Physics 211

Sections 1 & 70

Dr. Geoffrey Lovelace

Fall 2012

Lecture 13 (10/11/12)

Lecture 13 outline

- Announcements
- Work & energy
  - Constant force
  - Variable force example: spring
- Kinetic energy & work-energy theorem
- Potential energy
- Introduction to conservation of energy

Announcements

- Homework
  - Homework #6: due today 11:59PM
  - Homework #7: assigned today
- Reading: for Tuesday: Ch. 5 through Sec. 5.4
- Office hours
  - 10AM-11AM, 4PM-5PM today in MH-601B

	Sep 20	Force, laws of motion *HW #3 due*
	Sep 25	**Exam 1**
	Sep 27	Laws of motion, *HW #4 due*
	Oct 2	Free body diagrams
	Oct 4	Free body diagrams, friction, *HW #5 due*
	Oct 9	Free body diagram practice & wrap-up
Today →	Oct 11	Work, energy, kinetic & potential energy *HW #6 due*
	Oct 16	Kinetic & potential energy, conservation of energy
	Oct 18	Conservation of energy, power, *HW #7 due*
	Oct 23	**Exam 2**
	Oct 25	Linear momentum, conservation of linear momentum, *HW #8 due*
	Oct 30	Conservation of linear momentum, collisions
	Nov 1	Center of mass, rockets, *HW #9 due*
	Nov 6	Circular motion, gravitation
	Nov 8	Gravitation, Kepler's laws
	Nov 13	Special feature: temperature, heat, entropy *HW #10 due*
	Nov 15	**Exam 3**
	Nov 20	*Fall Recess — No class*

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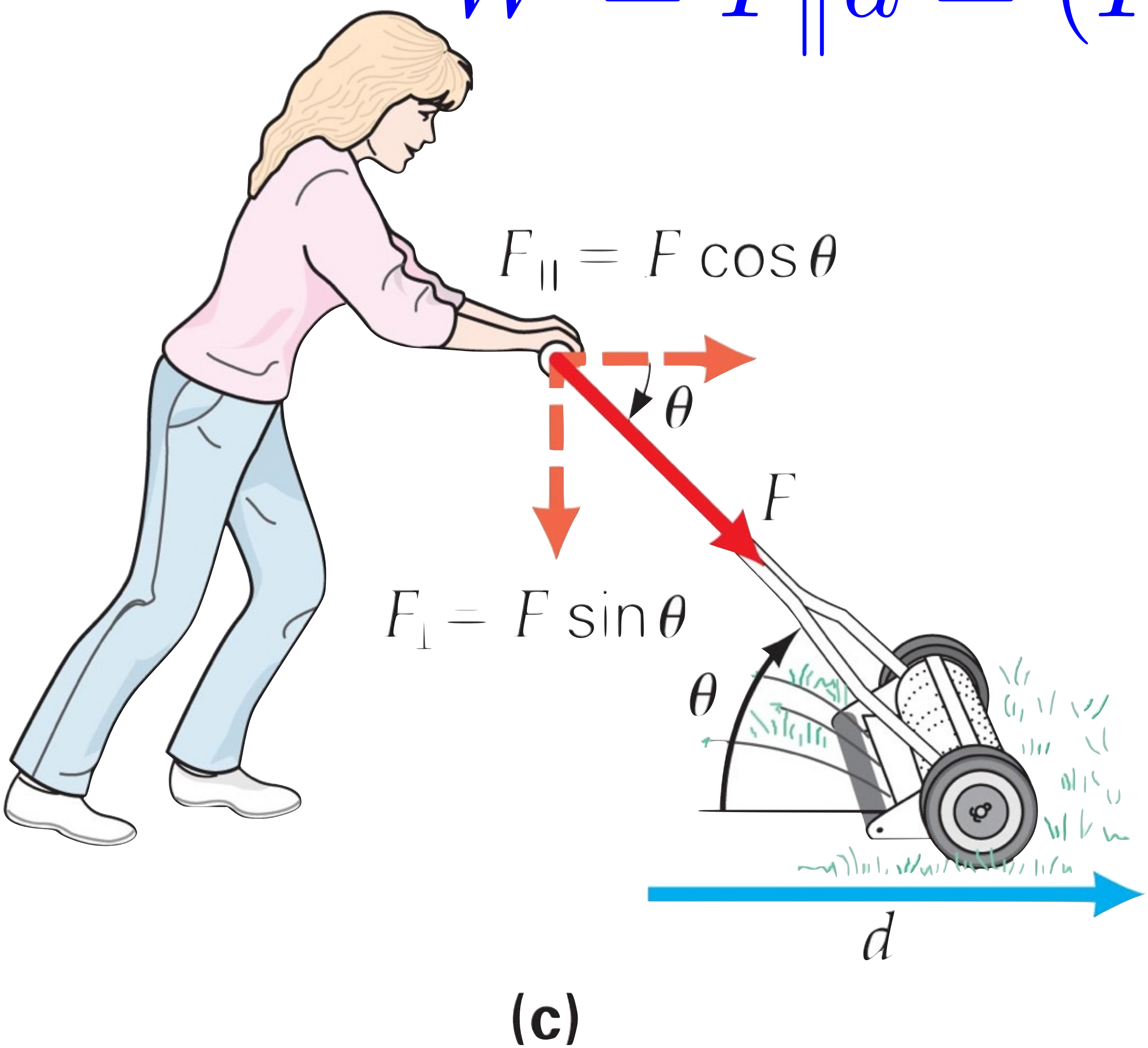
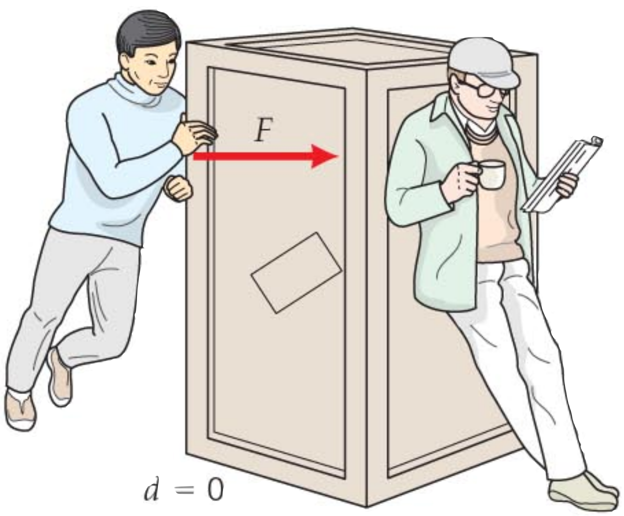
Work (constant force)

