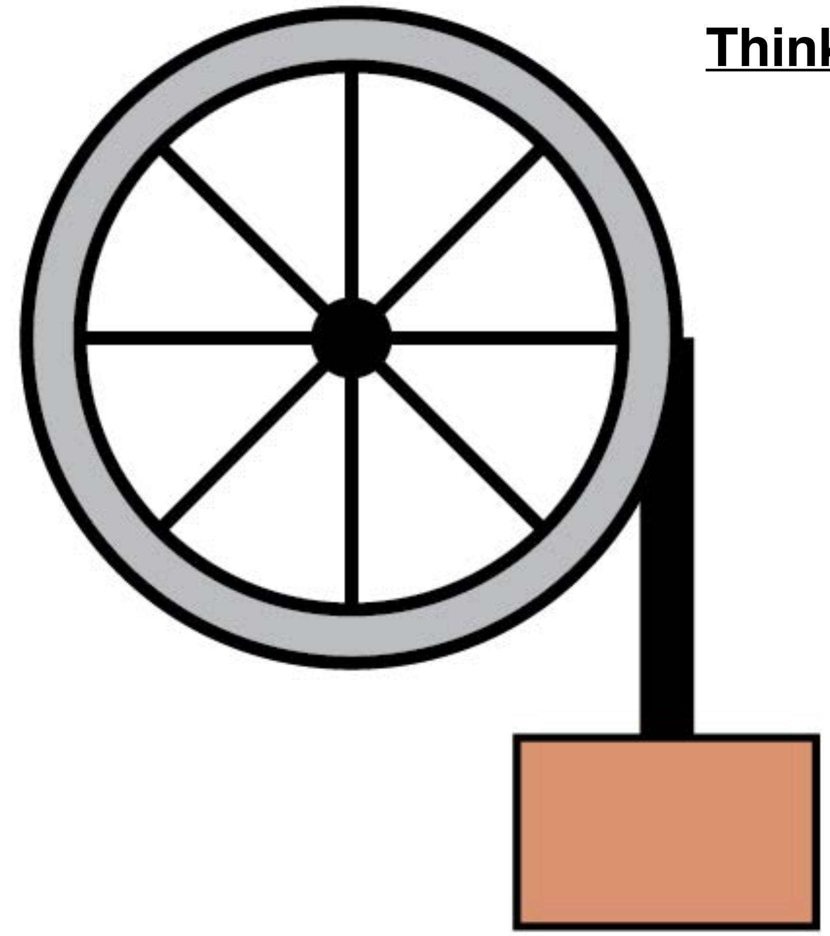
Question # 25

In which case will the block be moving faster just before it hits the floor?

A



B

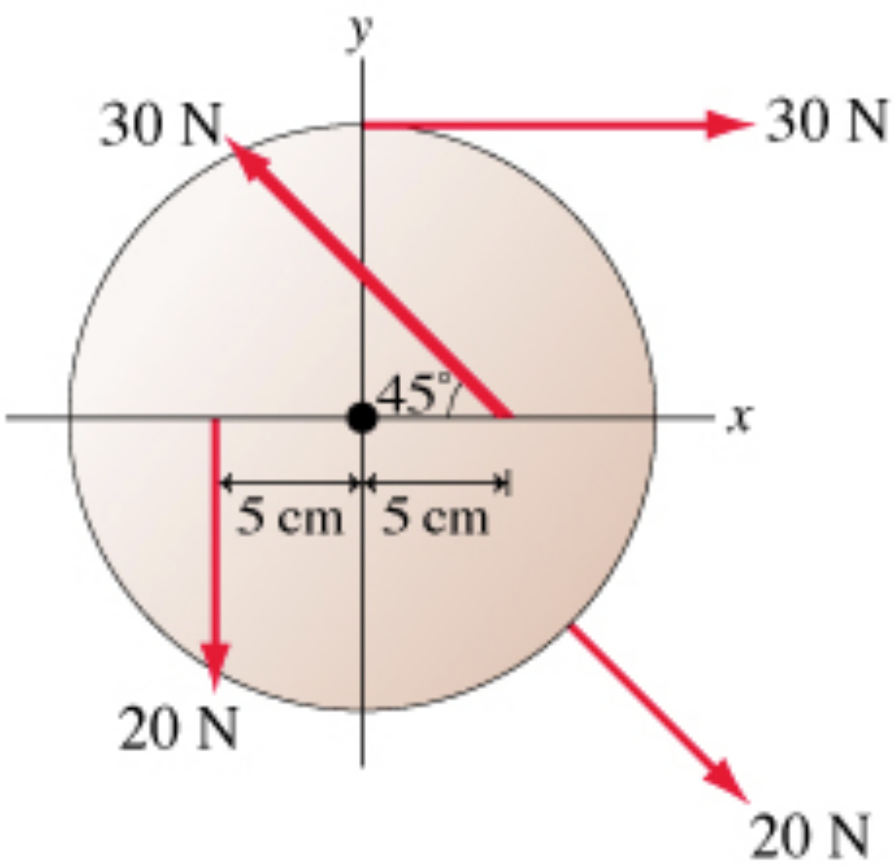


Think energy!!

