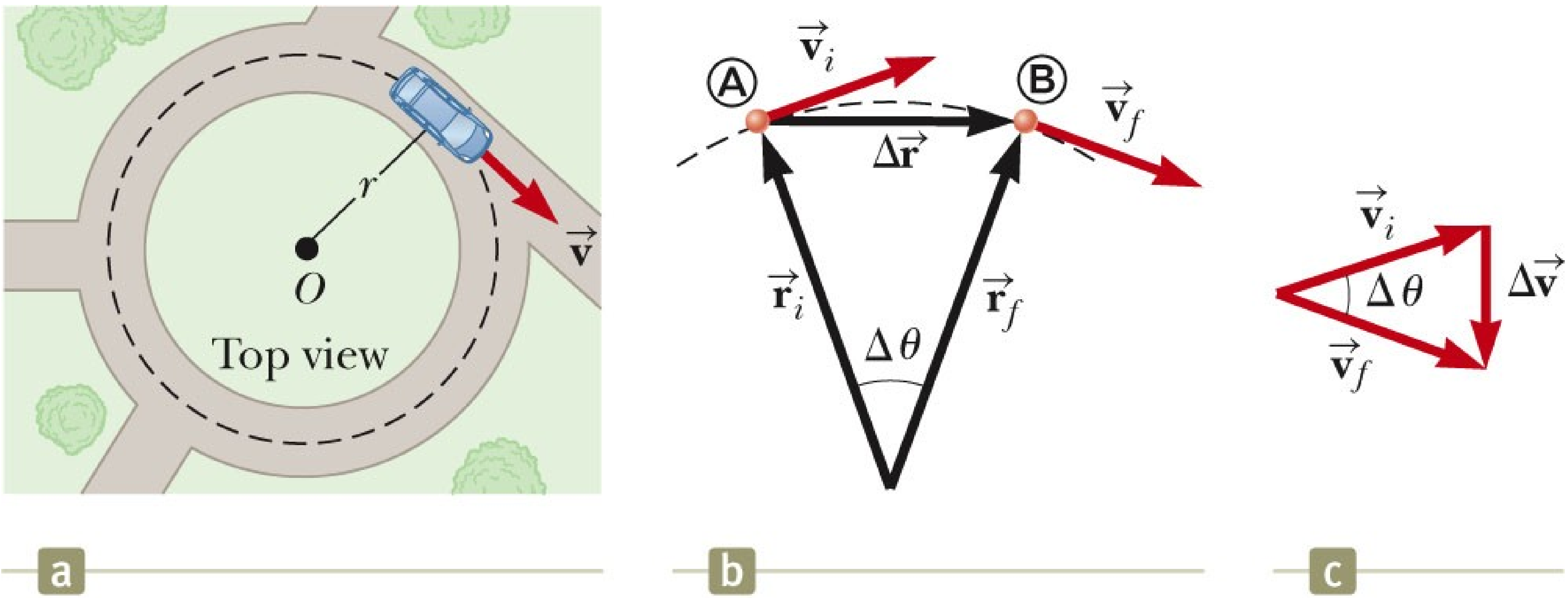
Week 5 outline

Chapter 4. Review circular motion
Chapter 5. The Laws of Motion

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



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

Fig. 4.15, p. 86

Total acceleration – sum of tangential and centripetal components

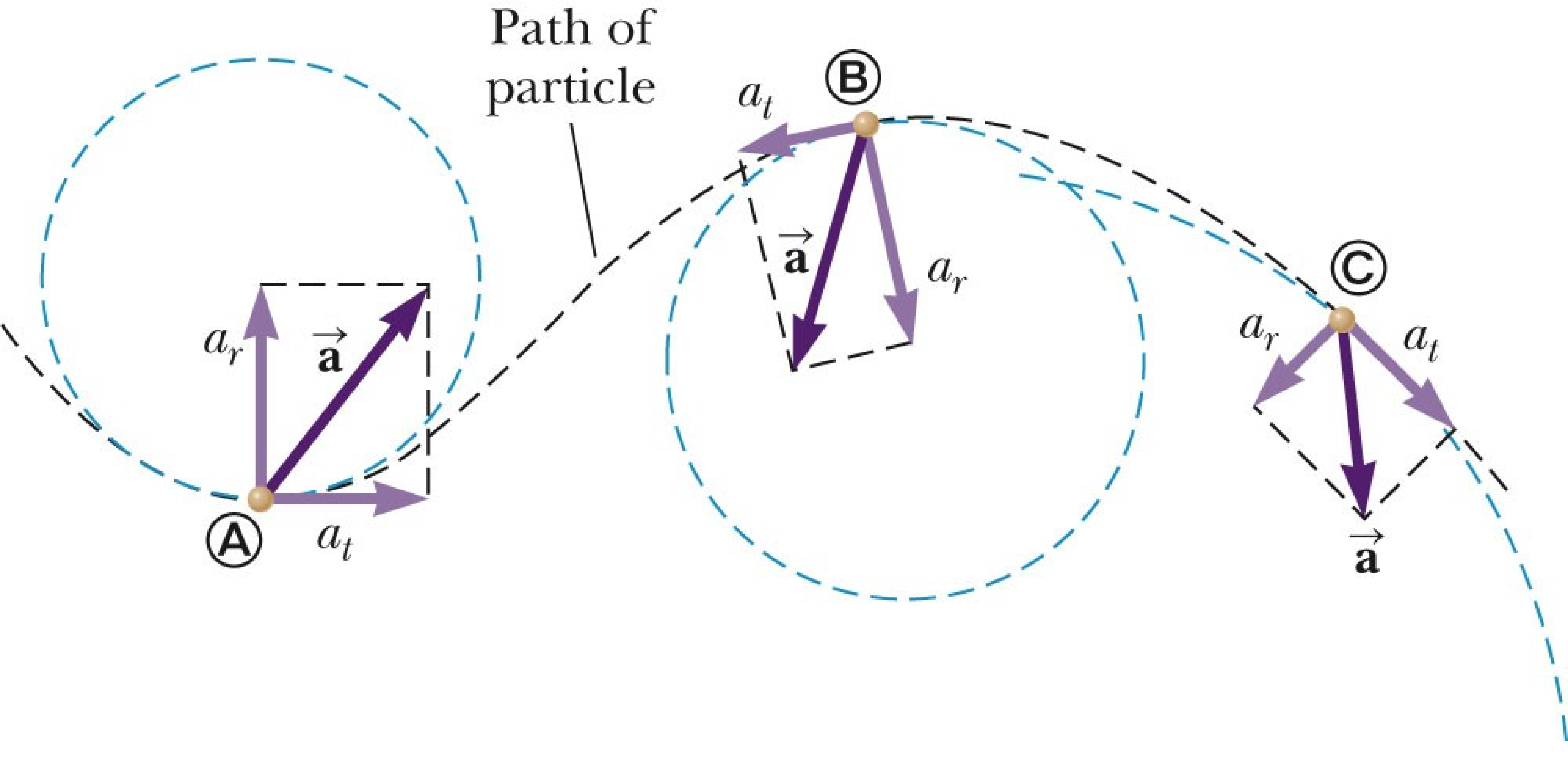


Fig. 4.16, p. 88

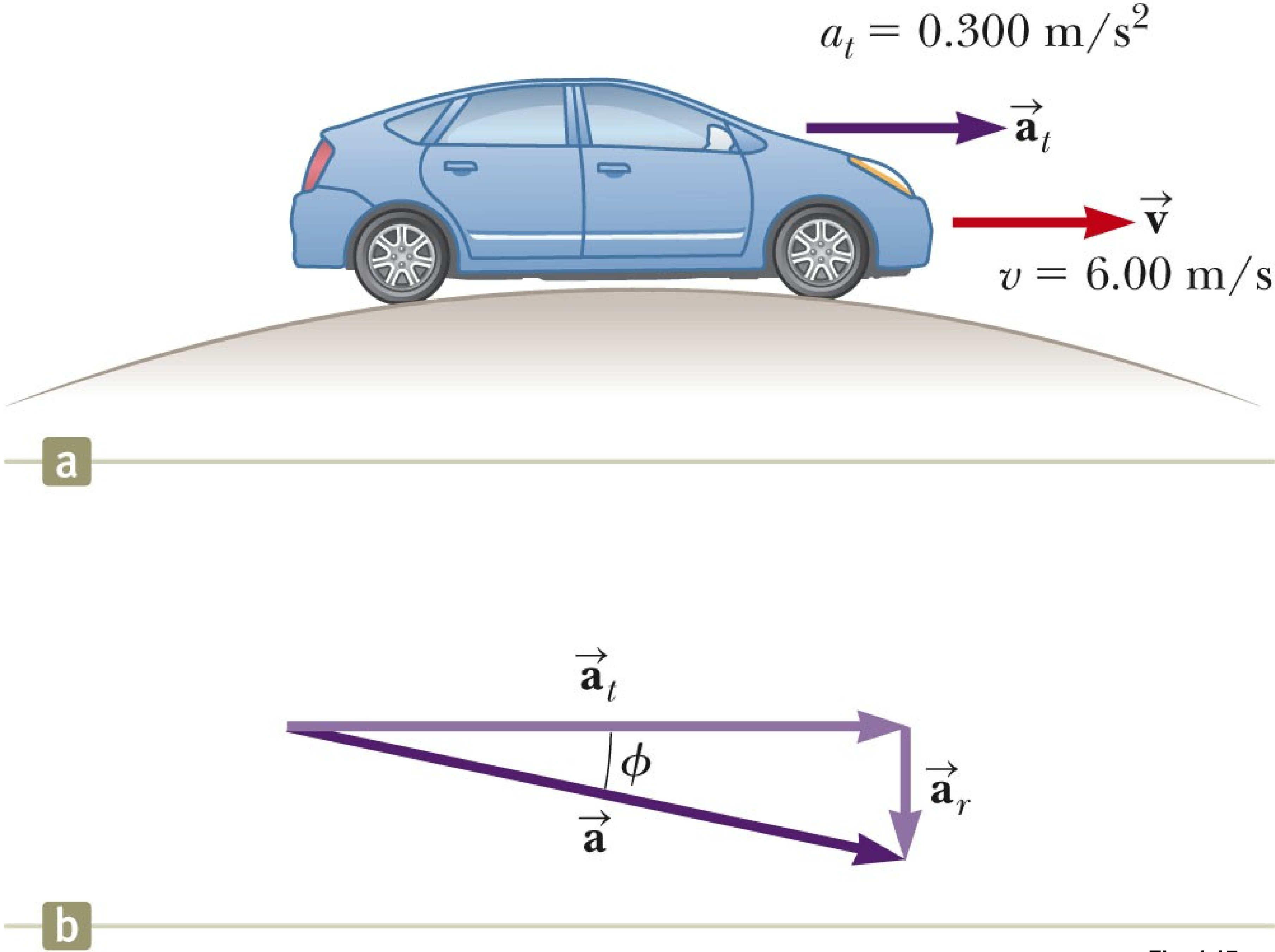

$a_t = 0.300 \text{ m/s}^2$
$\vec{a}_t$
$\vec{v}$
$v = 6.00 \text{ m/s}$
a
$\vec{a}_t$
ϕ
$\vec{a}_r$
$\vec{a}$
b

