Physics 211

Sections 1 & 70
Dr. Geoffrey Lovelace
Fall 2012
Lecture 14 (10/16/12)

Lecture 14 outline

- Announcements
- Positive and negative work
- Potential energy
- Conservation of energy
  - Demo: Wheaties, migrating birds, ball bounce
  - Quantitative example: ball toss
  - Conceptual examples

Announcements

- Homework
  - Homework #7: due Thursday 11:59PM
- Tuesday, October 23 (1 week!): Exam #2
  - Bring: #2 pencils, eraser, sci. calculator, **CWID**
  - I provide: scantron form, formula sheet
  - Cumulative but emphasis on new material (projectiles and onward)
- Reading: for Thursday: finish chapter 5
- Office hours
  - 4PM-5PM today in MH-601B

Exam advice

- What to study
  - Examples in text (work, then check)
  - Clicker questions from class
  - Learning path review: summarize materials
  - Homework problems
  - Odd-# problems (conceptual and quant.)
- Exam format
  - Same as last time: conceptual and quantitative problems, mostly multiple choice

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
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*

Today

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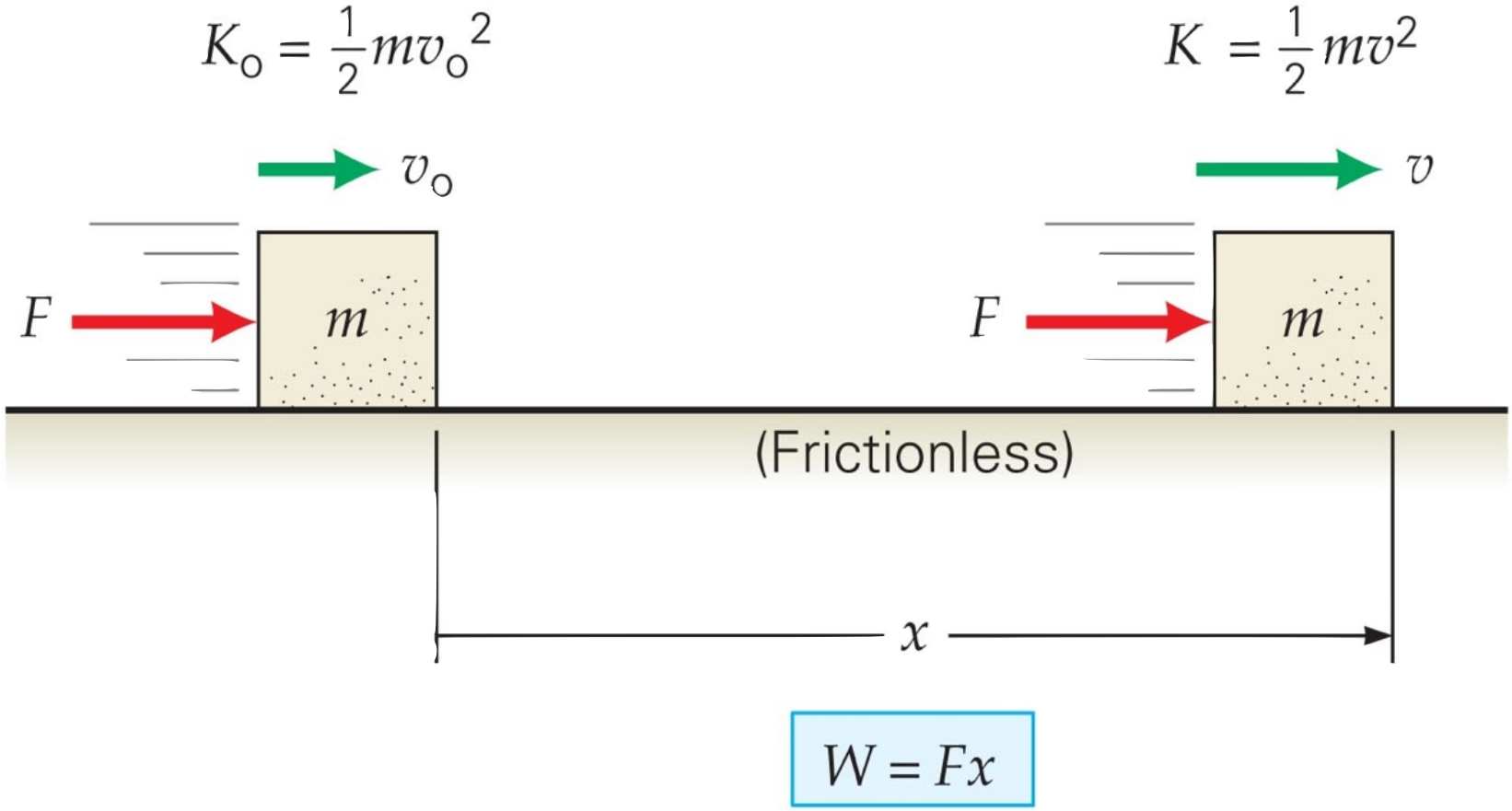
Kinetic energy & work

