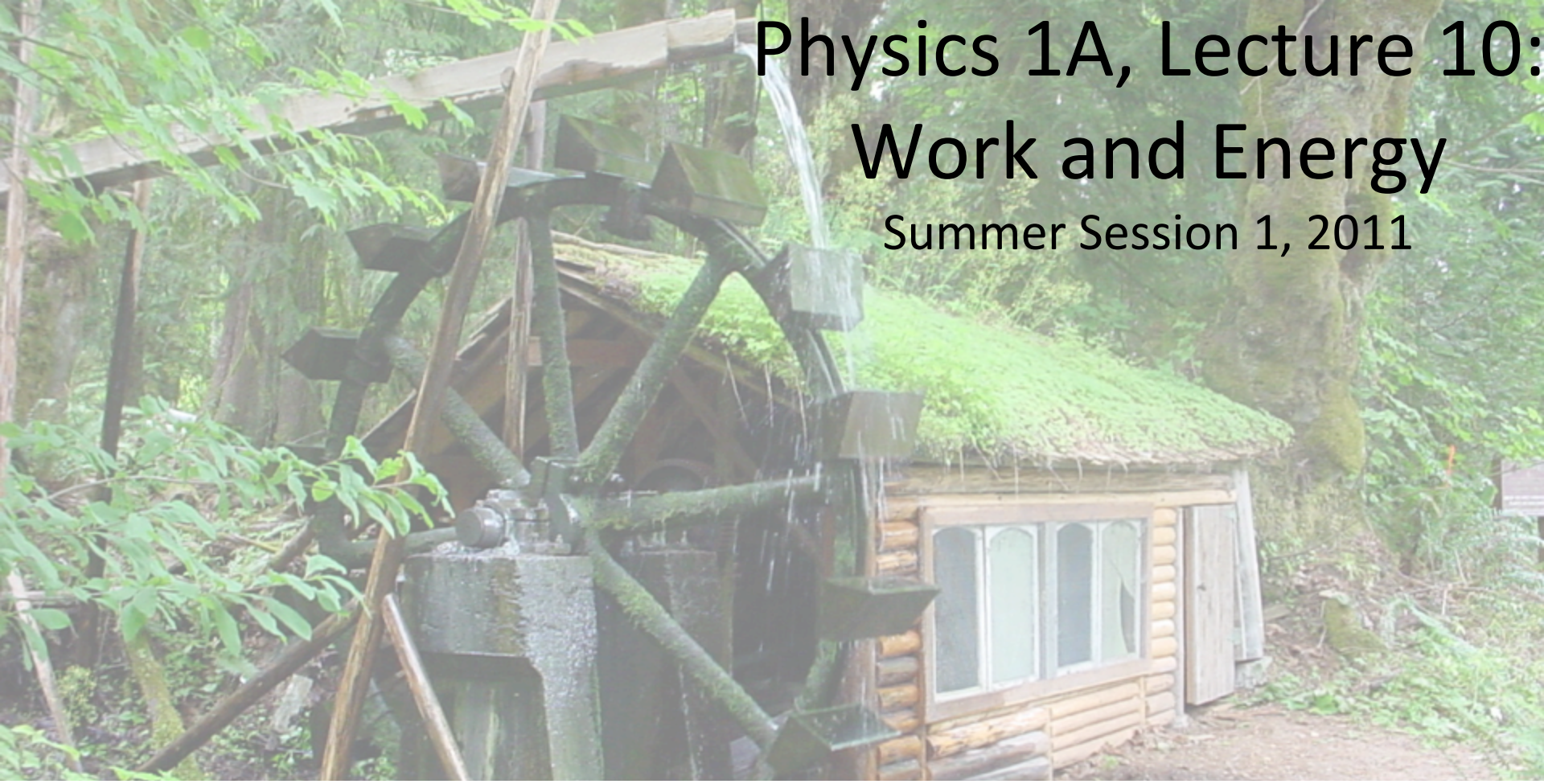


Physics 1A, Lecture 10: Work and Energy

Summer Session 1, 2011

The quiz will commence at 9:33 AM.

Key Questions: (Discuss with neighbors before quiz)

1) What is Hooke's Law?
2) What are the units of Kinetic and Potential energy?
3) How does Kinetic energy depend on velocity?
4) What is gravitational Potential Energy?
5) How can you calculate Work when Force depends on displacement?

Reading Quiz #8-1

Hooke's Law is a model for

A. the force of gravity

B. the force of friction

C. the potential energy due to gravity

D. the force of a spring

E. the normal force

Reading Quiz #8-2

What are the units of Kinetic and Potential energy?

A. The Joule, $J = kg\ m/s^2$

B. The Joule, $J = kg\ m^2/s^2$

C. The Newton, $N = kg\ m/s$

D. The Newton, $N = kg\ m/s^2$

E. The Watt, $W = kg\ m^2/s^3$

Reading Quiz #8-3

How does Kinetic energy depend on velocity?

Kinetic Energy is…

A. independent of velocity.

B. inversely proportional to velocity.

C. directly proportional to velocity.

D. inversely proportional to velocity squared.

E. directly proportional to velocity squared.

Reading Quiz #8-4

What is gravitational Potential Energy?

A. Tells you how fast something is falling towards the earth

B. The energy an object has by being a certain vertical distance from a reference point.

C. It is always proportional to the Kinetic Energy

D. It can only be increased by falling.

E. A vector that points in the vertical direction.

Reading Quiz #8-5

How can you calculate Work when Force depends on displacement?

