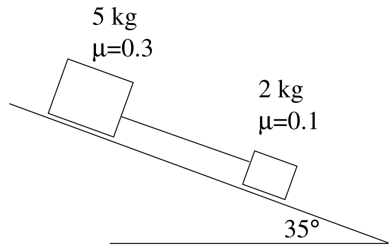
Announcements

1. **Exam 1 occurred…**
   a. Average was pretty high → well done!
   b. You will get the exam back by Thurs 5 pm
      i. Pick up your exams in boxes by N357 ESC (between the two tutorial labs)
      ii. They will be distributed according to first two numbers of CID
   c. Solutions will be posted in glass case near room N361, ESC
   d. Last problem typo—if you worked the problem by converting the mph to m/s and think you deserve credit, bring your exam to me.
2. **Reminder**: Newton's 2nd Law Problems
   a. inclined planes
   b. pulleys
   c. ropes
   d. friction
   e. etc.

   → Remember: N2 is a <u>blueprint</u> for finding a useful equation; it's not really the equation itself.

Review Problem



a = ?

What is tension in rope?

Work

Demo: Equal pay for equal work

Who did the most work?
a) the one who lifted the weight to the table
b) the one who moved the weight to the far end
c) same work done.

<u>Definition of work in physics</u>:

$$W = F_{//} \Delta x$$ (not a vector!)

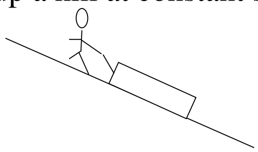
The work done by a force on an object is the component of the force along the direction of motion, times the magnitude of the object's displacement.
(assumes $F_{//}$ is constant…otherwise need calculus)

SI Units: 1 N × 1 meter = 1 Joule

Positive vs. Negative

- positive if force is in line with motion
  → adds energy to system
- negative if force is opposite the motion
  → removes energy from system
- zero if force is perpendicular to the path
  → leaves energy unchanged

A girl pulls a sled up a hill at constant speed.



For the following forces, decide if the work is …

a. positive
b. negative
c. zero

The girl's force on the sled?

Q4. Friction?

Q5. The force of gravity on the sled?

Q6. The sled's force on the girl?

Q7. The normal force on the sled?

Why use work/energy?
→ Energy is easier!

Some problems that are hard using Newton's 2nd law can be worked **easily** with energy ideas, if you don't need to know _______!

Kinetic energy

Definition: An object's ability to do work that is inherent in its motion.

$$KE = ½\, m\, v^2$$

"Work-Energy theorem"

$$E_{before} + W = E_{after}$$

aka "Law of conservation of energy"

Worked Problem

An object at initial speed v_o is pushed with acceleration a for a distance Δx. Find the final speed.

Method 1: use the kinematic equations

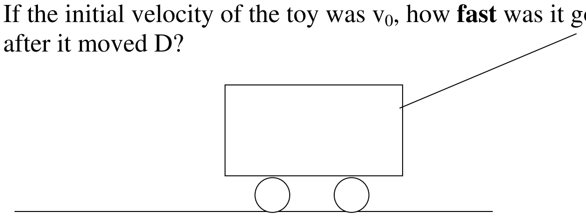
Method 2: use work & energy concepts

If the object sped up, the net work done was ______.
If it slowed down, the net work done was ________.
If its speed didn't change, the net work done was ___.

Worked Problem

A boy pulls his toy **mass m** with a **force P**, at an **angle θ** above the horizontal. He moves the toy a **distance D** along the ground without friction.

If the initial velocity of the toy was v_0, how **fast** was it going after it moved D?



Method 1. Work-energy theorem

Method 2: Newton's laws and kinematic eqns.:
→ have to use if we want to know **time it took**

You pull on a 60 kg load with a force of 80 N at an angle 30 degrees above horizontal. It starts from rest, and after traveling 12 meters, it's going 3 m/s. There is also some work done by friction.

