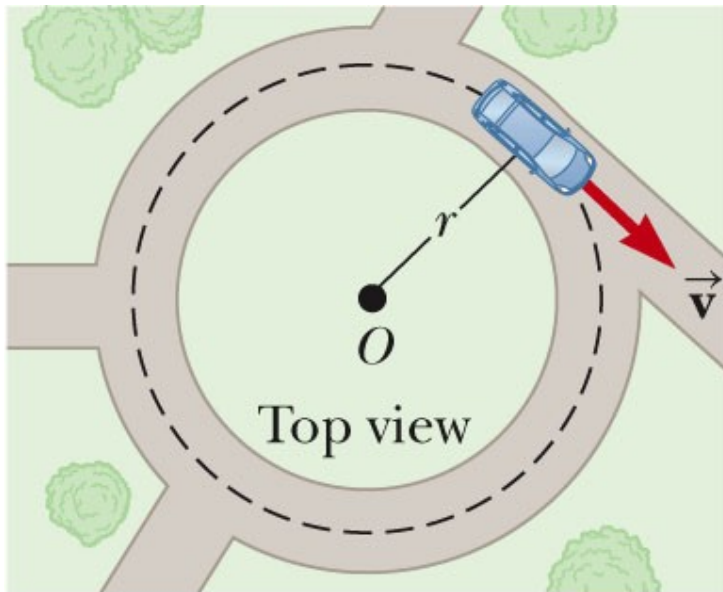


## **Week 5 outline**

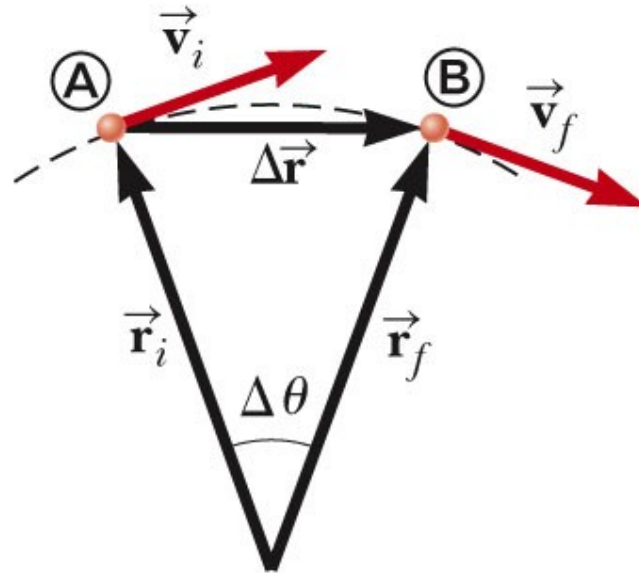
**Chapter 4. Review circular motion**

**Chapter 5. The Laws of Motion**

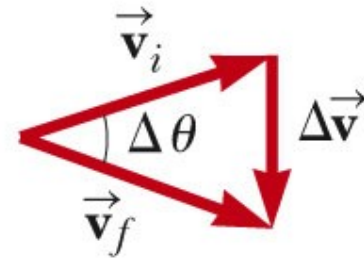
Uniform circular motion = object moves at constant speed in a circular path.



a



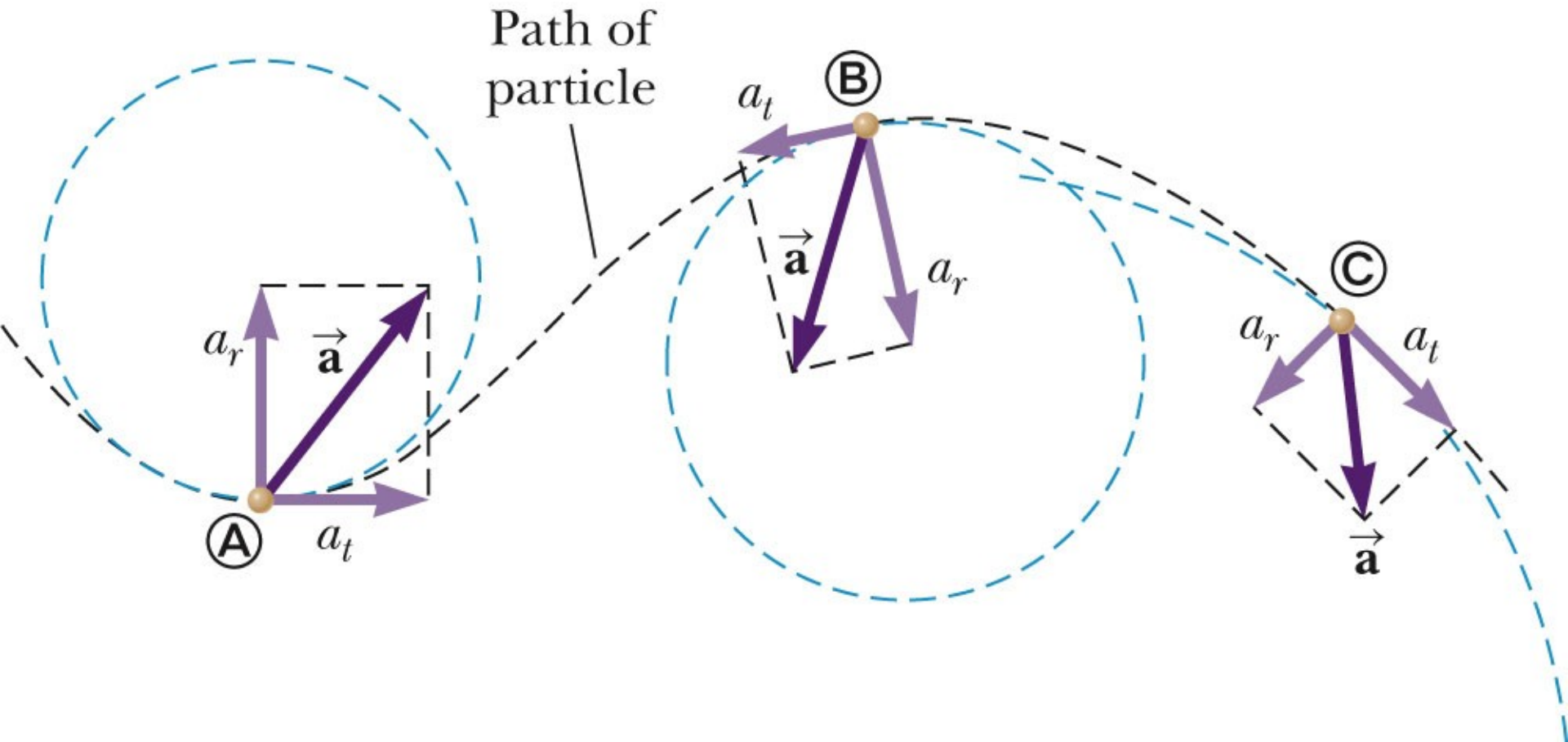
b

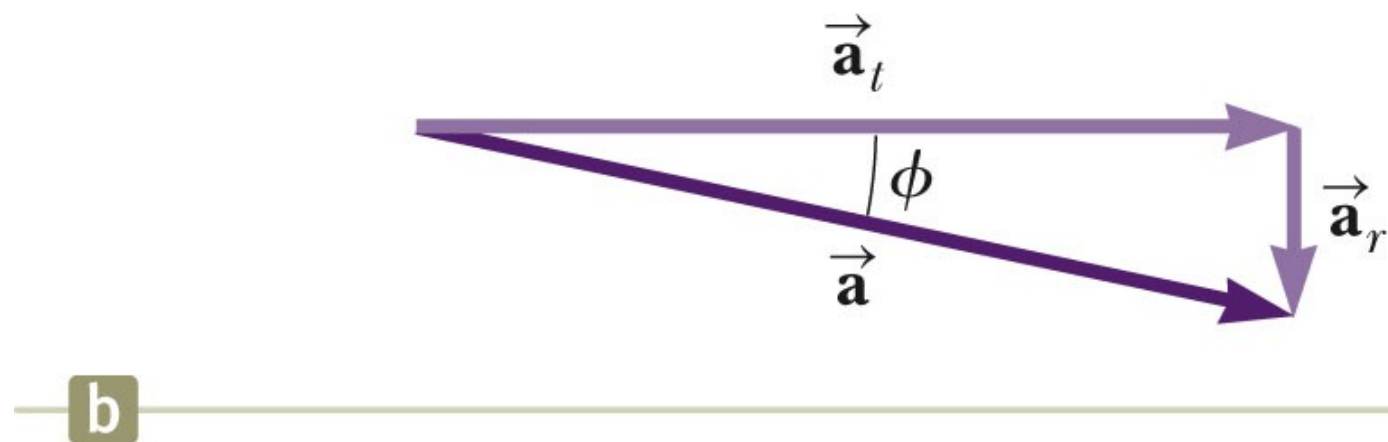
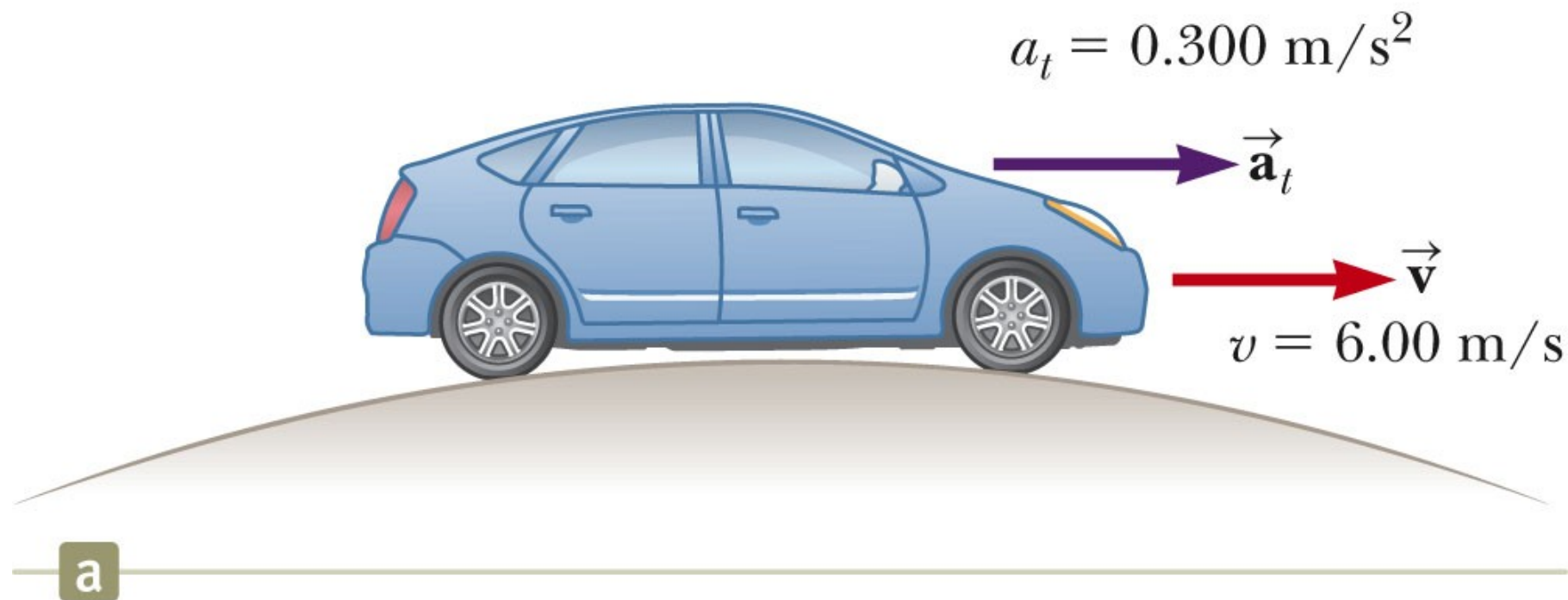


c

Time to make one cycle = period =  $T$  = circumf/speed

Total acceleration – sum of tangential and centripetal components





# Physics I

## Week 5 Monday outline

Hwk: **Ch. 3 P. 1,3,6,...,39, Due today at SA 111.**  
Ch. 4 Read Sec. 4.1-4.8, Read 3.9 (rel. vel.)  
MiscQ 1-11 (odd) Due  
Probs. 1-5,7,12-14, + next Mon  
Notes: Lab this week is “Projectile Motion”  
Quiz 2 results: mean=7.9/10.  
(Can go over next time.)  
“NEW STUFF” has lecture notes from Fri.

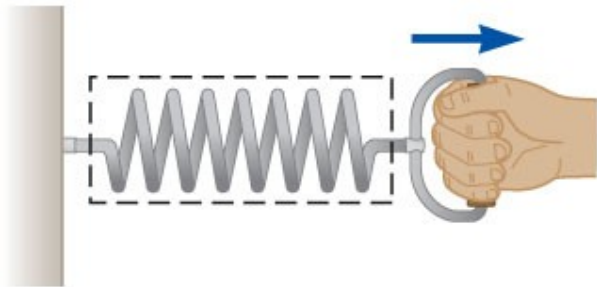
**TODAY: Forces (Ch. 4)**  
Contact vs Field forces  
Newton’s first law (and frames of reference)

# Forces – the *cause* of acceleration

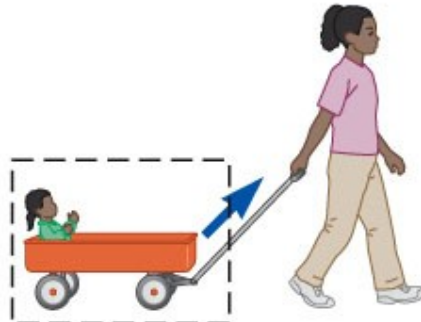
Forces are vectors

Forces act between systems (the dashed boxes)

