You can draw here

GET READY: Go here and make sure you see the “Are you Ready” Sli.do Q
Canvas -> Course Content -> Lecture (under Week 7 - Chapter 6)

Physics 111 - Lecture 7

October 22, 2020

Do not draw in/on this box!

You can draw here

You can draw here

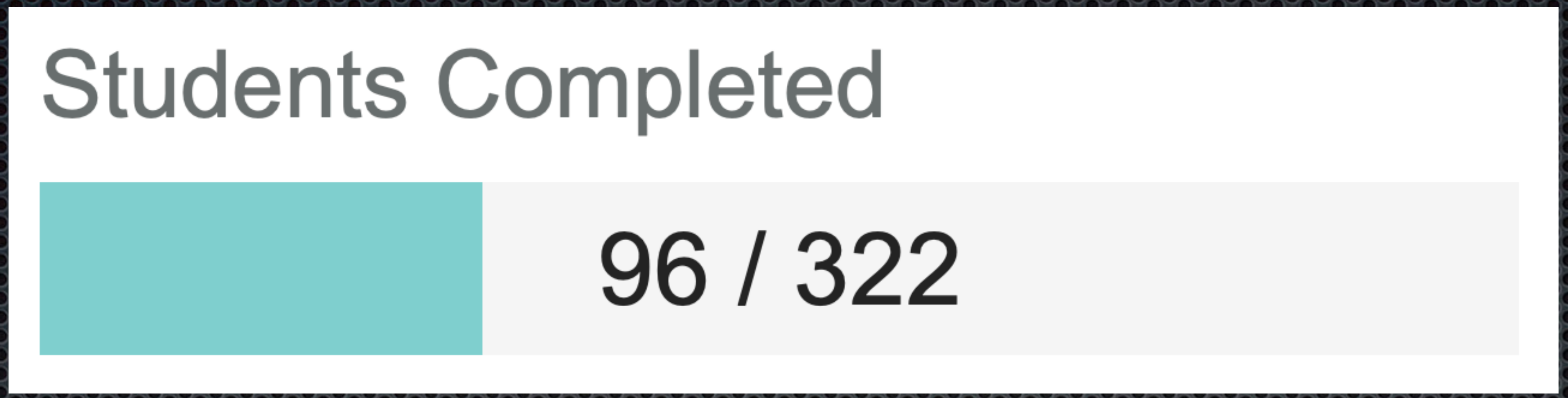
Reminders/Announcements

- Bonus Test 2 (Chapters 4 and 5) starts today from 6PM - Saturday at 6 PM
- Remember: If you want me to record a worked example for content this week, post on the Piazza thread!
    - Arrow question (from last class) was a test question so I'll record that after Bonus Test 2

Reminders/Announcements

	Homework (due Wed 6 pm)	Test/Bonus Test (Thurs 6pm - Sat 6pm)	Learning Log (Sat 6pm)
Week 1	-	-	-
Week 2	HW01 - Intro to Mastering Physics	Test 0 **(not for marks)**	Learning Log 1
Week 3	HW02 - Chapter 2 HW03 - Chapter 3	Test 1 (on Chapters 2 & 3)	Learning Log 2
Week 4	HW04 - Chapter 4	Bonus Test 1	Learning Log 3
Week 5	HW05 - Chapter 5	Test 2 (on Chapters 4 and 5)	Learning Log 4
Week 6	N/A	N/A	N/A
Week 7	HW07 - Chapter 6	Bonus Test 2	Learning Log 5
Week 8	HW08 - Chapter 7	Test 3	Learning Log 6
Week 9			
Week 10			

Summary of comments from Homework 7 (Chapter 6)



Too long of a break from physics?

Summary of comments from Homework 7 (Chapter 6)

Students Completed

96 / 322

Too long of a break from physics?

- Questions 16 and 17 required calculus… (extra credit)
- Terminal velocity and Drag
- No penalty for multiple attempts on HW?
- Truck and box of nails; incline plane
- More accurate Free Body diagrams with complex angles

An investigation has been opened into contract cheating.

If you have an account on a course “help” site,

or have used someone else’s account,

or have accessed “help” sites during a Test,

or have used “help” sites during a Lab,

or have had someone else write your Test for you,

or anything else similar that would constitute as academic dishonesty,

You have **one** chance …

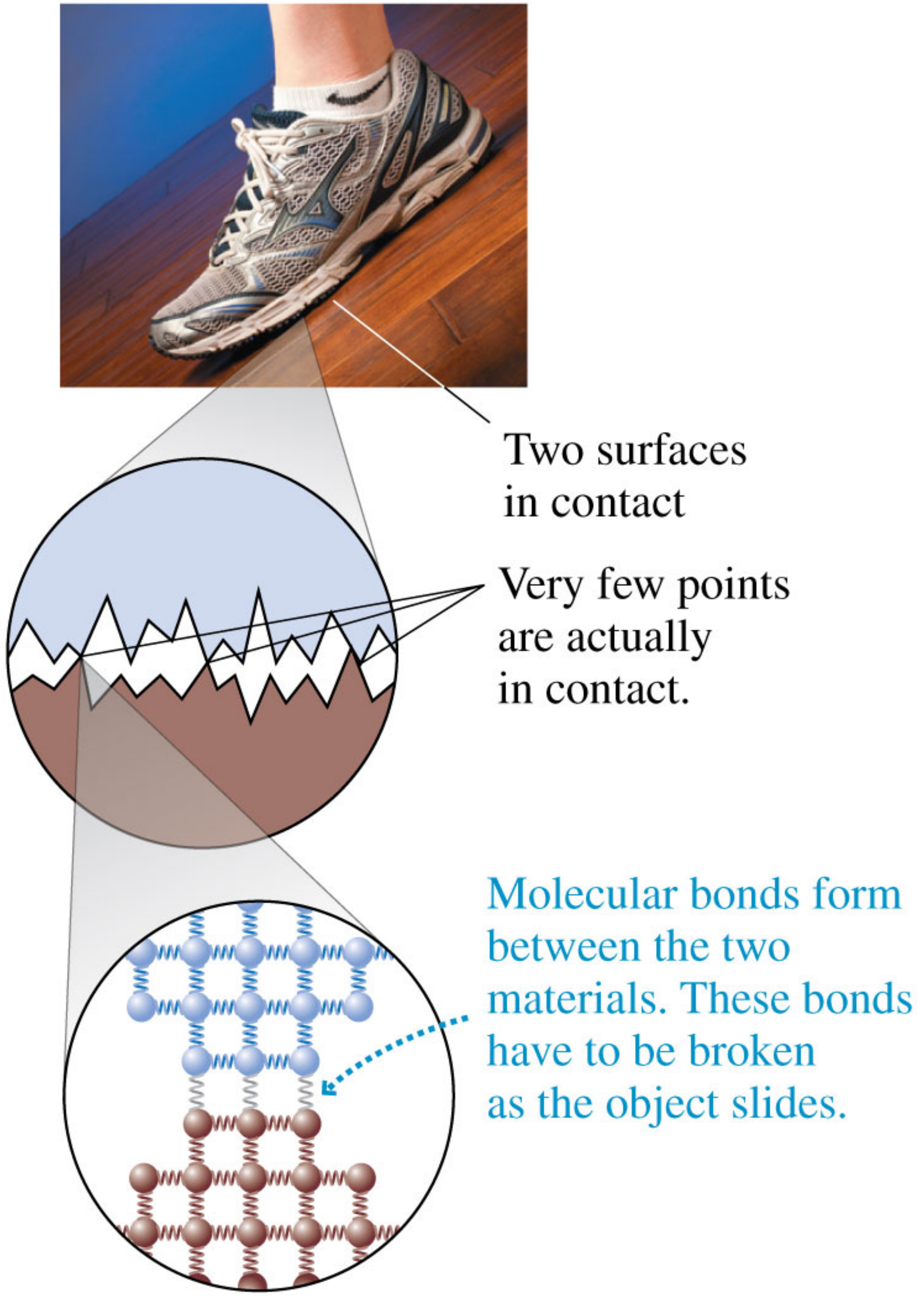
You should self-report (form coming soon) for leniency. Otherwise, if you are caught, an investigation will be opened. You do not want this.

Course “help” sites: Chegg, CourseHero, Slater, etc…

Chapter 6
Important Concepts

Causes of Friction

- All surfaces are very rough on a microscopic scale.
- When two surfaces are pressed together, the high points on each side come into contact and form molecular bonds.
- The amount of contact depends on the normal force n.
- When the two surfaces are sliding against each other, the bonds don't form fully, but they do tend to slow the motion.



Drag

- The air exerts a drag force on objects as they move through the air.
- Faster objects experience a greater drag force than slower objects.
- The drag force on a high-speed motorcyclist is significant.
- The drag force direction is opposite the object's velocity.