A. Take an integral of Work over displacement $\int W \cdot dx$

B. Take a derivative of Work with respect to displacement $\frac{dW}{dx}$

C. Take an integral of Force over displacement $\int F \cdot dx$

D. Take a derivative of Force with respect to displacement $\frac{dF}{dx}$

E. Don't even try, it can't be done.

Announcements

- HW #4 is posted, due this Wednesday
- Solutions to extra problems . . .
- Office hours today at noon (Mayer 5623)

Announcements

- Grades are posted for clickers and reading quizzes
  - I've already found several mistakes because I had to match up 3-digit codes with people by hand ☹
  - I will be re-uploading the grades next weekend.
  - These serial codes are not matched up with students:

- #01463B7C
- #058DC941
- #05F89F62
- #08DBF122
- #0E9D69FA
- #1AA4B00E
- #1C45DE87
- #1CC3EA35
- #1E6BDAAF
- #21AE46C9
- #2364BBFC
- #26B7CC5D

Grade adjustment

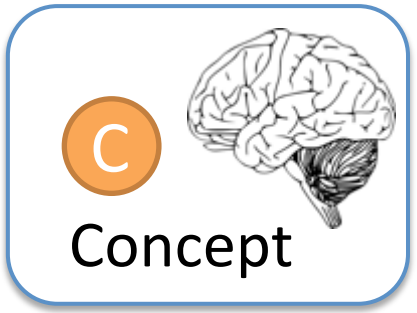
- First two quizzes will be adjusted with a horizontal shift to the right.
  - Quiz #1 (add 10%)
  - Quiz #2 (add 20%)

Anonymous Poll

- Did it help to work on problems with your neighbors in lecture last week?

A) Yes, otherwise the lecture would have gone too fast and I wouldn't get what you were talking about.
B) Yes, but I think it took up too much class time.
C) It didn't help or hurt, but I enjoyed the break.
D) No, the problems were either too easy or too hard to solve in the time that you gave us, and it took up too much class time.
E) No, my neighbors are clueless.

Energy / Money analogy

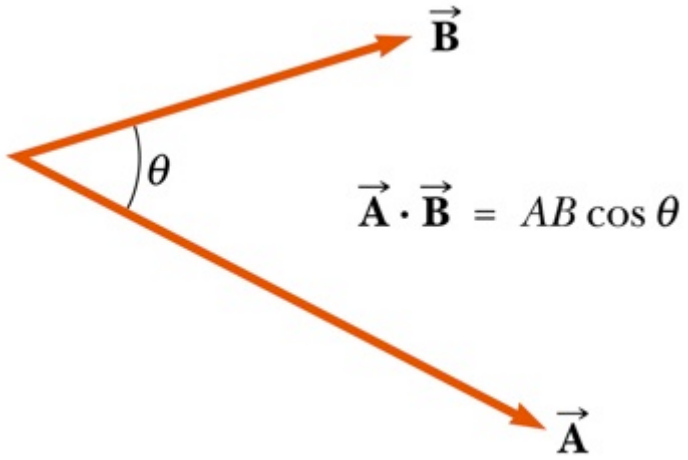


Types of Energy	Types of Money
• Kinetic Energy	• Cash
• Potential Energy	• Money in bank account
• Work	• A paycheck or bill

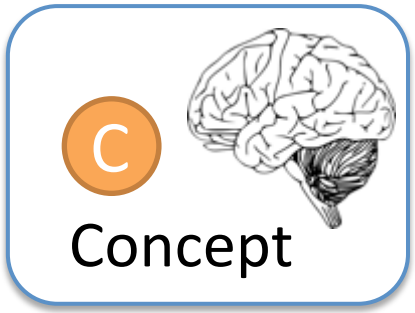
Math review:
Scalar product of two vectors

- Two vectors in any direction
- Find component of $\vec{A}$ in the direction of $\vec{B}$ and multiply by $|B|$.
- Tells you a measure of how much two vectors lie along the same axis pointing

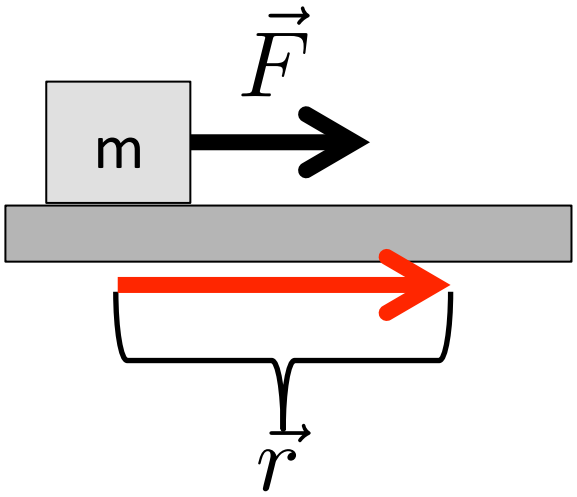
  in the same direction
- Input: Two vector
- Output: One scalar



Work by a constant force

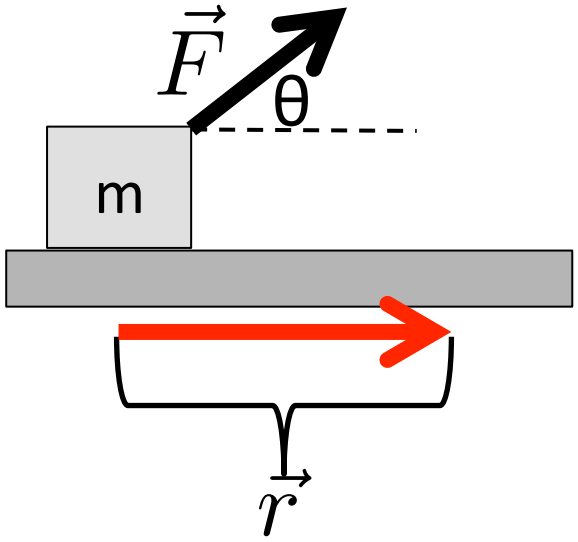


Force in direction of displacement:



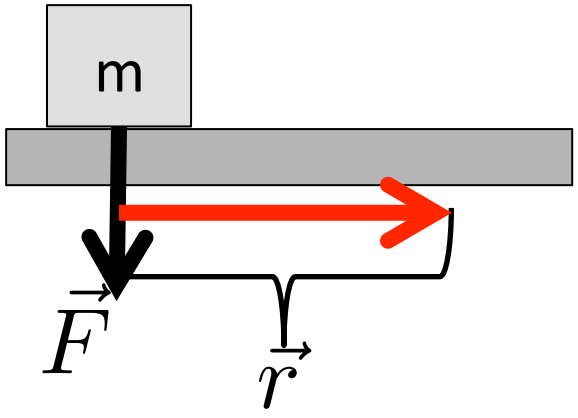
$$W = \vec{F} \cdot \vec{r}$$
$$W = |F| \cdot |r|$$

Force at an angle:



$$W = \vec{F} \cdot \vec{r}$$
$$W = |F| \cdot |r| \cos\theta$$

Force perpendicular to displacement:



$$W = \vec{F} \cdot \vec{r}$$
$$W = 0$$

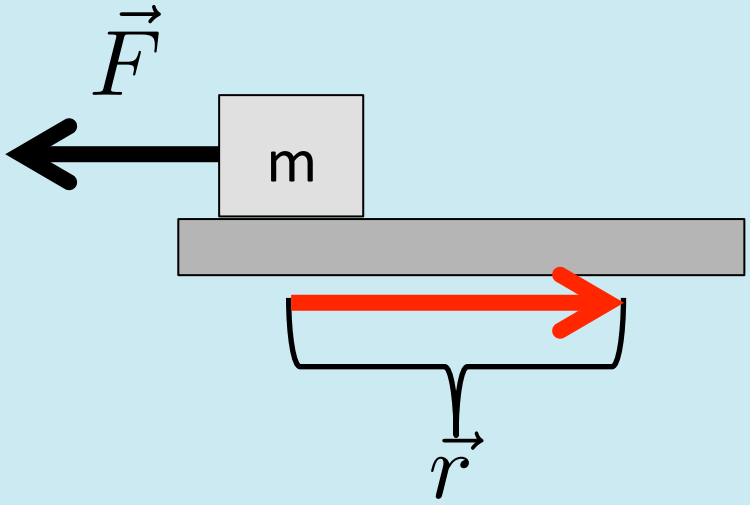
Clicker Question 8-1

- What is the work done by the force?

A) Zero

B) $W = |F| \cdot |r|$

C) $W = -|F| \cdot |r|$



Clicker Question 8-2

A box is being pushed horizontally by a force F and there is kinetic friction. What is the sign of the work done by the normal force on the box?

A) Zero

B) Positive

C) Negative

Clicker Question 8-3

A box is being pushed horizontally by a force F and there is kinetic friction. What is the sign of the work done by the friction force on the box?

A) Zero

B) Positive

C) Negative

Clicker Question 8-4

A box is being pushed by a force F which is not able to overcome the force of static friction. What is the sign of the work done by the force F on the box?

