A batter can hit the ball farther in Denver, where the Rockies play, than in San Diego, where the Padres play. Why?

A. The air is less dense in the Mile High City—so there is less air resistance.

B. Denver is farther from the center of the earth than San Diego, so gravity is a bit weaker here.

C. The Rockies are just stronger, faster, and better hitters than the Padres.

D. All of the above.
A batter can hit the ball farther in Denver, where the Rockies play, than in San Diego, where the Padres play. Why?

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Part I: Air

Air has mass. Making it move requires forces. This is a big deal for weather, and for baseball!

Weather and Science Day

The thinner air of mile-high Denver lets a fly ball go a bit farther than in other ballparks, because there is less air drag.
Fog-Filled Weather Balloon

The air inside the balloon has a mass of nearly 400 kg. (Over 800 pounds!) The large mass contrasts with the very small force of the stretchy rubber.

Weather and Science Day

When we pop the balloon, the large mass of air doesn’t go anywhere for a while.
Giant Beach Ball Volleyball

The air inside the beach ball has a mass of 32 kg, more than the 20 kg mass of the plastic ball. Most of the mass of the ball is the mass of the air inside.

Weather and Science Day

Buoyancy means you don’t have to support the air, but you do need to start it and stop it. It “lifts light” but “hits heavy.”
Air Bags

Most of the mass of the air bag is the mass of the air inside!

Moving the air bag around means moving other air out of the way. You can feel this force.
Vortex Launcher

Air from the opening develops a rapid spin which stabilizes the moving ring of air. It’s like a tornado in a circle. The ring will stay together as it moves.

Weather and Science Day

Fog lets you see the ring and the spin.
Rocket Balloons

The balloon pushes down on the air, so the air pushes up on the balloon.

It’s Newton’s 1st Law in action!

Weather and Science Day

The sound the balloons make is due to air pressure effects at the rubber tip.
Baseball Science, Part I: Interactions with the air
If a spinning pitched ball pushes air to the right, the air pushes the ball

A. Up.
B. Down.
C. To the right.
D. To the left.
If a spinning pitched ball pushes air to the right, the air pushes the ball

A. Up.
B. Down.
C. To the right.
D. To the left.
Curve Balls

When the ball pushes on the air, the air pushes back on the ball. This causes the path of the ball to curve.

Weather and Science Day

The styrofoam balls are light—and very rough—so the force is big enough to make the balls curve a great deal.
Drag force

The hexagons on the surface of the lightweight Blitzballs reduce drag (air resistance) so the lightweight balls can fly a great distance.

Weather and Science Day

Thanks to the Blitzball folks for the 200 Blitzballs!
Part II: Energy

Energy can't be created or destroyed, only be transferred from one object to another, or transformed from one form to another.

Weather and Science Day

When a batter hits a ball, energy is transferred from the bat to the ball.
Arrow Copter

As the toy is launched, flies skyward, and then floats down, there are many energy transformations.

1. Stretched rubber band has elastic potential energy.
2. Flying toy has kinetic energy.
3. Toy at highest point has gravitational potential energy.
4. As the toy floats down, energy is slowly converted to thermal energy.
Hot Air Balloons

The heat added to the air in the balloons provides the energy for them to rise into the sky.

As the balloons rise, they cool. If you keep adding heat, the balloons keep rising.
Flash Cotton

Flash cotton burns very rapidly and very completely. The heat from the combustion evaporates moisture on the palm; the palm stays relatively cool.

Weather and Science Day

When liquid goes to the gas phase (evaporation), energy is absorbed. This keeps the hand cool.
Baseball Science, Part II: Energy transfers
Beefy Baseballs

The bat should be heavier than the ball if the ball is to come off of the bat at high speed. If the ball is too heavy, the energy transferred is not enough to get the ball moving quickly.

Weather and Science Day

The three balls weigh 32 ounces, 5 ounces (a regular ball) and 2 ounces.
A batter can put a certain amount of energy into the bat as he swings. If the bat is made heavier, the final speed of the bat will be

A. Greater.
B. The same.
C. Less.
A batter can put a certain amount of energy into the bat as he swings. If the bat is made heavier, the final speed of the bat will be

A. Greater.
B. The same.
C. Less.
Beefy Bats

If the bat is very heavy, the batter can’t get the bat moving fast enough for a good hit.

The heavy bat is filled with sand, and weighs nearly 10 pounds!
Part III: Time

Time is an important part of understanding motion, and in understanding waves.

Weather and Science Day

Times in baseball are at the limits of what human reaction time allows.
Wavelength and Frequency

Shaking the band faster (higher frequency) leads to a wave with a shorter wavelength.

Weather and Science Day

The wave on the bands is called a “standing wave” because it stands in place—it doesn’t go anywhere.
Frequency and Energy

The short wavelengths of ultraviolet have high frequencies, and thus have high energy photons.

The ultraviolet photon energy is high enough to change the colors of the pigments!

Thanks to Tiffany Few's students for the artwork on display today!
Wave Speed

Light waves are a million times faster than sound waves, so you’ll see the flames from the explosion before you hear the boom.

Weather and Science Day

Thanks to the CSU Chem Club for setting up and running this demonstration.
Baseball Science, Part III: Time
How much time does it take a baseball to get from the pitcher to the plate?

A. About two seconds.
B. About a second and a half.
C. About one second.
D. About half a second.
How much time does it take a baseball to get from the pitcher to the plate?

A. About two seconds.
B. About a second and a half.
C. About one second.
D. About half a second.
Waves In The Earth

When everyone jumps, we set up a wave that travels through the ground. The display shows the wave reaching each geophone in turn, showing the speed of the wave!

Weather and Science Day

A lot of people jumping means a big wave.
A Team Effort.

Thanks to the Rockies, Colorado State & 9News for making this event possible.

Weather and Science Day

Weather and Science Day 2014
Bigger!

The Little Shop of Physics team likes to go big.

Weather and Science Day

The inside of the giant vortex cannon.
Thanks!

Thanks to the schools who joined us at the ballpark today.

Weather and Science Day

See you in 2016!