Drag

- For normal-sized objects on earth traveling at a speed v which is less than a few hundred meters per second, air resistance can be modeled as

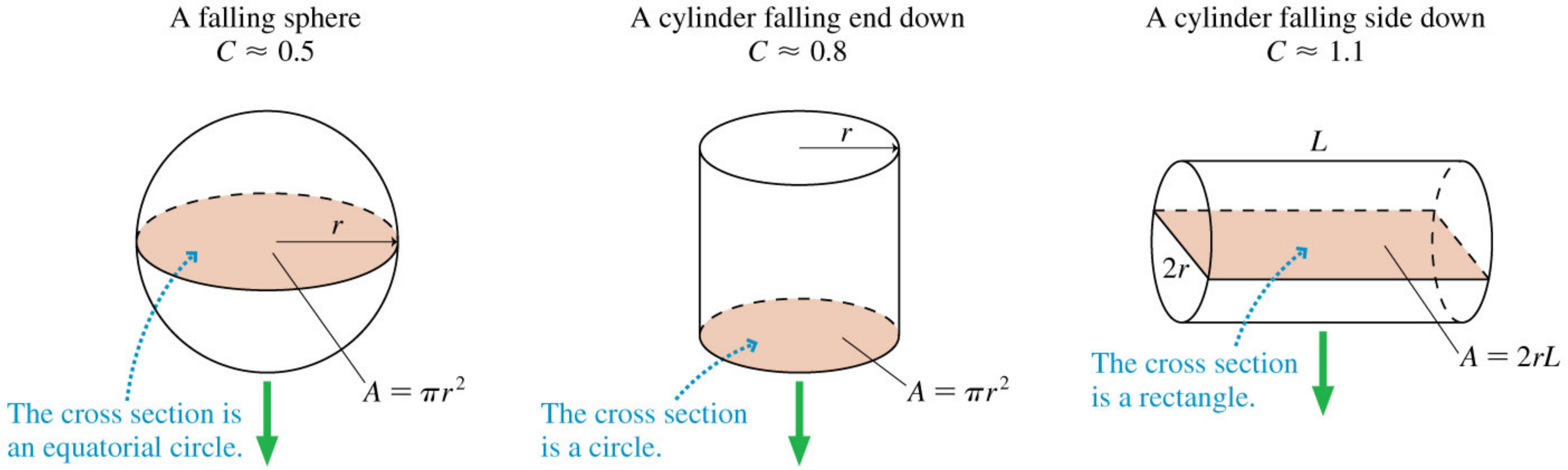
$$\vec{F}_{\text{drag}} = \left(\tfrac{1}{2}C\rho A v^2, \text{ direction opposite the motion}\right)$$

- A is the *cross-section area* of the object.
- ρ is the density of the air, which is $1.3\ \text{kg/m}^3$, at atmospheric pressure and $0°\text{C}$, a common reference point of pressure and temperature.
- C is the **drag coefficient**, which is a dimensionless number that depends on the shape of the object.

- For normal-sized objects on earth traveling at a speed v which is less than a few hundred meters per second, air resistance can be modeled as

$$\vec{F}_{\text{drag}} = \left(\tfrac{1}{2}C\rho A v^2, \text{ direction opposite the motion}\right)$$

- A is the *cross-section area* of the object.
  - Cross-section areas for objects of different shape.



A falling object reaches **terminal speed**

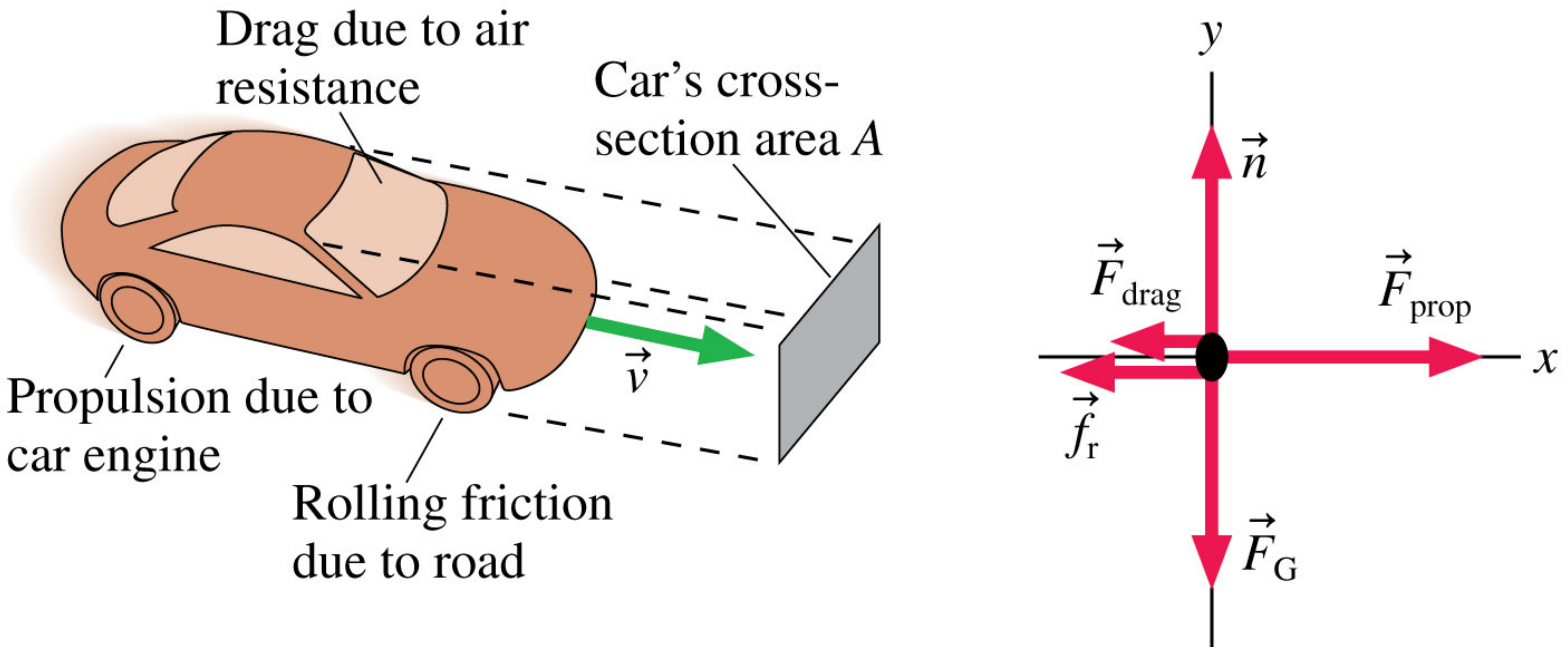
$$v_{\text{term}} = \sqrt{\frac{2mg}{C\rho A}}$$

Terminal speed is reached when the drag force exactly balances the gravitational force: $\vec{a} = \vec{0}$.

Example 6.7 Air Resistance Compared to Rolling Friction

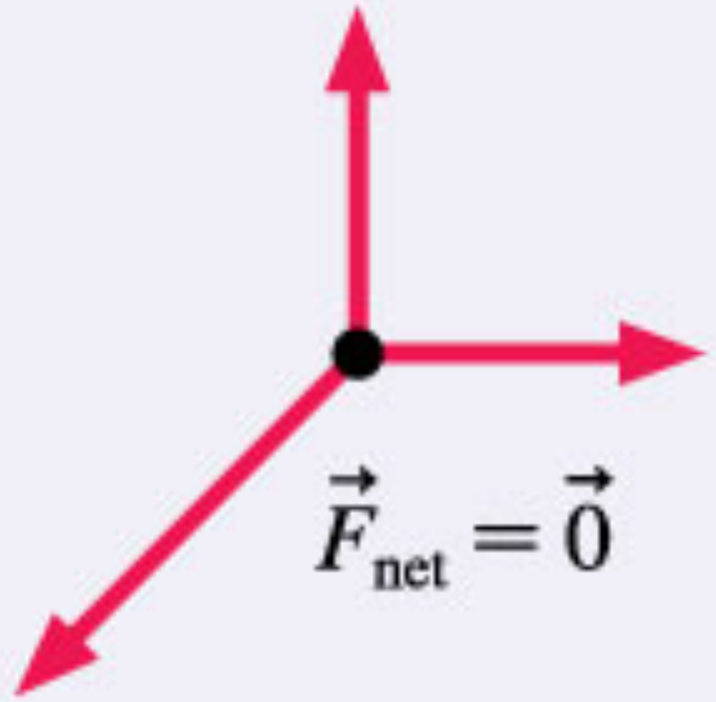
EXAMPLE 6.7 | **Air resistance compared to rolling friction**

VISUALIZE **FIGURE 6.20** shows the car and a free-body diagram. A full pictorial representation is not needed because we won't be doing any kinematics calculations.



