Week 5 outline

Chapter 5. The Laws of Motion

Homework: Ch. 5 P. 2,3,5,6,7,9,12,
17,18,20,22,26,31 Due Friday
(Read 5.1-5.8)

Notes: Moodle Quiz 3 mean ~ 6.6/9
Other grades were imported to Moodle.
Physics tutoring on Thurs 7-9pm, SA116

TODAY: Forces – types
Newtons Laws

Forces – the *cause* of acceleration

Forces are vectors

Forces act between systems (the dashed boxes)

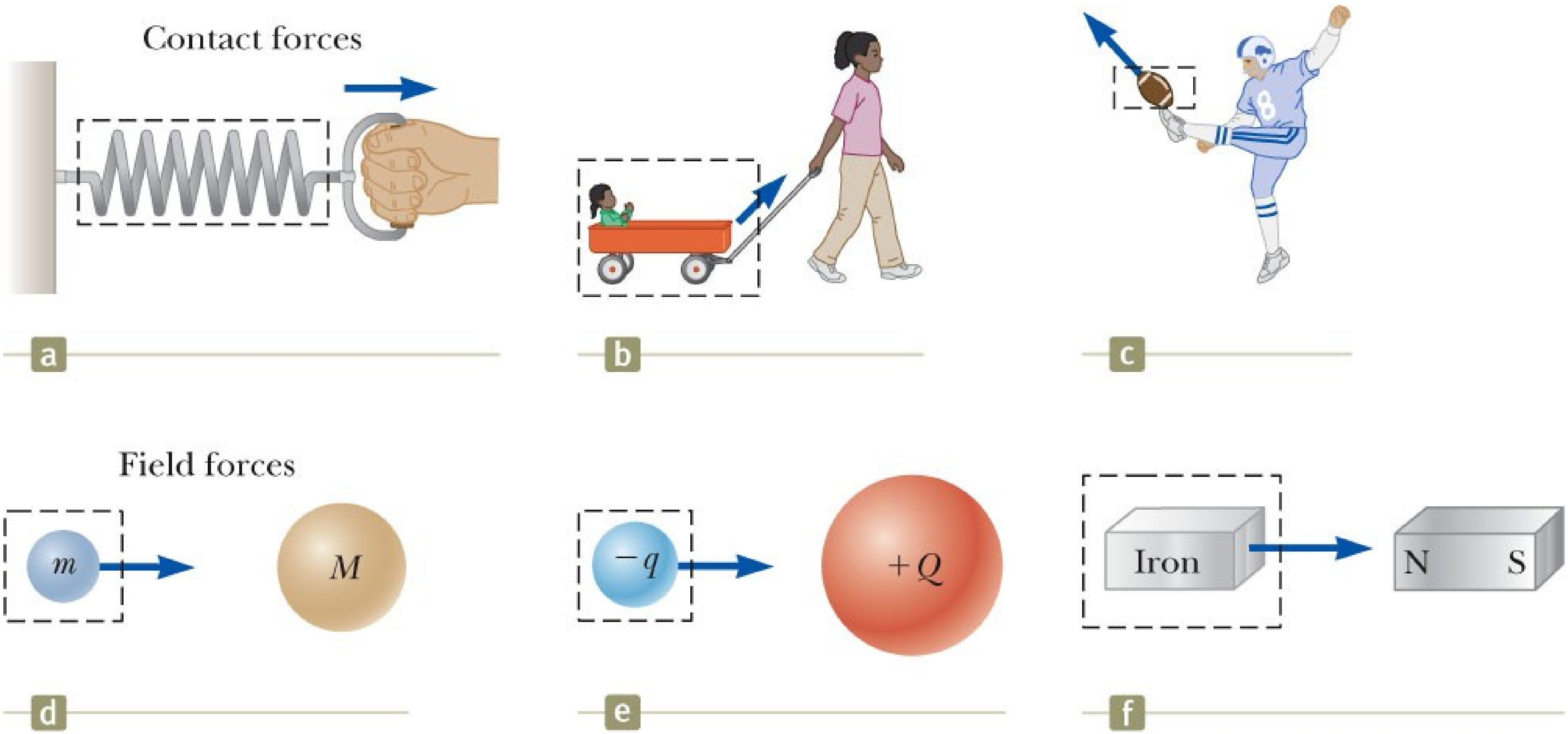
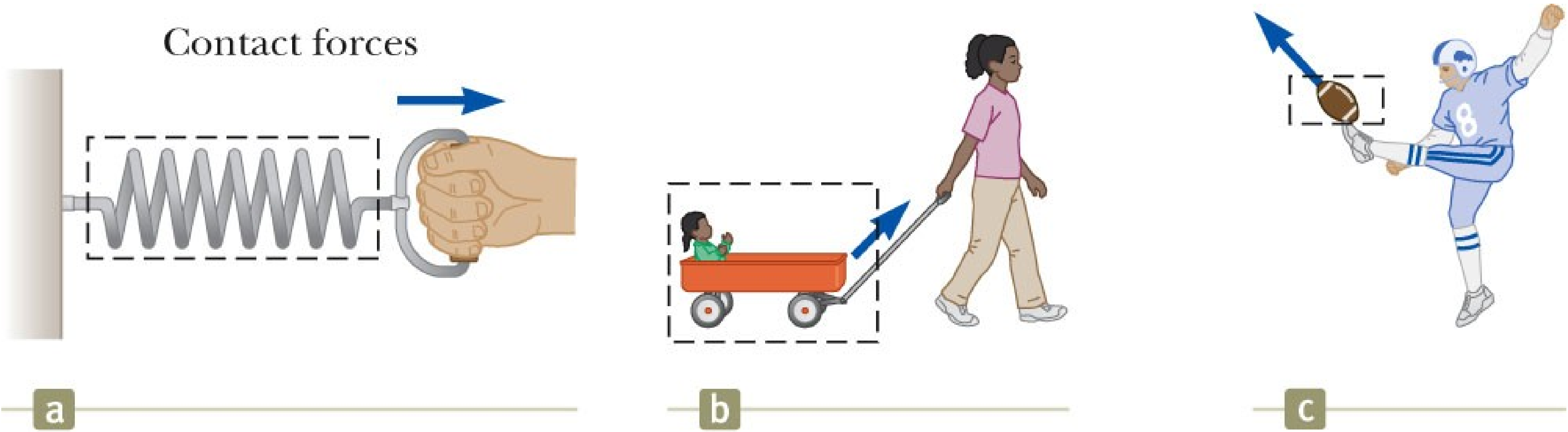


Fig. 5.1, p. 104

Types of forces

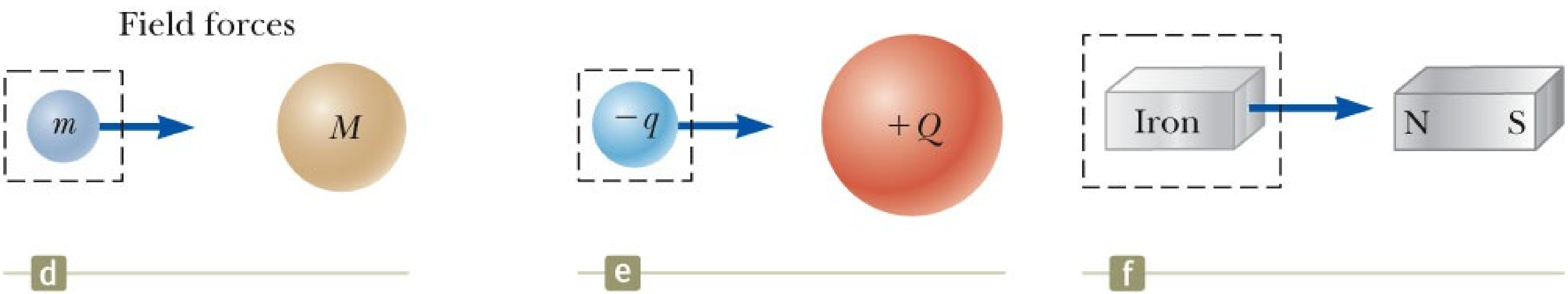


contact forces

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

Fig. 5.1, p. 104

Types of forces



Field forces (act “at a distance”)