$$W = F_{\|} d = (F \cos\theta) d$$

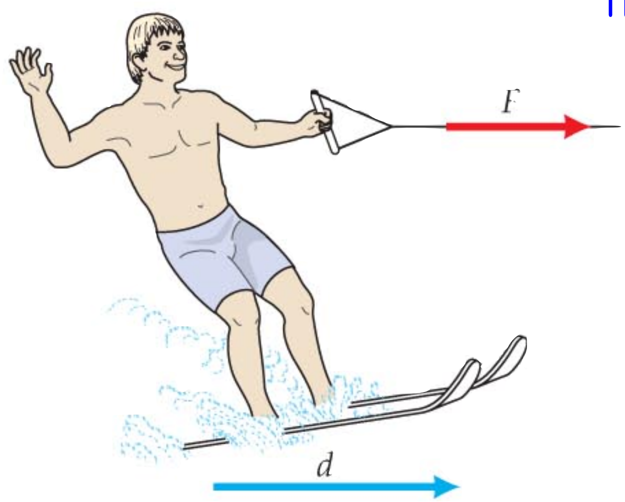


Work (constant force)

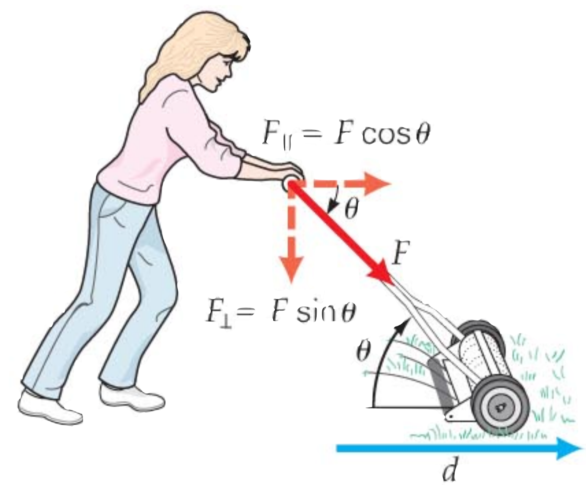
- Work: what's done when a force acts on an object as it moves through a distance
  - Net work: done by net force over displacement *d*
  - Done **only by force component ll to displacement**
  - Scalar, units: J = N•m $W = F_{\|} d = (F\cos\theta) d$



$W = 0 \text{ if } d = 0$



$W = Fd$



$W = (F\cos\theta)\, d$

Clicker question #46

Question 5.1 To Work or Not to Work

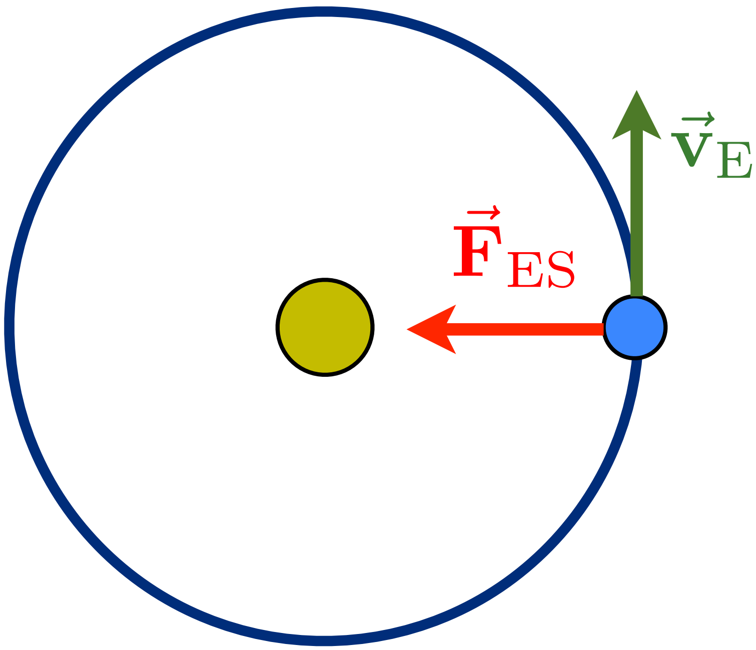
Is it possible to do work on an object that remains at rest?

A yes

B no

Clicker question #47

- If the earth orbits the sun in a circular orbit and tidal friction can be neglected, what is the work done on the earth by the sun?



A $-W$

B 0

C $+W$

D not enough information to know

Clicker question #48

Question 5.4 Lifting a Book

You lift a book with your hand in such a way that it moves up at constant speed. While it is moving, what is the *total work* done on the book?