HW-style problem

M = 2 kg

Find the angular acceleration of the wheel

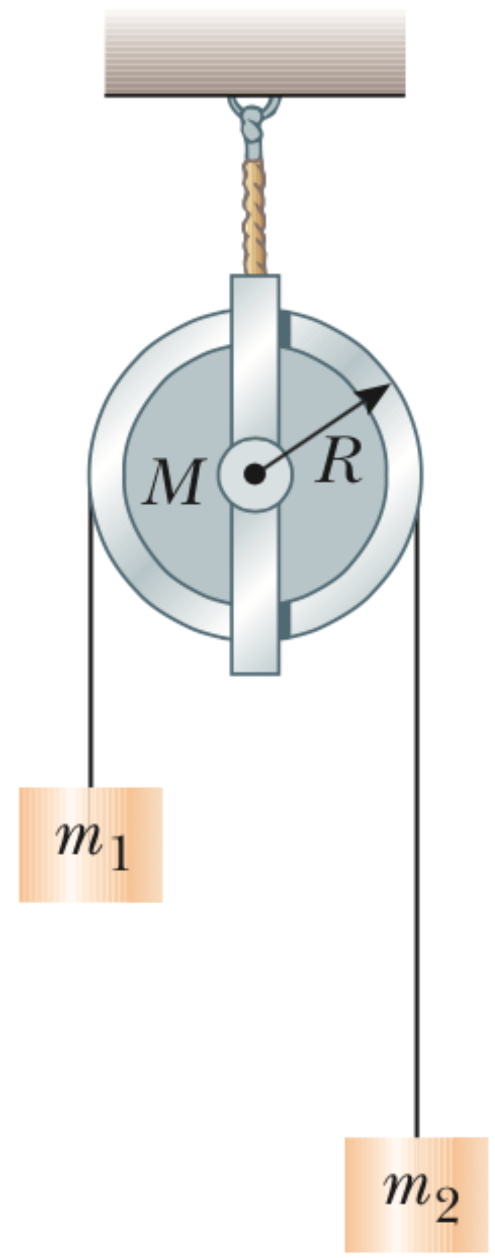


$$\tau_{\text{net}} = I\alpha$$

$m_1 = 20.0\ \mathrm{kg}$ $m_2 = 12.5\ \mathrm{kg}$ $M = 5.00\ \mathrm{kg}$

$R = 0.200\ \mathrm{m}$

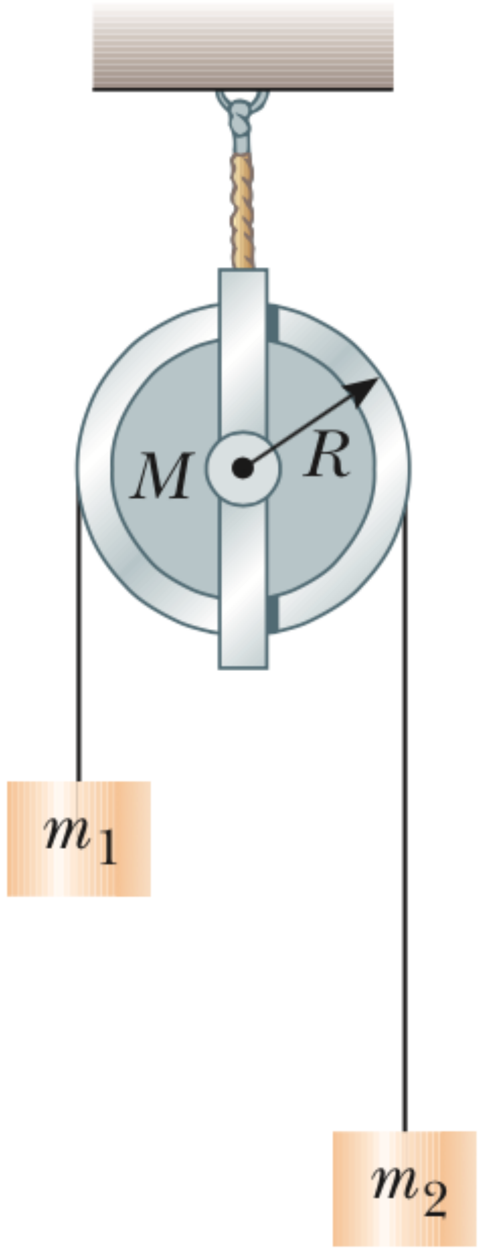
m_1 is 4.00 m above m_2 initially. How long before m_1 hits the floor?