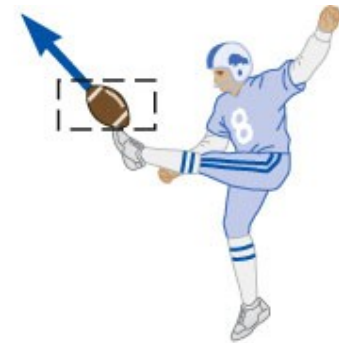
Contact forces



a



b

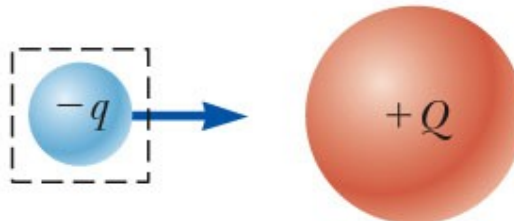


c

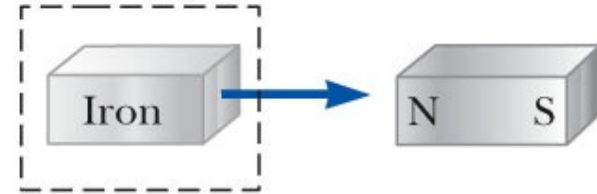
Field forces



d



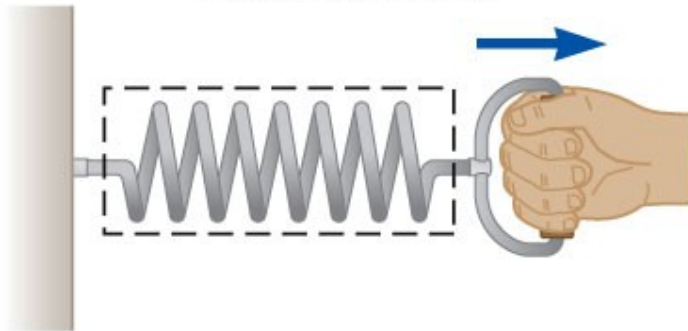
e



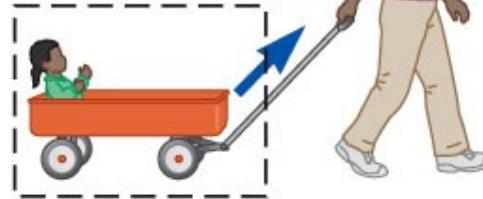
f

# Types of forces

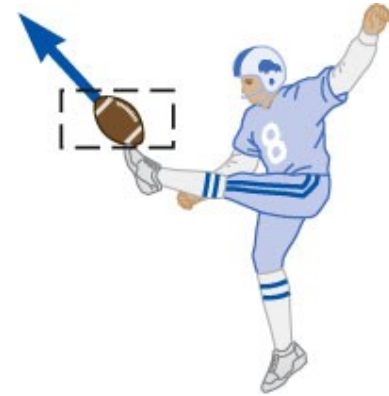
Contact forces



a



b



c

## contact forces

tension – pulling apart

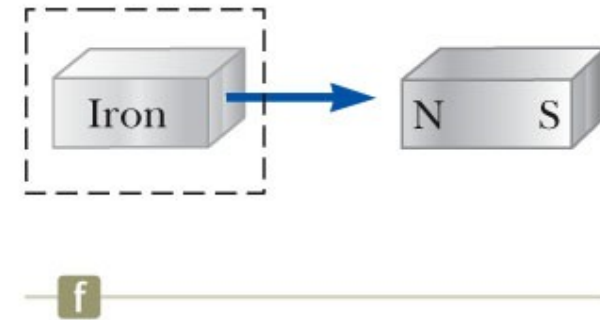
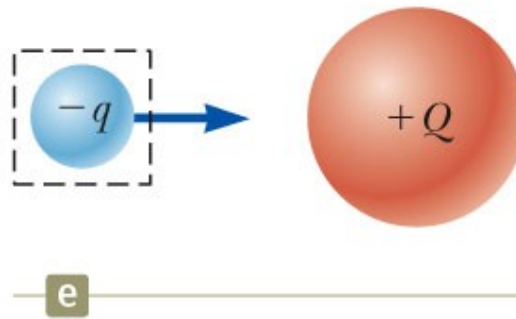
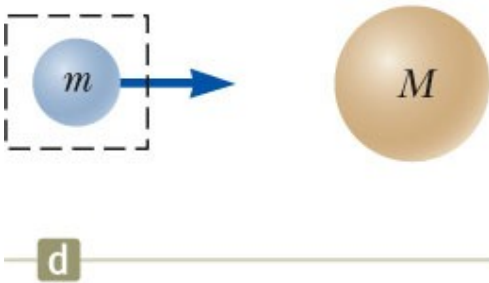
compression – pushing together

shear – pushing tangentially

torsion - twisting

# Types of forces

Field forces



Field forces

gravitational

electric

magnetic



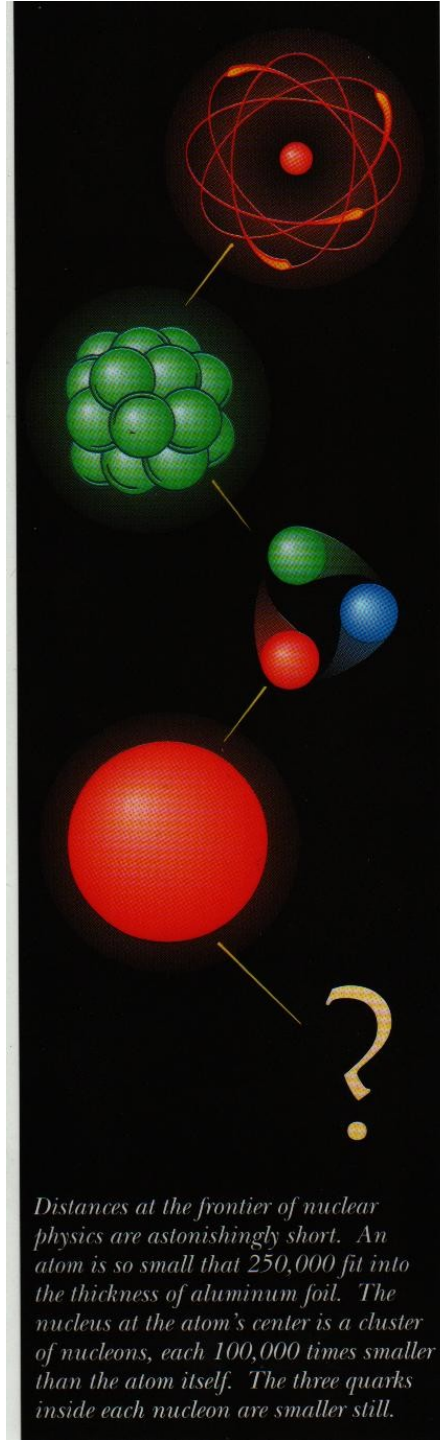
# The 4 Fundamental forces

Gravity

Electromagnetic Force

Nuclear Strong Force – holds nuclei together

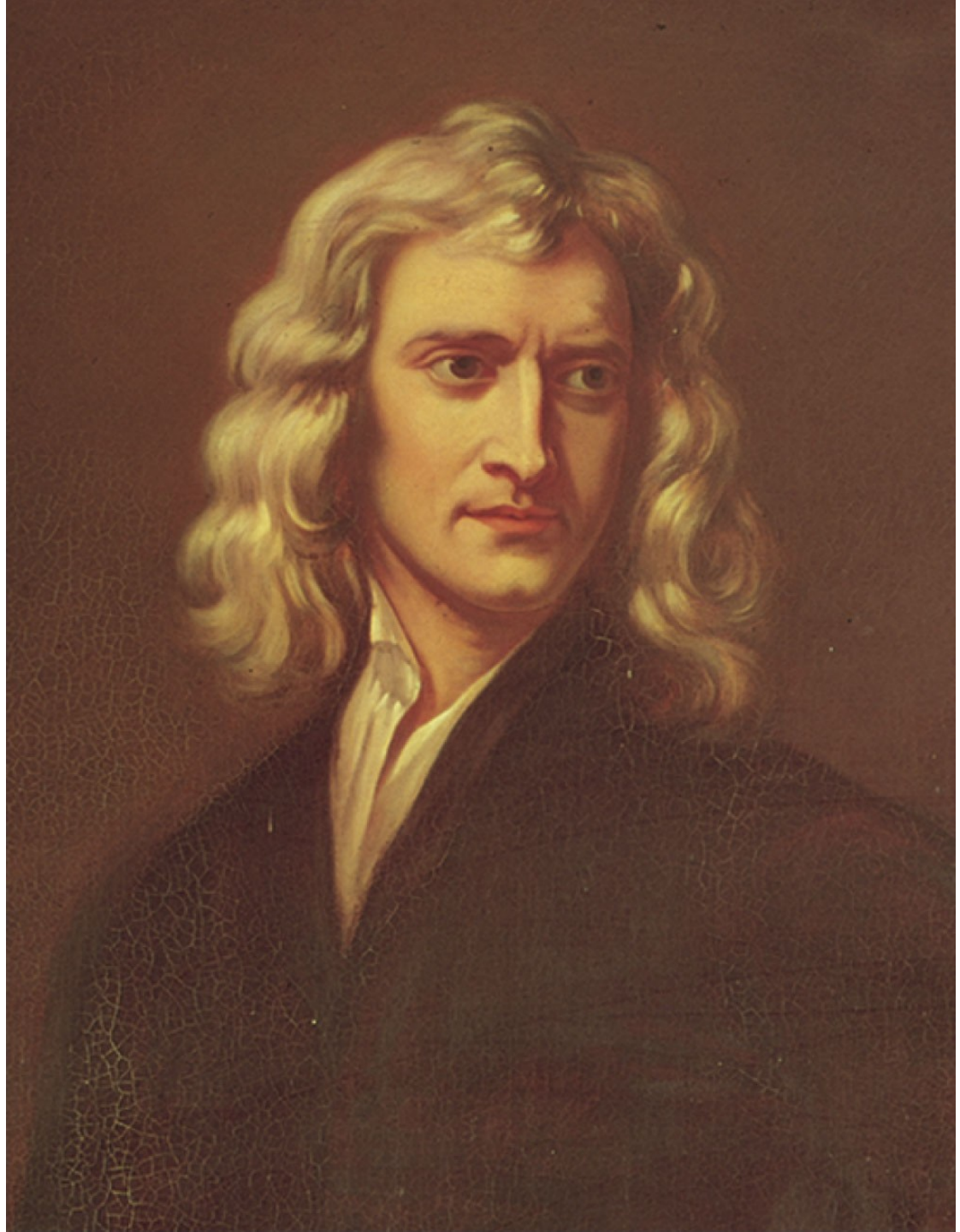
Nuclear Weak force – decay of n and p



Isaac Newton  
(1642 - 1727)

3 laws of motion

1 law of Universal  
Gravitation

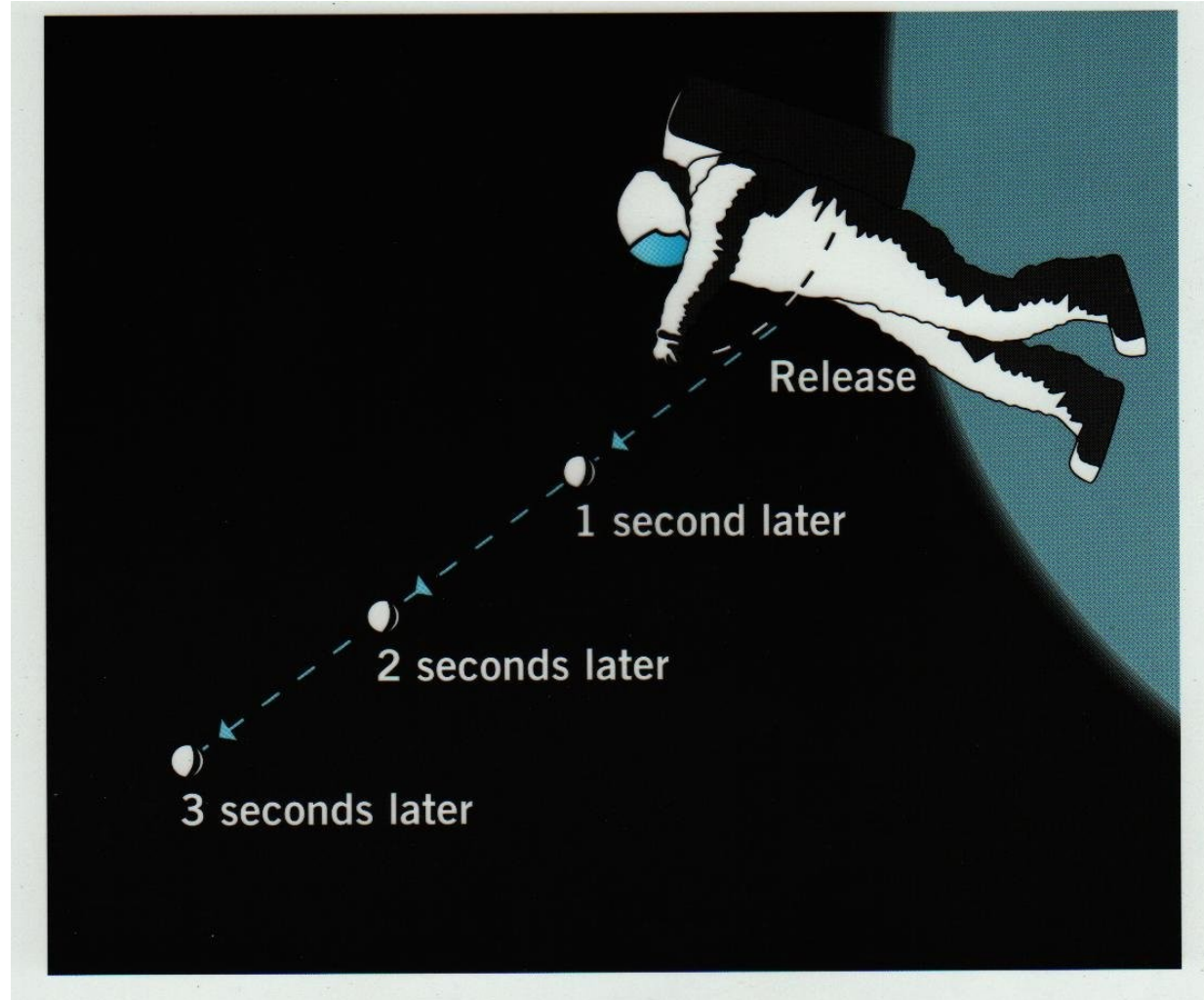


Newton's 1<sup>st</sup> law = inertial frames of reference exist such that an object will move with a constant velocity if no forces act upon it.

Overthrows Aristotle  
and medieval thought:

“natural state” is at  
rest

“impetus” pushes an  
arrow along



The woman standing on the beltway sees the man moving with a slower speed than does the woman observing the man from the stationary floor.

Each person is in a different inertial frame-of-reference.

