Overview

Jeff Gordon is a terrific driver, but he wins races because he and his pit crew know that the key to being the fastest is knowing your physics.

Physics--the branch of science that deals with the physical world-- holds the key to racing moves like the slingshot, which can help Jeff take the lead in the last lap and ultimately capture the checkered flag. It's just one of many examples of how racing and science are connected.

You and your kids can learn all about the scientific principles a driver and their crew must think about during the course of a race by playing the games available here. To get started, print out a copy of the **Racing Science Guide** for each person who wants to play. The Racing Science Guide highlights key information about different scientific principles, as well as how they might help a driver or team win a race. Keep the Racing Science Guide with you for easy reference as you play each game.

If you're ready to start learning about the physics of racing with your kids, challenge them to a game of **Hangman's Race, Design a Better Race Car or Pit Crew Challenge!**

RACING SCIENCE GUIDE

Refer to the diagrams and principles here to play the games included in this guide.

Diagram	Action	Scientific Principle
	increasing speed	**DRAFTING** **Drafting** is a technique where two objects remain very close to one another. This reduces the effect of drag or aerodynamic resistance by using the lead object's slipstream or low pressure wake. **How does drafting help a race car driver improve his or her speed**? When two cars remain bumper to bumper they can both travel 3 to 5 mph faster than if they were alone. The low pressure behind the lead car reduces the aerodynamic resistance on the front of the trailing car while the trailing car pushes high-pressure forward so less fast-moving air hits the lead cars rear spoiler. ***Both cars have less drag and both cars go faster.***
	gaining grip on the racetrack	**DOWNFORCE** **Downforce** is a force produced by air resistance and the weight of a vehicle (gravity), pressing it down and increasing stability. **Why does a driver care about the effects of downforce on their tires?** Millions of air molecules hit a race car. A pit crew can control the position of a car's front splitter and rear spoiler directing those air molecules to create areas of high and low pressure. ***That downforce pushes the tires down into the track giving the tire more grip on the track*** and thereby giving the car more stability.

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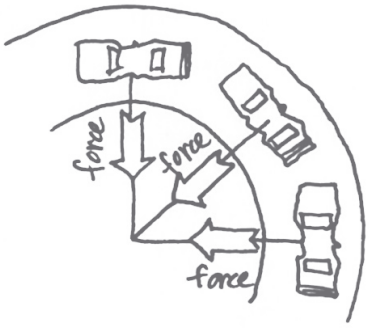
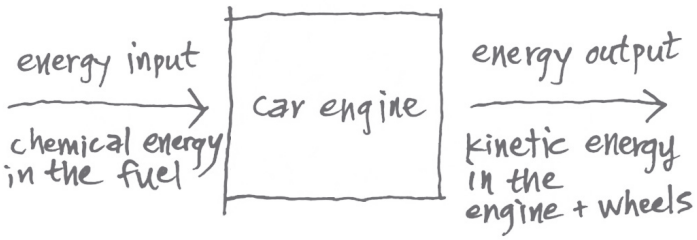
Diagram	Offensive Action	Scientific Principle
	turning on a racetrack	**CENTRIPETAL FORCE** **Centripetal Force** is a force or combination of forces causing an object to move on a circular or curved path. **How does centripetal force help a race car corner at high speed?** If a race car comes down a straightaway and heads into a turn at 180 mph, it will take 10,000 pounds of centripetal force to make the car turn. The creation of this ***centripetal force relies on the friction from the tires, track and air exerting a force at the center of the turn***. The greater the speed of the car in the turn, the greater the force you will need.
	powering an engine	**KINETIC ENERGY** **Kinetic Energy** is the energy of motion. Engines convert the chemical energy stored in fuel into kinetic energy. **How is kinetic energy created in a race car?** ***Energy cannot be created or destroyed, but it can be converted***. In a race car, the energy starts out as potential energy, the energy stored in the fuel. When fuel is mixed with air to create combustion (heat), the ***potential energy is converted to thermal energy*** (via combustion). The heat operates the pistons which are connected to the drive shaft which make the rear wheels move. This converts ***thermal energy into kinetic energy***, the energy of motion. It would take the engines of approximately six regular cars to equal the horsepower in one race car.