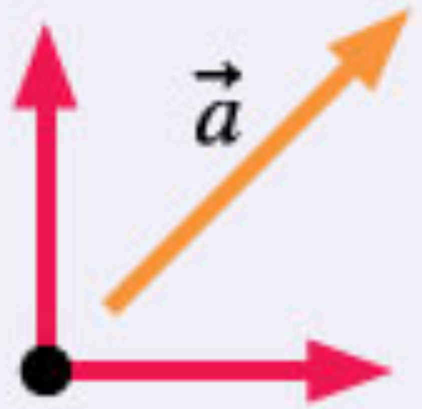
Two Explanatory Models

An object on which there is no net force is in **mechanical equilibrium**.



- Objects at rest.
- Objects moving with constant velocity.
- Newton's second law applies with $\vec{a} = \vec{0}$.

An object on which the net force is constant undergoes **dynamics with constant force**.



- The object accelerates.
- The kinematic model is that of constant acceleration.
- Newton's second law applies.

A Problem-Solving Strategy

A four-part strategy applies to both equilibrium and dynamics problems.

MODEL Make simplifying assumptions.

VISUALIZE

Go back and forth between these steps as needed.

- Translate words into symbols.
- Draw a sketch to define the situation.
- Draw a motion diagram.
- Identify forces.
- Draw a free-body diagram.

SOLVE Use Newton's second law:

$$\vec{F}_{\text{net}} = \sum_i \vec{F}_i = m\vec{a}$$

"Read" the vectors from the free-body diagram. Use kinematics to find velocities and positions.

ASSESS Is the result reasonable? Does it have correct units and significant figures?

Specific information about three important descriptive models:

Gravity $\vec{F}_G = (mg, \text{downward})$

Friction $\vec{f}_s = (0 \text{ to } \mu_s n, \text{direction as necessary to prevent motion})$

$\vec{f}_k = (\mu_k n, \text{direction opposite the motion})$

$\vec{f}_r = (\mu_r n, \text{direction opposite the motion})$

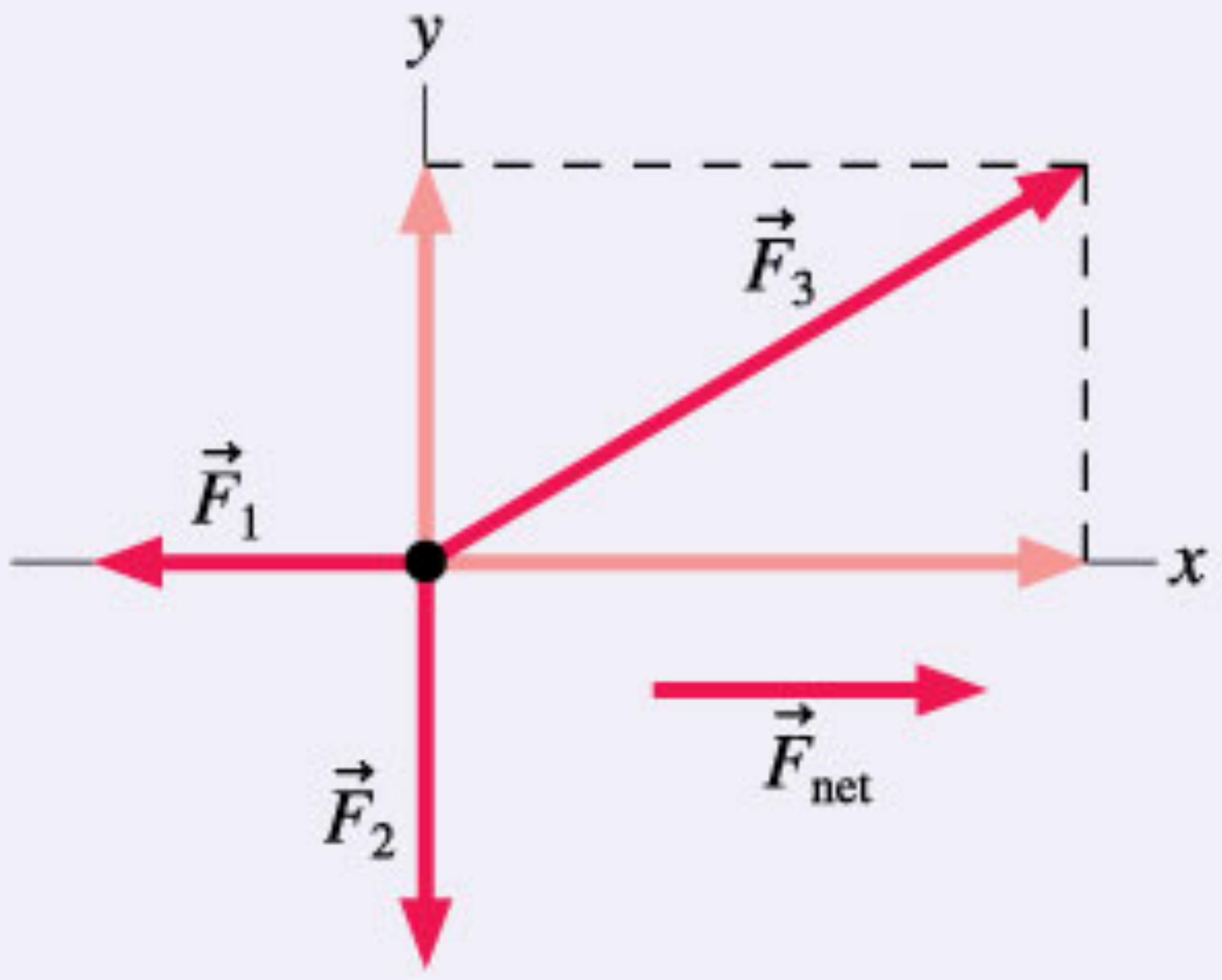
Drag $\vec{F}_{drag} = \left(\frac{1}{2} C\rho A v^2, \text{direction opposite the motion}\right)$

Newton's laws are vector expressions. You must write them out by **components**:

$$(F_{net})_x = \sum F_x = ma_x$$

$$(F_{net})_y = \sum F_y = ma_y$$

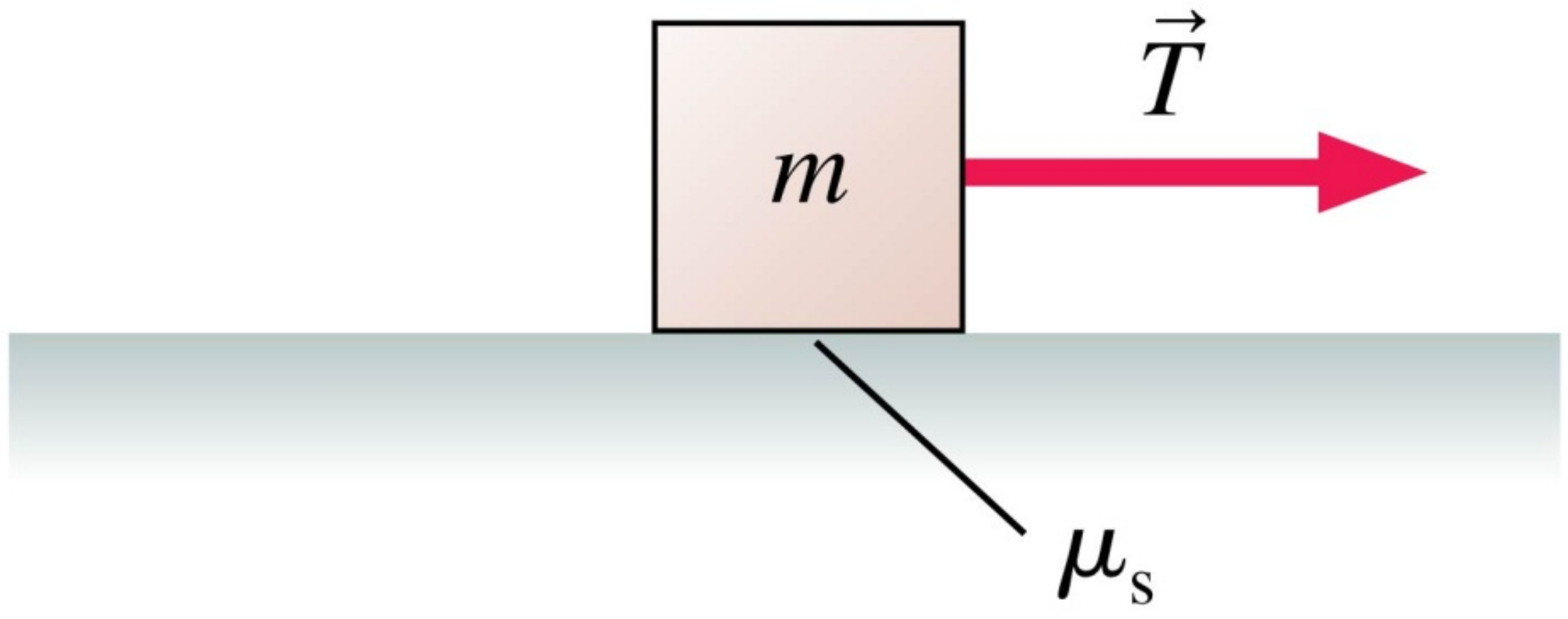
The acceleration is zero in equilibrium and also along an axis perpendicular to the motion.