gravitational electric magnetic

Fig. 5.1, p. 104

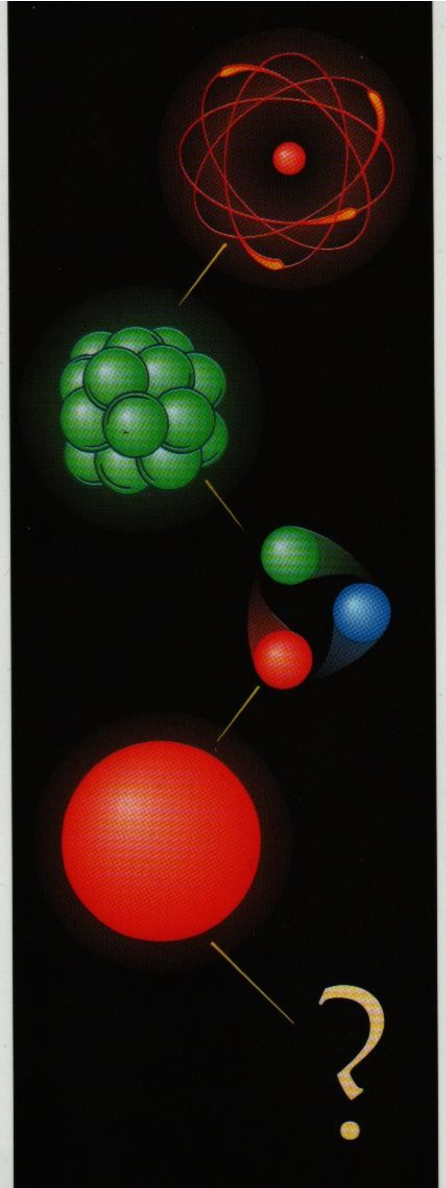
The 4 Fundamental forces

Gravity

Electromagnetic Force

Nuclear Strong Force – holds nuclei together

Nuclear Weak force – decay of n and p

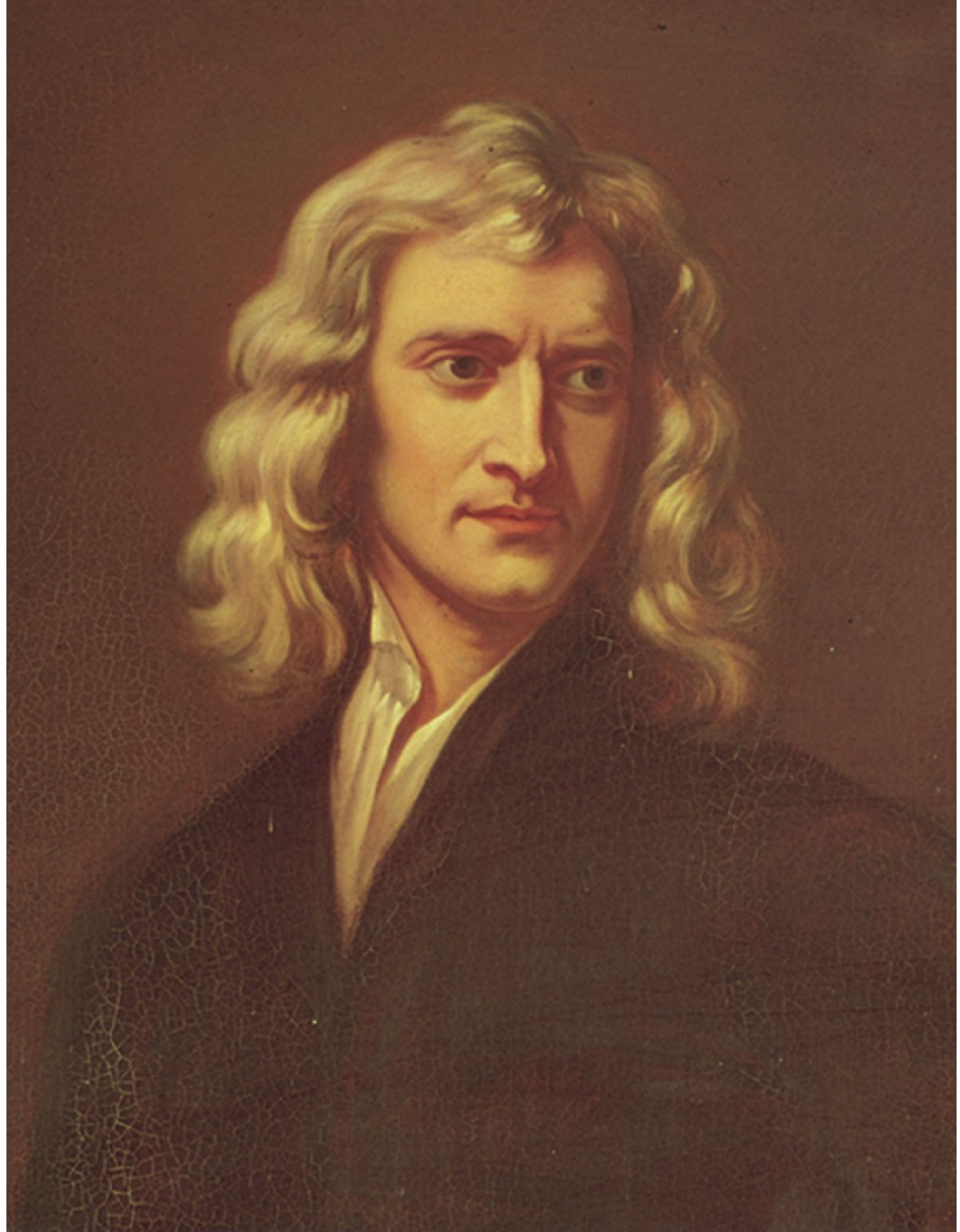


Distances at the frontier of nuclear physics are astonishingly short. An atom is so small that 250,000 fit into the thickness of aluminum foil. The nucleus at the atom's center is a cluster of nucleons, each 100,000 times smaller than the atom itself. The three quarks inside each nucleon are smaller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

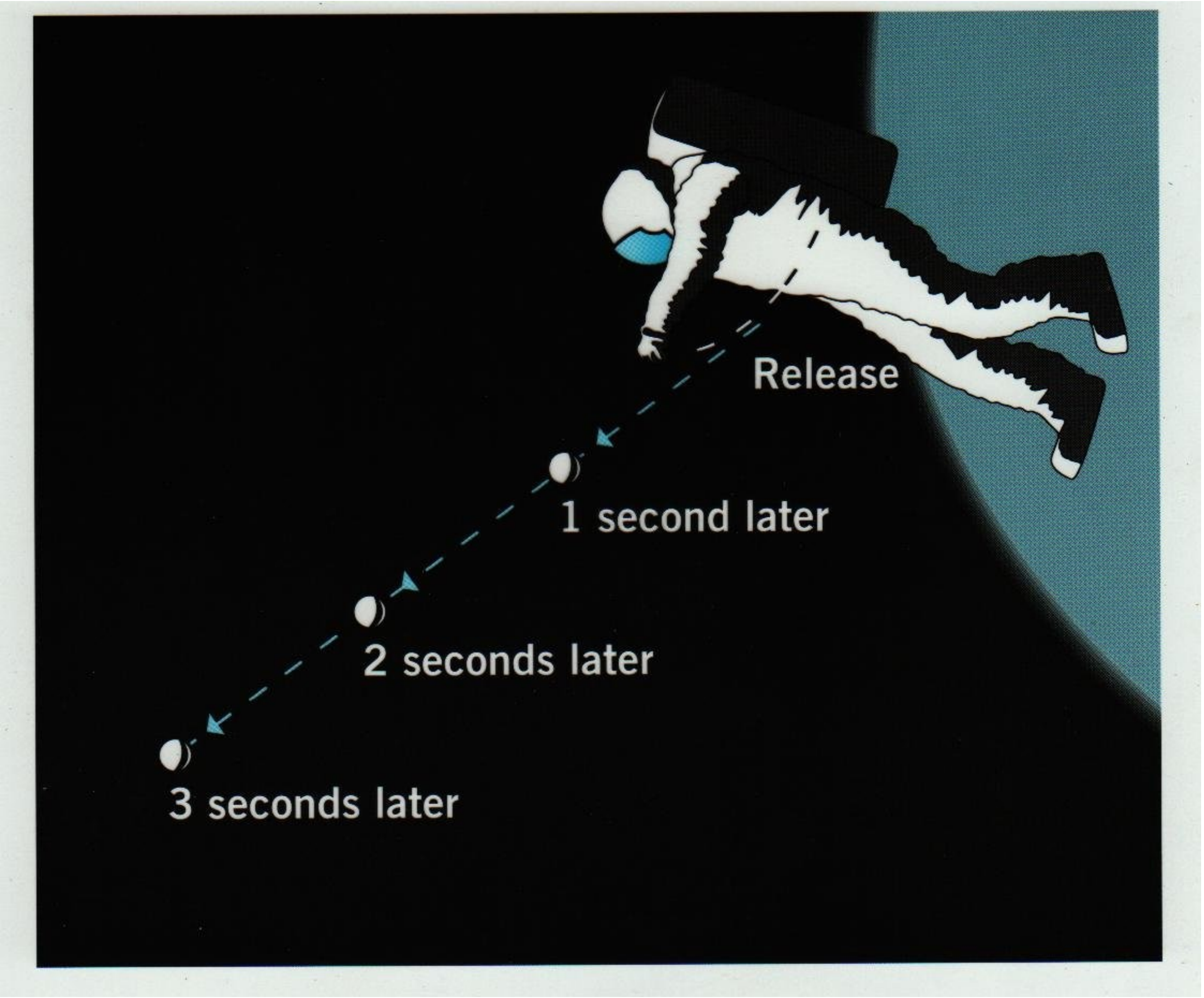
Isaac Newton
(1642 - 1727)

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

Heavy objects fall faster

Watch 17:05 – on. "Frames of Reference":
https://www.youtube.com/watch?v=bJMYoj4hHqU&t=1036s&ab_channel=TrevM

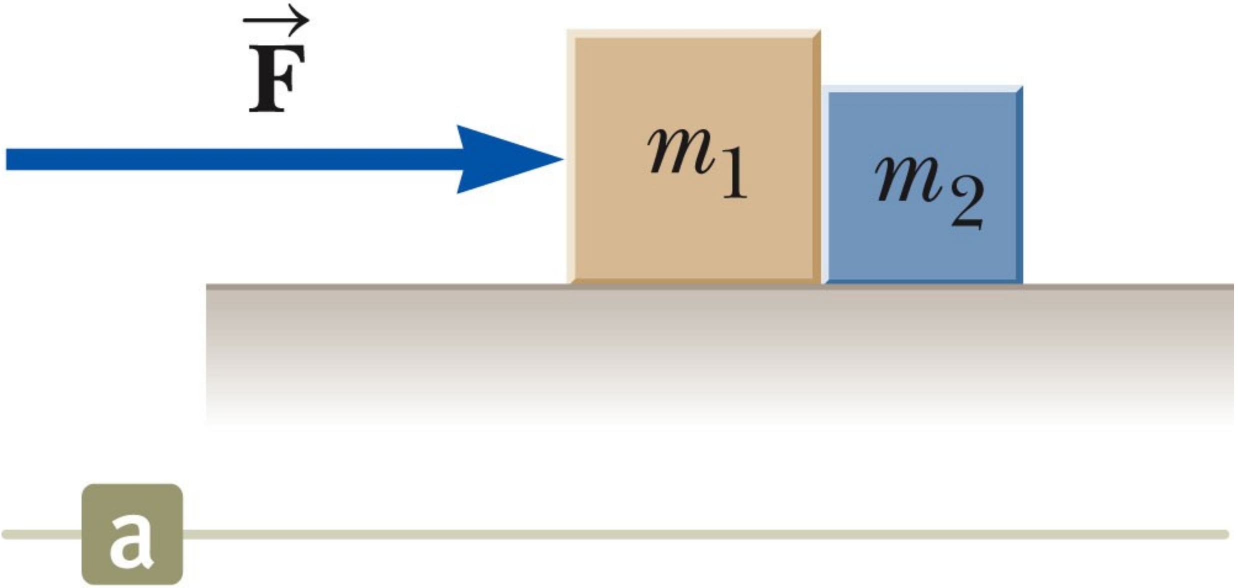
Week 5 Day 2 outline
Chapter 5. The Laws of Motion

Homework: Ch. 5 P. 2,3,5,6,7,9,12,
17,18,20,22,26,31 Due Friday
(Read 5.1-5.8)

Notes: Moodle Quiz 3 mean ~ 6.4/9 (regraded)
Physics tutoring on Thurs 7-9pm, SA116

TODAY: Quiz 3 review
Newtons 2nd law; weight vs mass
Newton's 3rd law; contact & field forces
Apparent weight
Applications of Newton's laws

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.