Fig. 4.17, p. 89

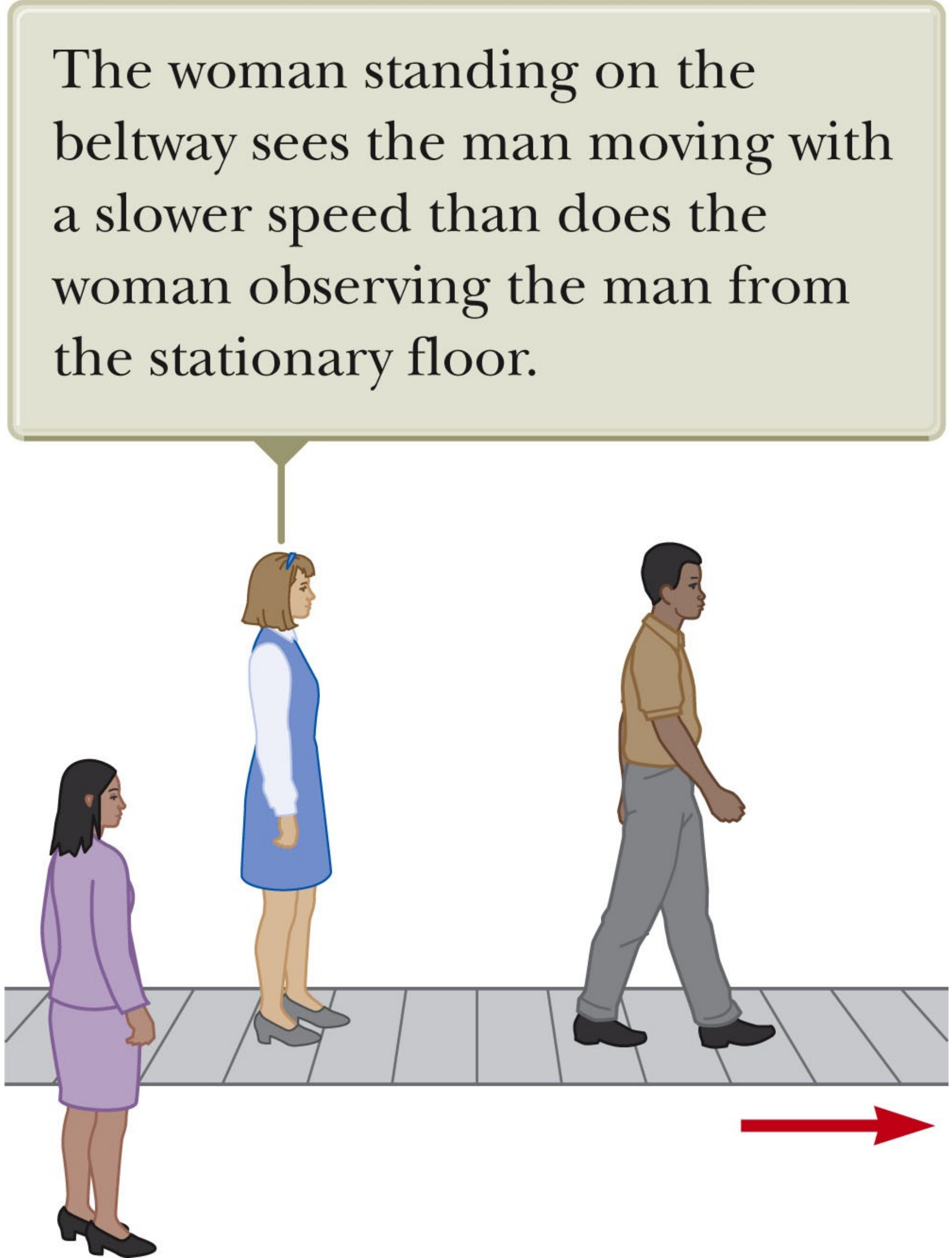
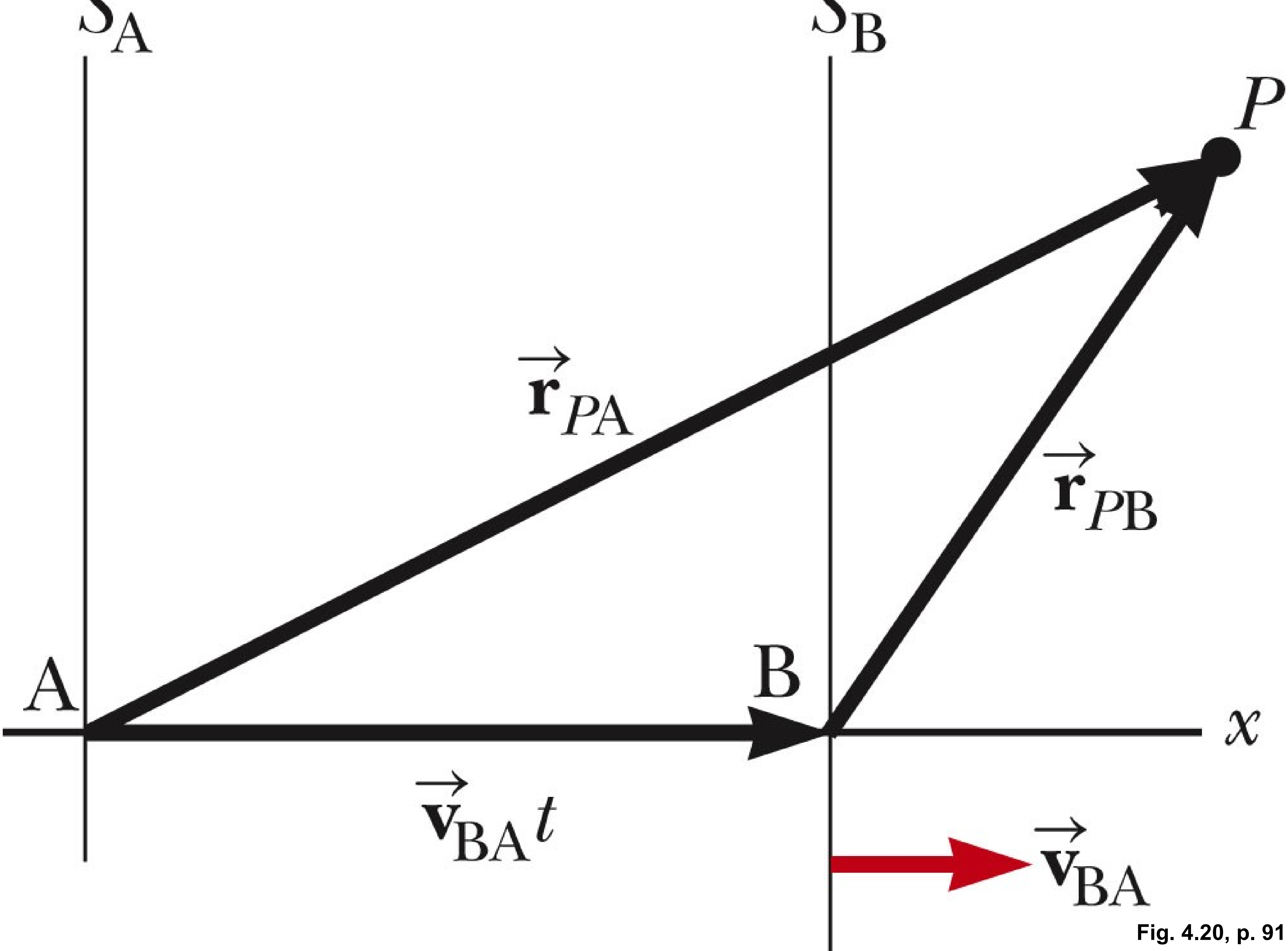

The woman standing on the beltway sees the man moving with a slower speed than does the woman observing the man from the stationary floor.

Fig. 4.19, p. 90



S_A
S_B
P
$\vec{\mathbf{r}}_{PA}$
$\vec{\mathbf{r}}_{PB}$
A
B
x
$\vec{\mathbf{v}}_{BA}t$
$\vec{\mathbf{v}}_{BA}$

Fig. 4.20, p. 91

Forces – the *cause* of acceleration

Forces are vectors

Forces act between systems (the dashed boxes)

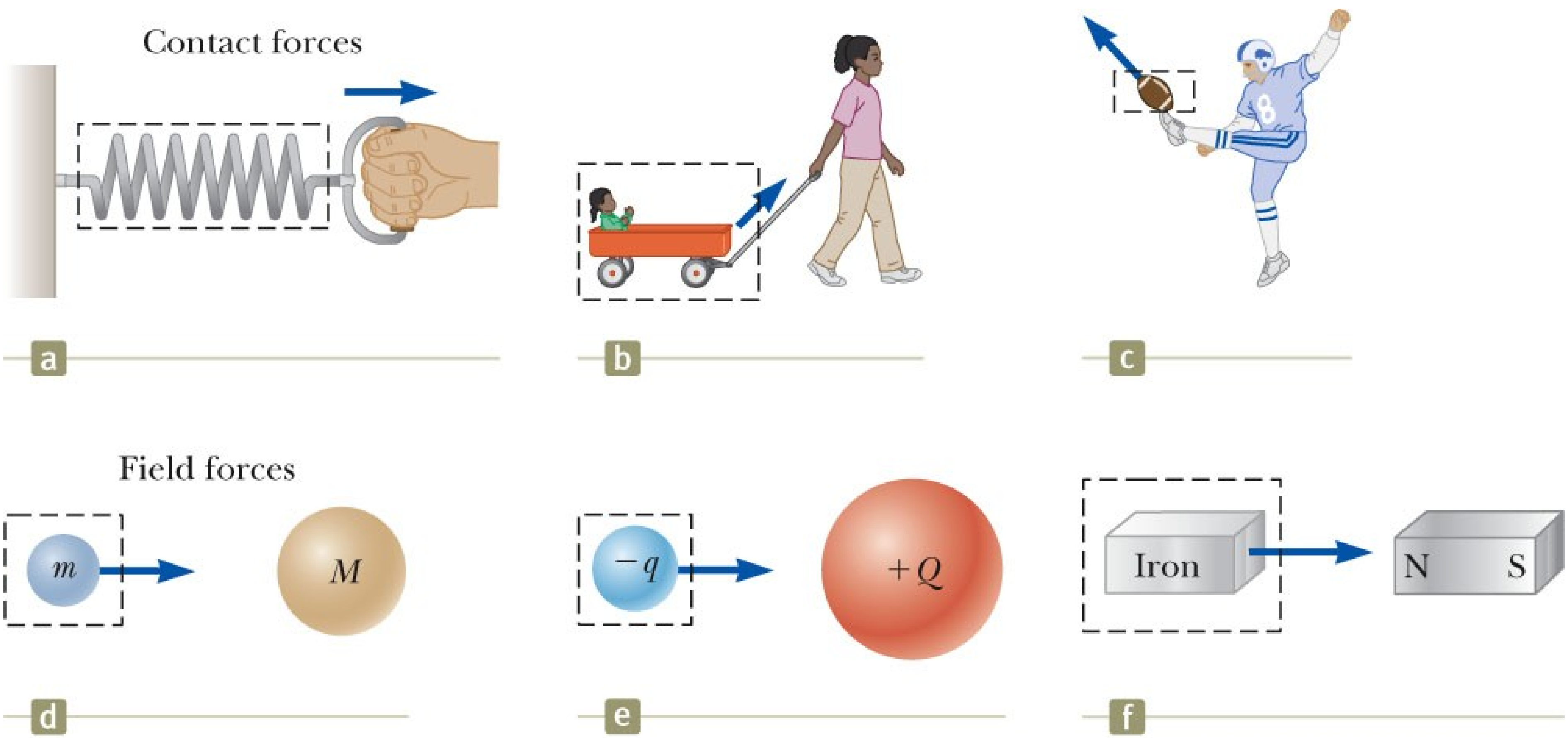
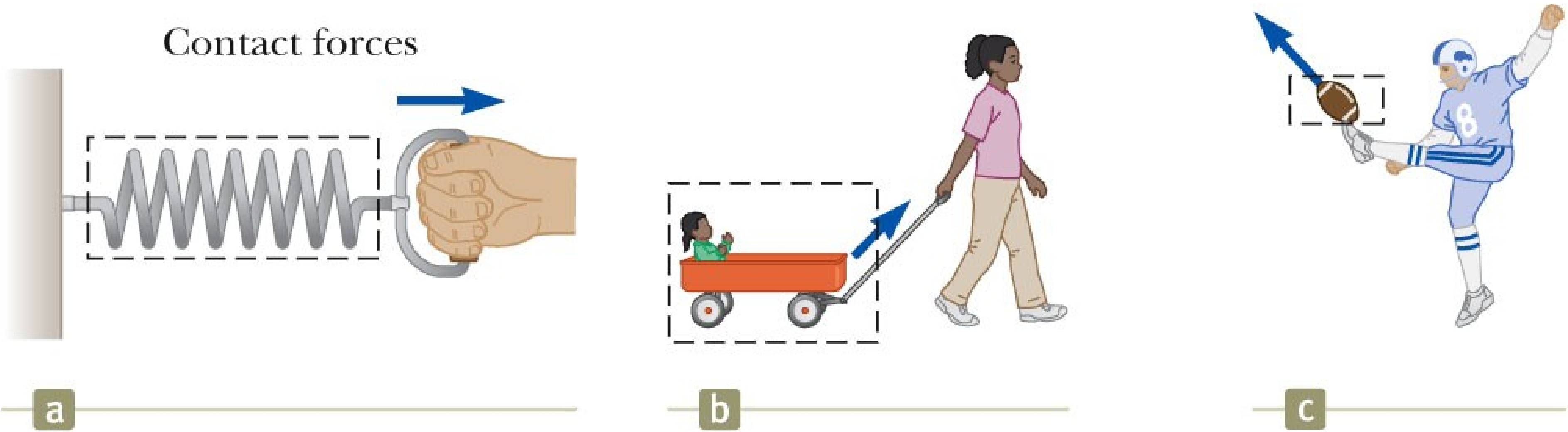