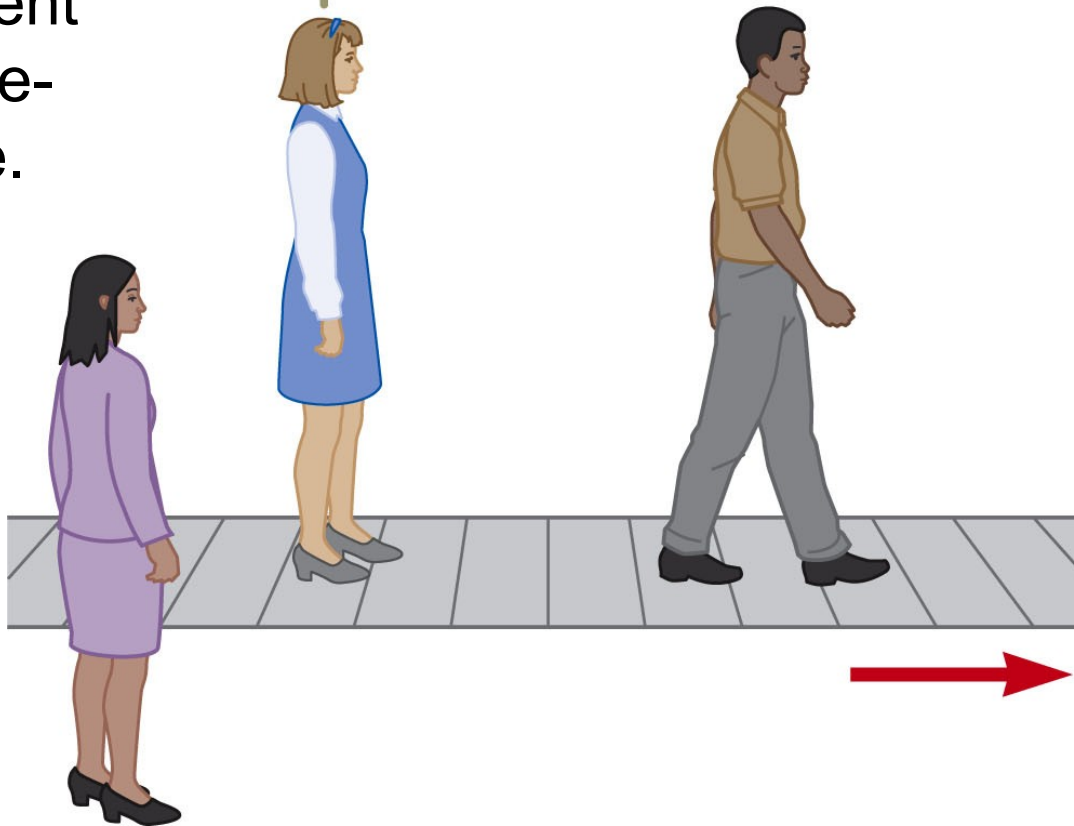


Fig. 4.19, p. 90

Transforming between two frames of reference, A and B.

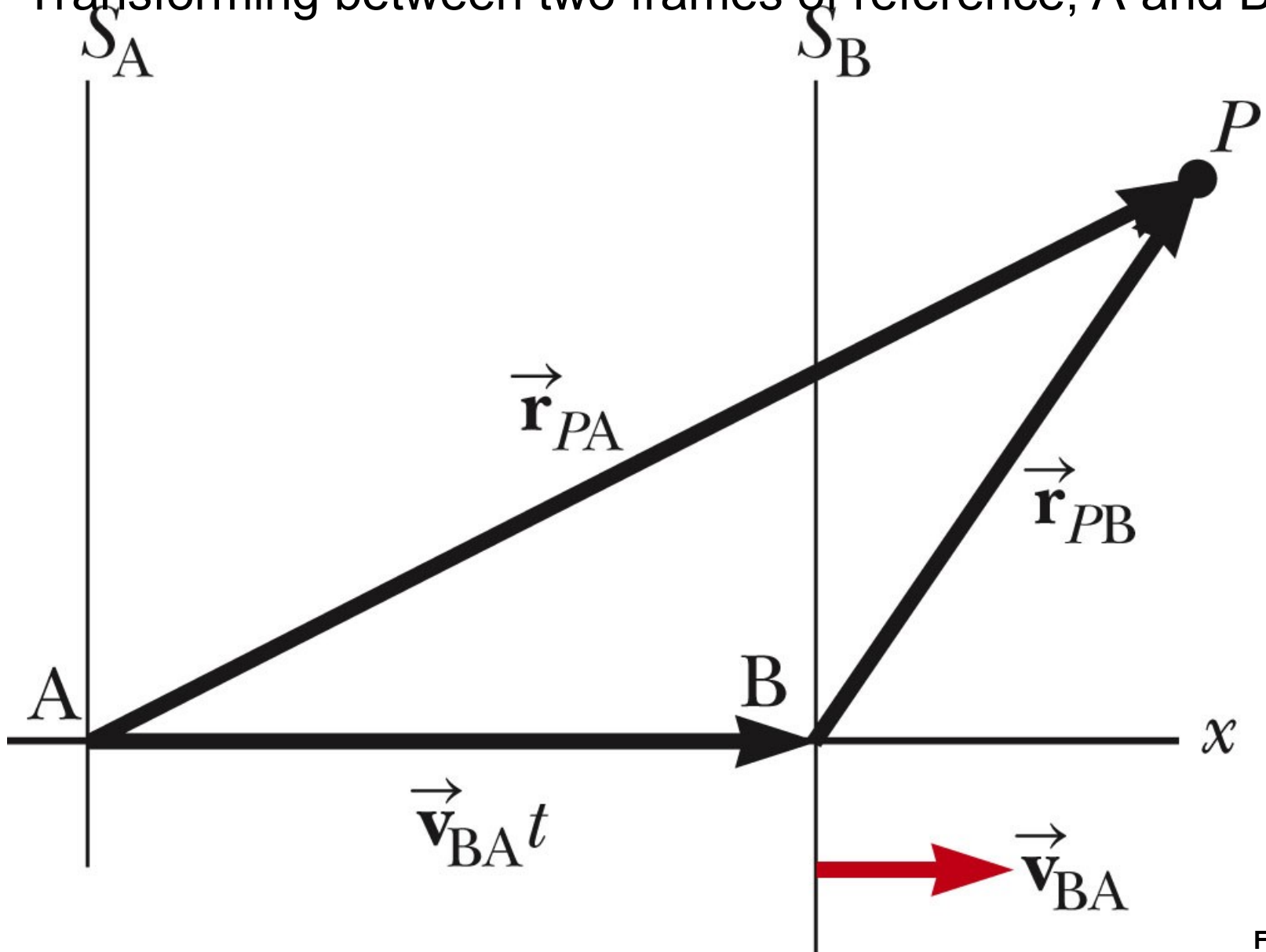
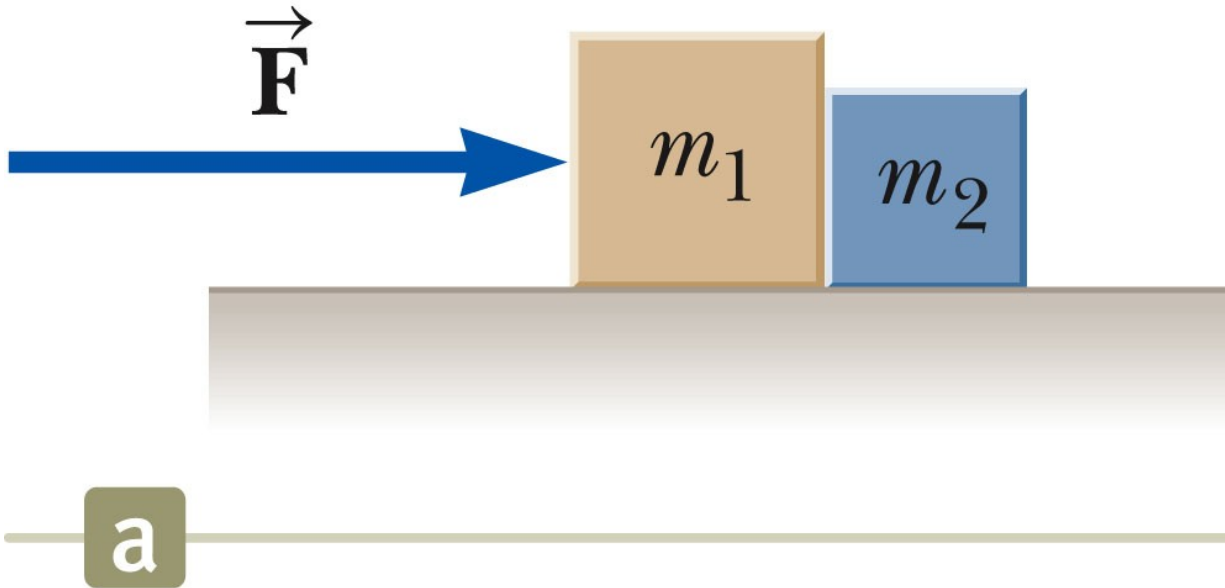


Fig. 4.20, p. 91

Newton's 2<sup>nd</sup> law = the acceleration of an object is proportional to the net force and inversely proportional to the mass.



$$\vec{a} = \frac{\vec{F}_{net}}{m}$$

If same force acts on  $m_1$ ,  $m_2$ , and  $m_1+m_2$ , the accelerations are different.

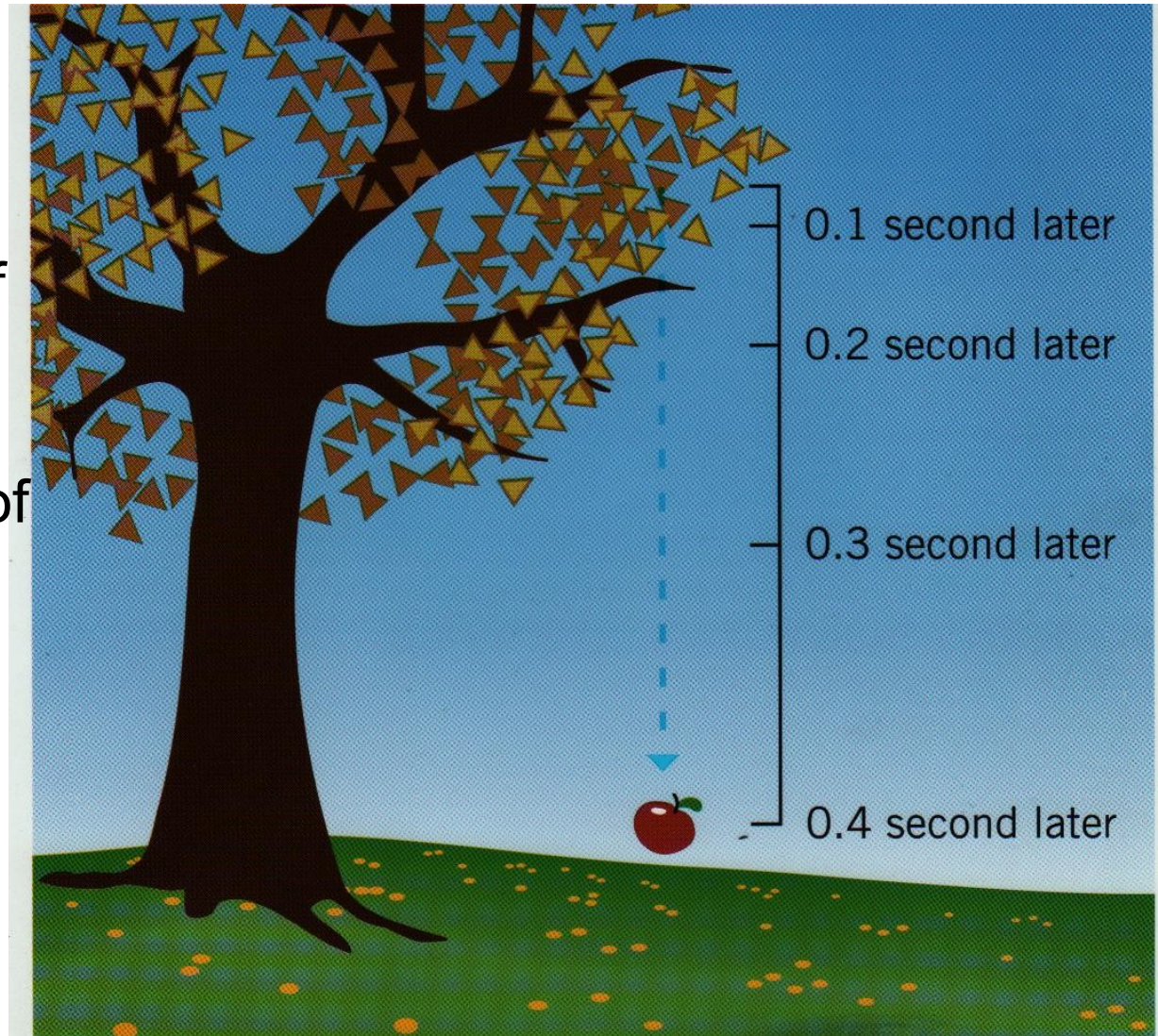


# Newton's 2<sup>nd</sup> law (cont.)

## Example: gravity

Weight = the force of gravity on an object

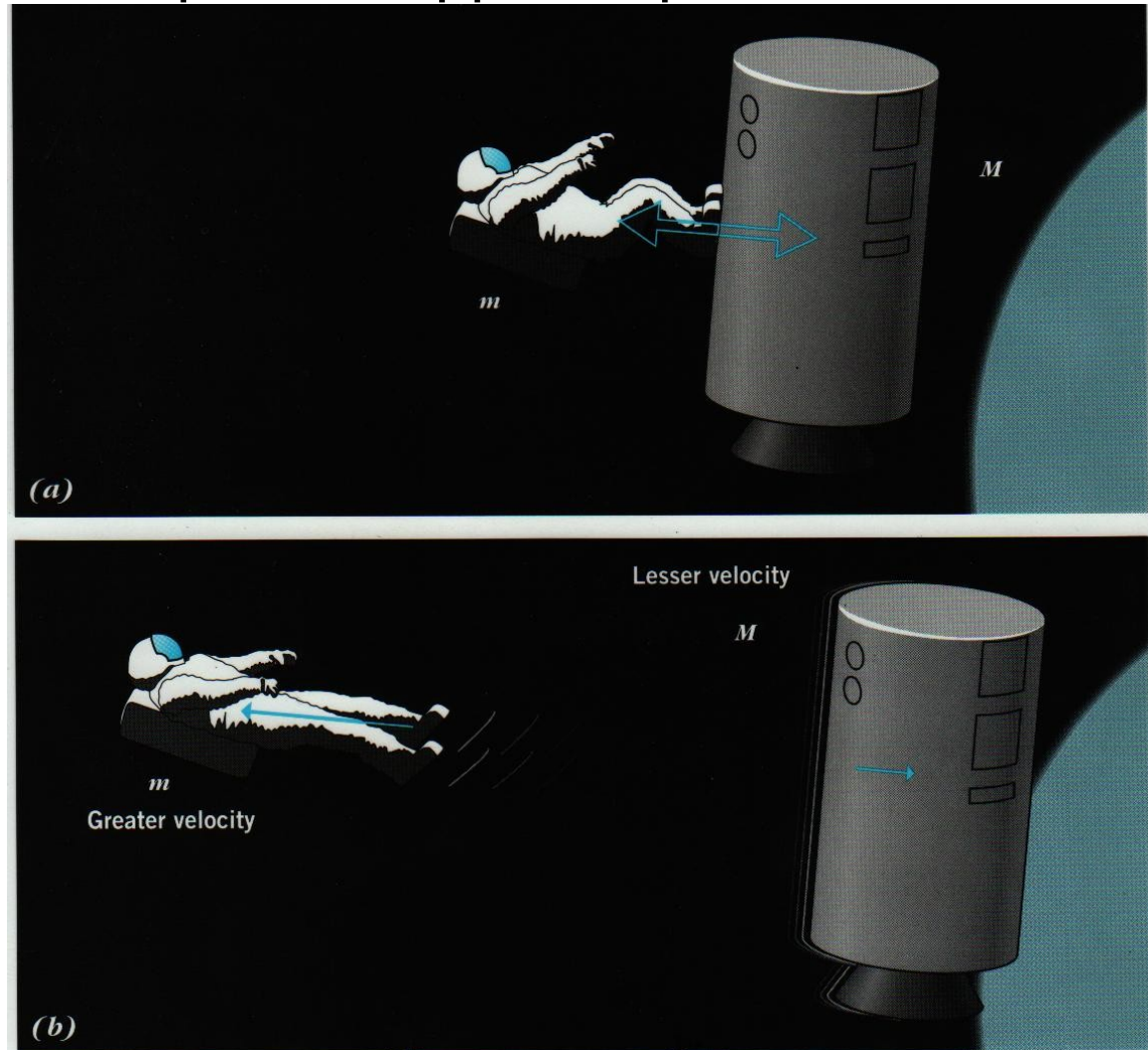
Mass = the amount of matter in an object