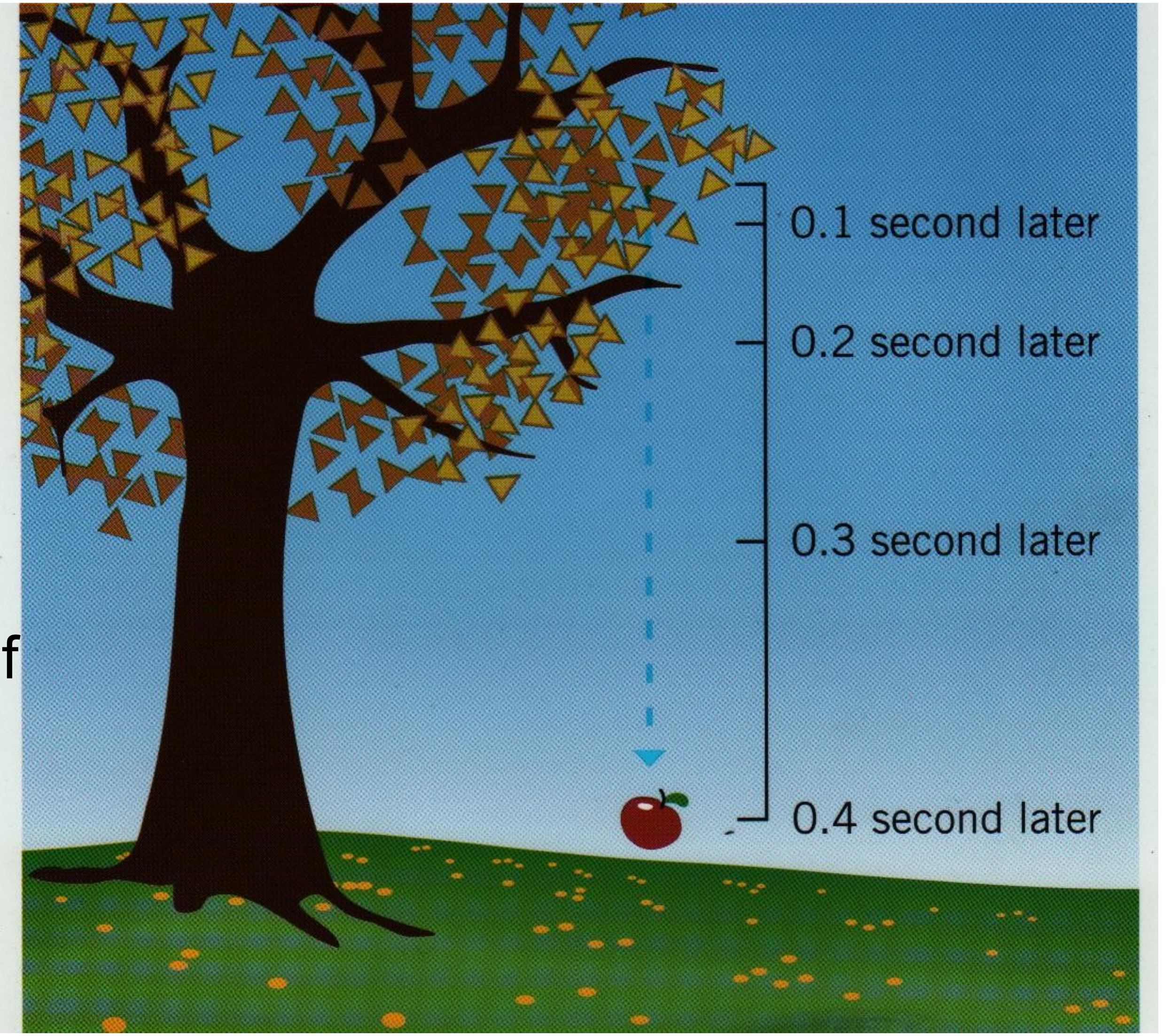
Newton's 2nd law (cont.)

Example: gravity

Weight = the force of gravity on an object

$W = F_g = mg$

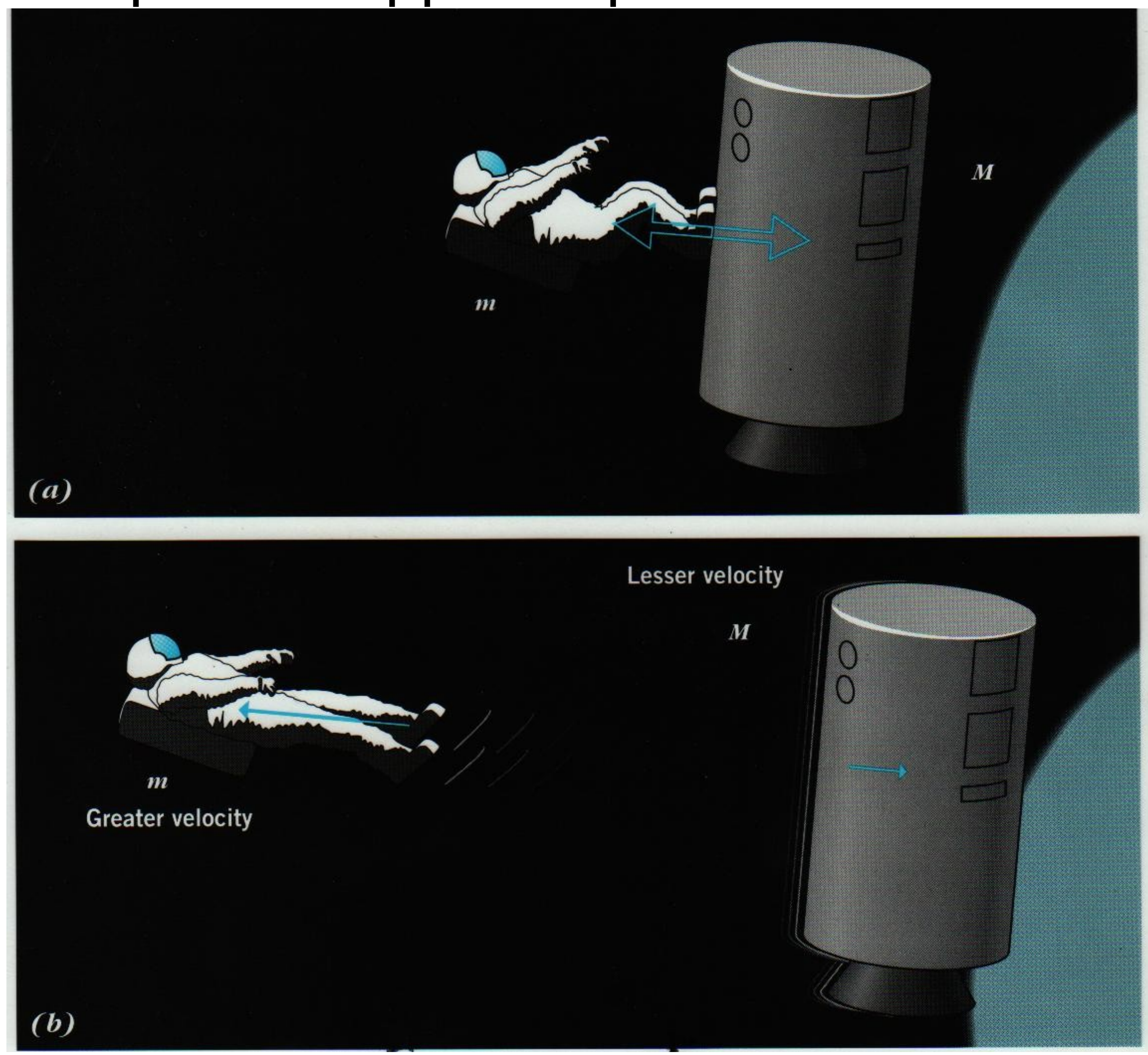
Mass = the amount of matter in an object



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 all fundamental forces also obey Newton's 3rd.