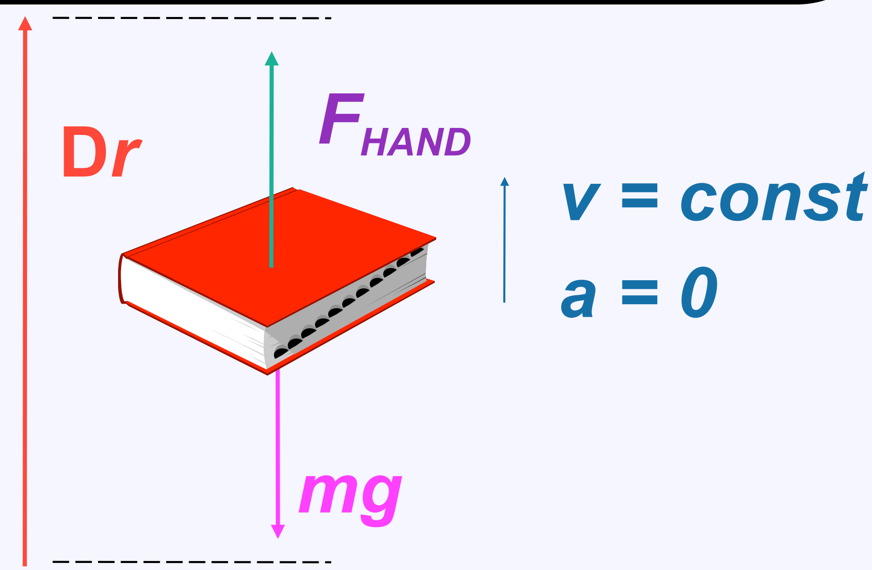
A. $mg \times \Delta r$

B. $F_{HAND} \times \Delta r$

C. $(F_{HAND} + mg) \times \Delta r$

D. zero

☐ none of ABCD



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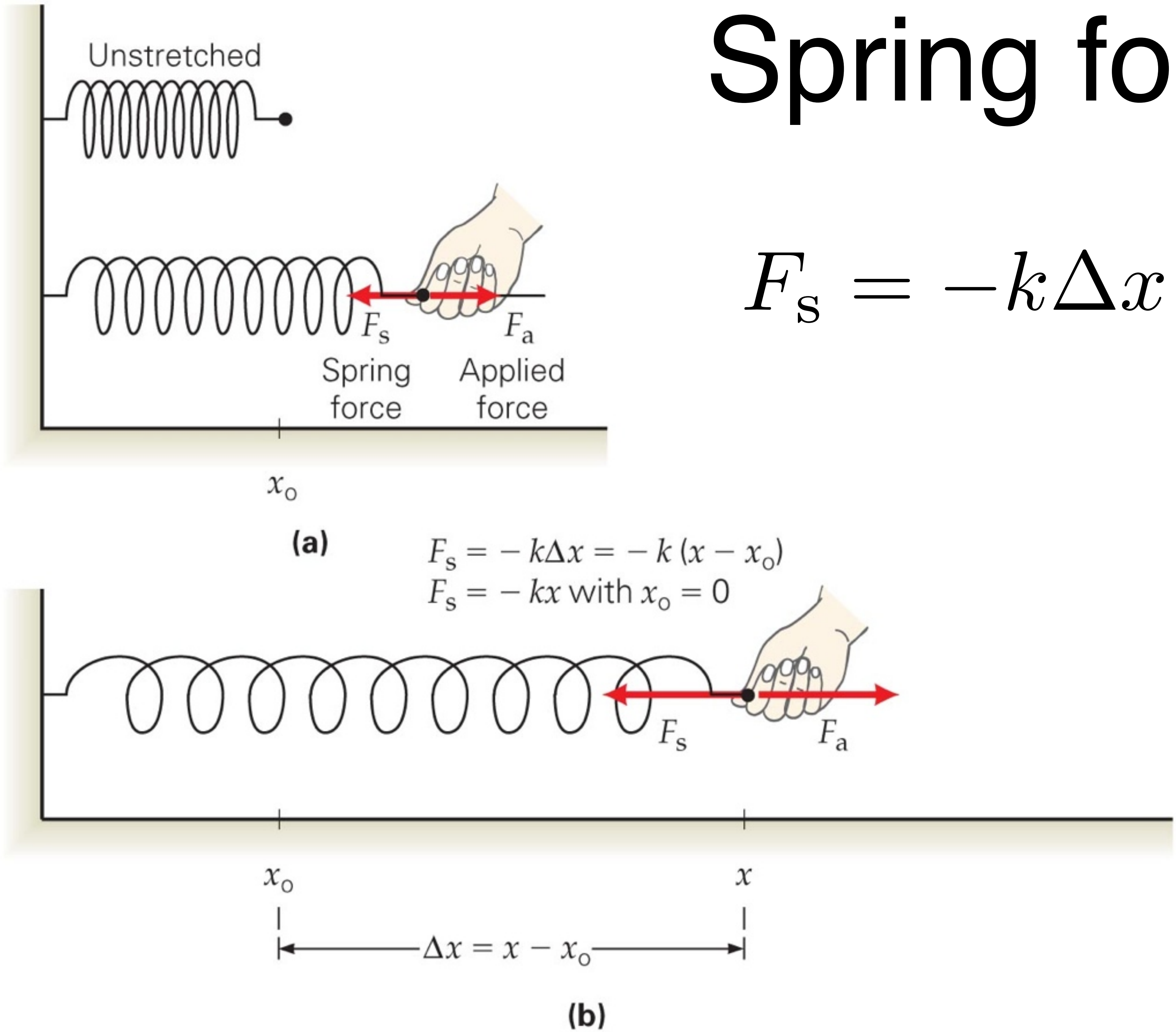
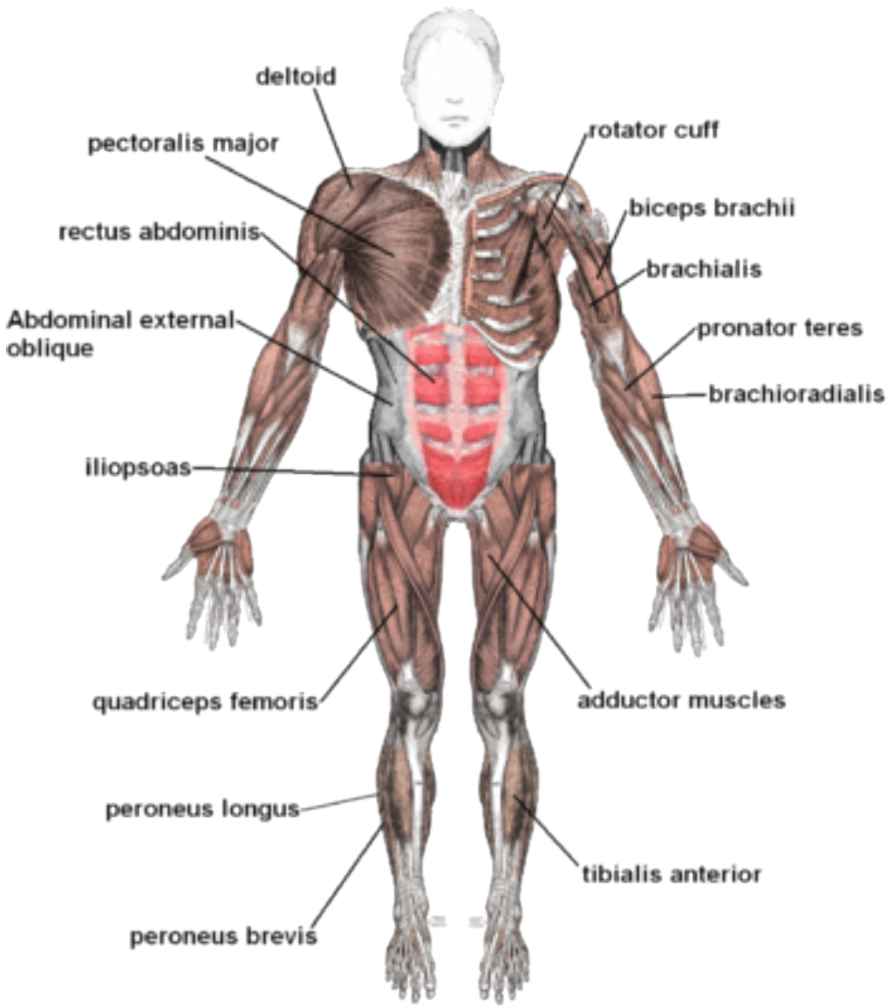
Spring force