RACING SCIENCE GUIDE

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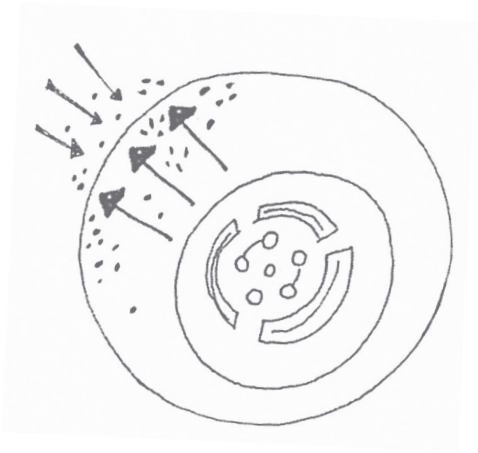
Diagram	Defensive Action	Scientific Principle



gaining grip on the racetrack

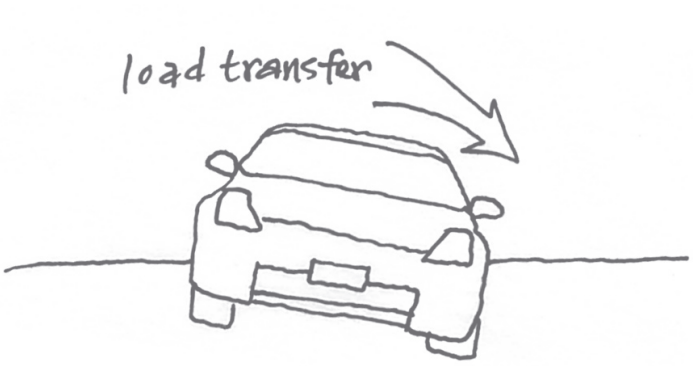
TIRE PRESSURE

The **Tire Pressure** on a race car, during a race, can increase due to the friction of a tire on a track and the heat that is generated. During a race, tires can reach temperatures of 250 to 325 degrees fahrenheit.

Can a crew chief do anything, during a race, to control the tire pressure of a race car?

The friction of a tire on a track causes the tires to heat up. This causes the air molecules inside the tire to move faster. As the molecules move with more force, they create more pressure. This is called "the build". Since crew chiefs want to control how much pressure builds and when it builds, ***pit crews fill tires with nitrogen instead of air***. Nitrogen is a drier gas and gives the race team more control over the pressure build.

gaining grip on the racetrack



LOAD TRANSFER

Load Transfer is a change, that can be measured, showing the different loads carried by each wheel during acceleration, braking and deceleration.

Does load transfer have an impact on how a race car handles?

Load transfer can cause the traction of all four wheels to vary when a car accelerates, turns or brakes. When a race car is going through a turn, a turn has three parts; entry, middle and exit. As a driver accelerates, turns or brakes, causing the load on each wheel to transfer; from front to rear and left to right, ***the car's grip can change in each part of the turn***. It challenges a crew chief to minimize weight shift around turns.

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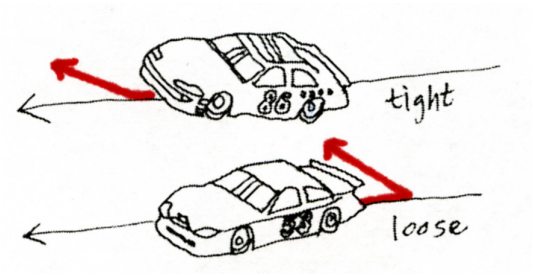


gaining grip on the racetrack

BALANCE

Balance in a race car allows a driver to push the car to the limit.

What does a crew chief juggle to keep a car balanced during a race?