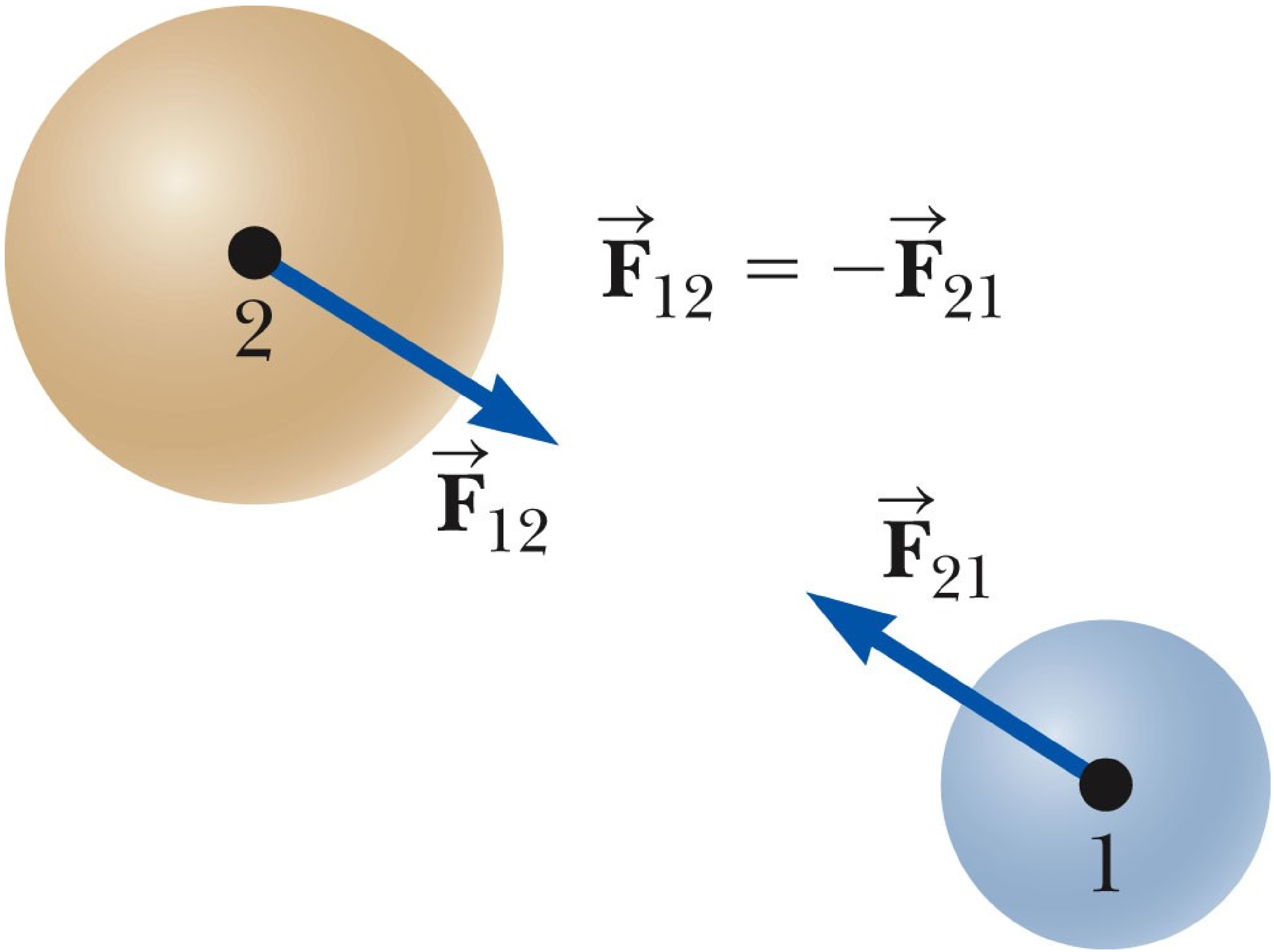
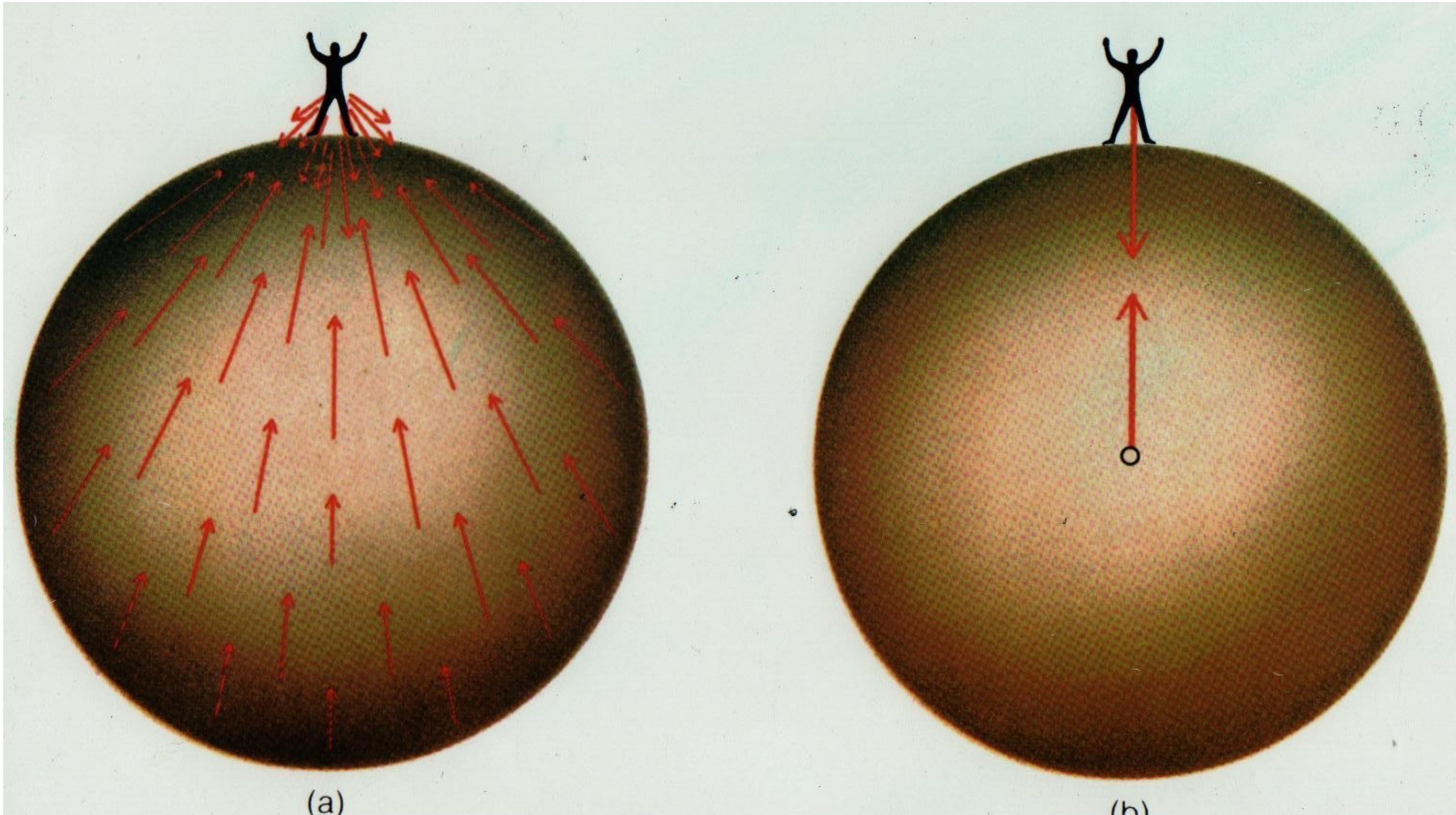


Fig. 5.5, p. 111

Newton's 3rd law (cont.)



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

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

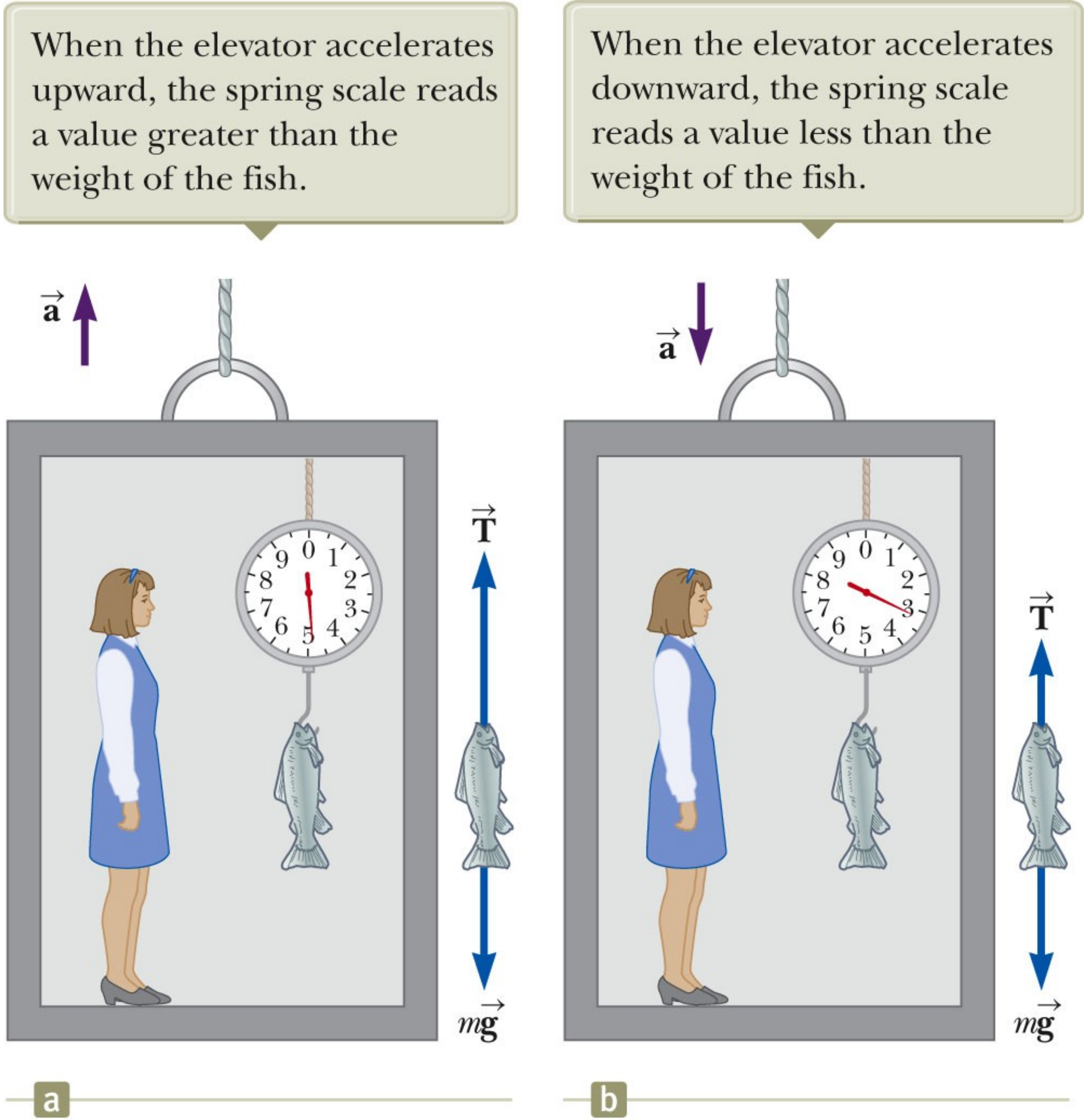

When the elevator accelerates upward, the spring scale reads a value greater than the weight of the fish.
When the elevator accelerates downward, the spring scale reads a value less than the weight of the fish.
a
T
mg
a
b

