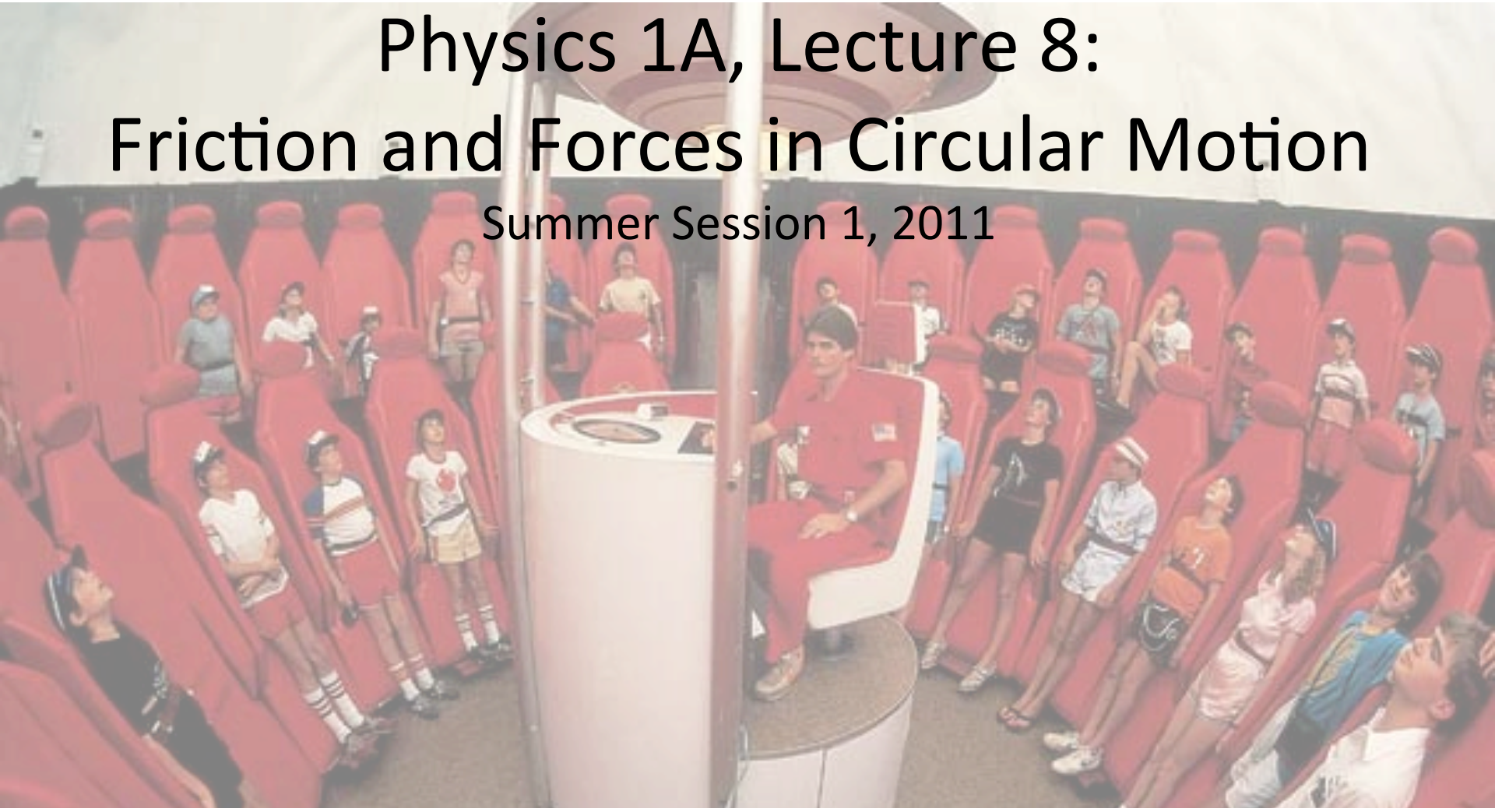
Physics 1A, Lecture 8:
Friction and Forces in Circular Motion

Summer Session 1, 2011



The quiz will commence at 9:33 AM.

Key Questions: (Discuss with neighbors before quiz)

1) How is friction related to the normal force?
2) What are the units for the coefficient of static friction?
3) What is a banked curve?
4) What might happen if you go too slowly around a banked curve? Too fast?

Reading Quiz #6-1

- How is friction related to the normal force?

A) Friction is always greater than the normal force

B) Friction is directly proportional to the normal force

C) Friction is inversely proportional to the normal force

D) Friction has nothing to do with the normal force because they are perpendicular to each other

E) Friction is the integral of the normal force

Reading Quiz #6-2

- What are the units for the coefficient of static friction?

A) kg m/s

B) kg/s^2

C) meters

D) Newtons=$kg\ m/s^2$

E) It is dimensionless

Reading Quiz #6-3

- What is a banked curve?

A) A curve with a helical shape

B) A curve with friction

C) A curve where the road is on an incline

D) A curve that makes a half circle

E) A curve where the net force points inwards

Reading Quiz #6-4

- What might happen if you go too slowly around a slippery banked curve? Too fast?

A) Too slow – slide up, too fast – slide down

B) Too slow – slide down, too fast – slide up

C) Too slow – nothing, too fast – slide down

D) Too slow – slide down, too fast – nothing

E) Too slow – nothing, too fast – slide up

Announcements

- Extra office hours tonight:
  - Mayer 5623 from 5-6pm
- Homework #3 is due tomorrow by 1pm
- Quiz #2 is on Thursday, will cover:
  - Newton's Laws
  - Friction
  - Circular motion
  - Drag force
  - Cumulative material from last section
- Come pick up your old homework after class
- Haven't posted grades yet. I will try to do it Friday.

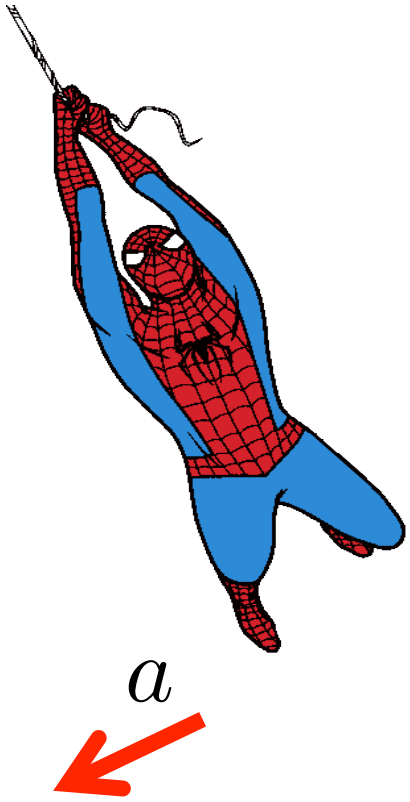
Anonymous poll
(I will keep this histogram hidden)