## Newton's 3<sup>rd</sup> law (cont.)

“For every action there is an equal but opposite reaction.”  
“Forces come in equal but opposite pairs.”

$$F_{12} = -F_{21}$$





## Newton's 3<sup>rd</sup> law (cont.)

Gravity and the electromagnetic forces obey Newton's 3rd.

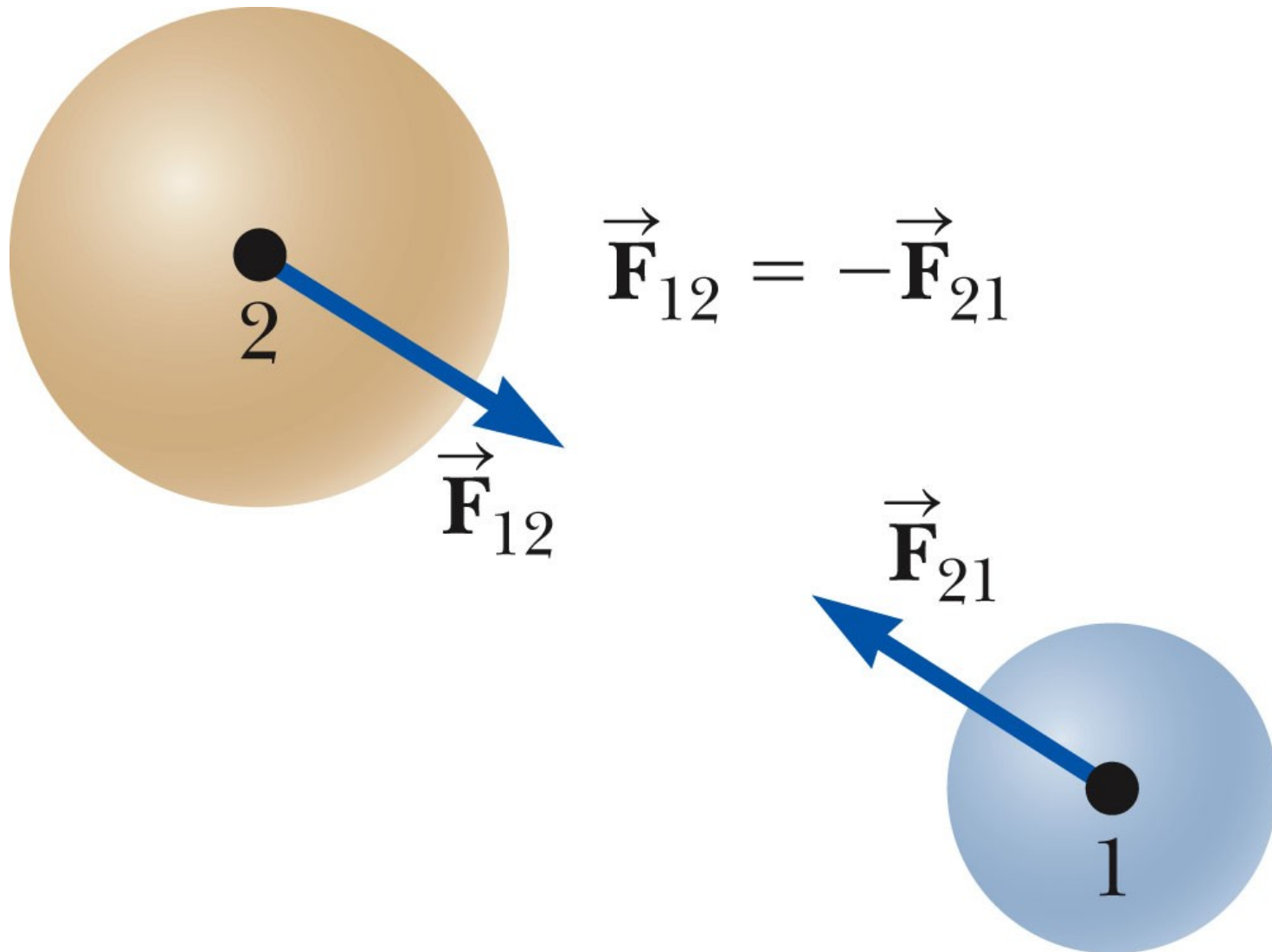
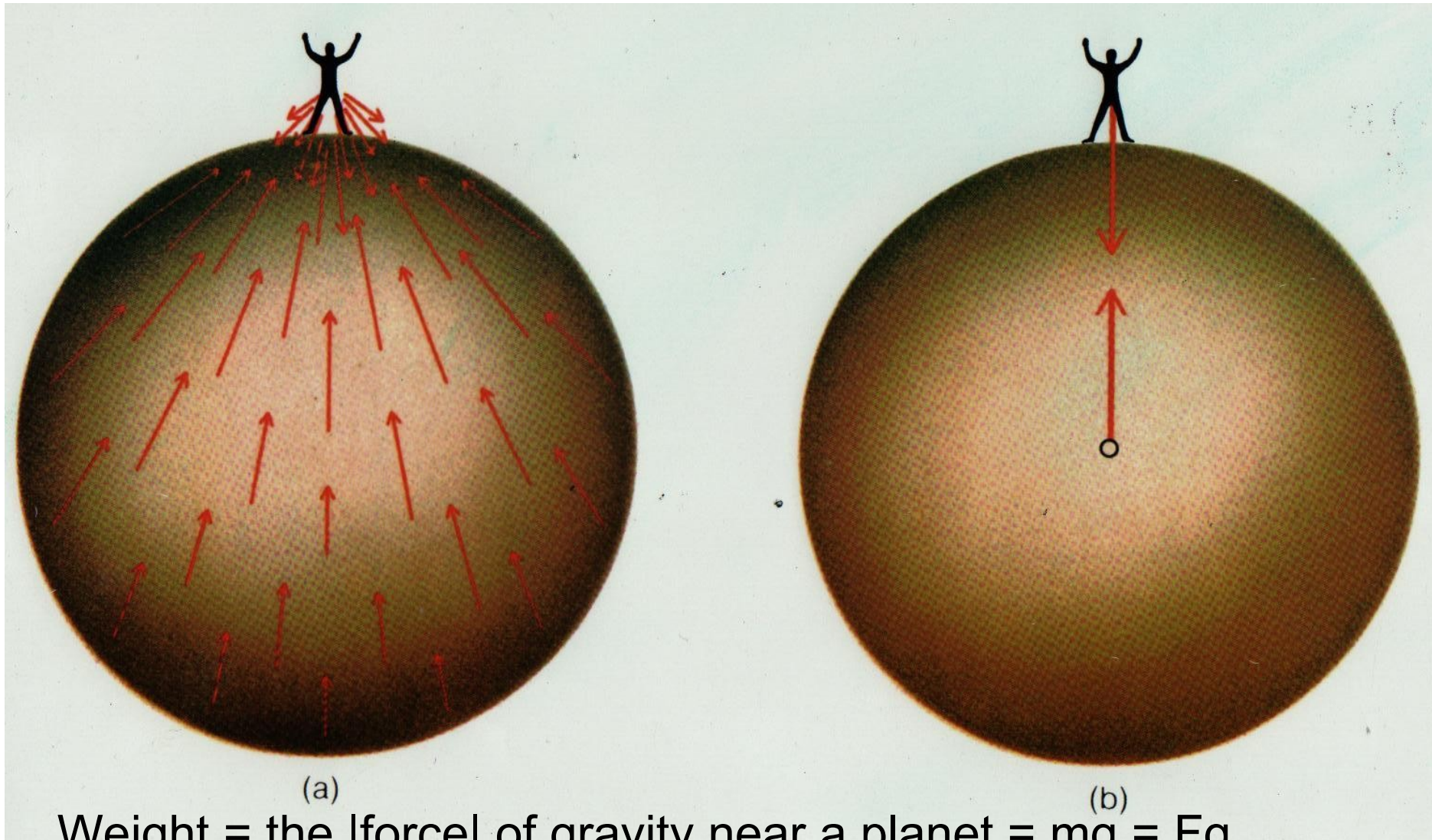


Fig. 5.5, p. 111

## Newton's 3<sup>rd</sup> law (cont.)



Weight = the |force| of gravity near a planet =  $mg = F_g$

*Apparent* weight may differ from weight in accelerating reference frames or when buoyant forces are present.

When the elevator accelerates upward, the spring scale reads a value greater than the weight of the fish.

When the elevator accelerates downward, the spring scale reads a value less than the weight of the fish.

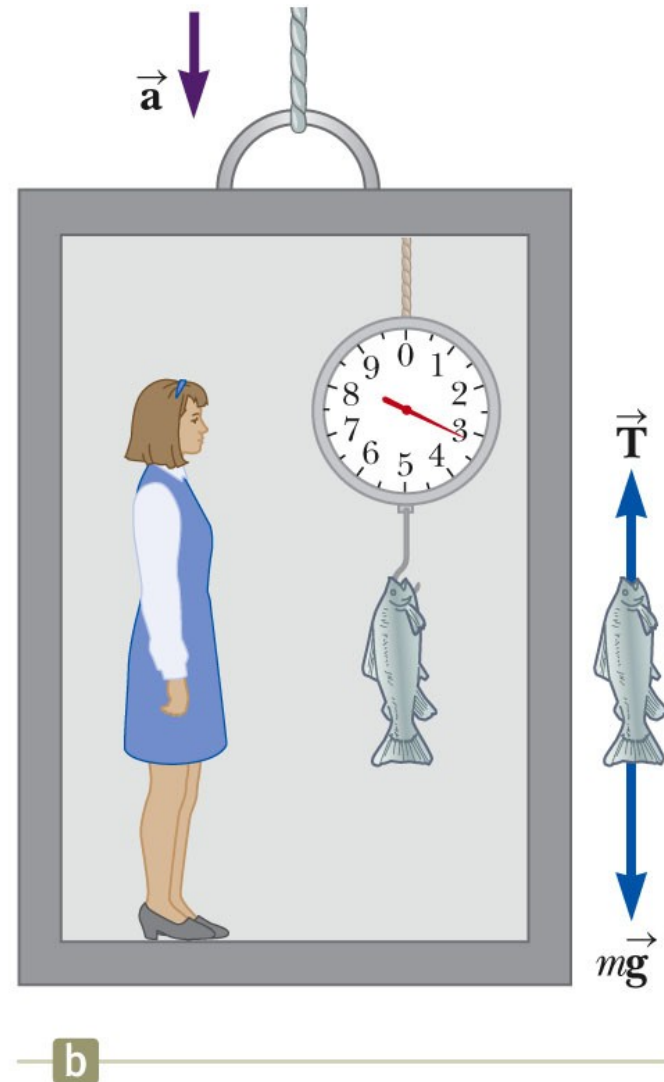
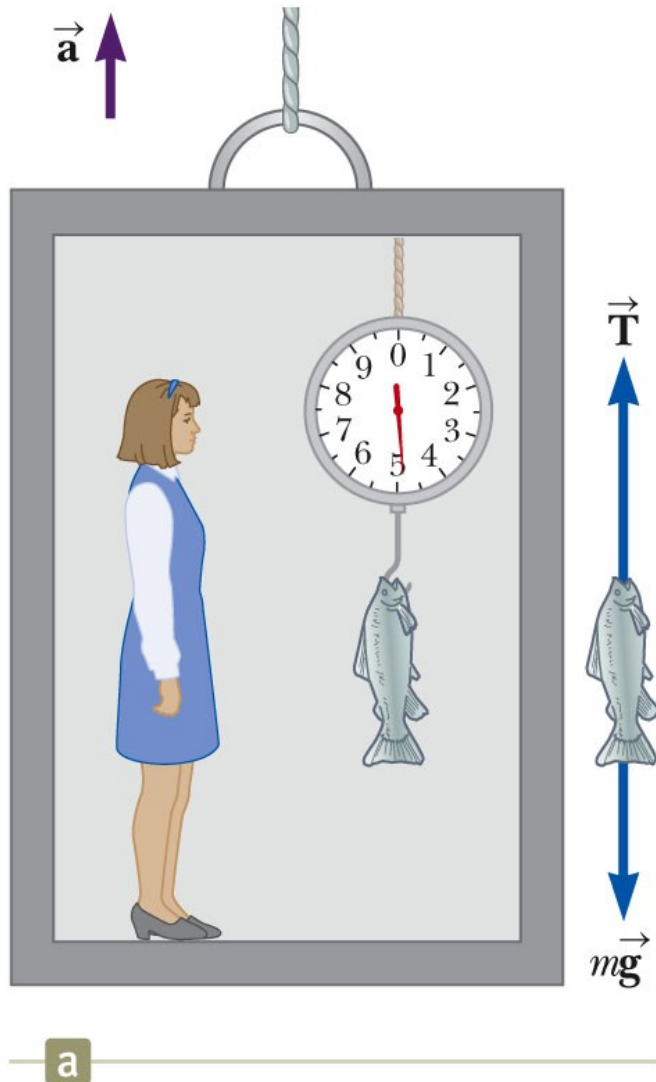


Fig. 5.13, p. 119

# The Application of Newton's Laws

## Problem solving method

### 1. Conceptualize

- What is problem asking for?
- Write down knowns and unknowns.
- Draw picture.