Fig. 5.13, p. 119

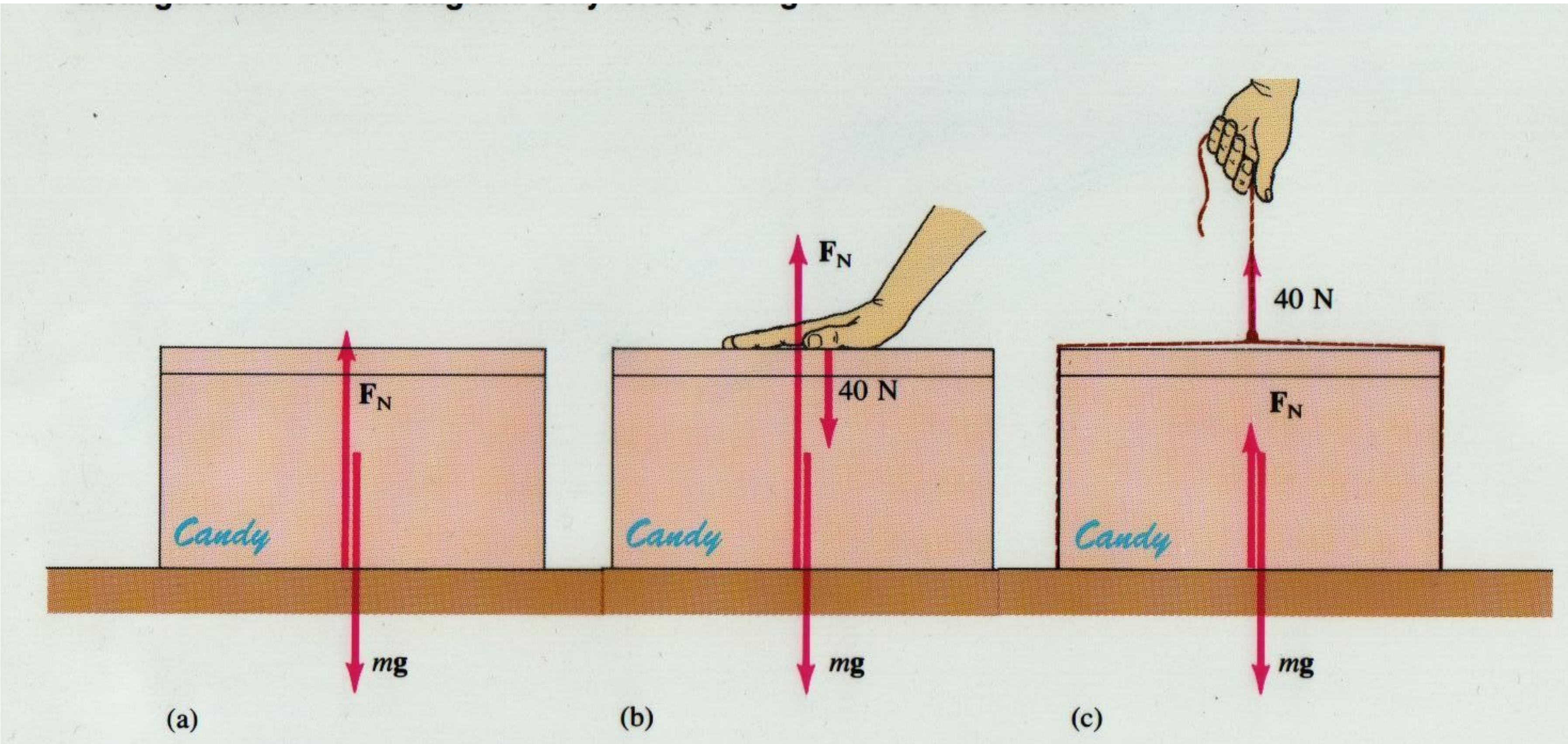
The Application of Newton's Laws

Problem solving method

1. Conceptualize
   - What is problem asking for?
   - Write down knowns and unknowns.
   - Draw picture.
2. Categorize
   - Equilibrium problem: $a=0$ (often, $v=0$ too)
   - Newton's 2nd law problem: object's accelerate, ($a \neq 0$)
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=8 kg. (Use $g=10\ m/s^2$)



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

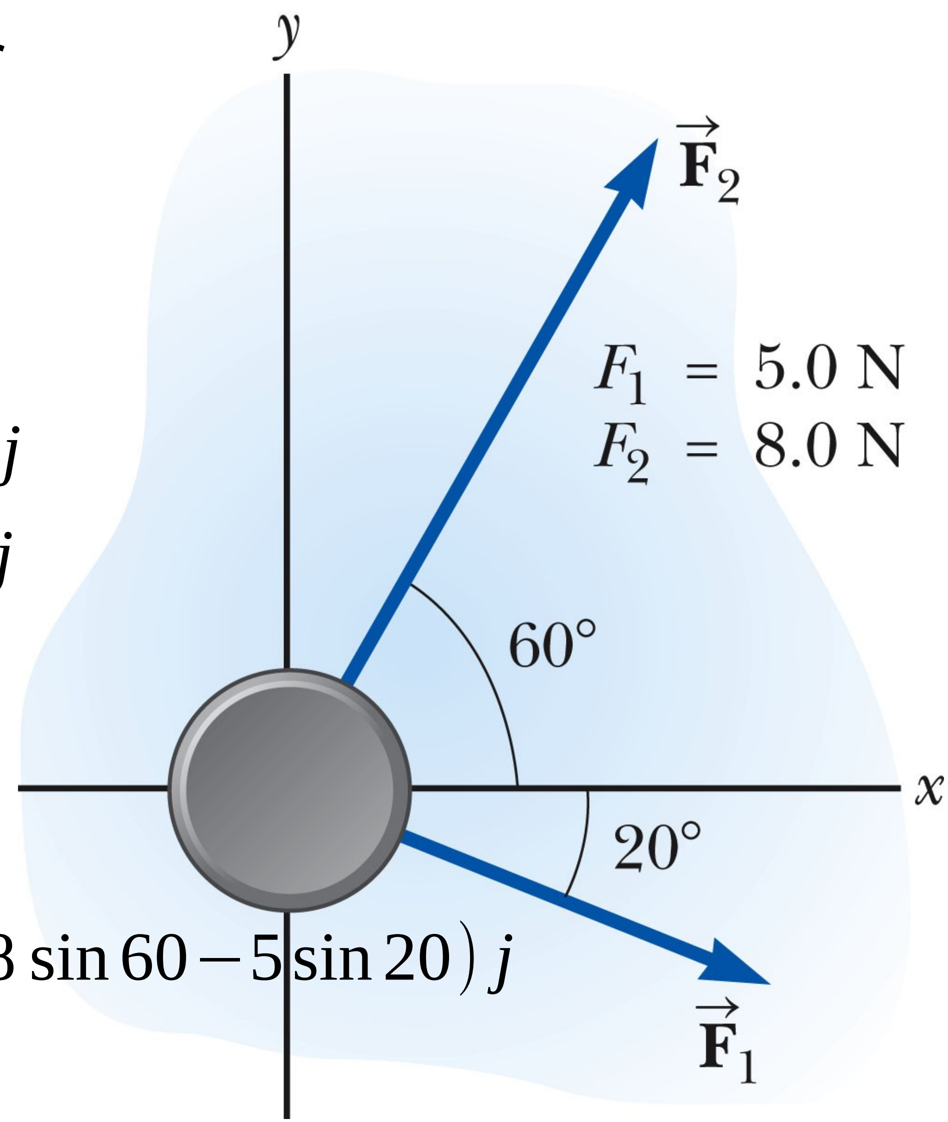
The Application of Newton's Laws

Find the acceleration vector for the 0.2 kg hockey puck.