Fig. 5.1, p. 104

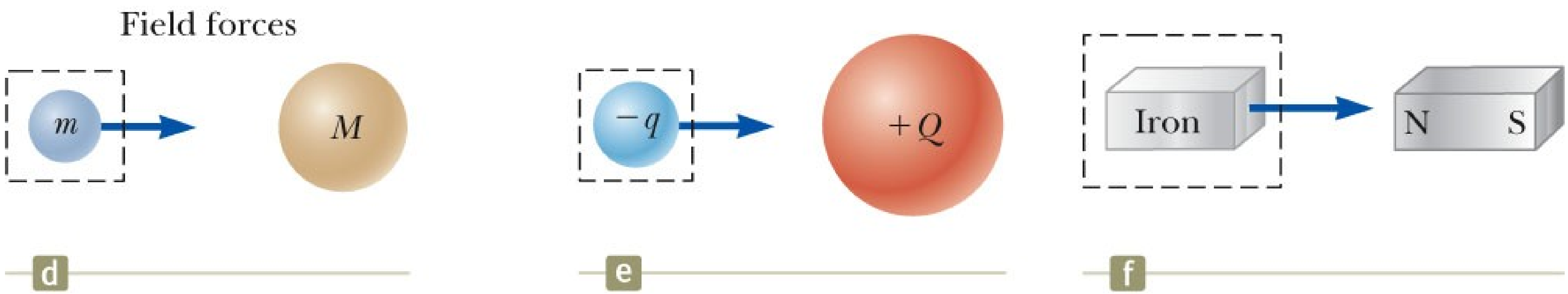
Types of forces



contact forces
- tension – pulling apart
- compression – pushing together
- shear – pushing tangentially
- torsion - twisting

Fig. 5.1, p. 104

Types of forces



Field forces

gravitational electric magnetic

Fig. 5.1, p. 104

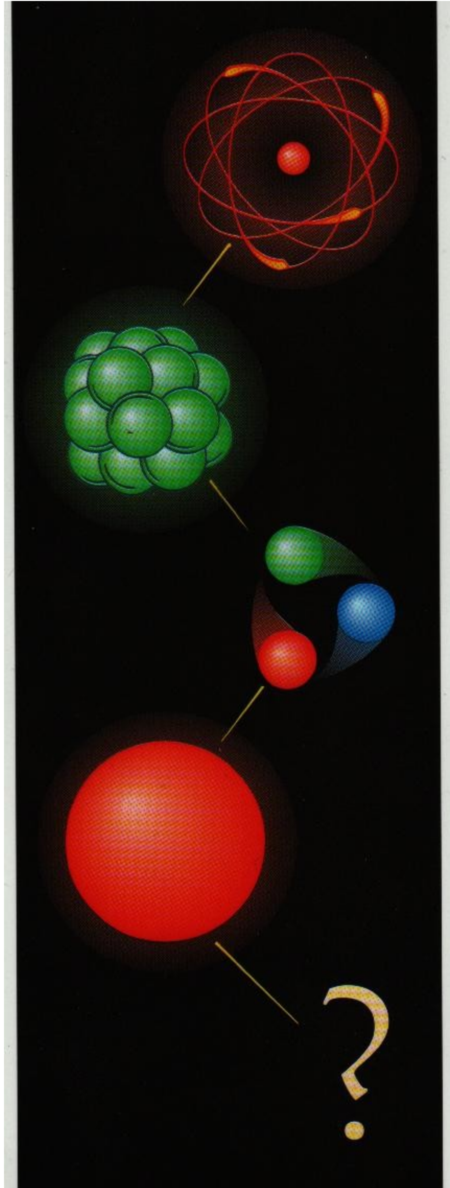
The 4 Fundamental forces

Gravity

Electromagnetic Force

Nuclear Strong Force – holds nuclei together

Nuclear Weak force – decay of n and p

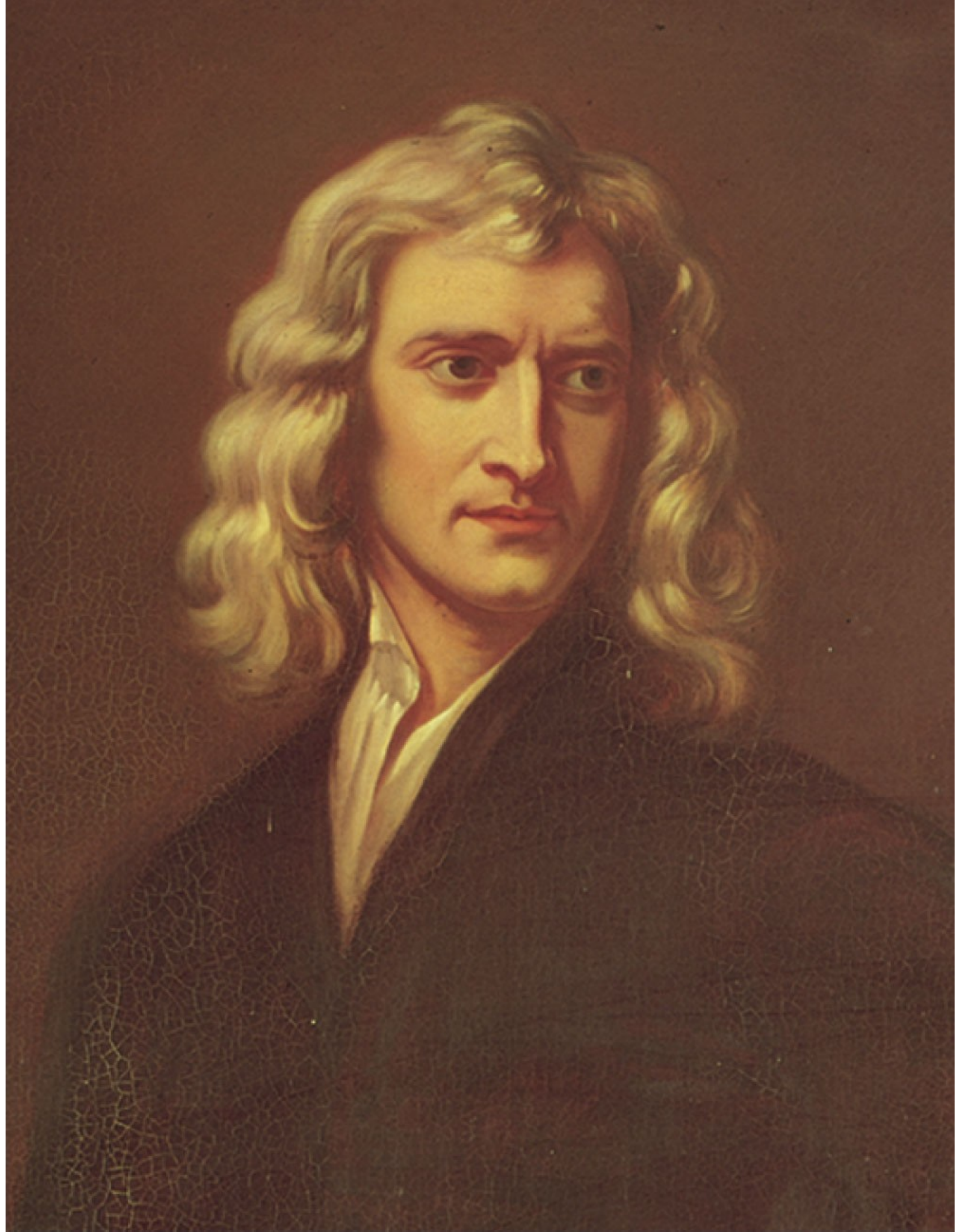


Distances at the frontier of nuclear physics are astonishingly short. An atom is so small that 250,000 fit into the thickness of aluminum foil. The nucleus at the atom's center is a cluster of nucleons, each 100,000 times smaller than the atom itself. The three quarks inside each nucleon are smaller still.

Isaac Newton
(1642 - 1727)

3 laws of motion

1 law of Universal
Gravitation

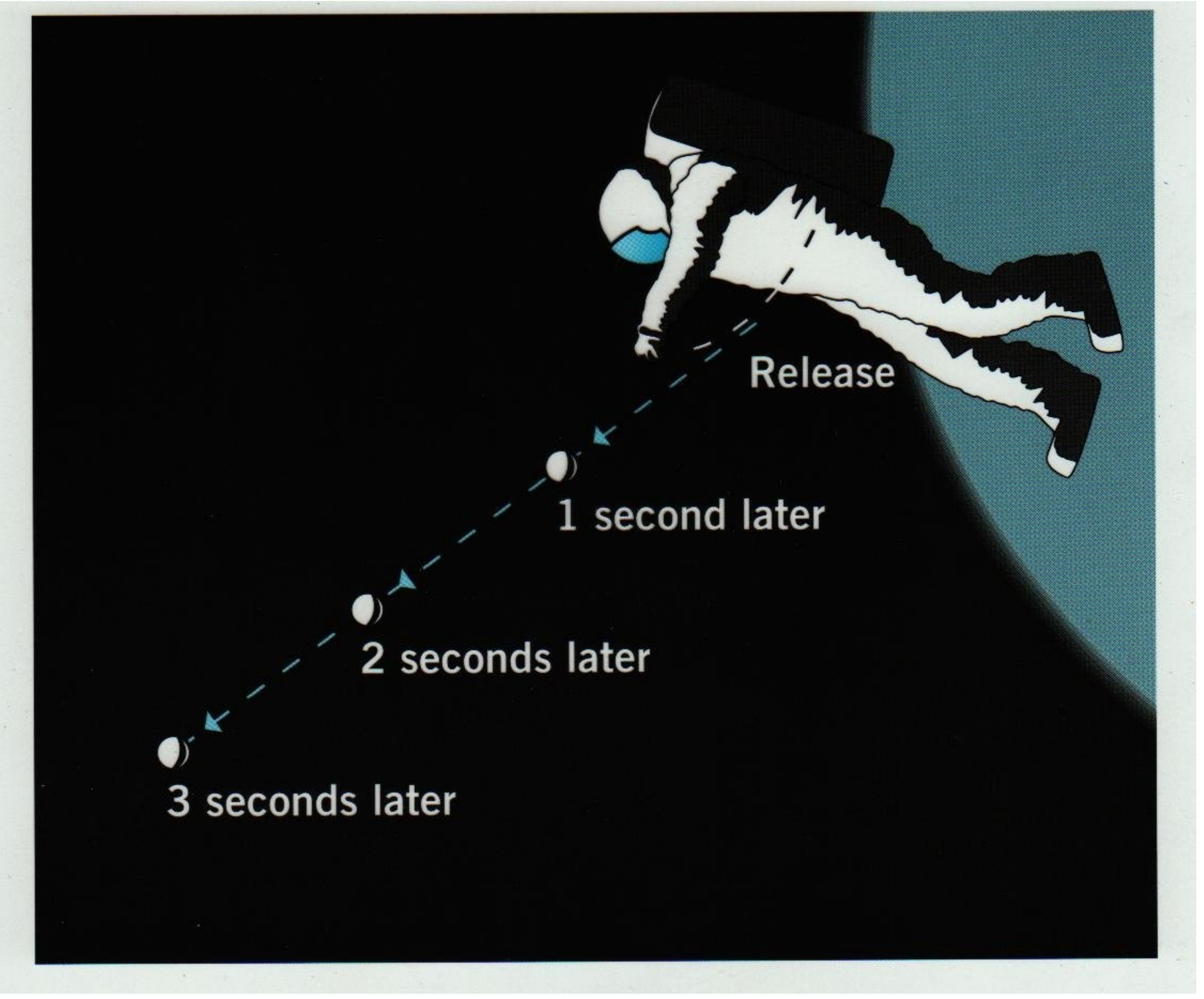


Newton's 1st law = inertial frames of reference exist such that an object will move with a constant velocity if no forces act upon it.