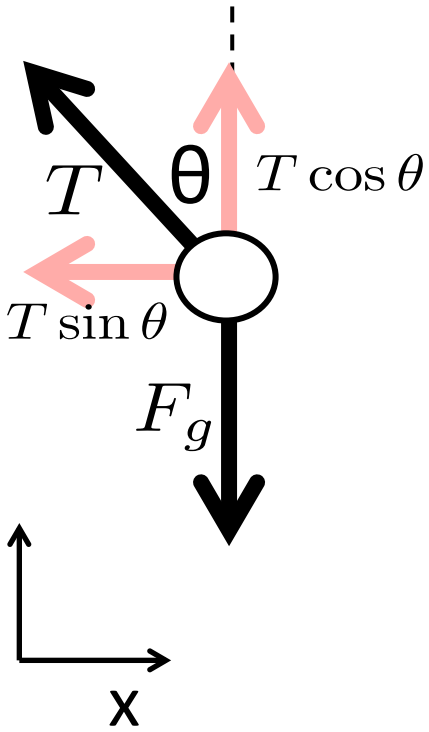
I think clicker questions are:

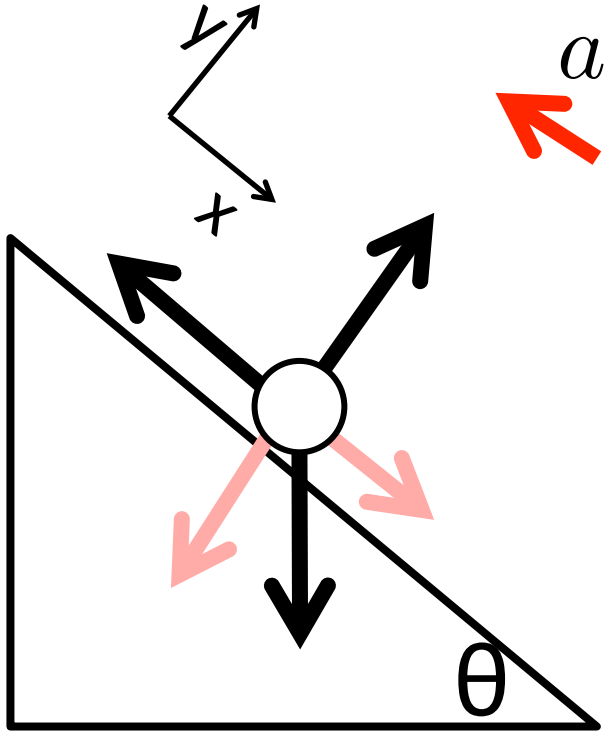
A) Totally useful, I would never want to take a physics class without them
B) Fun and useful, but we probably do too many of them
C) Silly and take away too much time from lecture
D) Make me depressed about what I don't know and stressed out during lecture
E) I'm upset that you made me buy a clicker and expect me to come to class