$$\vec{a} = \frac{\vec{F}_{1+2}}{0.2\,kg}$$

$$\vec{F}_1 = (5\cos 20)\,i - (5\sin 20)\,j$$

$$\vec{F}_2 = (8\cos 60)\,i + (8\sin 60)\,j$$



$$\vec{F}_{1+2} = (8\cos 60 + 5\cos 20)\,i + (8\sin 60 - 5\sin 20)\,j$$

$$\vec{a} = 43.5\,i + 26.1\,j\;m/s^2$$

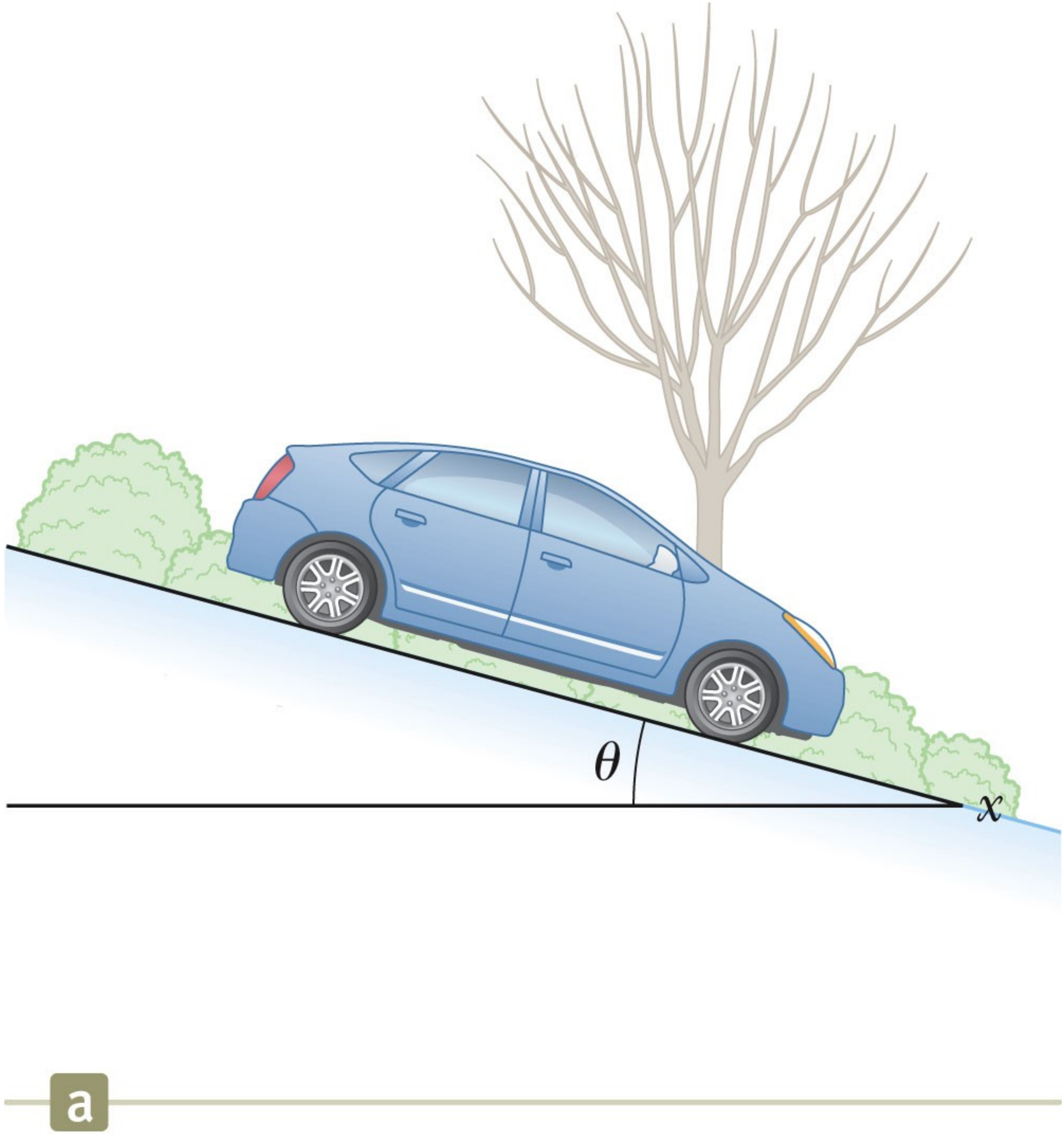
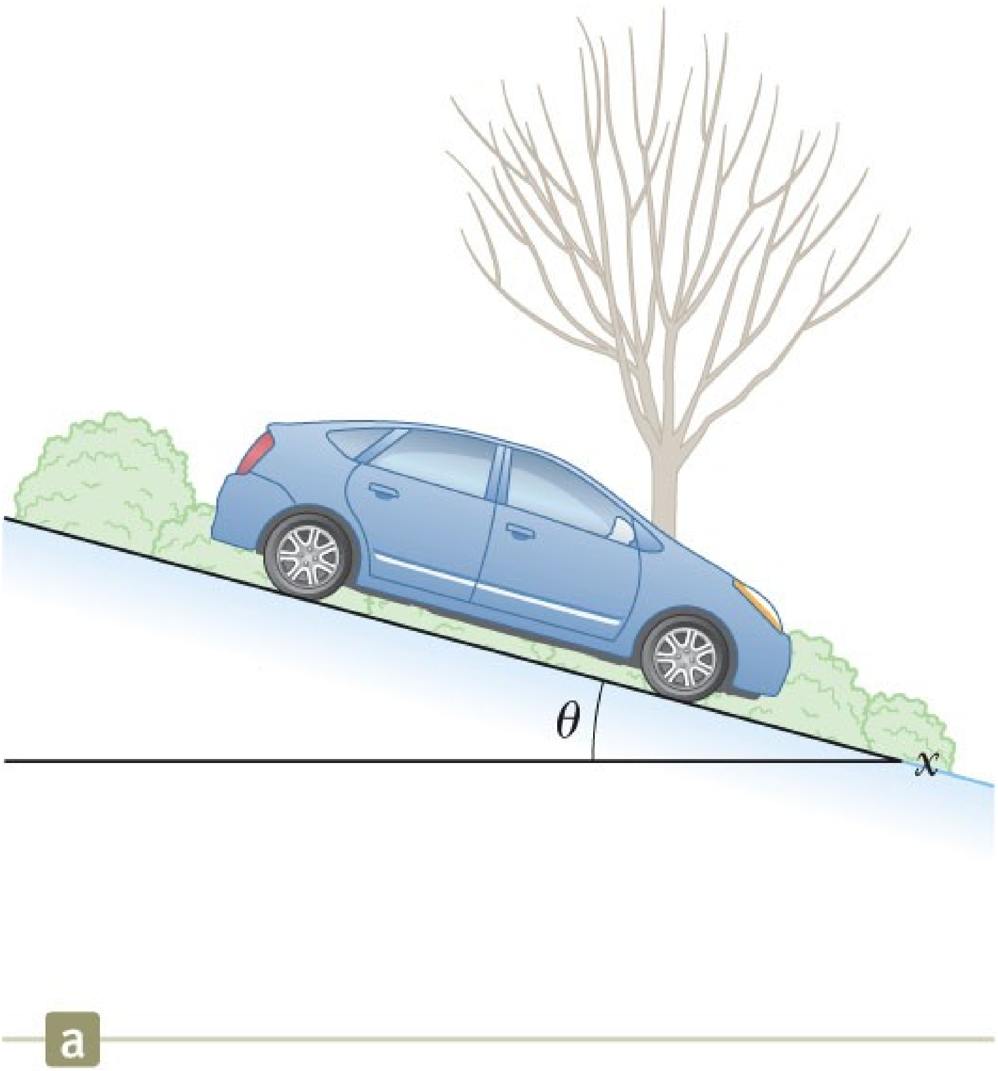


Fig. 5.11, p. 116


θ
x
a

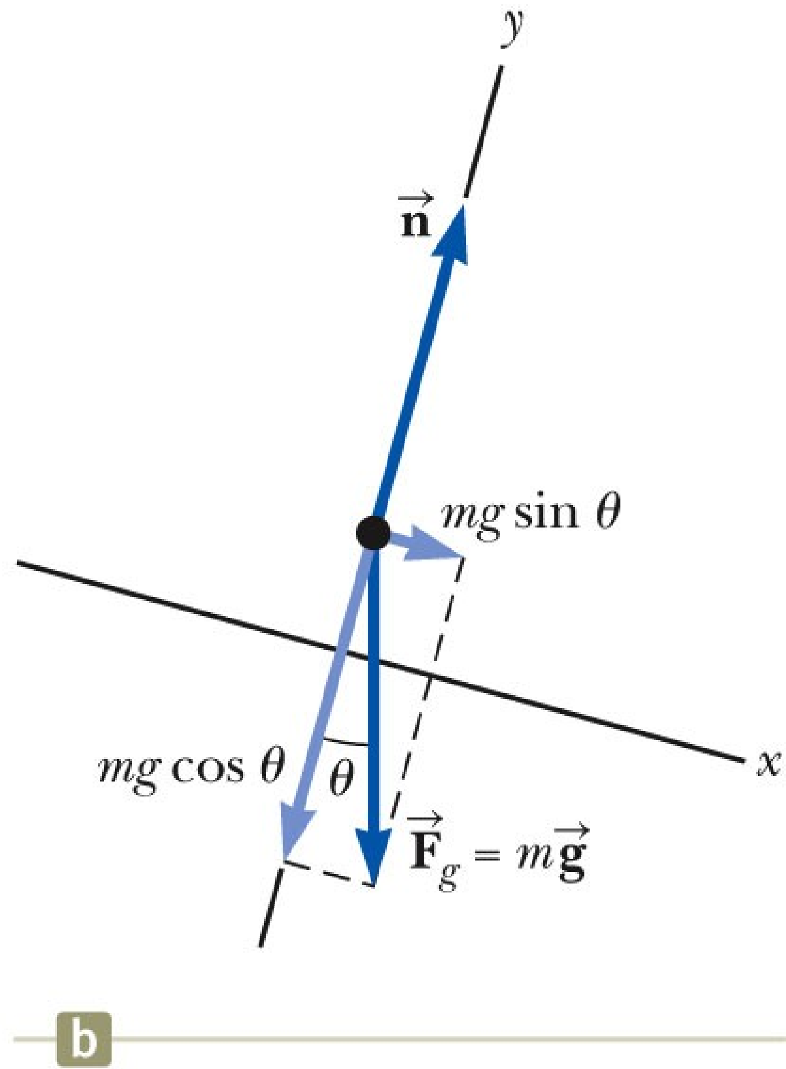
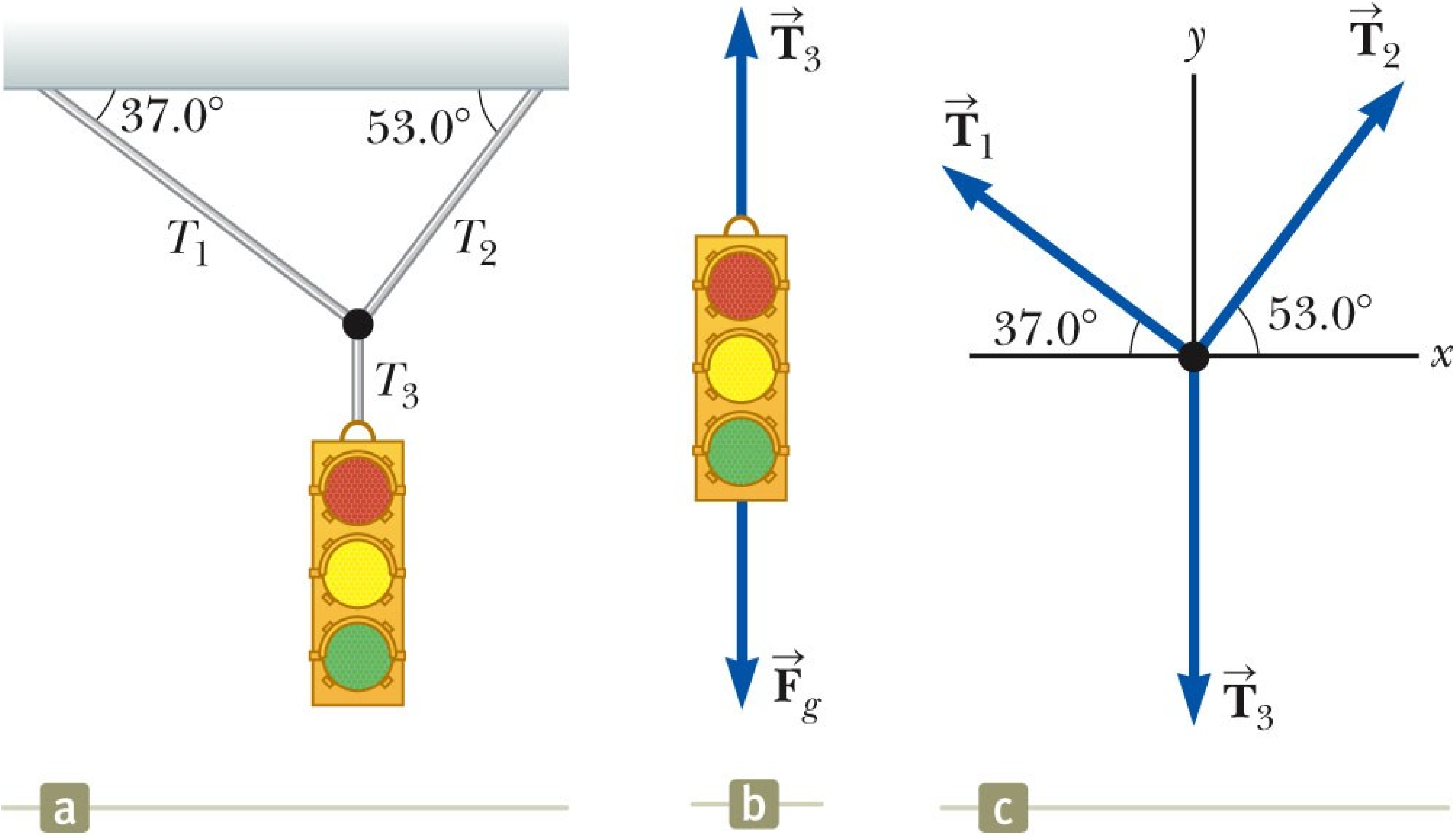
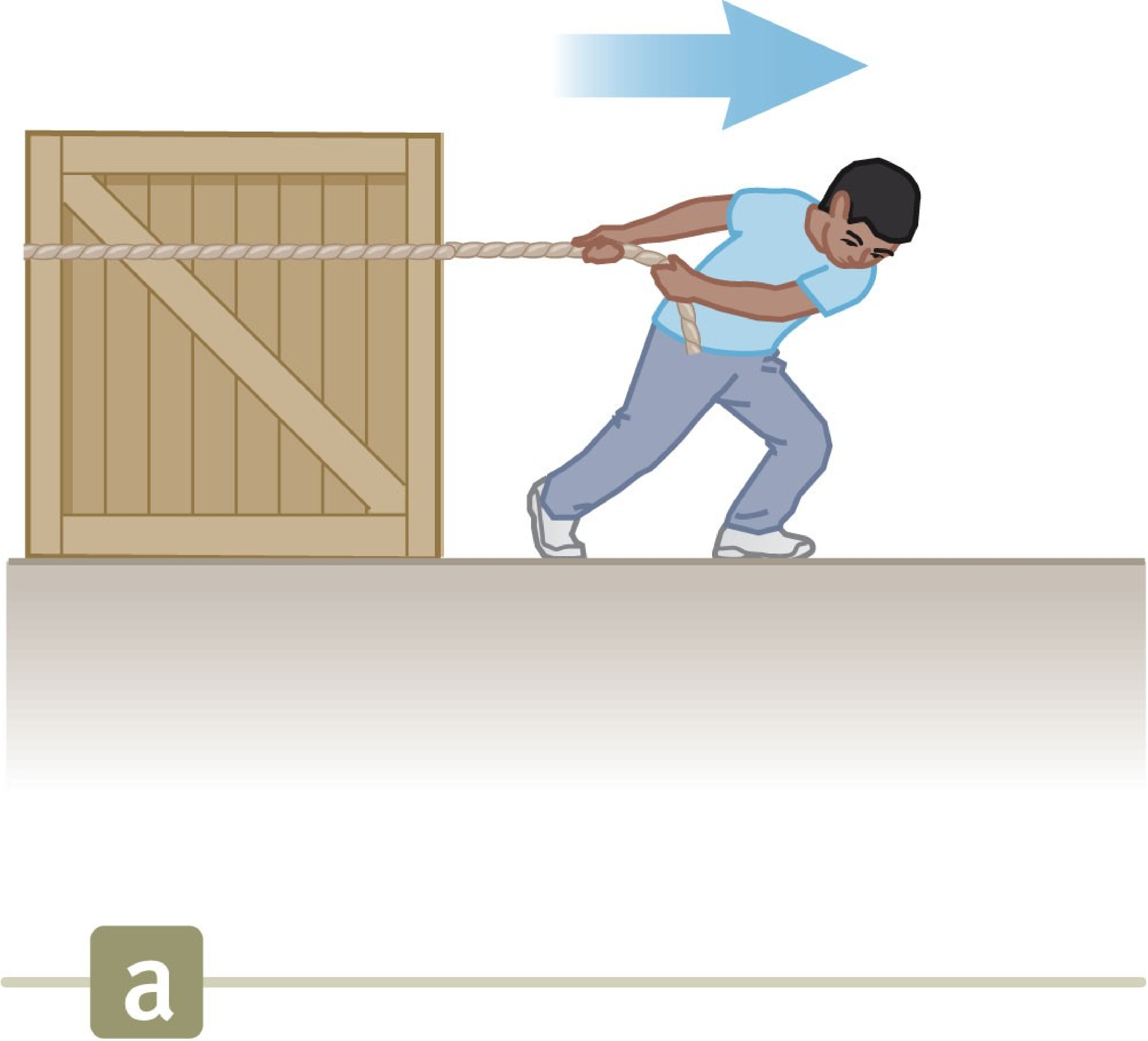