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

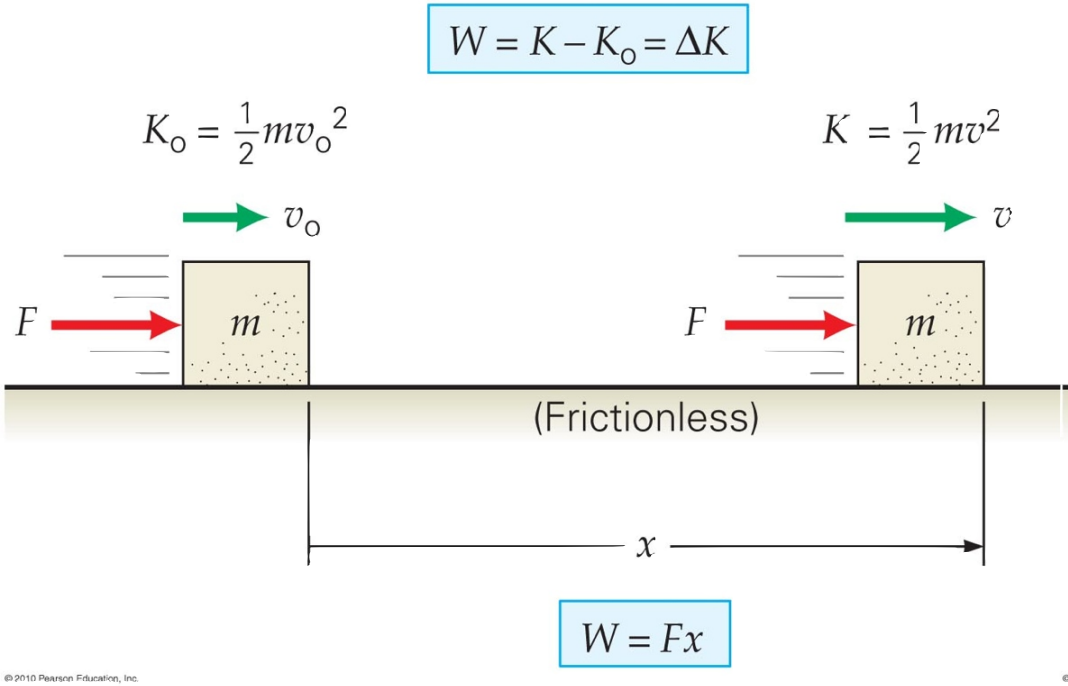
$W = K - K_0 = \Delta K$

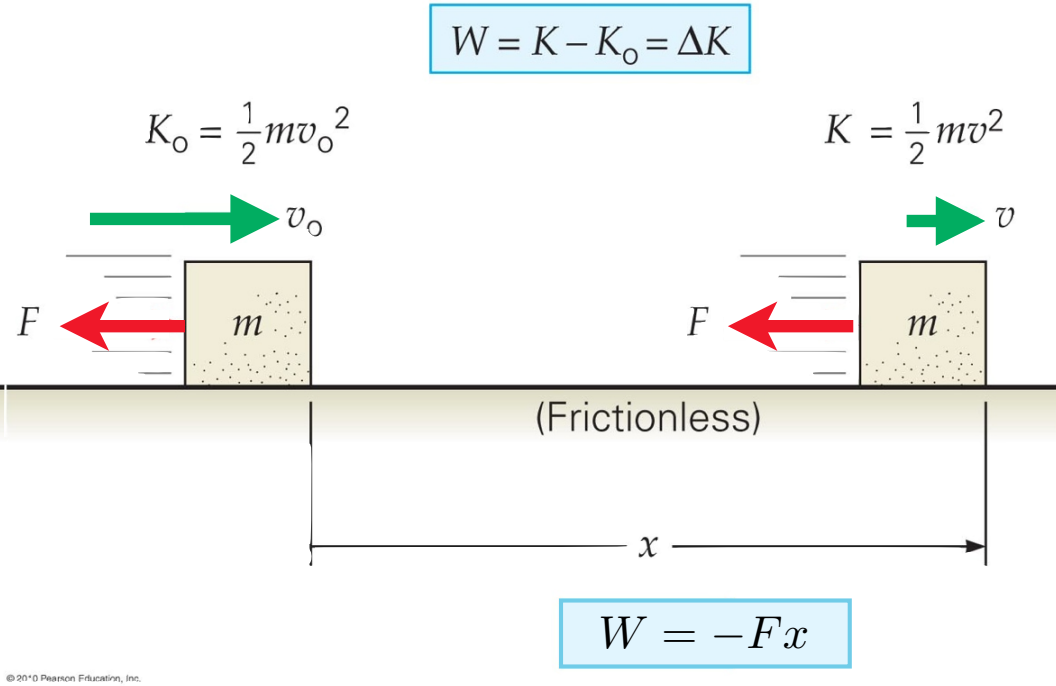