Items that impact balance are; ***a car's weight pushing into the track, degredation of tires, the burning of fuel, weight distribution, and tire loads***. An unbalanced car can get tight (issues in the front end), or too loose (issues in the rear end).

increasing speed

family car engine	race car engine
250 hp	850 hp
2,500 rpm	9,500 rpm
more friction	less friction

RACE ENGINE

Race engines use hydrocarbon molecules for food. This allows for fuel to be used at maximum efficiency.

What are the differences between a production engine (family car) and a race engine.

The faster an engine converts energy from fuel into motion, through combustion, the more horsepower an engine has. ***The average family car has approximately 250 hp, while a race engine has 850 hp***. Another difference is how fast the engine spins. A family car may average 2,500 rpm, while a race engine is closer to 9,500 rpm. There is also less friction in a race engine than a family car's engine. All these differences allow a race car engine to be more efficient at getting the energy created during combustion to the wheels.

GAME #1: HANGMAN'S RACE

MATERIALS

Two sheets of paper containing four cards each, eight different cards in total (provided in PDF). Each card contains a clue and the exact number of blank spaces needed to supply the correct answer. One sheet of paper with a car diagram (also used in the Design a Better Race Car game). Each player will also need blank sheets of paper and pens or pencils for drawing and keeping score.

SET UP

Cut out the eight individual cards from the two sheets provided. Then, divide the cards evenly between the players, making sure you hide the answers which are displayed on the back of each card. Display the diagram of the race car where all players can see it. Give each player a blank sheet of paper and a pen or pencil.

TO PLAY

Each player takes a turn placing one card on the table, revealing a clue and the blank spaces that indicate how many letters are in the correct answer. This player is the monitor for this round and does not guess the letters in the word. Before the player places the card on the table, they should look at the answer on the back of the card. Now they can monitor the guesses from the other players.

The other players read the clue and moving left to right, take turns guessing a letter that would appear in the answer. If they guess a correct letter, the monitor writes the letter on the appropriate blank space on the card and the player is awarded a point for a correct guess. If the guess is incorrect, the player draws one of the six parts of the car on their own piece of paper.

A player who guesses six letters incorrectly (drawing all six car parts on their own paper) is eliminated from the game. Play continues until all players have placed their cards (with clues) on the table and all guessing is complete. The player with the most points for correct letter guesses is the winner.

During play, players should refrain from looking at the Racing Science Guide, but if players are challenged by the clue, they can reference it for help.

HANGMAN'S RACE CARDS #1 FRONT

Allows both cars to have less drag and to go faster

Pushes the tires down into the track, giving the car more grip on the track

Relies on the friction from the tires, track and air exerting a force at the center of the turn

Converted from thermal energy to give cars their speed

HANGMAN'S RACE CARDS #1 BACK

Downforce

Drafting

Kinetic Energy

Centripetal Force

HANGMAN'S RACE CARDS #2 FRONT

Controlled by pit crews who fill tires with nitrogen instead of air

_ _ _ _
_ _ _ _ _ _ _ _

Allows the car's grip to change in each part of the turn

_ _ _ _
_ _ _ _ _ _ _ _

Includes a car's weight pushing into the track, degradation of tires, the burning of fuel, weight distribution, and tire loads

_ _ _ _ _ _ _

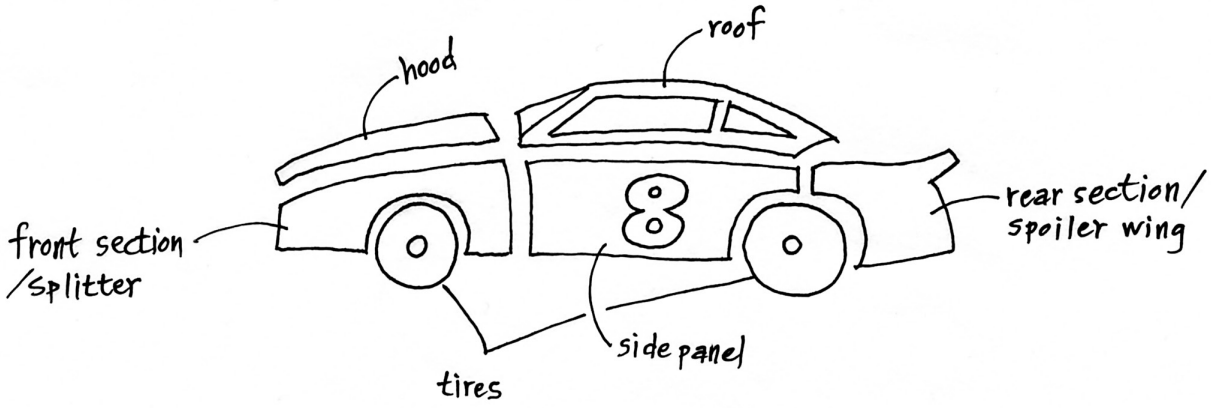
Runs on 850 hp, compared to the 250 hp of the average family car