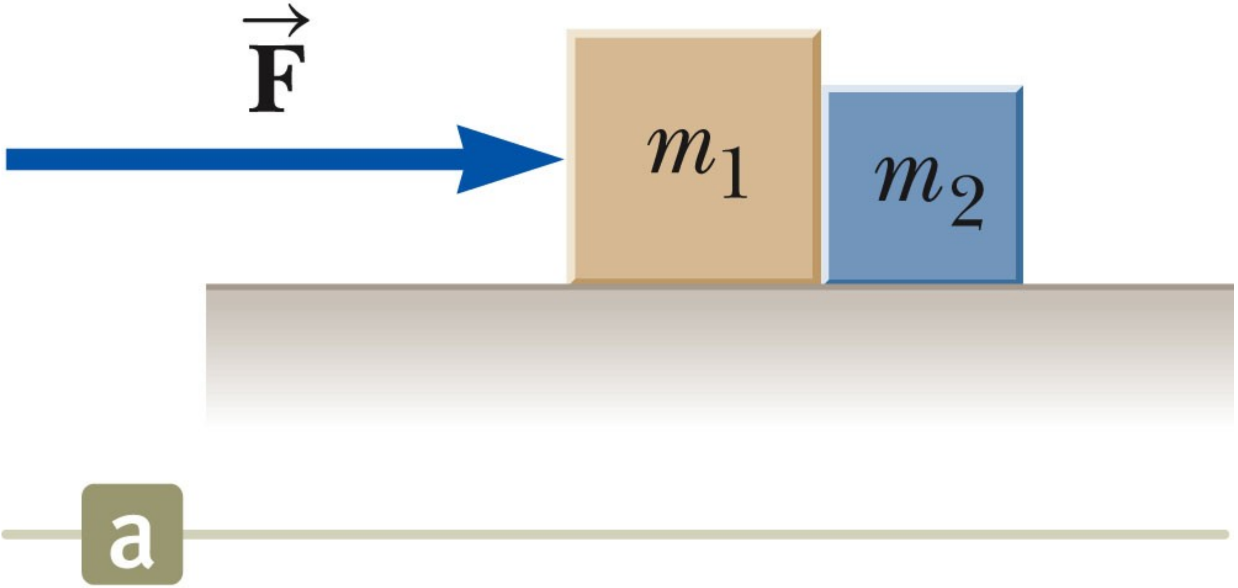
Overthrows Aristotle and medieval thought:

“natural state” is at rest

“impetus” pushes an arrow along



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

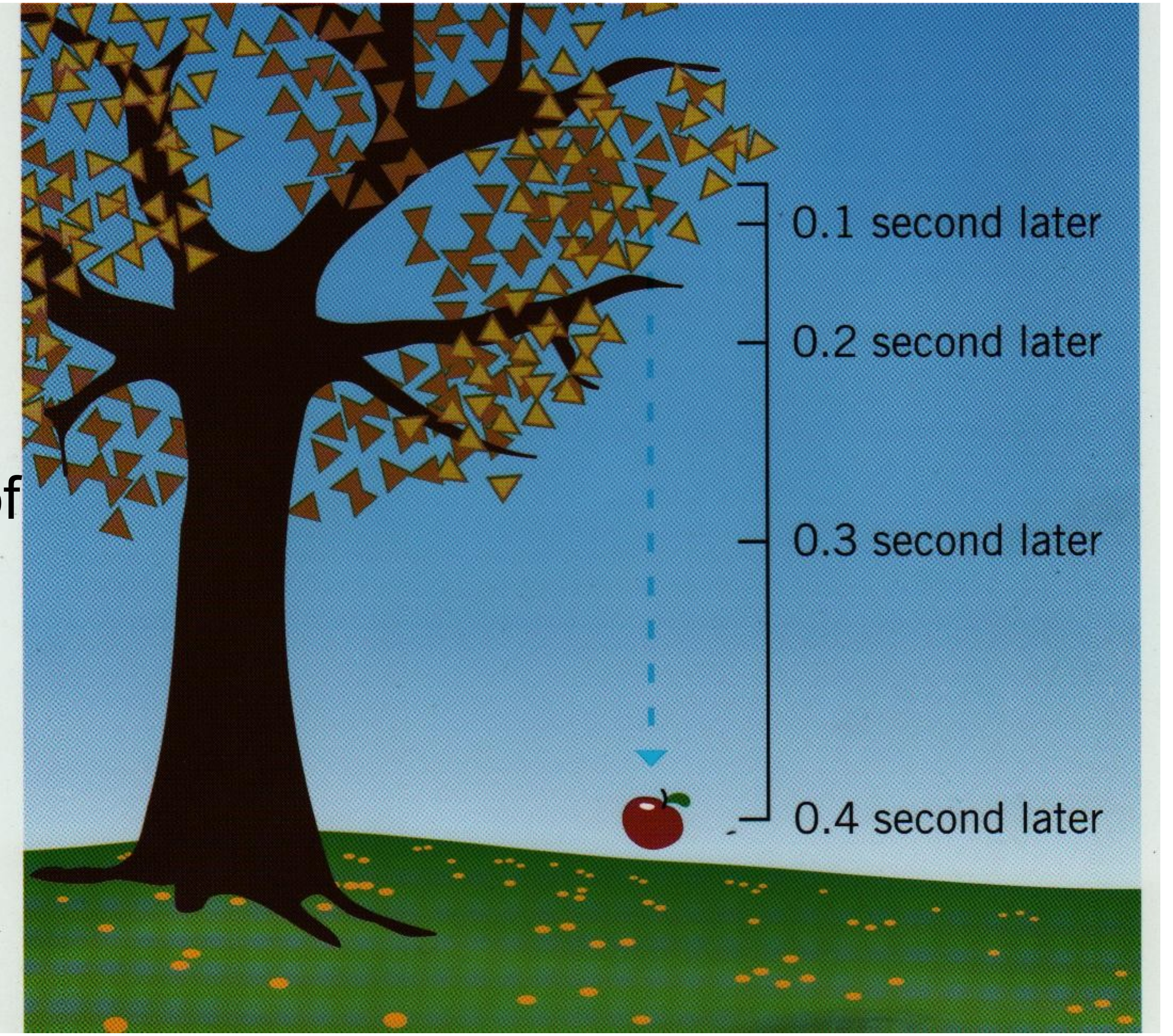


$$\vec{a} = \frac{\vec{F}_{net}}{m}$$

If same force acts on m1, m2, and m1+m2, the accelerations are different.

Newton's 2nd law (cont.)

Example: gravity



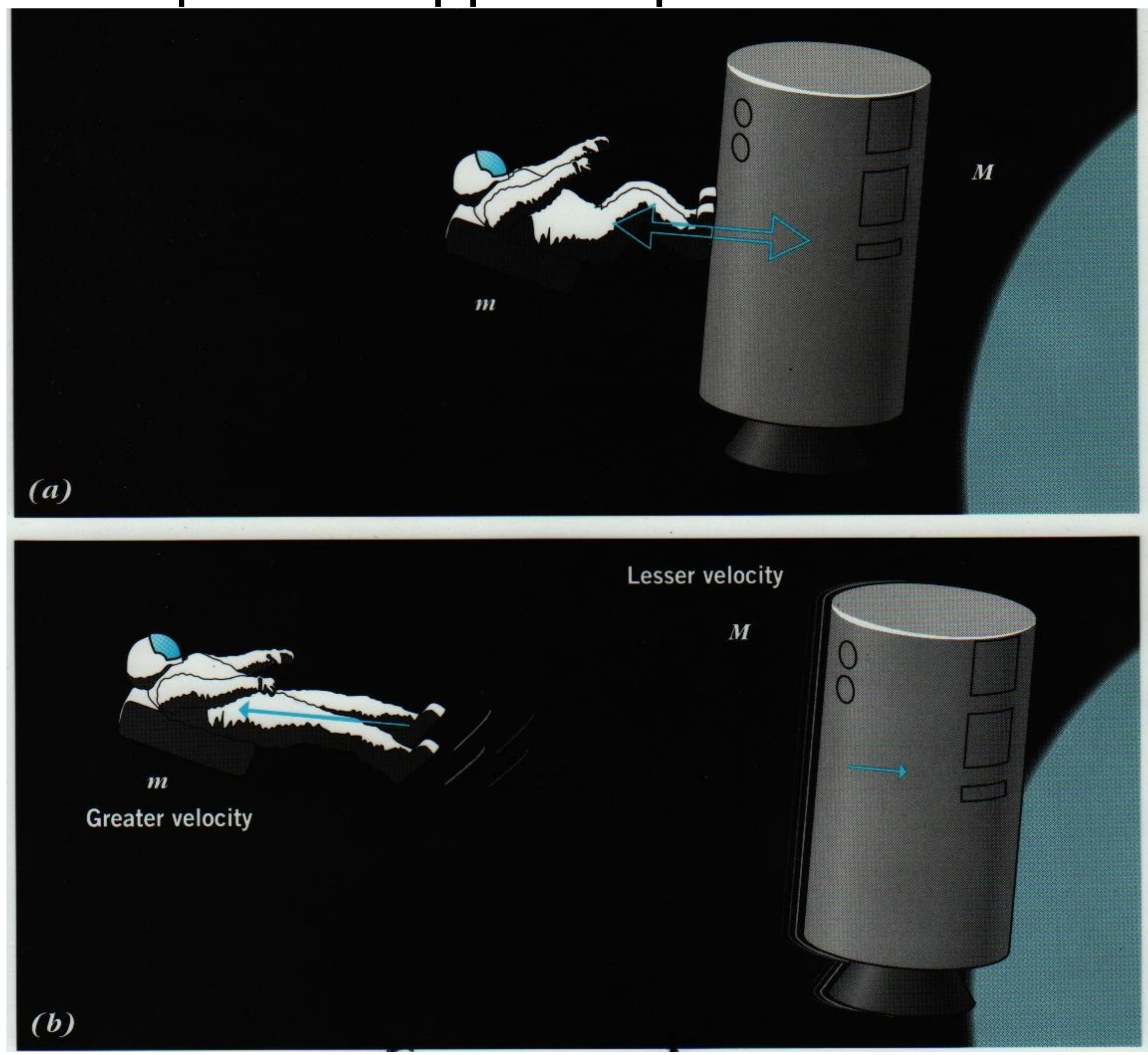
Weight = the force of gravity on an object

Mass = the amount of matter in an object

Newton's 3rd law (cont.)

