Outline for Day W4,D2

Newton's 1st law
Relative velocity and motion
Types of Forces

Homework

Ch. 4 P. 1-5,7,12-14,28,33,42,45,47,48
MisQ 1-11 (odd), Read Sec 1-8. Due Fri
Read 3.9 (rel motion)

Notes: Lab this week: "Acceleration of Gravity"

"NEW STUFF" has new PPT, YouTube (FOR), exam-like problems for Ch. 3, rel. motion problems.

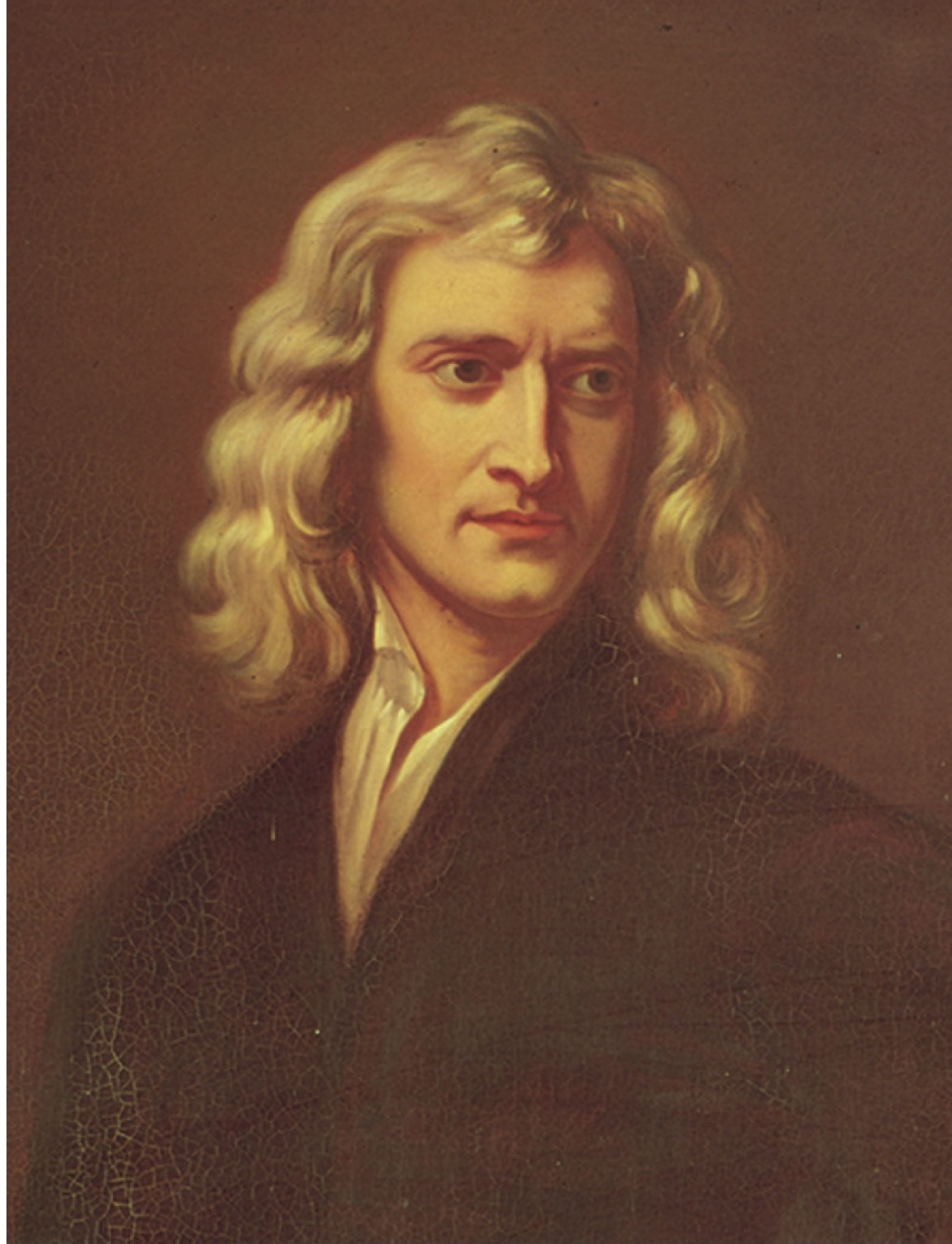
Exam I follows Chapter 5 material.

Week 4-6 Topics

Chapter 3. Relative 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.

Isaac Newton
(1642 - 1727)

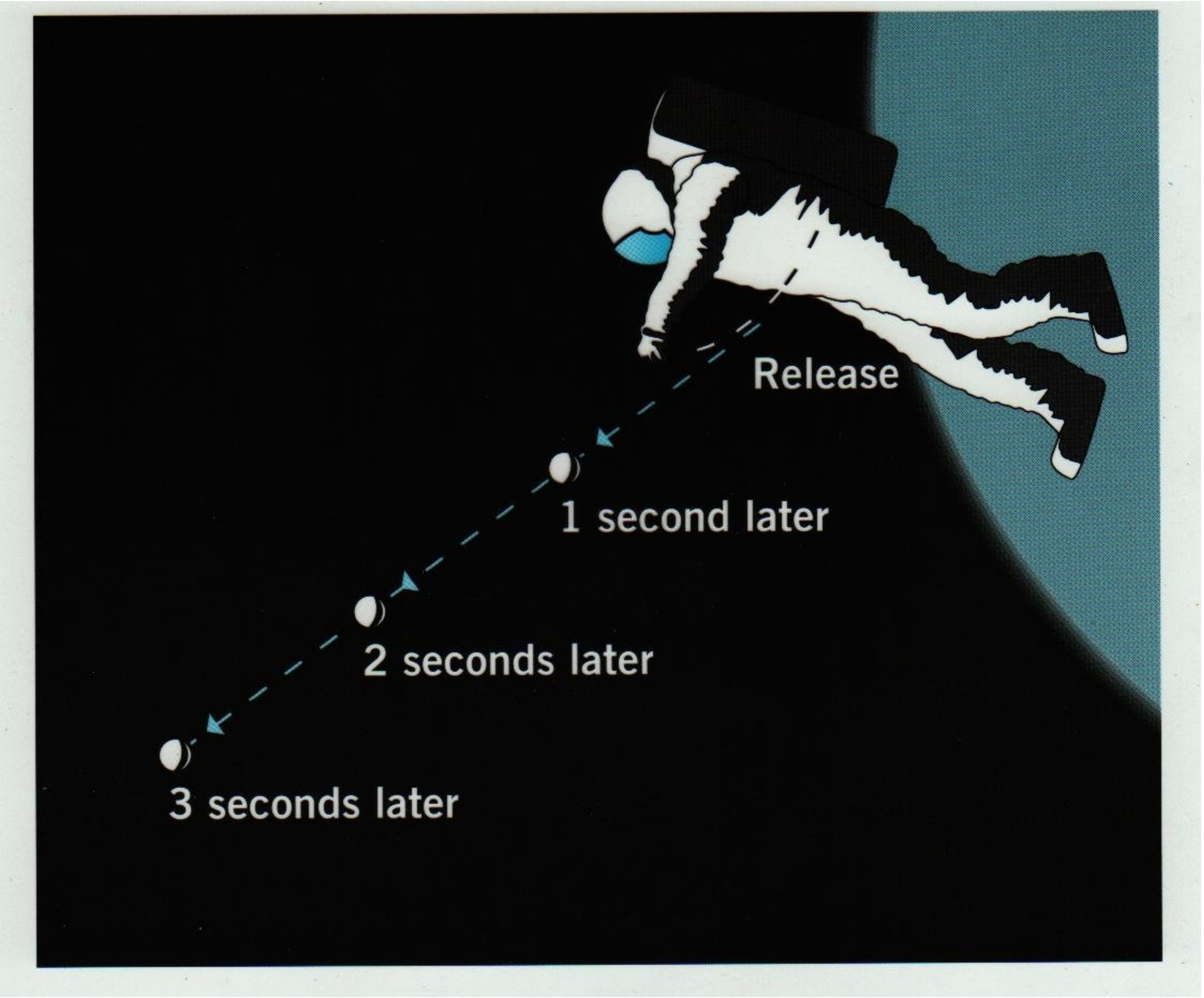


3 laws of motion

1 law of Universal
Gravitation

Co-invented calculus

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:

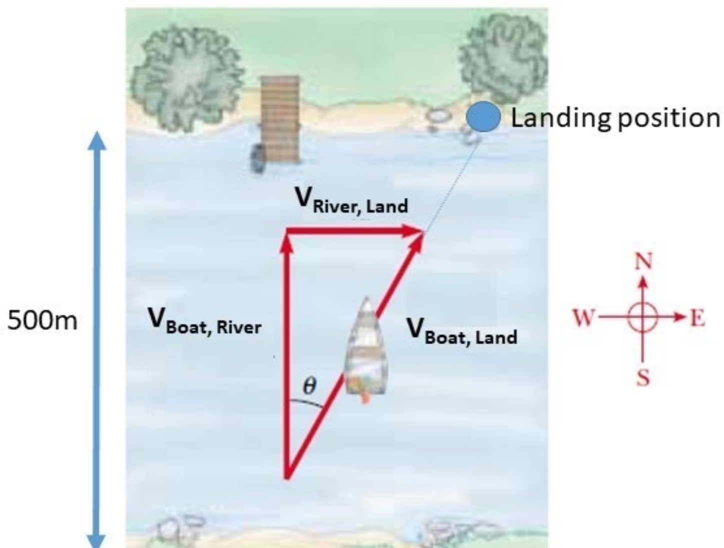
"natural state" is at rest

"impetus" pushes an arrow along

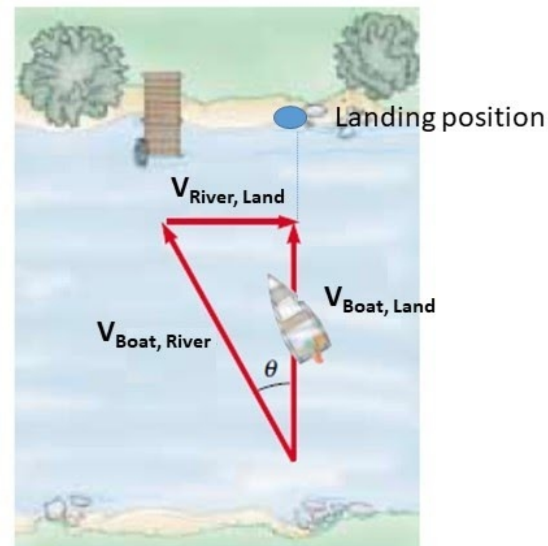
Frames of reference and relative motion

The assumption of inertial frames of reference was Implicit in Ch. 3's "relative velocity" examples.

Problem 1



Problem 2



3 frames of ref: the boat (B), the land (L) and the river (R).

Given $\mathbf{v}_{RL}$ = 3 m/s E, $\mathbf{v}_{BR}$ = 8 m/s N.

1) Find v_{BL}. $\mathbf{v}_{BL} = \mathbf{v}_{BR} + \mathbf{v}_{RL} = 8\hat{\imath} + 3\hat{\jmath}$, $|\mathbf{v}_{BL}|$=8.54 m/s, θ=20.6°

2) What θ is needed so that the boat goes straight N?
Need $\mathbf{v}_{BL}$ = ? m/s N. $\sin\theta = \mathbf{v}_{RL}/\mathbf{v}_{BR}$=3/8. θ=22.0°