Predict Motion

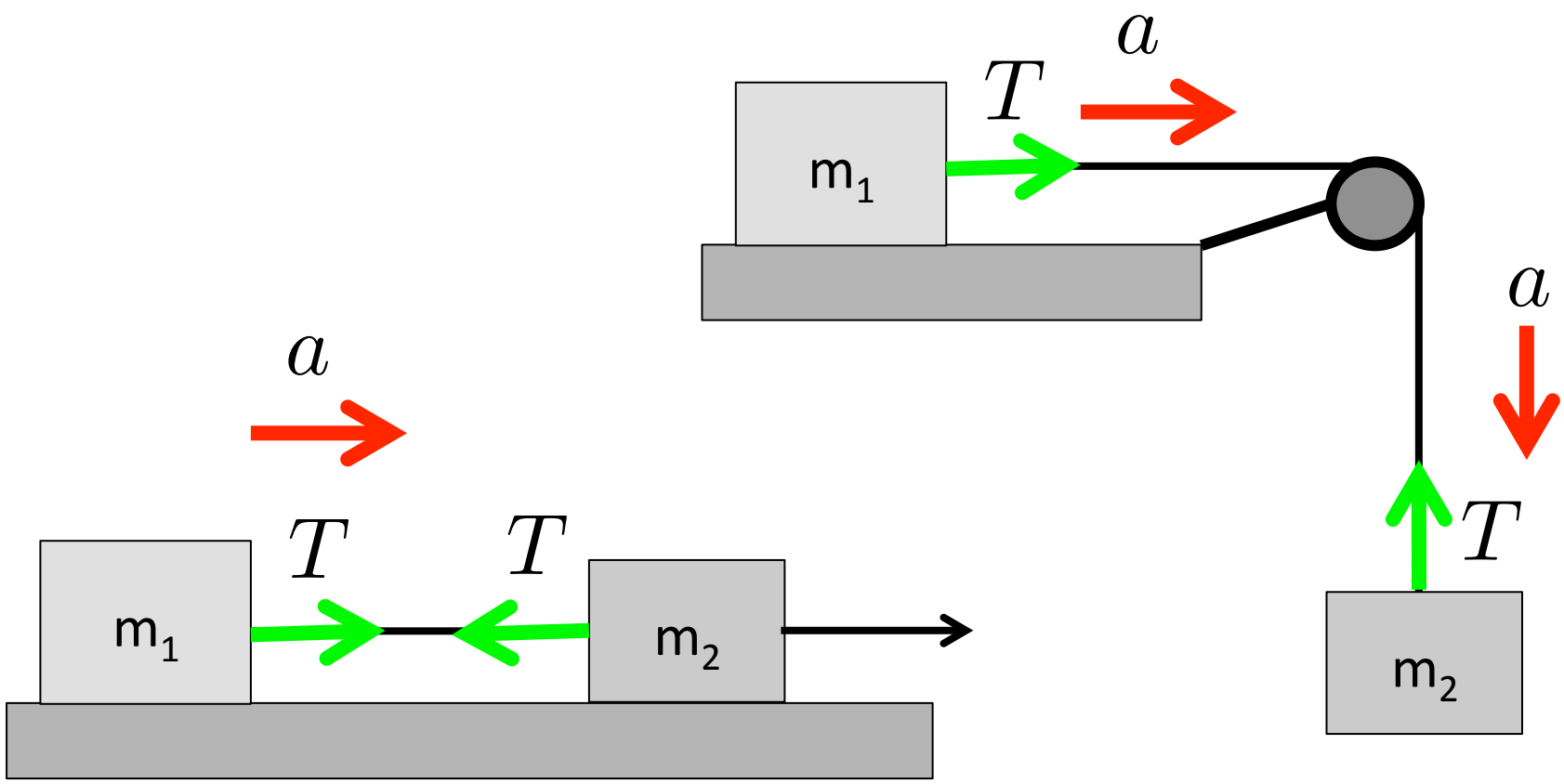
C Concept



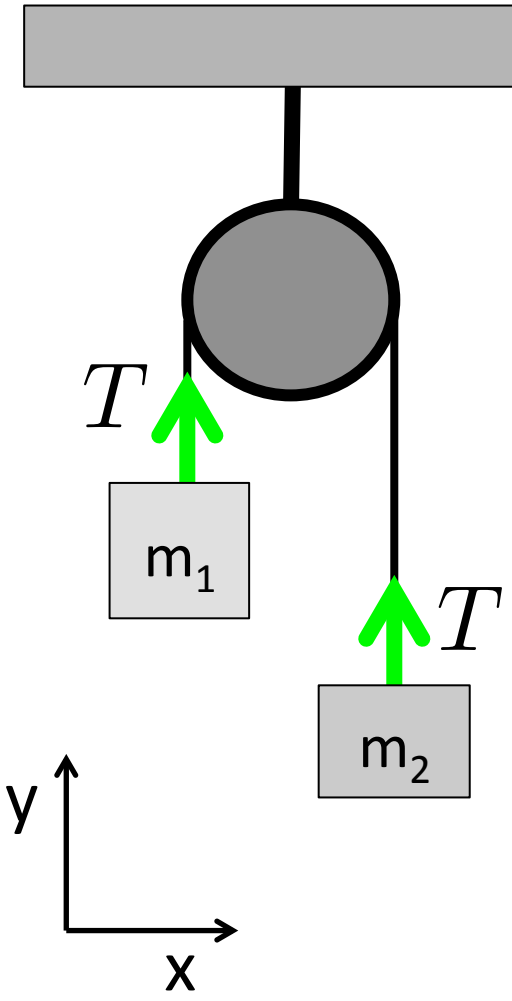


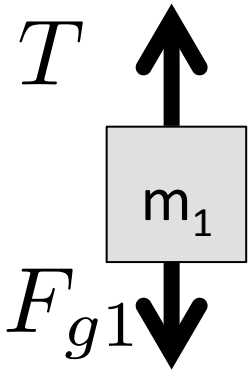


Attached objects and pulleys



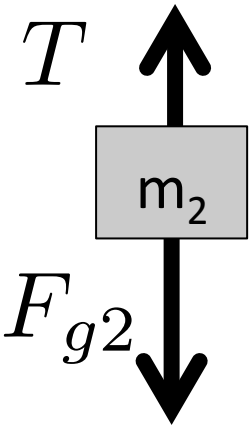
Attwood machine





$$\sum F_{y1} = T - F_{g1}$$

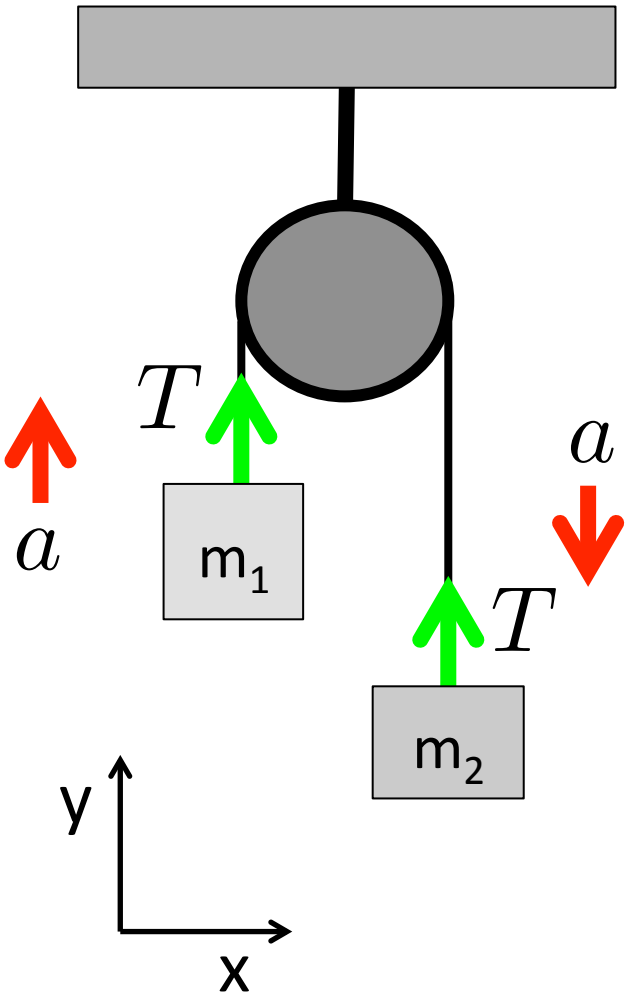
$$= m_1 a_1$$

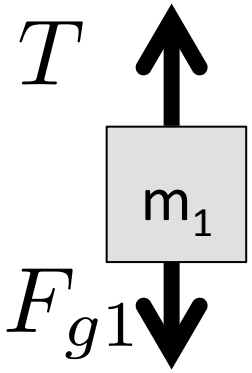


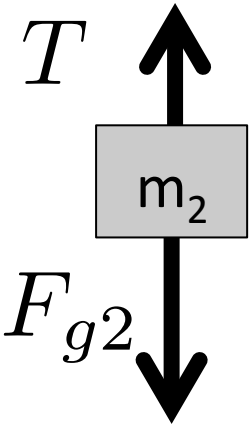
$$\sum F_{y2} = T - F_{g2}$$

$$= m_2 a_2$$

Attwood machine





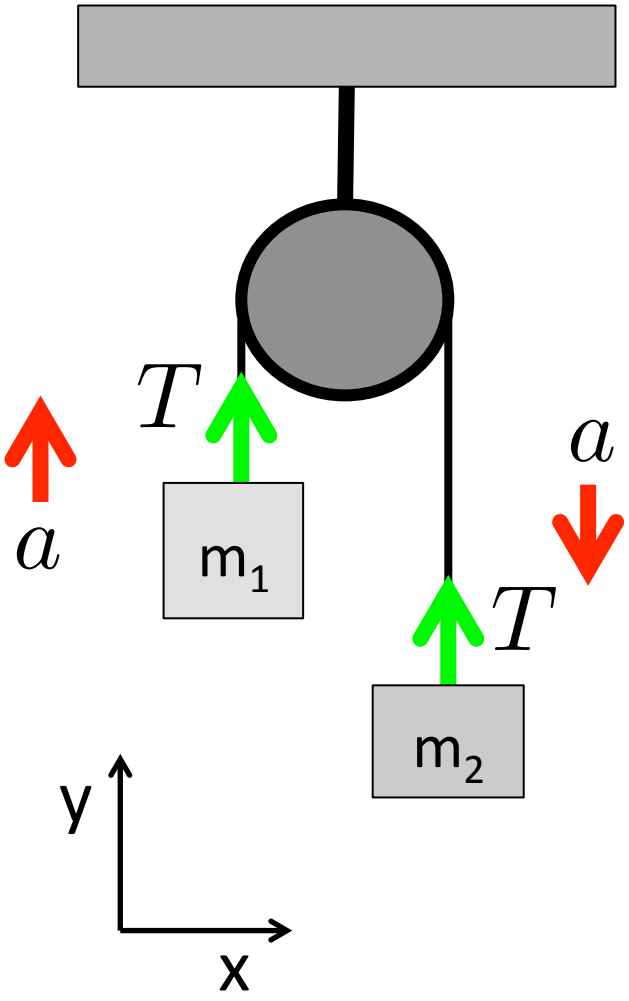


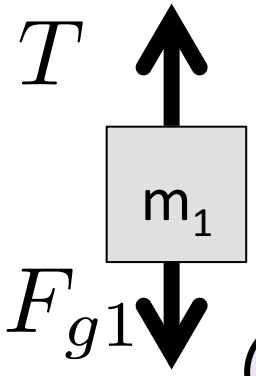
$$T - F_{g1} = m_1 a_1$$
$$T - F_{g2} = m_2 a_2$$