$$m_1 = 20.0 \text{ kg} \qquad m_2 = 12.5 \text{ kg} \qquad M = 5.00 \text{ kg}$$

$$R = 0.200 \text{ m}$$

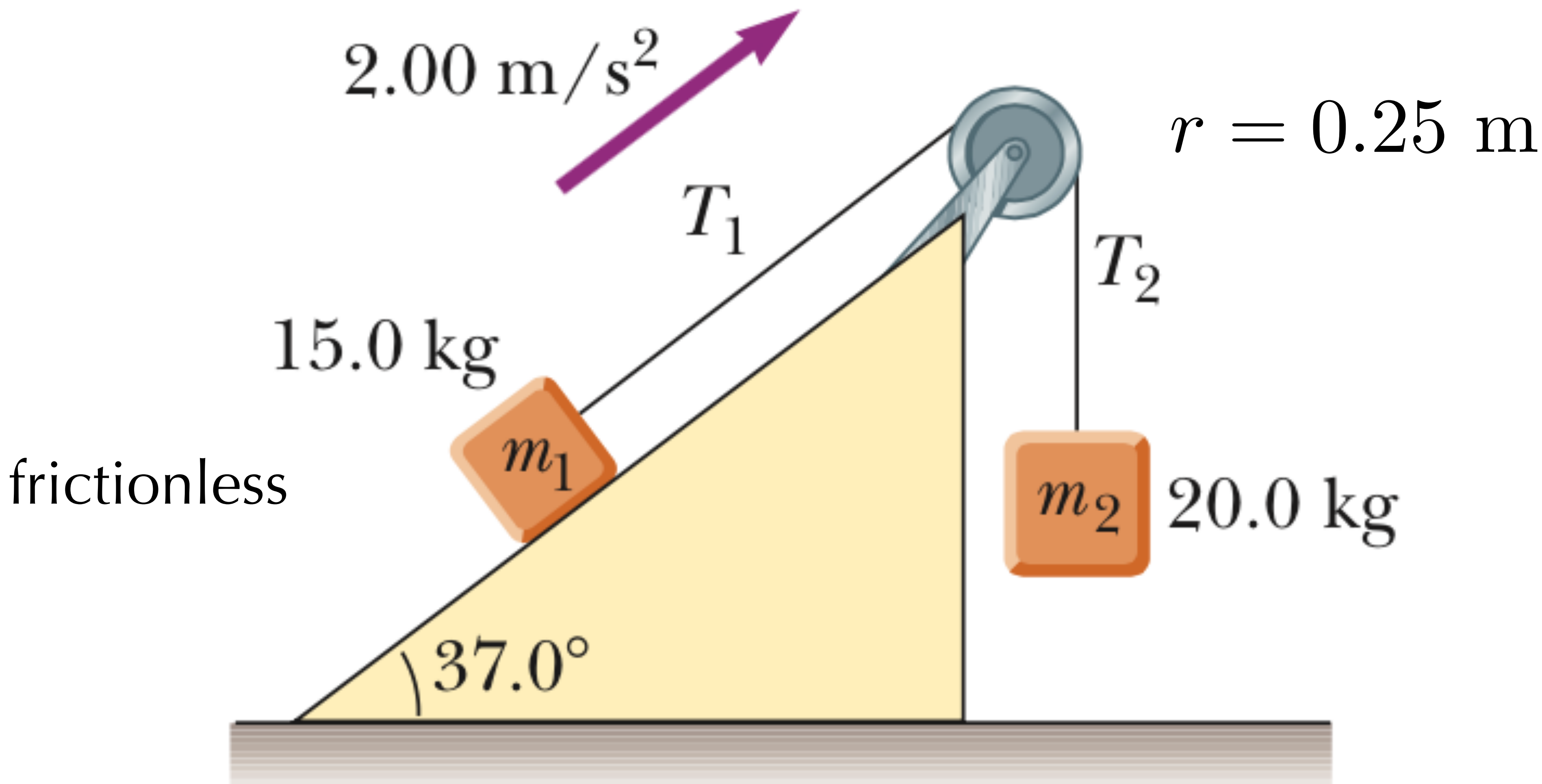
m_1 is 4.00 m above m_2 initially. How long before m_1 hits the floor?



$$a = 2.1 \text{ m/s}^2$$

$$t = 1.95 \text{ s}$$

Find T_1, T_2, and I(the moment of inertia of the pulley)



$T_1 = 118$ N $\quad T_2 = 156$ N $\quad I = 1.17$ kg m^2