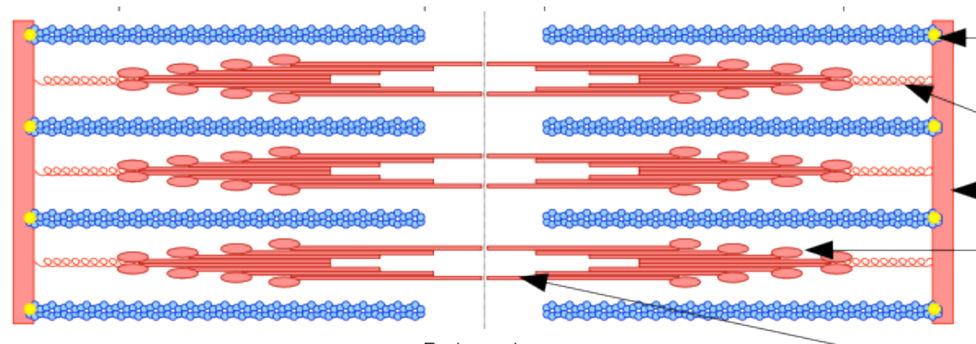
$$F_s = -k\Delta x$$



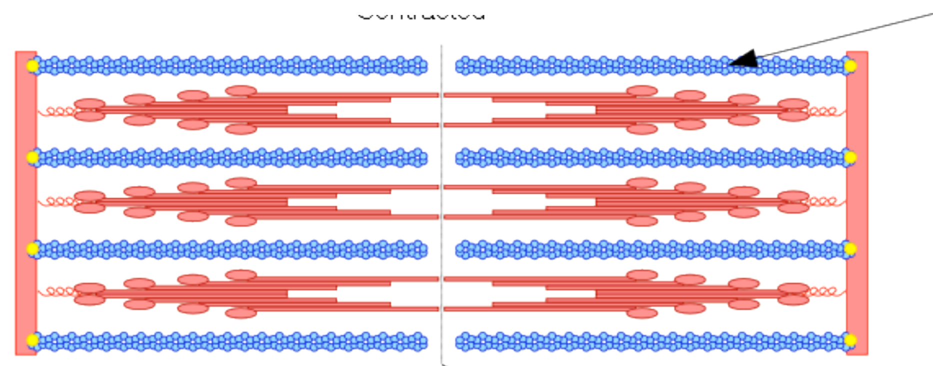
Examples: springs

- Real-life spring
- Example: muscles



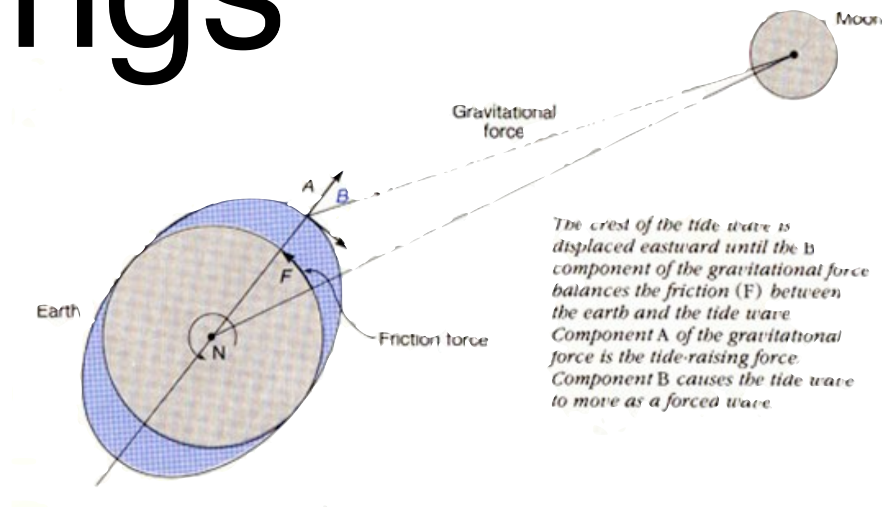


Relaxed muscle

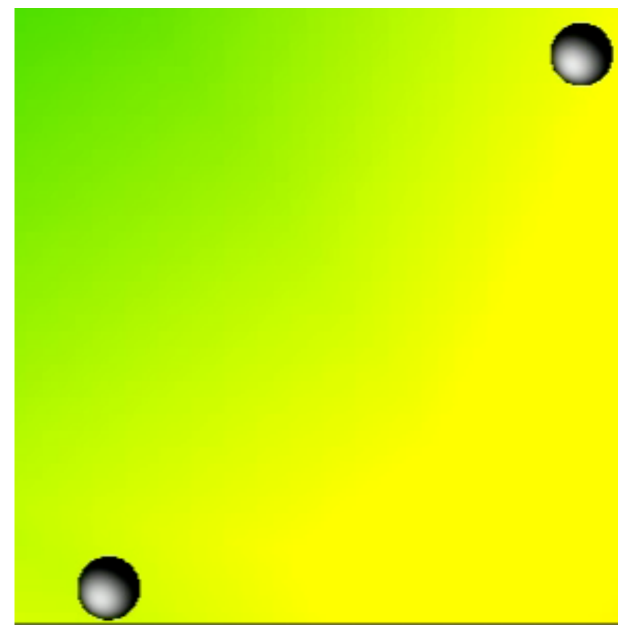


Contracted muscle

Examples: springs



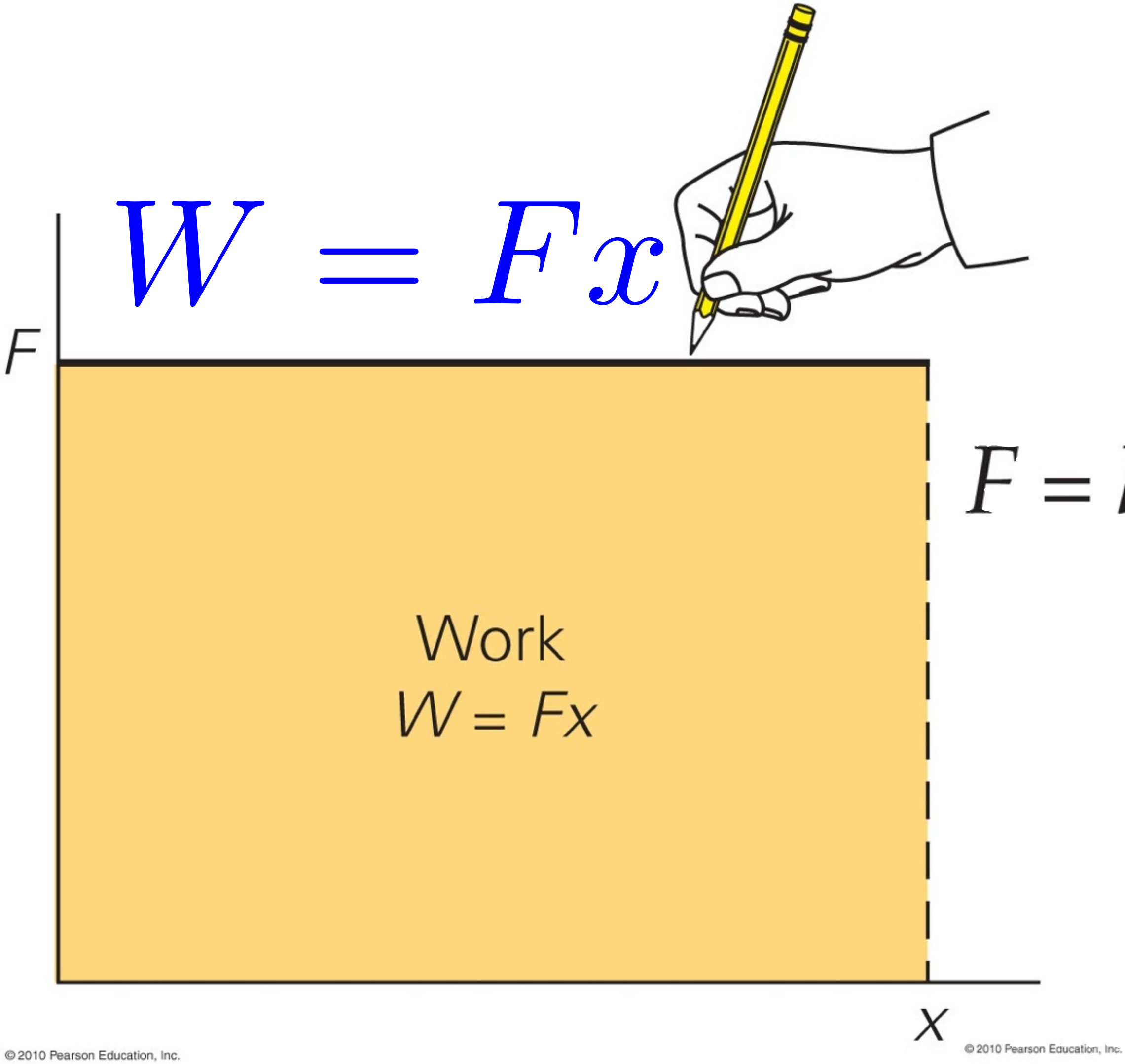
- Disturbed
  black-hole horizon