$W = Fx$

Positive & negative work

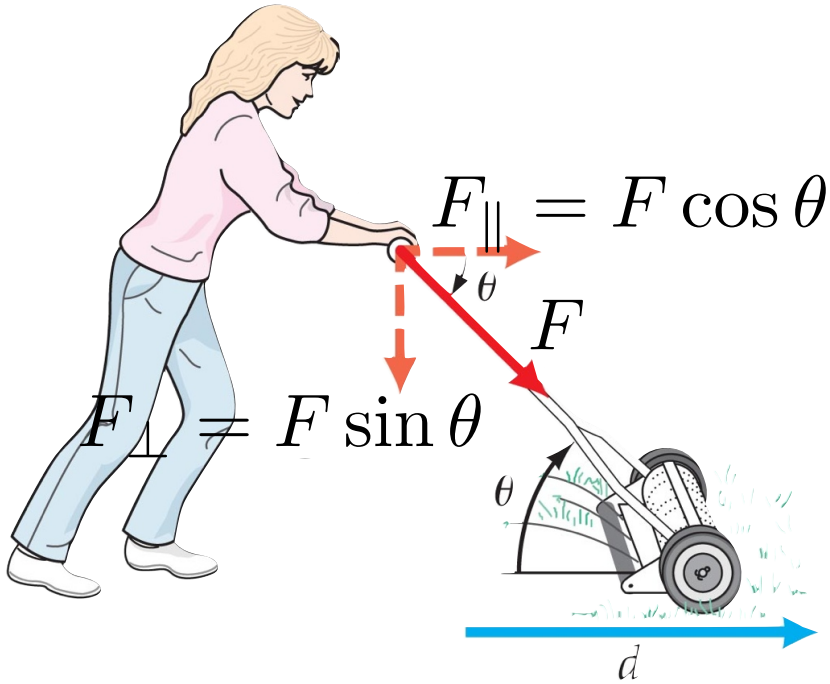
- Work energy theorem
  $W_{\text{net}} = \Delta K$