A) Zero

B) Positive

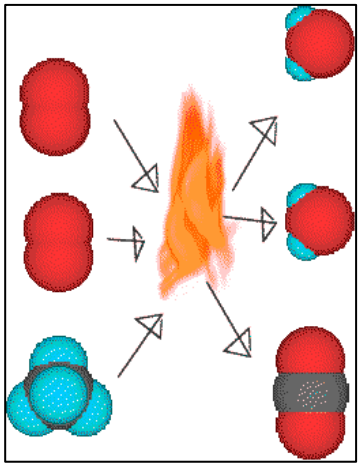
C) Negative

Types of energy

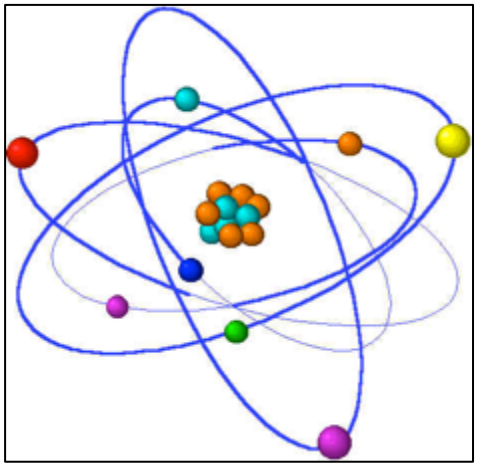
Heat

Mechanical

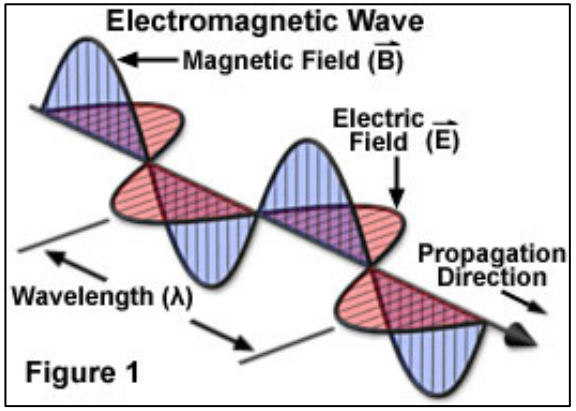
Chemical



Atomic or Nuclear



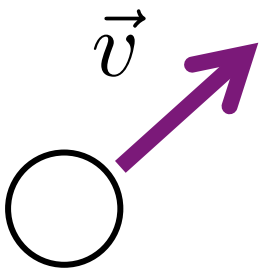
Electromagnetic



Kinetic and Potential Energy

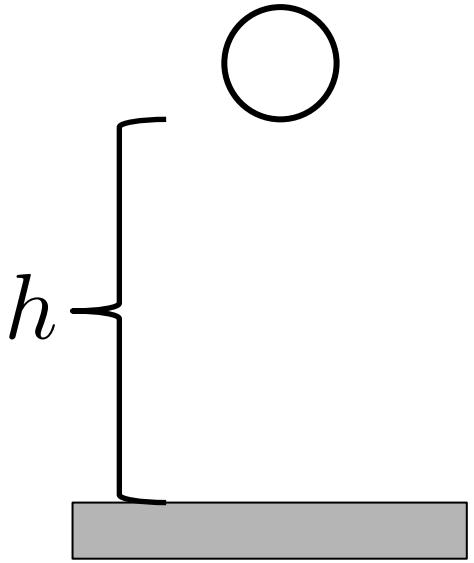
Translational Kinetic Energy

$$KE = \frac{1}{2}mv^2$$



Gravitational Potential Energy

$$PE_g = mgh$$



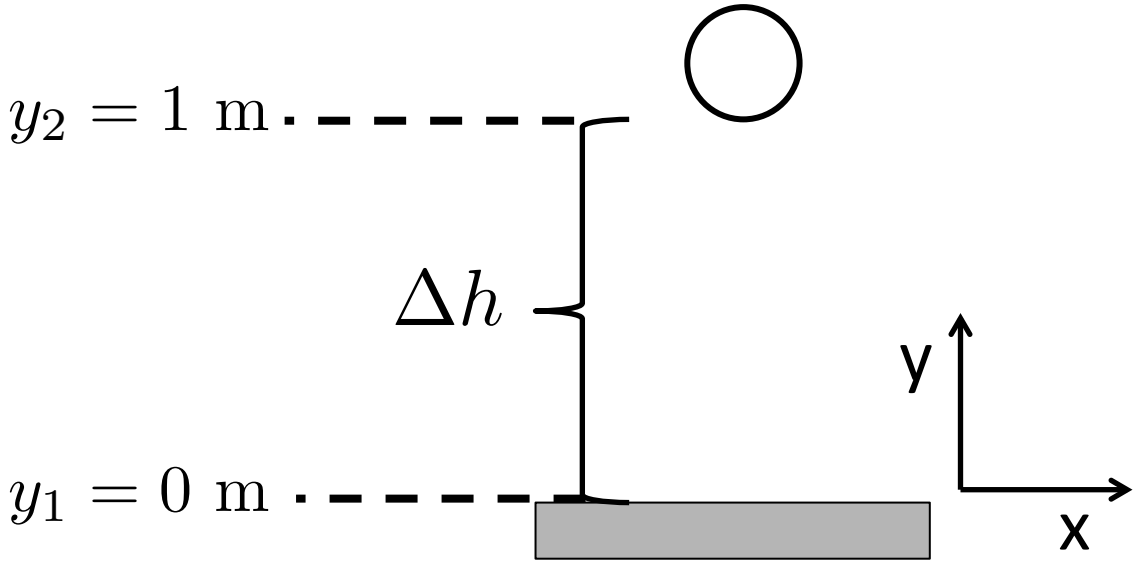
Kinetic and Potential Energy

(shouldn't depend on where you define the origin of your coordinate system)

Change in Gravitational Potential Energy

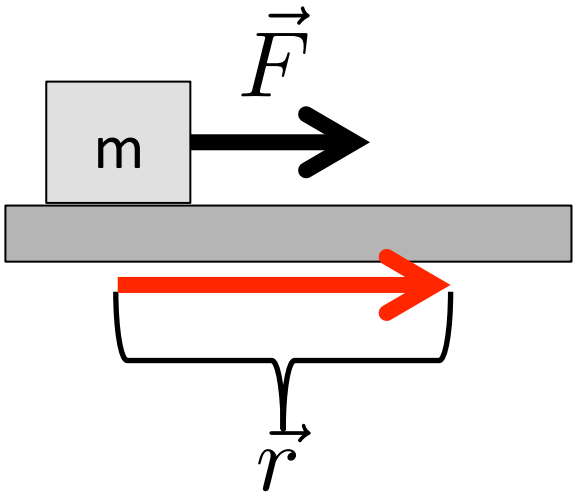
$$\Delta PE_g = mg\Delta h$$

$$\begin{aligned}\Delta h &= y_2 - y_1 \\ &= 1\ \text{m}\end{aligned}$$



Kinetic Energy and Work

$$W = \Delta KE$$



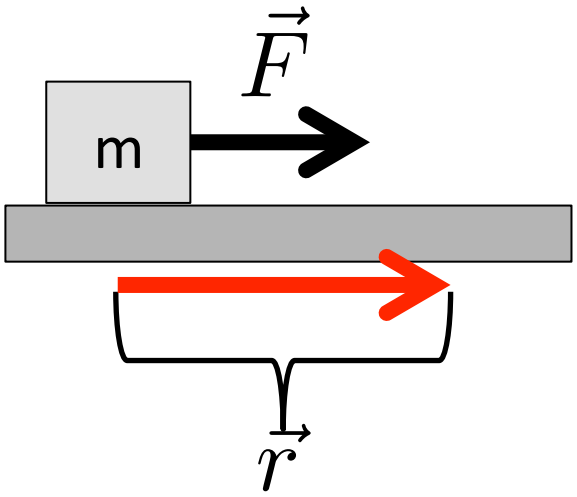
- You push a box of mass *m* from rest a distance *r* across a frictionless floor with a constant force *F*. What is the final velocity of the box?