  - Inside horizon,
    gravity so strong even
    light can’t escape
  - 2 black holes: raise tides on
    each other
  - When deformed,
    horizon oscillates like a mass
    on a spring (same equation!)
  - Movie: simulated, deformed horizons



Work: variable force

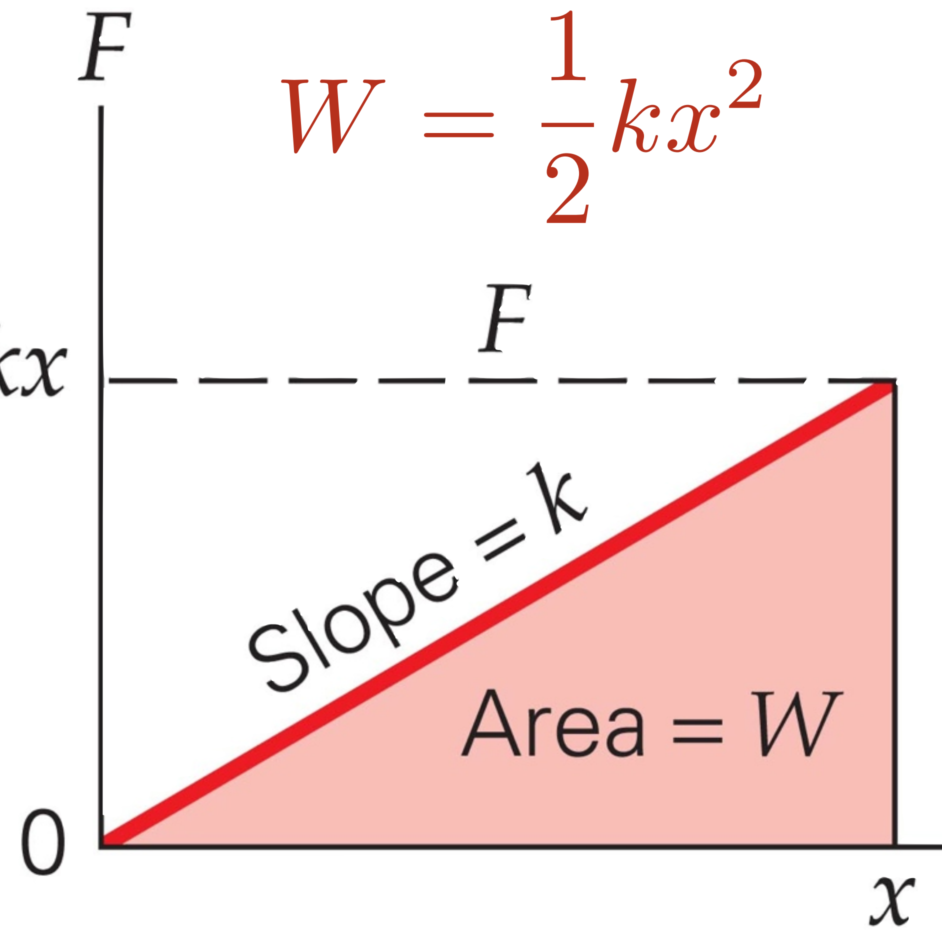
- Work = area under force vs. displacement curve