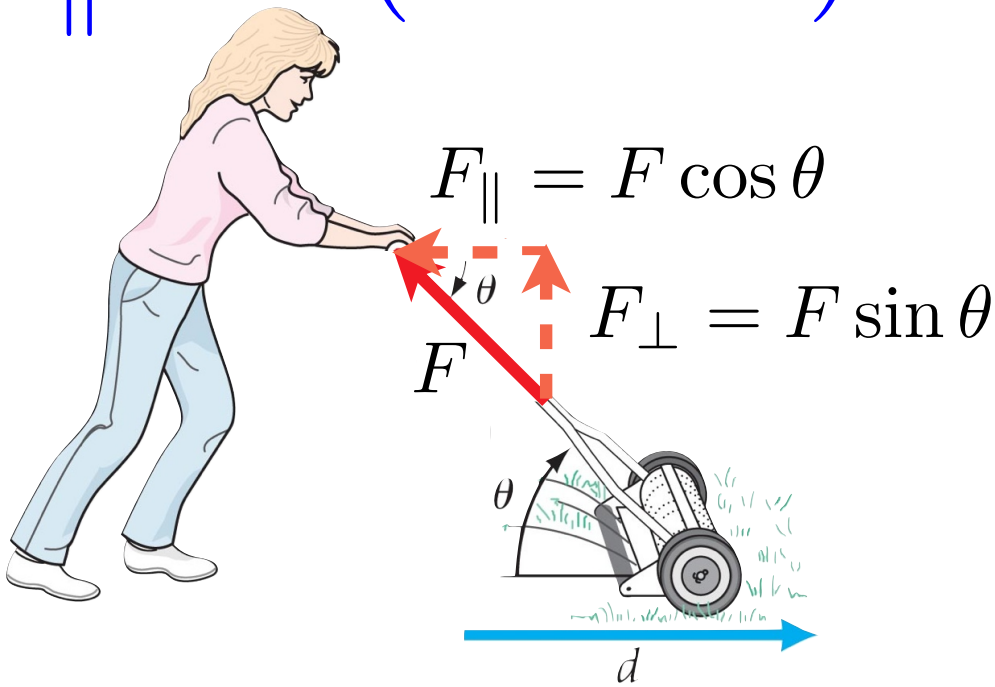


Positive & negative work

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



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



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

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Clicker question #53

Question 5.7 Work and KE

A child on a skateboard is moving at a speed of 2 m/s. After a force acts on the child, her speed is 3 m/s. What can you say about the work done by the external force on the child?

A positive work was done

B negative work was done

C zero work was done

Clicker question #54

Question 5.2c Play Ball!

In a baseball game, the catcher stops a 90-mph pitch. What can you say about the work done by the catcher on the ball?

A. catcher has done positive work

B. catcher has done negative work

C. catcher has done zero work

Clicker question #55

Question 5.3 Force and Work

A box is being pulled up a rough incline by a rope connected to a pulley. How many forces are doing work on the box?