### 2. Categorize

- Equilibrium problem – object stationary (or constant velocity)
- Newton's 2<sup>nd</sup> law problem – object accelerates

### 3. Analyze

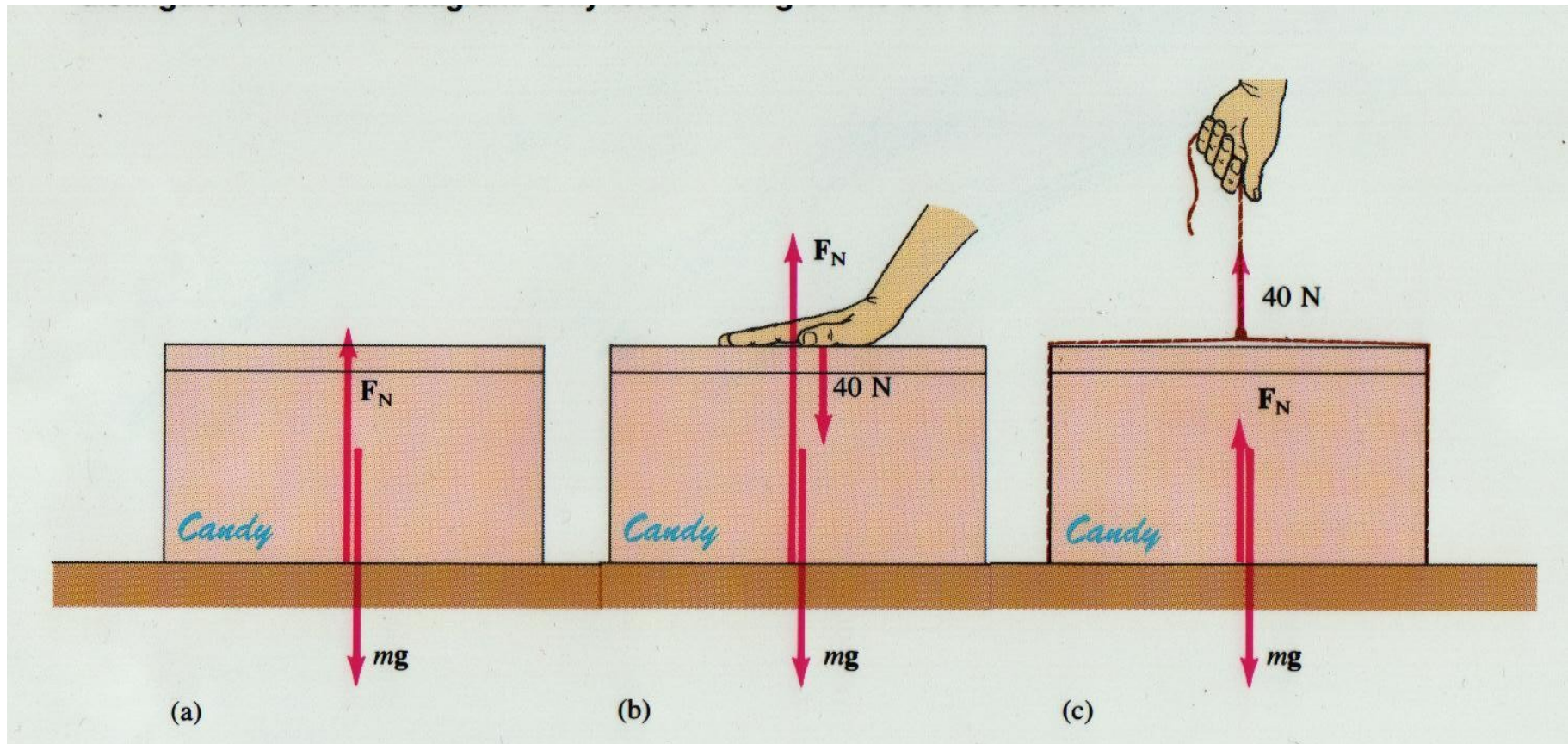
- Isolate object of interest and draw forces acting on it.
- Don't draw the forces object exerts on surroundings (usually).
- Form equations for x and y components independently.
- Plug and chug.

### 4. Finalize – check units, dimensions, etc.



# The Application of Newton's Laws

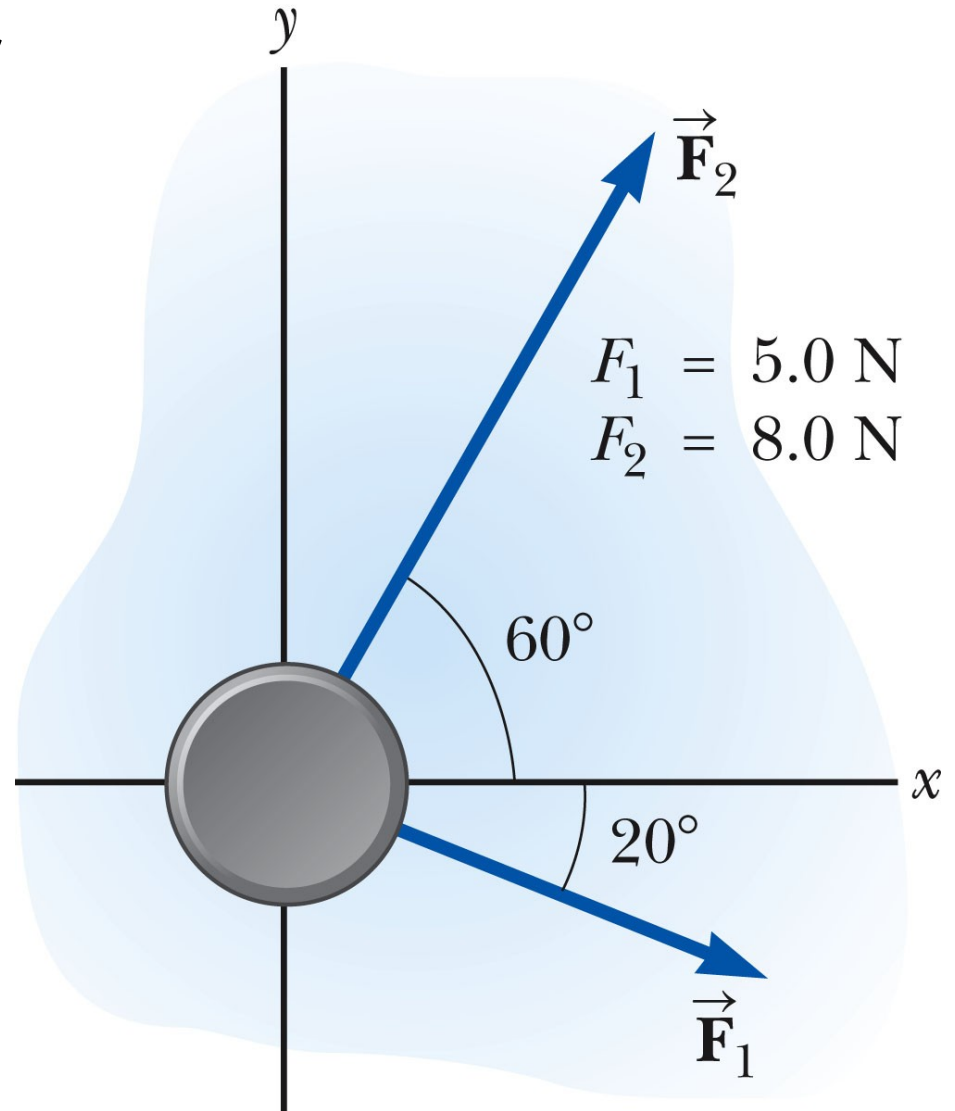
Find the normal force in each case if  $m=1$  kg. (Use  $g=10$  m/s<sup>2</sup>)

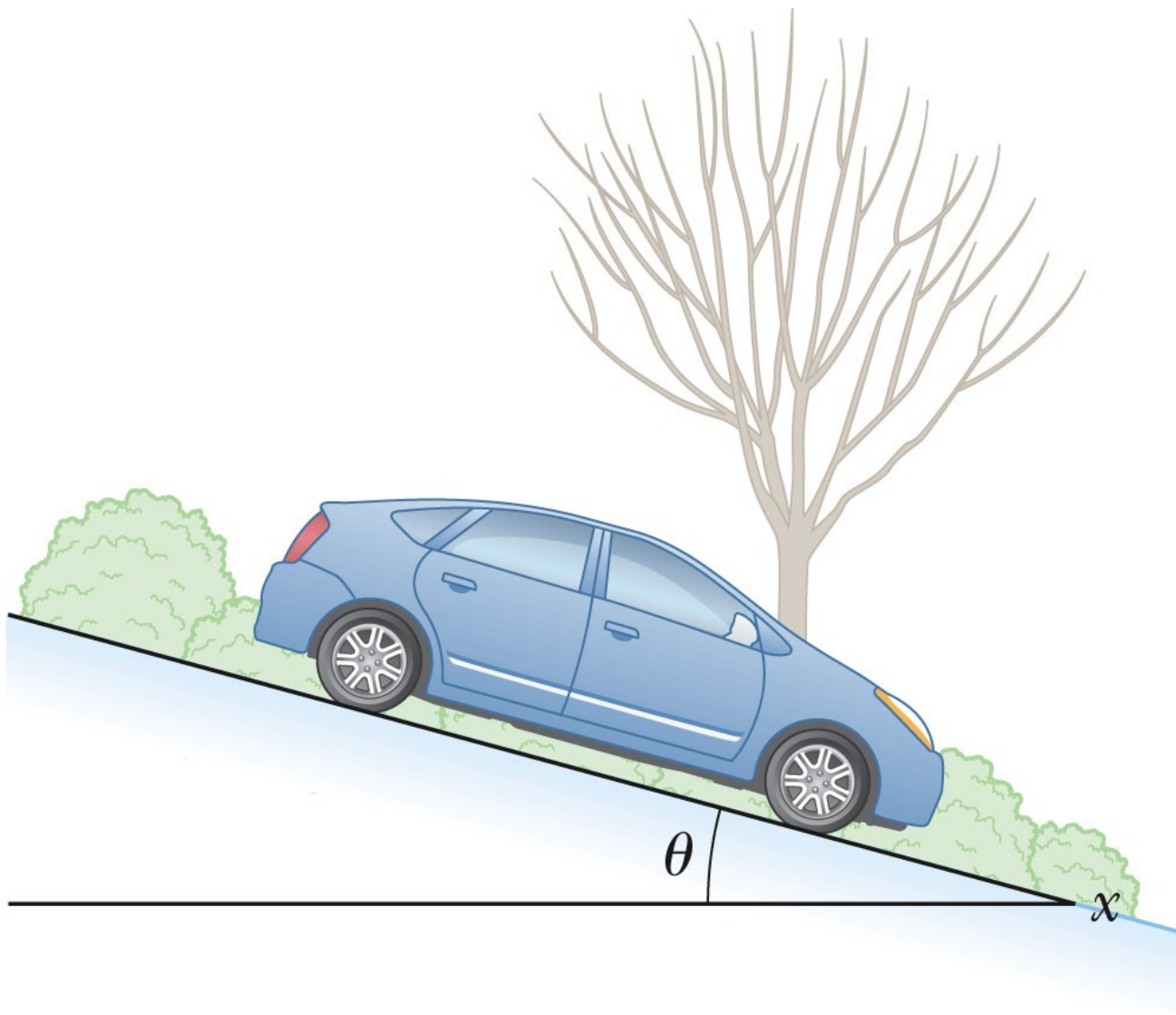


**Note:** if  $m=5$  kg, you get a more realistic normal force in (c).

# The Application of Newton's Laws

Find the acceleration vector for the 0.2 kg hockey puck.