Relative Motion Problem

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

So we can say

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

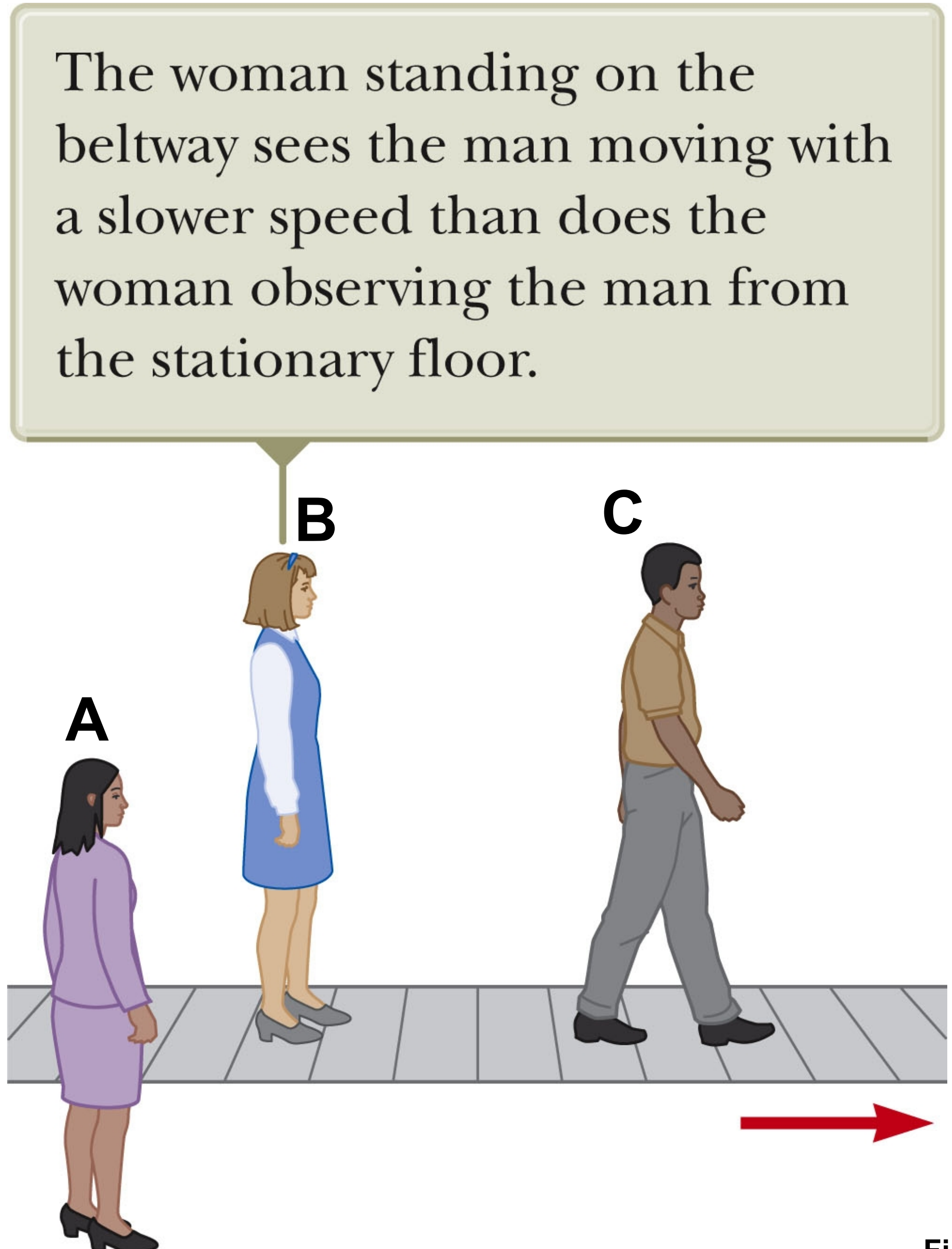
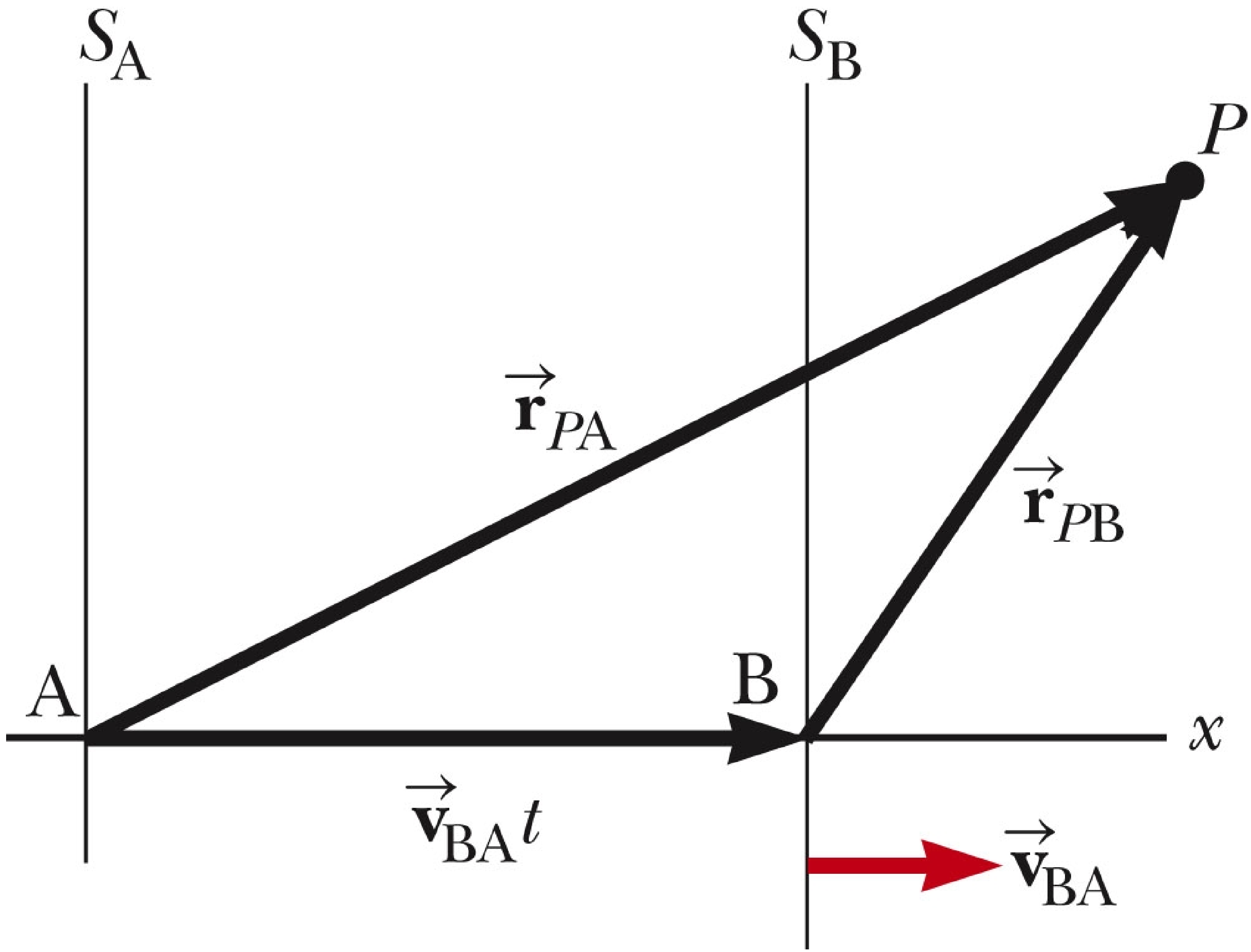


Fig. 4.19, p. 90

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" 17:05-22:00)

4) The Earth's surface! (See movie "Frames of Reference" and the Foucault pendulum 24:20-26:00.)

Forces – the *cause* of acceleration

Forces are vectors

Forces act between *systems* (the dashed boxes)

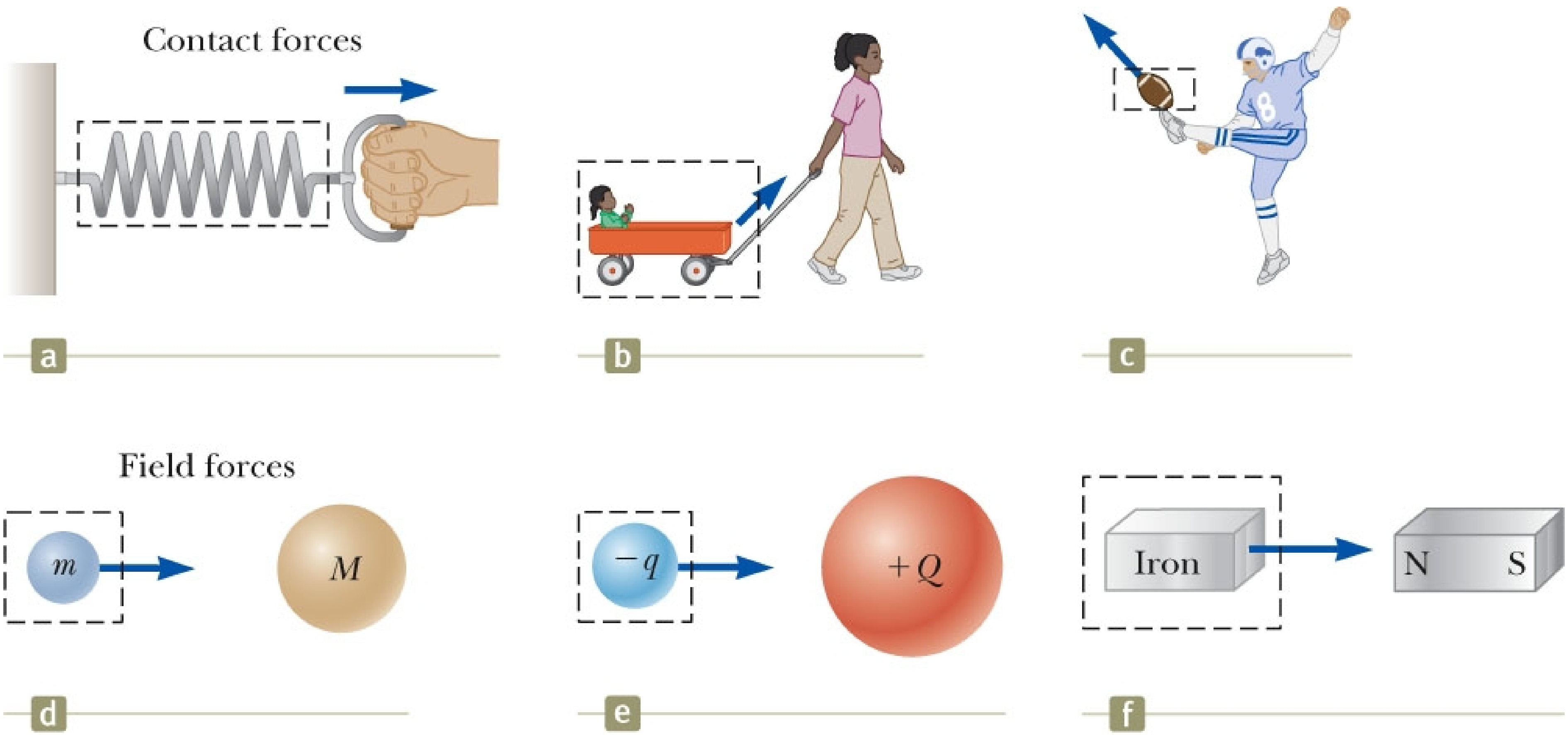
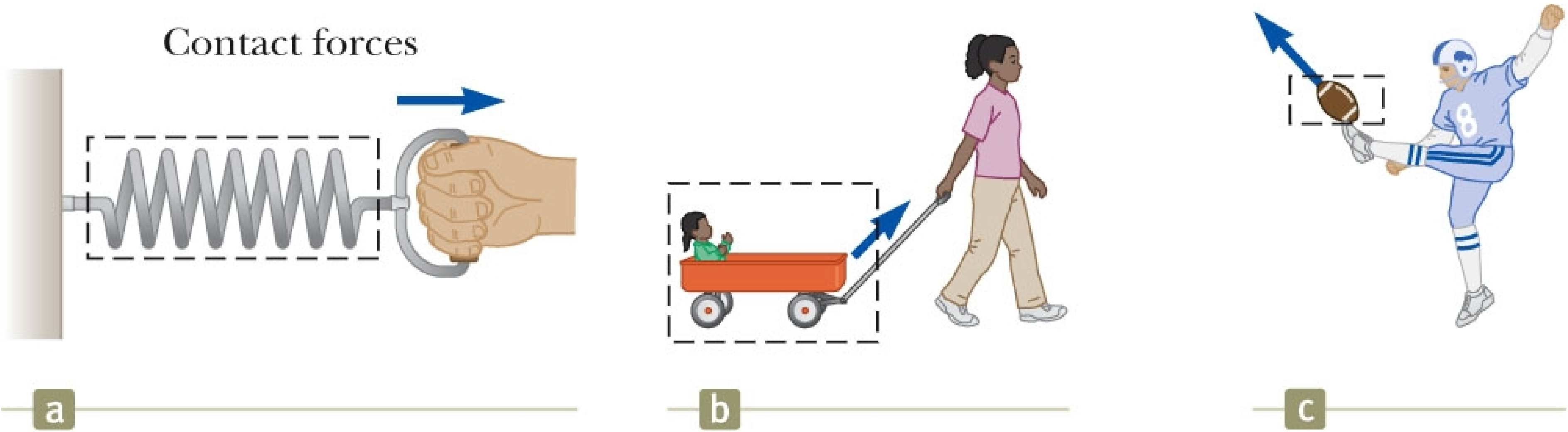


Fig. 5.1, p. 104

Types of forces

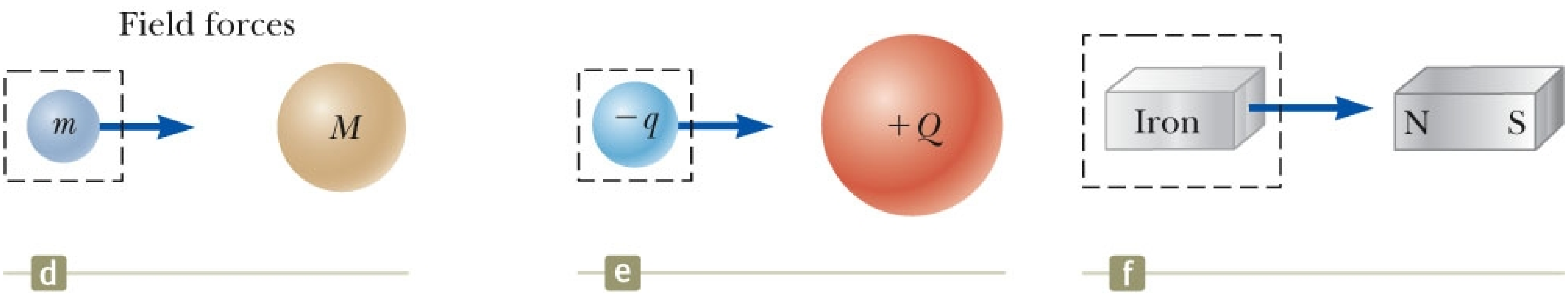


contact forces

- 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

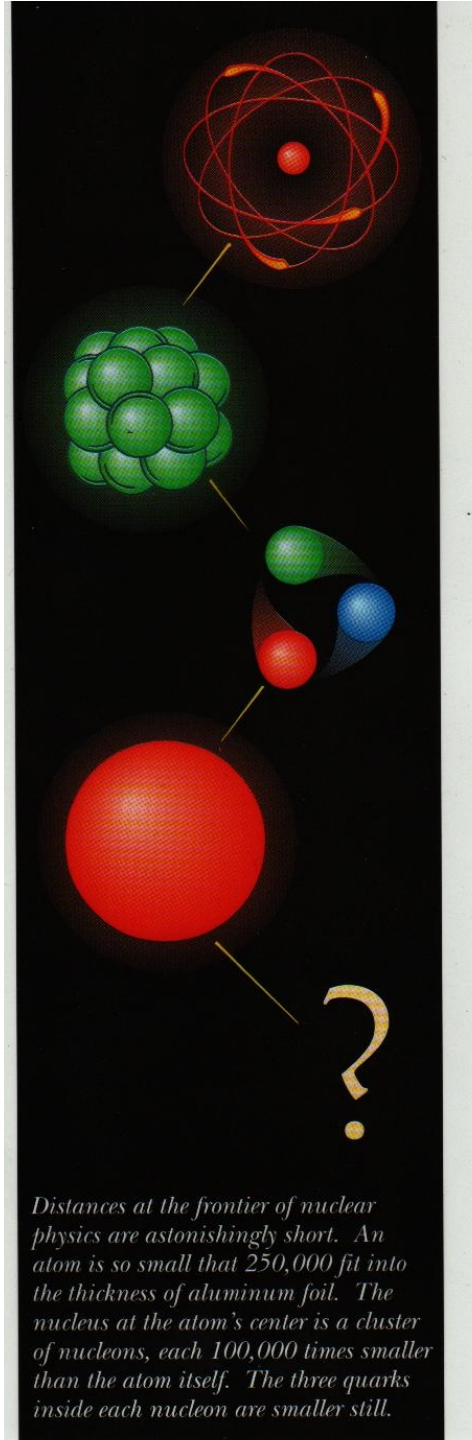
The 4 Fundamental forces

Gravity

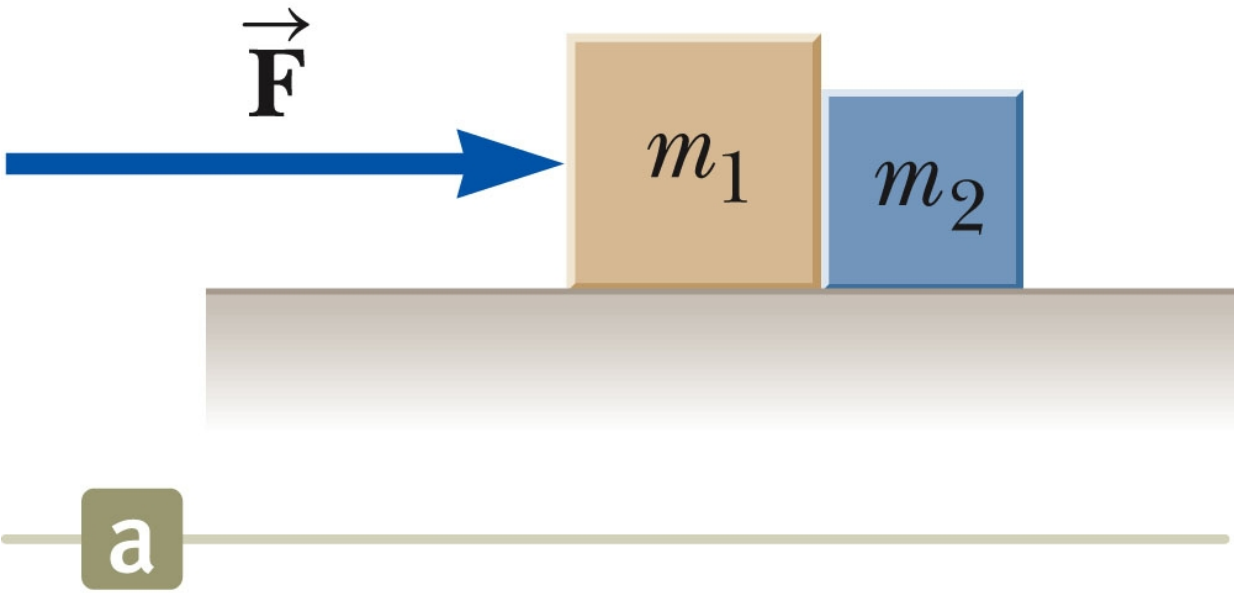
Electromagnetic Force

Nuclear Strong Force – holds nuclei together

Nuclear Weak force – decay of n and p



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.