$$W = Fx$$



$$F = kx$$

$$W = \frac{1}{2}kx^2$$



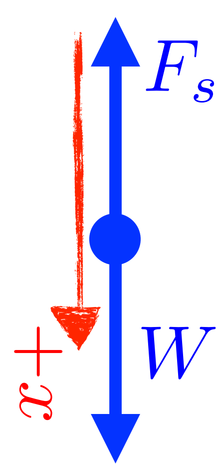
Ex. 5.4

- Mass m_1 hung on an unstretched spring, which comes to rest distance Δx below start (x=0). Mass m_2 added; where are masses at rest then?

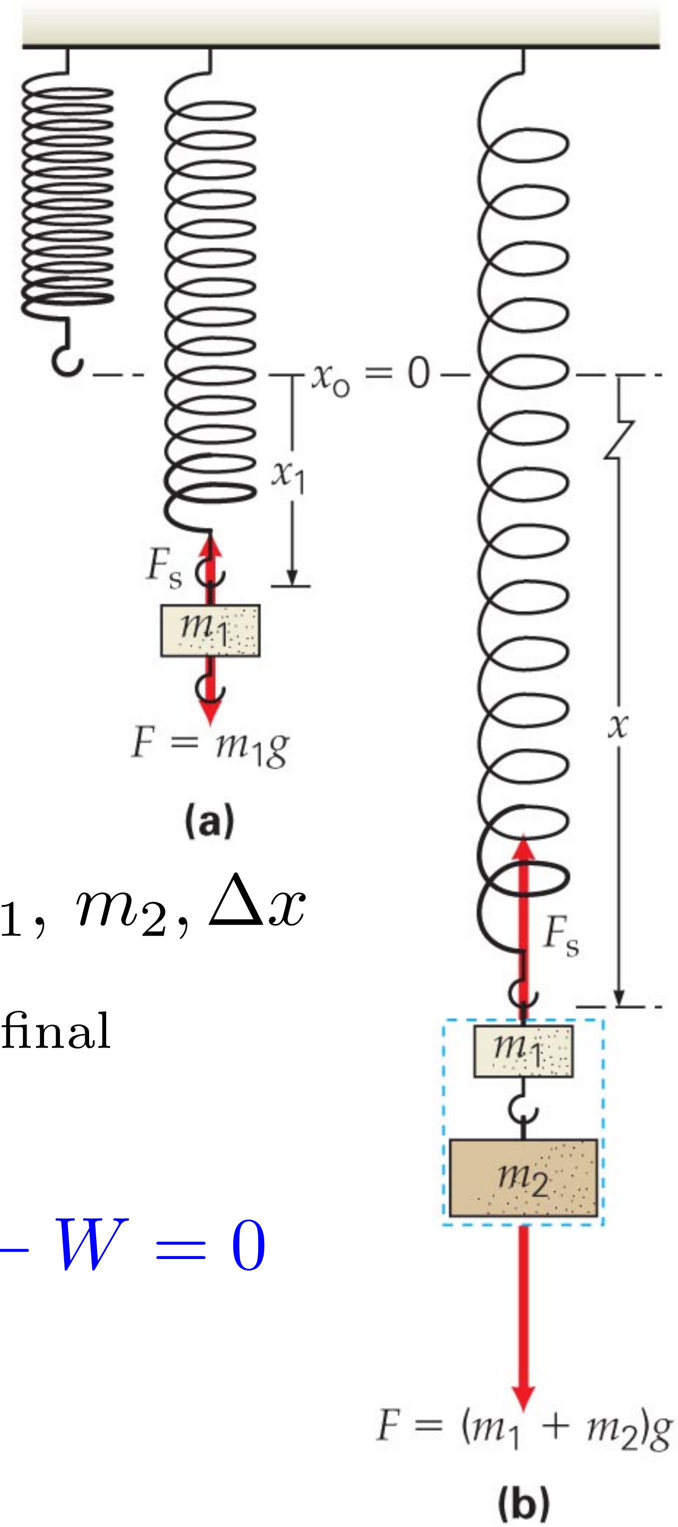
1. Read carefully
2. Draw a sketch = space diagram
3. Given? Goal?
4. Brainstorm: 2nd law + friction
   4a. For each body, draw a free-body diagram
   4b. Write equations

Given: $m_1, m_2, \Delta x$

Goal: Δx_{final}

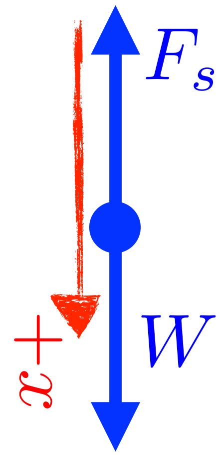


$$F_s - W = 0$$



Ex. 5.4

1. Read carefully
2. Draw a sketch = space diagram
3. Given? Goal?
4. Brainstorm: 2nd law + friction
    4a. For each body, draw a free-body diagram
    4b. Write equations
5. Calculate
6. (Plug in numbers)
7. Is answer reasonable?