Chapter 5
Clicker Questions

QuickCheck 6.12

A box on a rough surface is pulled by a horizontal rope with tension T. The box is not moving. In this situation,



A. $f_s > T$

B. $f_s = T$

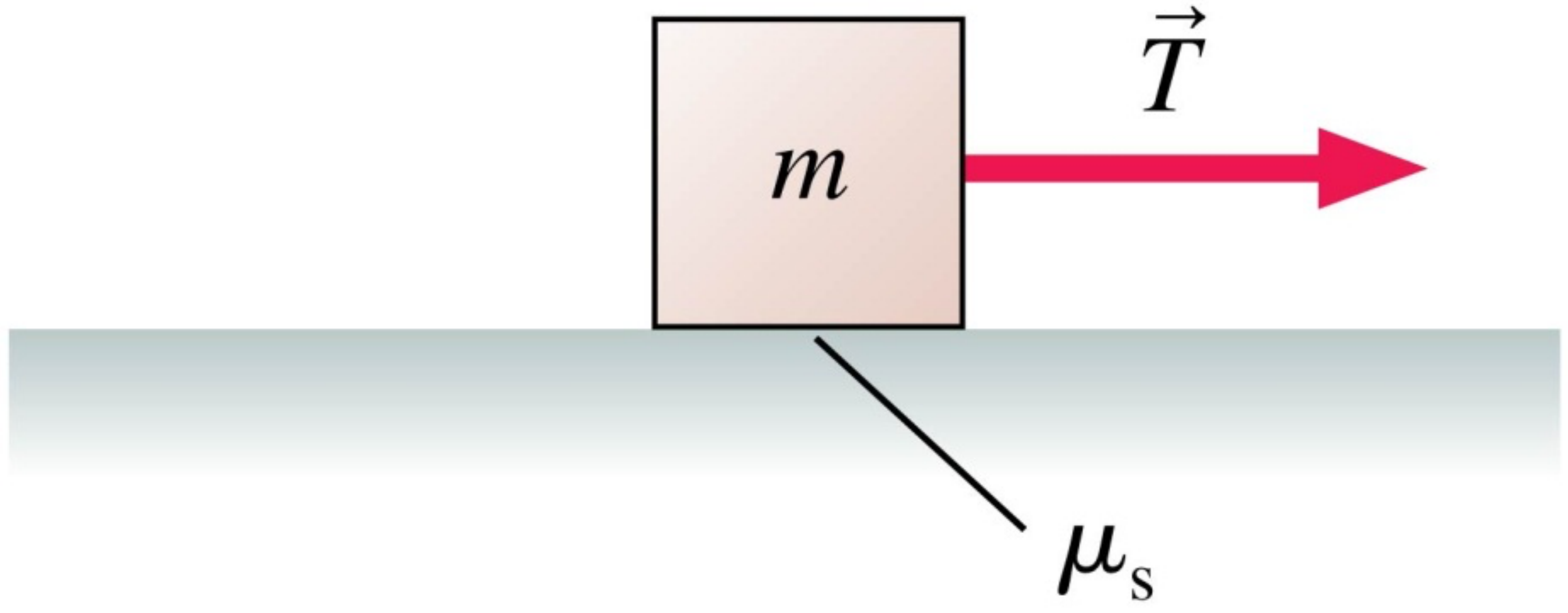
C. $f_s < T$

D. $f_s = \mu_s mg$

E. $f_s = 0$

QuickCheck 6.12

A box on a rough surface is pulled by a horizontal rope with tension T. The box is not moving. In this situation,



A. $f_s > T$

B. $\boldsymbol{f_s = T}$ Newton's first law.

C. $f_s < T$

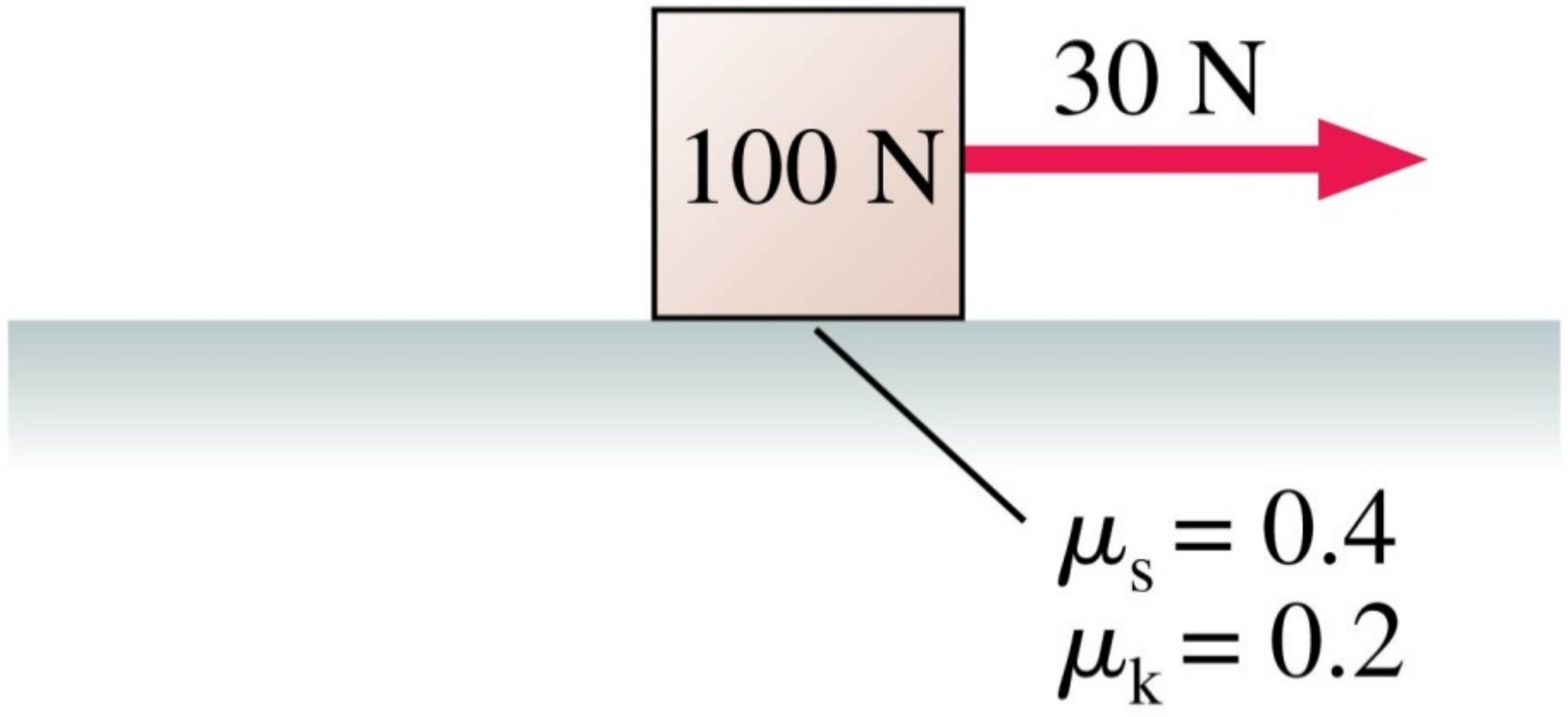
D. $f_s = \mu_s mg$

E. $f_s = 0$

QuickCheck 6.13

A box with a weight of 100 N is at rest. It is then pulled by a 30 N horizontal force.

Does the box move?



