Week 4-6 Topics

Chapter 3. Relative position and velocity
Chapter 4. Newton's laws of motion
Types of forces
Free body diagrams
Chapter 5. Friction and centripetal force

Exam I follows Chapter 5.

Outline for Day W5,D1

Return Quiz 2 (mean = 5.4/7)
Relative Velocity & Newton's 1st law
Types of Forces
Newton's 2nd law.

Homework

Ch. 4 P. 1-5,7,12-14,28,33,42,45,47,48
MisQ 1-11 (odd), Read Sec 1-8. Due 2/23

Notes:

"NEW STUFF" has new PPT, YouTube (FOR), rel. motion problems, practice problems on force.

Exam I follows Chapter 5 material.

Outline for Day W5,D3

Newton's laws

Weight and mass

Newtons 2nd and 3rd law example problems

Homework

Ch. 4 P. 1-5,7,12-14,28,33,42,45,47,48

MisQ 1-11 (odd), Read Sec 1-8. Due 2/23->26

Notes:

Make sure you do the tasks in my email.

No observatory tonight.

Exam I follows Chapter 5 material.

Outline for Day W6,D1

Newtons 2nd and 3rd law example problems

- General Approach
- Mass vs weight
- Weighing fish on elevator, Atwood's machine, Window washer, etc.

Homework

Ch. 4 P. 1-5,7,12-14,28,33,42,45,47,48
MisQ 1-11 (odd), Read Sec 1-8. Due <3 pm

Ch. 5 Read 5.1-5.5, P. 1,2,3,6,7,19,23,35,36,
38,45 Due Mon

Notes:

Exam I follows Chapter 5 material, next Wed.
See "NEW STUFF", FCI, Equations, key

Outline for Day W6,D2

Hwk 4 comments

Newtons 2nd and 3rd law examples

Atwood's machine, frictionless incline, box stack

Friction

Circular motion

Homework

Ch. 4 Return. Mean=8.9/10 Chkd MQ1,3, P. 13,42

Ch. 5 Read 5.1-5.5, P. 1,2,3,6,7,19,23,35,36,
38,45 Due Mon

Notes:

Exam I follows Chapter 5 material, next Wed.

Outline for Day W6,D3

Friction
Circular motion

Homework

Ch. 5 Read 5.1-5.5, P. 1,2,3,6,7,19,23,35,36,
38,45 Due Mon

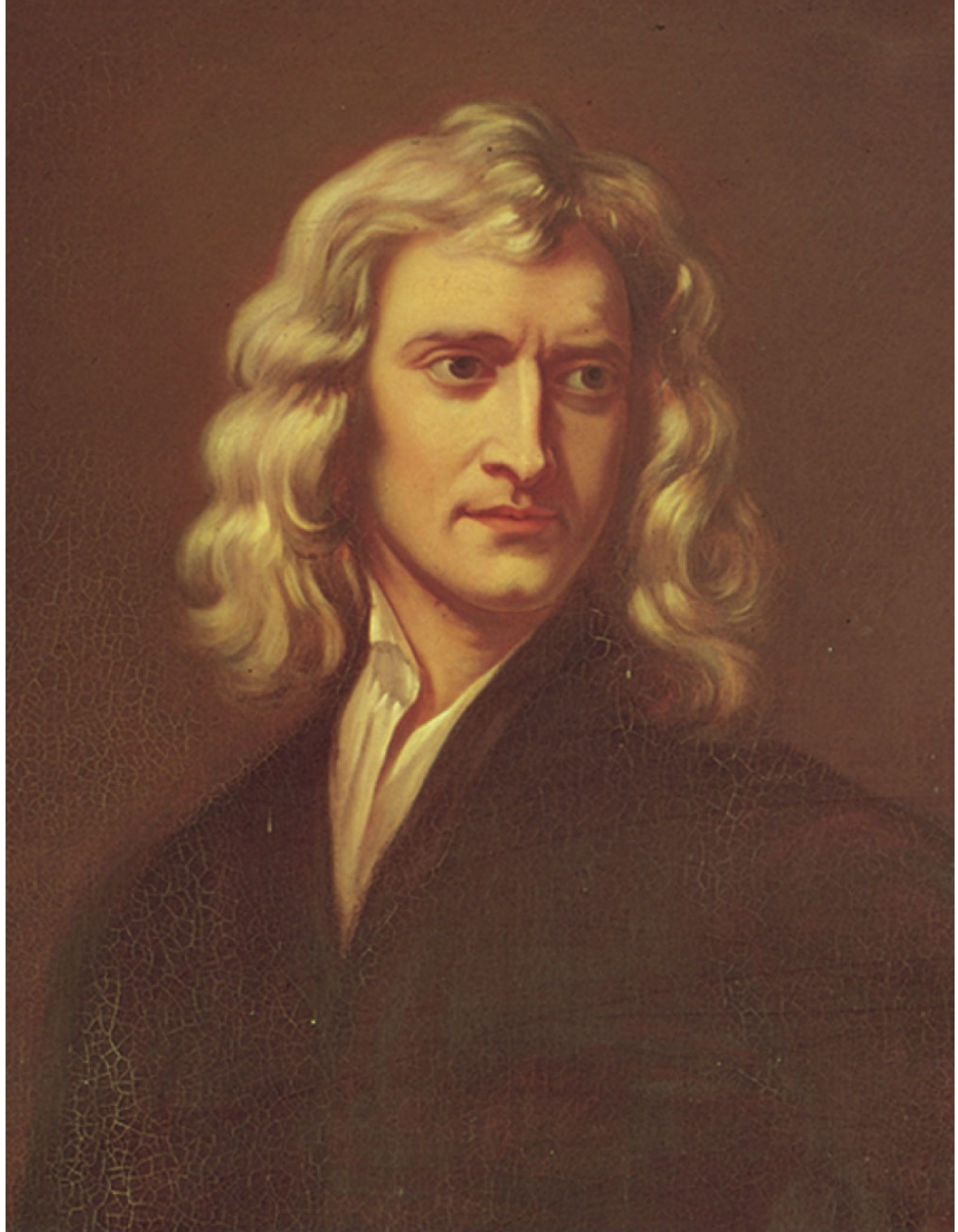
Notes:

Exam I follows Chapter 5 material, next Wed.

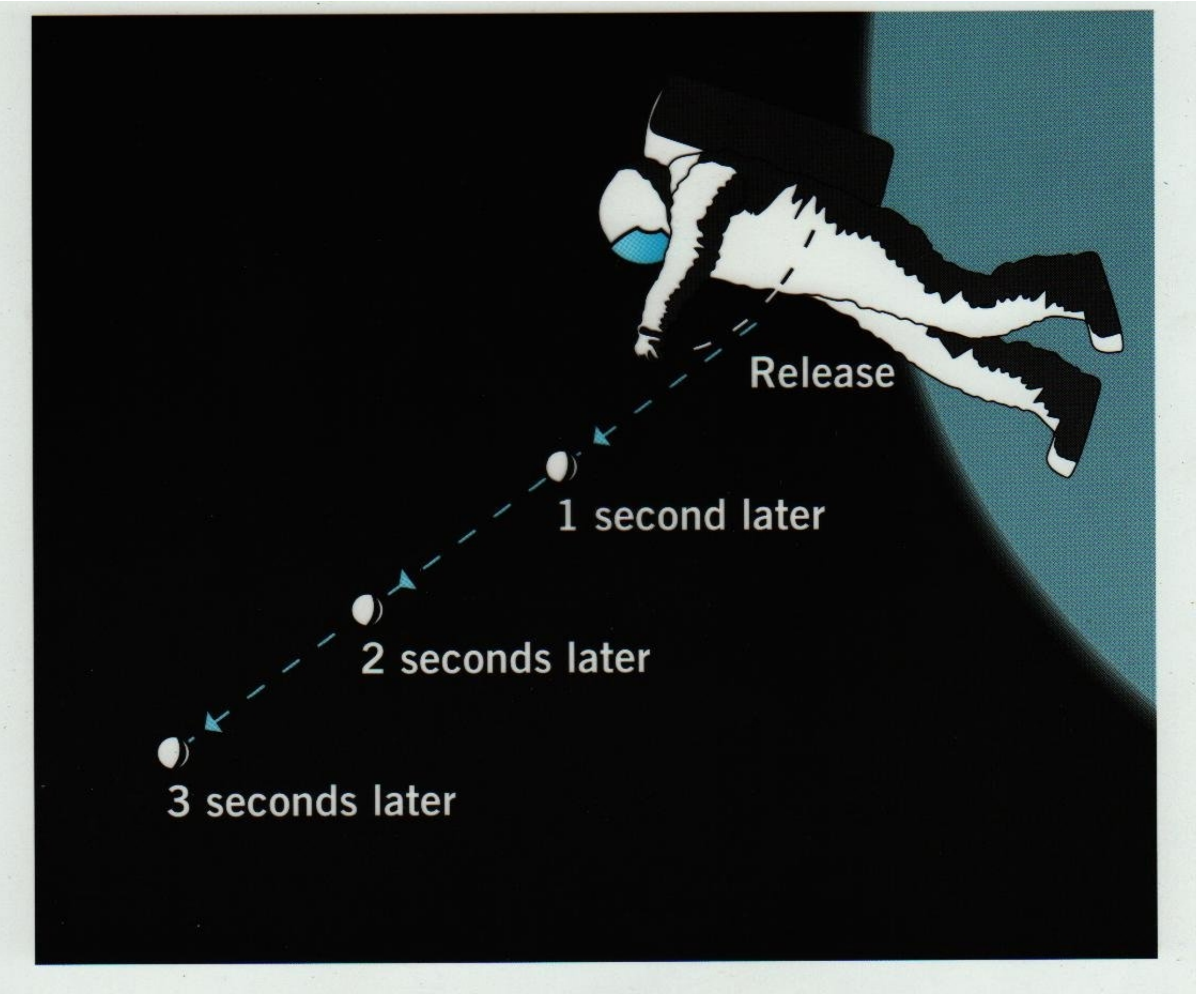
Isaac Newton
(1642 - 1727)

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 ideas:

"natural state" is at rest

"impetus" pushes an arrow along

Relative Motion Problem

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

So we can say

$v_{CA}=v_{CB}+v_{BA}$

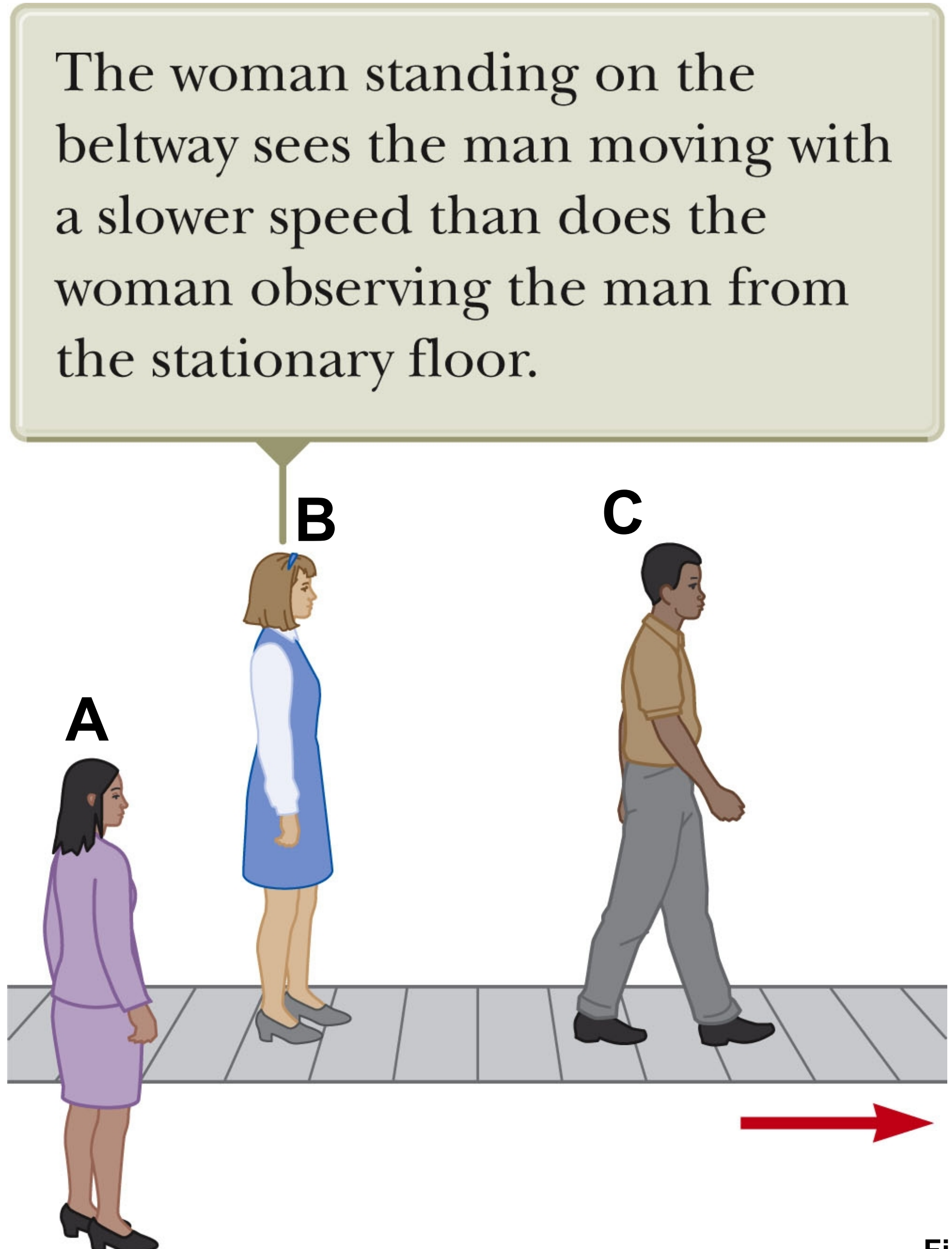
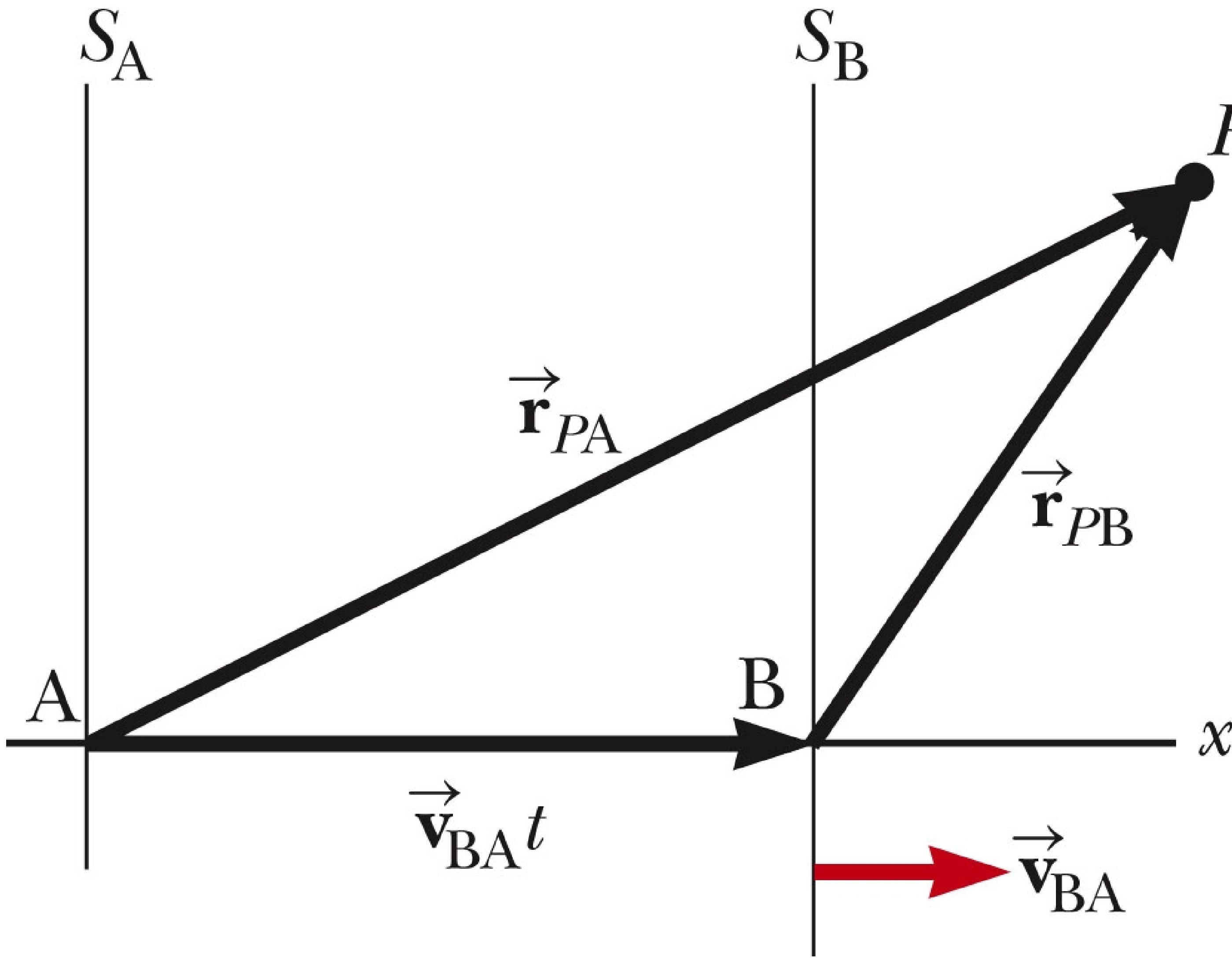