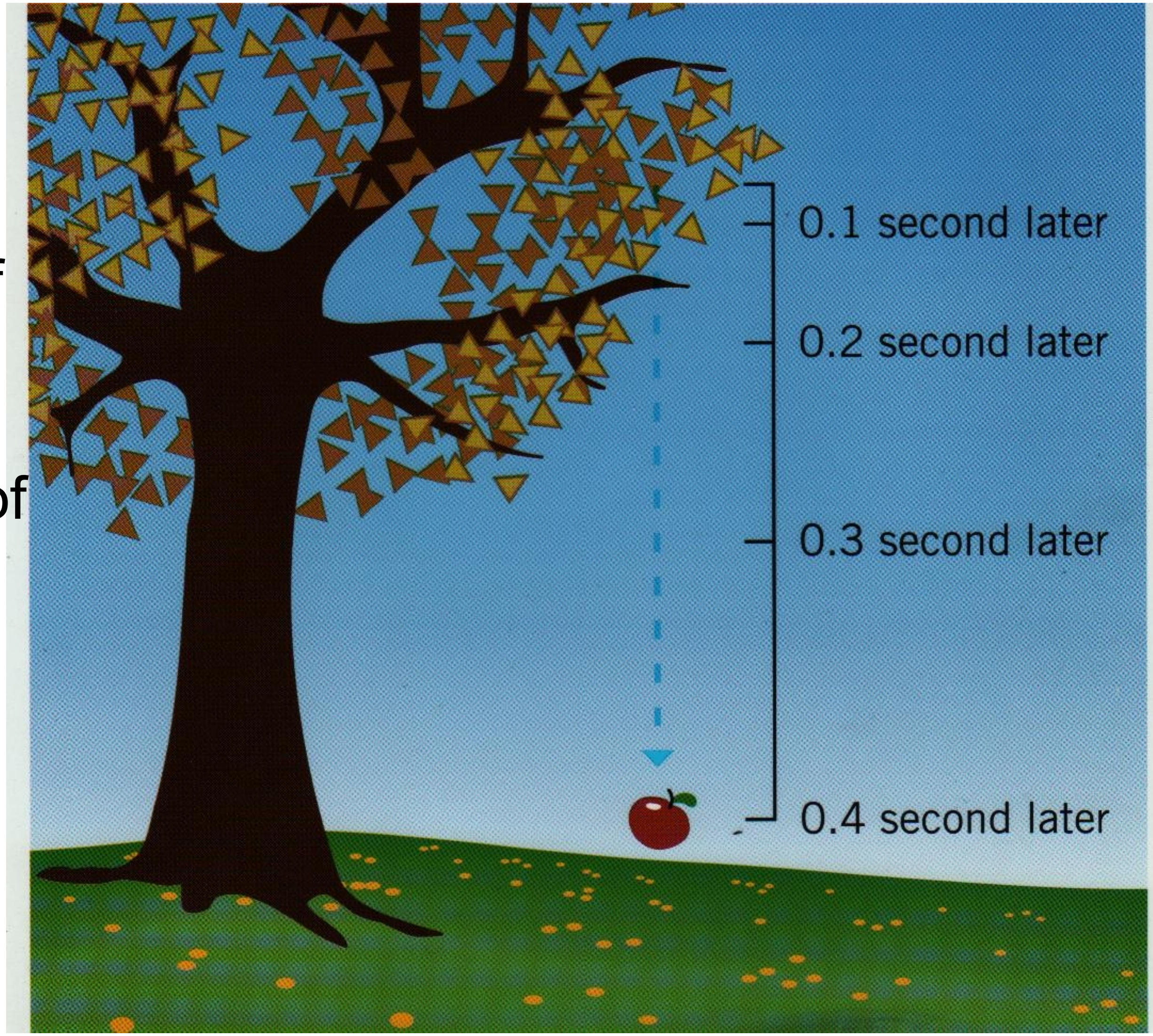
Newton's 2nd law (cont.)

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

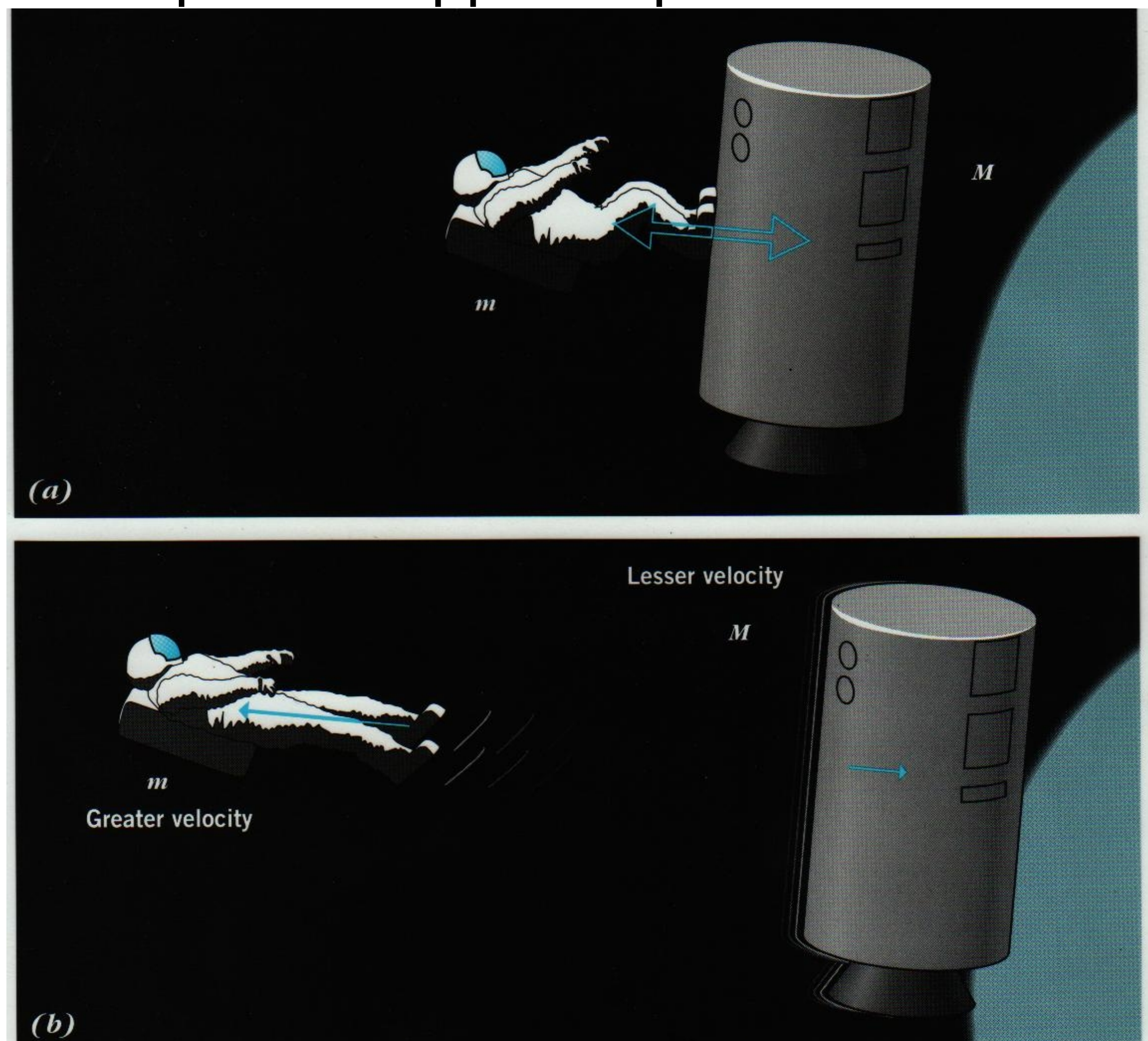
Inertial mass = gravitational mass



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.

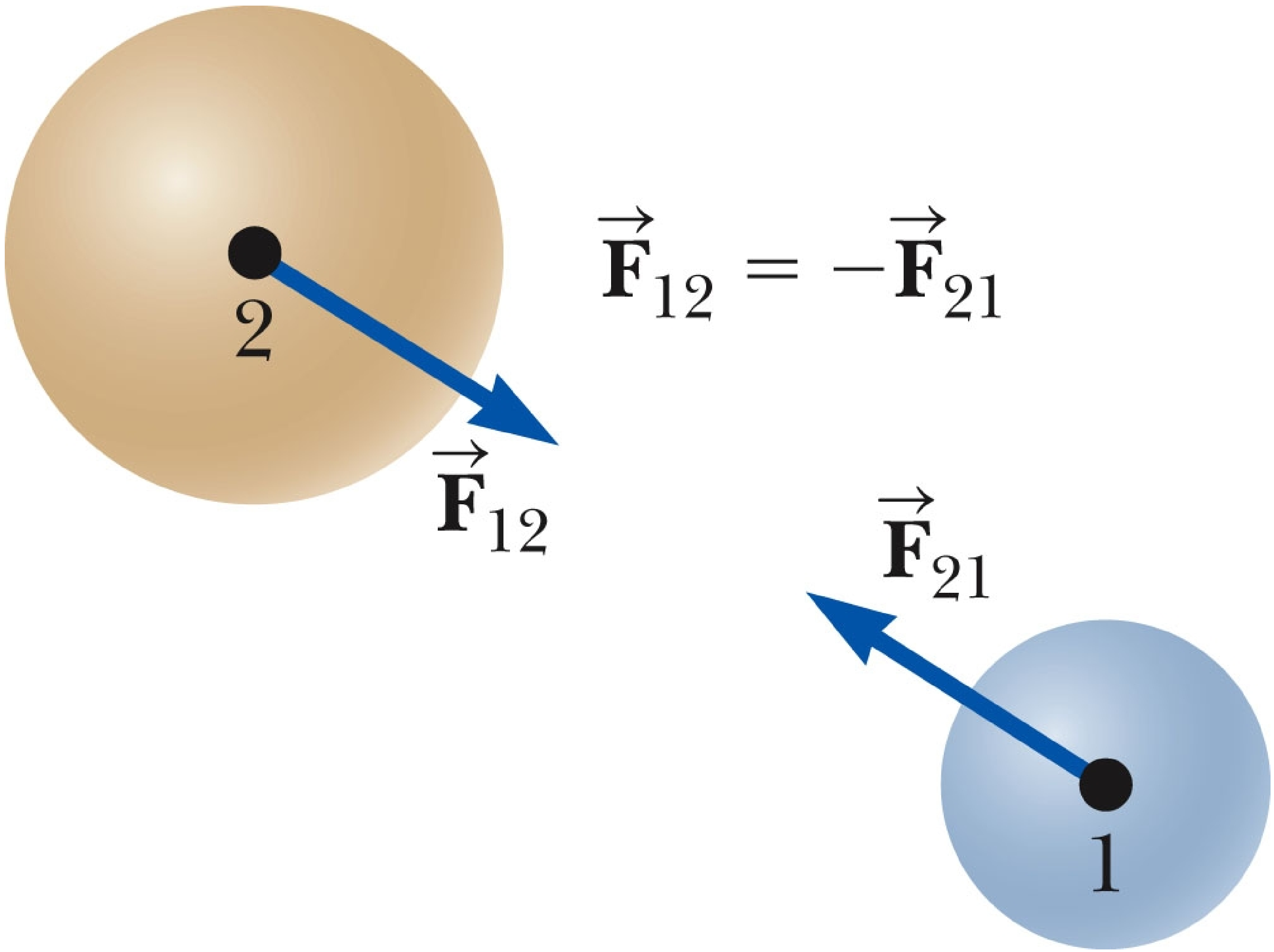
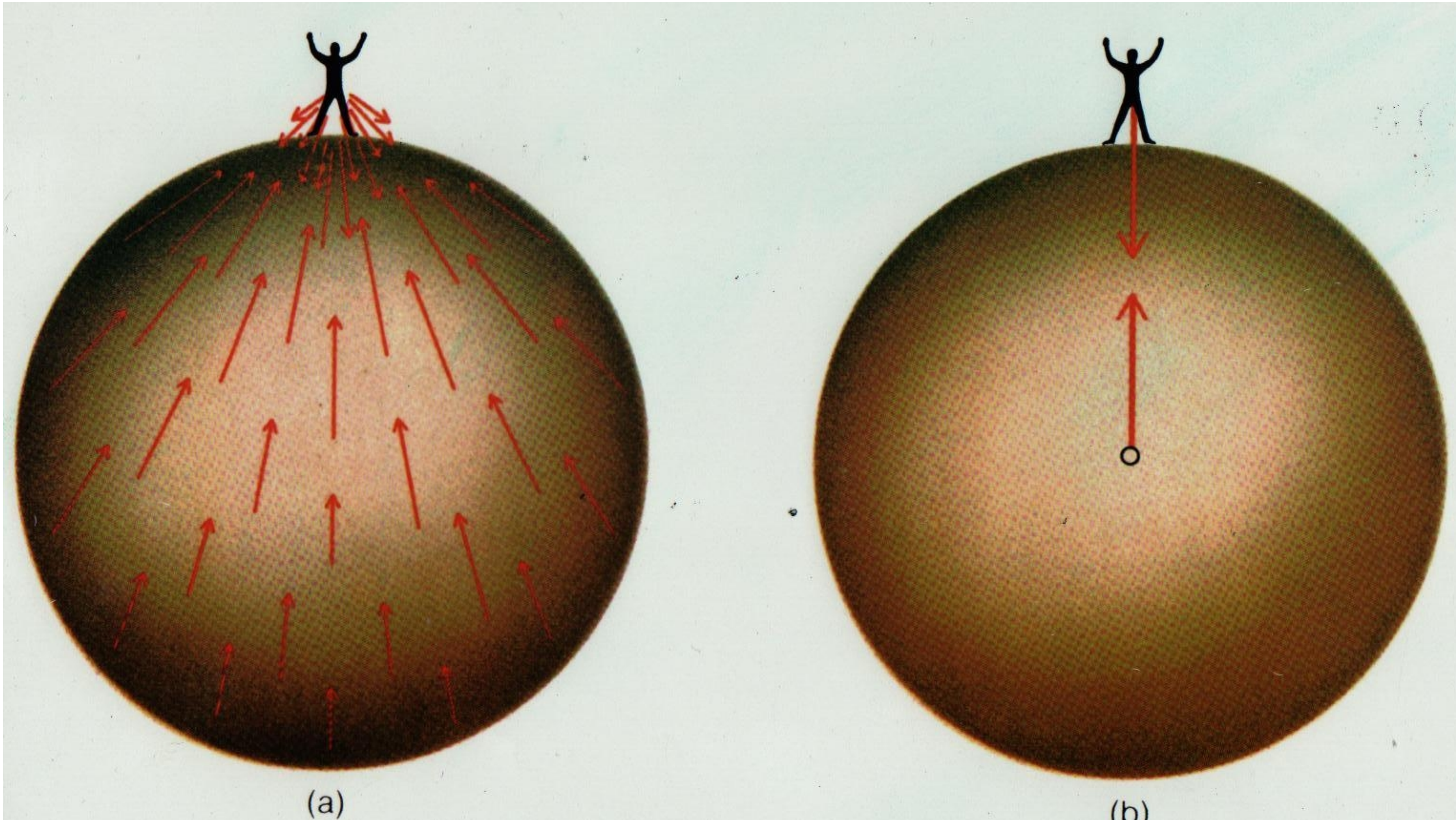