Given: $m_1, m_2, \Delta x$

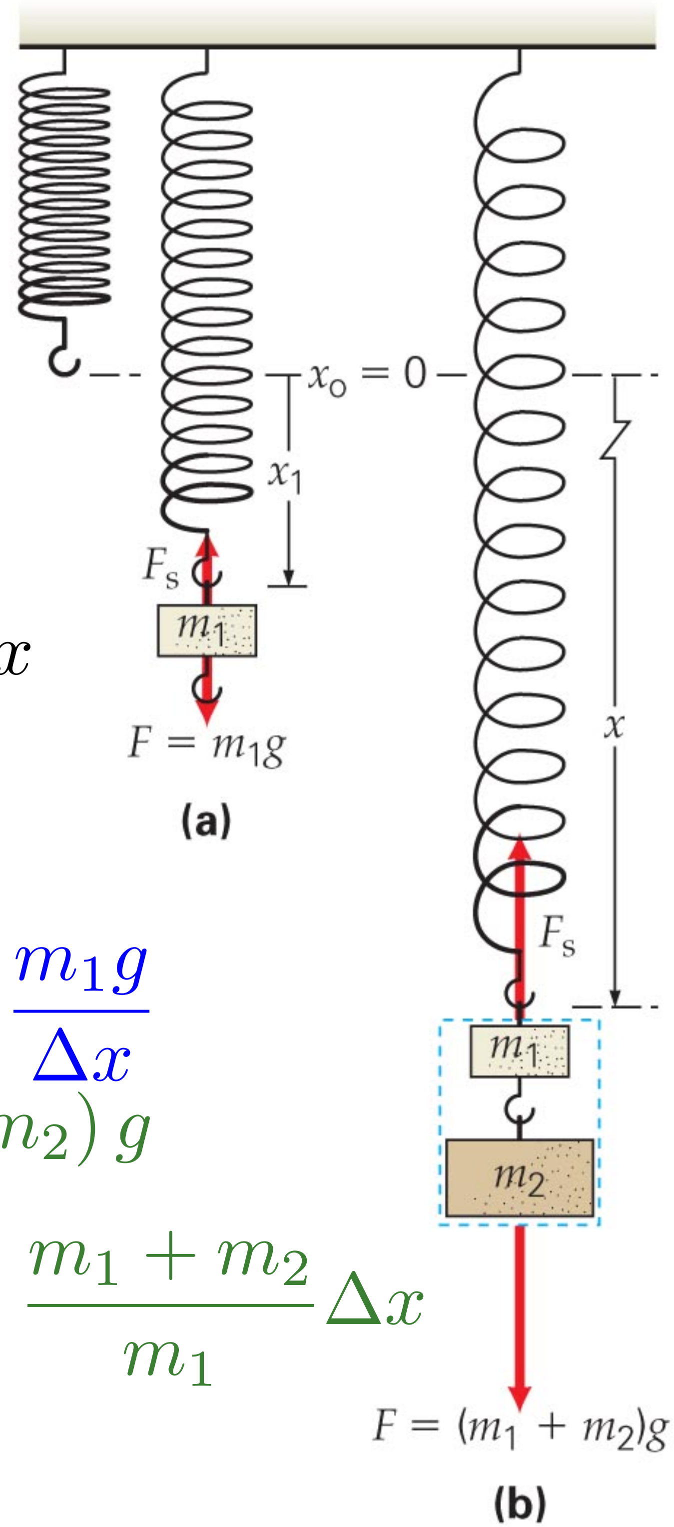
Goal: Δx_{final}

$$F_s - W = 0$$

$$k\Delta x = m_1 g \qquad k = \frac{m_1 g}{\Delta x}$$

$$k\Delta x_{\text{final}} = (m_1 + m_2)\, g$$

$$\Delta x_{\text{final}} = \frac{(m_1 + m_2)\, g}{k} = \frac{(m_1 + m_2)\, g}{m_1 g}\Delta x = \frac{m_1 + m_2}{m_1}\Delta x$$



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Energy

Convert ~5 x 10^8 J electrical energy to sound, light, thermal, …

- Energy
  - Many forms: sound, kinetic (motion), gravitational, light, thermal, elastic, electrical, chemical, nuclear, mass…
  - Scalar (units: J = N•m)
  - Can move energy & change its form
  - **Impossible to create or destroy energy**
    - Why? Emmy Noether 1915: Because laws of physics are the same at all times.

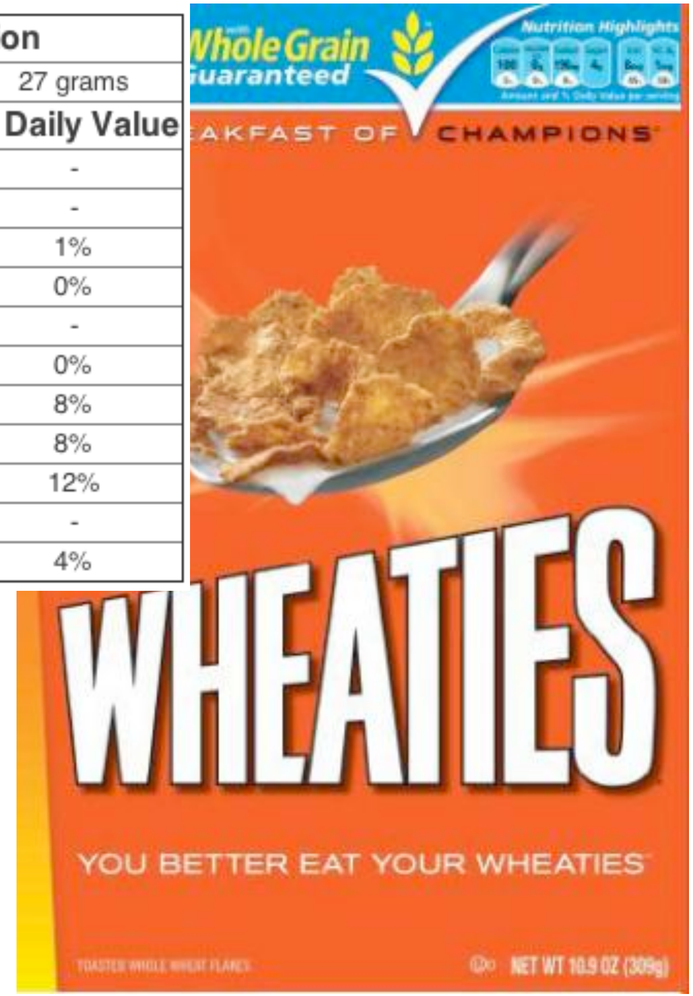
Examples of energy

100 J/s 27 J/s

Equally bright

1 Watt = 1 J/s

Wheaties Basic Nutrition		
Serving Size		27 grams
Nutrition Fact	Amount	% Daily Value
Calories	100	-
Calories from Fat	5	-
Total Fat	0 grams	1%
Saturated Fat	0 grams	0%
Trans Fat	0 grams	-
Cholesterol	0 milligrams	0%
Sodium	190 milligrams	8%
Total Carbohydrates	22 grams	8%
Fiber	3 grams	12%
Sugars	4 grams	-
Protein	2 grams	4%