Fig. 4.19, p. 90

Transforming between two frames of reference, A and B.



$r_{PA}=r_{PB}+r_{BA} \quad \longrightarrow \quad v_{PA}=v_{PB}+v_{BA}$

Fig. 4.20, p. 91

Examples of non-inertial frames of reference

1) Inside of a truck that is accelerating in a line.

2) Inside of a car that is turning (even if moving at a constant speed).

3) Standing on a rotating platform. (See movie "Frames of Reference")

4) The planet Earth! (See movie "Frames of Reference" and the Foucault pendulum.)

Forces – the *cause* of acceleration

Forces are vectors

Forces act between systems (the dashed boxes)

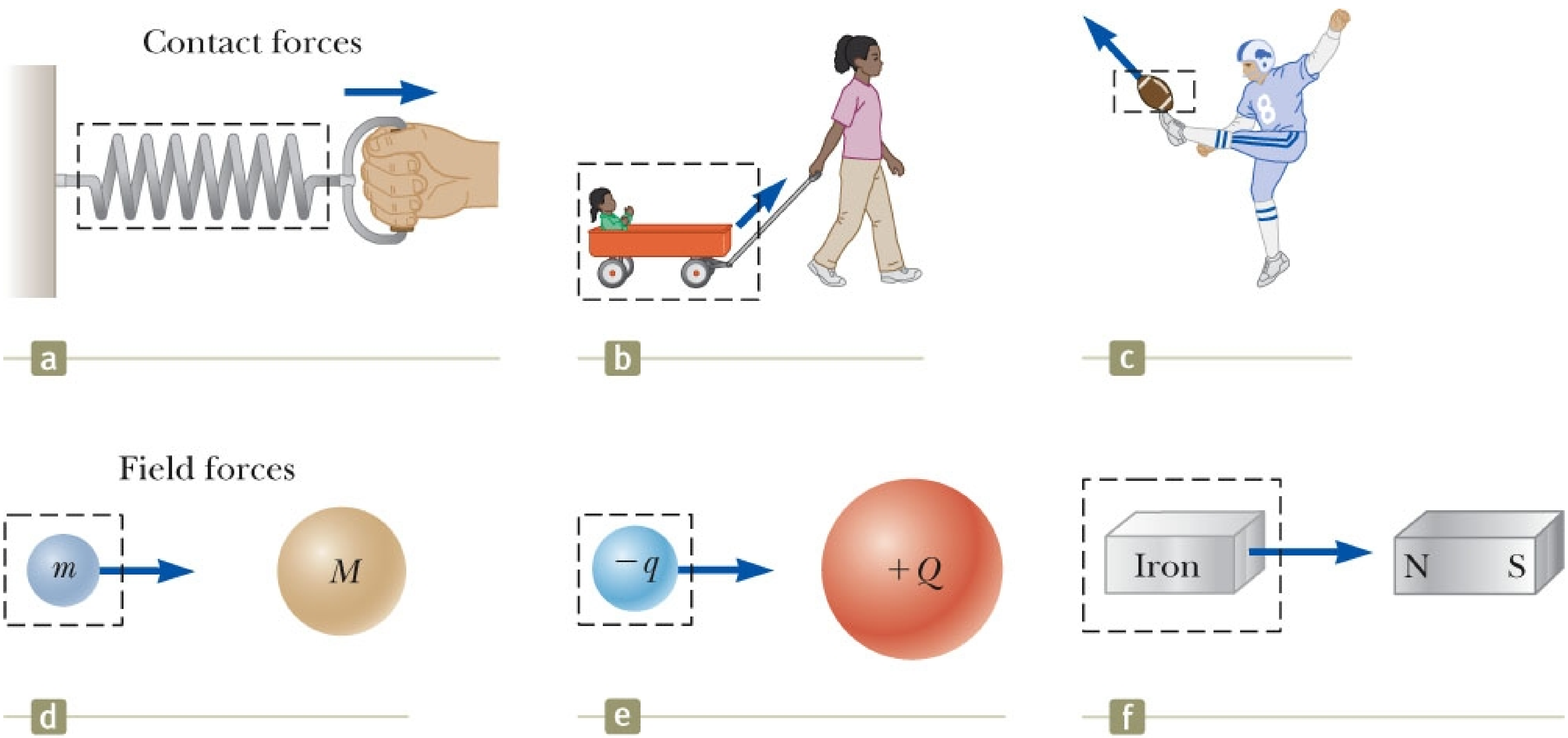


Fig. 5.1, p. 104

Types of forces

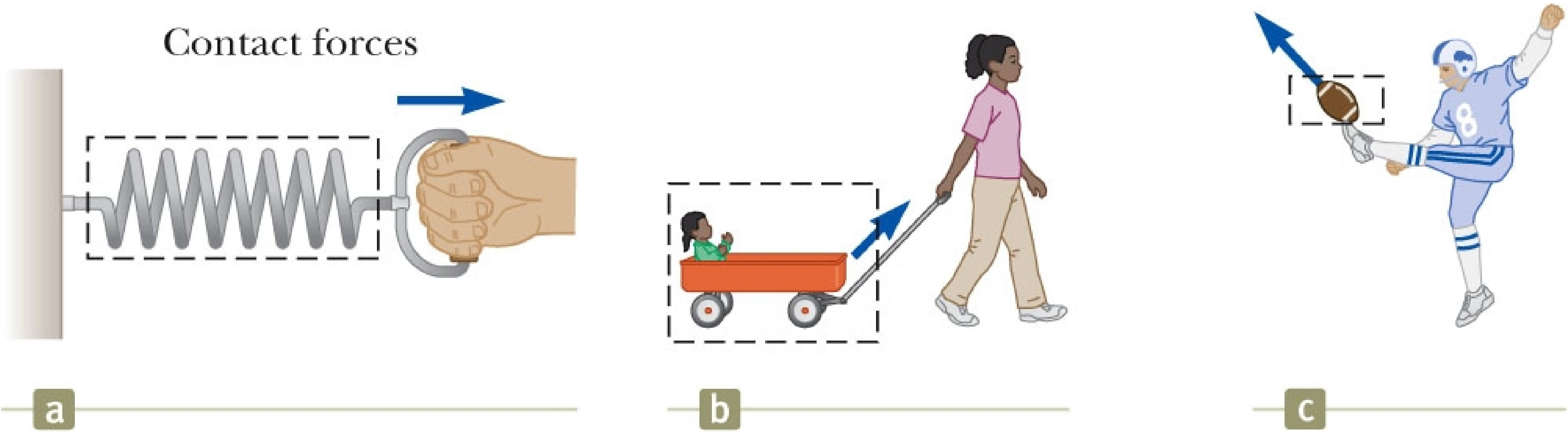
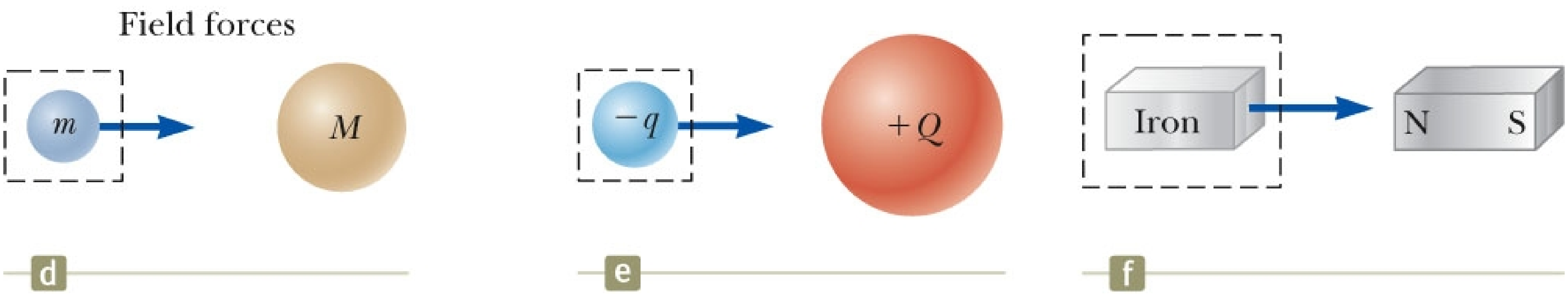


Fig. 5.1, p. 104

contact forces

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

Types of forces



Field forces

gravitational electric magnetic

Fig. 5.1, p. 104

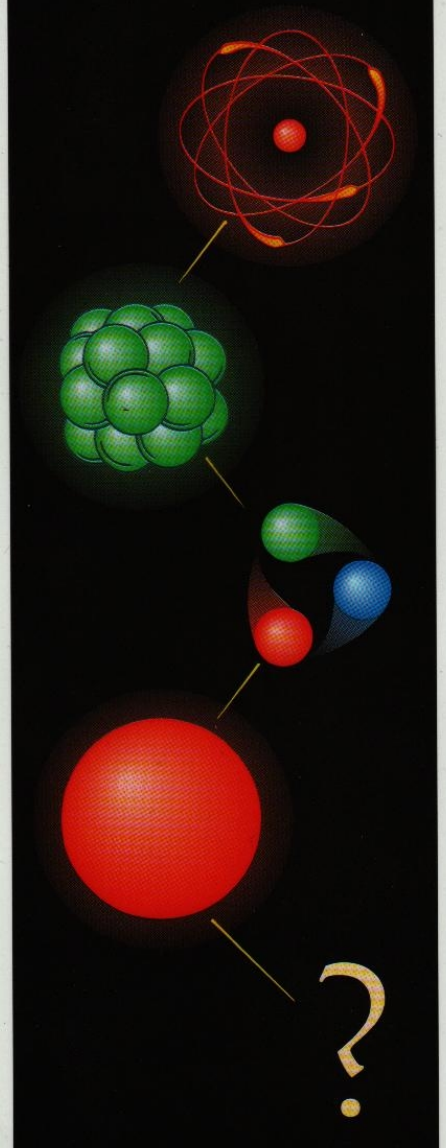
The 4 Fundamental forces

Gravity

Electromagnetic Force

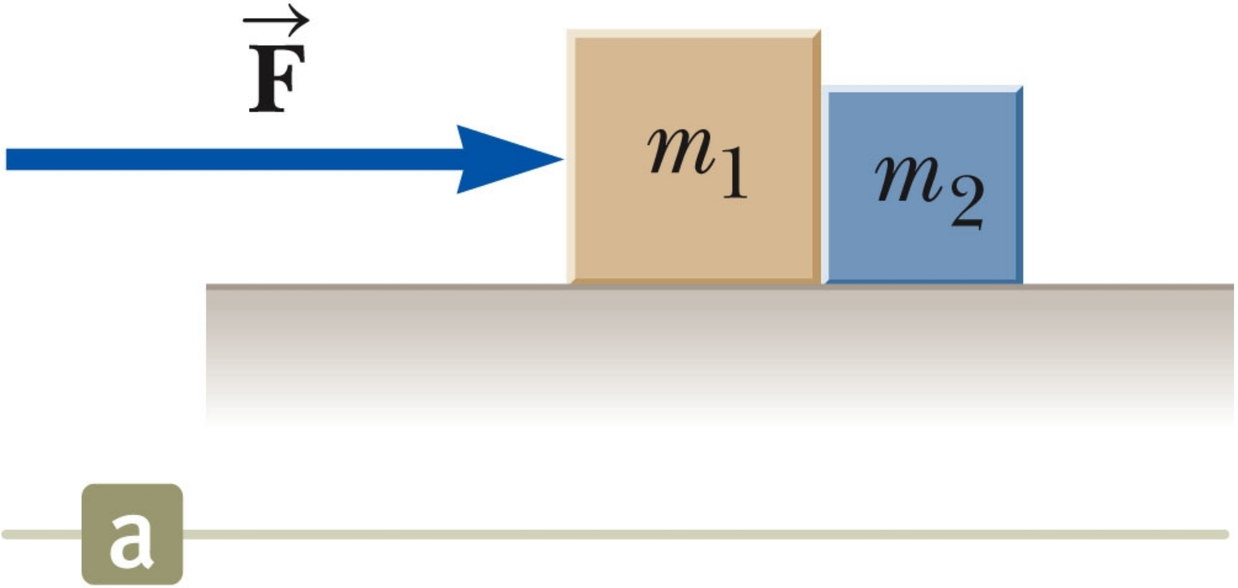
Nuclear Strong Force – holds nuclei together

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.