$$F_{g1} = m_1 g$$
$$F_{g2} = m_2 g$$

$$a_1 = -a_2$$
$$= a$$

Attwood machine



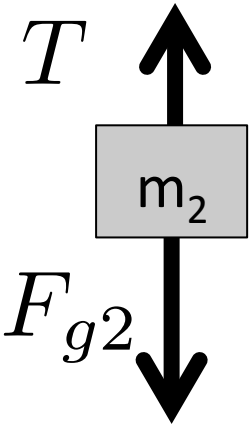


$$T - F_{g1} = m_1 a_1$$
$$T - F_{g2} = m_2 a_2$$

---

(1) $T - m_1 g = m_1 a$

(2) $T - m_2 g = -m_2 a$



$$(m_2 - m_1)g = (m_2 + m_1)a$$

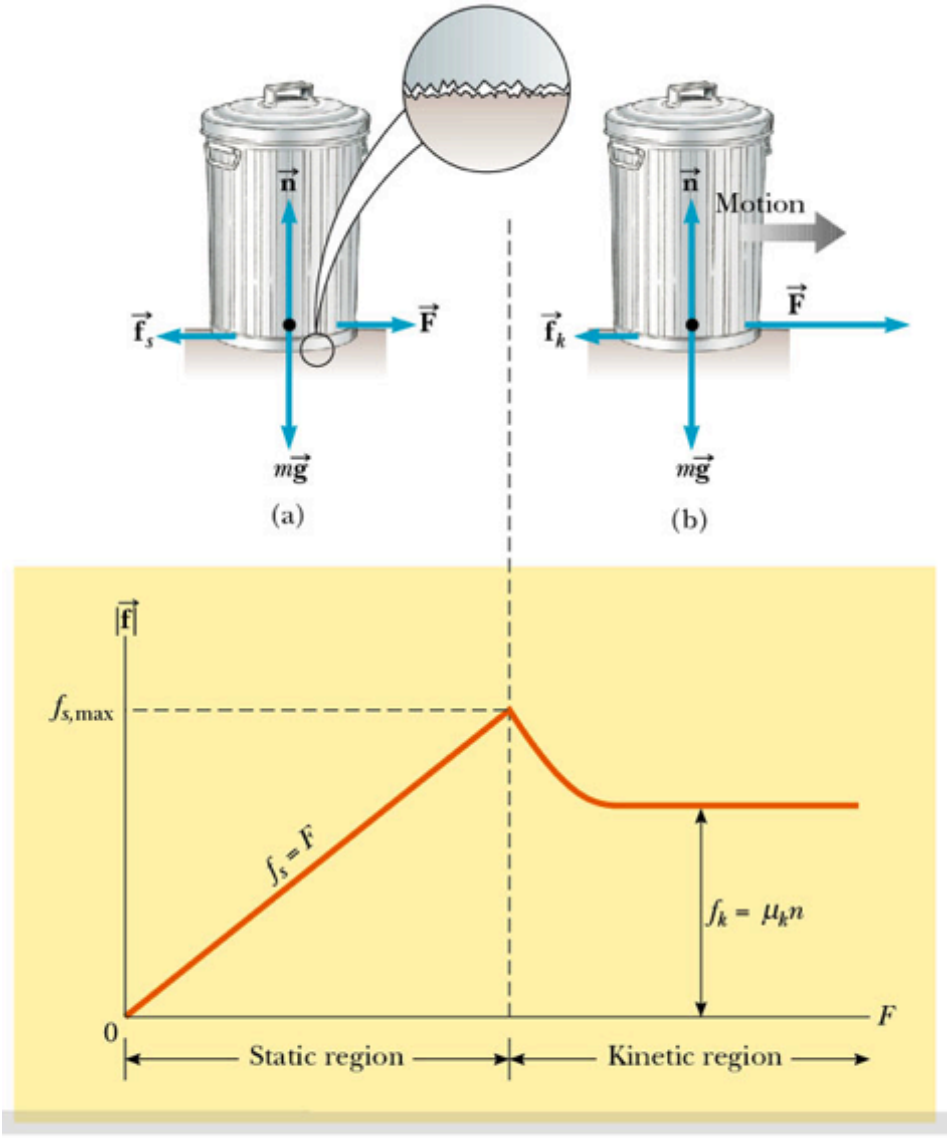
$$\boxed{a = \frac{(m_2 - m_1)g}{(m_2 + m_1)}}$$

Sticking

(static friction)

Slipping

(kinetic friction)



Friction!

C

Concept

Sticking

(static friction)

Friction force balances forces in opposite direction → No motion!

$$f_s \leq \mu_s F_N$$

Slipping

(kinetic friction)

Friction force Is less than the forces in opposite direction → Motion!

$$f_k = \mu_k F_N$$

$$0 \leq \mu \leq 1$$

Just a number, depends on the two materials that are in contact

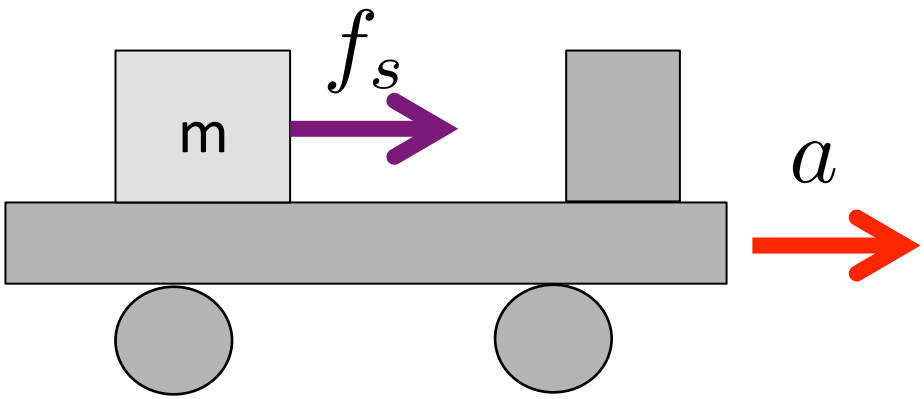
Friction!

C Concept

Sticking

(static friction)

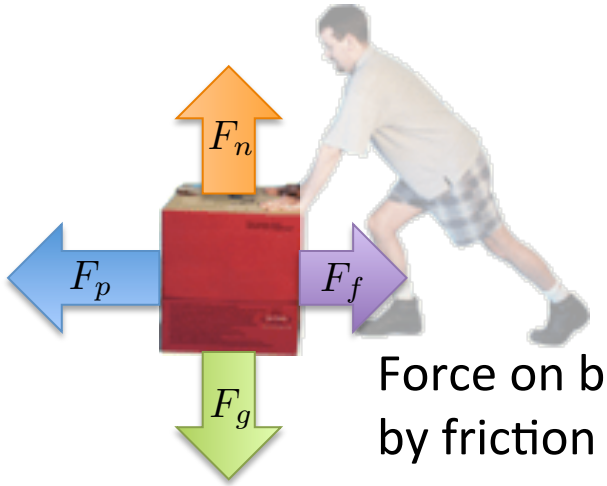
Points in the direction opposite the motion that would happen in friction was not there.