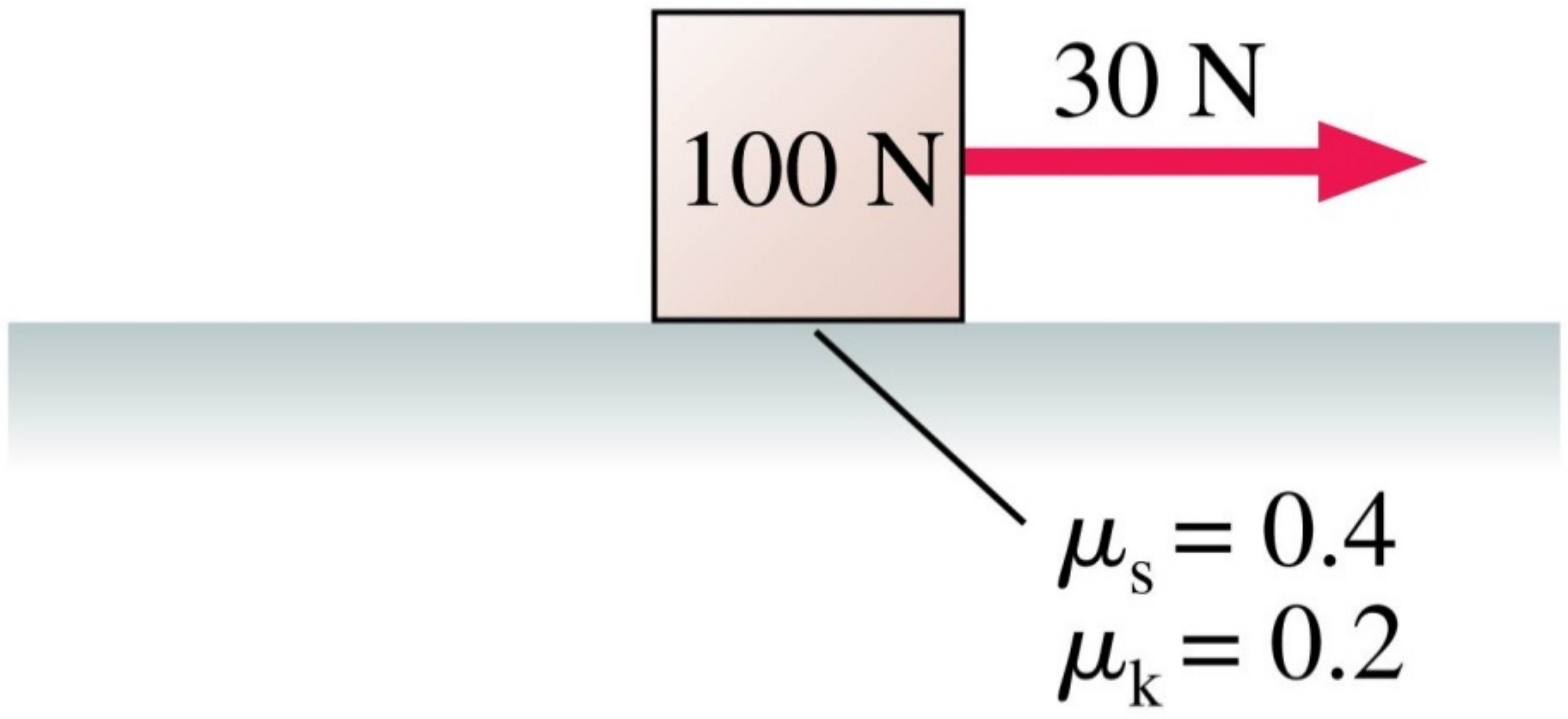
A. Yes

B. No

C. Not enough information to say.

QuickCheck 6.13

A box with a weight of 100 N is at rest. It is then pulled by a 30 N horizontal force.



Does the box move?

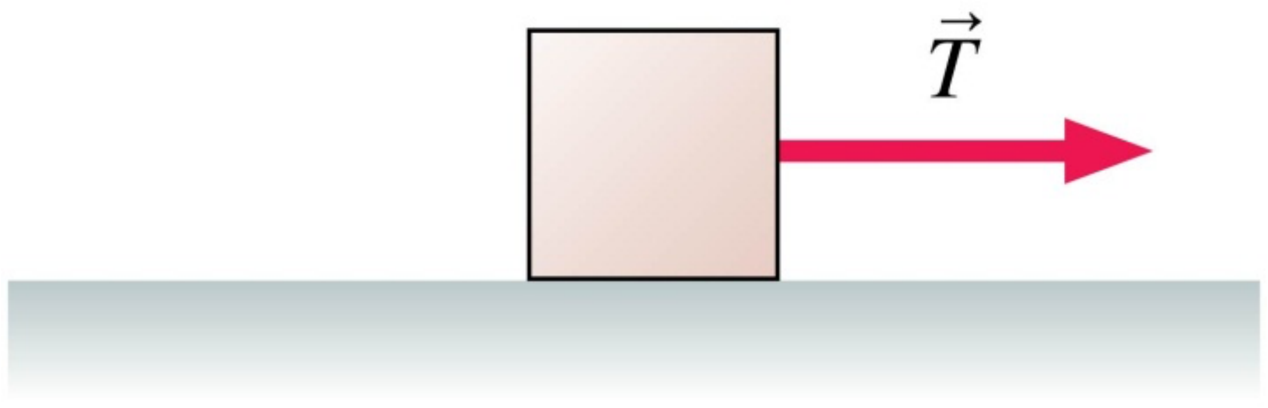
A. Yes

✔ **B. No** $30\text{ N} < f_{s\,max} = 40\text{ N}$

C. Not enough information to say.

QuickCheck 6.14

A box is being pulled to the right over a rough surface. $T > f_k$, so the box is speeding up. Suddenly the rope breaks.



What happens? The box

A. Stops immediately.

B. Continues with the speed it had when the rope broke.

C. Continues speeding up for a short while, then slows and stops.

D. Keeps its speed for a short while, then slows and stops.

E. Slows steadily until it stops.

QuickCheck 6.14

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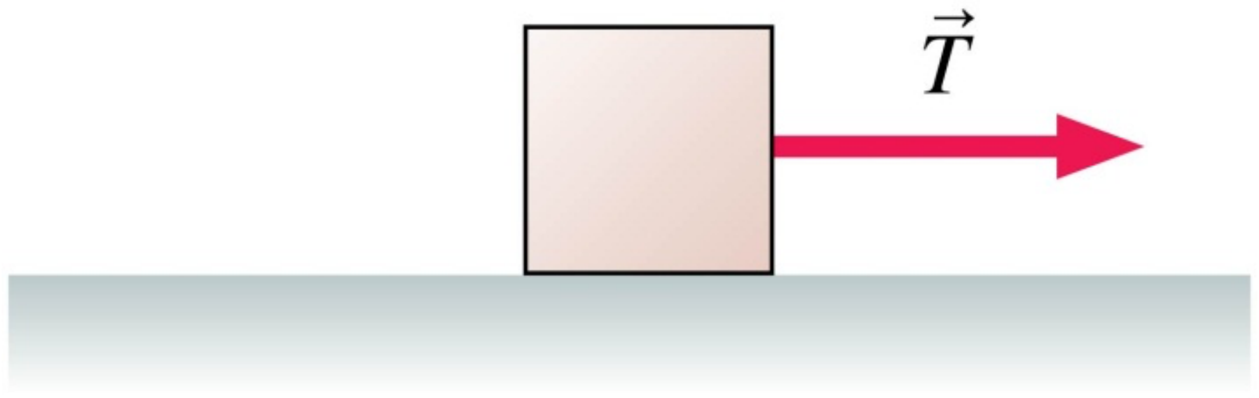

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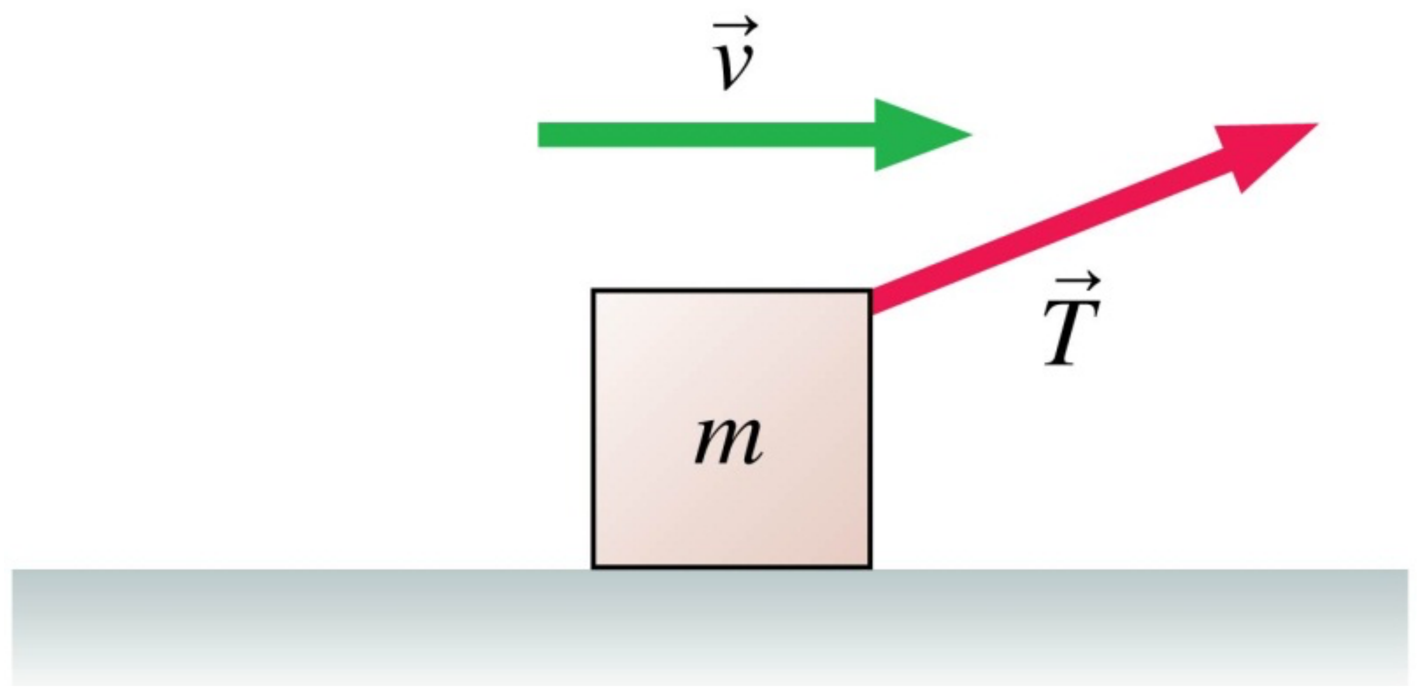
D. Keeps its speed for a short while, then slows and stops.