a

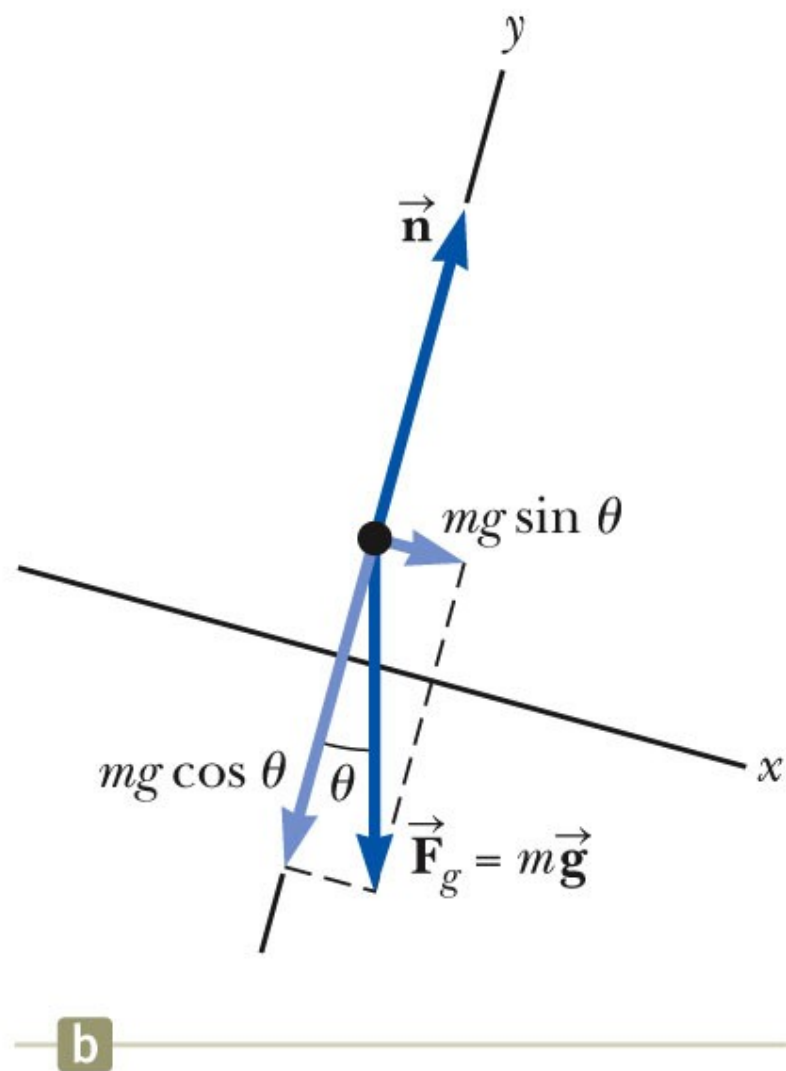
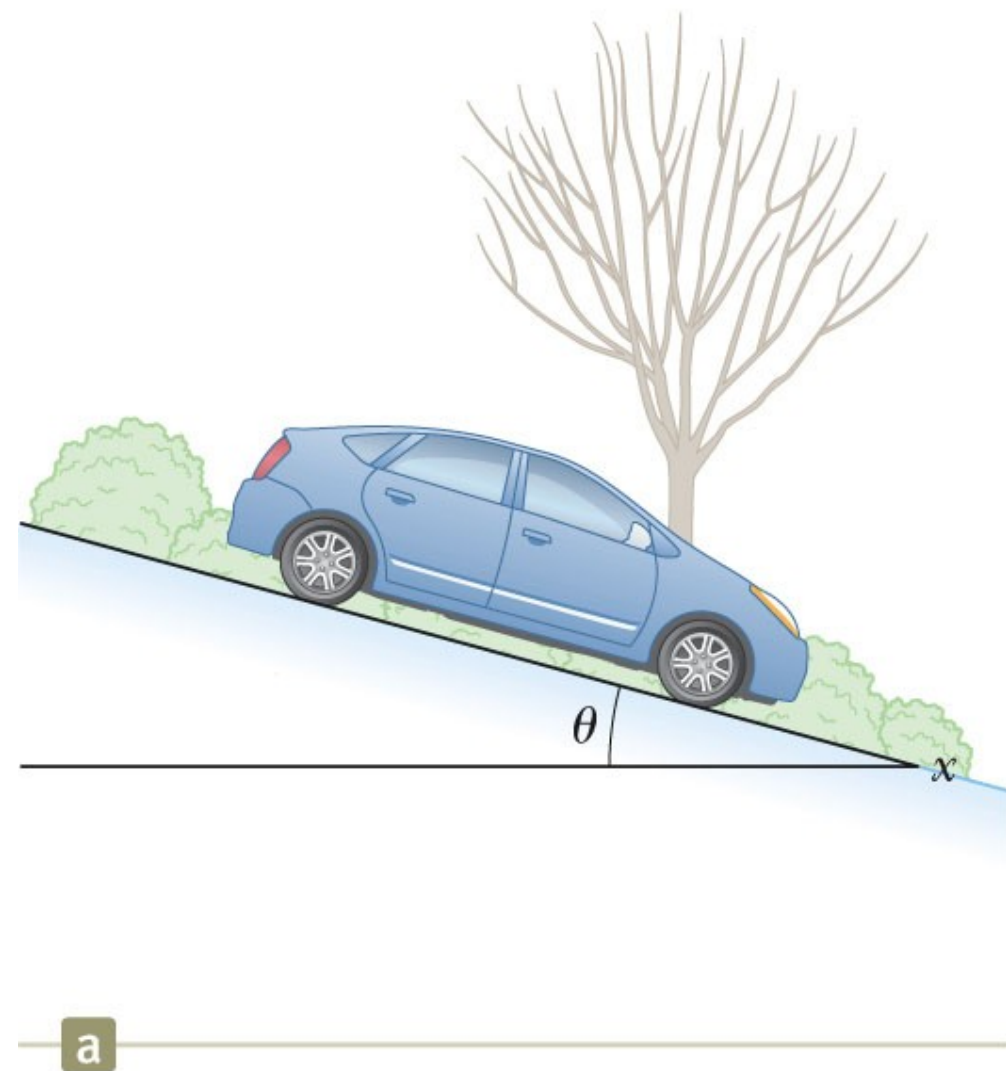
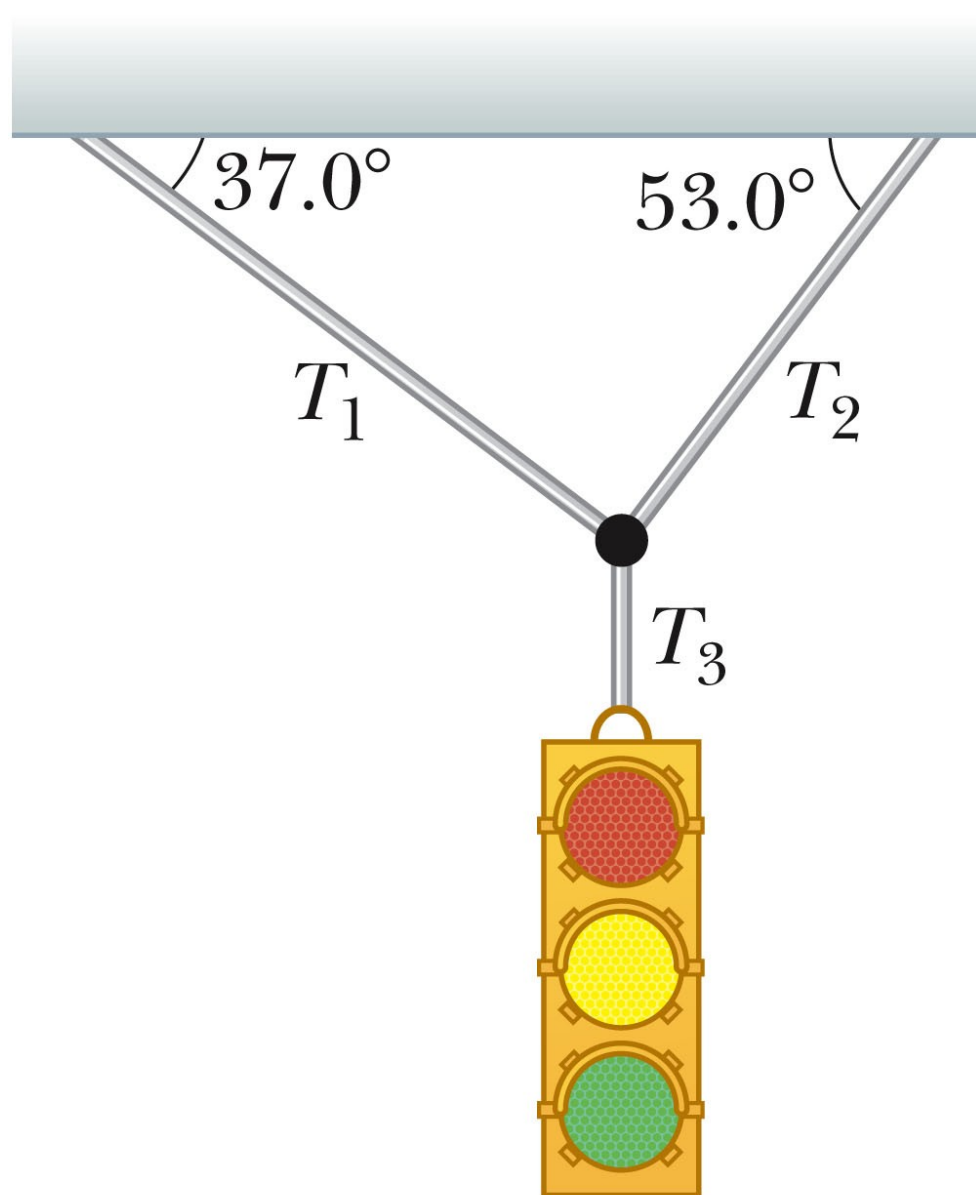
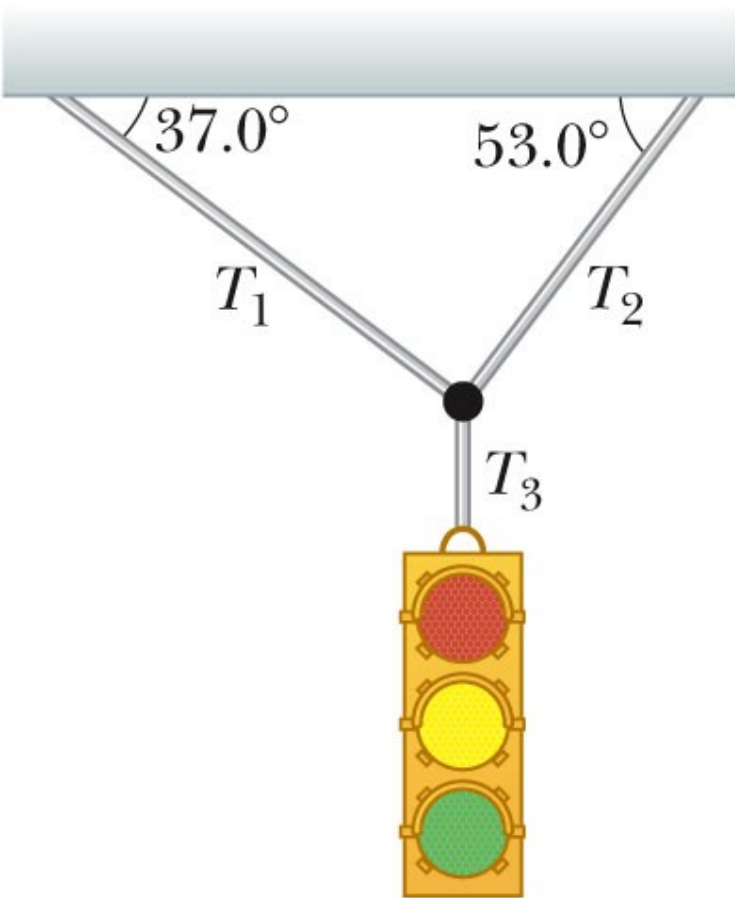


Fig. 5.11, p. 116





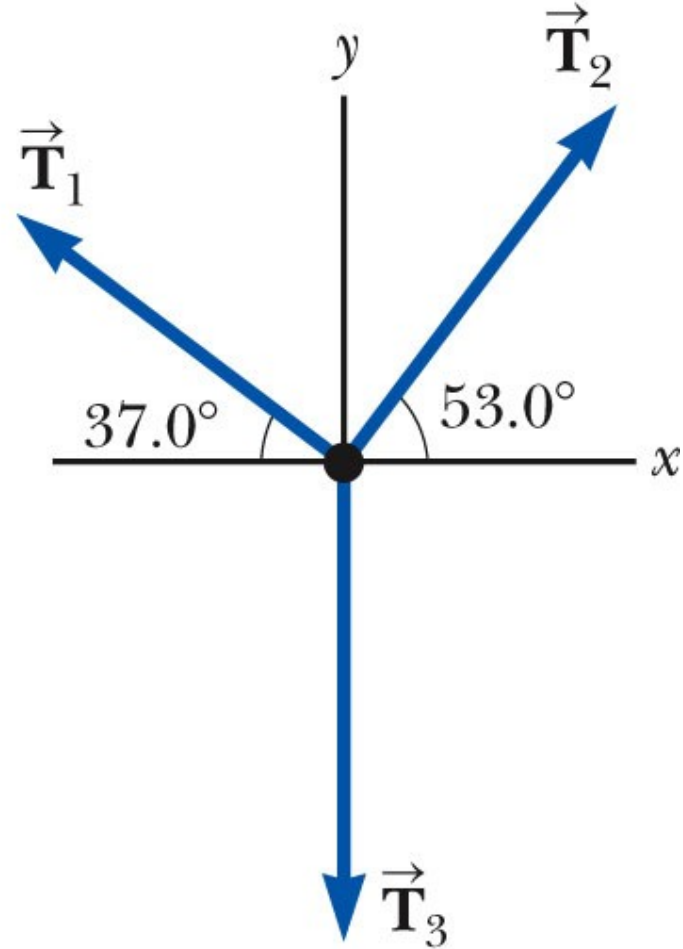
a



a



b



c

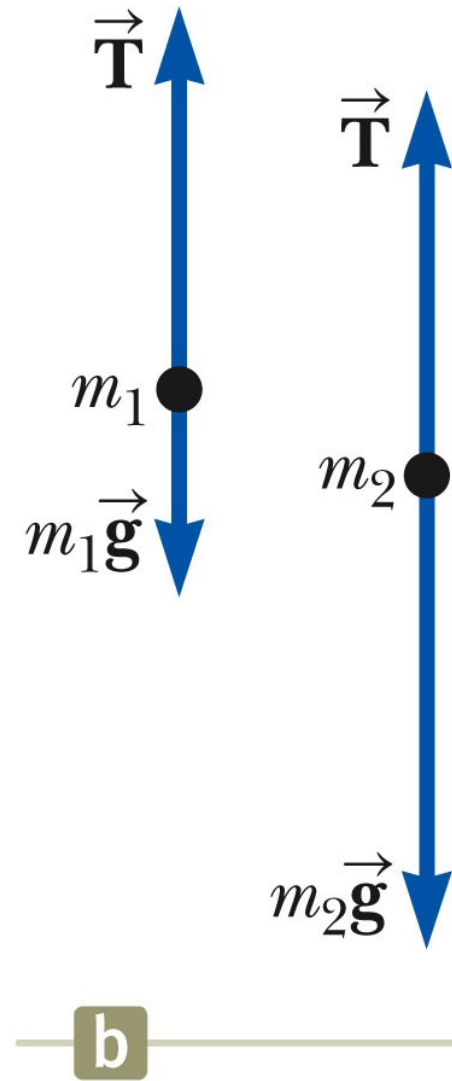
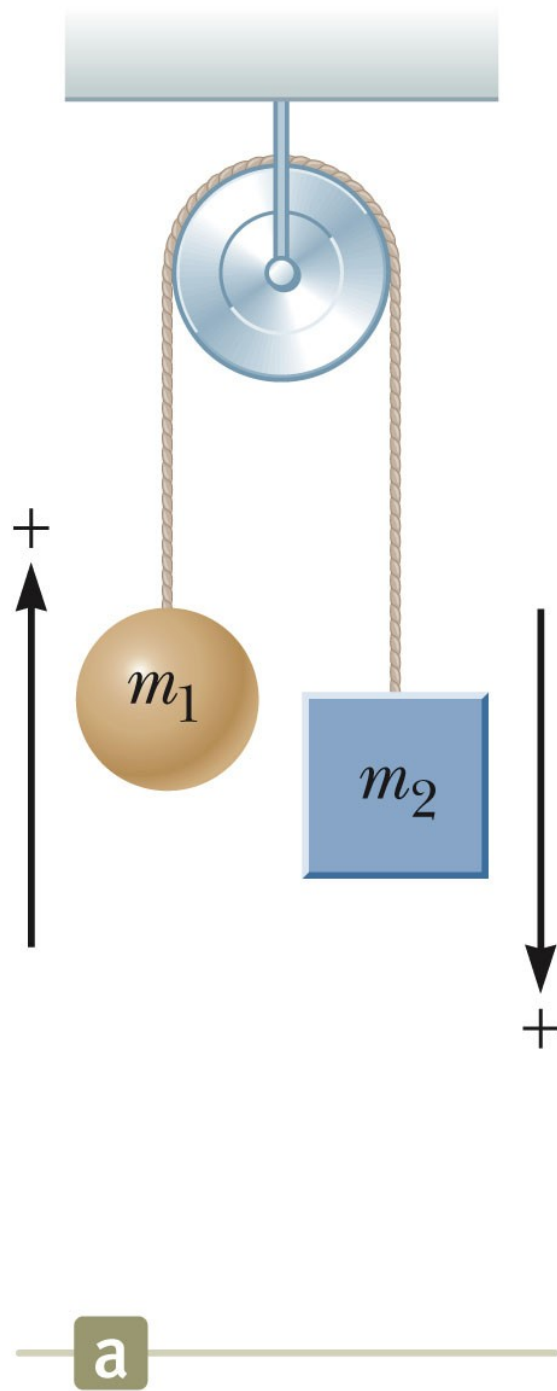