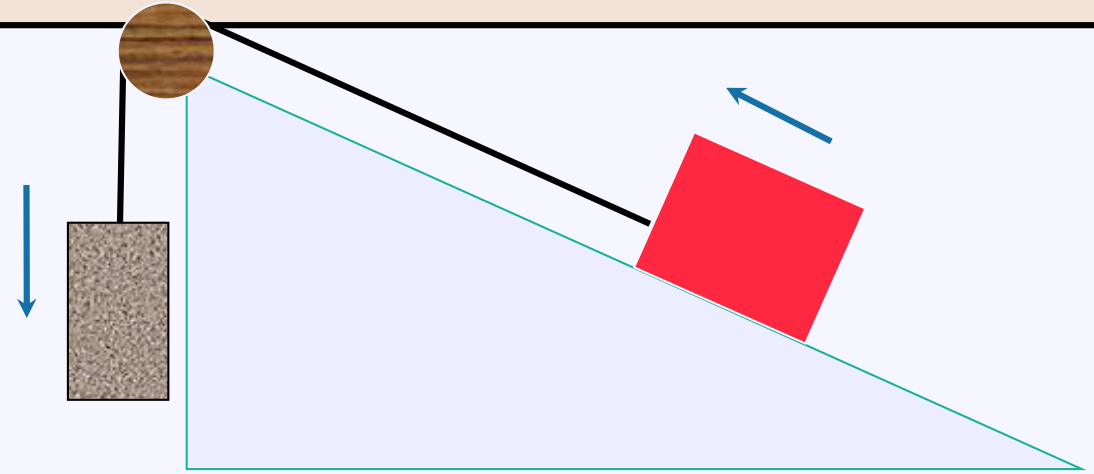
A one force

B two forces

C three forces

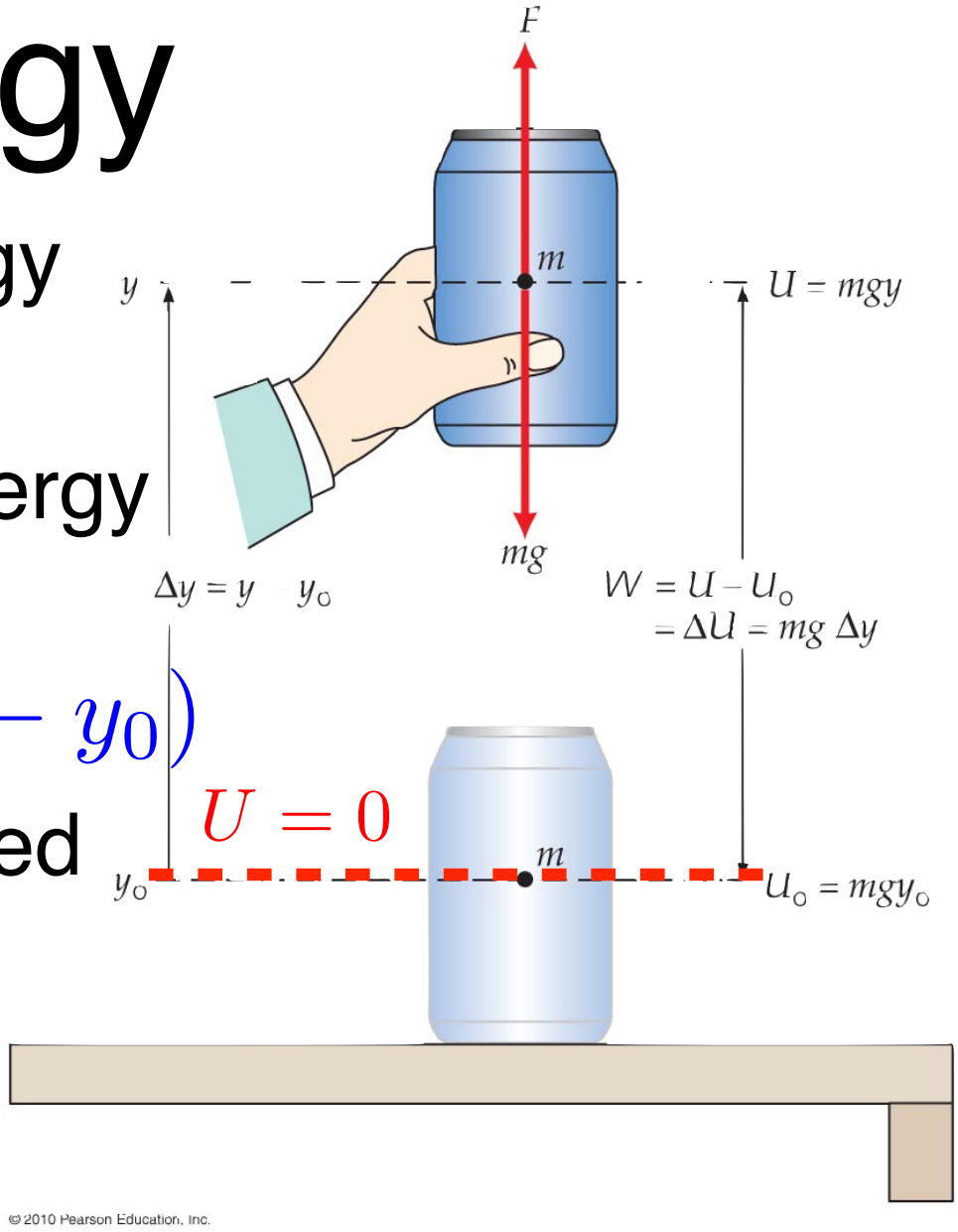
D four forces

no forces are doing work



Potential energy

- Potential energy = energy of position
- Changes in potential energy
  - Gravitational potential energy $\Delta U = mg(y - y_0)$
  - Energy of a compressed spring $\Delta U = \frac{1}{2}k(x^2 - x_0^2)$
  - Can **choose** where *y*=0 *and U*=0, so $U = mgy$



Clicker question #56

Question 5.11 Sign of the Energy II

Is it possible for the gravitational potential energy of an object to be negative?

