UNIT 5
THE SCIENCE OF SPORTS

BODY SYSTEMS

(45-60 MINUTES)

Introduction: Proper nutrition is one of the key components of success for NFL players. NFL athletes are routinely concerned about the foods they put in their body. They work with nutritionists and coaches to develop healthy eating plans to stay in the best possible shape during the regular and off-season. As players consume healthy food, their bodies convert the chemical energy in food into mechanical energy which the body uses to fuel its muscles. NFL players have to constantly monitor what they eat to ensure their bodies have the chemical energy necessary to keep them healthy and effective on the football field.

Objective: Members will use science and mathematics principles to create a breakfast meal plan, nutritional values and ingredients for an NFL player, and then cook and create the meal option they designed.

MATERIALS

- ☐ Cooking skillets (2)
- ☐ Blender (1)
- ☐ Pack of paper or Styrofoam plates (1)
- ☐ Pack of plastic utensils (1)
- ☐ Stove with at least two eyes or two hot plates (1)
- ☐ Spatulas (2)
- ☐ Can of cooking spray (1)
- ☐ Pack of plastic cups (1)
- ☐ Measuring cups (2)
- ☐ Measuring spoons (2)

NGSS Alignment: Grades 3-5: Engineering Design

1. 3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time or cost.

2. 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

Food Type	Serving Size	Calories Per Serving	Sodium Per Serving
Egg white	1	17	33 mg
Whole egg	1	91	88 mg
Shredded cheese	1 oz.	110	180 mg
Turkey sausage	1 link	88	670 mg
Turkey bacon	1 slice	35	140 mg
Pork sausage	1 link	229	644 mg
Pork bacon	1 slice	103	436 mg
Orange juice	1 cup	112	2 mg
Low fat milk	1 cup	102	107 mg
Soy milk	1 cup	100	95 mg
English muffin	1	120	220 mg
Bagel	1	354	590 mg
Toast (white bread)	1 slice	64	130 mg
Banana	1	105	1 mg
Strawberry	1 cup	49	2 mg
Apple	1	116	2 mg
Peanut butter	2 tbsp.	188	5 mg

Facilitator's Notes (40-50 minutes): Members will cook on stoves or hot plates as facilitators monitor the food preparation. Make sure that all facilitators have ServSafe certificates on file if required by your state.

- Break members into groups of three to four and give each member one of the following roles: recorder, chef (2) and mathematician. (The mathematician needs to calculate the total calories and sodium of the meal.)
- Using the chart provided – including the serving sizes, amount of ingredient per meal and calorie and sodium counts – members will create a menu for their meal. They can use 1,500 calories for breakfast and must use math and science principles to keep an accurate tally of the number of calories and amount of sodium in their breakfast.
- If they choose to include more than one serving of an ingredient, they should calculate the total calories and sodium and include them in their tally. Additionally, members will use the kitchen or a hot stove and blender to create and sample the meal they created.
- The food should be rich in protein, grains and fiber so their quarterback will have a nutritious meal option.

NFL QUARTERBACK BREAKFAST FOOD ITEMS			
Selected Food	Selected Food	Selected Food	Selected Food
Total Calories -	**/1500 Calories for Breakfast**		

Extending Your Learning (10 minutes):

1. Based on the calculations on your chart, what did you learn about the lack of nutritional value of some of the foods you may eat on a daily basis?
2. What are some changes you may need to make to ensure you are not consuming too many calories for breakfast?
3. Why would NFL players need to consume 1,500-2,000 calories for breakfast during the regular season?
4. What would happen to the energy transformation process if the body did not receive the proper amount to fuel its muscles?

WEATHER
(50 MINUTES)

Introduction: Extreme weather can have a dramatic impact on the outcome of a professional sporting event. Currently, 24 out of 32 NFL teams have open stadiums where players are exposed to extreme weather conditions including heat, rain, cold and snow. There are four teams with retractable roofs that can be closed when inclement weather arises, and four teams that play in a dome stadium. Extreme cold or heat impacts the pressure maintained within the football. Scientific studies have shown that extreme cold temperatures can cause a football to shrink and become less bouncy, and extreme heat can cause the football to expand and become bouncier than normal. These size changes can have negative impacts on how well the quarterback throws the football, how the football sails off the kicker's foot and how the football bounces after it is kicked or fumbled.

Objective: Members will use math and science principles to conduct an experiment to test how heat, wind, rain and cold impact the accuracy of a football thrown by a quarterback.