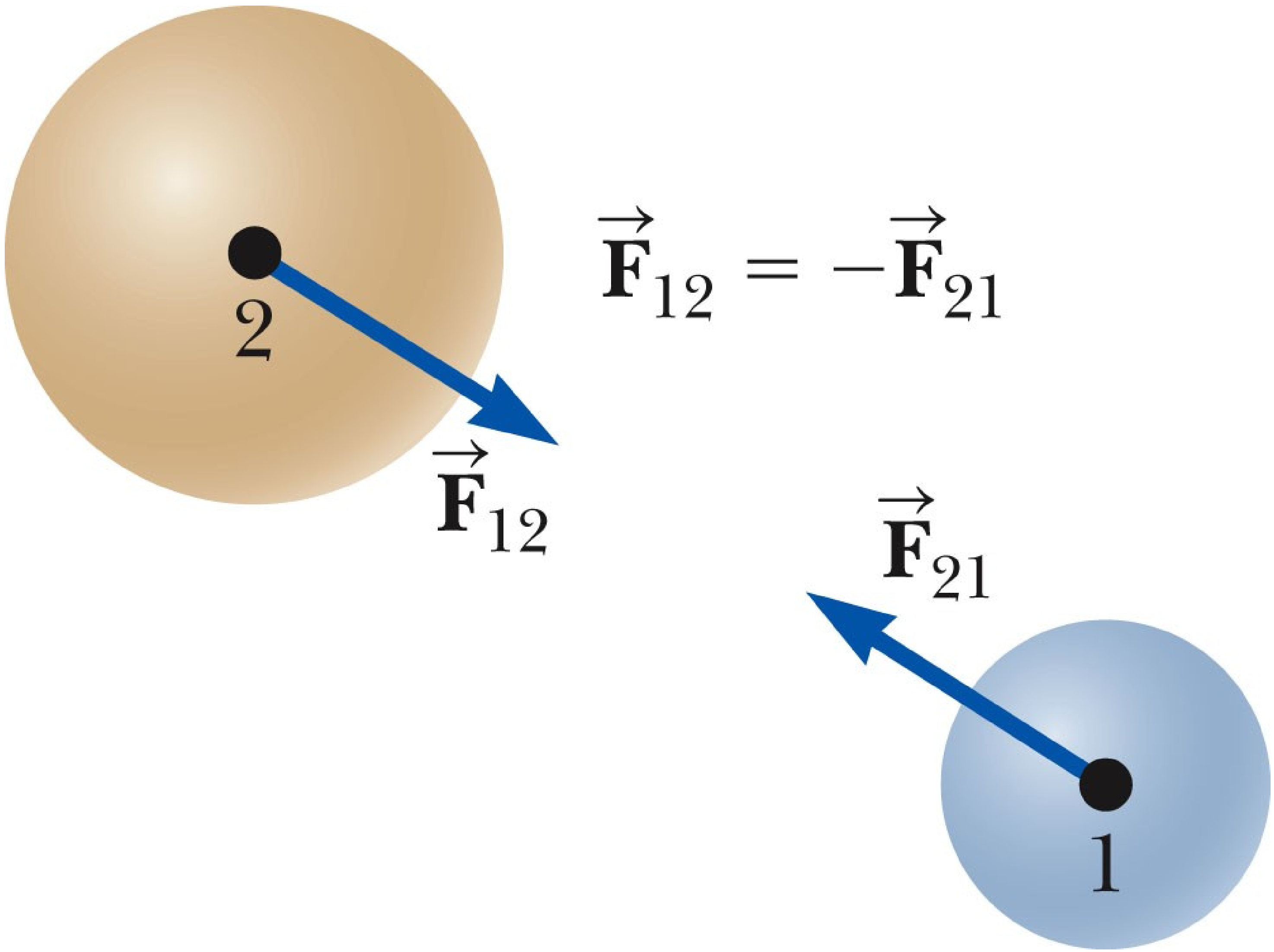
"For every action there is an equal but opposite reaction."
"Forces come in equal but opposite pairs."

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



Newton's 3rd law (cont.)

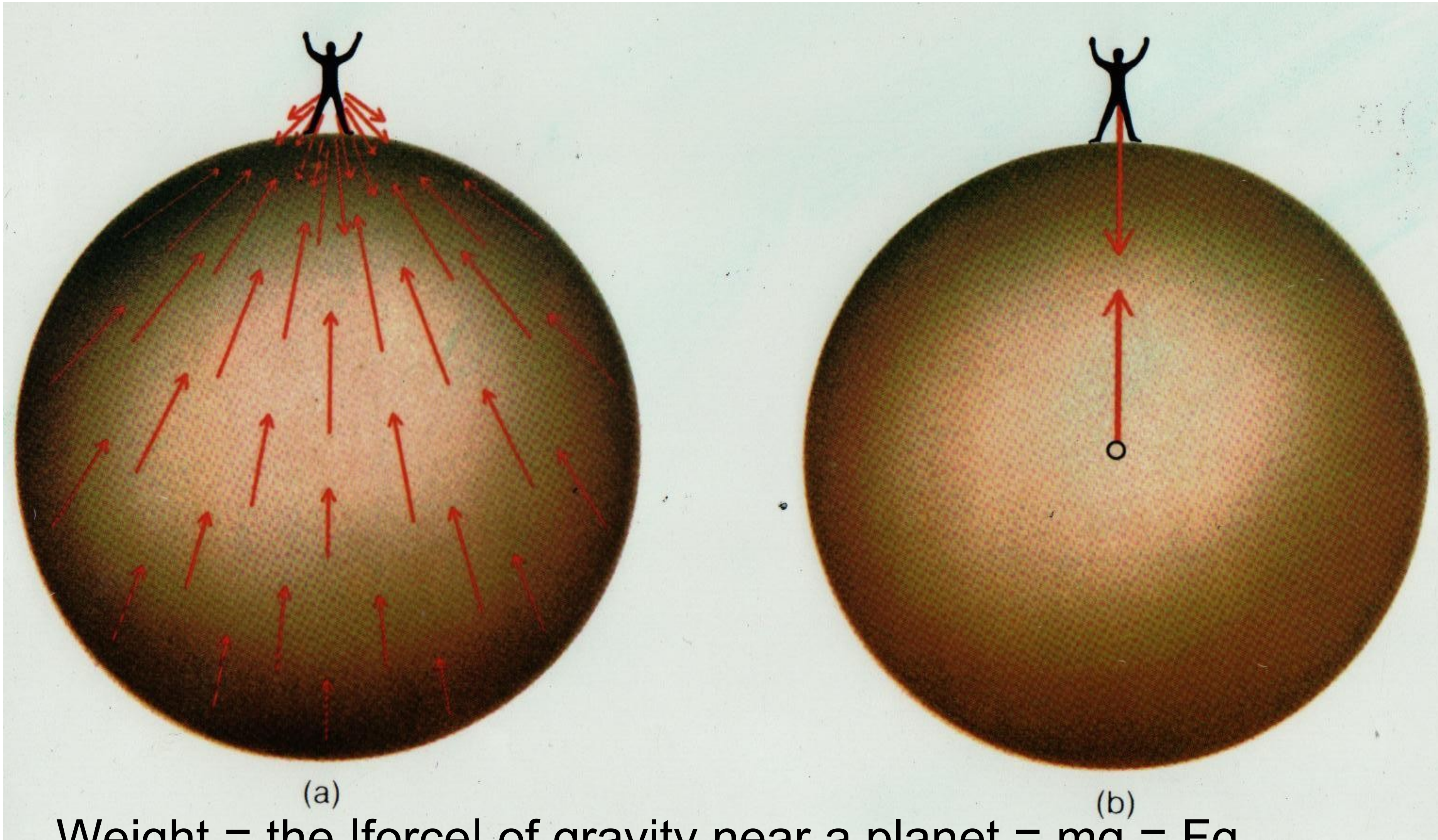
Gravity and the electromagnetic forces obey Newton's 3rd.



$$\vec{\mathbf{F}}_{12} = -\vec{\mathbf{F}}_{21}$$

Fig. 5.5, p. 111

Newton's 3rd law (cont.)



Weight = the |force| of gravity near a planet = mg = Fg
Apparent weight may differ in accelerating reference frames or when buoyant forces are present.

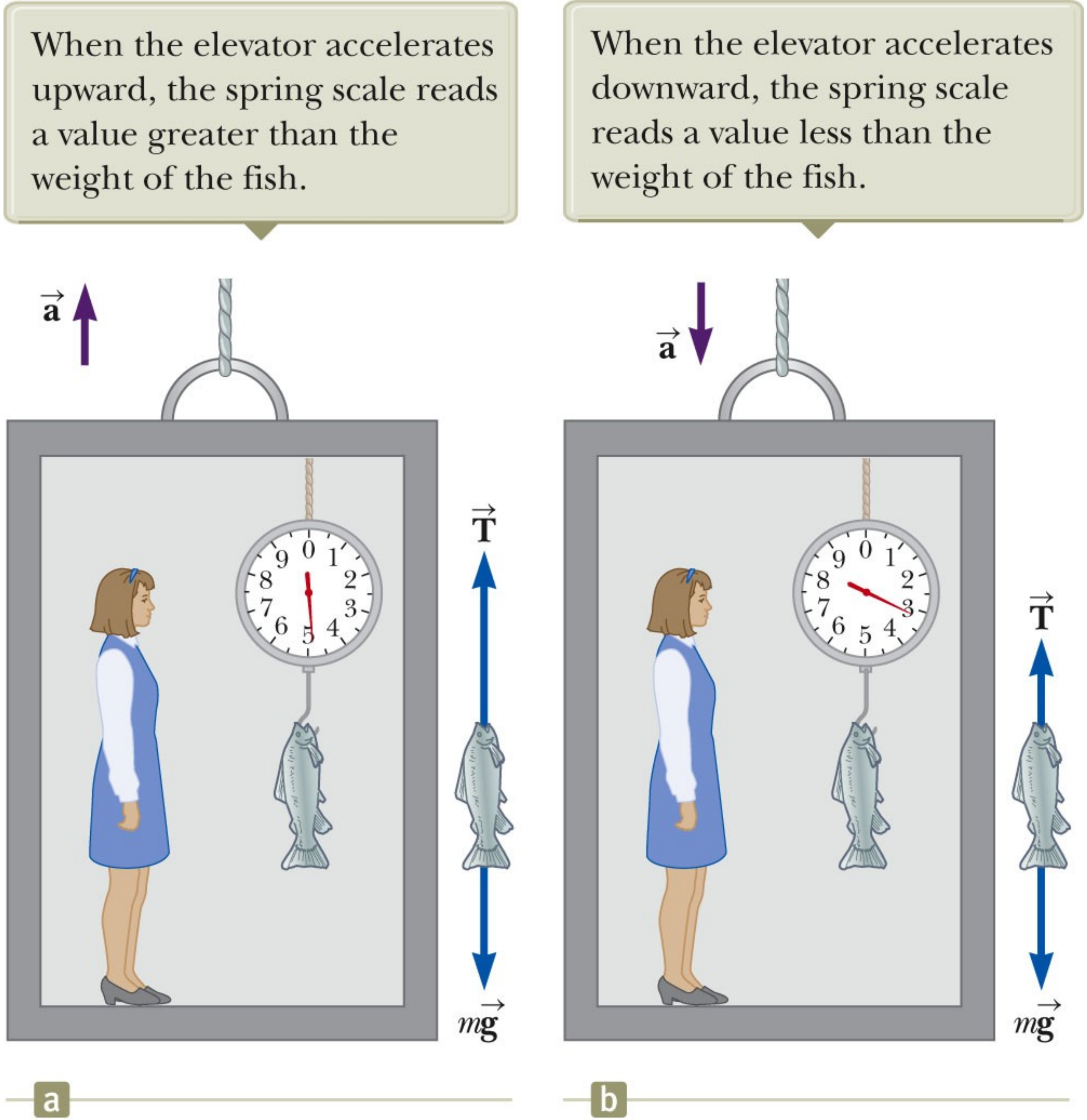

When the elevator accelerates upward, the spring scale reads a value greater than the weight of the fish.
When the elevator accelerates downward, the spring scale reads a value less than the weight of the fish.
$\vec{a}$
$\vec{T}$
$m\vec{g}$
$\vec{a}$
$\vec{T}$
$m\vec{g}$
a
b

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 2nd law problem – object's accelerate

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.

