The Physics of Flying: G-Forces

Physics Camp at Home Activity

This activity is designed for older campers to work through themselves, or parents to work through with younger campers. It explores the concepts of g-force and drag.

How to Muggles fly? What do they need to do to prepare?

How do wizards fly? What do they need to do to prepare?

What is a g-force?
A g-force is the normal acceleration due to gravity. This is what gives objects weight. (Even though we call it a force, technically a g-force is an acceleration, not actually a force! Newton's second law says that force is measured as mass *times* acceleration.)

What is the value for the g-force on earth? (What is the acceleration due to gravity?)
9.81 meters per second squared. You may have heard this number in your physics studies! We refer to 9.81 meters per second squared as "1g." If you're accelerating up or down during an activity or moving in a vehicle, you will feel more or less than 1g.

Is the g-force the same on other planets?
No! The g-force is determined by how much gravity a planet has, so smaller planets have smaller g-forces than Earth and larger planets have larger g-forces. This is why you would fall more slowly on smaller planets and more quickly on larger planets.

A g-force is just the force an object feels due to acceleration. We usually feel a regular g-force of 1g on Earth, but what other activities could you do in the real world where you might feel more or less g's than normal?

What activities could you do in the Wizarding world where you might feel more or less g's than normal?

Activity: Calculate the g-force on Harry during quidditch

In this activity, we will calculate the g-force that Harry feels on his broom during a quidditch match. We provide some sample calculations, but you can watch the clip on your own and come up with your own measurements!

1) Determine how fast Harry flies on a broom.

Since g-force is an acceleration, and acceleration is speed over time, we need to figure out how fast Harry is going on his broom, and how long it takes him to get up to that speed.

Watch this clip from *Harry Potter and the Chamber of Secrets.* You can watch the whole clip first; then follow along with the time stamps to do physics! (The sound kicks in at about 7 seconds.)

From about 0:26 to 0:28, Harry flies half the length of the entire quidditch pitch. If an entire quidditch pitch is 152 meters, how quickly is Harry going if he moves 152 meters in about 2 seconds?

$$\frac{152\ meters\ for\ a\ whole\ pitch}{2} = 76\ meters\ in\ half\ a\ pitch$$

$$\frac{76\ meters}{2\ seconds} = 38\ meters/second$$

2) Determine how long it takes Harry to get up to that speed.

Harry's Nimbus 2000 is capable of accelerating very quickly! From about 0:12 to 0:14, Harry goes from 0 meters/second (being still in the air) to moving at his top speed of 38 meters/second. What is his acceleration?

$$\frac{38\ meters/second}{2\ seconds} = 19\ meters/second^2$$

"meters/second^2" is another way of writing "meters per second squared," which is how we measure acceleration/g's.

3) Calculate the number of g's Harry is feeling.

If 1g is 9.81 meters/second^2 and Harry feels 19 meters/second^2 on his broom, how many g's is he feeling when he accelerates to his top speed?

$$\frac{19\ meters/second^2}{9.81\ meters/second^2} = 1.94\ g's$$

4) Compare Harry's g's to other activities.

Too many g's is unhealthy because it feels like too much force on your body. A high-g roller coaster makes riders feel about 3.5-6 g's. Astronauts coming back from space feel about 7 g's. Humans start to get sick of they feel too many g's for too long—most humans can handle about 5 g's. *With these numbers, does the amount of g-force that Harry experiences feel realistic? Based just on the g-force of acceleration (not on the flying!), could quidditch happen in the real world?*

5) Did we measure properly?

It's possible that when we counted the amount of time it took Harry to fly across the pitch or accelerate from 0 meters/second, we got the time wrong. Go back and look carefully at the clip to see if you would measure differently. *Physicists do multiple trials of their experiments so they can make sure they measured everything correctly*.

Did you get the same numbers, or different ones? If you got different ones, use the math that we showed above to calculate the new g-force on Harry. Is it still realistic?