y
$\vec{\mathbf{n}}$
$mg \sin \theta$
$mg \cos \theta$
θ
x
$\vec{\mathbf{F}}_g = m\vec{\mathbf{g}}$
b

Fig. 5.11, p. 116



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

Fig. 5.10, p. 114



5.8, p. 113

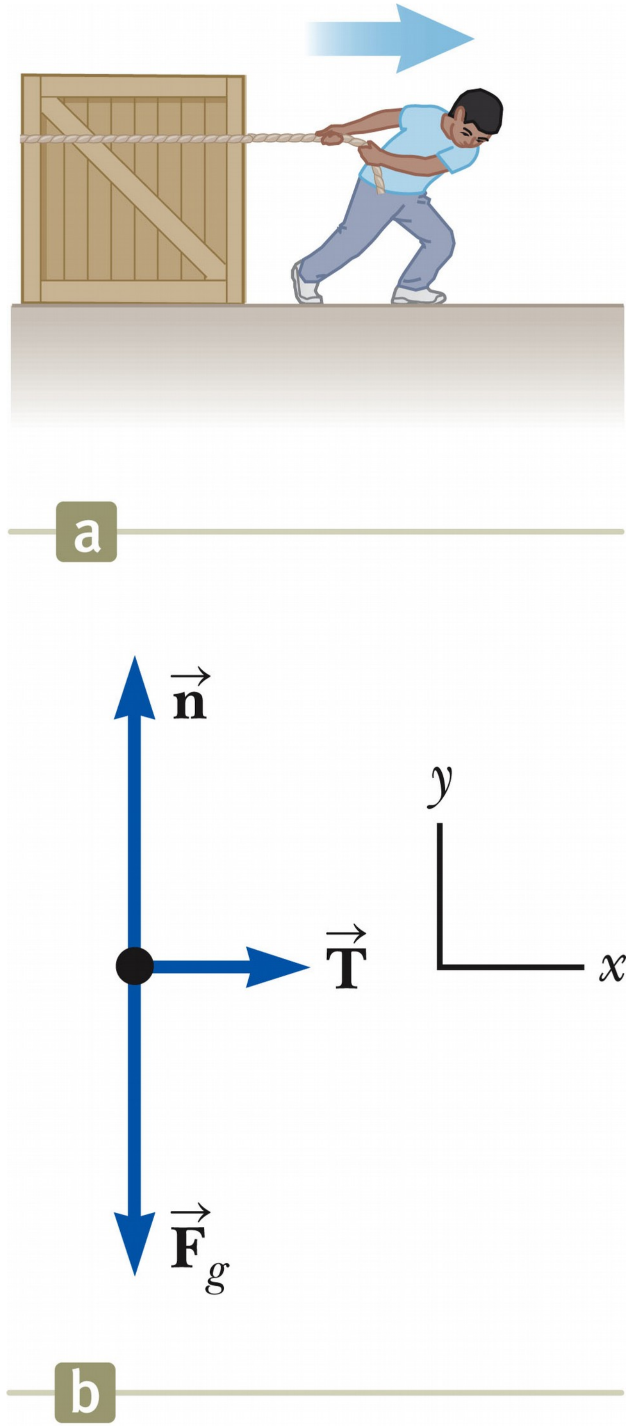


Fig. 5.8, p. 113

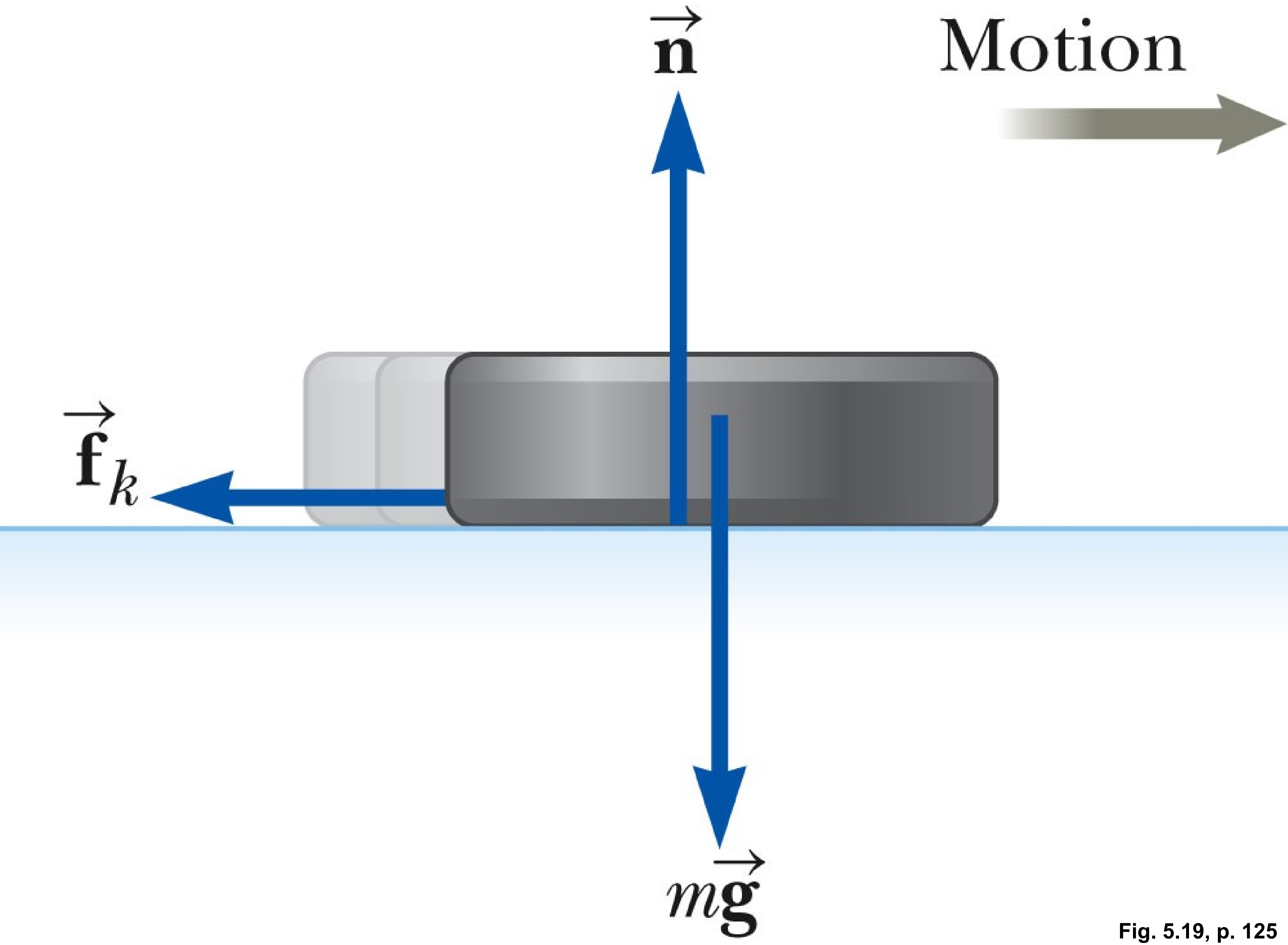
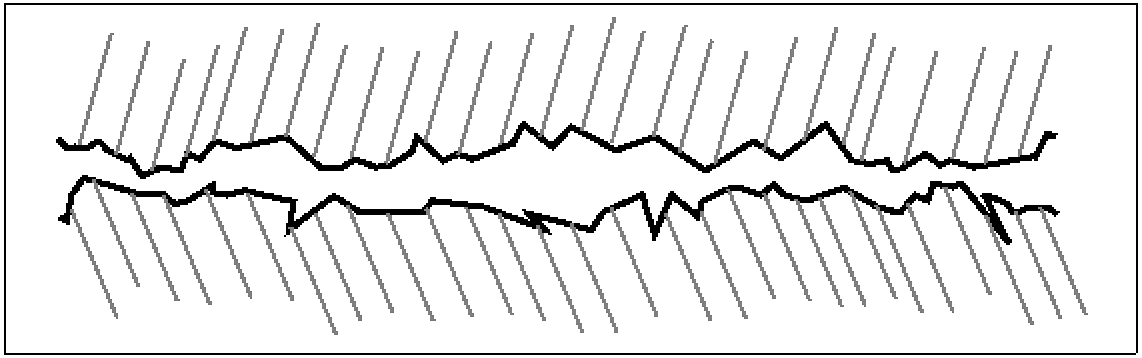


Fig. 5.19, p. 125

Close-up of surfaces.



Plot of friction vs force applied

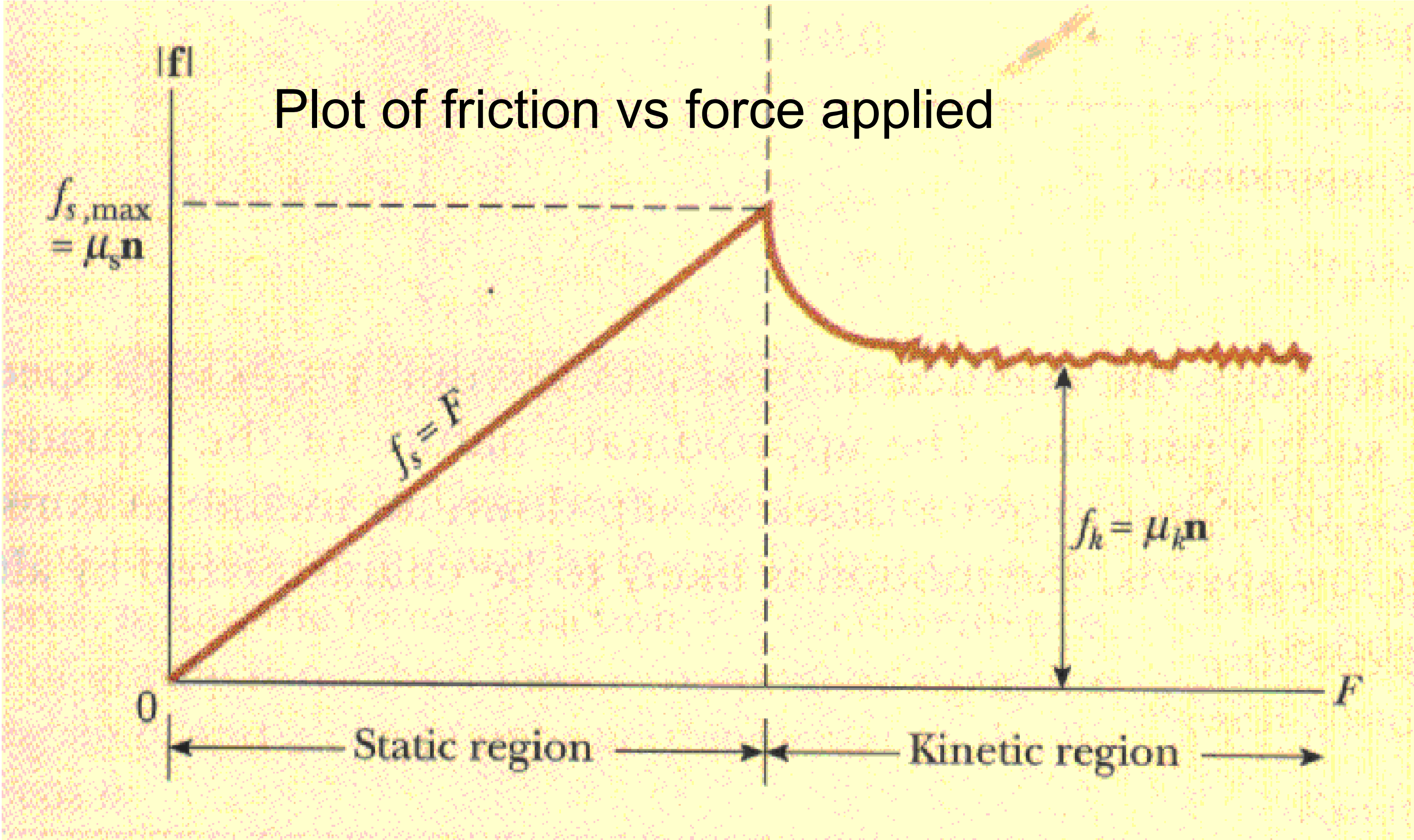
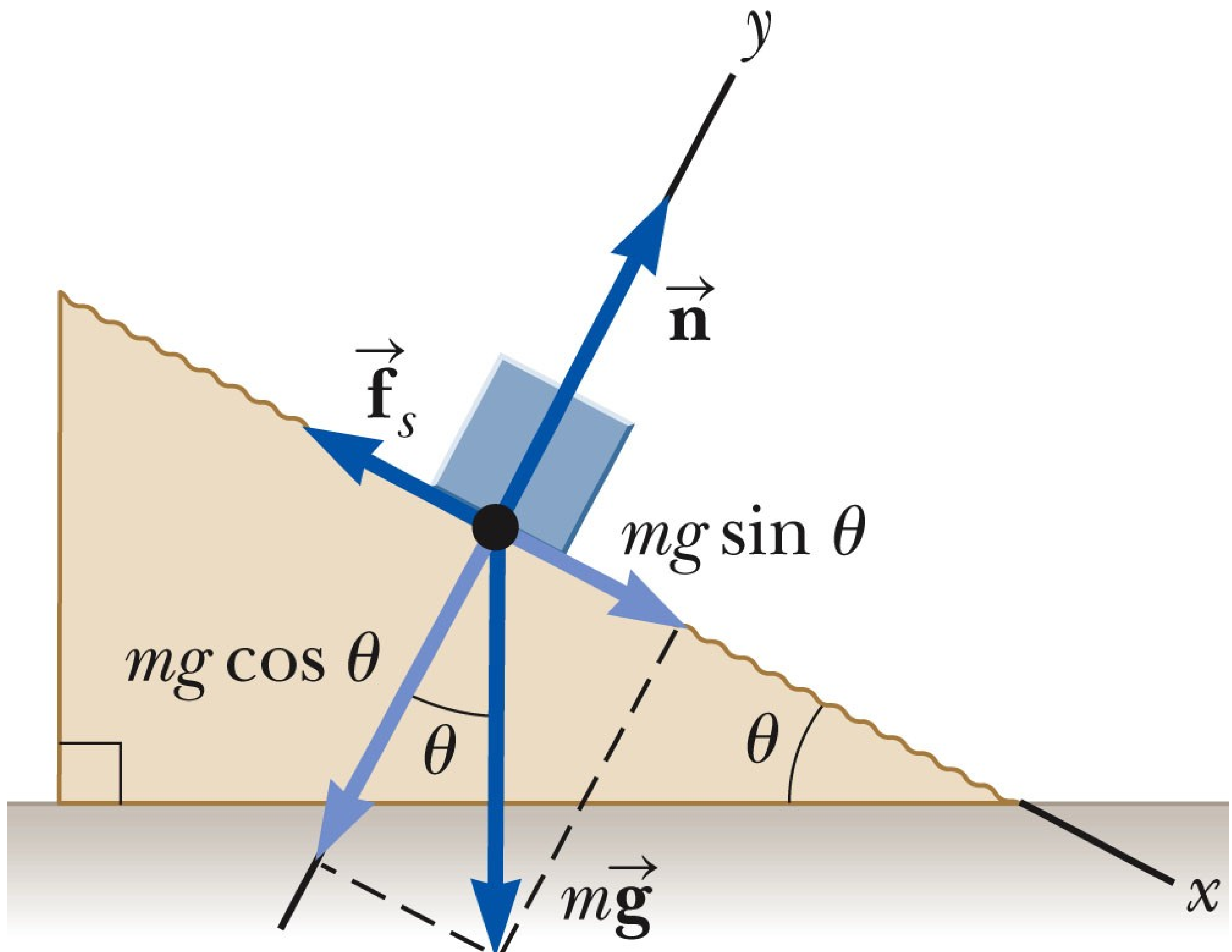


TABLE 5.1 *Coefficients of Friction*

	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