Fig. 5.5, p. 111

Newton's 3rd law (cont.)



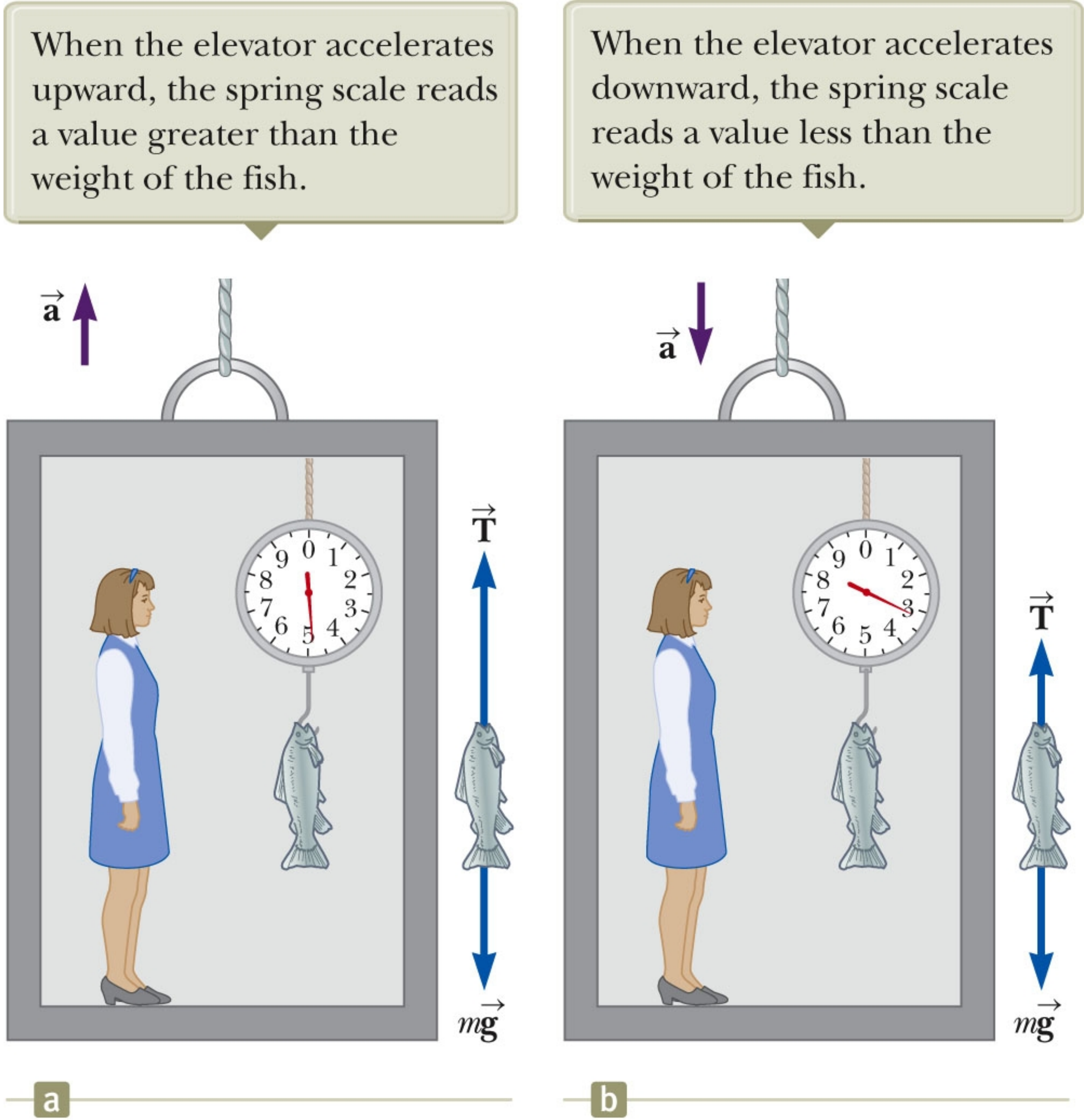
Weight = the |force| of gravity near a planet = mg = Fg

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 2^{nd} law problem – object accelerates
3. Analyze
   - Isolate object of interest and draw forces acting on it. **F.B.D.!**
   - 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.

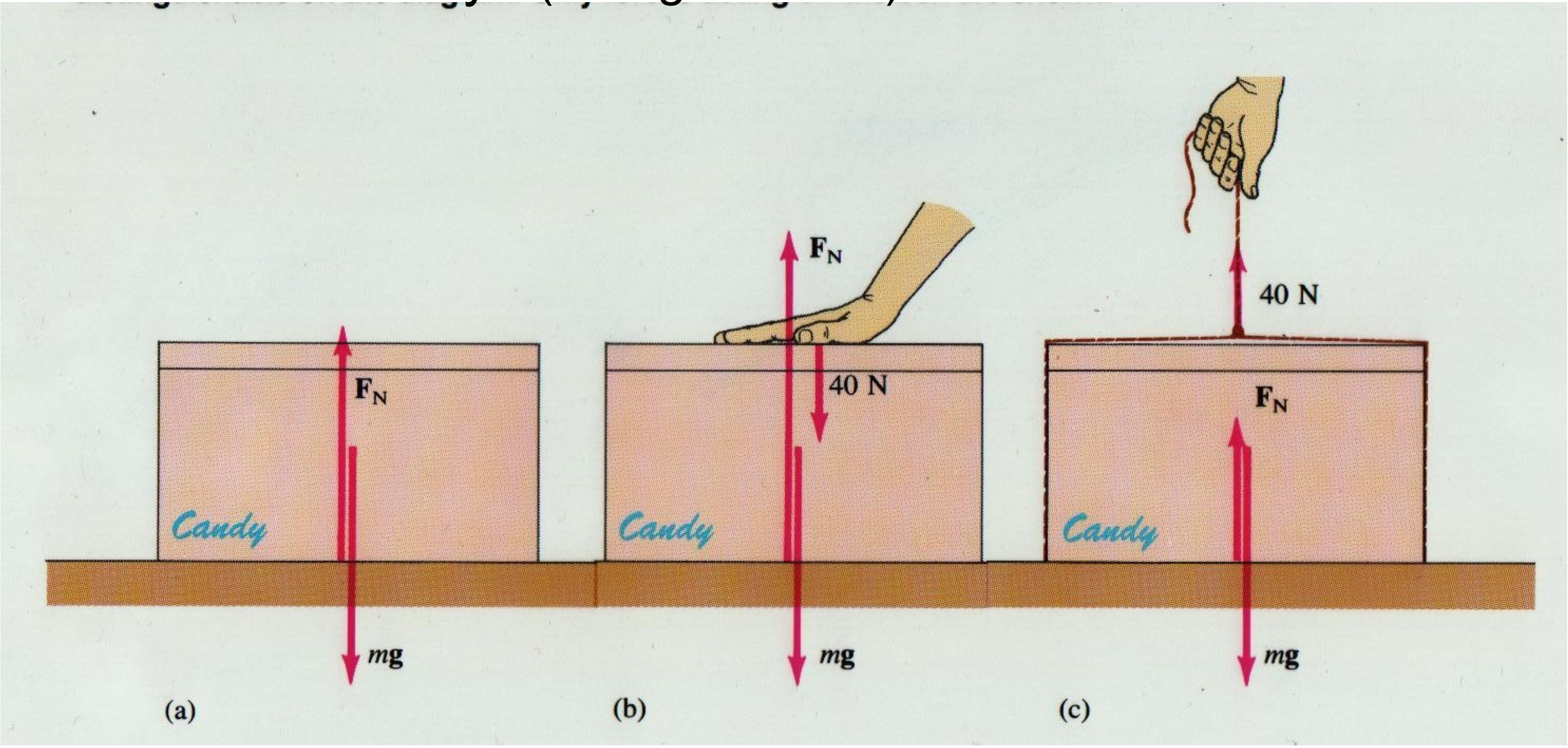


When the elevator accelerates upward, the spring scale reads a value greater than the weight of the fish.
When the elevator accelerates downward, the spring scale reads a value less than the weight of the fish.
$\vec{a}$
$\vec{T}$
$m\vec{g}$
$\vec{a}$
$\vec{T}$
$m\vec{g}$
a
b

Fig. 5.13, p. 119

The Application of Newton's Laws

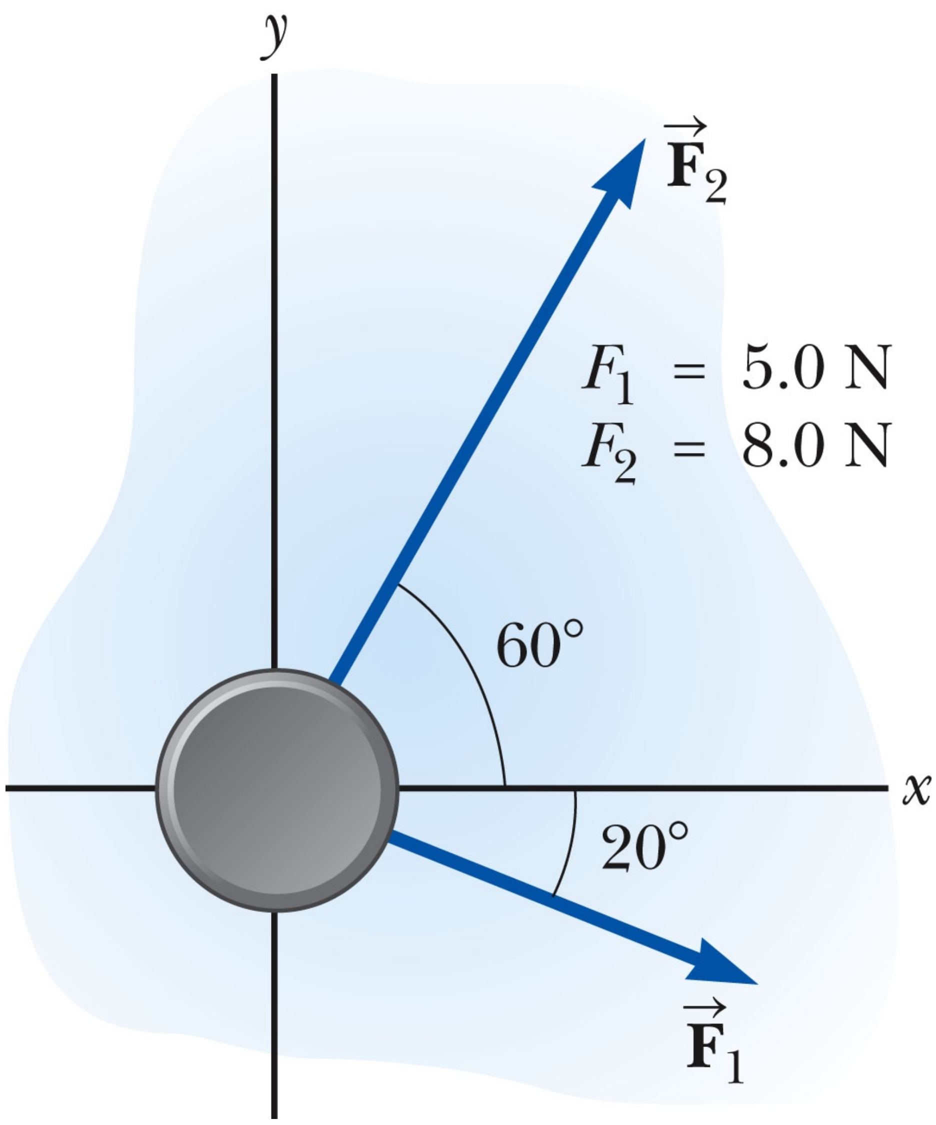
Find the normal force in each case if m=1 kg and the box remains stationary. (Use $g=10\ m/s^2$)



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.