NGSS Alignment:

Middle School, Human Impacts

1. **MS-ESS3-3.** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Middle School, Properties of Matter

2. **MS-PS1-4.** Develop a model that predicts and describes changes in particle motion, temperature and state of a pure substance when thermal energy is added or removed.

MATERIALS

- ☐ Bucket or large tub (1)
- ☐ Large bag of ice cubes (2)
- ☐ Box fan or industrial fan (1)
- ☐ Industrial strength heater or small heater (1)
- ☐ Gallon of water (2)
- ☐ NFL or NCAA footballs (2)
- ☐ Cardboard boxes or white poster boards (3)
- ☐ Black permanent markers or black markers with chisel tips (2)
- ☐ Roll of masking tape (2)
- ☐ Air pump with needle (1)
- ☐ Air pressure gauge (1)
- ☐ Measuring tape (1)
- ☐ Lab notebook for each participant (1)

All of the materials for the experiments can be purchased at a supermarket, office supply or sporting goods store.

KEY VOCABULARY

Retractable – roof on a stadium that can be rolled back on tracks to expose the inside of a stadium to the outdoors

Inclement – unpleasant cold or wet weather

Dehydration – a lack of water and fluids in the body necessary to carry out normal functions

Frostbite – injury to body tissues caused by being exposed to extreme cold

Cramps – painful, involuntary contraction of the muscles caused by being tired or lacking necessary fluids in the body

Simulated – replicating an exercise

Velocity – the speed an object is traveling in a given direction

Facilitators: Participants will participate in five separate experiments to analyze the effects of extreme cold, water, heat and wind on accurately hitting a target. To get through all five experiments, place members in groups and have four to five NFL footballs available so that multiple groups can conduct their experiments simultaneously. Prior to beginning simulations, you will need to measure 15 yards from the line of scrimmage and mark this with a strip of masking tape. Participants will use the black permanent markers or black markers with chisel tips to create a large bulls-eye on the cardboard box or white poster board. Participants should make the bulls-eye large enough to see clearly from 15 yards away. If it is convenient, you can use the tape to stick the poster to a wall.

Before beginning the experiment, make sure the football is properly inflated with 15 pounds of air pressure. Use the air pressure gauge to help you evaluate the football's air pressure. Your members will be simulating different levels of air pressure in the football due to its exposure to the elements. The members will need to create the chart listed below to record the data from their experiments.

EXPERIMENT DATA COLLECTION CHART			
Football Throw	**Football Conditions**	**What do You Predict Will Happen**	**Number of Throws Required to Hit the Bulls-eye**
First Experiment	Normal		
Second Experiment	Wet		
Third Experiment	Windy		
Fourth Experiment	Extreme Cold		
Fifth Experiment	Extreme Heat		

Experiment #1 – Normal Throwing Conditions (10 minutes)

Members will establish a baseline with a properly inflated football and no extreme weather conditions.

- Members will practice throwing the football to hit the bulls-eye from the simulated line of scrimmage, which is 25 yards across the gym or field. It may take less experienced members a little longer to determine the appropriate arm angle and velocity needed to hit the target 25 yards away.
- Give members suggestions about holding the ball properly with their fingers on the laces and stepping into the throw to improve their accuracy.
- Once members have hit their target, ask them to record the data on their chart below.

Experiment #2 – Simulated Impact of Rain (10 minutes)

Members will simulate the impact of rain on the football with 15 pounds of pressure during a game with no extreme weather conditions.

- Participants should fill the small tub with two gallons of water and place the football in the water until it is completely coated.
- Ask members to dip their hands in the water prior to removing the football from the water until they have soaked both the football and their hands. Ask members to wet their hands every time they throw the football to ensure they have the proper amount of moisture on both their hands and on the ball.
- They should repeat the experiment by throwing from the simulated line of scrimmage and record the waters impact on their accuracy as they attempt to hit the bulls-eye.
- Ask members to record how the slickened ball impacts their ability to throw accurately for 15 yards.

Experiment #3 – Simulated Impact of Wind (10 minutes)

Members will simulate the impact of windy conditions on their ability to hit the bulls-eye from 15 yards away. The desired outcome is to determine if the windy conditions alter the accuracy of the football when it nears its target.

- Use an industrial fan (preferably) or a box fan and turn it to its maximum speed. Place the fan closely to the right or left of the bulls-eye so the wind is blowing directly across it.
- Have members stand 15 yards away from the fan and try to hit the bulls-eye.
- Ask members to record how the wind affected their accuracy, along with the number of throws it took to hit the bulls-eye.
- Additionally, they should record whether or not they can see the football move away from the bulls-eye as it comes into contact with the air from the fan on their table in their scientific notebook.

