‘What if? Serious Scientific Answers to Absurd Hypothetical Questions’
- by Randall Munroe

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WEIGHTLESS ARROW

Q. Assuming a zero-gravity environment with an atmosphere identical to Earth’s, how long would it take the friction of air to stop an arrow fired from a bow? Would it eventually come to a standstill and hover in midair?
A. IT’S HAPPENED TO ALL of us. You’re in the belly of a vast space station and you’re trying to shoot someone with a bow and arrow.

Compared to a normal physics problem, this scenario is backward. Usually, you consider gravity and neglect air resistance, not the other way around.[1]

As you’d expect, air resistance would slow down an arrow, and eventually it would stop . . . after flying very, very far. Fortunately, for most of that flight, it wouldn’t be much of a danger to anyone.

Let’s go over what would happen in more detail.

Say you fire the arrow at 85 meters per second. That’s about twice the speed of a major-league fastball, and a little below the 100 m/s speed of arrows from high-end compound bows.
The arrow would slow down quickly. Air resistance is proportional to speed squared, which means that when it’s going fast, the arrow would experience a lot of drag.

After ten seconds of flight, the arrow would have traveled 400 meters, and its speed would have dropped from 85 m/s to 25 m/s; 25 m/s is about how fast a normal person could throw an arrow.

At that speed, the arrow would be a lot less dangerous.

We know from hunters that small differences in arrow speed make big differences in the size of the animal it can kill. A 25-gram arrow moving at 100 m/s could be used to hunt elk and black bears. At 70 m/s, it might be too slow to kill a deer. Or, in our
case, a space deer.

Once the arrow leaves that range, it’s no longer particularly dangerous . . . but it’s not even close to stopping.

After five minutes, the arrow would have flown about a mile, and it would have slowed to roughly walking speed. At that speed, it would experience very little drag; it would just cruise along, slowing down very gradually.

At this point, it would have gone much farther than any Earth arrow can go. High-end bows can shoot an arrow a distance of a couple hundred meters over flat ground, but the world record for a hand bow-and-arrow shot is just over a kilometer.
This record was set in 1987 by archer Don Brown. Brown set his record by firing slender metal rods from a terrifying contraption that only vaguely resembled a traditional bow.

**AND TO YOU, LEGOLAS, I GIVE THE BOW OF DON BROWN.**
**WE'VE BEEN TOO NERVOUS TO TRY FIRING IT.**

As the minutes stretch into hours and the arrow slows down more and more, the airflow changes.

Air has very little viscosity. That is, it’s not gooey. That means things flying through the air experience drag because of the momentum of the air they’re shoving out of the way—not from cohesion between the air molecules. It’s more like pushing your hand
through a bathtub full of water than a bathtub full of honey.

After a few hours, the arrow would be moving so slowly that it would be barely visible. At this point, assuming the air is relatively still, the air would start acting like honey instead of water. And the arrow would, very gradually, come to a stop.

The exact range would depend heavily on the precise design of the arrow. Small differences in an arrow’s shape can dramatically change the nature of the airflow over it at low speeds. But at minimum, it would probably fly several kilometers, and could conceivably go as far as 5 or 10.

Here’s the problem: Currently, the only sustained
zero-g environment with an Earth-like atmosphere is the International Space Station. And the largest ISS module, Kibo, is only 10 meters long.

This means that if you actually performed this experiment, the arrow would fly no more than 10 meters. Then, it would either come to a stop . . . or really ruin someone’s day.

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1 Also, you don’t usually shoot astronauts with a bow and arrow—at least not for an undergraduate degree.