Engineered for Air

Grade Level: High School

Student Objectives

- Define aerodynamics and how it impacts everyday life
- Understand the key facets of aerodynamics including downforce, lift and drag
- Conduct experiments to demonstrate key points
- Explore the impact of aerodynamics in racing through two key pieces of a racecar
- Engineer an at-home wind tunnel to test aerodynamic principals
- Conduct experiment and measure downforce due to air

Materials List

- NASCAR Hall of Fame aerodynamics video
- Generations of race car photos
- Engineering Process PDF
- Paper (printer, construction or newspaper)
- Straw
- Scissors
- Invisible tape
- Measuring tape or yard stick
- Worksheet PDF
- Online app (Wind speed, speed gun or speed meter)
- Cardboard boxes (at least three)
- Box fan or vortex fan
- Car (diecast, preferably 1:24 scale)
- Ribbons, embroidery thread or fishing line (light weight)
- Digital scale (if available)
- Duct tape

Lesson Plan and Procedures

1) Explore the definition of aerodynamics as a science term and racing term. Complete vocabulary and definition section of worksheet.
2) Conduct a personal aerodynamics experiment by riding a bike and testing three different ways to go faster.
   - pedaling
   - using gravity
   - using aerodynamics (bending forward over the handlebar and reducing air resistance)
3) Using a wind speed app and/or speed radar, measure wind speed or your speed.
4) Don't have a bike? Ask your parents to take you for a drive in the neighborhood or on the way to the store (in accordance to stay at home regulations for your state.)
   - With the window down, test the impact of air resistance by holding your arm outside.
   - Hold your hand vertically and then horizontally. Which had more air resistance (push/drag)?
   - If you can drive on a highway, ask your parents to drive behind a tractor trailer safely.
   - Change how close and far away you are to the back of the tractor trailer. Do you feel the car shaking? Do you feel the car being pulled along with the tractor trailer?
5) Write down your findings on the worksheet.
6) Explore the engineering process: ask, imagine, plan, create, test and improve. Ask then use the engineering process by making your favorite dinner recipe for your family. Think about each step and the time involved. Ask your family to give you feedback. Complete the worksheet section on family dinner.
7) **Experiment 1**: Using the engineering process, create three different paper airplanes.
   - The airplanes can be different types of paper and different shapes and designs.
   - Test each plane to see which one travels the farthest distance.
   - Record each plane distance.
   - Continue with engineering process to test different variables. (HINT: If you have never made a paper airplane, ask an older relative by going virtual or look online for ideas.)
   - Think about what you discover in your experiment.
8) **Experiment 2**: Using the engineering process, build a drag airplane.

- You will need scissors, tape and a straw. The paper will need to be two different sizes and shaped into loops to attach to the straw. The loops of paper need to be on opposite ends of the straw.
- You will need to think about how you will toss/throw the plane.
- Record the distance the plane travels on the worksheet.
- Improve your design and try again. Try tossing the plane at least three times.
- Think about how the air is moving around the plane. Why is it a drag plane?

9) Examine the images of race cars on the website.
10) Air is a competitor in racing. Locate the splitter and spoilers and answer the questions on the worksheet. The splitter is located on the front of the race car. The spoiler is located on the back or trunk of the car. To see more about the impact of air on a race car, view the NASCAR Hall of Fame video.

NASCAR Background Information

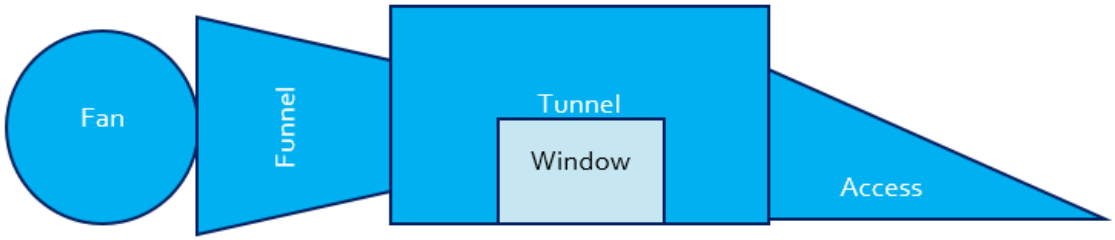
Engineers are always looking for ways to reduce drag and increase downforce on the race car. Race cars are rear-wheel drive. This means they operate like a bike – where the back wheel pushes the bike forward when the chain transfers the energy from your pedaling to the back wheel. In a race car, the engine power is transferred through the drive train to the back axles, which turn the tires and propel the car forward with a pull.

Air resistance works against the car as it travels to push it backwards. Engineers use the engineering process to figure out how to lessen air resistance. Starting in the 50s, race car engineers changed the shape of the car by re-shaping the nose (or front of the car.) In the 60s and 70s – in what was called the aero-wars – teams and manufacturers experimented with designs and parts that would impact air resistance. Then, the spoiler was introduced.

As the years passed, different tactics to reduce air resistance have been introduced such as adjusting the height of the car (how far it sits above the track), adding a splitter, re-shaping of the front end and re-shaping the sides of the car. Even today, air is still shaping every piece and part of the race car. The engineering process is never ending for aerodynamics and racing.
Racing Vocabulary: https://www.nascar.com/news-media/2017/08/01/news-media/twenty-nascar-terms-you-need-to-know/

High School Expansion Activity:

1. Take your experiments up a notch by building your own at-home wind tunnel to test the impact of air on objects, including a race car.
2. View the 'How to Make a Wind Tunnel' video on YouTube.
3. Gather supplies and materials. Using the engineering process, outline your wind tunnel design and building process.
   - The purpose of a wind tunnel is to channel the air from a fan through a narrow box to create a funnel. You will need to connect the narrow box to the fan by using additional cardboard to seal the front of the fan (where the air is) to the narrow box. You may wish to use cereal box cardboard as it is more flexible.
   - Then, connect the funnel to a larger box through an opening that fits exactly or is even narrow. The box the funnel is connected to can be larger.
   - You can create a window to view inside the tunnel on one side of the slightly larger box and then attach clear window plastic tightly to the hole. Ensure you seal the window completely so little air can escape.
   - Create a flap by cutting a square in the back of the box, where you can insert your object and scale through. Do not cut the square on all four sides. Cut on three sides to have a hinge at the top.
   - Idea for a simple design:



4. Build your wind tunnel.
5. Test your tunnel for wind speed using a wind speed app.
6. Identify objects that you can test in the tunnel for impact of air by attaching strings or ribbons to the objects with invisible tape. Start the tunnel and identify how the air is flowing over the object.
7. Add a digital kitchen scale to place your object on inside the tunnel. Zero out the scale with the object on the scale. Turn on the wind tunnel and take readings before and after of the weight of the object. What did you notice?
8. Repeat with different objects, including a race car or vehicle if available. Record your observations.

NASCAR Background Information

Testing aerodynamics is critical in racing. (Example: see YouTube testing video.) Each team is looking for an edge over the others to have the best car, and that can come down to air resistance and its impact on the car. Teams schedule time with a wind tunnel to test their cars. The data and the process are private, since you do not wish to have another team see what you are doing or how you are testing your car. Based on this data, teams will create a final car spec sheet for how the car will be prepared for a racetrack.

There is one aspect that teams cannot control the day of the race – the weather. Air pressure, humidity and overall conditions on race day can throw a wrench into plans. The wind tunnel can give you an idea for what you need to do, but on the day of the race, engineers work with the crew chief to make the final decisions. Even then, air can still overcome all the teams and win.