Humans use:
~2000 Cal/day

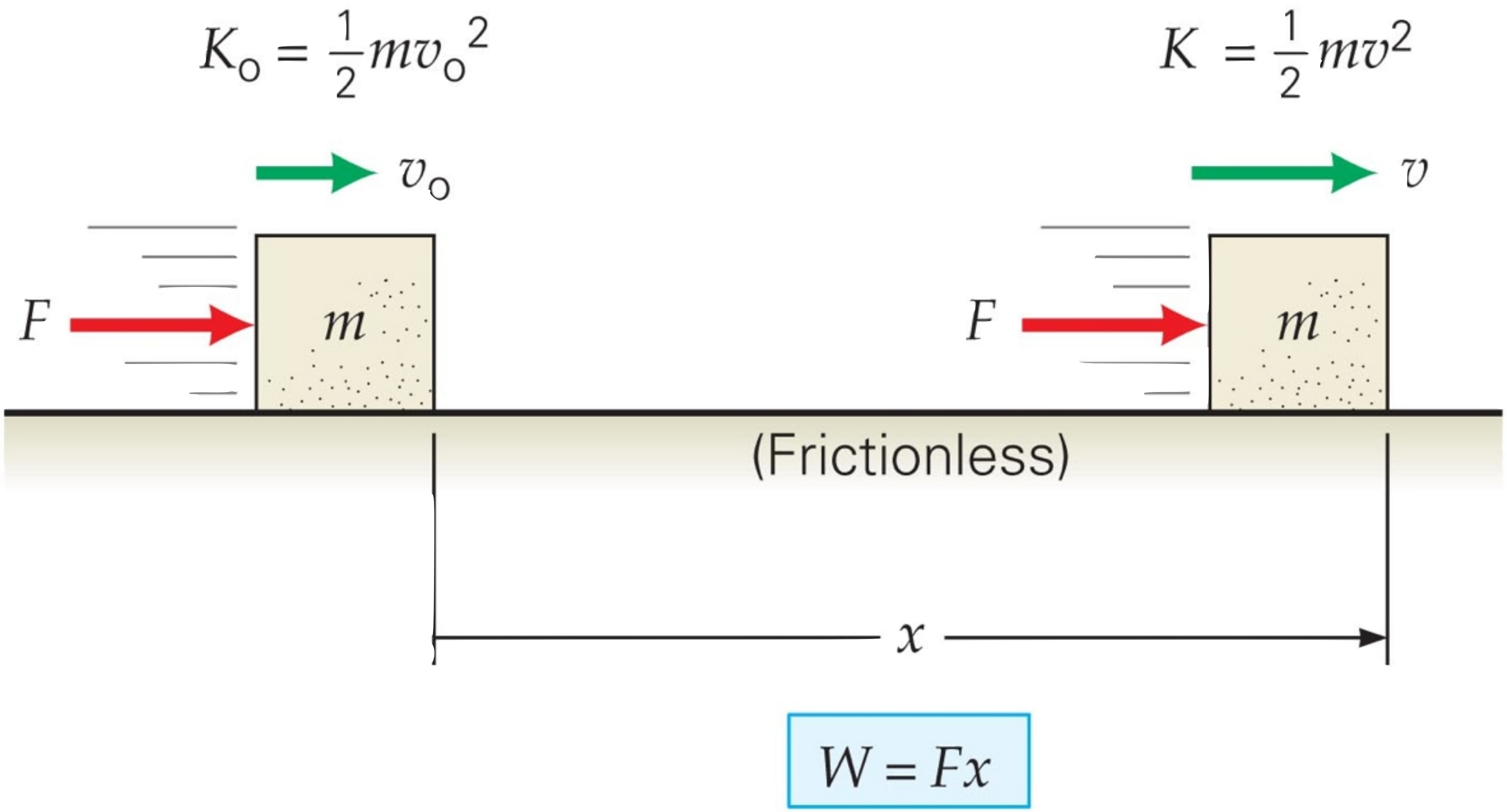
1 Cal = 4184 J

Brain uses 1/5 of that
= 400 Cal/day
= 20 J / s = 20 Watt

Kinetic energy & work

- Kinetic energy = $K = \frac{1}{2}mv^2$
  energy of motion
- Work energy theorem
  $W_{\text{net}} = \Delta K$

$$W = K - K_o = \Delta K$$



Clicker question #50

Question 5.5a Kinetic Energy I

By what factor does the kinetic energy of a car change when its speed is tripled?

A) no change at all
B) factor of 3
C) factor of 6
D) factor of 9
E) factor of 12

Clicker question #51

Question 5.6b Free Fall II

Two stones, one twice the mass of the other, are dropped from a cliff. Just before hitting the ground, what is the final speed of the heavy stone compared to the light one?

- A quarter as much
- B half as much
- C the same
- D twice as much
- four times as much

Clicker question #52

Question 5.6a Free Fall I

Two stones, one twice the mass of the other, are dropped from a cliff. Just before hitting the ground, what is the kinetic energy of the heavy stone compared to the light one?

A) quarter as much
B) half as much
C) the same
D) twice as much
four times as much

Clicker question #49

Question 5.2a Friction and Work I

A box is being pulled across a rough floor at a constant speed. What can you say about the work done by friction?

A. friction does no work at all

B. friction does negative work

C. friction does positive work