Slipping

(kinetic friction)

Points in the direction opposite the motion



Force on box by friction

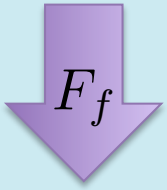
Clicker Question 8-1

A box is being pushed up against a wall. The force from the hand is at a minimum so that the box does not slide *down* the wall. Which vector shows the direction that the friction force is pointing?

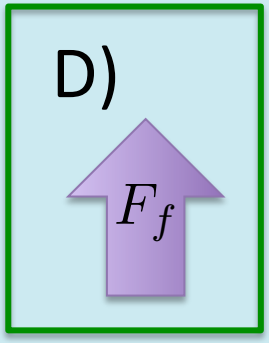
A)

B)

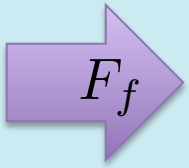
C)



D)



E)



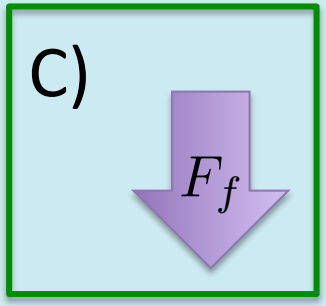
Clicker Question 8-2

A box is being pushed up against a wall. The force from the hand is at a maximum so that the box does not slide *up* the wall. Which vector shows the direction that the friction force is pointing?

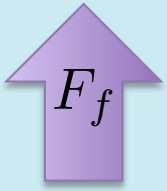
A)

B)

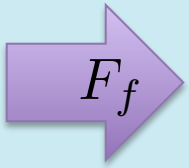
C)



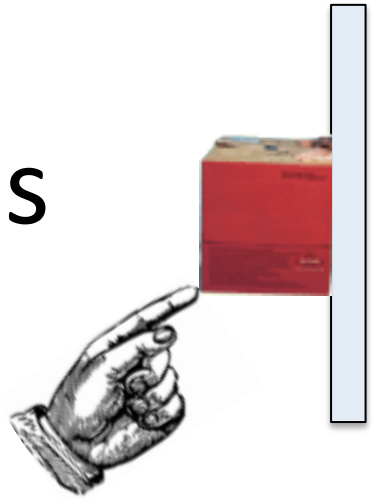
D)



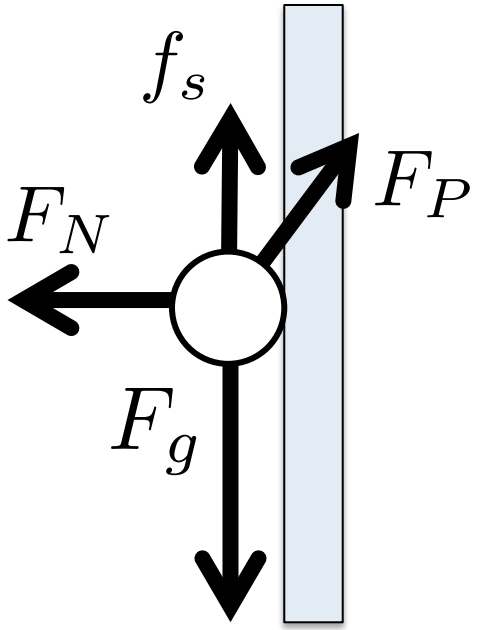
E)



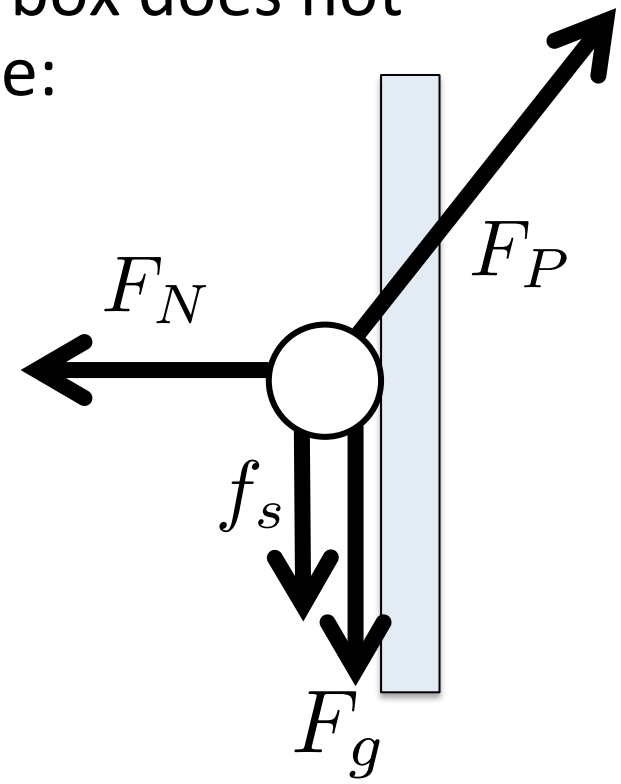
Practice with FBDs



Force is a minimum so that box does not move:

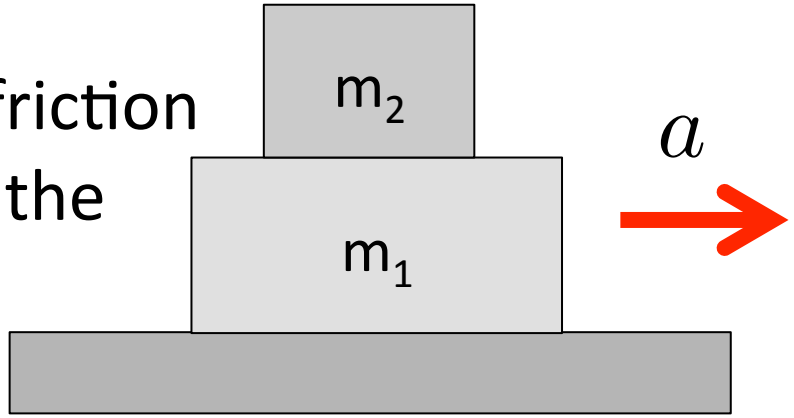


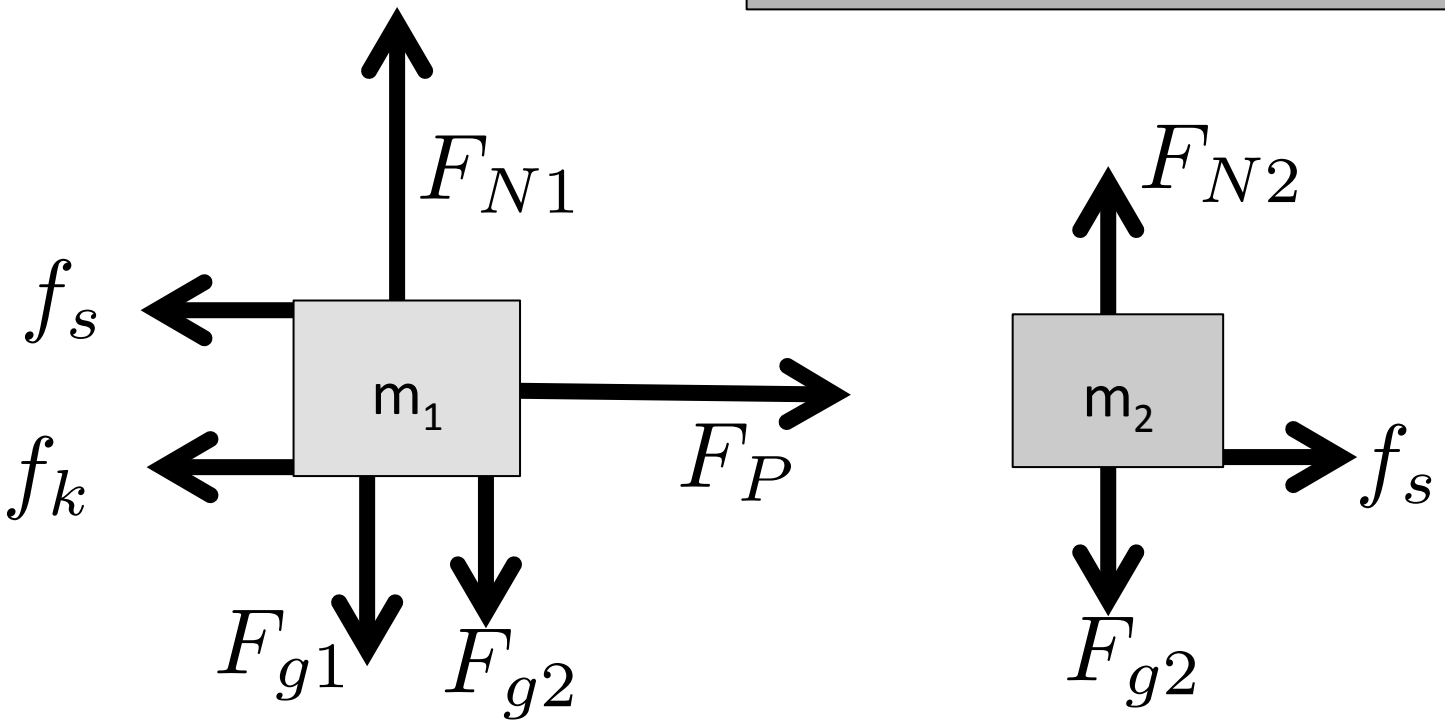
Force is a maximum so that box does not move:



Practice drawing FBDs

You push box 1 that has box 2 stacked on top of it. There is friction everywhere. Box 1 moves but the boxes stay attached.



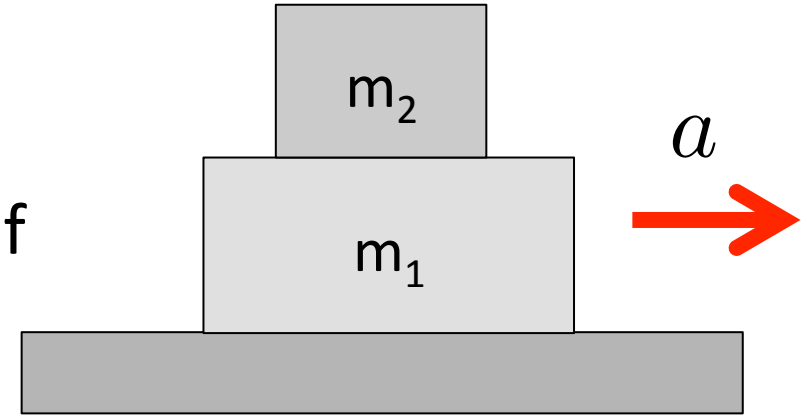


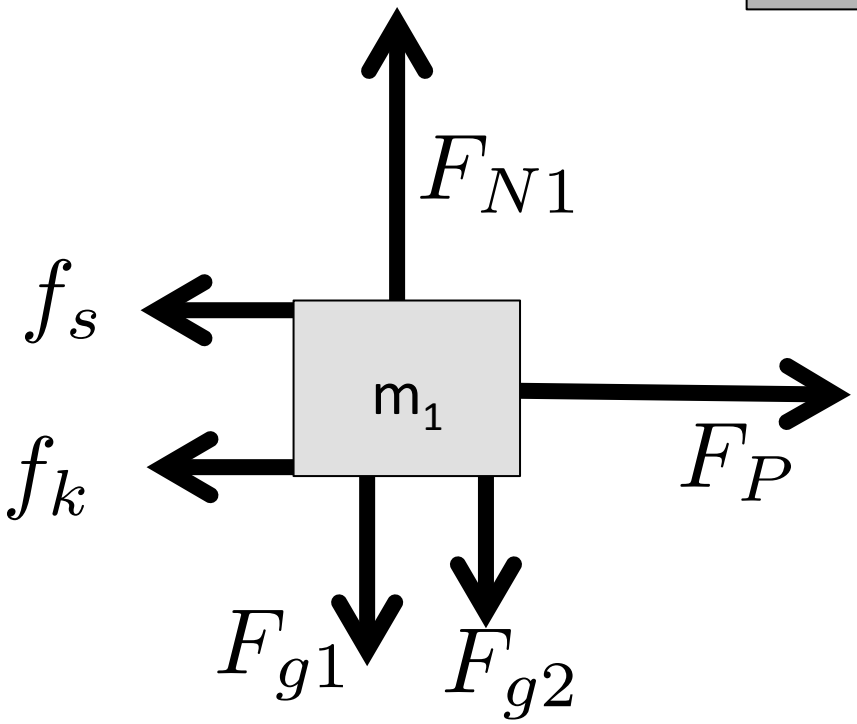
Practice drawing FBDs

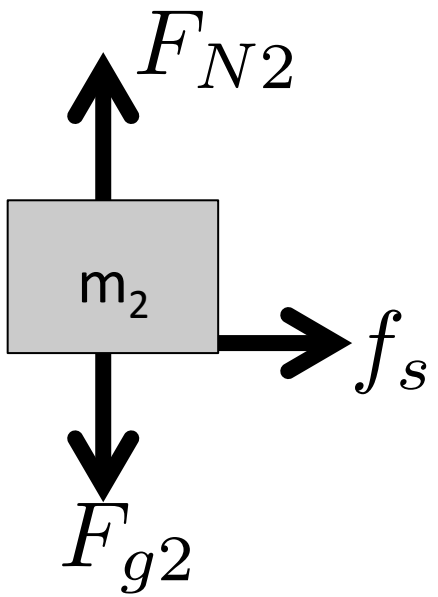
μ_k between box and table

μ_s between boxes

Write friction force in terms of μ and masses.