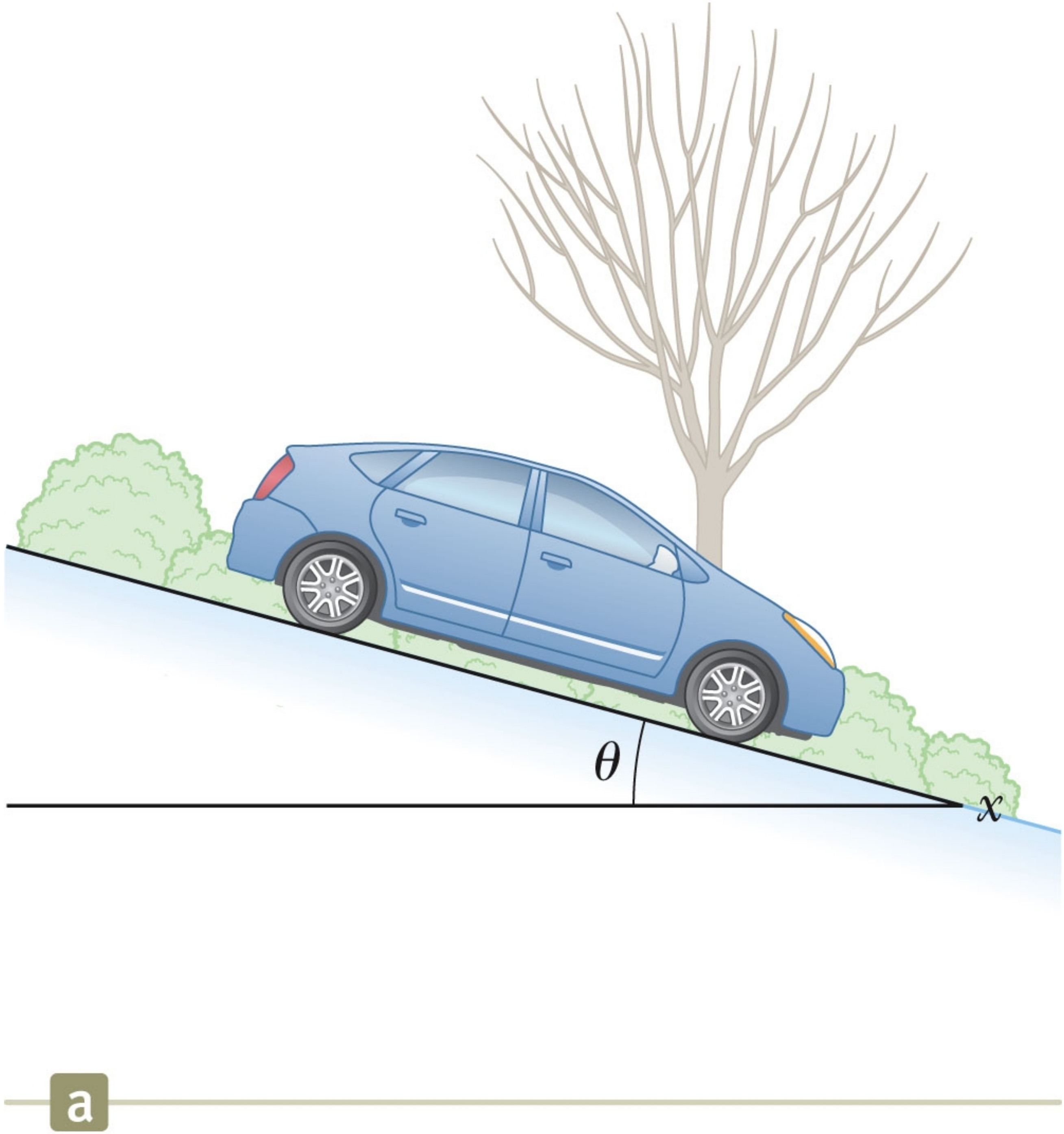


Fig. 5.11, p. 116

Find the acceleration of an object on a frictionless incline.

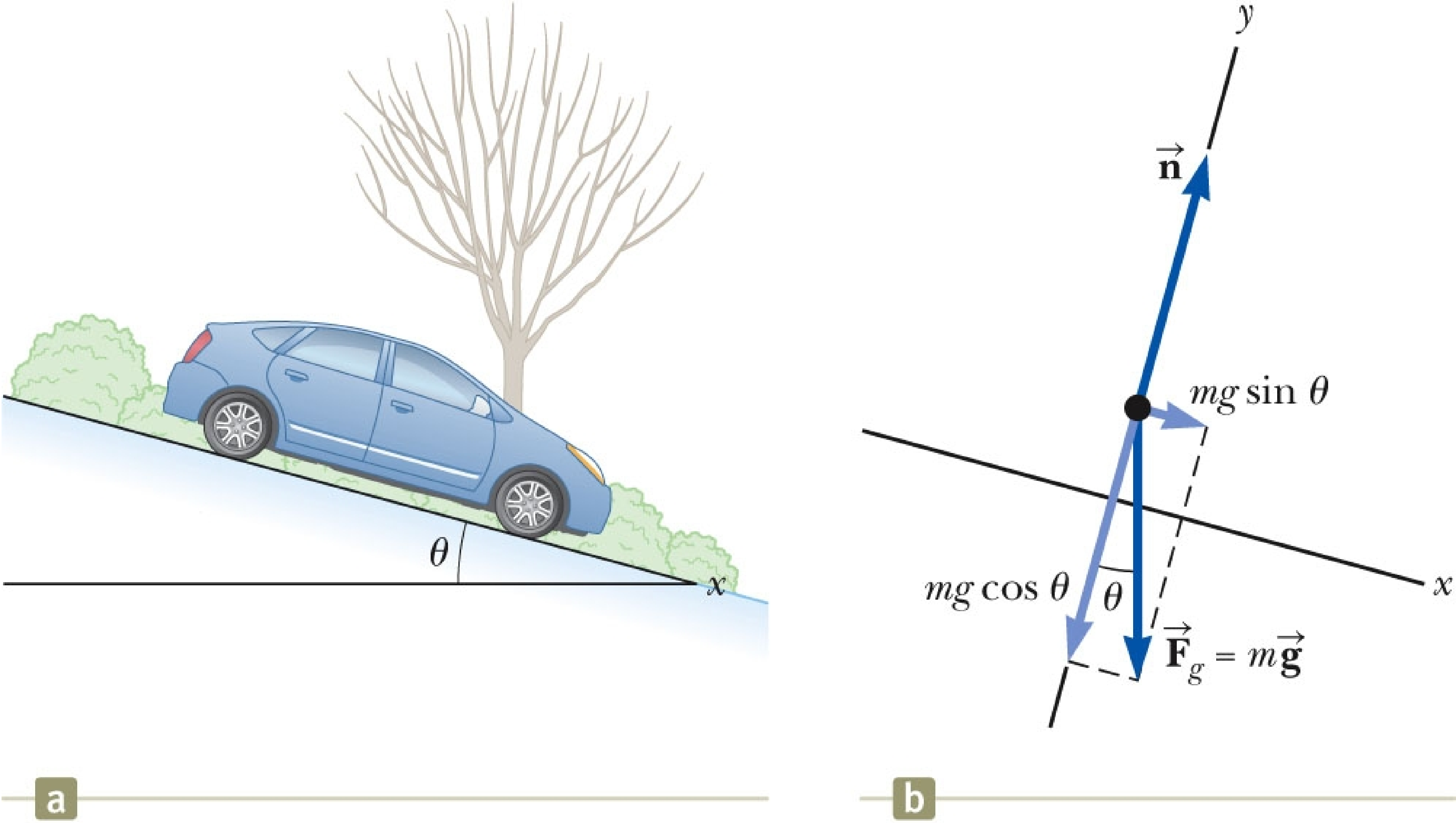
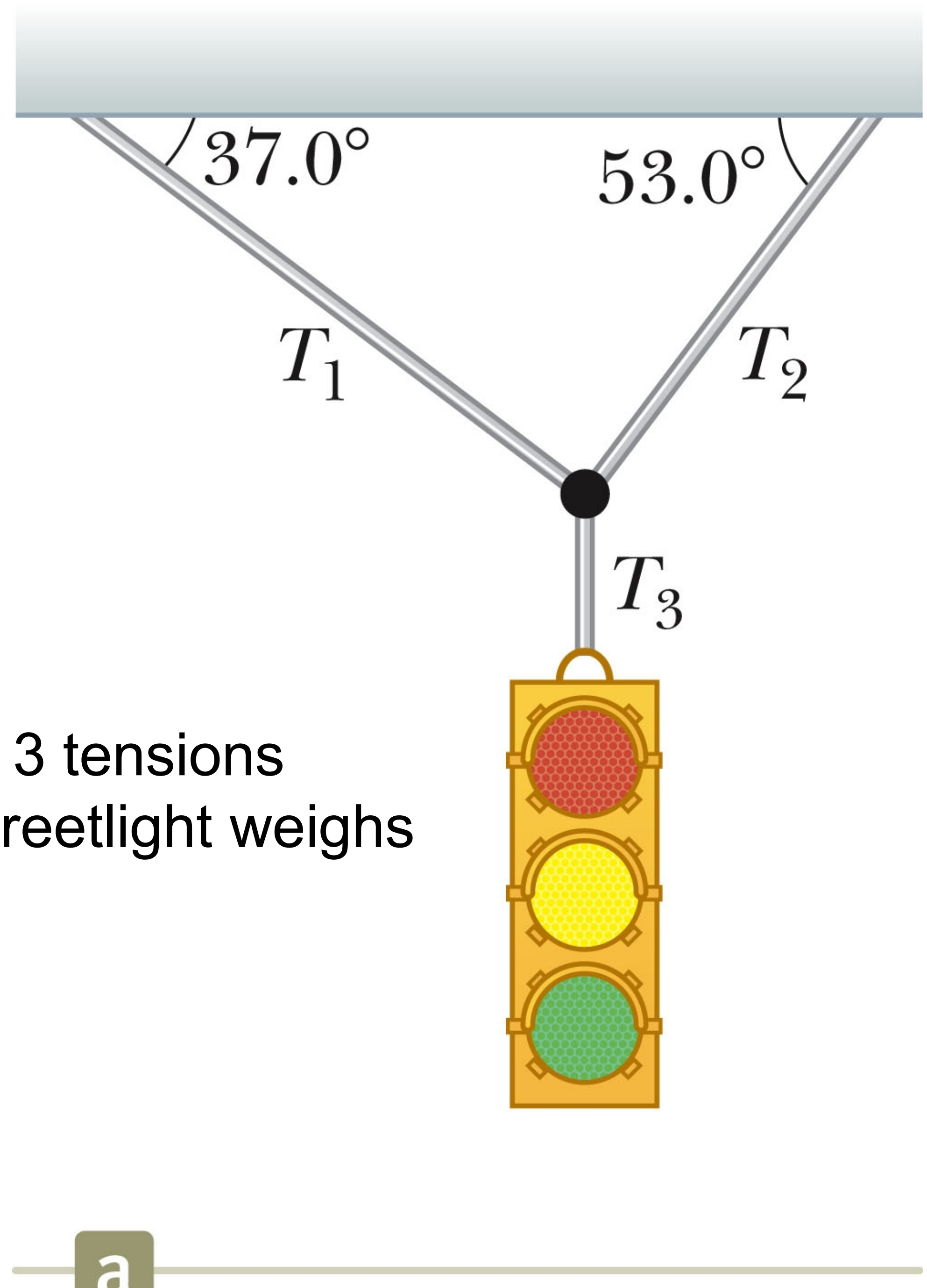


Fig. 5.11, p. 116



Find all 3 tensions
If the streetlight weighs
200 N.