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

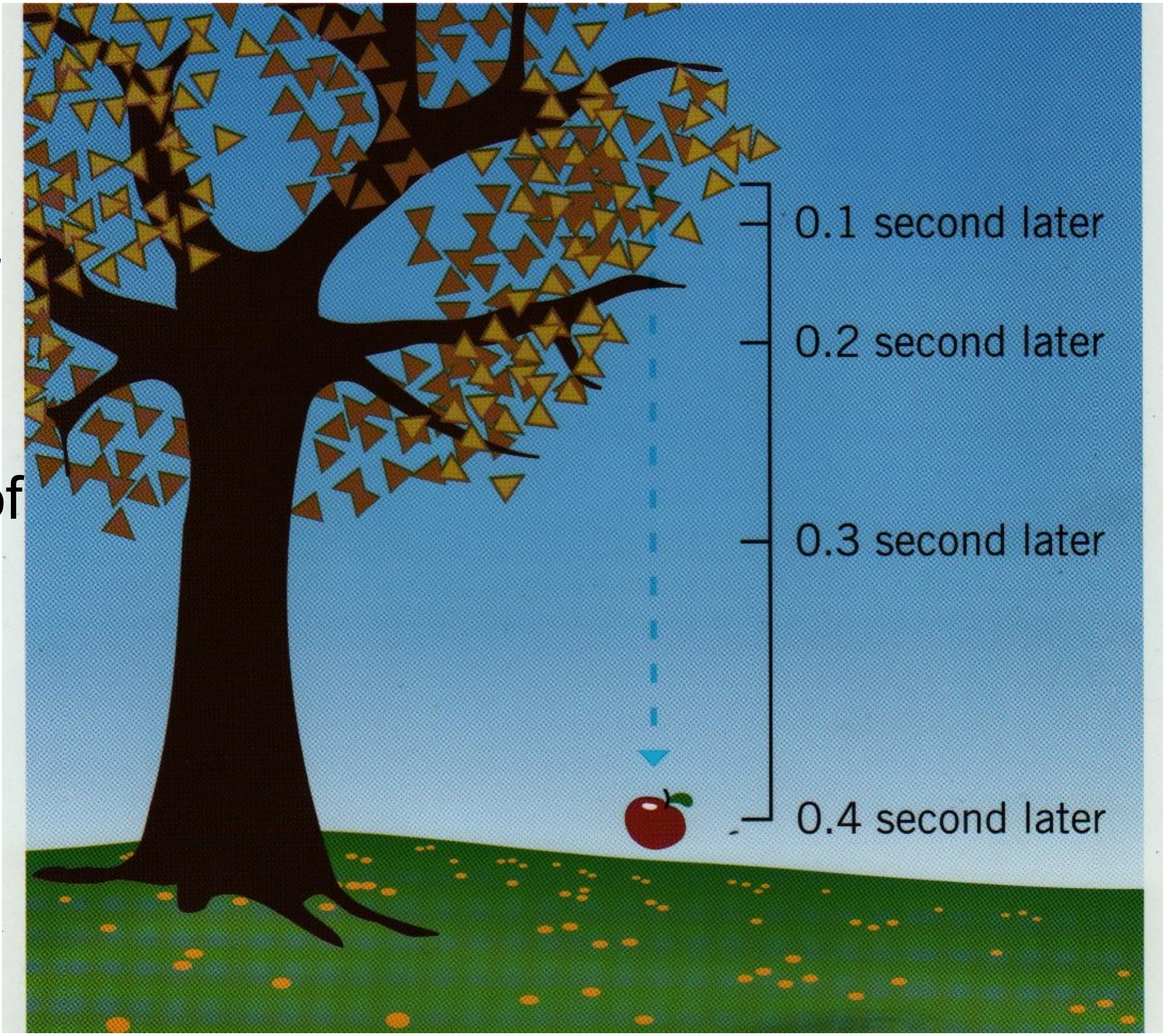


$$\vec{a} = \frac{\vec{F}_{net}}{m}$$

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

Newton's 2nd law (cont.)

Example: free fall due to gravity obeys $a = F_{grav}/m = mg/m = g$



Weight = the force of gravity on an object

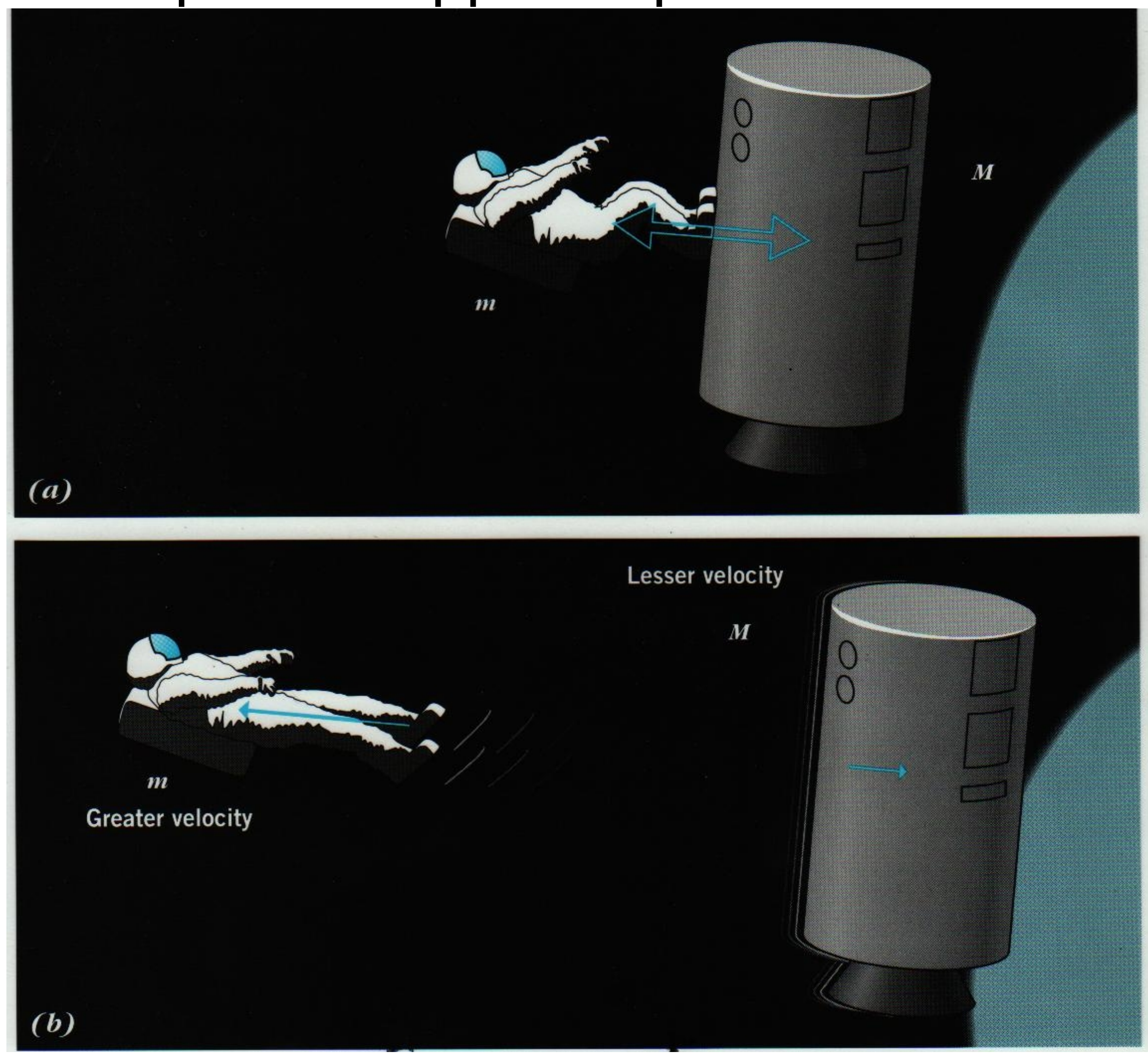
Mass = the amount of matter in an object

Inertial mass = gravitational mass

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.

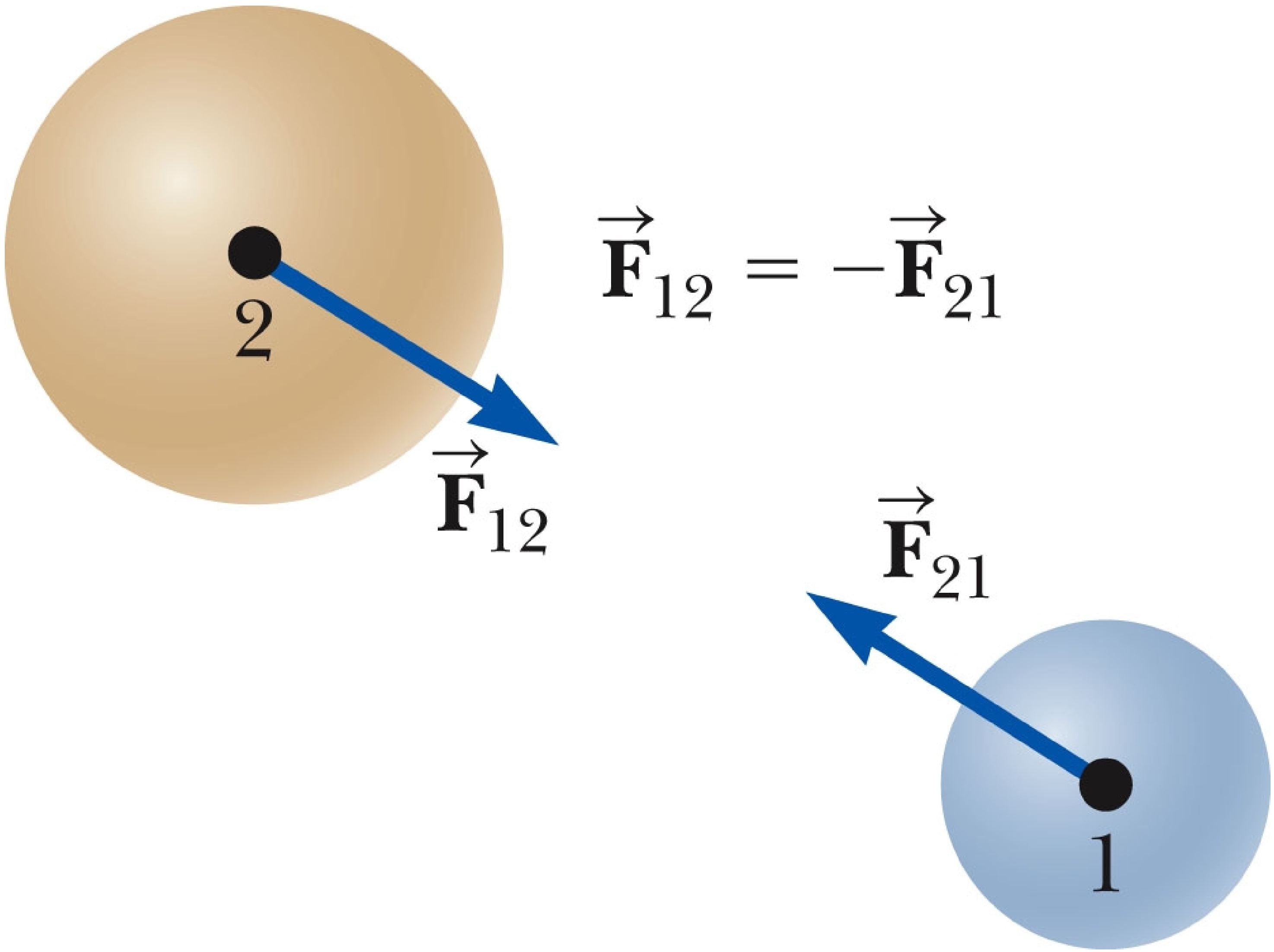
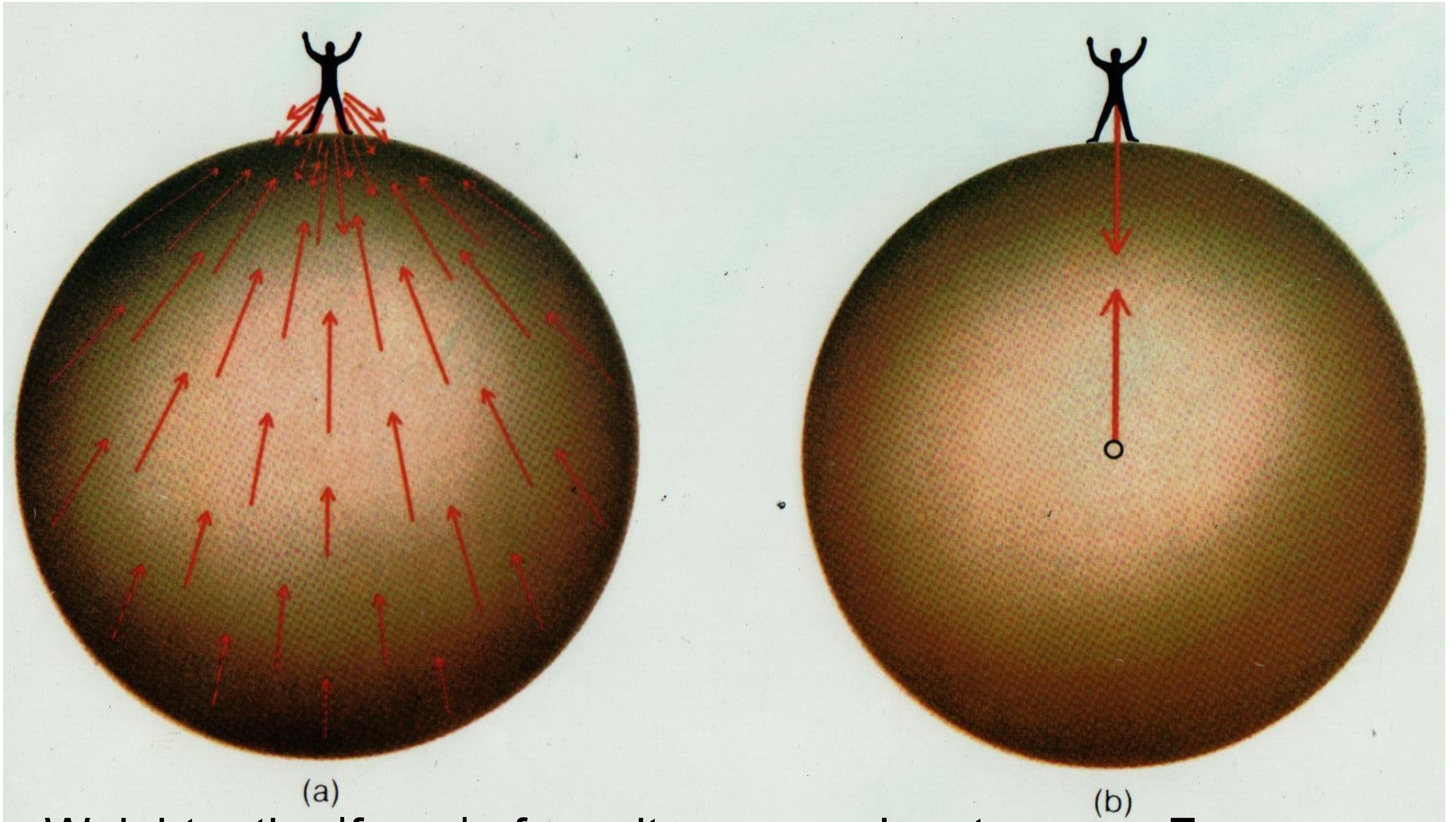


Fig. 5.5, p. 111

Newton's 3rd law (cont.)



