Tight and Loose

Grade Level: High School

Student Objectives

- Understand how forces impact racing, especially balanced and unbalanced forces
- Understand racing terms as they apply to racing
- Calculate force through applying Newton's second law
- Demonstrate the difference between speed and velocity
- Apply force and motion fundamentals to building a car that runs on rubber band power
- Calculate the comparison of motion to banking angles by building a banking track

Materials List

- NASCAR Hall of Fame aerodynamics video
  - Videos: https://www.youtube.com/watch?v=8Q1tw_QWy-8
    STEM in 30: https://www.youtube.com/watch?v=4Fc6QABHnYA
- Scissors
- Duct or packing tape
- Base/chassis (heavy duty cardboard or plastic corrugated board)
- Wheels (wooden wheels, wheels from toy kits, bottle caps, etc.)
- Axle (straw, paper clips, wire hanger, bamboo skewers, etc.)
- Straw or tube for bushing (to hold the axle to attach to your base/chassis)
- Paper clip
- Rubber bands (various sizes)
- Cardboard (various thickness)
- Tape
- Protractor (digital app) or adjustable square for angles

NASCAR HALL OF FAME CHARLOTTE

- Chair, table or counter for gravity launch
- Pre-purchased track (such as Hot Wheels) can be used

Lesson Plan and Procedures

1. Review knowledge of forces from kindergarten up to current year. Use the workshop to complete definitions you know.
2. Forces and motion are tied together. Balanced and unbalanced forces affect motion and direction. Think about forces being balanced and unbalanced through a quick experiment. Create a see-saw or teeter-totter using a can from the pantry and a ruler. Find objects in your home to balance on either end of the see-saw. Can you get the two ends to balance so each end is suspended in the air? Think about what you need to do to achieve this. Add your responses to the worksheet.
3. Review balanced and unbalanced forces: https://www.youtube.com/watch?v=8Q1tw_QWy-8
4. NASCAR needs to have unbalanced forces to get a race car to move. Watch STEM in 30 (video above) to learn more about the forces acting on a race car. This video was produced at the NASCAR Hall of Fame with the Smithsonian Air and Space Museum: https://www.youtube.com/watch?v=4Fc6QABHnYA
5. Think about other forces acting on a race car that start balanced and become unbalanced. One example is tires. Race car tires are not like car tires. For each race, the tires are different from side to side and differ in diameters. Review the PDF slide about two different tracks and the tire notes for each track. Write why you think the tires may be different on a race car and from track to track on your worksheet. (HINT: Shape and banking of each track is different.)
6. If we know there is more pressure on the driver side of the car – especially the front tire due to the degree of banking change at the track – the car is unbalanced. And if the tire blows, the increased unbalanced forces acting on the car may lead to loss of control by the driver. Which Newton's laws come into play? Write you response on the worksheet.
7. One last factor of unbalanced impact from the tires is tire wear. The heat of the track (caused by the sun and friction) causes a tire to lose its grip, and the car can become too loose. That in turn causes the back of the race car to slide up the track, increasing its unbalance factor. Why is it important to change the tires and have pit stops throughout the race? How can the impact of the sun transitioning from day to night impact the balance of the tires? What can a crew chief change within a tire? Write your answers on your worksheet.

8. Examine the "set-up," or how the car will be designed for the racetrack, then adjusted at the track after inspection before the race to make it race-ready. Like normal cars, race cars need to pass inspection to be approved to race. Unlike normal cars, though, this occurs at each race as the race car can change from track to track to address the forces of each track. After inspections, NASCAR allows teams to place their car in race mode and make the final adjustments (with officials watching) to the suspension of the car. This is where most of the changes will occur during a race. During a pit stop, a driver will notify the crew chief on the balance of the car – or in racing terms, if it's tight or loose.

   NASCAR Definitions:

   - **Loose:** Also known as "oversteer." When the rear tires of the car have trouble sticking in the corners. This causes the car to "fishtail" as the rear end swings outward during turns. A minor amount of this effect can be desirable on certain tracks.
   - **Tight:** Also known as "understeer." A car is said to be tight if the front wheels lose traction before the rear wheels do. A tight race car doesn't seem able to steer sharply enough through the turns. Instead, the front end continues toward the wall**.**
   - **Track bar: Device used to make adjustments.** A lateral bar that keeps the rear tires centered within the body of the car. It connects the frame on one side and the rear axle on the other. Also called the panhard bar.

   Listen to and watch a race to see when the race cars and announcer mention tight and loose **(**or even wiggles**)** in the back end of the race car. Suggested races:

   - Martinsville 2019 **-** https://www.youtube.com/watch?v=BNVTflHopls
   - Daytona 500 2020 - https://www.youtube.com/watch?v=tmfKfEZGxH4

9. Using the following guidelines and worksheet to record your information, build a race car that uses rubber bands to move.
   - Design a car with the following guidelines:
     - Must be propelled by a force that is not human impacted, such as rubber bands.
     - Must be able to travel at least 4 feet.
     - Must be able to complete three trials.
     - Trial 1: Base Line
       - Distance: travel the furthest distance.
       - Calculate force by measuring mass and velocity.

- Trial 2: Variable Change
    - Addition of weight to the car: impact on the car for distance. (The change of mass is in relation to velocity and force.)
    - Calculate velocity – or rate of speed.
- Trial 3: Direction Change
    - Alter layout to get the car to turn left between a 45- and 90-degree angle during travel.
    - Add in a barrier for change of paths i.e. add in a heavier car such as plastic.

- Engineer: 15 minutes to engineer, build and test a car
    - Engineering is critical in NASCAR to achieve the best-performing car. The body, engine, brakes and tires are built by different units and assembled together.
    - Unknown Fact: New engines are not put into new cars to race. Engines need to have miles on them before they reach 'prime time.' Why?
- Test: Run three tests and record results within 10 minutes.
    - Run test to see results and change the variables within the guidelines.
    - Run trials and record results.
    - Of the top five cars, race in one final heat.
- Analyze: Review and analyze your results.
    - After a race, each component is reviewed and analyzed for performance in order to make changes to improve performance.
    - How did you use balanced and unbalanced forces?

10. Review your notes on unbalanced and balanced forces. Send your worksheet to education@nascarhall.com.

Extension

1. Challenge – Create a track for your race car. Keep factors to consider for unbalanced forces, NASCAR races on tracks that are banked. Each turn at a track can be at different angles. The greatest angle that NASCAR races at is at Talladega Speedway in Alabama – which is 33 degrees. Tracks have what is call progressive backing that the high angle is at the top near the wall and lower degree of banking is at the bottom of the raceway.
2. Look at a few examples of different track banking:
    - Daytona International Speedway: https://www.daytonainternationalspeedway.com/About-Us/Track-Facts.aspx
    - Texas Motor Speedway: https://www.texasmotorspeedway.com/about/track-facts/
    - Atlanta Motor Speedway: https://www.atlantamotorspeedway.com/media/track-info/ (click on the fact buttons)
3. Banking creates an unbalanced aspect for the driver and car. But it is the track owner/corporation who determines what the track design will be and what challenges the banking turns will add to the race.
4. Create a progressive bank track for your race car or a die-cast car. You will need to change the angle from the base to the top of the "wall." Your track should have a relatively flat entrance into the turn. The turn needs to measure between 5 and 32 degrees.
5. Using gravity as a power source, launch your car into your track to see what impact the banking has on your car. Did your car make it through the banking degree? If not, why? What force might have impacted the car?
6. Change either your track or the height of your launch point. What was the impact?
7. Calculate velocity of your car.
8. Think or discuss: what were the unbalanced and balanced forces?