Welcome back to Physics 215

Today's agenda:

- *Energy*
- *Elastic collisions*
- *Work*

Midterm 2

- Thursday, October 24th.
- In class.
- Covers mainly weeks 5-8, though there will be some stuff from weeks 1-4 you need to retain, of course
- Forces through potential energy and power.

Reading for Thursday

- Potential energy
- Reading 8.1-8.5

SG Cart A moving to the right at speed *v* collides with an identical stationary cart (cart B) on a low-friction track. The collision is *elastic* (*i.e.,* there is no loss of kinetic energy of the system).

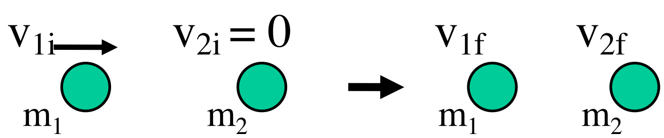
What is each cart's velocity after colliding (considering velocities to the right as positive)?

	Cart A	**Cart B**
1	$-v$	$2v$
2	$-{}^{1}/_{3}\,v$	${}^{4}/_{3}\,v$
3	0	v
4	${}^{1}/_{3}\,v$	${}^{2}/_{3}\,v$

Check conservation of momentum and energy

	Cart A *(m)*	Cart B *(m)*	Final momentum	Final kin. energy
1	- *v*	2 *v*		
2	$-{}^{1}/_{3}\,v$	${}^{4}/_{3}\,v$		
3	0	*v*		
4	${}^{1}/_{3}\,v$	${}^{2}/_{3}\,v$		

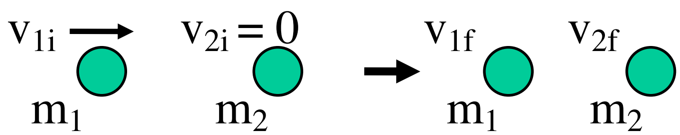
Elastic collision of two masses



Momentum → $m_1v_{1i} + 0 = m_1v_{1f} + m_2v_{2f}$

Energy → $(1/2)m_1v_{1i}^2 + 0 = (1/2)m_1v_{1f}^2 + (1/2)m_2v_{2f}^2$

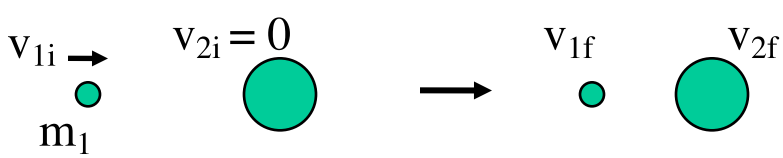
Special cases: (i) $m_1 = m_2$



$$v_{1f} = \frac{m_1 - m_2}{m_1 + m_2} v_{1i}$$

$$v_{2f} = \frac{2m_1}{m_1 + m_2} v_{1i}$$

Special cases: (ii) $m_1 << m_2$



$$v_{1f} = \frac{m_1 - m_2}{m_1 + m_2} v_{1i}$$

$$v_{2f} = \frac{2m_1}{m_1 + m_2} v_{1i}$$

Work, Energy

- Newton’s Laws are ***vector*** equations

- Sometimes easier to relate speed of a particle to how far it moves under a force – a single equation can be used – need to introduce concept of ***work***

What is work?

- Assume ***constant*** force in 1D
- Consider:
- Multiply by m/2 →
- But: F = ma

Work-Kinetic Energy theorem (1)

$$(1/2)mv_F^2 - (1/2)mv_I^2 = Fs$$

Points: $s = \Delta x$ = displacement (for 2D)

- $W = Fs \rightarrow$ defines **work done** on particle
  = force times displacement
- $K = (1/2)mv^2 \rightarrow$ defines **kinetic energy**
  =1/2 mass times square of v

Improved definition of work

- For forces, write $F \rightarrow F_{AB}$
- Thus $W = Fs \rightarrow W_{AB} = F_{AB}\,\Delta s_B$ is **work done by A on B as B undergoes displacement Δs_B**
- Work-kinetic energy theorem:

$$W_{net,B} = \Sigma_A W_{AB} = \Delta K$$

The Work - Kinetic Energy Theorem

$$W_{net} = \Delta K = K_f - K_i$$

The *net work* done on an object is equal to the *change in kinetic energy* of the object.