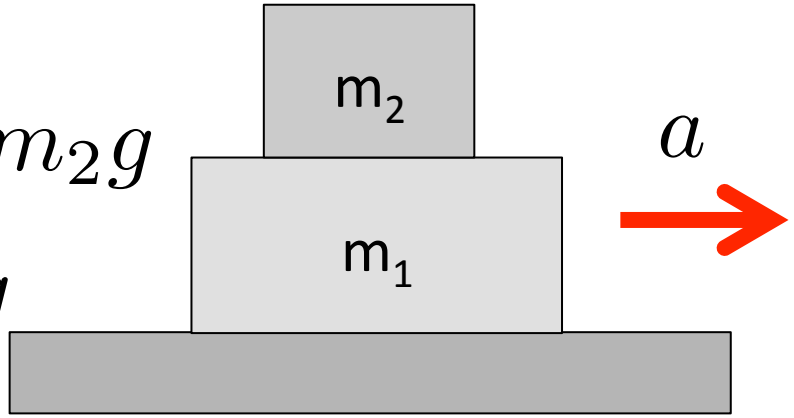


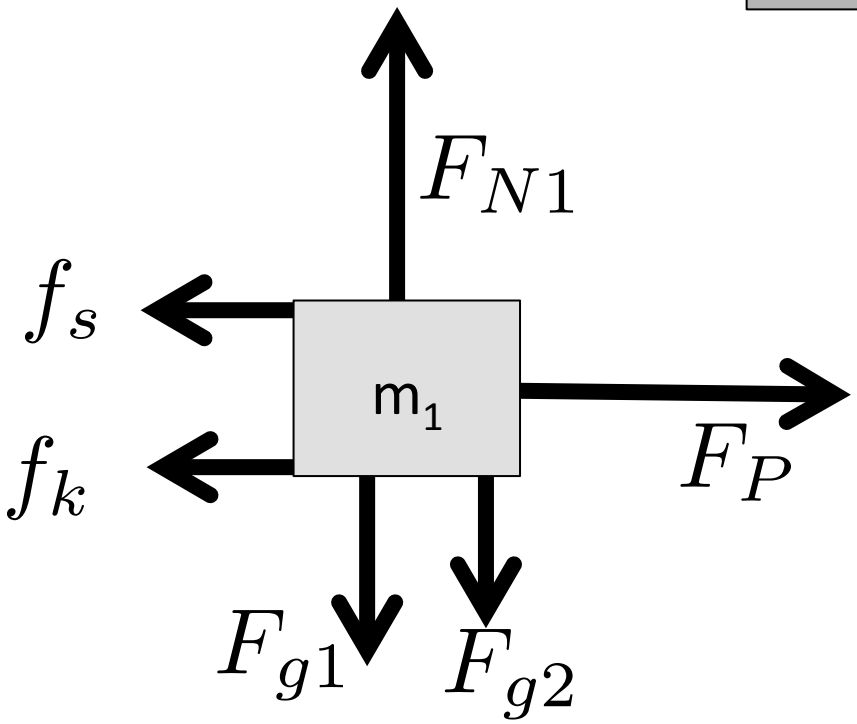


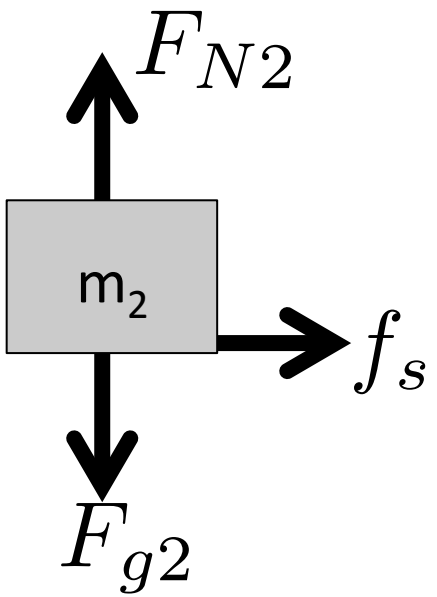
Practice drawing FBDs

$$f_s = \mu_s m_2 g$$

$$f_k = \mu_k (m_1 + m_2) g$$



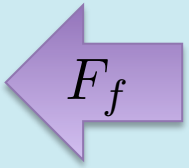




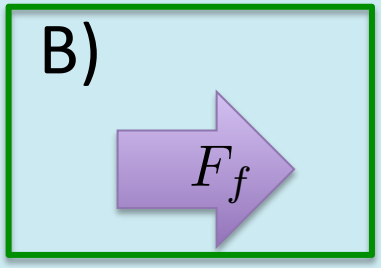
Clicker Question 8-3

What is the direction of friction when you take a step?

A)



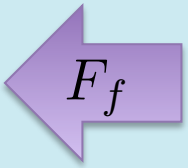
B)



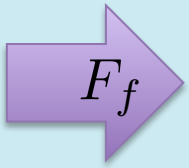
Clicker Question 8-4

What is the direction of friction for a wheel that is rolling without slipping?

A)

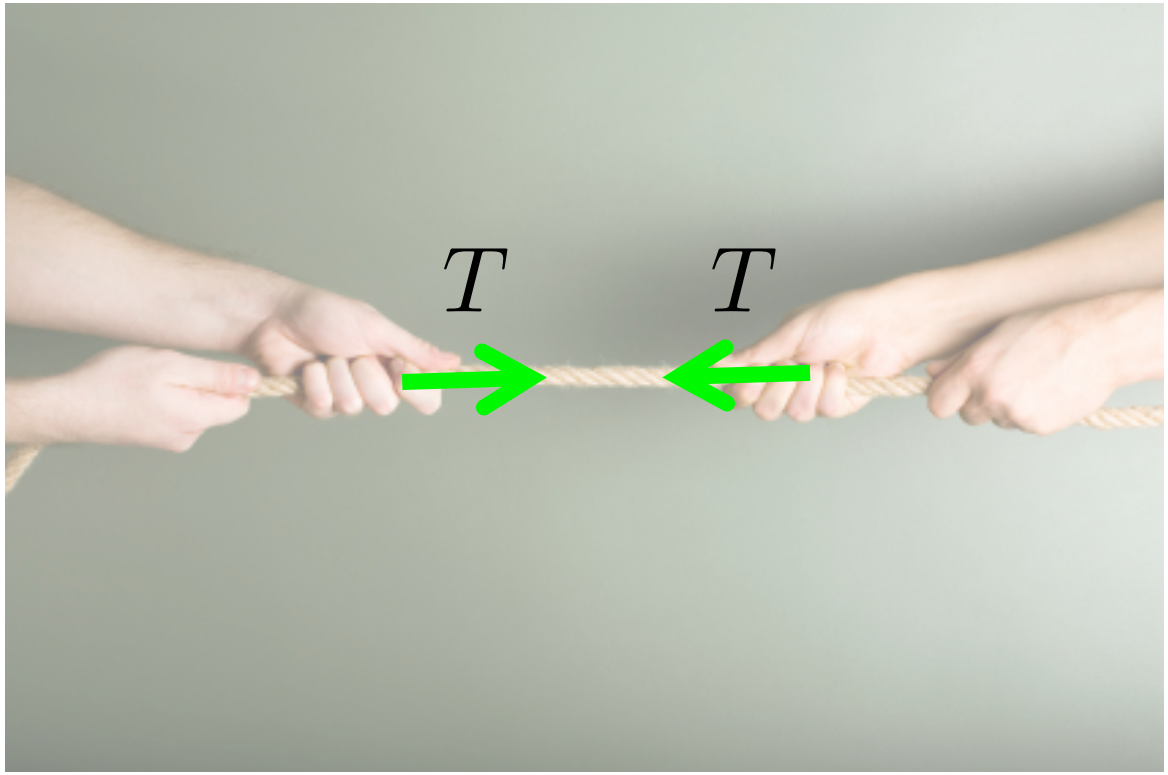


B)