✔ **E. Slows steadily until it stops.**

QuickCheck 6.15

A box is being pulled to the right at steady speed by a rope that angles upward. In this situation:



A. $n > mg$

B. $n = mg$

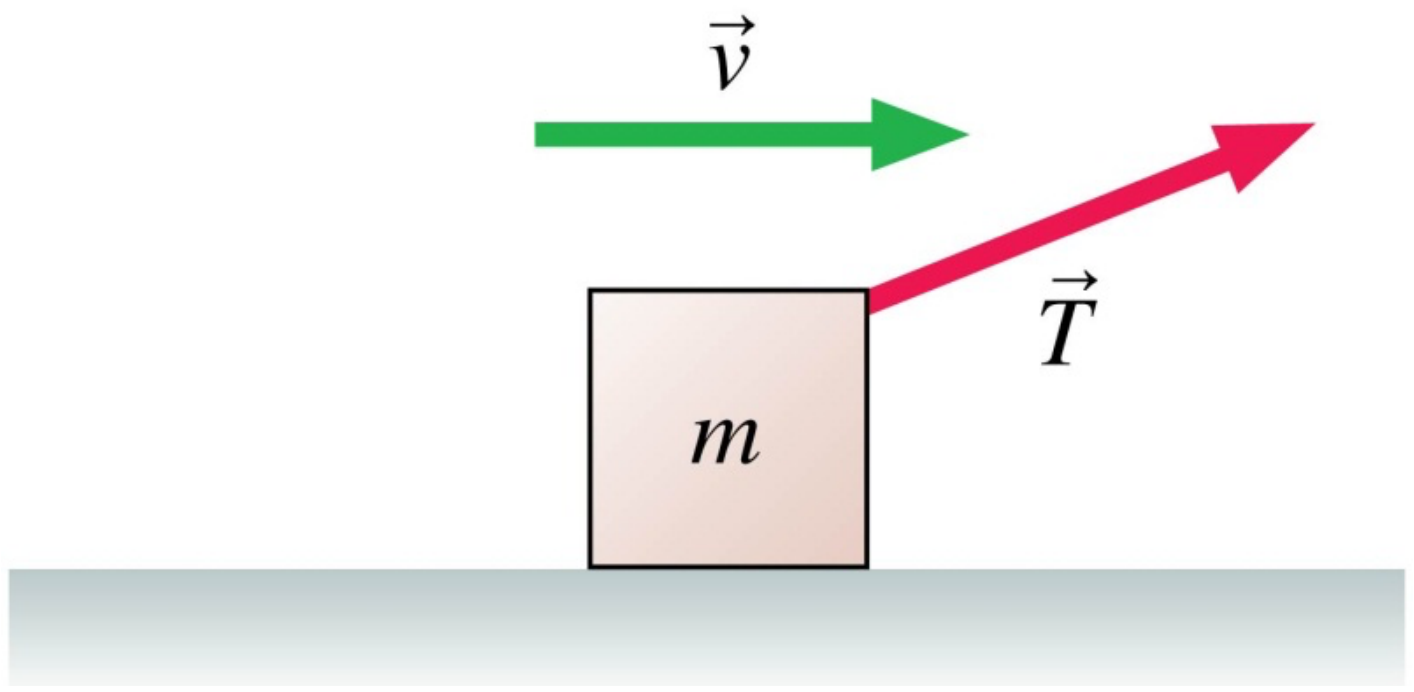
C. $n < mg$

D. $n = 0$

E. Not enough information to judge the size of the normal force.

QuickCheck 6.15

A box is being pulled to the right at steady speed by a rope that angles upward. In this situation:



A. $n > mg$

B. $n = mg$

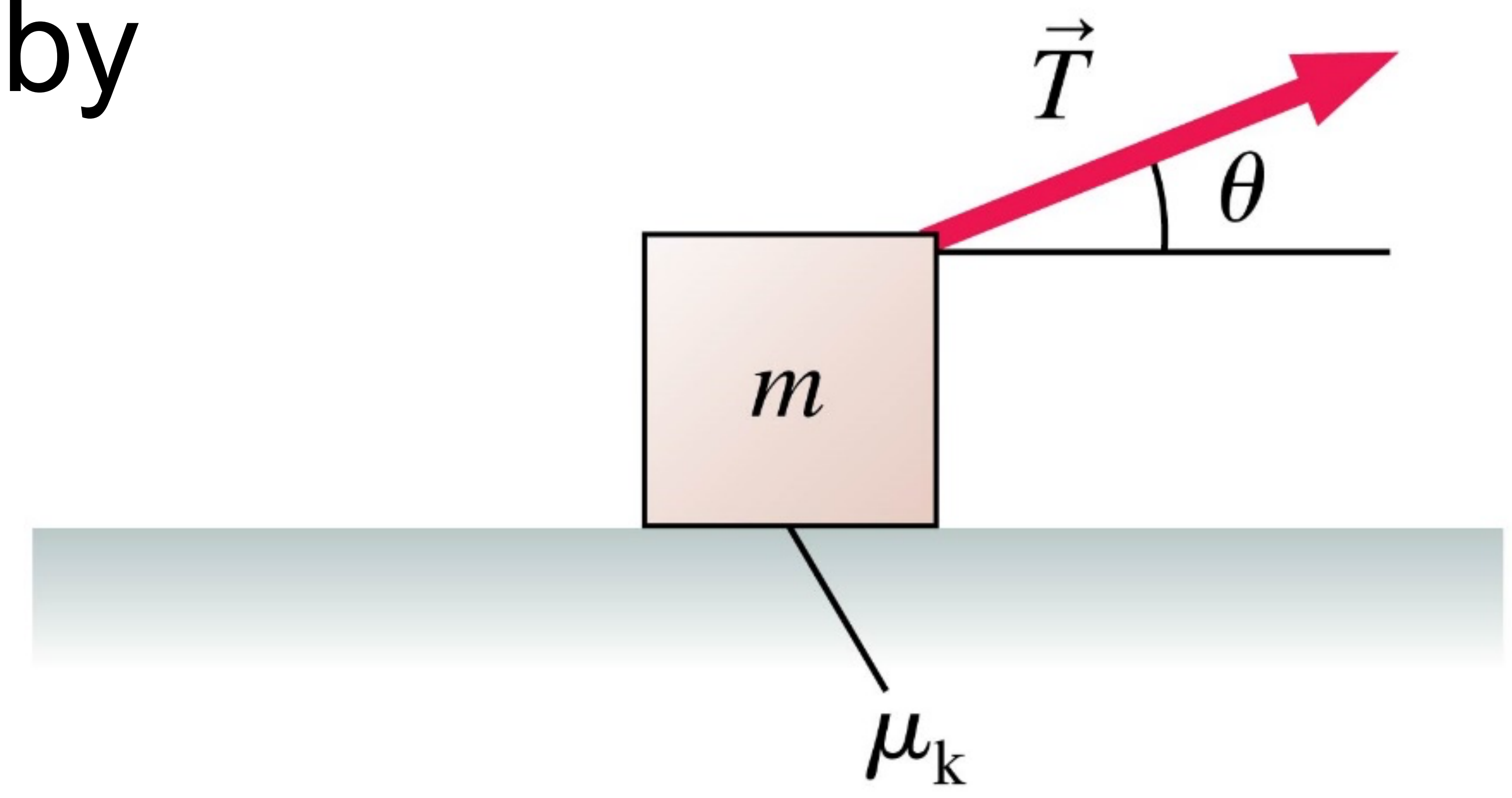
C. $n < mg$

D. $n = 0$

E. Not enough information to judge the size of the normal force.

QuickCheck 6.16

A box is being pulled to the right by a rope that angles upward. It is accelerating. Its acceleration is