SG Suppose a tennis ball and a bowling ball are rolling toward you. The tennis ball is moving much faster, but both have the *same momentum (mv),* and you exert the same force to stop each.

Which of the following statements is correct?

A. It takes equal distances to stop each ball.
B. It takes equal time intervals to stop each ball.
C. Both of the above.
D. Neither of the above.

SG Suppose a tennis ball and a bowling ball are rolling toward you. Both have the *same momentum (mv),* and you exert the same force to stop each.

It takes equal time intervals to stop each ball.

The distance taken for the bowling ball to stop is

A. less than.

B. equal to

C. greater than

the distance taken for the tennis ball to stop.

SG Two carts of different mass are accelerated from rest on a low-friction track by the same force for the same time interval.

Cart B has greater mass than cart A ($m_B > m_A$). The final speed of cart A is greater than that of cart B ($v_A > v_B$).

After the force has stopped acting on the carts, the kinetic energy of cart B is

A. less than the kinetic energy of cart A ($K_B < K_A$).

B. equal to the kinetic energy of cart A ($K_B = K_A$).

C. greater than the kinetic energy of cart A ($K_B > K_A$).

D. "Can't tell."

Work and Kinetic Energy in 2D

Work done by object 2 on object 1:

Kinetic energy of an object:

$$K = \tfrac{1}{2} m v^2 \quad \text{[or: } \tfrac{1}{2} m(\vec{v} \bullet \vec{v})\text{]}$$

Scalar (or "dot") product of vectors

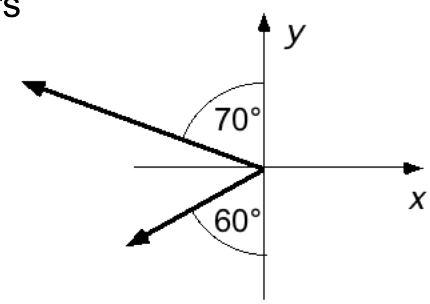
The scalar product is a way to combine two vectors to obtain a number (or *scalar*). It is indicated by a dot (•) between the two vectors.

(Note: component of A in direction n is just A•n)

$$\vec{A} \bullet \vec{B} = AB\cos\theta$$

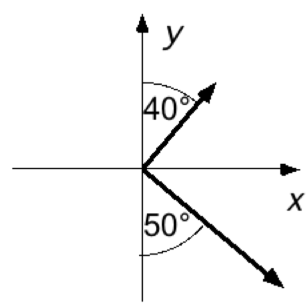
$$= A_x B_x + A_y B_y + A_z B_z$$

SG Is the scalar ("dot") product of the two vectors



A. positive
B. negative
C. equal to zero
D. "Can't tell."

SG Is the scalar ("dot") product of the two vectors

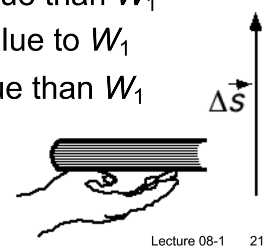


A. positive
B. negative
C. equal to zero
D. "Can't tell."

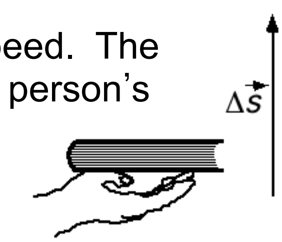
SG A person lifts a book at constant speed. Since the force exerted on the book by the person's hand is in the same direction as the displacement of the book, the work (W_1) done on the book by the person's hand is positive.

The work done on the book by the earth is:

A. negative and equal in absolute value to W_1
B. negative and less in absolute value than W_1
C. positive and equal in absolute value to W_1
D. positive and less in absolute value than W_1



A person lifts a book at constant speed. The work (W_1) done on the book by the person's hand is positive.