In-class questions (for attendance)

Put name in top right corner

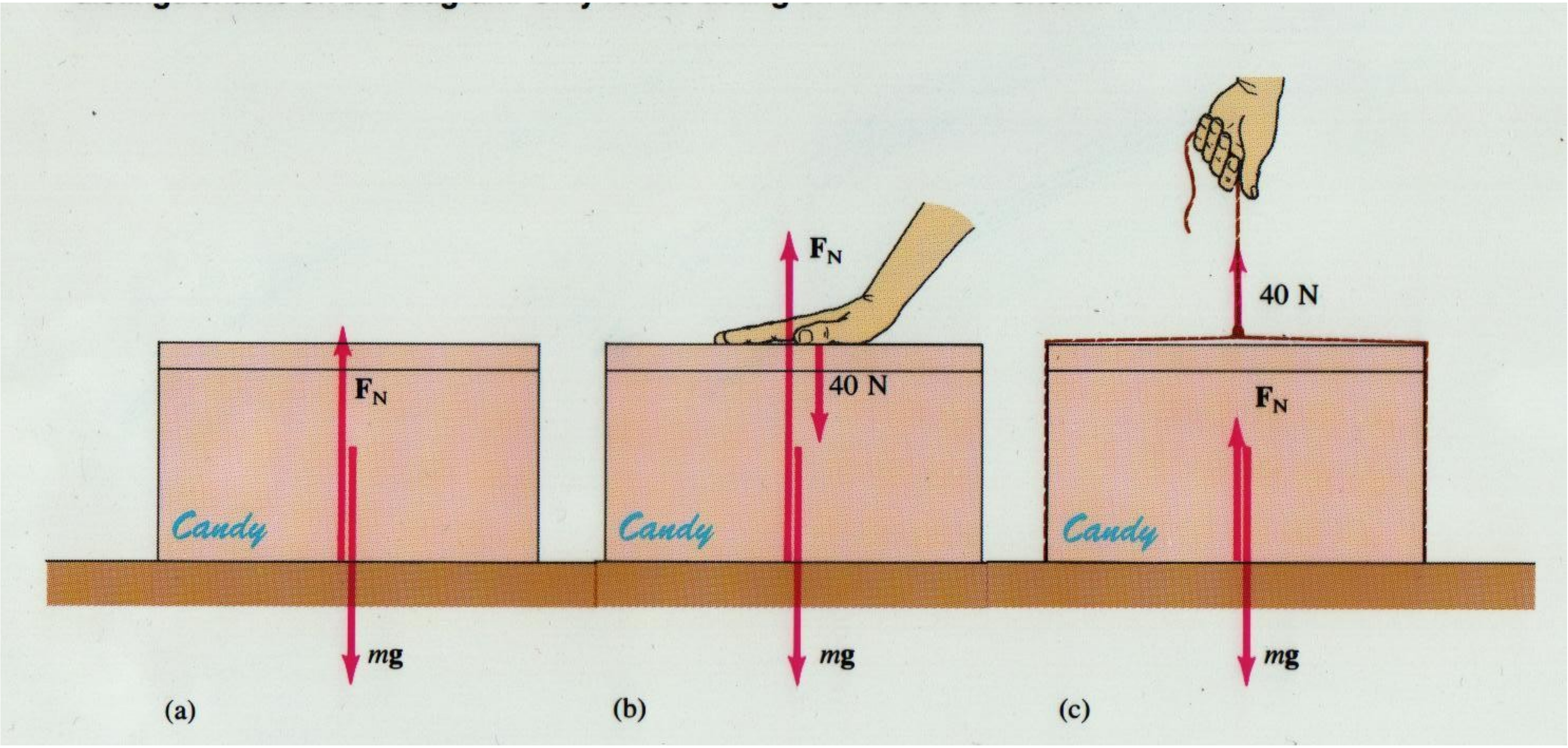
Q1: If you weigh a 1 kg fish on an elevator which is accelerating *downward* at 2 m/s^2, what is the apparent weight?

Q2: Find the normal force on the box in each case if $m=8$ kg.

[See cases a, b, c, and d on slide 21.]

The Application of Newton's Laws

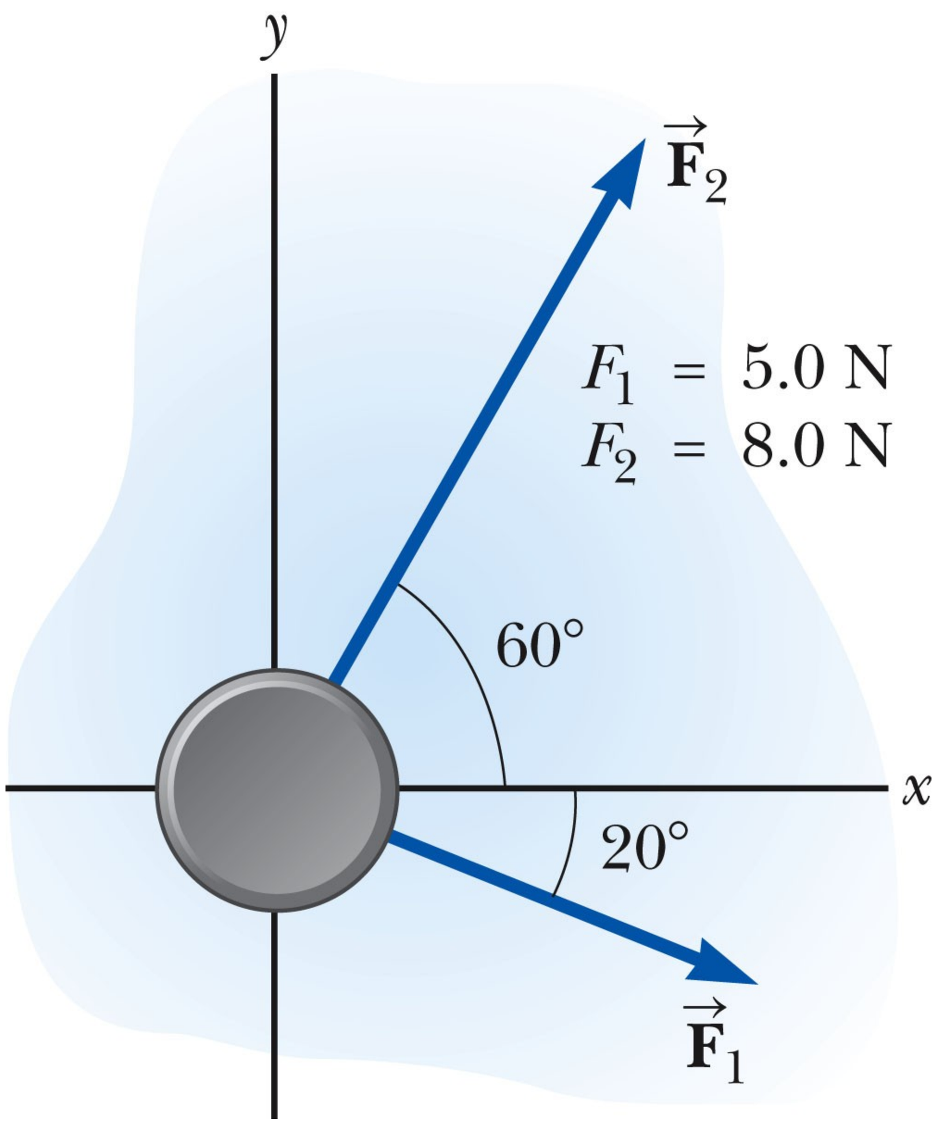
Find the normal force in each case if m=8 kg. (Use g=10 m/s^2)

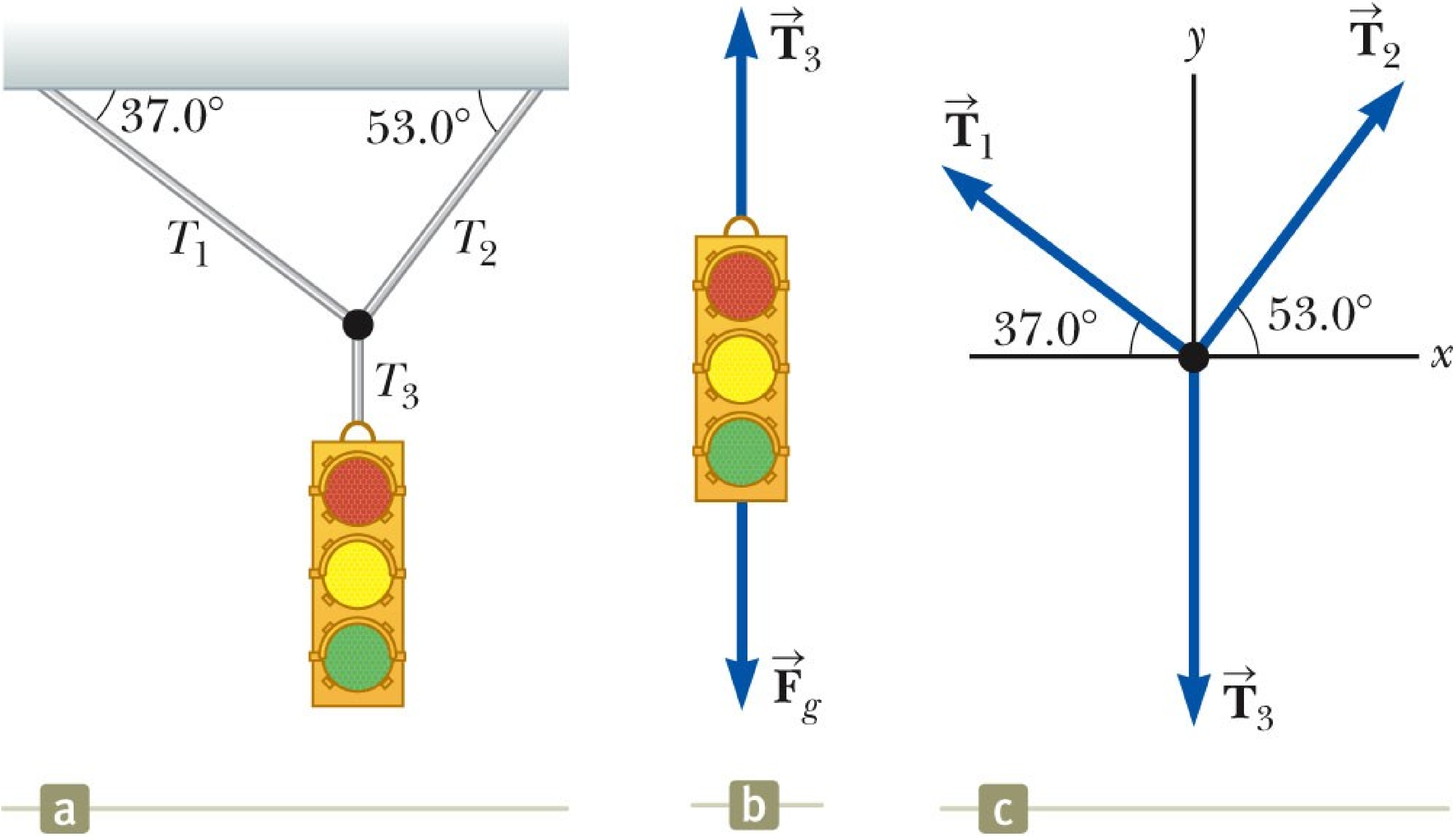


d) If m<4 kg, would it still be an equilibrium problem for (c)?

The Application of Newton's Laws

Find the acceleration vector for the 0.2 kg hockey puck.





Given mass of traffic light, can we find T_1, T_2, and T_3?