Weight = the |force| of gravity near a planet = mg = Fg

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

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 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.

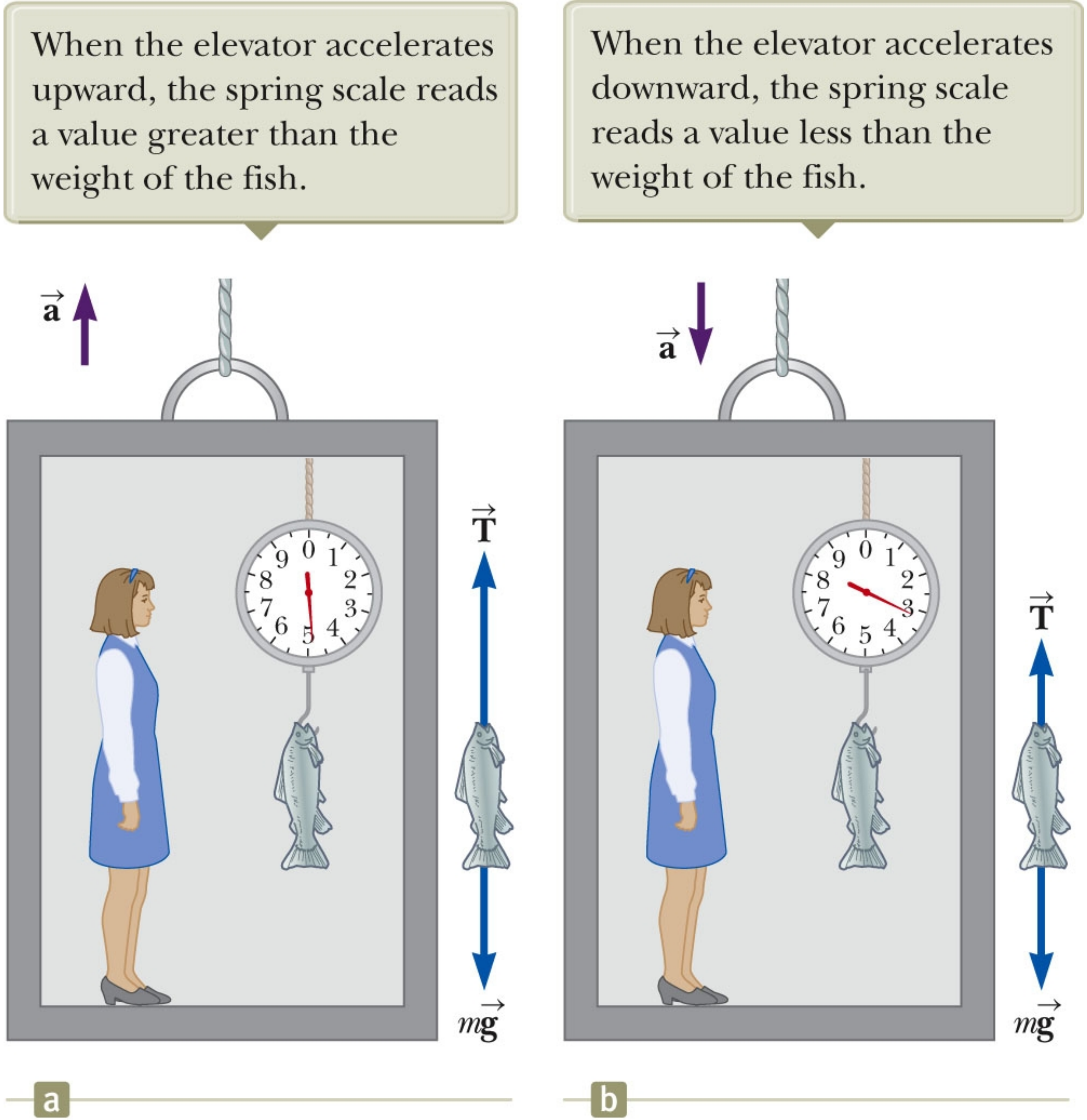
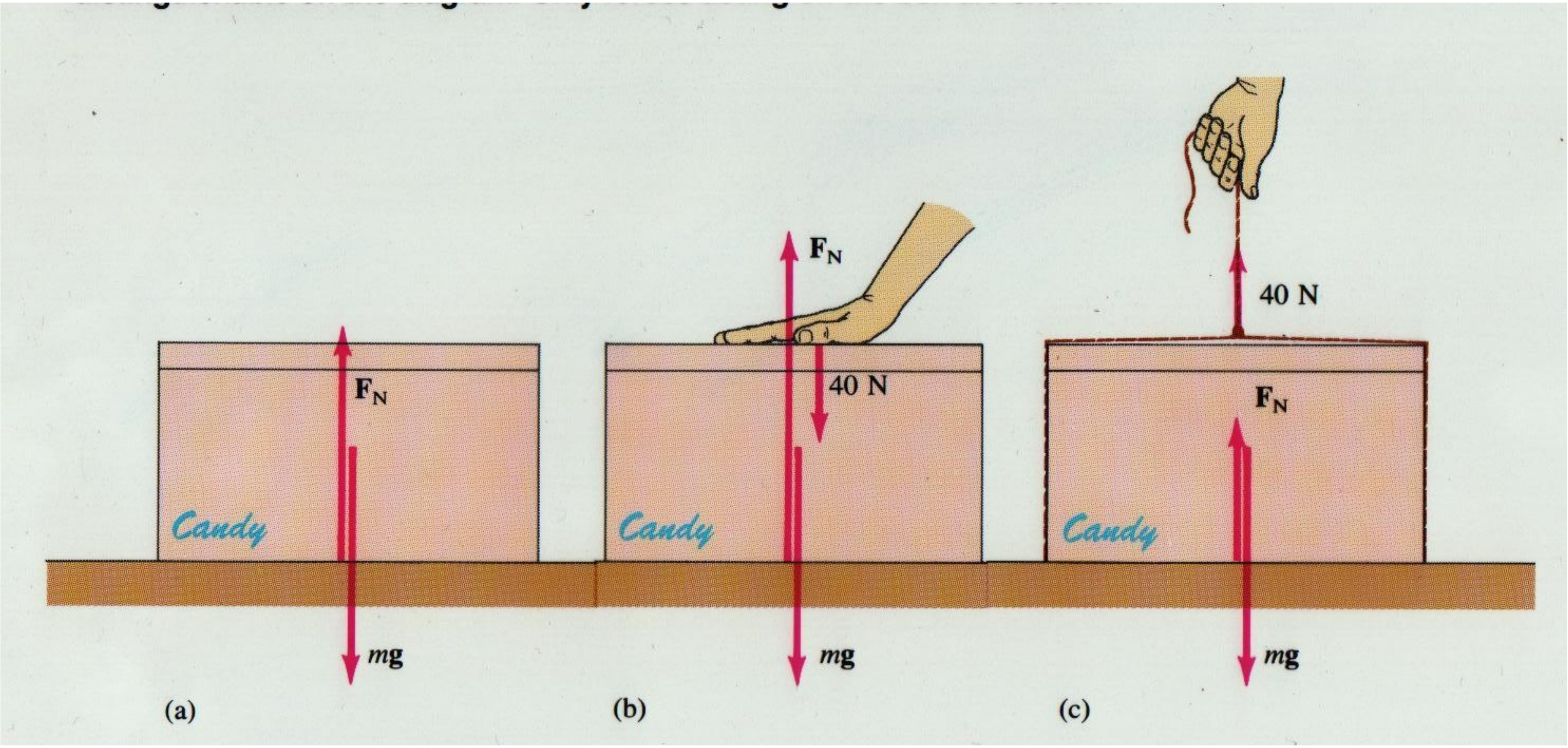

When the elevator accelerates upward, the spring scale reads a value greater than the weight of the fish.
When the elevator accelerates downward, the spring scale reads a value less than the weight of the fish.
$\vec{a}$
$\vec{T}$
$m\vec{g}$
$\vec{a}$
$\vec{T}$
$m\vec{g}$
a
b

Fig. 5.13, p. 119

The Application of Newton's Laws

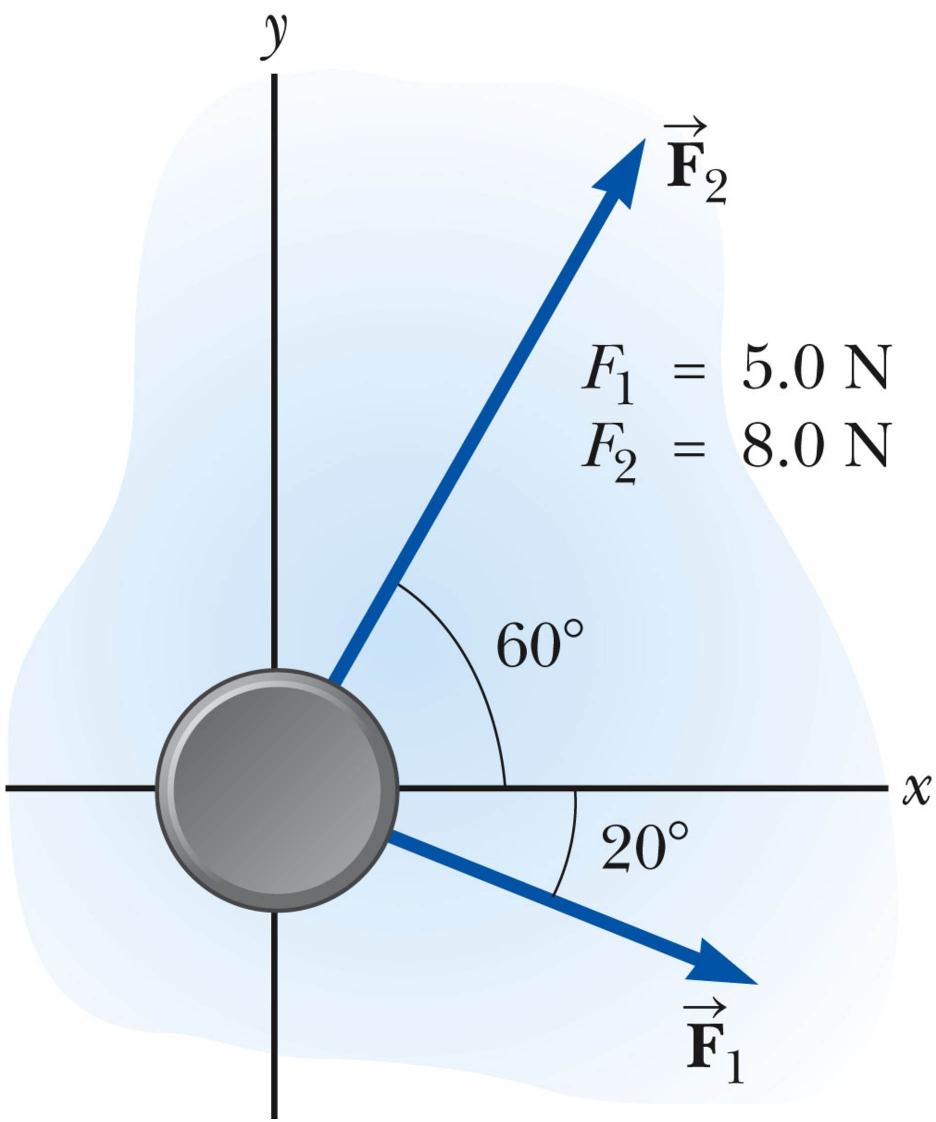
Find the normal force in each case if m=1 kg. (Use g=10 m/s^2)



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.