$$W = Fr$$

$$\Delta KE = \frac{1}{2}mv_f^2 - \cancel{\frac{1}{2}mv_0^2}$$

$$\frac{1}{2}mv_f^2 = Fr \rightarrow \boxed{v_f = \sqrt{\frac{2Fr}{m}}}$$

Kinetic Energy and Work



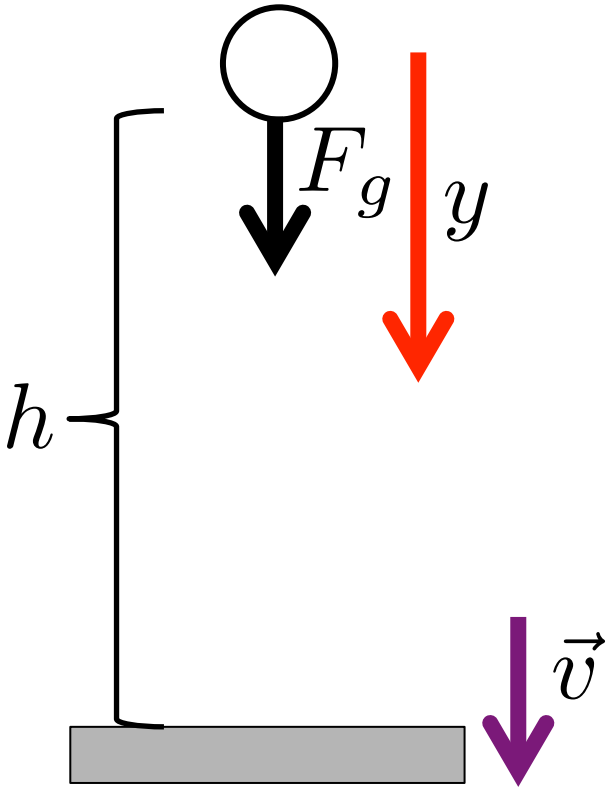
- You push a box of mass *m* from rest a distance *r* across a frictionless floor with a constant force *F*. What is the final velocity of the box?