Fig. 5.10, p. 114

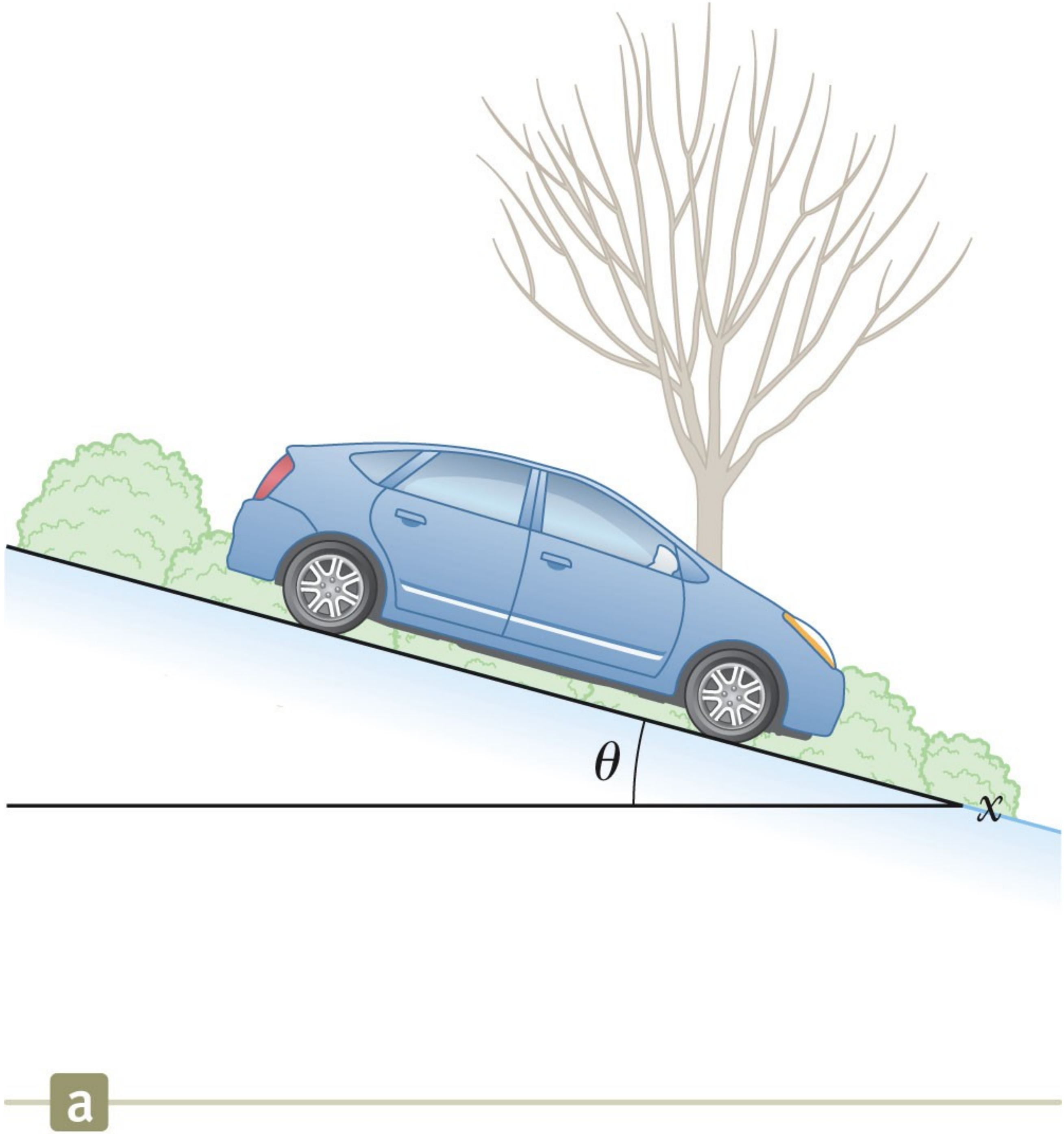
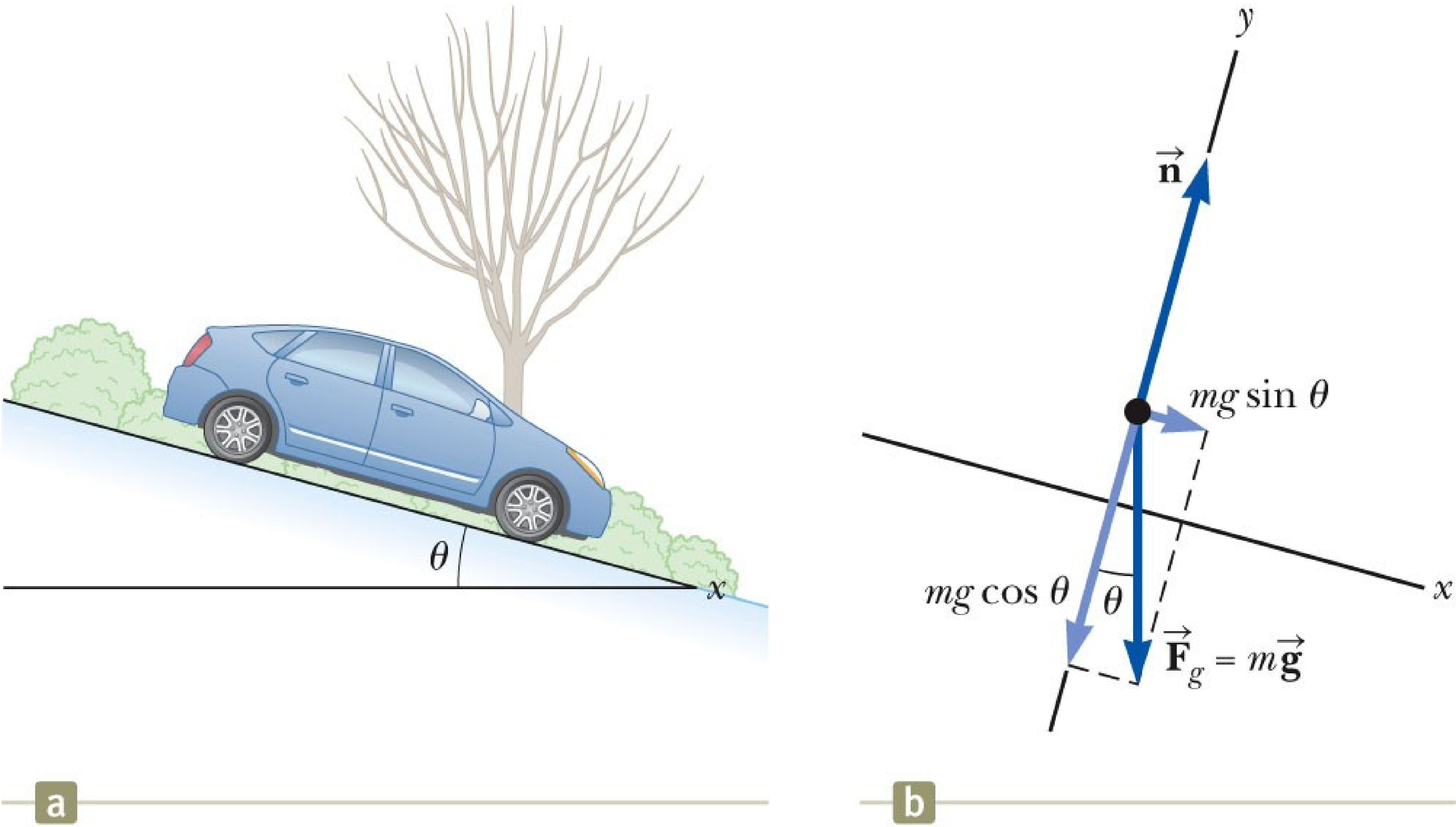


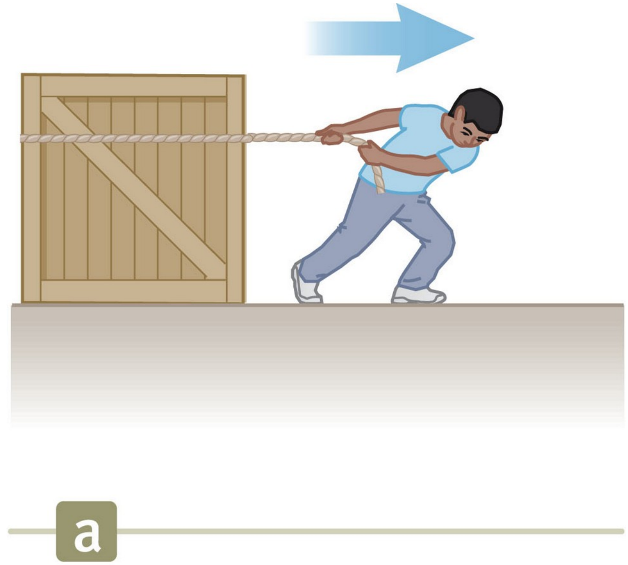
Fig. 5.11, p. 116



θ
x
a
y
$\vec{\mathbf{n}}$
$mg \sin \theta$
$mg \cos \theta$
θ
x
$\vec{\mathbf{F}}_g = m\vec{\mathbf{g}}$
b