Fig. 5.10, p. 114

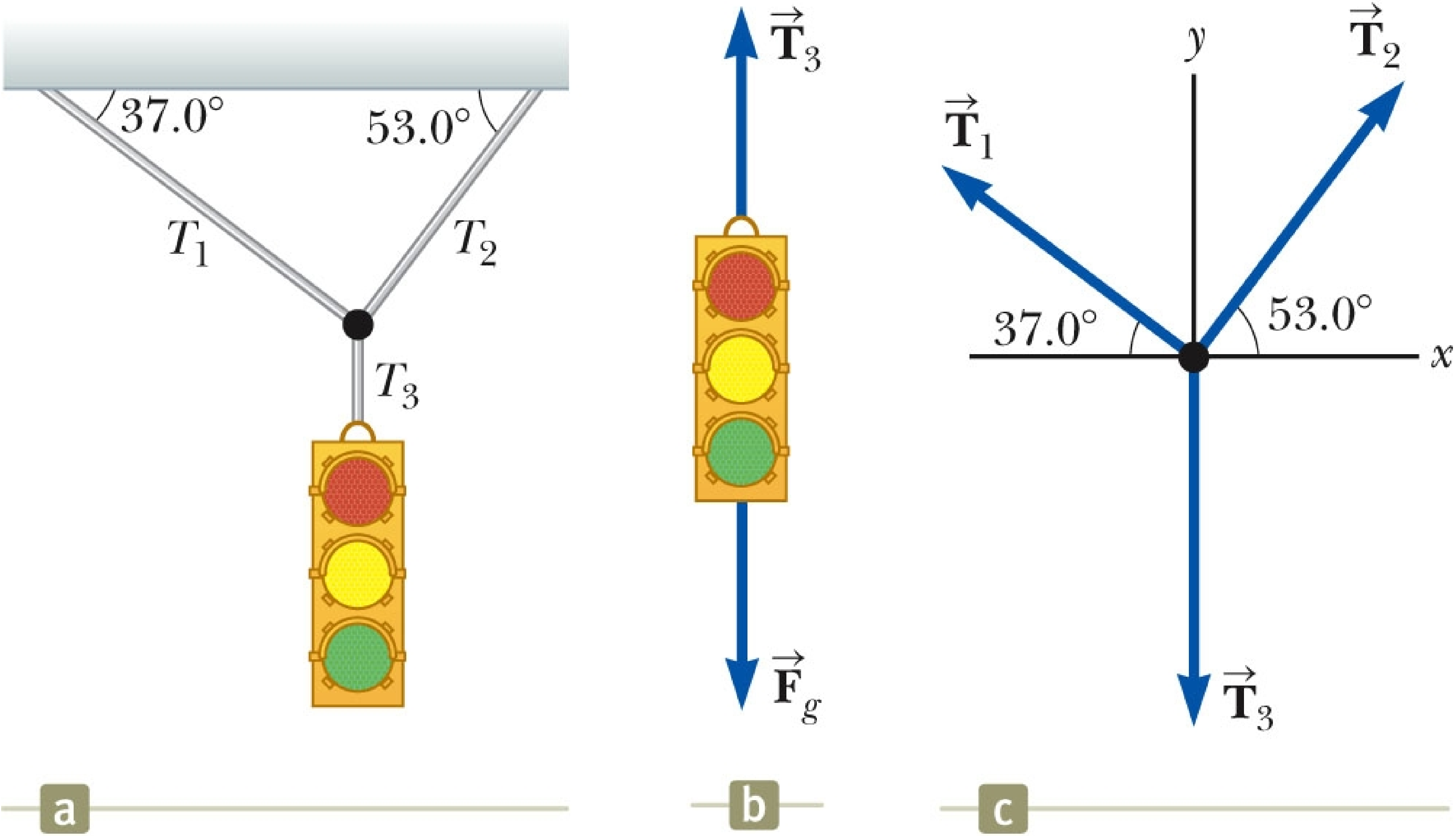
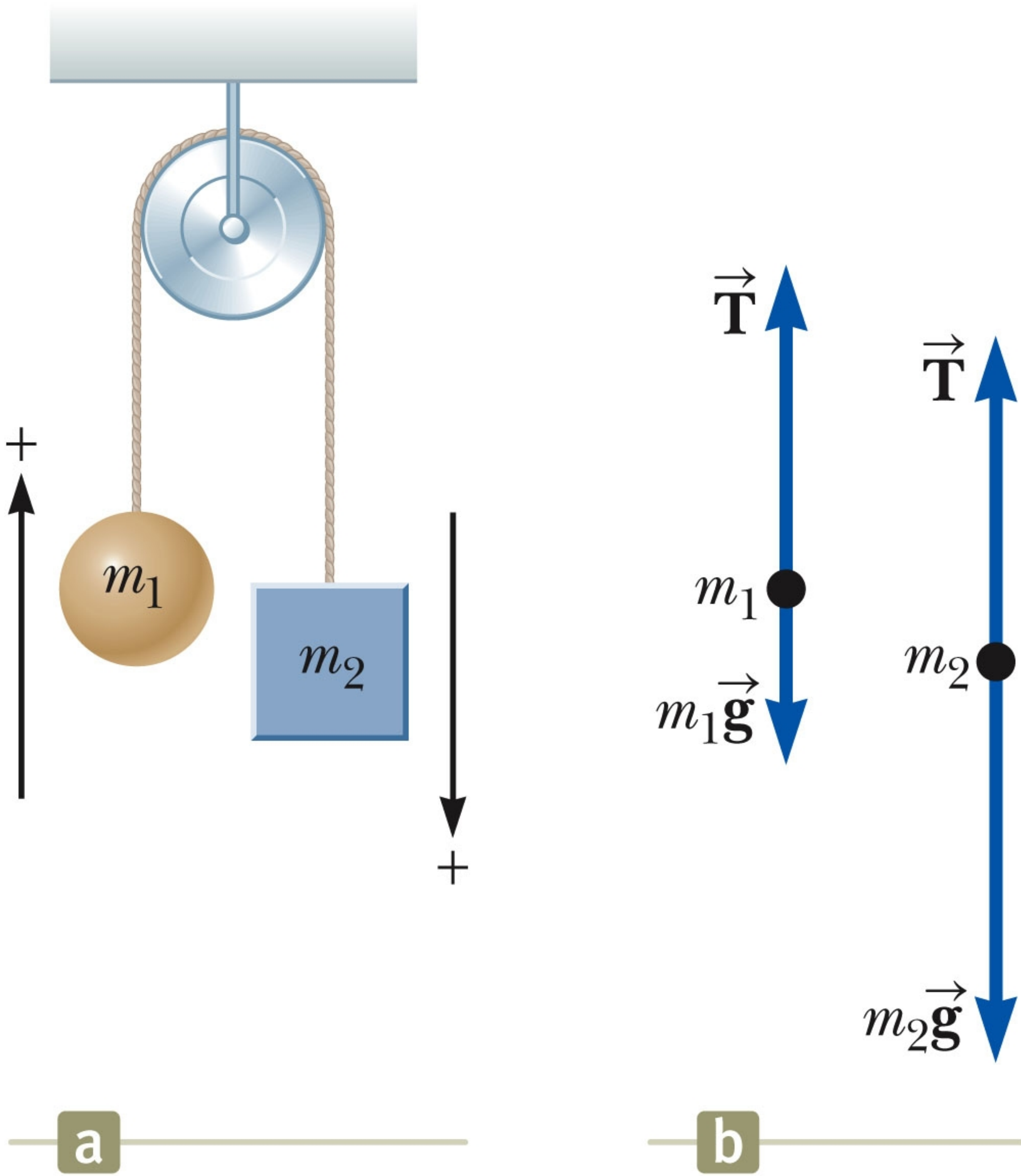


Fig. 5.10, p. 114



+
m_1
m_2
+
$\vec{\mathbf{T}}$
m_1
$m_1\vec{\mathbf{g}}$
$\vec{\mathbf{T}}$
m_2
$m_2\vec{\mathbf{g}}$
a
b

Fig. 5.14, p. 120

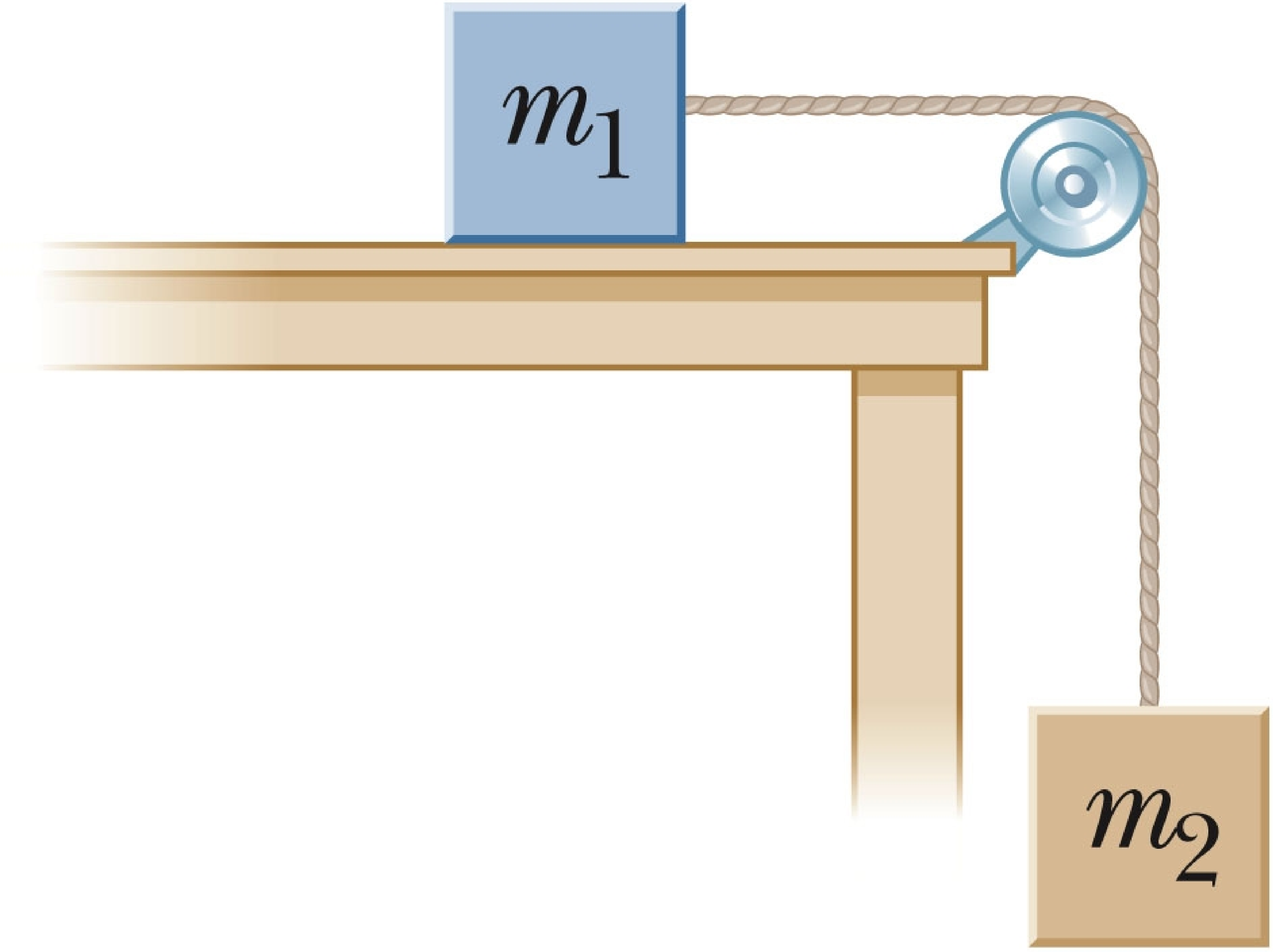
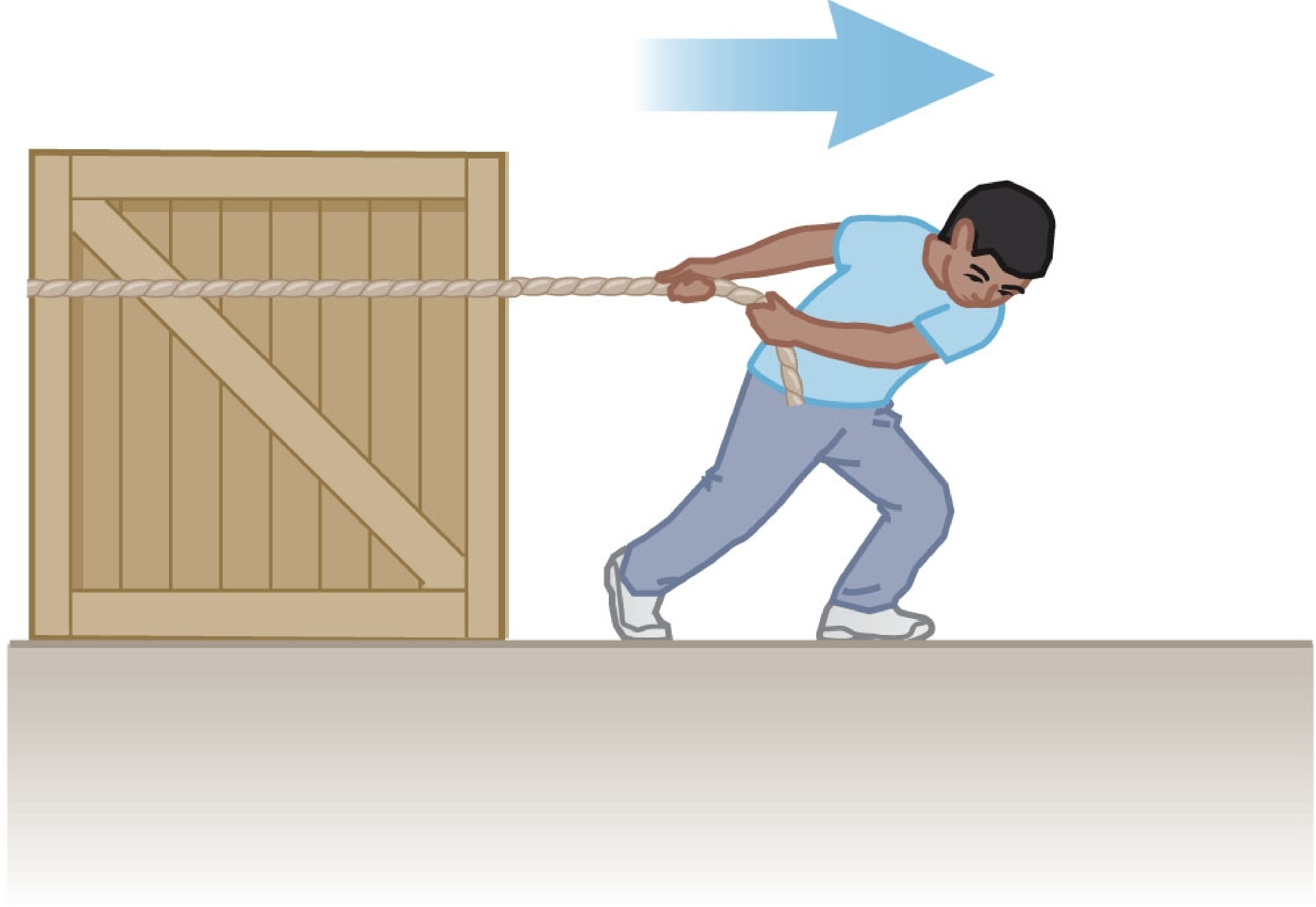
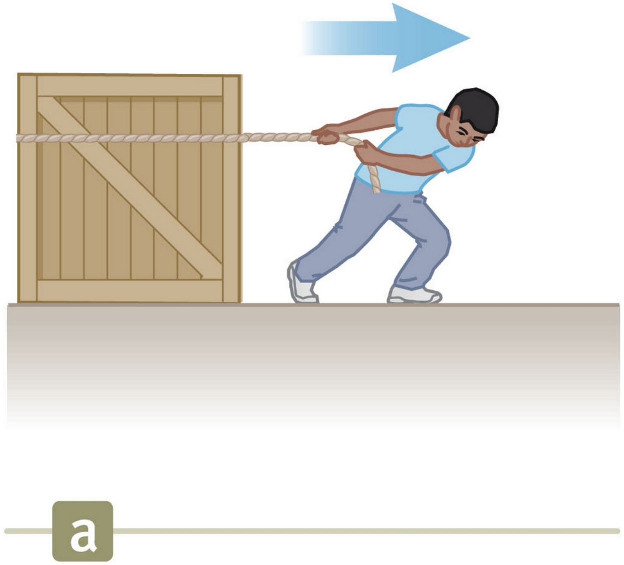