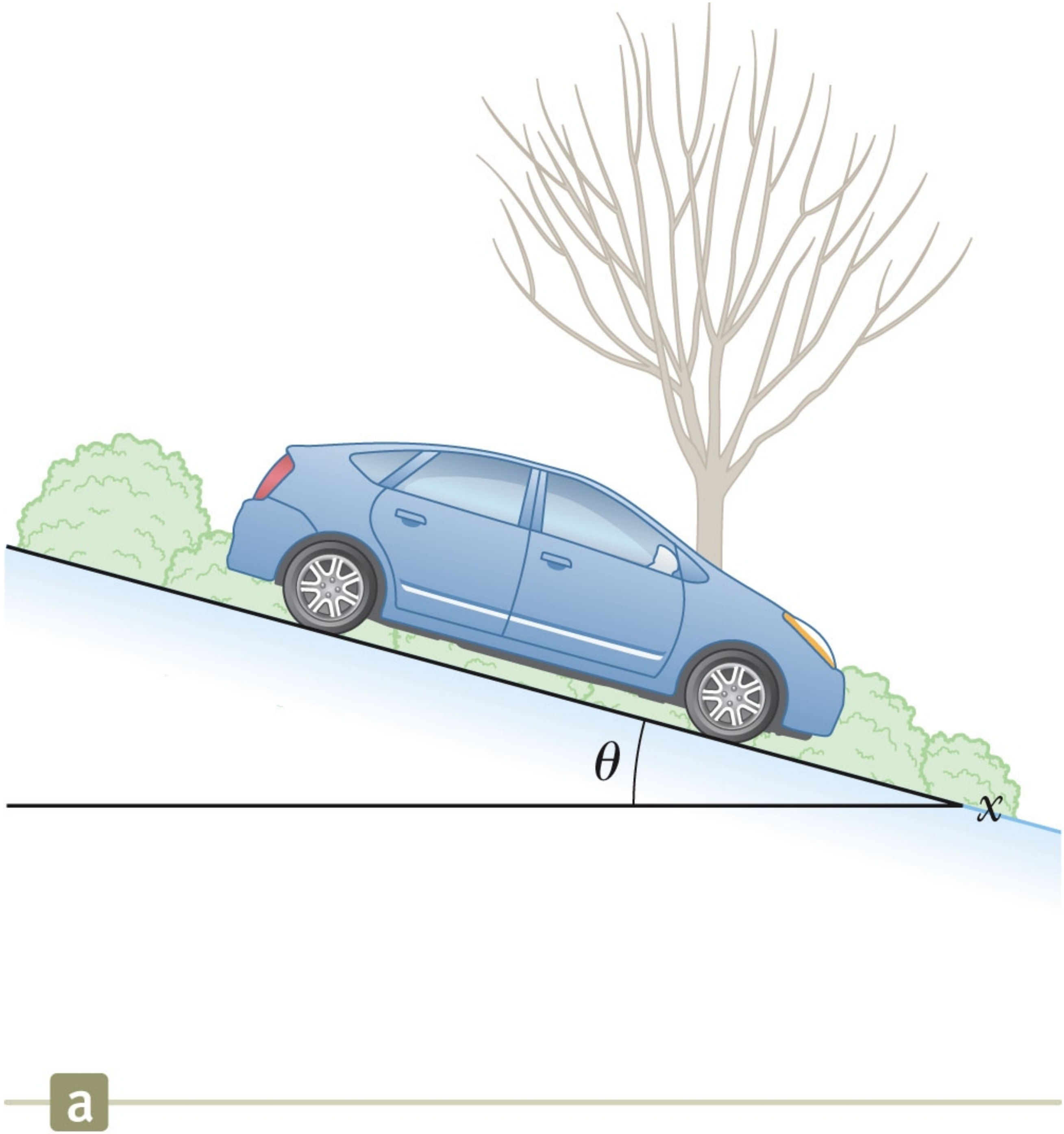
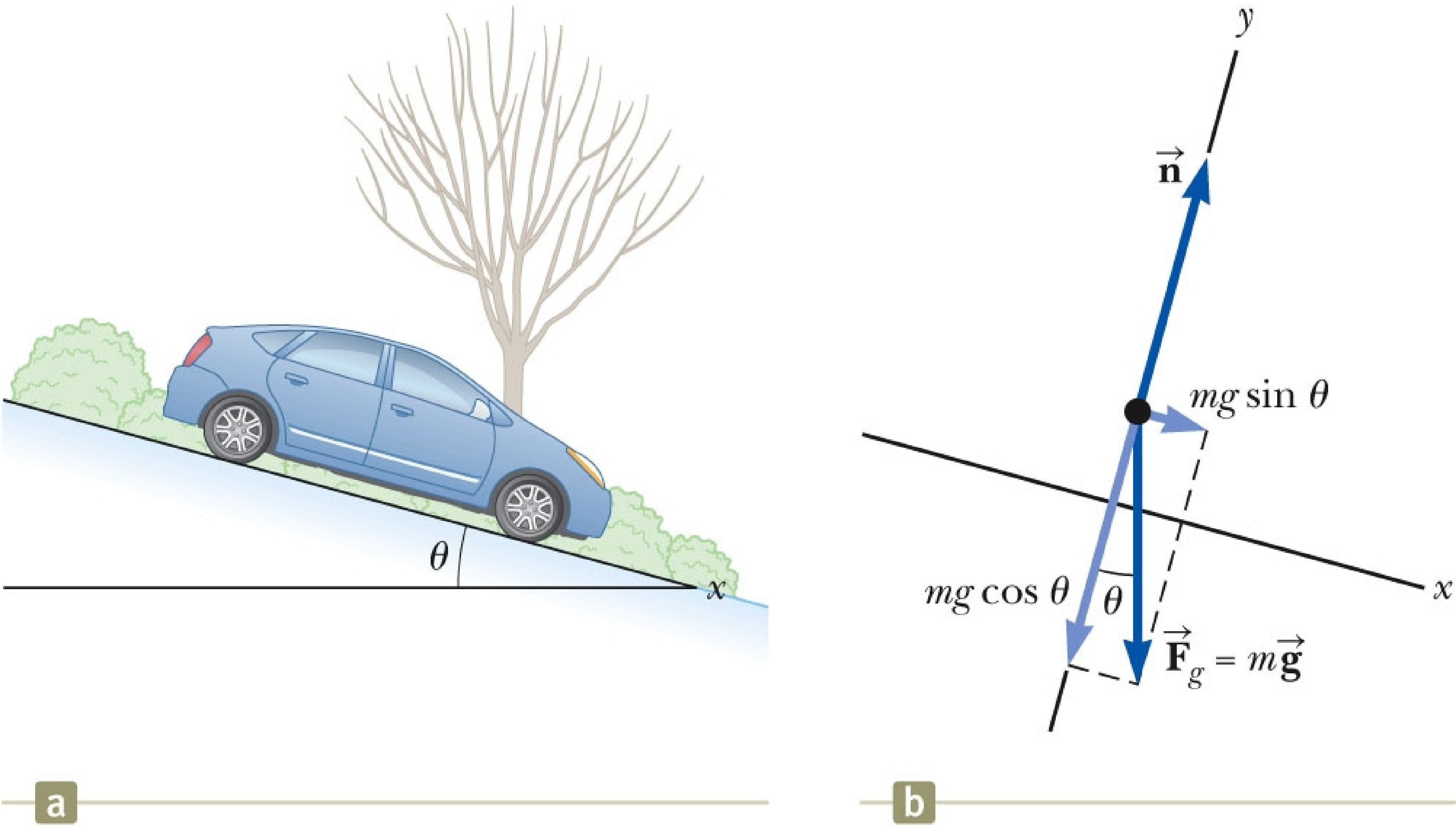
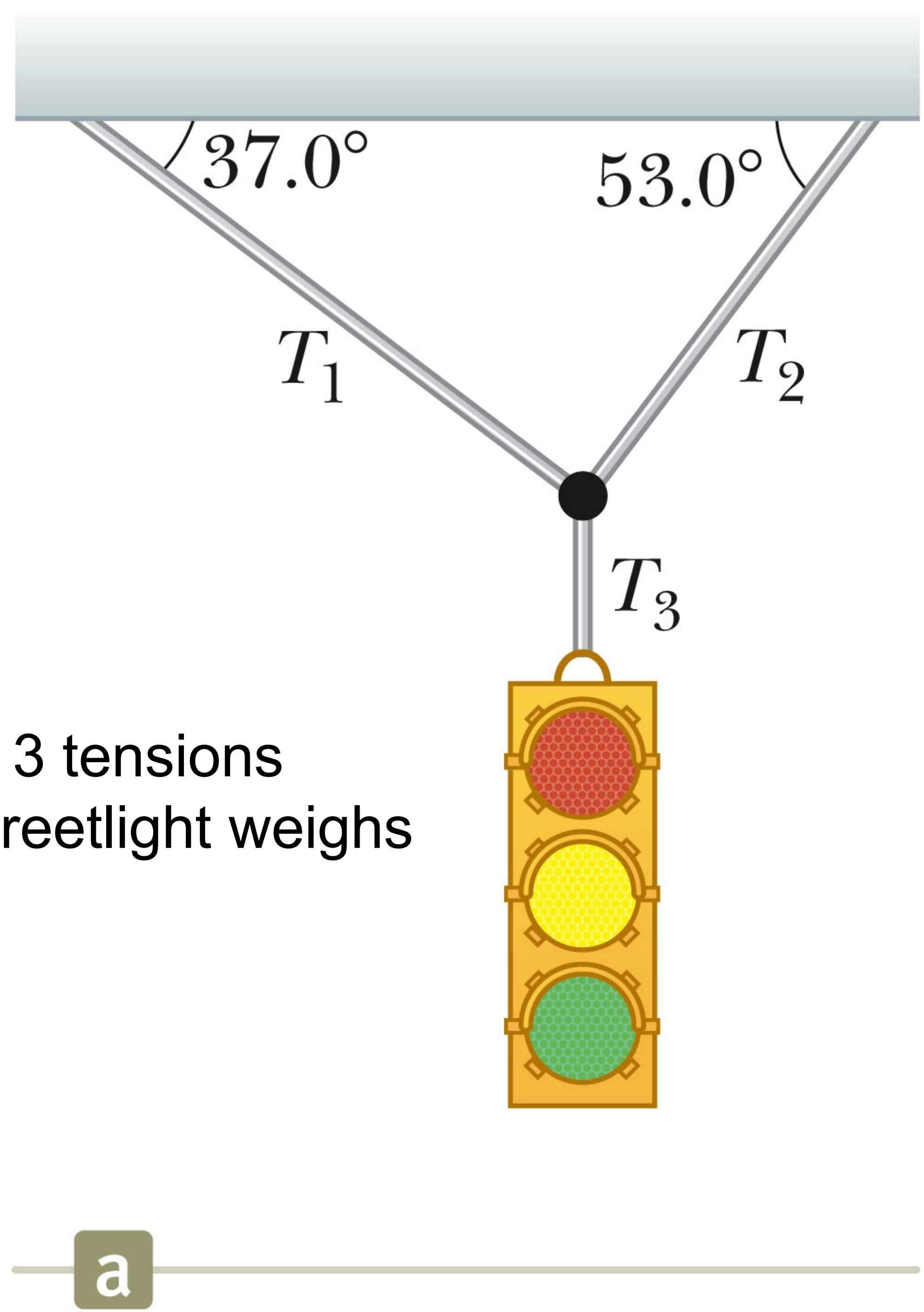


Fig. 5.11, p. 116



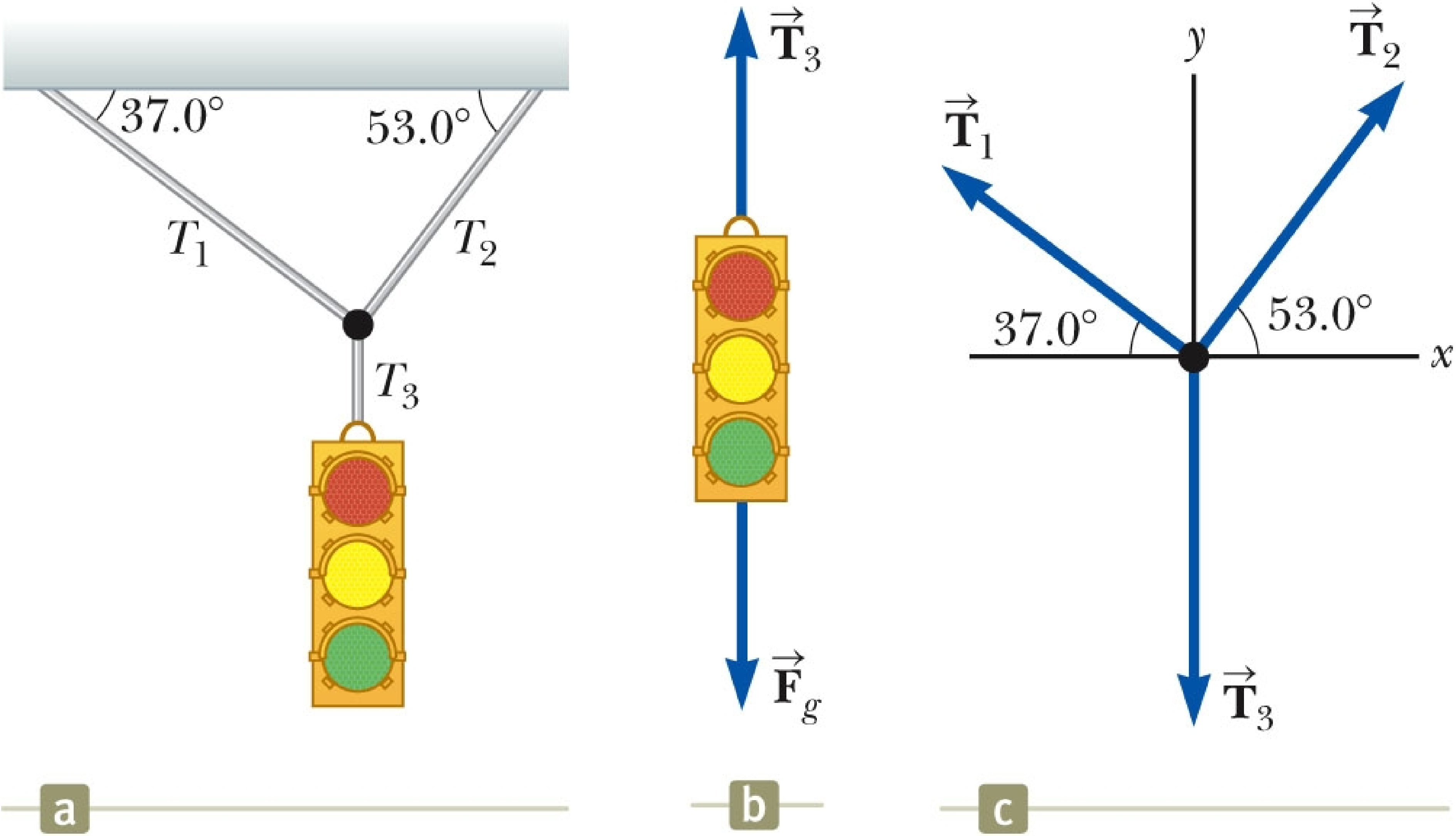
θ
x
a
y
$\vec{\mathbf{n}}$
$mg \sin \theta$
$mg \cos \theta$
θ
x
$\vec{\mathbf{F}}_g = m\vec{\mathbf{g}}$
b

Fig. 5.11, p. 116



Find all 3 tensions
If the streetlight weighs
200 N.