A. $\dfrac{T}{m}(\cos\theta + \mu_k \sin\theta) - \mu_k g$

B. $\dfrac{T}{m}(\cos\theta - \mu_k \sin\theta) - \mu_k g$

C. $\dfrac{T}{m}(\sin\theta + \mu_k \cos\theta) - \mu_k g$

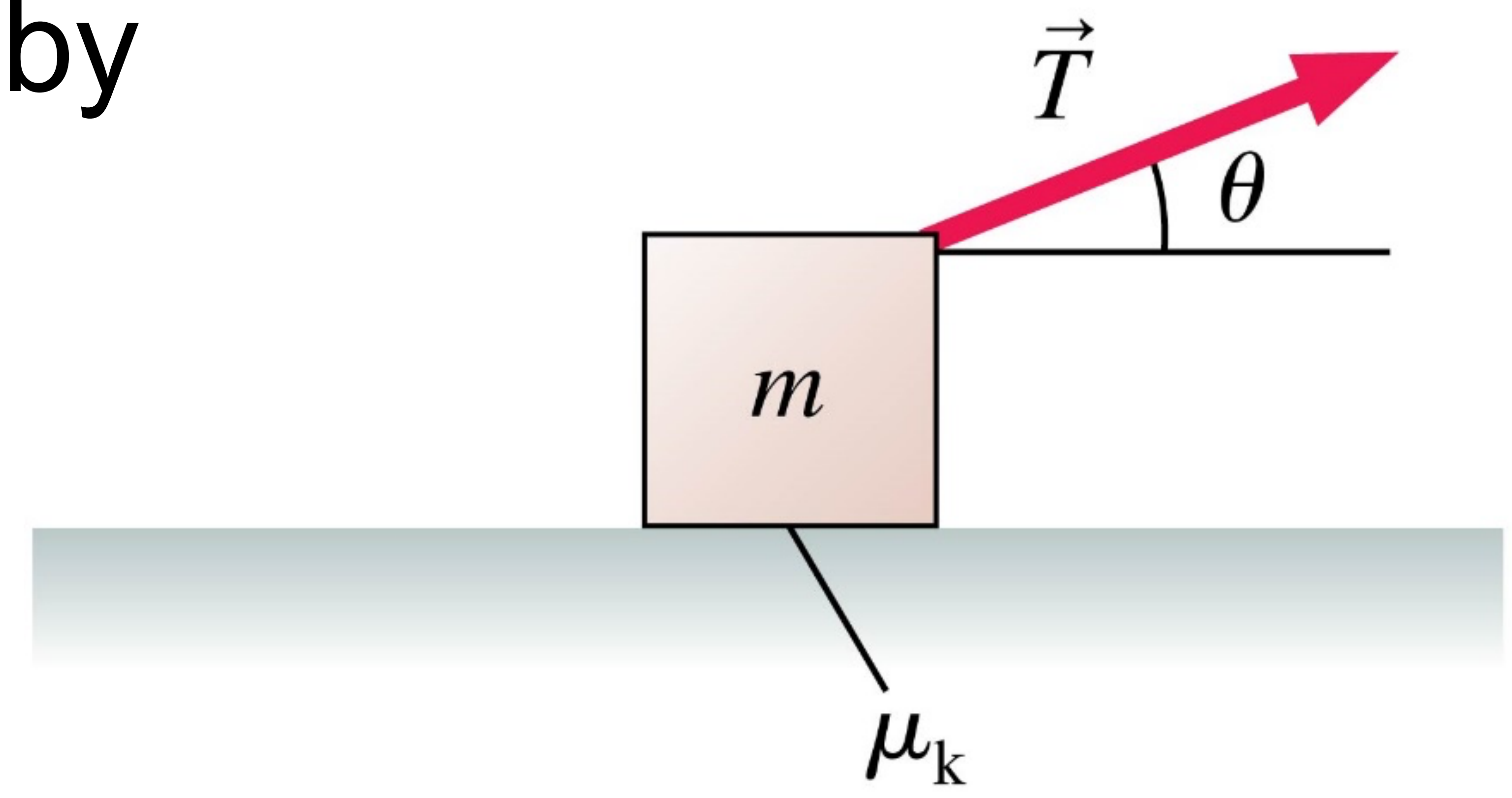
D. $\dfrac{T}{m} - \mu_k g$

E. $\dfrac{T}{m}\cos\theta - \mu_k g$

You'll have to work this one out.
Don't just guess!

QuickCheck 6.16

A box is being pulled to the right by a rope that angles upward. It is accelerating. Its acceleration is



A. $\boldsymbol{\frac{T}{m}(\cos\theta + \mu_k \sin\theta) - \mu_k g}$

B. $\frac{T}{m}(\cos\theta - \mu_k \sin\theta) - \mu_k g$

C. $\frac{T}{m}(\sin\theta + \mu_k \cos\theta) - \mu_k g$

D. $\frac{T}{m} - \mu_k g$

E. $\frac{T}{m}\cos\theta - \mu_k g$

You'll have to work this one out.
Don't just guess!

Example 6.10 Make Sure the Cargo Doesn't Slide

EXAMPLE 6.10 | **Make sure the cargo doesn't slide**

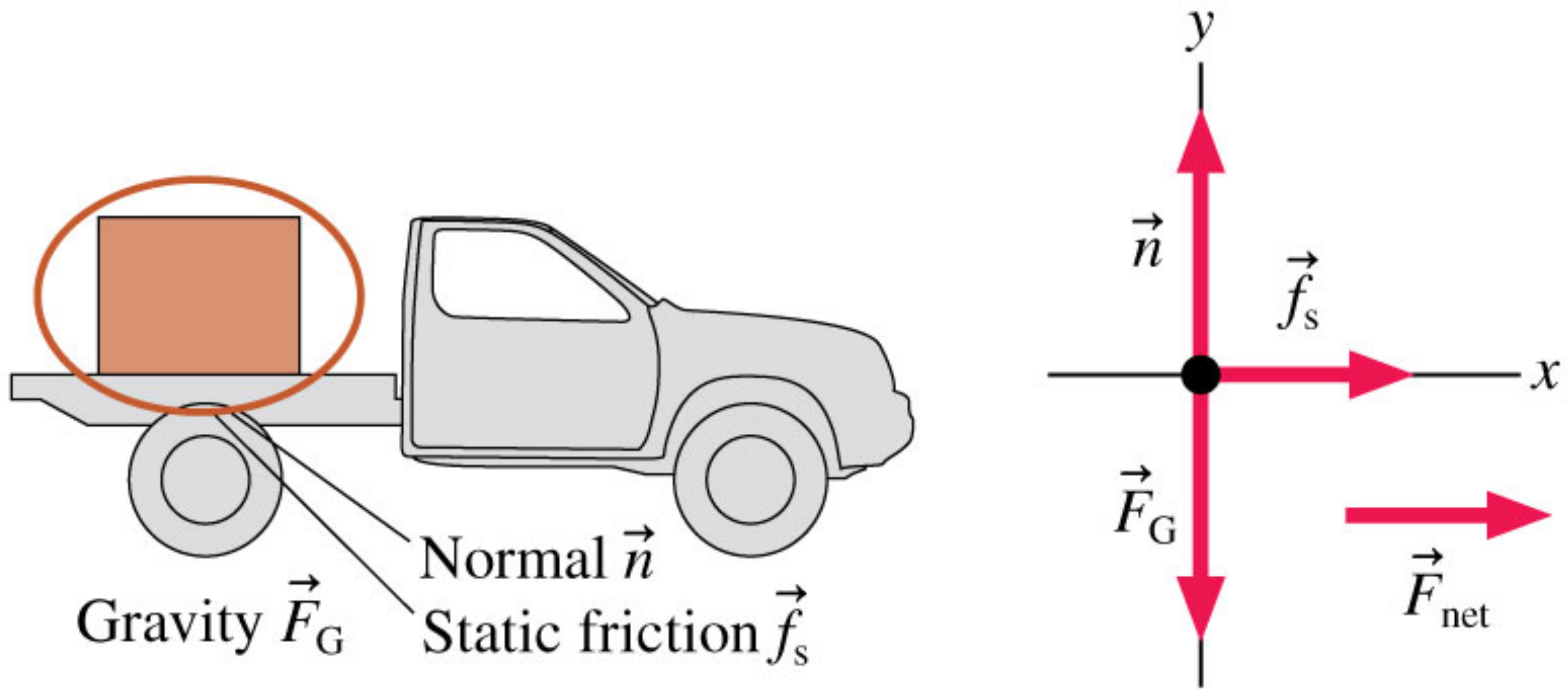
VISUALIZE This situation is shown in **FIGURE 6.26**. There is only one horizontal force on the box, $\vec{f}_s$, and it points in the *forward* direction to accelerate the box. Notice that we're solving the problem with the ground as our reference frame. Newton's laws are not valid in the accelerating truck because it is not an inertial reference frame.

