Frisbee Experiment

Introduction

Tossing a Frisbee with your friends is a great way to have fun in the sun. As you practice your throws and become more accurate, you are learning about the **aerodynamics** of Frisbee flight. You are learning the body mechanics that will make the Frisbee go where you want it to go. This science project will get the thinking part of you into your Frisbee tossing. Who knows, it might even help you get better!

Two key **forces** that act on a Frisbee during its flight are **lift** and **drag.**

Lift is the force that allows a Frisbee to stay in the air, and it opposes the force of **gravity** on the mass of the Frisbee in flight. The Frisbee itself creates this lift force as it flies through the air. As the Frisbee flies along, it deflects some air downward, generating lift.

Drag is a backward force on the Frisbee, and it goes against the Frisbee's movement through the air. The force of drag acts perpendicular to the force of lift. Figure 2 below shows how lift and drag act on a Frisbee.

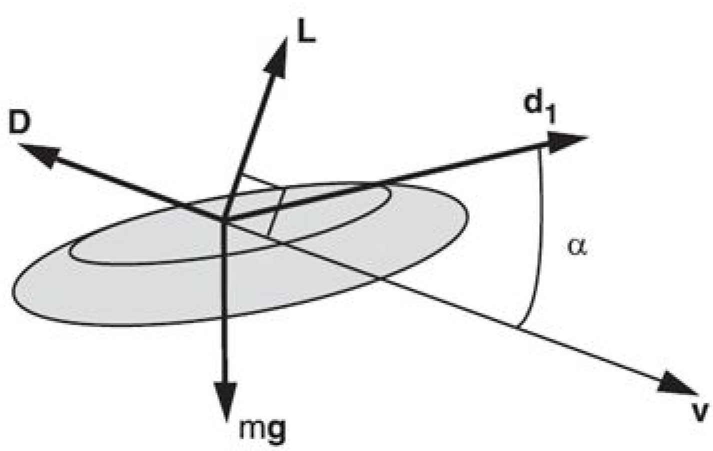

Figure 2. This diagram shows the forces on a Frisbee in flight. The arrow *v* shows the direction of flight (*v* stands for *velocity*). The downward arrow *mg* is the weight of the Frisbee (mass times gravity). The backward arrow, *D*, is the force of drag. The upward arrow *L* is the force of lift. It acts perpendicular to the direction of flight and drag. Both lift and drag change as a function of the angle of attack, α, of the disc, shown here as the difference between the direction of flight (*v*) and the direction the Frisbee is pointing (d_1). (Hubbard and Hummel, 2000)

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Procedure

1. Throw the Frisbee as flat and horizontal as you can. You can have a helper watch to confirm the angle at which you throw the Frisbee.

   How far did the Frisbee travel? Did it travel to the left or right of you?

2. If you have a piece of paper and a pencil or pen, you can record this data and all following flight data.

3. Throw the Frisbee as flat and horizontal as you can at least four more times. Each time throw the Frisbee with similar arm motion and speed, use a similar spin, and have the same release point. How far did the Frisbee travel each time? Did it travel to the left or right of you?

4. Throw the Frisbee tilted up, aiming for between 1 o'clock and 2 o'clock (about a 45 degree angle up from the ground). Throw it this way at least five times. Other than changing the launch angle, try to keep all other aspects of the Frisbee flights the same. How far did the Frisbee travel each time when thrown at an upward angle? Did it travel to the left or right of you?

5. Throw the Frisbee tilted down, aiming for between 4 o'clock and 5 o'clock (about a 45-degree angle down towards the ground), at least five times. Again try to keep all other aspects of the Frisbee flights the same. How far did the Frisbee travel each time when thrown at a downward angle? Did it travel the left or right of you?

6. Did you see a consistent relationship between launch angle and flight direction?

Is there a relationship between launch angle and distance? Why do you think you saw the relationships that you did?

What Happened?

To fly well, the Frisbee needs enough *lift* — which is the force that allows a Frisbee to stay in the air, and opposes the downward force of gravity — and not too much *drag* — which is the backward force on a Frisbee, going against its movement through the air. When a Frisbee is thrown tilted downward, it hits the ground sooner, so it does not have as much time to travel before it lands. As a result, it does not go as far. A Frisbee will go farther if you throw it horizontally or at an upward angle, since it will have a good amount of lift and will not crash into the ground right away. However, you may have noticed that if you throw a Frisbee up at *too* steep of an angle, it will probably stall out near the end of its flight, causing it to land gently and/or off to the side. When something flying through the air *stalls*, there is too much drag and not enough lift. Overall, the horizontal launches probably resulted in the overall "best" Frisbee throws in terms of distance and straightness.

Other tests to explore:

1. In this activity there was not a focus on **the effects of wind** on a Frisbee's trajectory, but wind can definitely be a factor. How will the flight of the Frisbee be affected by throwing the Frisbee into the wind? What about across the wind or with the wind? How does the launch angle change the flight in each of these conditions?

2. You have probably noticed that a Frisbee does not travel far if it is thrown without spin. Spinning the Frisbee helps it fly by supplying **angular momentum**, which helps keep the Frisbee stable while it is rotating. The faster it spins, the more stable it should be. Try throwing your Frisbee without spinning it and see what happens!