A yes

B no

Clicker question #57

Question 5.10 **Sign of the Energy I**

Is it possible for the kinetic energy of an object to be negative?

A **yes**

B **no**

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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.

Conservation of energy

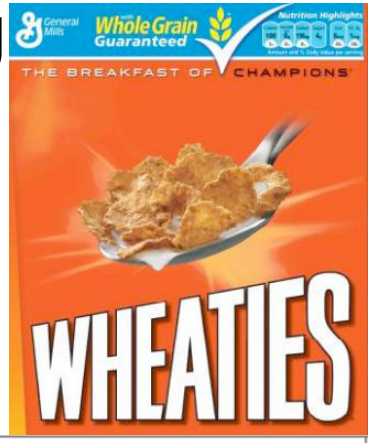
- Energy can't be created or destroyed, so…
  - The *total* energy is the same at all times…
  - But it can be *converted* to different forms

$$K + U_{\text{grav}} + U_{\text{elastic}} + U_{\text{sound}} = \text{const}$$

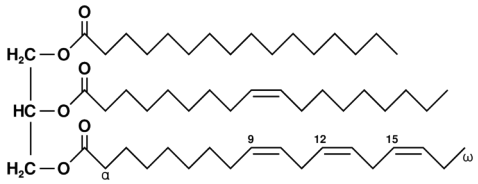
- Demo: ball bounce
  http://www.youtube.com/watch?v=3jI57WMOzbU

Energy conservation

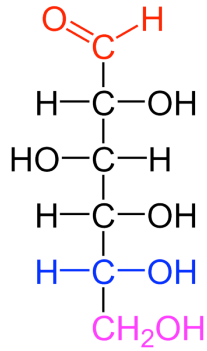
- More examples of converting energy to different forms
  - Chemical energy of Wheaties -> kinetic energy of Michael Jordan
  - Bird fat -> kinetic energy



Serving Size	
Nutrition Fact	Amount
Calories	100



vs.