Fig. 5.11, p. 116

5.8, p. 113



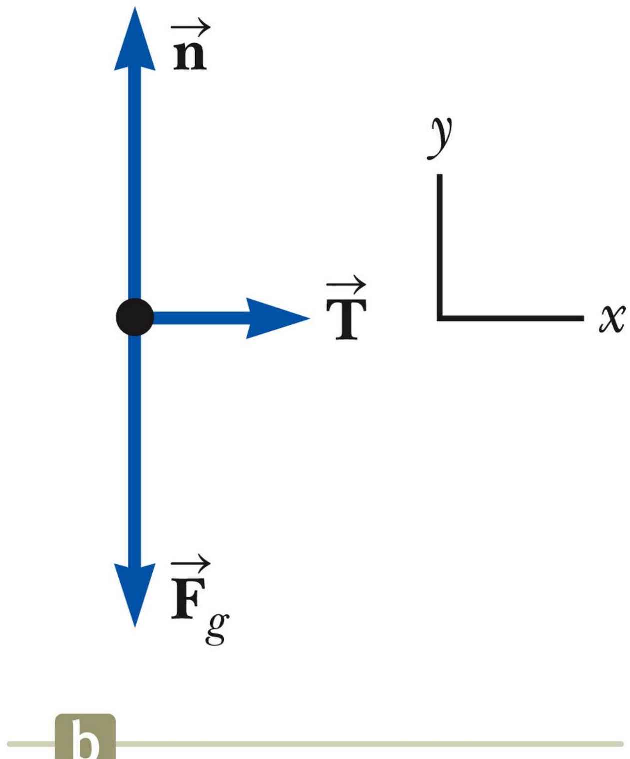


Fig. 5.8, p. 113

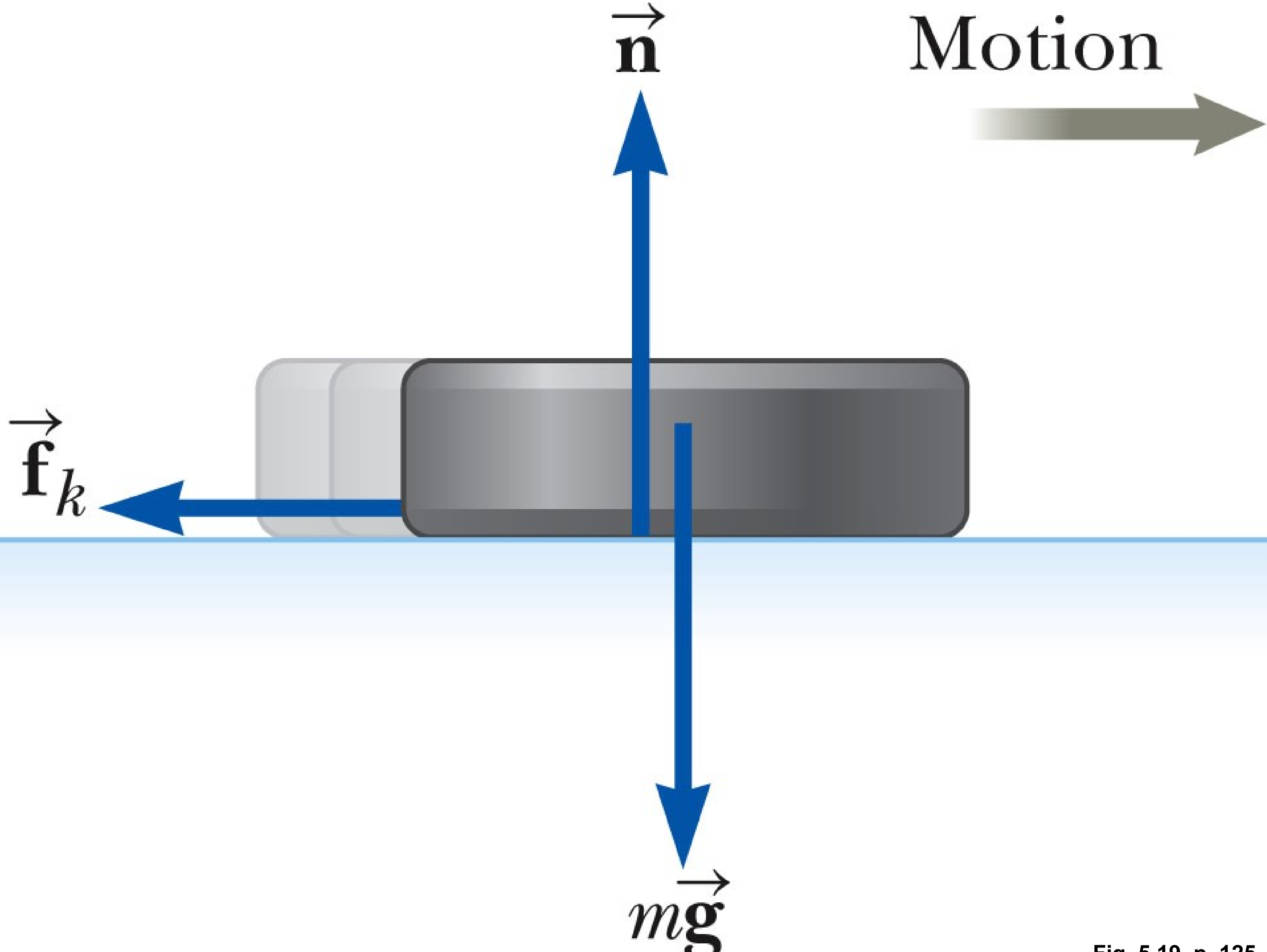
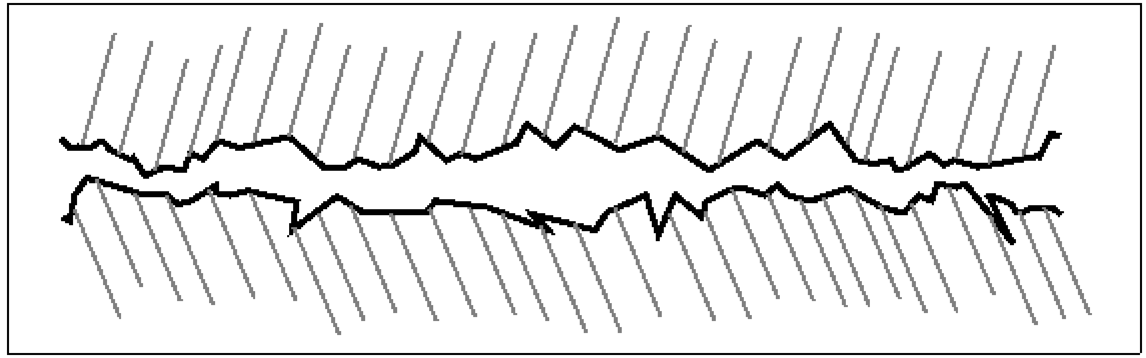


Fig. 5.19, p. 125

Close-up of surfaces.



Plot of friction vs force applied

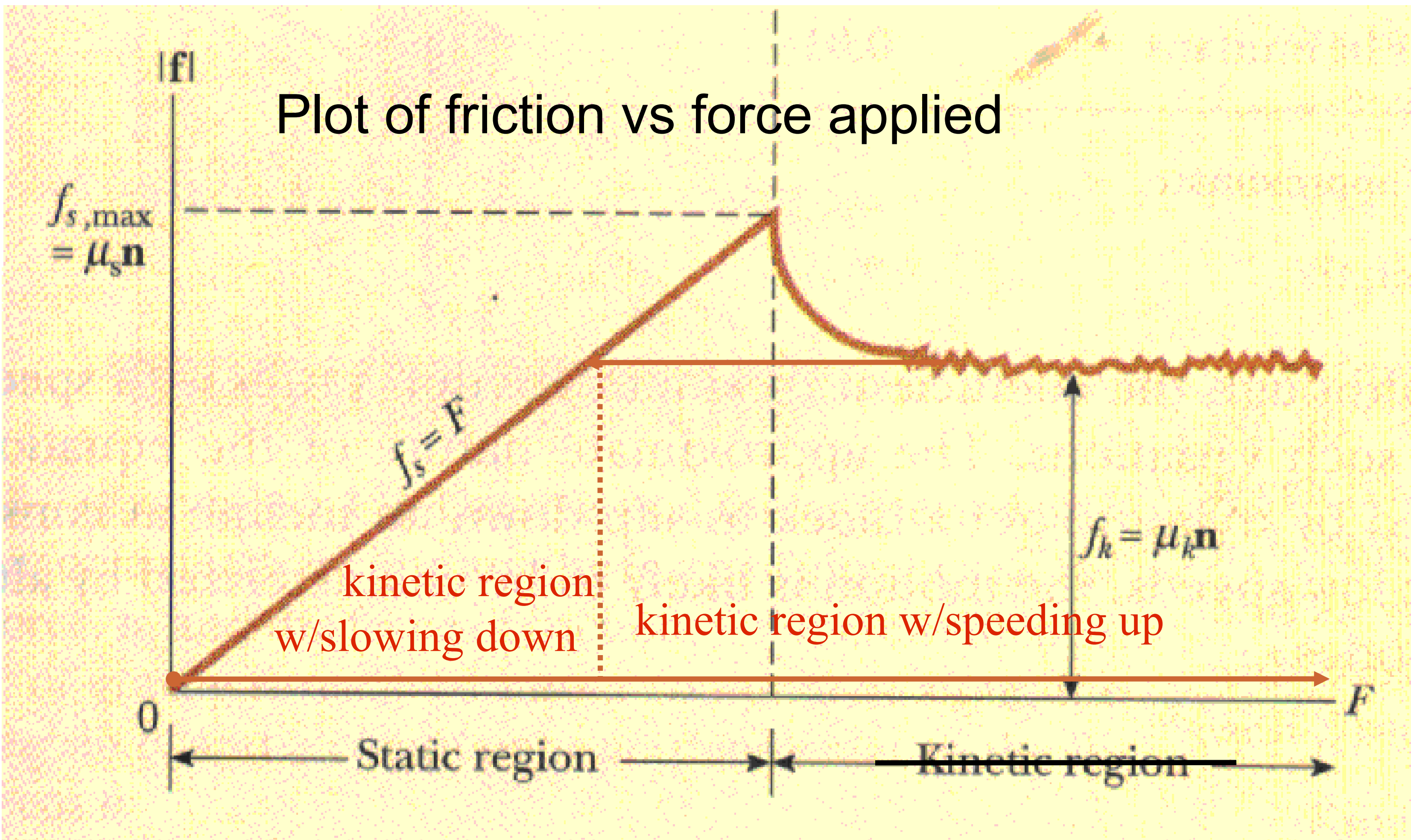
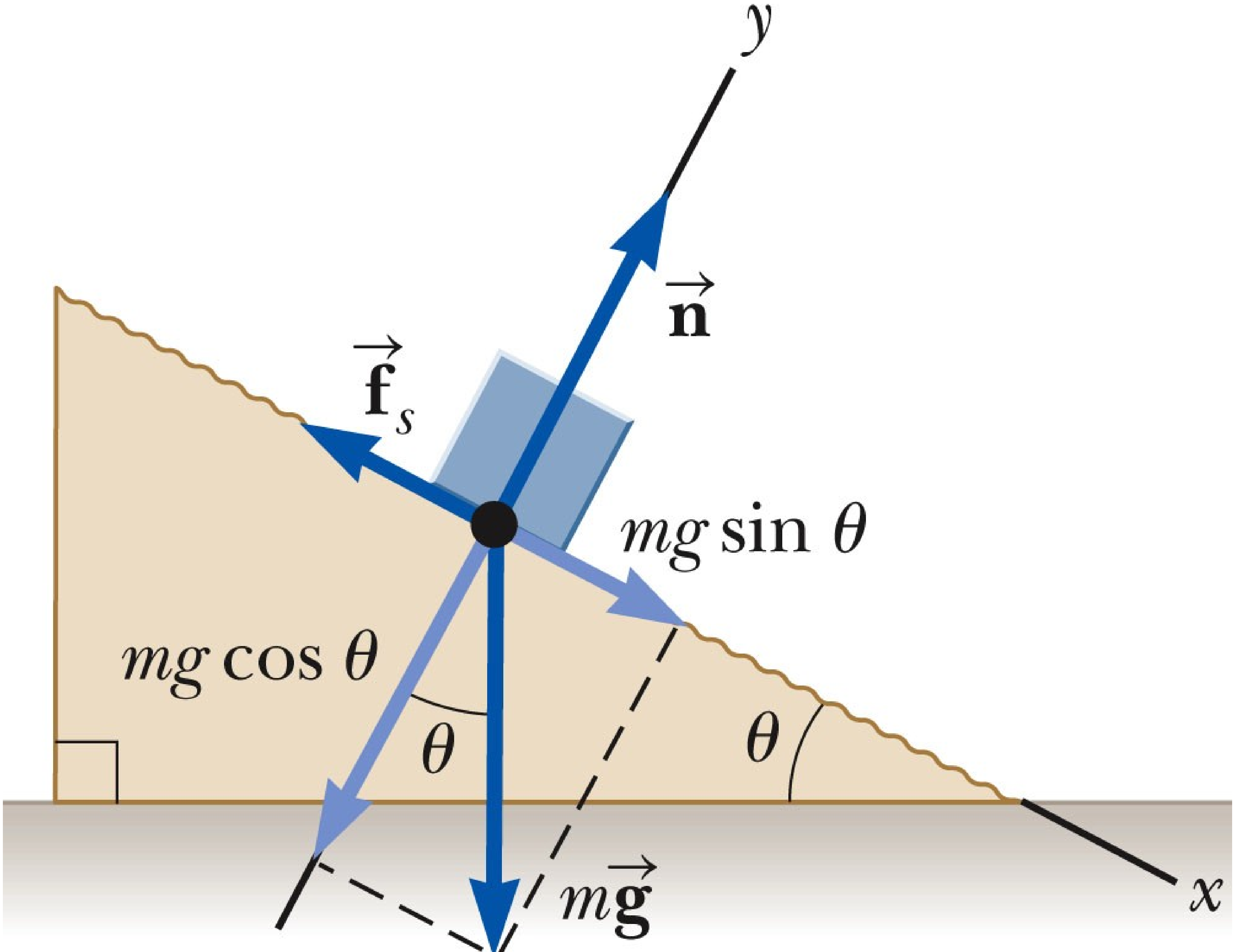


TABLE 5.1 *Coefficients of Friction*

	μ_s	μ_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.



y
$\vec{\mathbf{n}}$
$\vec{\mathbf{f}}_s$
$mg \sin \theta$
$mg \cos \theta$
θ
θ
$m\vec{\mathbf{g}}$
x

Fig. 5.18, p. 124