Fig. P5.28, p. 133



a

5.8, p. 113



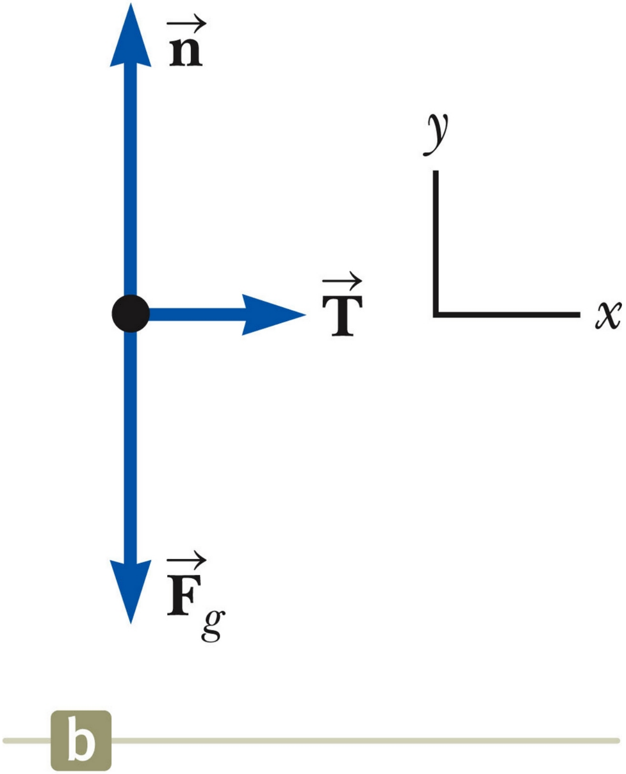


Fig. 5.8, p. 113

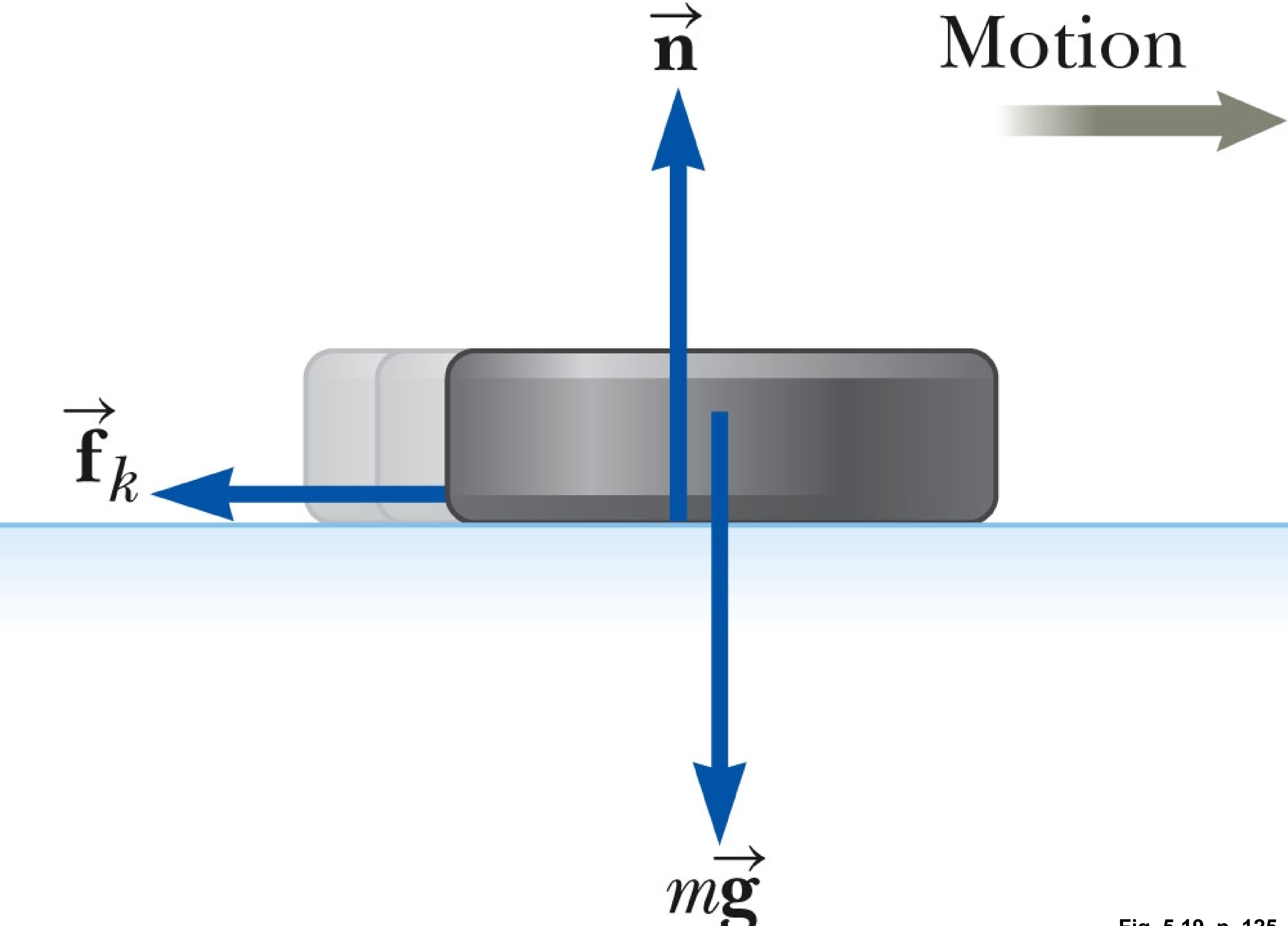
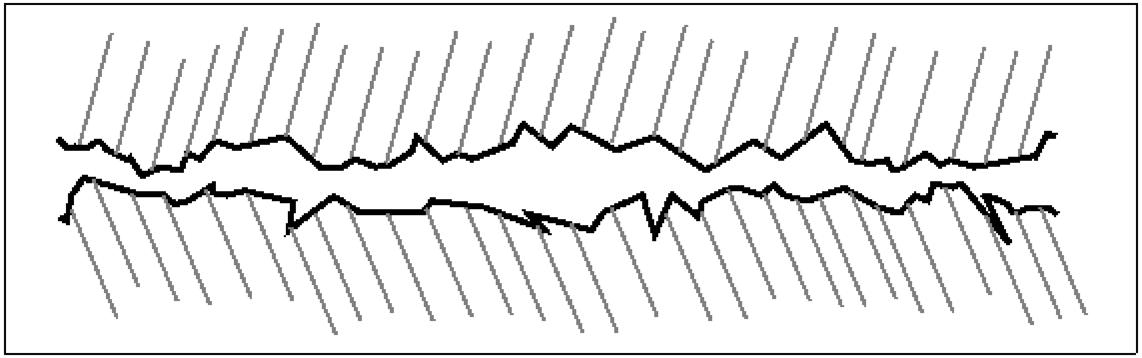
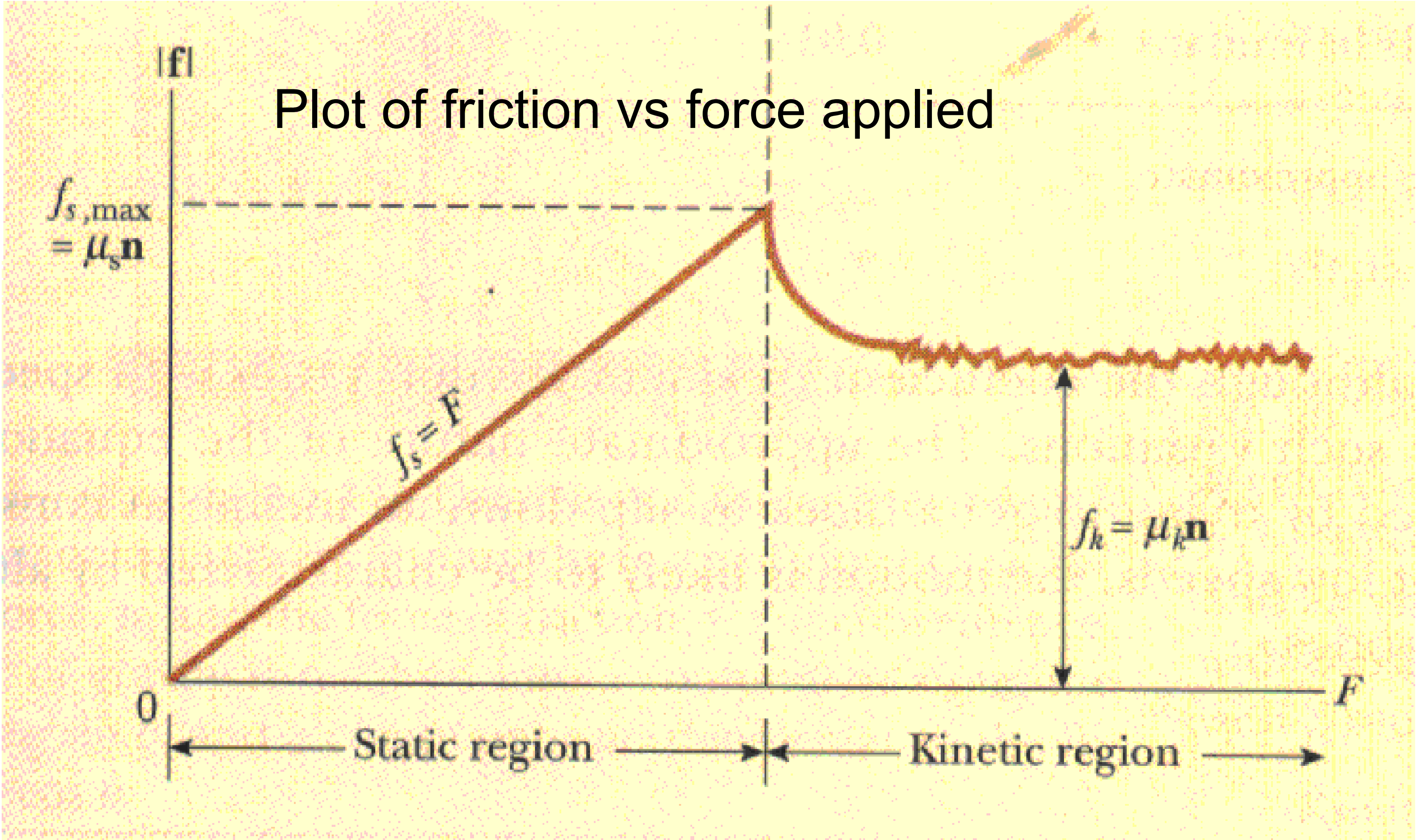


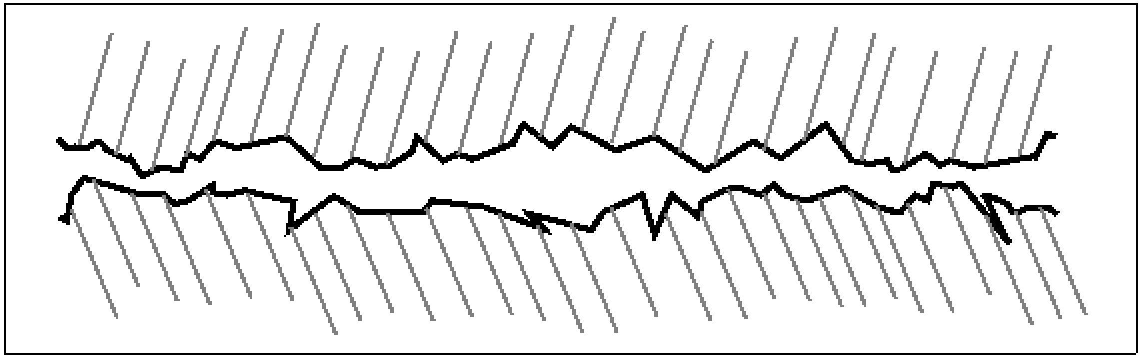
Fig. 5.19, p. 125

Close-up of surfaces.





Close-up of surfaces.



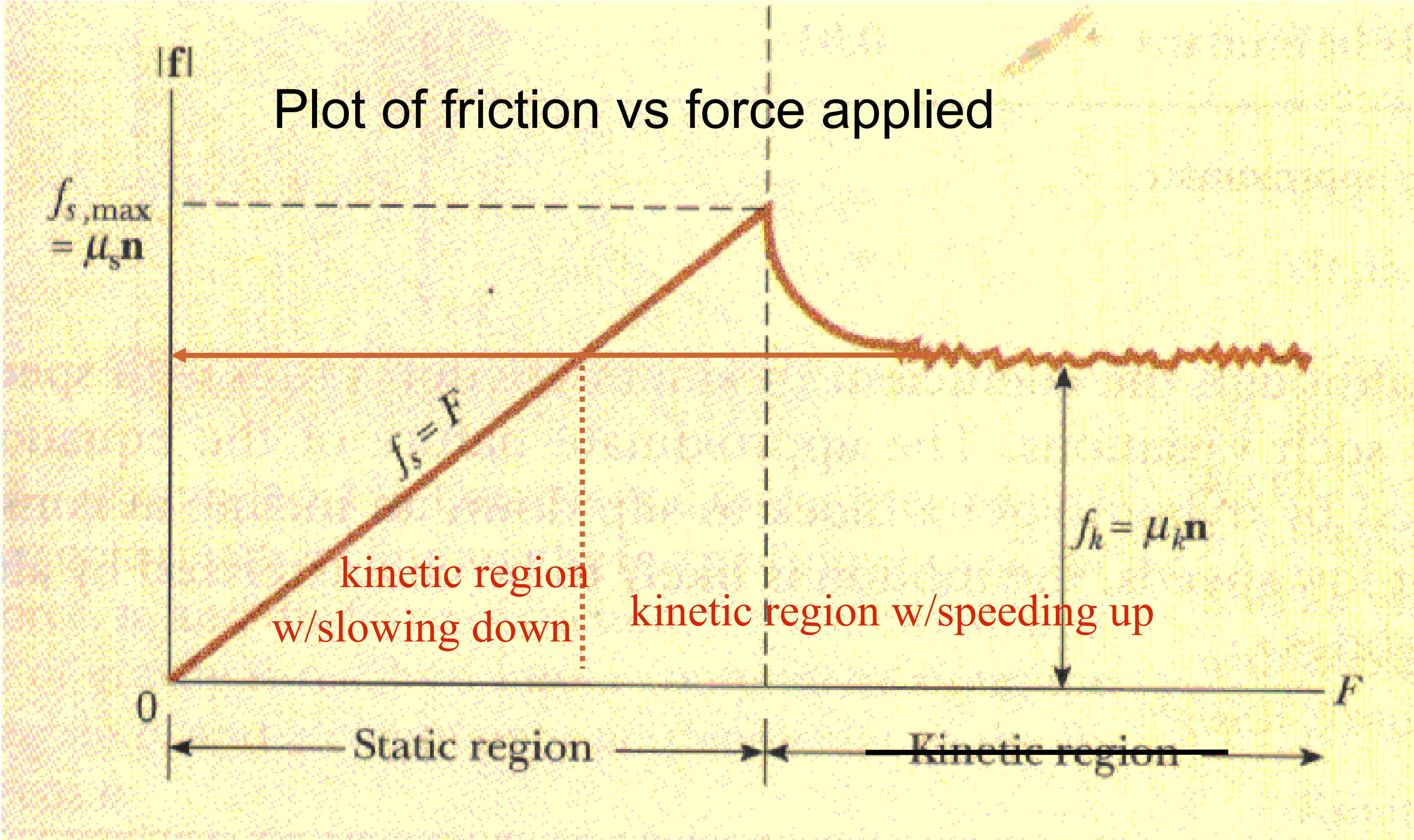
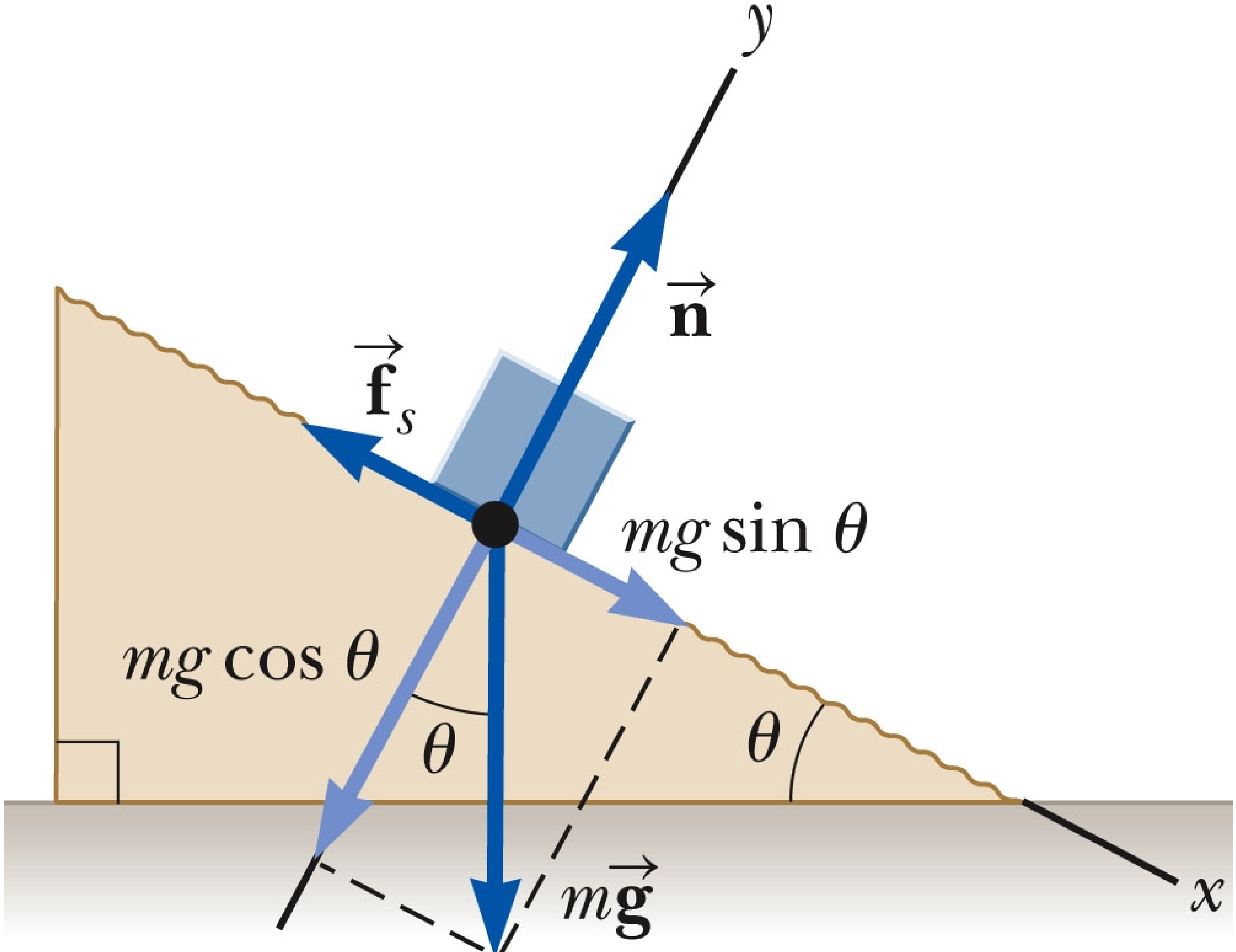