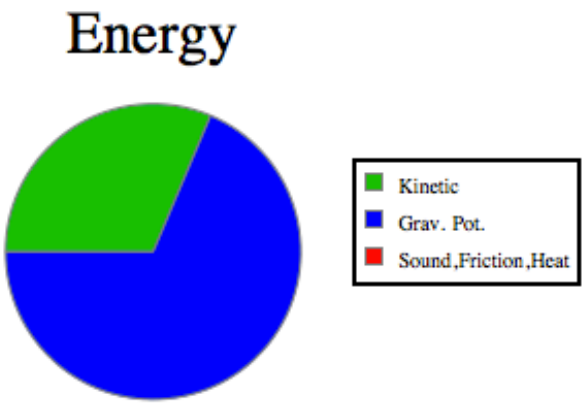


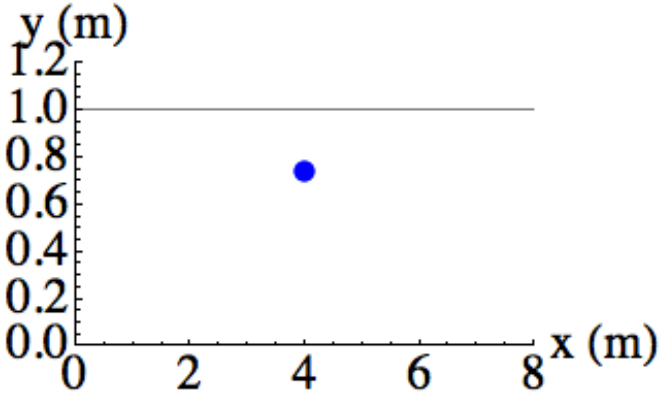
Fat≈9 Cal/gram Carbohydrate≈4 Cal/gram

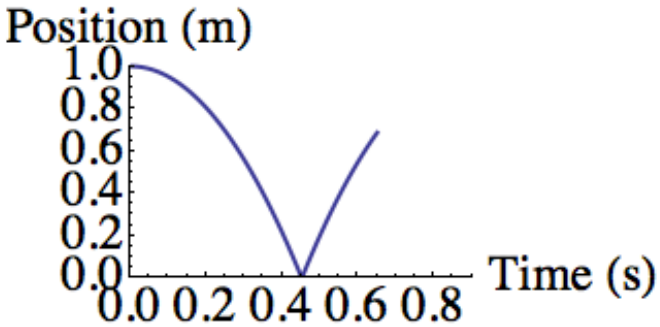
1 Cal ≈ 4000 J

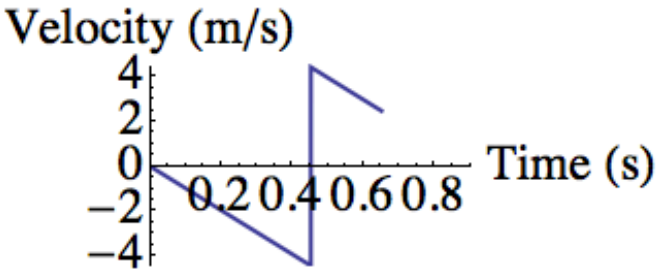
Energy conservation

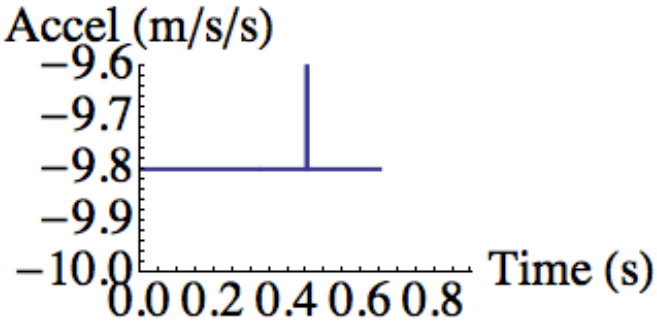
- More examples of converting energy to different forms
  - Bouncing ball