Q8. The net work done on the wagon was
- a. positive
- b. negative
- c. zero

Q9. What work did <u>you</u> do on the wagon? (From *your* force)
- a. 0-100 J
- b. 100-200
- c. 200-300
- d. 300-400
- e. 400+

Q10. What was the net work done by **all** the forces on the wagon? (Hint: from change in KE)
- a. 0-100 J
- b. 100-200
- c. 200-300
- d. 300-400
- e. 400+

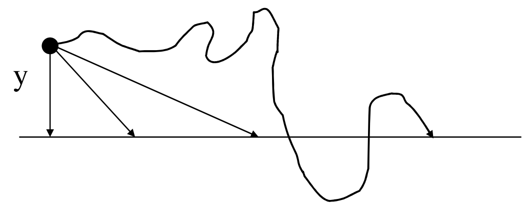
Then what was the work done by friction on the wagon?

Gravitational potential energy

$PE_{gravity}$ *keeps track* of the ____________ done against gravity

Formula: $PE_g = mgy$ (compare: work = force × distance)

Change in PE for the different paths?



Conservative vs. nonconservative forces

Video: 3-12 Energy Well Track.wmv
Video: 3-15 Triple Track.wmv
Video: VE #3-Galileo's pendulum
Demo: duckpin ball pendulum

Work-Energy theorem, revisited

$$E_{before} + W = E_{after}$$

"Law of conservation of energy"

<u>Statement one</u>:

$$KE_{bef} + W = KE_{aft}$$

W must include work done by <u>*all*</u> forces

<u>Statement two</u>:

$$KE_{bef} + PE_{bef} + W = KE_{aft} + PE_{aft}$$

W only includes work by <u>*nonconservative*</u> forces

<u>Both cases</u>: W can be positive or negative

Video: pole vaulter
"…energy cannot be created or destroyed, only changed from one form into another…" [*mostly* true]

From a cliff of height *h* you throw balls straight up, straight down and horizontally, all with the *same initial speed.*

Q11. Ignoring air friction, which ball has the the highest speed just before it hits the ground?

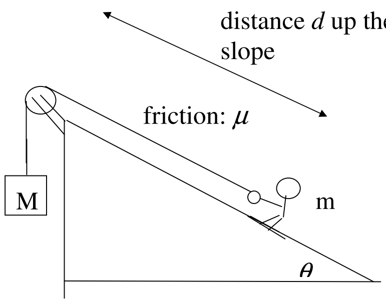
a. thrown straight up
b. thrown straight down
c. thrown horizontally
d. all the same speed

Q12. If you <u>include air friction</u>, then which one has the highest speed just before it hits the ground?

a. thrown straight up
b. thrown straight down
c. thrown horizontally
d. all the same speed

Pulley ski jumping, revisited

Before: what is the acceleration?
New question: what is the speed just at takeoff?

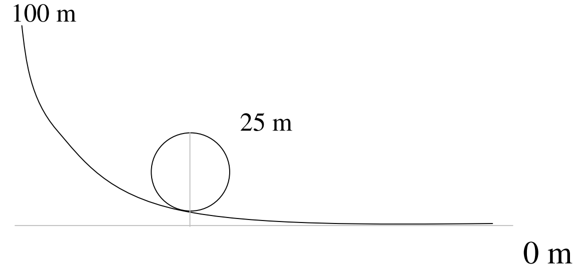


Old way: find *a* (like we did), use kinematic formulas

New way:

Q13. A 500 kg car starts from rest on a track 100 m above the ground. It does a loop-de-loop that is 25 m from the ground at the top. There is no friction. How fast is it going at the *top* of the loop?

a. 0-10 m/s
b. 10-20
c. 30-40
d. 40-50
e. 50+



Depends on mass?

Demo: Hot wheels track

Q14. Did you discuss at least half of the discussion quiz questions today with a neighbor?

a. Yes
b. No