Fig. 5.10, p. 114



37.0°
53.0°
T_1
T_2
T_3
a
$\vec{\mathbf{T}}_3$
$\vec{\mathbf{F}}_g$
b
y
x
$\vec{\mathbf{T}}_1$
$\vec{\mathbf{T}}_2$
$\vec{\mathbf{T}}_3$
37.0°
53.0°
c

Fig. 5.10, p. 114

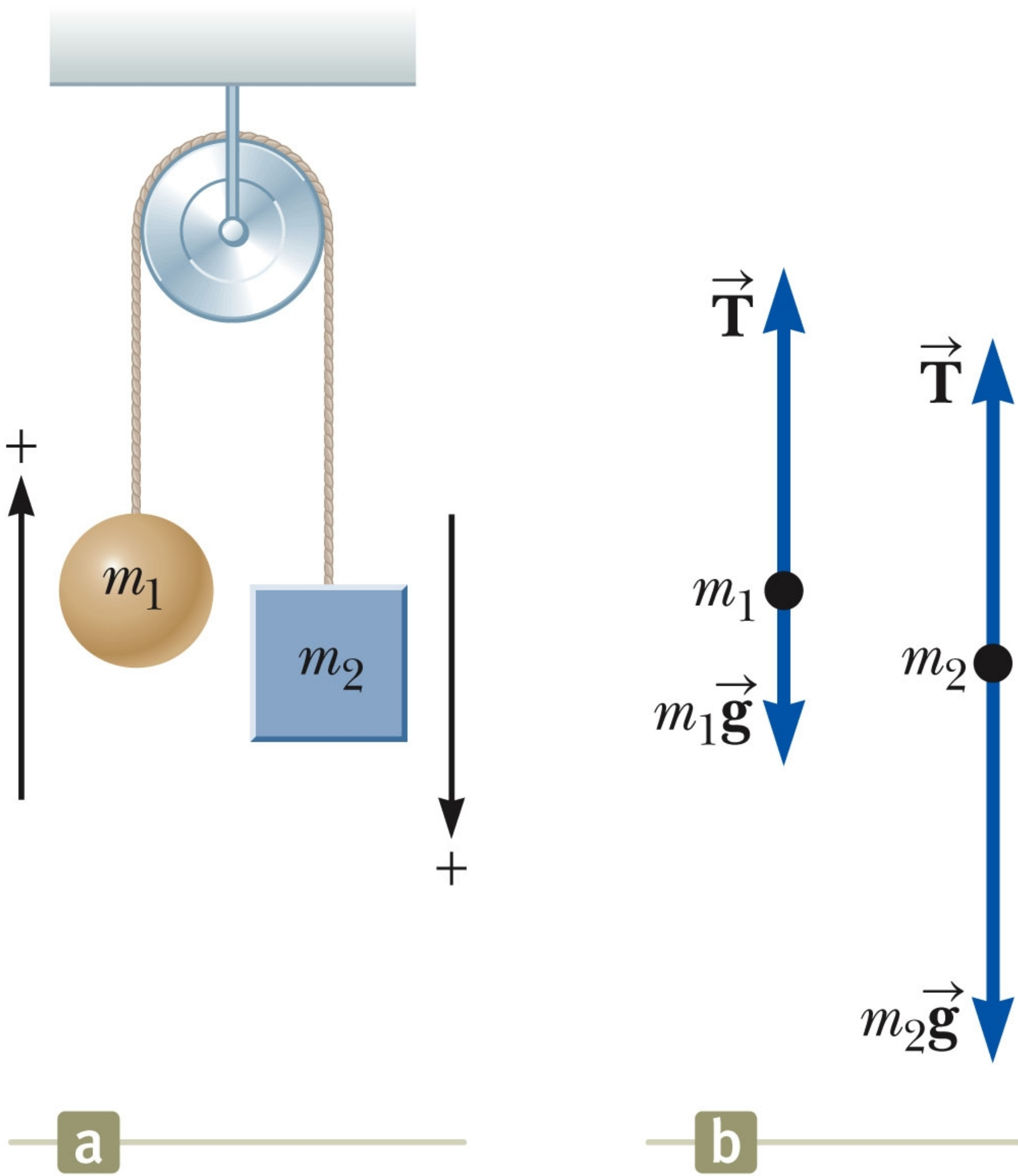


Fig. 5.14, p. 120

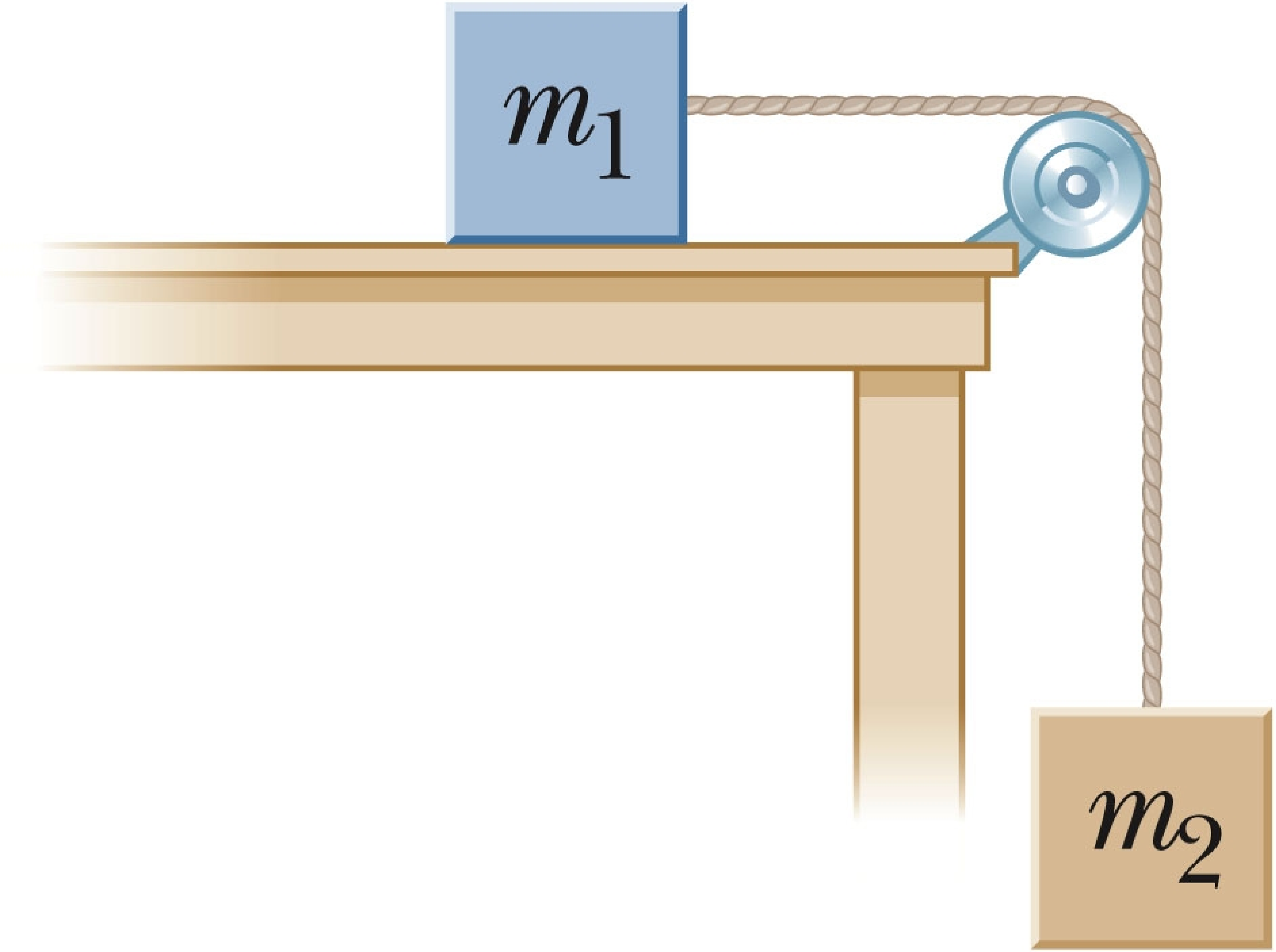
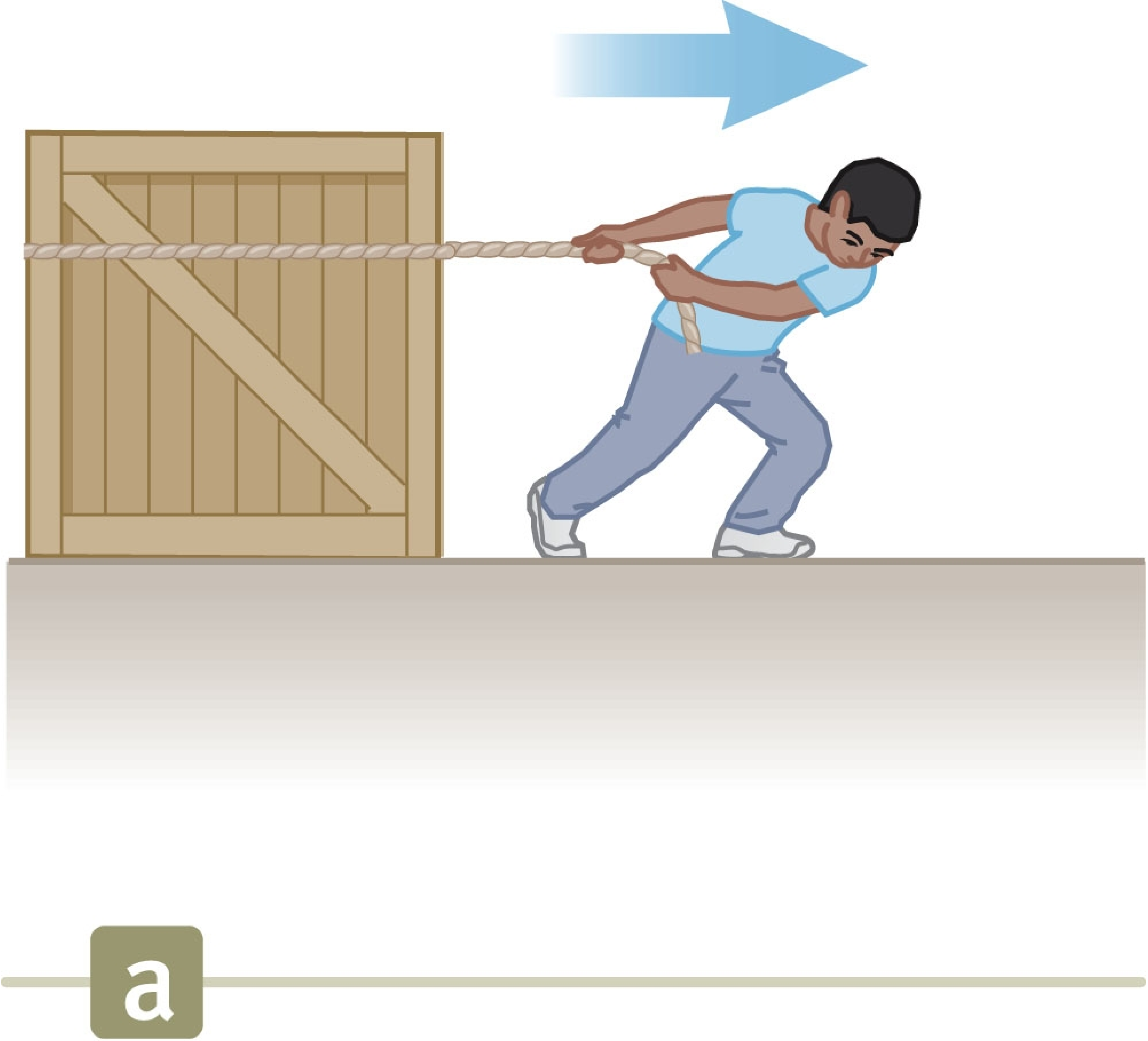
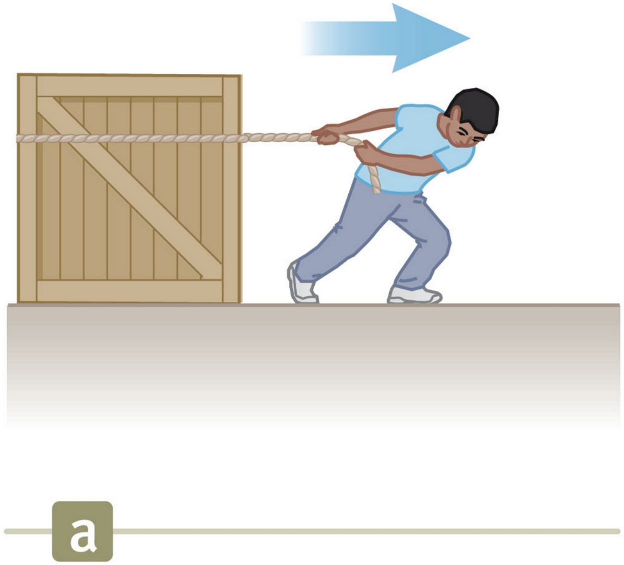