_ _ _ _
_ _ _ _ _ _

HANGMAN'S RACE CARDS #2 BACK

Tire Pressure	Load Transfer
Race engine	Balance

HANGMAN'S CAR DIAGRAM



GAME #2: DESIGN A BETTER RACE CAR

MATERIALS

Diagram of a race car with leader lines that point out six separate parts of the car. Jeff Gordon videos featured on the "STEM in Sports" website. Each player will also need blank sheets of paper and pens or pencils for drawing and making notes.

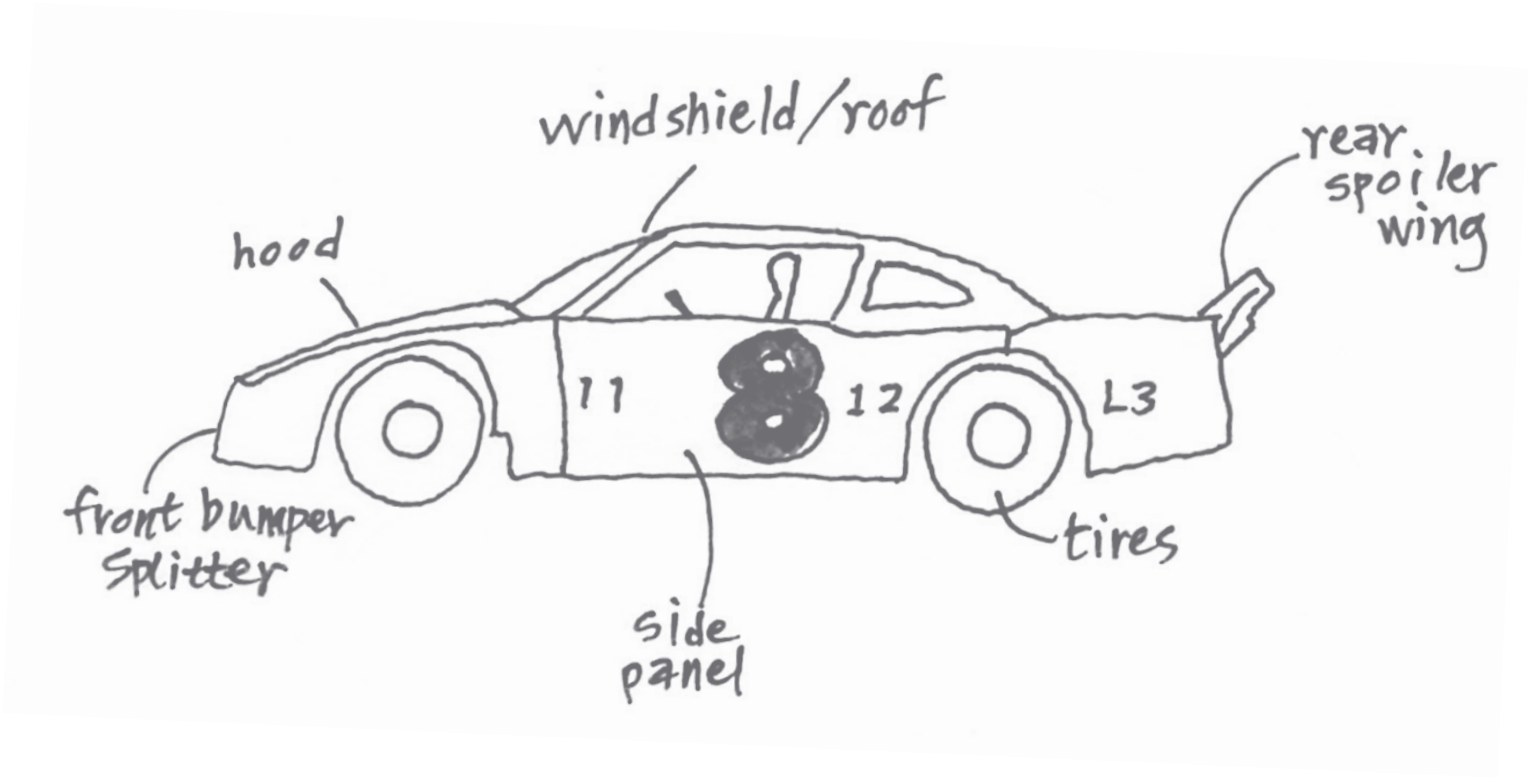
SET UP

Display the diagram of the car where all players can see it. Ask players to take a seat in front of a device where they can all view the Jeff Gordon videos. Also, encourage students to reference the Racing Science Guide for additional information.

TO PLAY

First, ask all players to review the race car diagram. Then, watch each of the videos featuring Jeff Gordon. What main point did Jeff make in each video? Write it down and then use the Racing Science Guide to help you think about how the design of Jeff's car might help him win a race. After reviewing this information, can you think of changes you would suggest that could make a car even faster than Jeff's? If you need help getting started, look back at the diagram of a race car and the Racing Science Guide. Offer an example, such as, "If downforce helps Jeff's car to grip the racetrack better, do you think that making changes to the front splitter or rear spoiler would help his car corner better? If so, draw the change you would suggest." After you've reviewed all the videos and diagram of a race car, try drawing the improvements you would make to the design of a race car and annotate it with your reasons for changing the original design. When all players have completed their drawings, share them with one another and discuss the changes that have been suggested. Did any players make the same suggestions? Where did they have differences?

GAME #2: DESIGN A BETTER RACE CAR



GAME #3: PIT CREW CHALLENGE