Fig. 5.14, p. 120

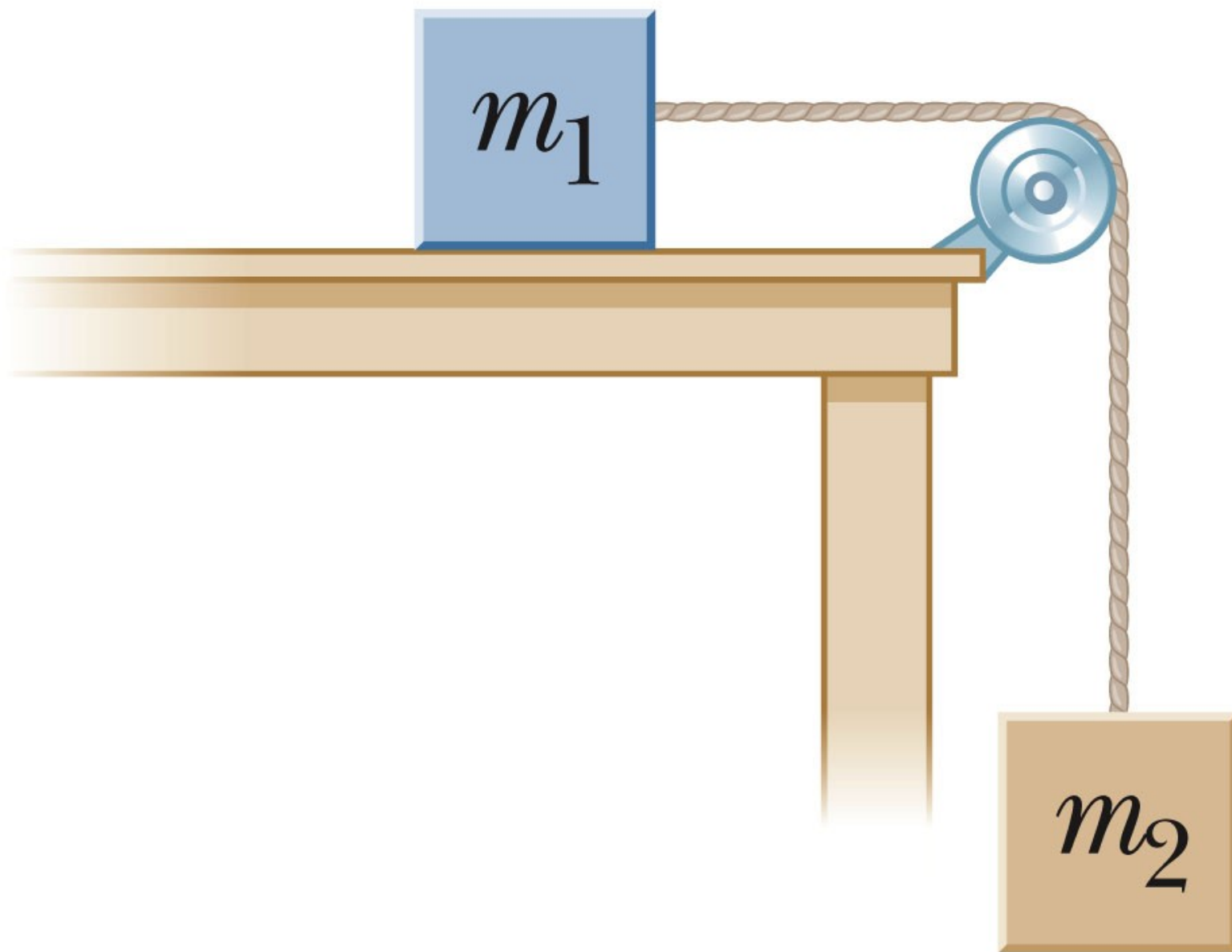
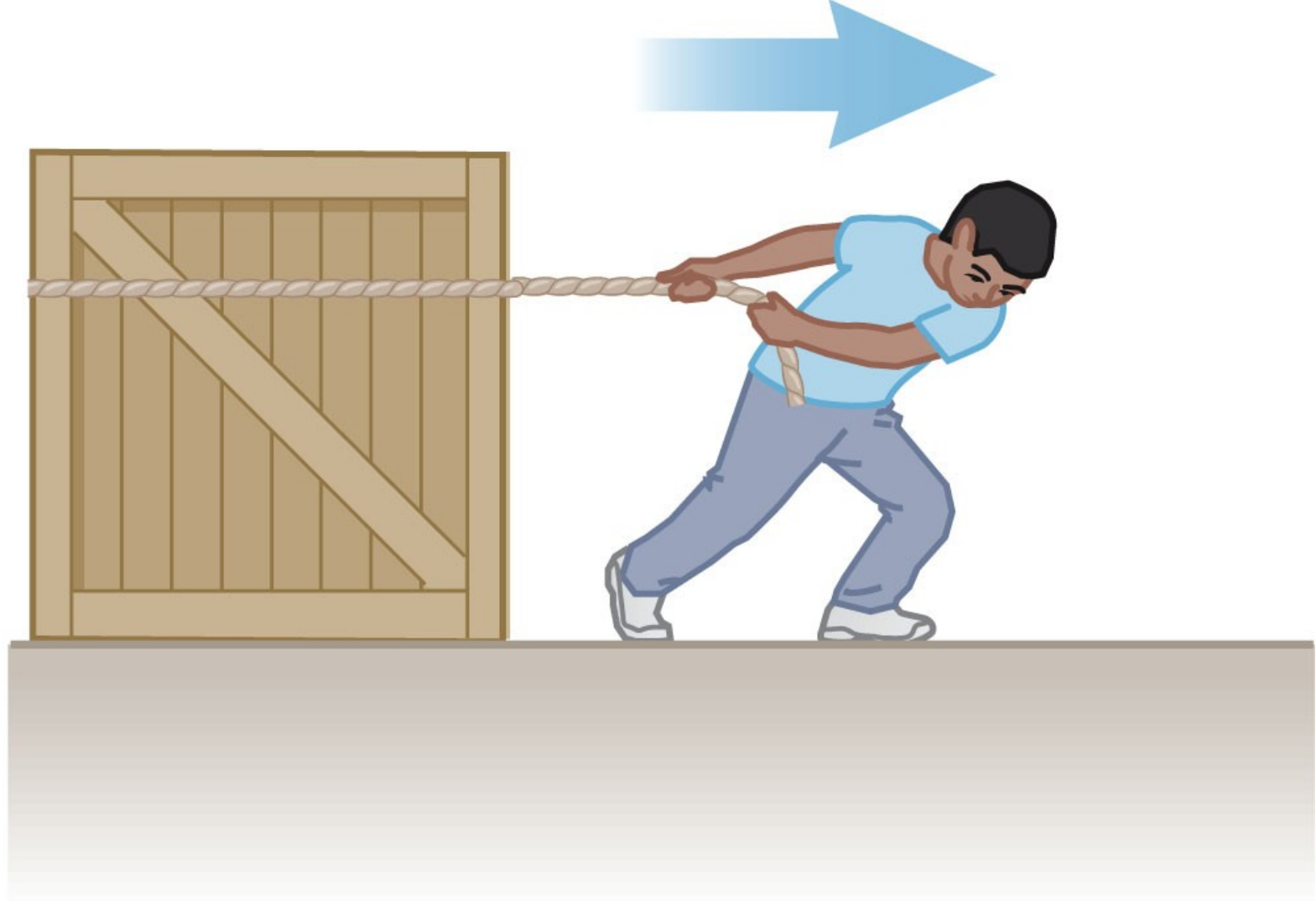
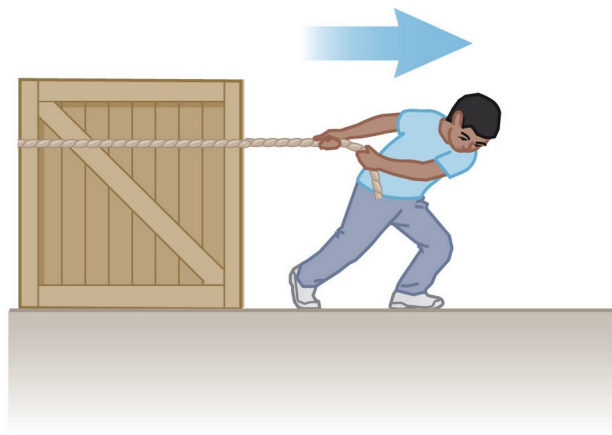