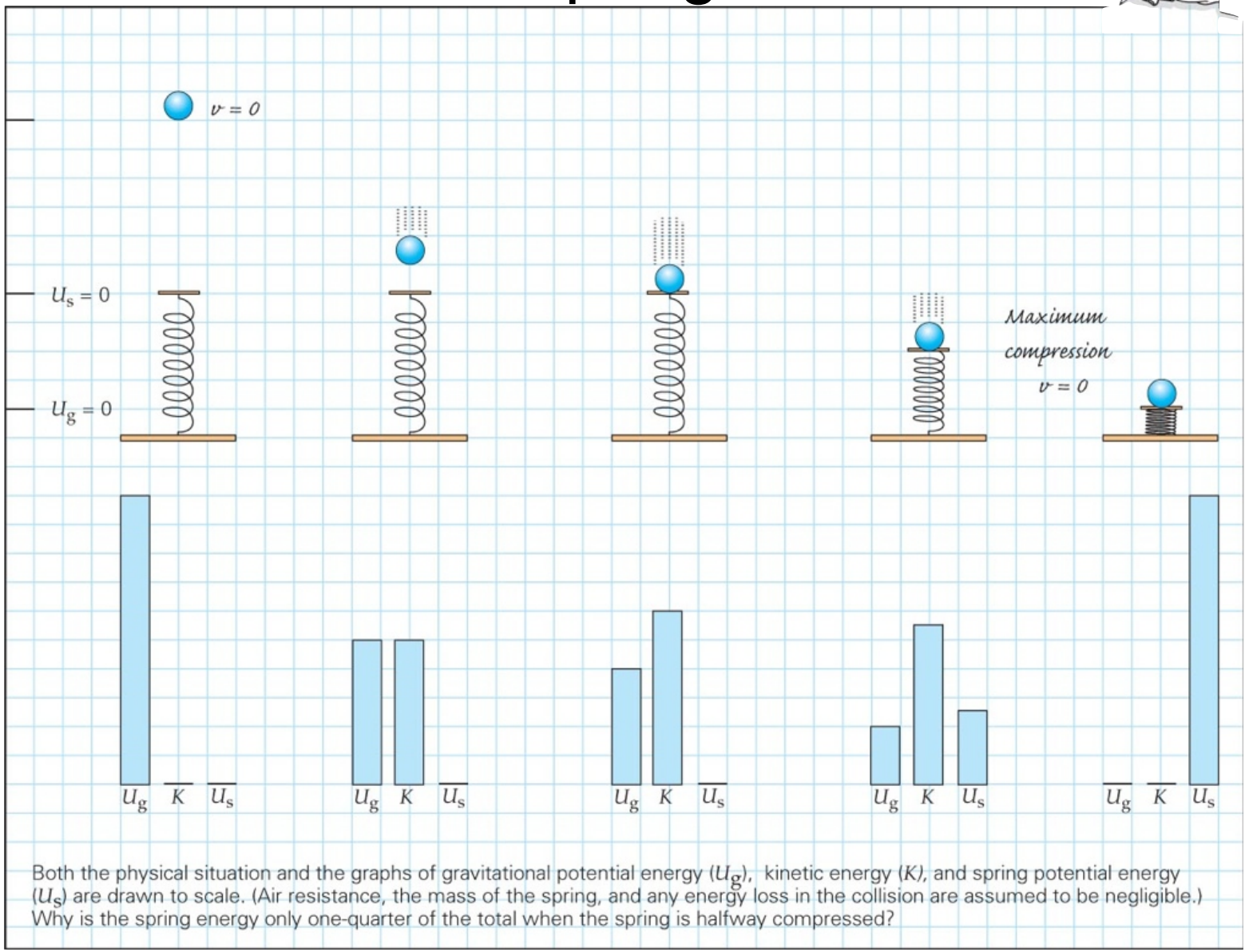






Energy conservation

- Ball bounce and spring



Both the physical situation and the graphs of gravitational potential energy (U_g), kinetic energy (K), and spring potential energy (U_s) are drawn to scale. (Air resistance, the mass of the spring, and any energy loss in the collision are assumed to be negligible.) Why is the spring energy only one-quarter of the total when the spring is halfway compressed?

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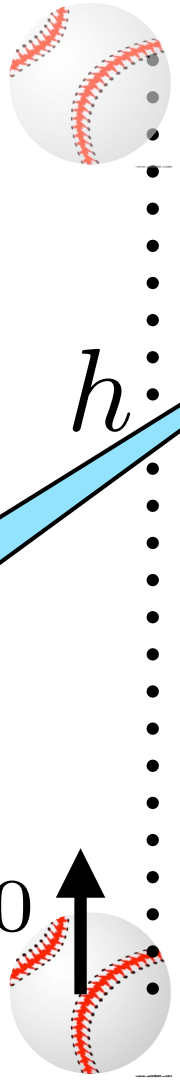
Example: ball toss

- Toss a ball upward with initial speed initial speed 10.0 m/s. How high does the ball go?



Given: $v_0 = 10.0$ m/s
Goal: h

1. Read carefully
2. Draw a sketch
3. Given? Goal?
4. Principles & equations?

Strategy:
Need to know time?
- If so, kinematic eqns.
- If not, energy conservation.

20% of class did not check the "read carefully" box in CP #11

Read the problem on the previous page carefully, and then check this box. ☐

Example: ball toss

$$\Sigma E = \frac{1}{2}\cancel{m}v_0^2 = \cancel{m}gh$$

$$h = \frac{v_0^2}{2g}$$

$$h = \frac{v_0^2}{2g} = \frac{(10.0\ \text{m/s})^2}{2\,(9.80\ \text{m/s}^2)} = 5.10\ \text{m}$$

Given: $v_0 = 10.0$ m/s
Goal: h

Energy at max height

$\Sigma E = mgh$

1. Read carefully
2. Draw a sketch
3. Given? Goal?
4. Principles & equations?
5. Calculate
6. Plug in numbers
7. Is answer reasonable?

h

Energy at start

$\Sigma E = \frac{1}{2}mv_0^2$

v_0

$U = 0$

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Class participation #13

- 0. Name
- 1. Going into Exam #2, what are you feeling *most confident* about?
- 2. Going into Exam #2, what are you feeling *least confident* about?