MATERIALS

Eight flash cards with one question on one side and answer on the other side. Questions on each card represent a driver's queries to his/her pit crew.

SET UP

Cut out the eight individual cards from the two sheets provided below. Then, divide the cards evenly between the players, hiding the answers which are displayed on the back of each card.

TO PLAY

Players take turns asking and answering the questions. Player one starts off as "the driver" pulling in to a pit stop. He or she takes a card and asks the question. For example, the player may ask, "If I want to go faster, other than stepping harder on the gas, what can I do?" The other players act as "the pit crew" and, using the Racing Science Guide for help if necessary, determine the answer. In this case it would be "use the aerodynamic effect called drafting".

Players switch roles throughout the game. Players are awarded one point for each correct answer. Player with the most points once all the flash cards have been read is the winner.

PIT CREW CHALLENGE #1 FRONT

If I want to go faster, other than stepping harder on the gas, what can I do?

What can give my car more grip on the track?

When I am going 180 mph in to a turn, what force will help me make the turn smoothly?

When I am moving down the track, what type of energy is my car displaying?

PIT CREW CHALLENGE #1 BACK

Downforce	Use drafting
Kinetic energy	Centripetal force

PIT CREW CHALLENGE #2 FRONT

If I am worried that my tires will have too much pressure by the end of the race, is there anything we can do to control the pressure?

Sometimes I can feel the car's grip change in a curve. What would make that happen?

If the front end of my car gets too tight or the back end gets too loose, what might cause that?

If my engine has 850 hp, how much horsepower does my family car have?

PIT CREW CHALLENGE #2 BACK

Load transfer	Fill the tires with nitrogen
250 hp	Lack of balance