Work done on the book by the earth:

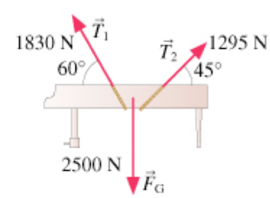
Net work done on the book:

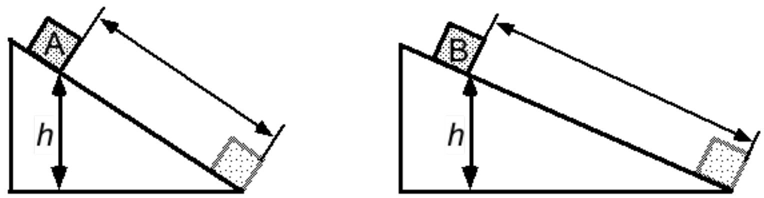
Change in kinetic energy of the book:

SG A person carries a book horizontally at constant speed. The work done on the book by the person's hand is

A. positive
B. negative
C. equal to zero
D. "Can't tell."

Sample problem: The two ropes seen in the figure are used to lower a 255 kg piano 5.1 m from a second-story window to the ground. How much work is done by each of the three forces?





SG Two identical blocks slide down two frictionless ramps. Both blocks start from the same height, but block A is on a steeper incline than block B.

Using the work-kinetic energy theorem, the speed of block A at the bottom of its ramp is

A. less than the speed of block B.
B. equal to the speed of block B.
C. greater than the speed of block B.
D. "Can't tell."

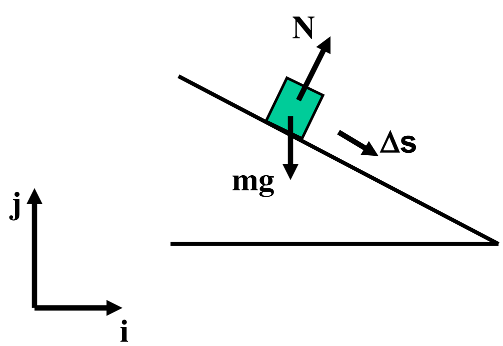
Reading for Thursday

- Potential energy
- Reading 8.1-8.5

Solution

- Which forces do work on block?
- Which, if any, are constant?
- What is **F•Δs** for motion?

Work done by gravity



Work W = -mg j•Δs

Therefore,
W = -mgΔh

N does no work!

Work done on an object by gravity

$$W_{(by\ \text{earth on object})} = -\,m\,g\,\Delta h,$$

where $\Delta h = h_{\text{final}} - h_{\text{initial}}$ is the change in height.

Object moves	Change in height Δh	Work done on object by earth
upward	positive	negative
downward	negative	positive

Defining gravitational potential energy

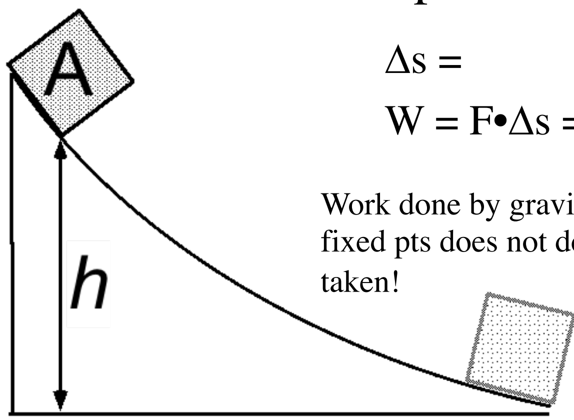
$$W_{(\text{on obj. by earth})} = \Delta K$$

$$0 = \Delta K - W_{(\text{on obj. by earth})}$$

$$0 = \Delta K + \Delta U_{\text{g}}$$

The *change* in gravitational potential energy of the object-earth system is just another name for the negative value of the work done on an object by the earth.

Curved ramp



$\Delta s =$

$W = F \bullet \Delta s =$

Work done by gravity between 2 fixed pts does not depend on path taken!

Work done by gravitational force in moving some object along any path is *independent* of the path depending *only* on the change in vertical height

Demo: 4 tracks