$$F = ma$$

$$v_f^2 = \cancel{v_0^2} + 2ar$$

$$v_f^2 = \frac{2Fr}{m} \rightarrow \boxed{v_f = \sqrt{\frac{2Fr}{m}}}$$

Potential Energy and Work

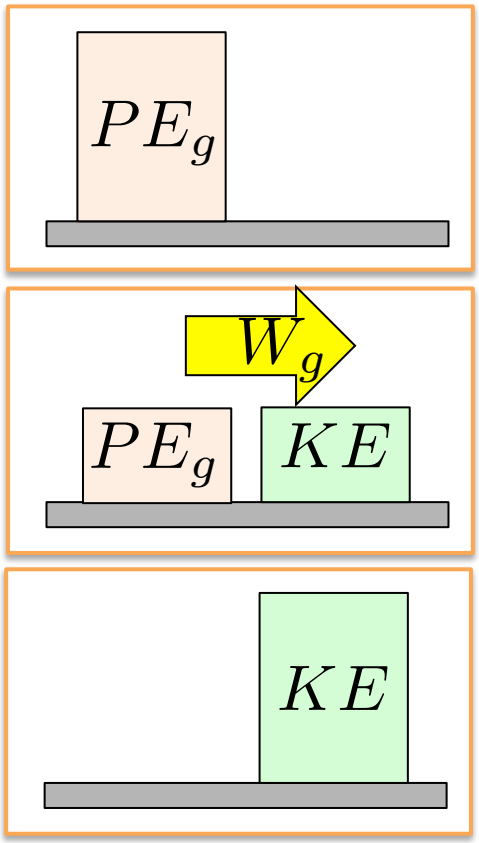


$$PE_g = mgh$$

$$W = -\Delta PE$$

$$W = \Delta KE$$

$$KE = \frac{1}{2}mv^2$$



Conservation of energy

$$E_{tot} = KE + PE$$

$$W = -\Delta PE$$

$$\Delta E_{tot} = \Delta KE + \Delta PE$$

$$W = \Delta KE$$

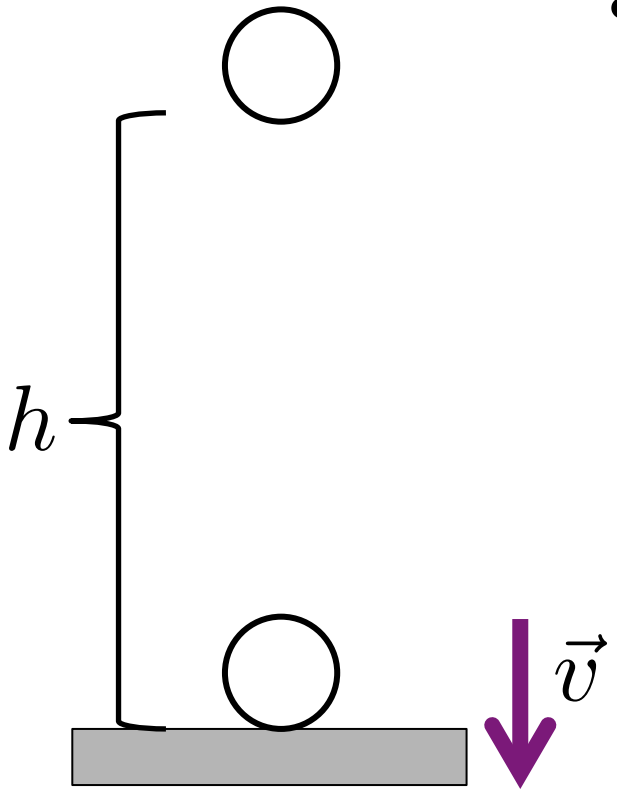
$$\Delta E_{tot} = W - W = 0$$

The total energy does not change over time

$$\Delta KE + \Delta PE = 0$$

Potential Energy and Work

$$\Delta KE + \Delta PE = 0$$

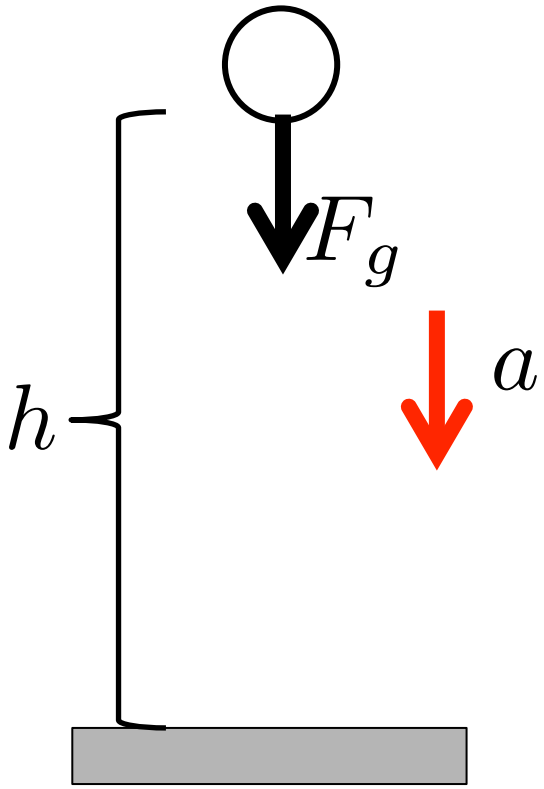


- You drop a ball of mass m from rest at a height of h. What is the velocity it has at the ground?

INITIAL	FINAL
$PE_i = mgh$	$PE_f = 0$
$KE_i = 0$	$KE_f = \frac{1}{2}mv_f^2$

$$\frac{1}{2}mv_f^2 = mgh \longrightarrow \boxed{v_f = \sqrt{2gh}}$$

Potential Energy and Work



- You drop a ball of mass m from rest at a height of h. What is the velocity it has at the ground?

$$F_g = mg = ma$$

$$v_f^2 = \cancel{v_0^2} + 2ah$$

$$v_f^2 = 2gh \longrightarrow \boxed{v_f = \sqrt{2gh}}$$

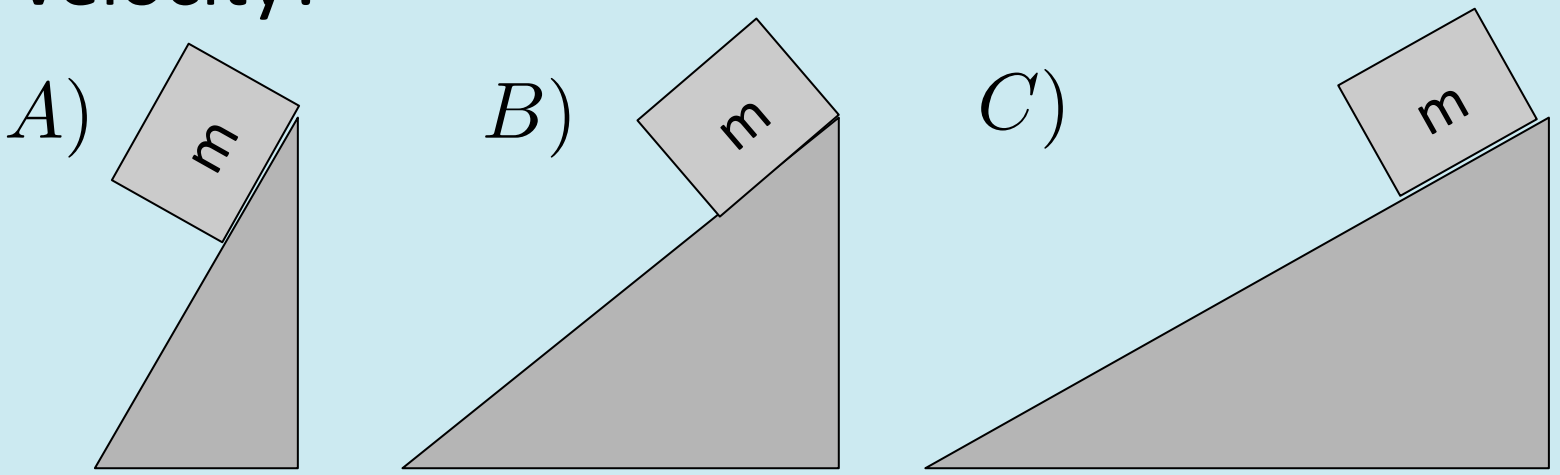
Clicker question 8-7

- Ball A and ball B have the same mass and are given the same initial velocity from the same height, but ball A is shot straight up in the air and ball B is shot horizontally. Which ball will have the larger final velocity when they land on the ground?