Fig. P5.28, p. 133



5.8, p. 113



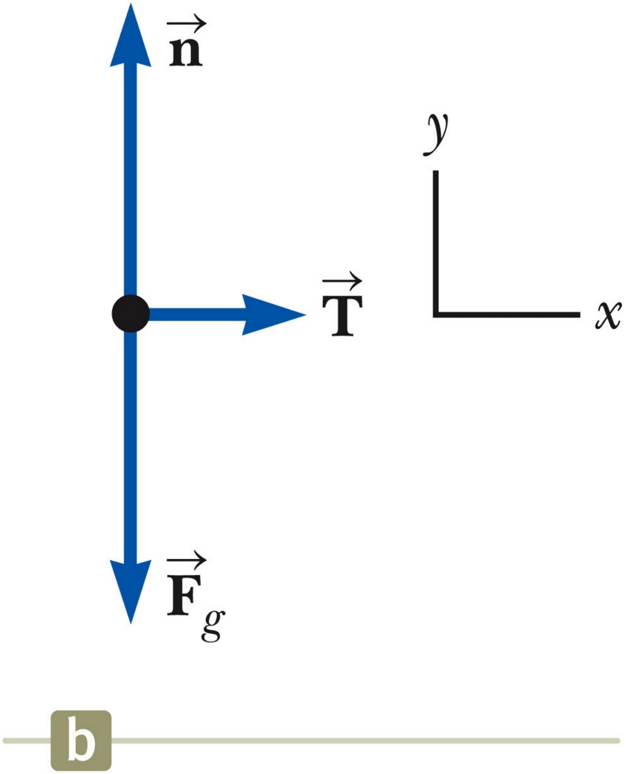


Fig. 5.8, p. 113

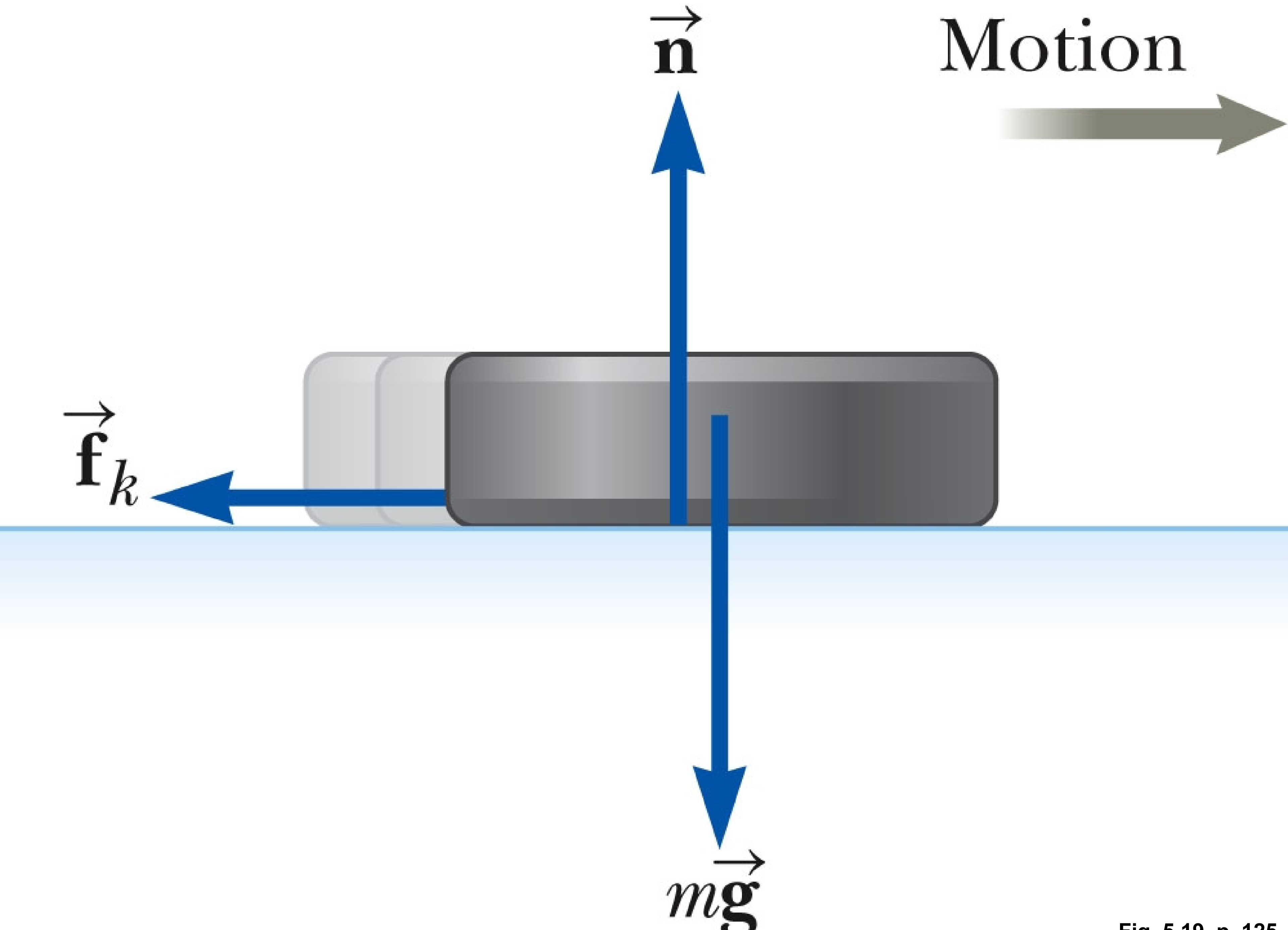
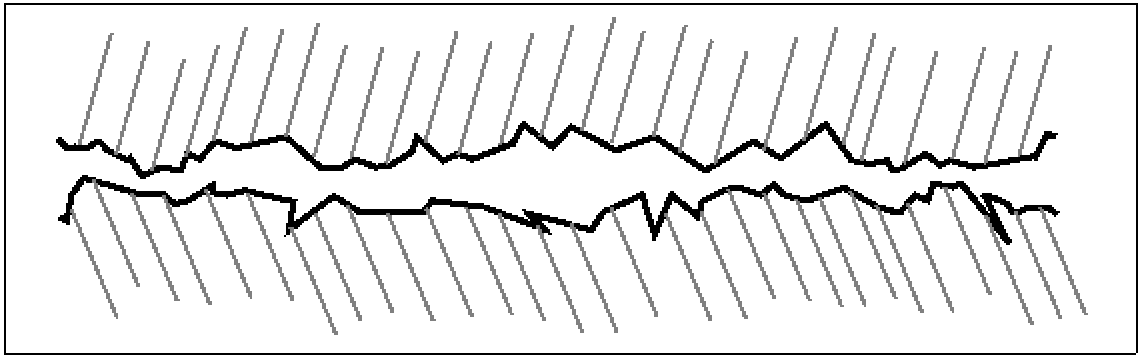
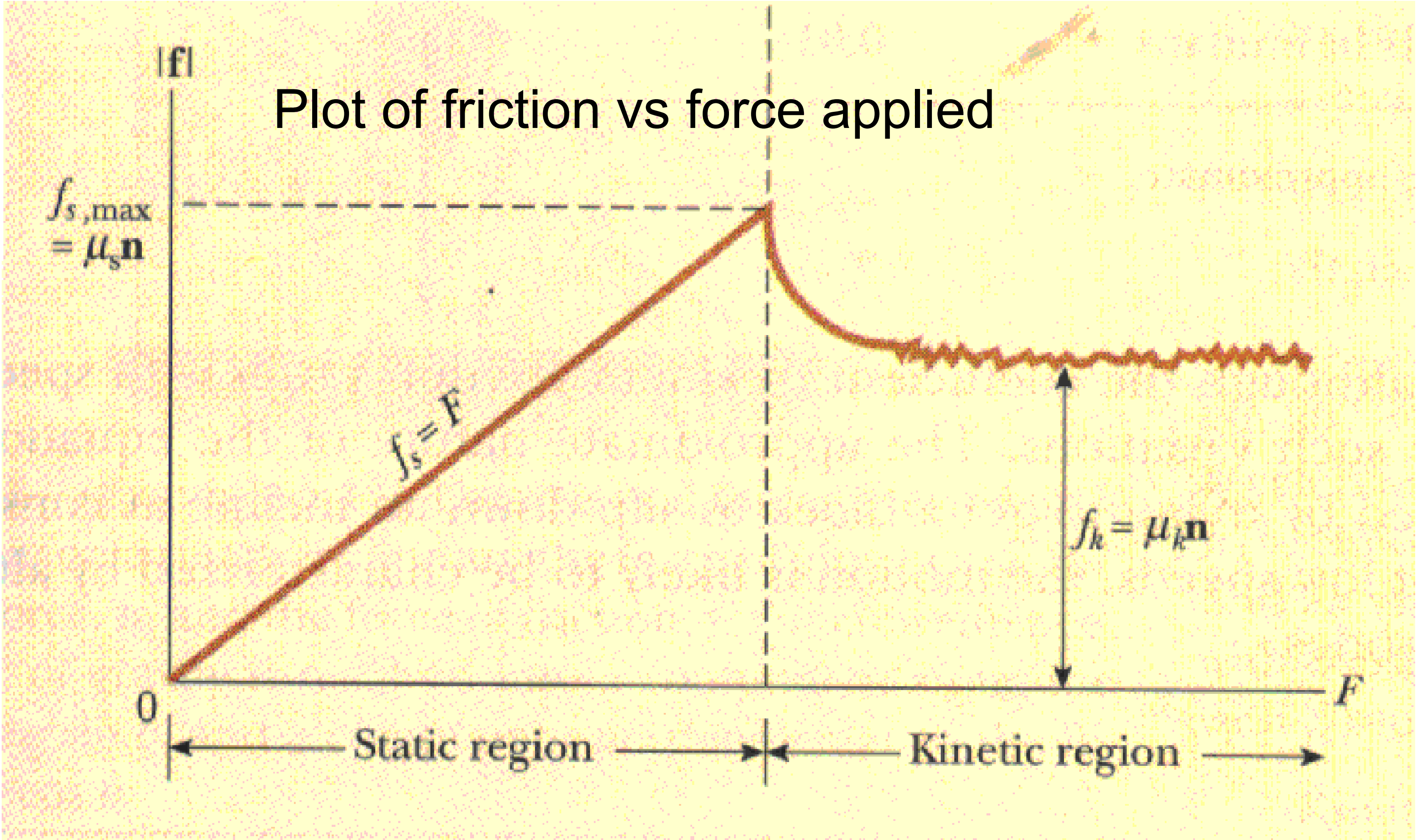


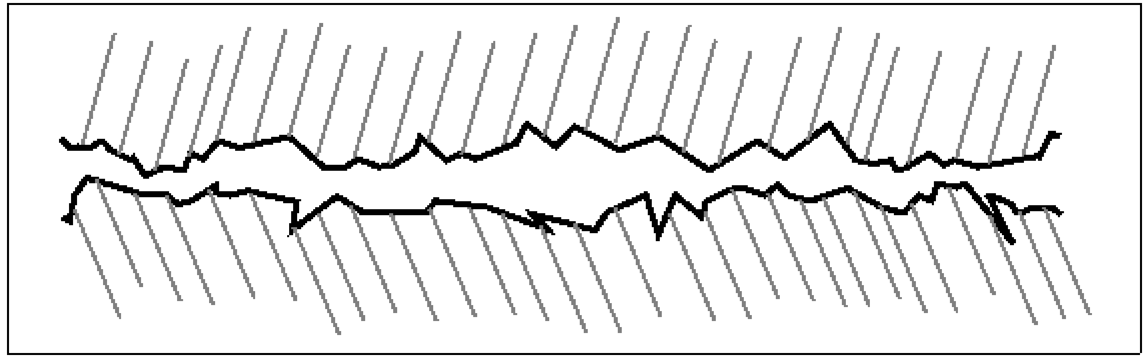
Fig. 5.19, p. 125

Close-up of surfaces.





Close-up of surfaces.



Plot of friction vs force applied

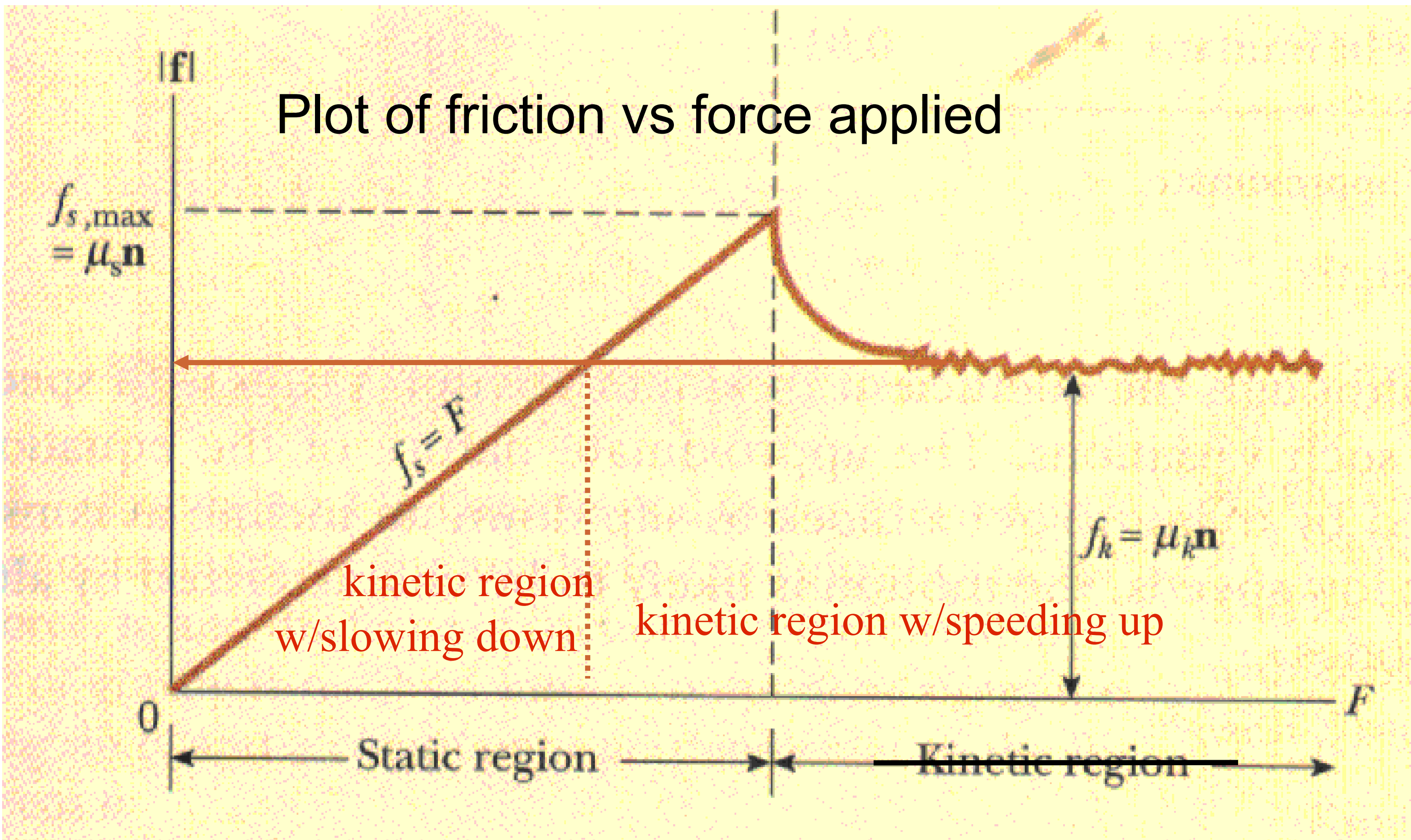
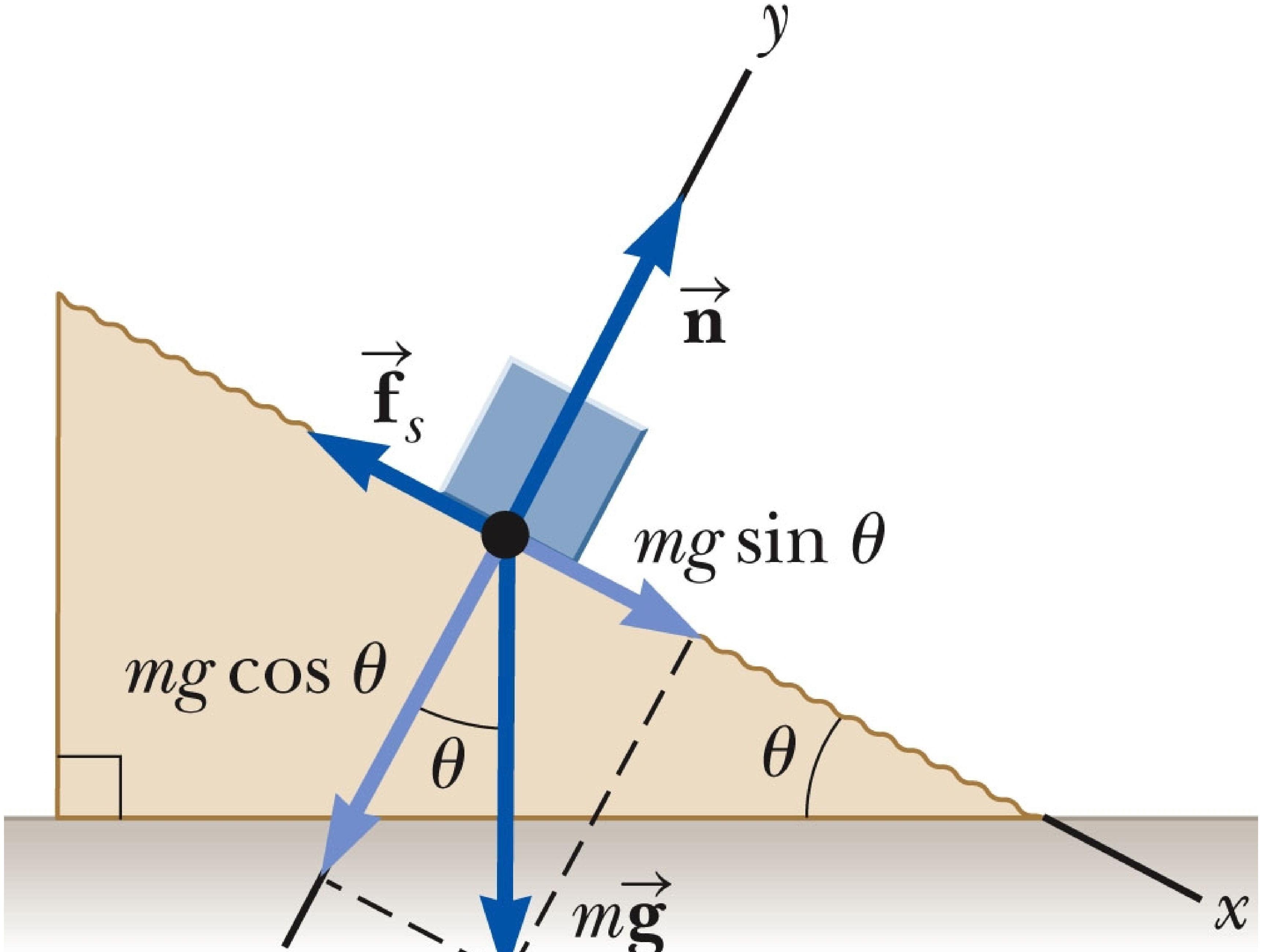