Known

$m = 100$ kg
Box dimensions 50 cm × 50 cm × 50 cm
$\mu_s = 0.40 \quad \mu_k = 0.20$

Find

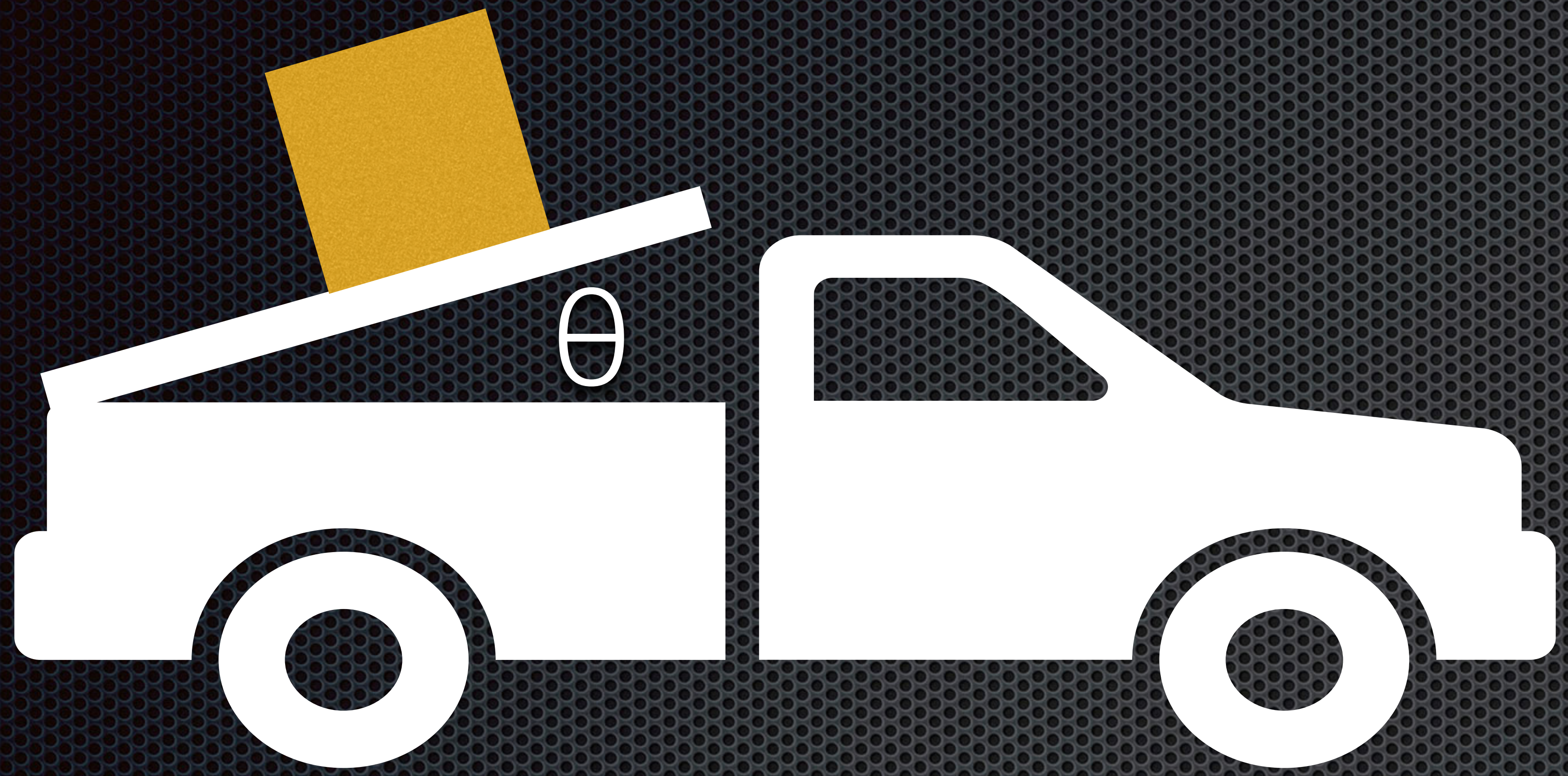
Acceleration at which box slips



You try! Answer is: 3.9 m/s²

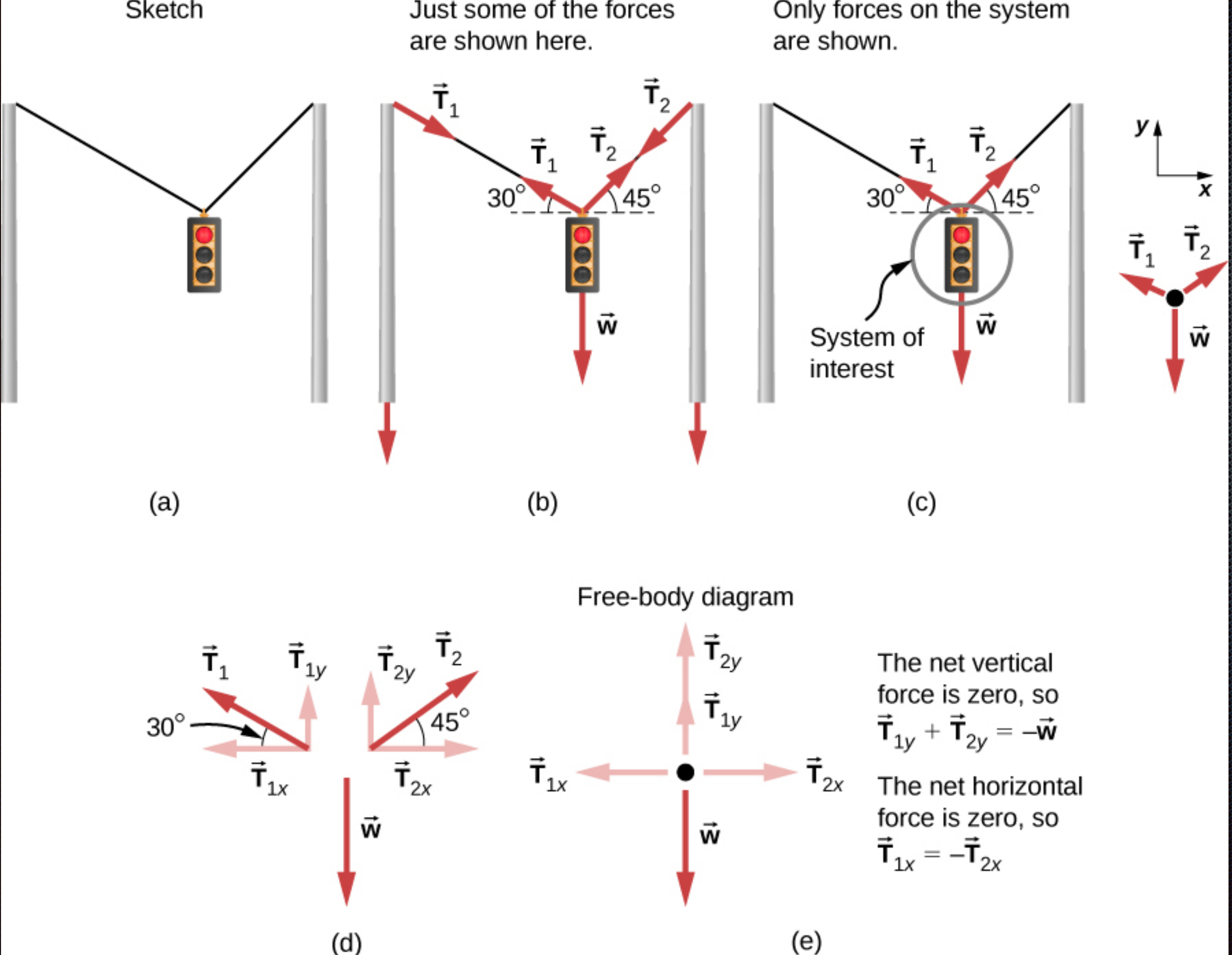
Example 6.10 Make Sure the Cargo Doesn't Slide

EXAMPLE 6.10 | Make sure the cargo doesn't slide



Now let's think of the situation when the truck bed is at an angle θ relative to the horizontal.

Does the maximum truck acceleration (before the box starts to slide) increase, decrease, or stay the same?



Source: Lumen Learning