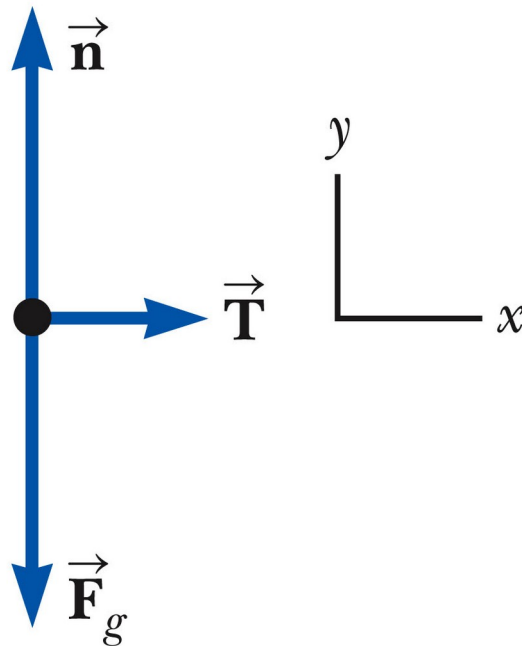
Fig. P5.28, p. 133



a



a



b

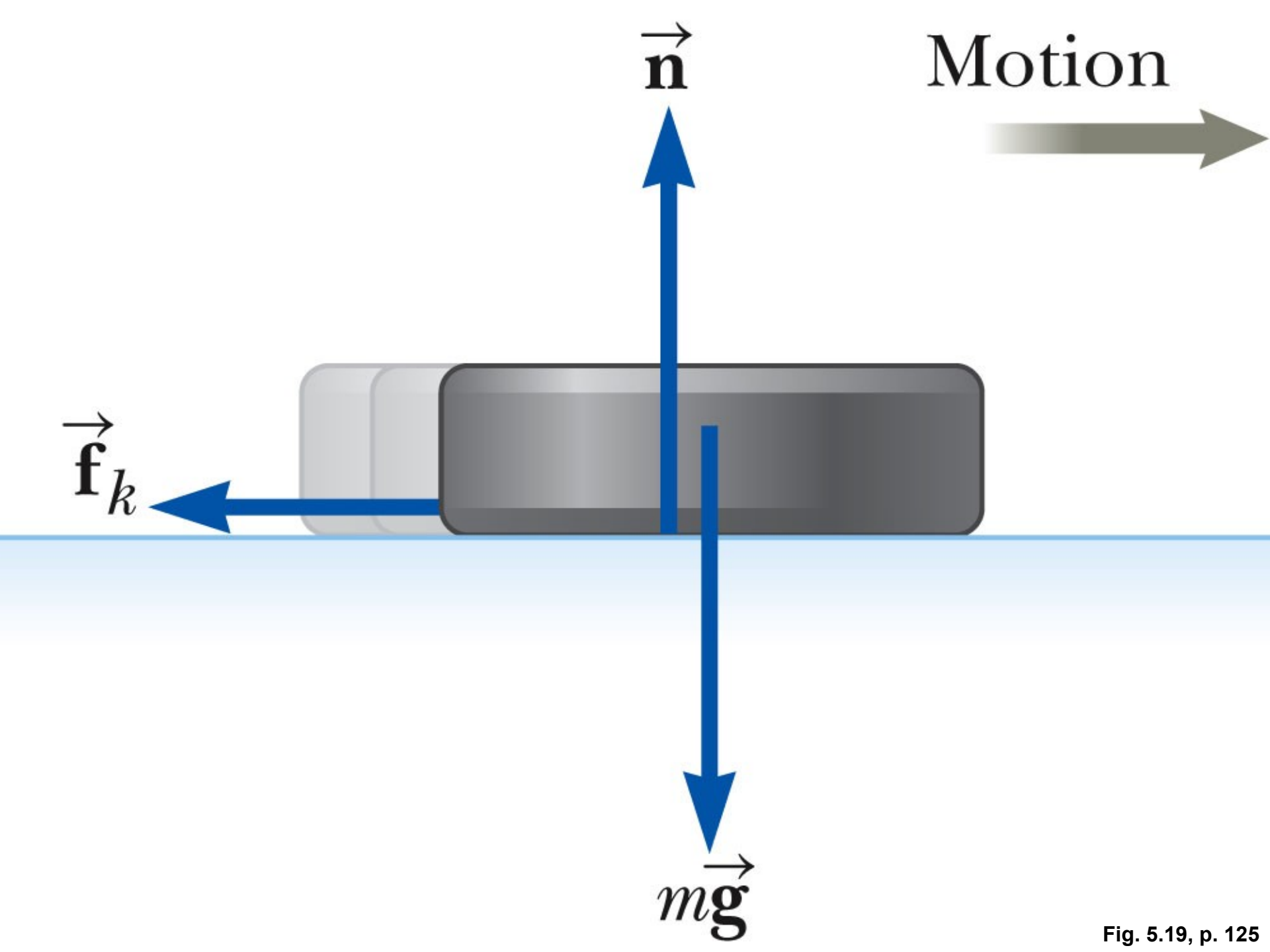
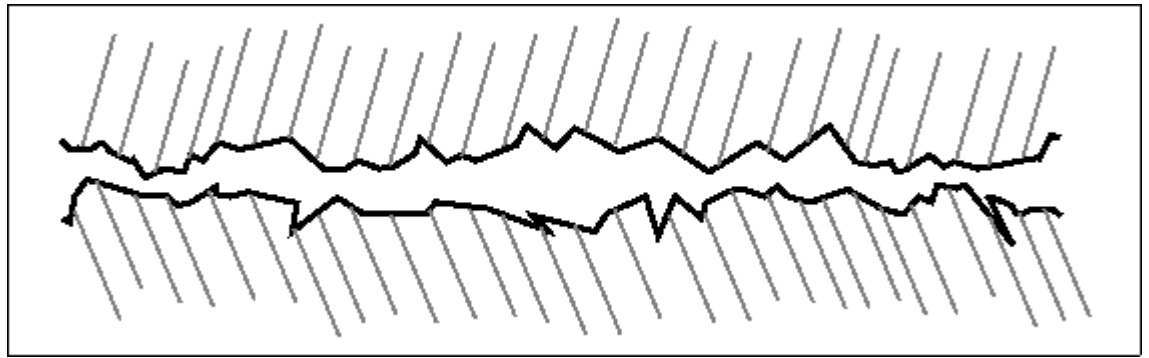
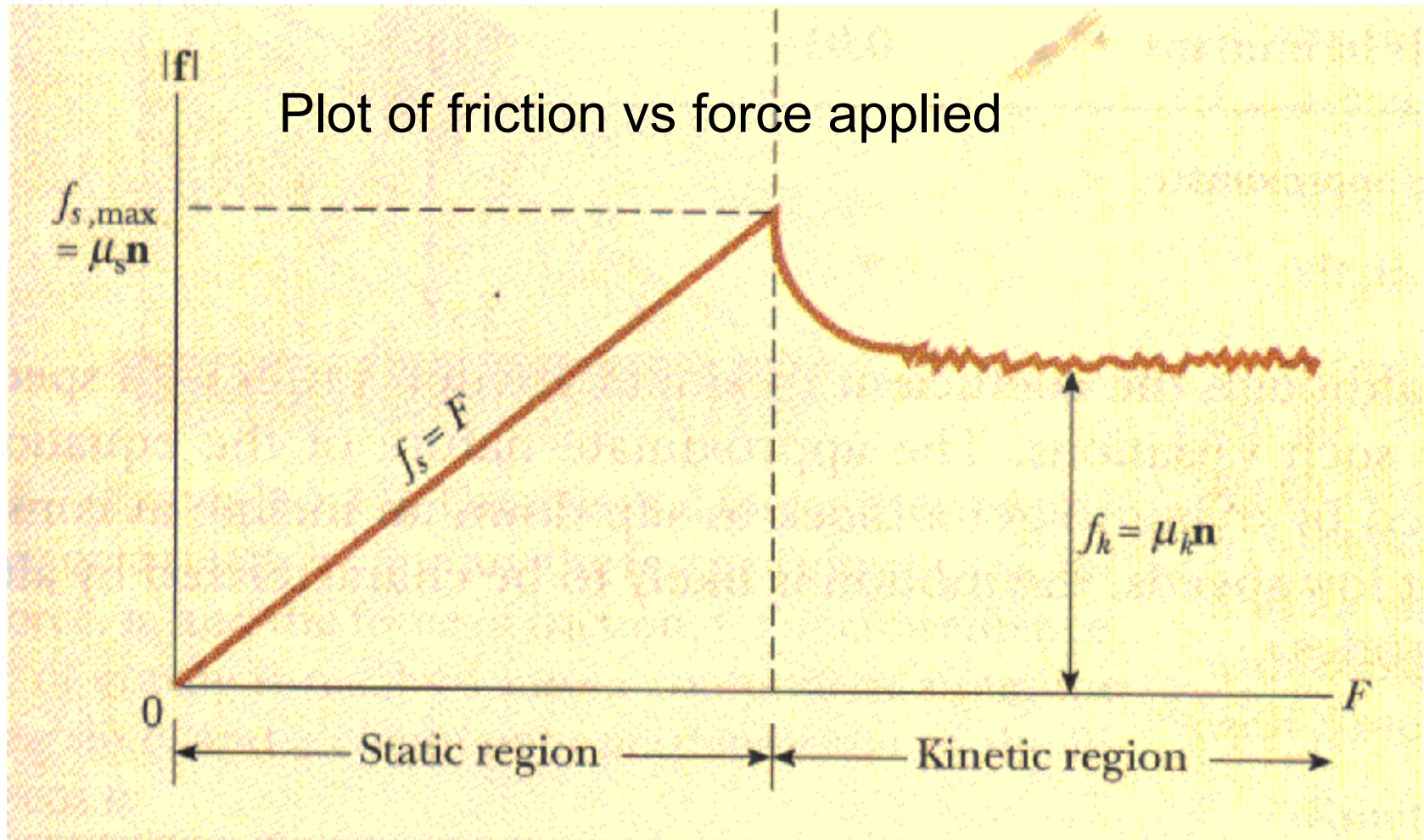


Fig. 5.19, p. 125

Close-up of  
surfaces.

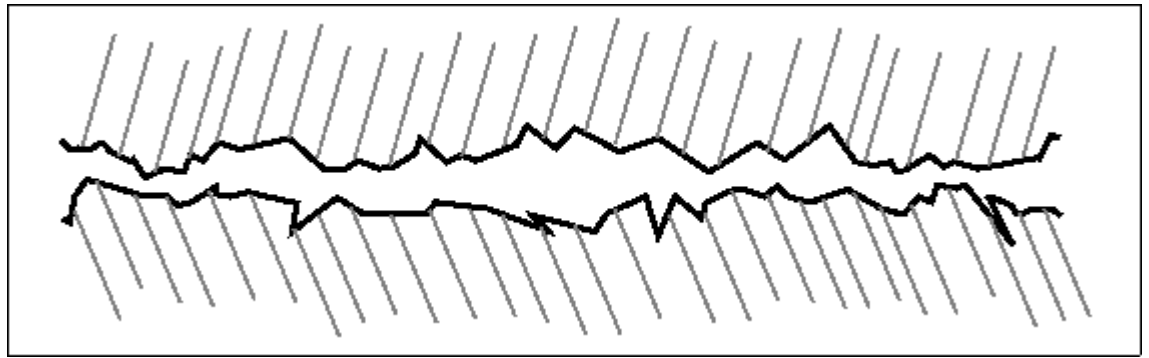


Plot of friction vs force applied

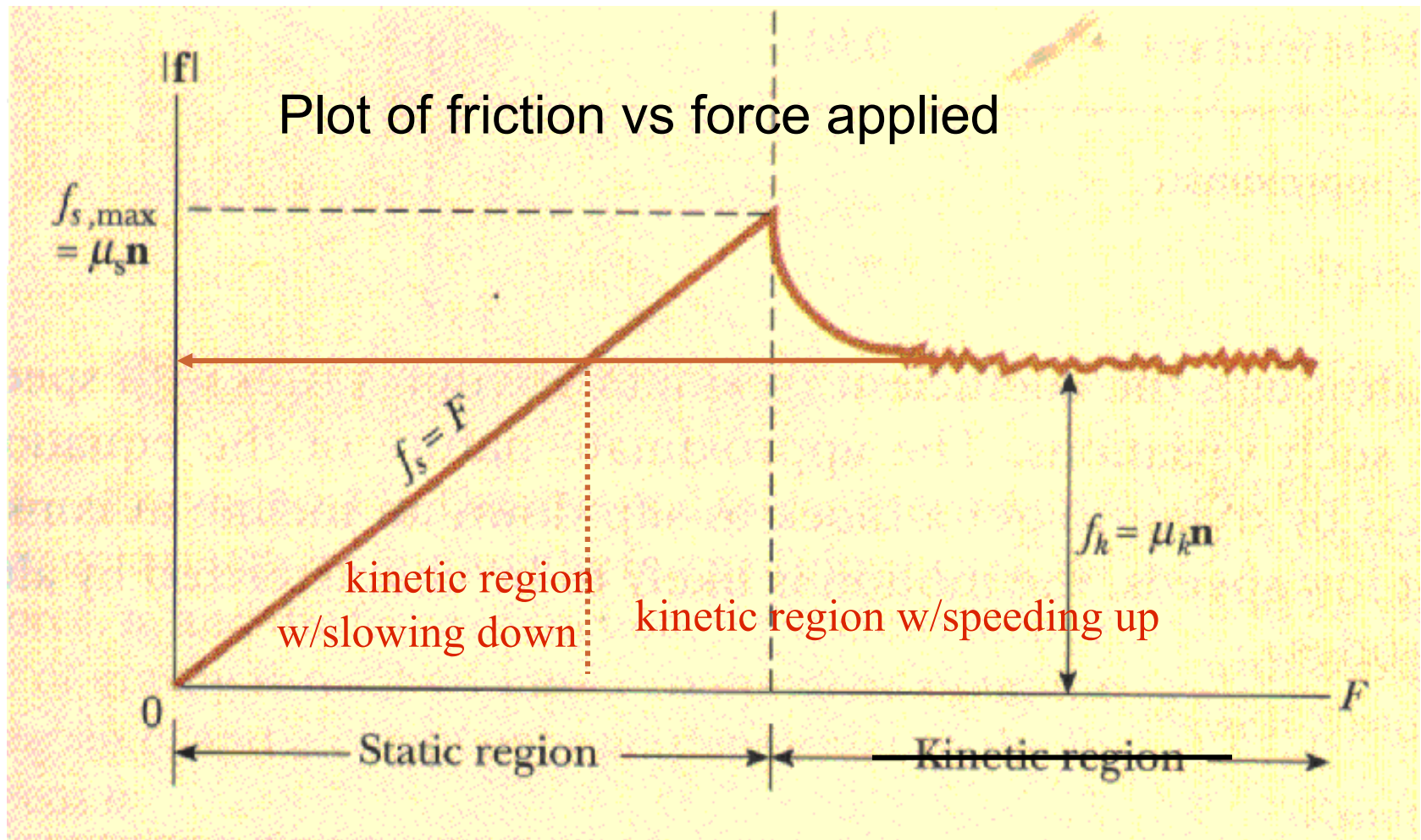




Close-up of  
surfaces.



Plot of friction vs force applied



**TABLE 5.1***Coefficients of Friction*

	$\mu_s$	$\mu_k$
Rubber on concrete	1.0	0.8
Steel on steel	0.74	0.57
Aluminum on steel	0.61	0.47
Glass on glass	0.94	0.4
Copper on steel	0.53	0.36
Wood on wood	0.25–0.5	0.2
Waxed wood on wet snow	0.14	0.1
Waxed wood on dry snow	—	0.04
Metal on metal (lubricated)	0.15	0.06
Teflon on Teflon	0.04	0.04
Ice on ice	0.1	0.03
Synovial joints in humans	0.01	0.003

*Note:* All values are approximate. In some cases, the coefficient of friction can exceed 1.0.

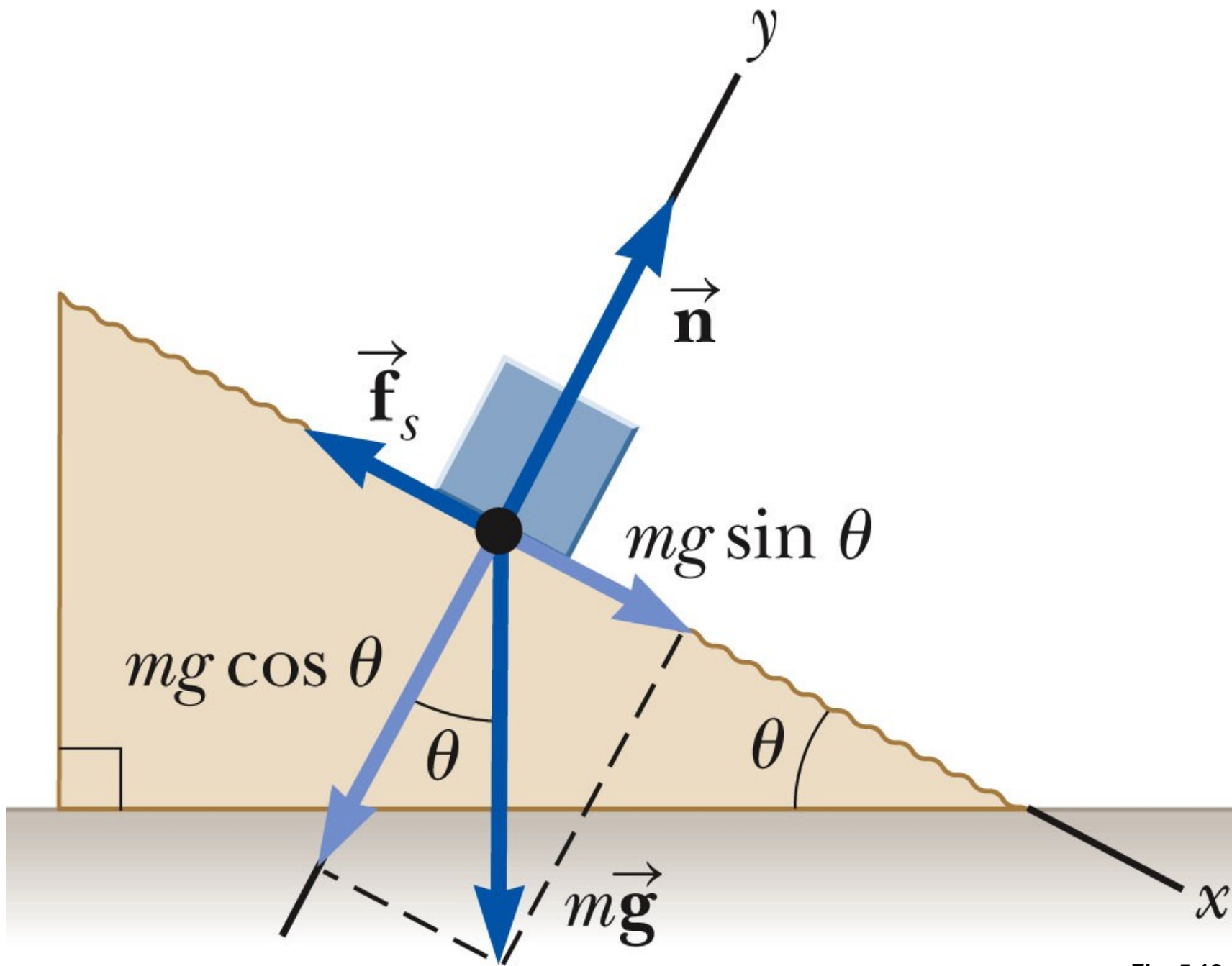


Fig. 5.18, p. 124