TABLE 5.1 *Coefficients of Friction*

	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.

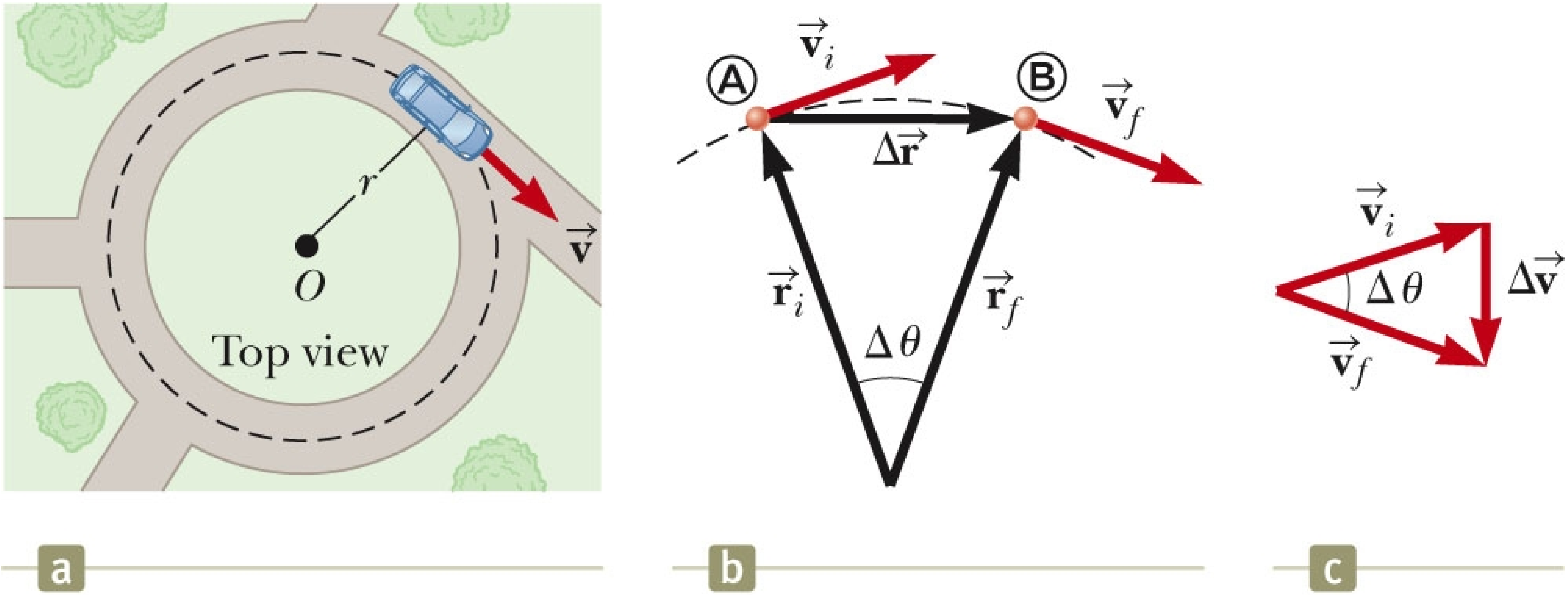
Table 5.1, p. 124



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

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

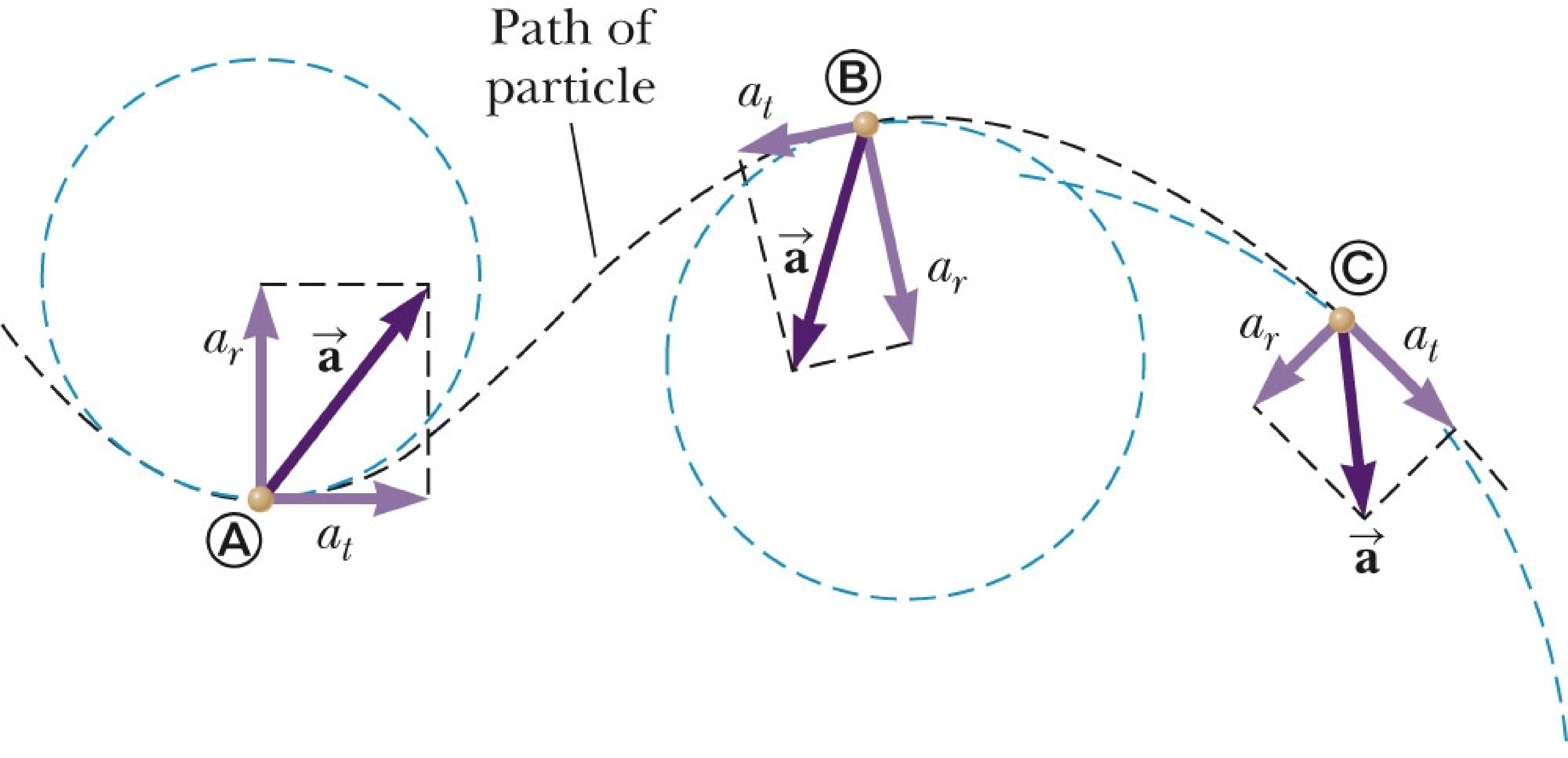


Fig. 4.16, p. 88

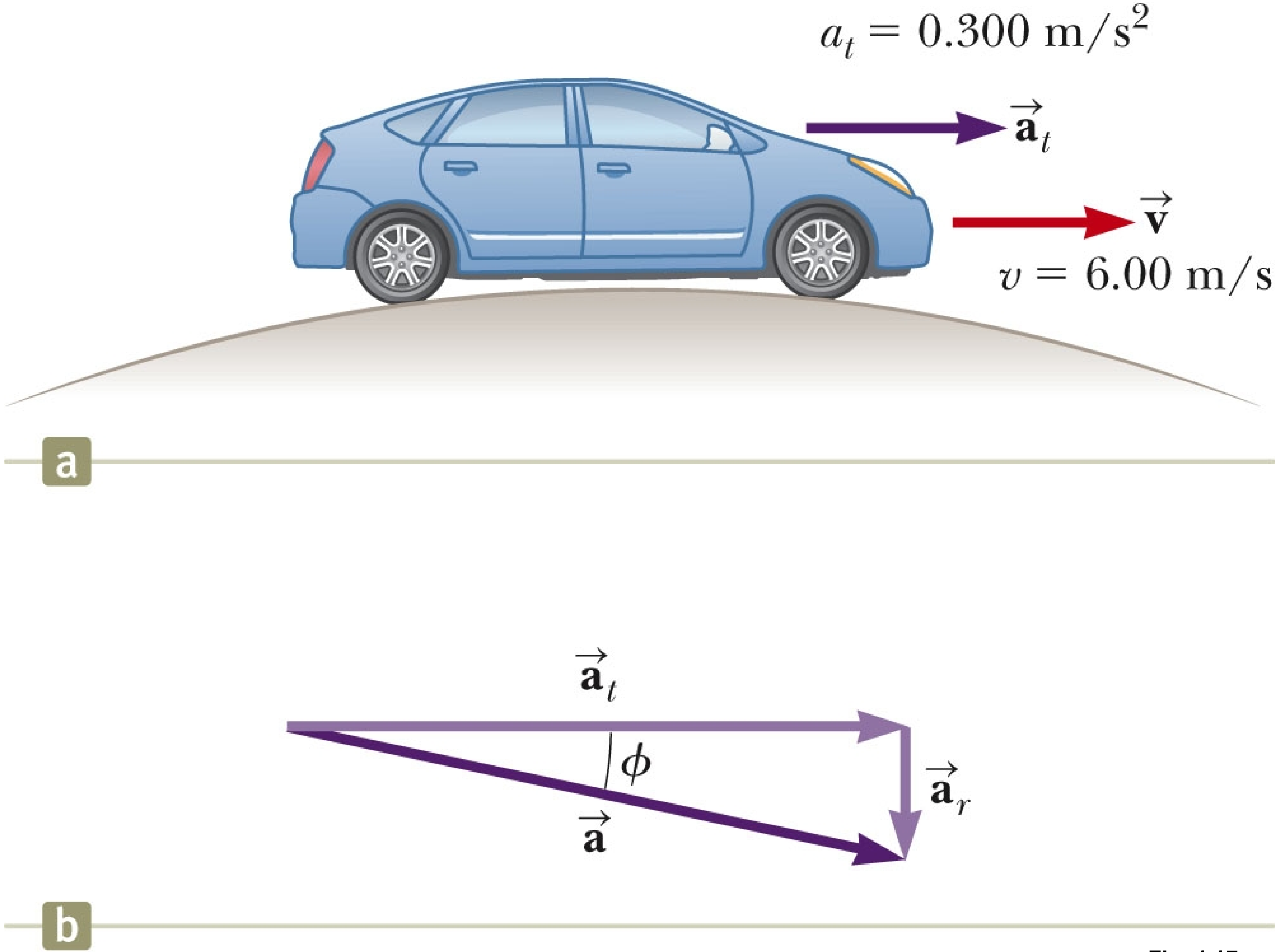

$a_t = 0.300 \text{ m/s}^2$
$\vec{\mathbf{a}}_t$
$\vec{\mathbf{v}}$
$v = 6.00 \text{ m/s}$
a
$\vec{\mathbf{a}}_t$
ϕ
$\vec{\mathbf{a}}_r$
$\vec{\mathbf{a}}$
b

Fig. 4.17, p. 89