TABLE 5.1 *Coefficients of Friction*

	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

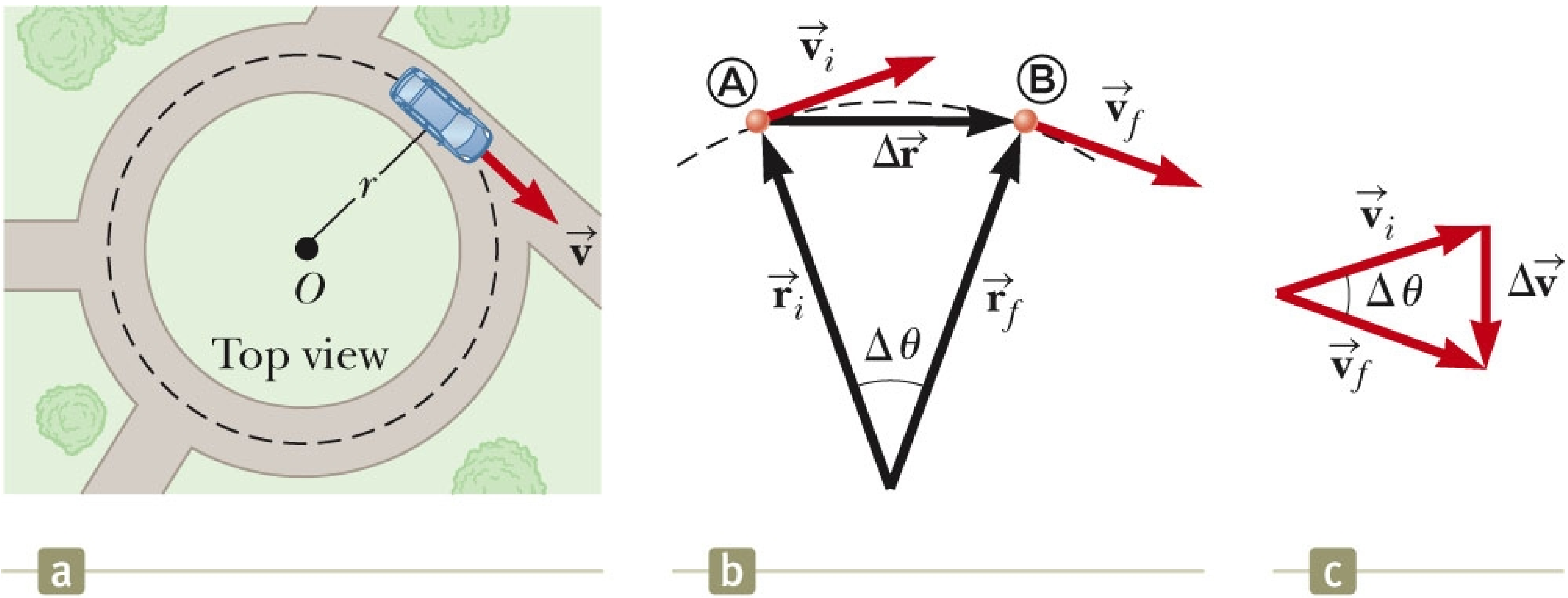
Note: All values are approximate. In some cases, the coefficient of friction can exceed 1.0.



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

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

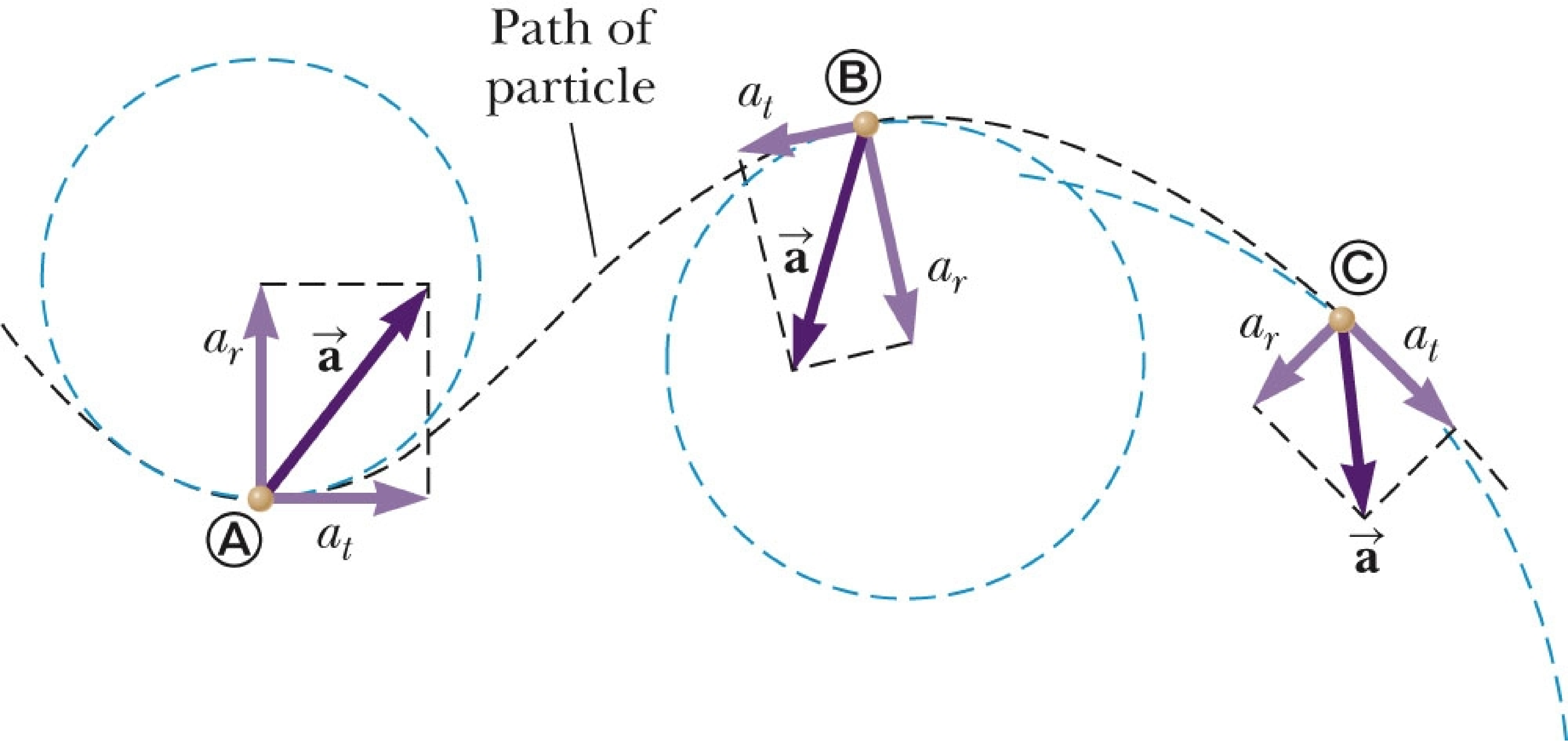
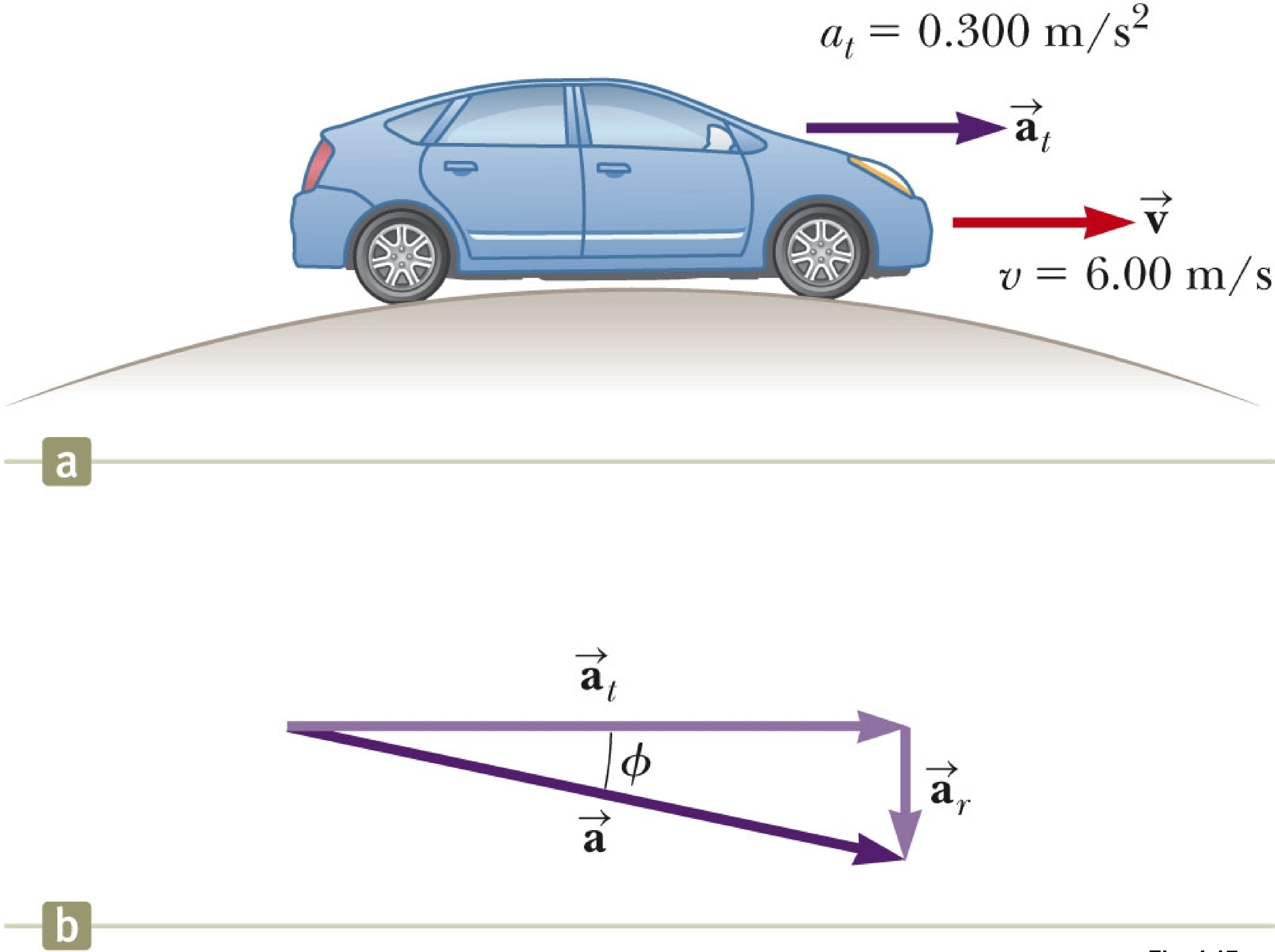


Fig. 4.16, p. 88



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

Fig. 4.17, p. 89

Outline for Day W8,D1

Non-uniform circular motion – examples
Work by constant force
Work by non-constant force

Homework

Ch. 7 Read 7.1-7.4, P. 1,2,5,8,12,18,20,22,25,37,
39,41,45,55,56,59,60,65 Due next Wed.
MiscQ: 1-13 (odd)

Notes:

Midterm: 50% Exam I, 25% Hwk, 25% Quiz
No class Friday!