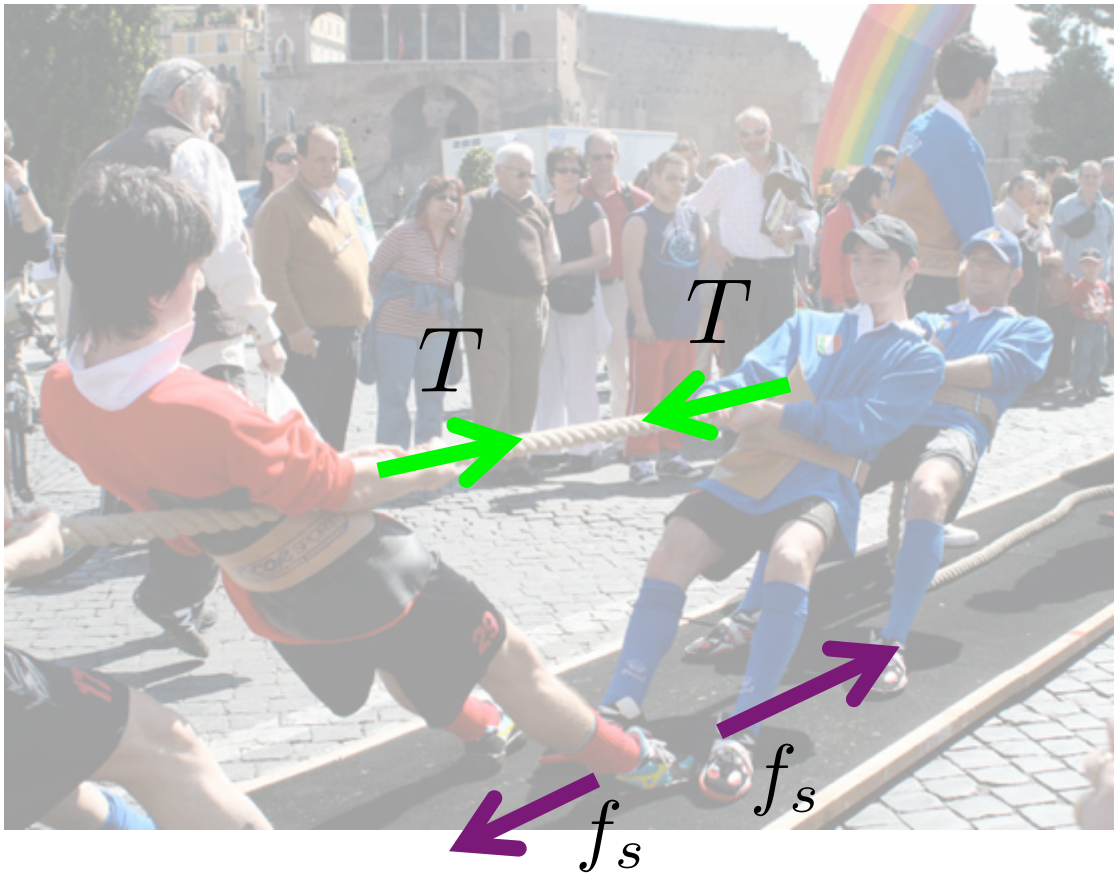
Practice with FBDs

If tension in a rope is always constant, how can anyone ever win a tug-of-war?



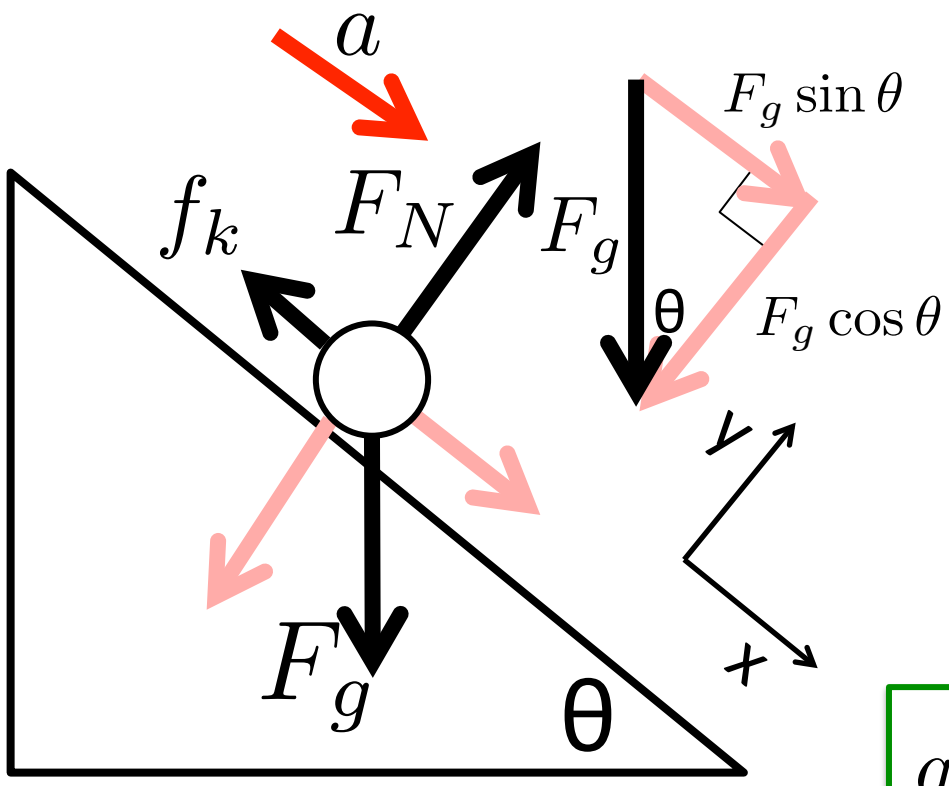
Practice with FBDs

If tension in a rope is always constant, how can anyone ever win a tug-of-war?



Practice drawing FBDs

- A box slides down a ramp with friction. Find acceleration down the ramp in terms of m and μ.



$$\sum F_y = 0$$

$$F_N = F_g \cos\theta$$

$$f_k = \mu_k F_N$$

$$f_k = \mu_k mg \cos\theta$$

$$\sum F_x = ma_x$$

$$mg \sin\theta - f_k = ma_x$$

$$a_x = g \sin\theta - \mu_k g \cos\theta$$

Homework

- Reading quiz tomorrow
- Homework #3 due tomorrow by 1pm
- Extra problems are posted (also solutions to even numbered problems)

- Office hours today at 5pm