A) Ball A
B) Ball B
C) They will have the same final velocity

Clicker question 8-8

- All ramps are frictionless and have the same height. Which box will have the largest final velocity?



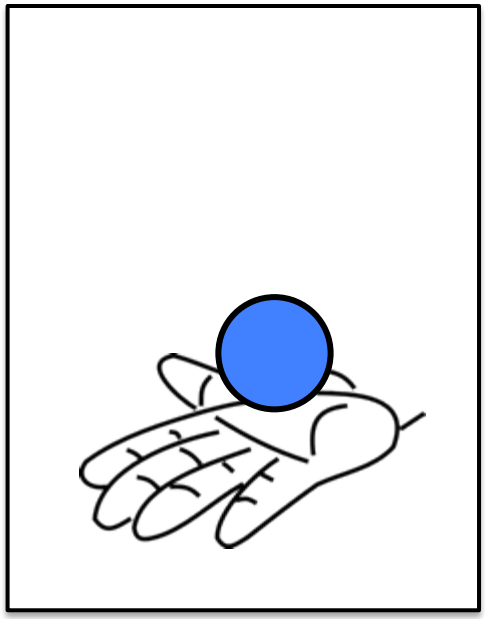
D) They will have the same final velocity

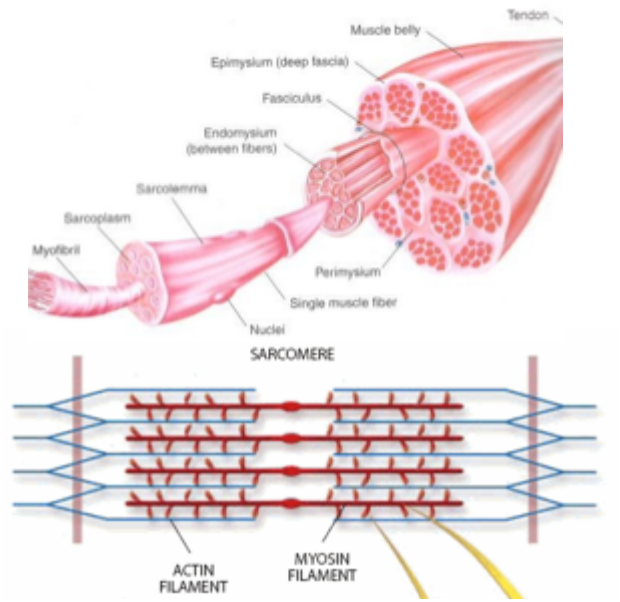
Isolated systems

C Concept

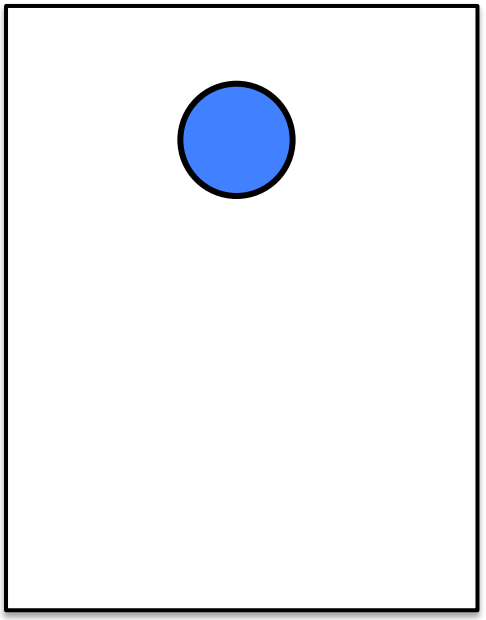
- System where total energy does not change over time (Energy is not added or dissipated away)
- Example:

Not an isolated system





An isolated system

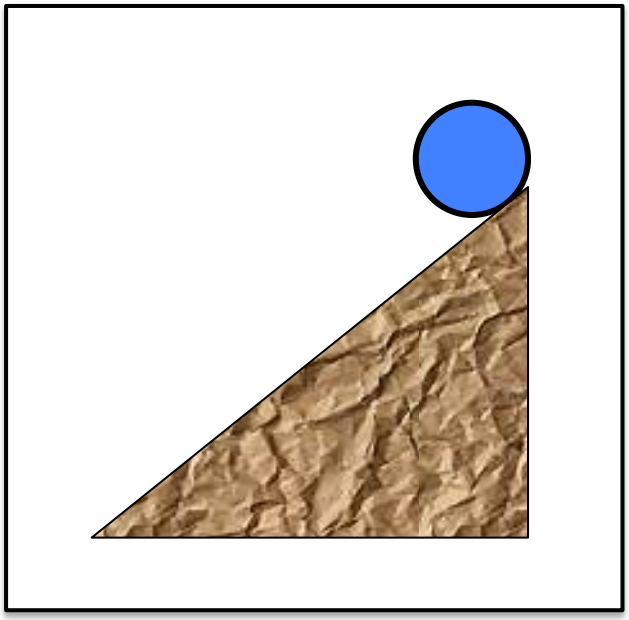


Isolated systems

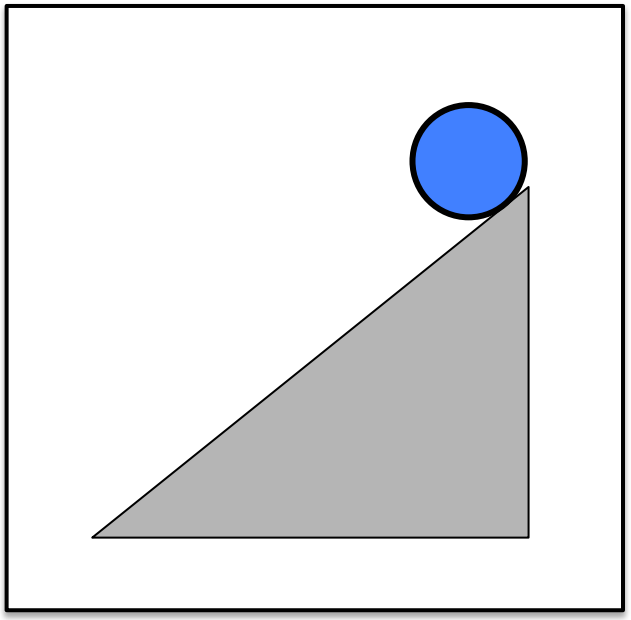
C Concept

- System where total energy does not change over time (Energy is not added or dissipated away)
- Example:

Not an isolated system



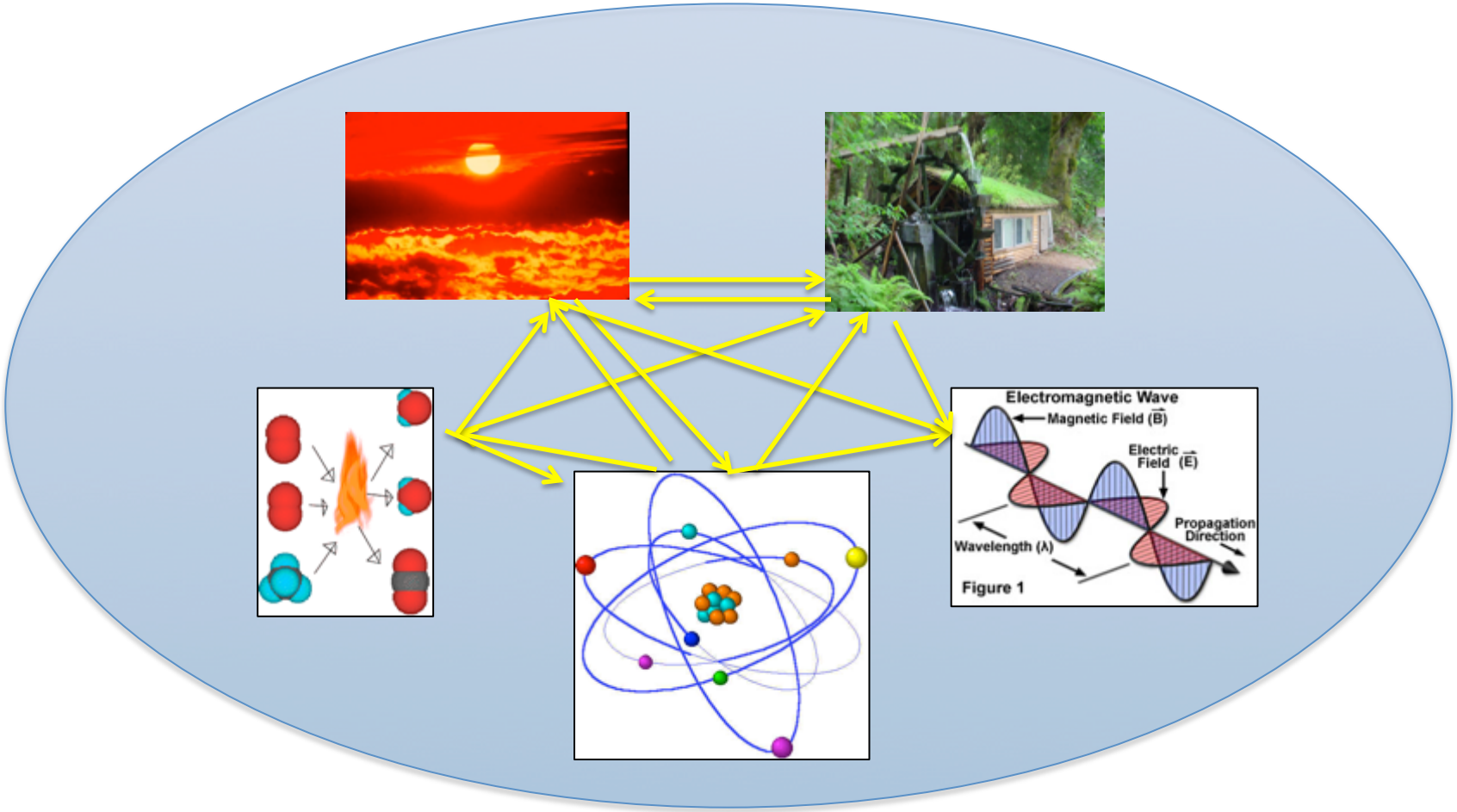
An isolated system



Isolated systems

C Concept

- The universe is an isolated system:



Homework

- HW #4 is posted, due this Wednesday
- Reading quiz tomorrow
- Check if your grades are posted for clickers and reading quizzes