Experiment #4 – Simulated Impact of Extreme Cold (10 minutes)

Extreme cold during a football game oftentimes causes a football to lose air pressure.

- Ask members to simulate extreme cold during a football game by removing two pounds of air pressure from the football.
- Have members measure the change in the air pressure with the air gauge to ensure that it is accurate.
- Participants should place the football in the tub of ice to allow the pigskin covering to become cold.
- Participants should also hold several cubes of ice in their hands for 30-45 seconds before throwing the football. This will let them experience the same numbness quarterbacks have in snowy and icy conditions.
- Make sure members do not hold the ice for more than 30-45 seconds, which could cause injury.
- Members should record on their chart whether their accuracy was impacted by the cold pigskin, the underinflated feel of the football or the numbness of their fingers from the cold. Their analysis should include the number of throws required to hit the bulls-eye.

Experiment #5 – Simulated Impact of Extreme Heat (10 minutes)

Extreme heat oftentimes causes a football to increase in air pressure.

- Ask members to simulate extreme heat by adding two pounds of air pressure to the football so that it has 17 lbs. of air pressure.
- Ask them to measure the change in the air pressure with the air gauge to ensure that it is accurate.
- Participants should hold the football in front of the heater for two to three minutes so they can replicate the temperature of the football that quarterbacks experience in very hot conditions.
- As members apply heat to the football, it is important that you supervise their use of the heaters. The heaters can get extremely hot and may hurt a child. Do not to use heat guns because they can get up to 3000 degrees and can really hurt a member.
- Participants should record whether their accuracy was impacted by the temperature of the pigskin or the overinflated feel of the football, along with the number of throws it took to hit the bulls-eye.

Extending Your Learning (10 minutes)

1. Based on the data you collected from your experiments, which simulated weather condition had the most significant impact on your accuracy? Provide evidence to support your answer.
2. What are the scientific reasons footballs often react to extreme temperatures?

3. What kind of competitive advantage exists for football teams that play in climate controlled domes or stadiums with retractable roofs?

4. What are some of the practices in terms of their throwing mechanics that quarterbacks need to use to combat rain, wind and extreme cold and heat to remain accurate?

KINESIOLOGY

(25 MINUTES)

Introduction: Athletes' creative celebrations both allow them to express their individual creativity and reflect a number of complex body motions and scientific principles in the human anatomy. Dance and football both incorporate a range of scientific principles including levers and motion. In a quarterback's throwing motion, the human body incorporates the simple machine – a lever – to build effort in the muscles of the arm. The elbow acts as a fulcrum, and the force is a contraction of the muscles in the arm to throw the football while the football serves as the load that is thrown. The muscles and tendons of the arm use effort in concert with the fulcrum in the quarterback's arm to throw a pass to a receiver. The body uses a similar process in the foot when players plant their foot into the ground to run. The toes are a fulcrum that bears the load of the foot and leg, while the Achilles tendon and calf muscle supply the effort needed to propel a runner forward.

Objective: Members will use science principles to create a replica of a simple machine in the human body, analyze the simple machines used in a touchdown celebration, and design a conditioning plan to protect and strengthen the simple machines used most by NFL players.

NGSS Alignment:

Grades 3-5:

1. **3-PS2-1.** Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

Middle School, Matter and Energy in Organisms and Ecosystems

1. **MS-LS2-4.** Small changes in one part of a system might cause large changes in another part.

MATERIALS

- ☐ **Lab notebook (1 per member)**
- ☐ **Stereo (1)**
- ☐ **Smartphone or tablet (2)**
- ☐ **Package of long balloons (1)**
- ☐ **Paper towel roll (3)**
- ☐ **Pack of jumbo paper clips (1)**
- ☐ **Permanent marker (2)**

All of the materials for the experiments can be purchased at a supermarket, office supply or sporting goods store.

KEY VOCABULARY

Simple machine – a basic mechanical device used to apply a force on another object

Lever – a bar that rests on a pivot which is used to move a heavy object

Fulcrum – the point where the lever rests or turns

Load – the weight or mass that is supported

Facilitators: Members will use balloons and paper towel rolls to create a replica of the muscles and bones in the human body by creating their own simple machine.

Members can use the empty roll from the paper towels. If they do not have access to paper towel rolls, they can use a cardboard box that they roll into a cylinder and hold together with tape. Participants should use a permanent marker to label the three major bones in the arm, which are the humerus, radius and ulna.

- Members should thread a paper clip through the radius, ulna and humerus bone so all three are held together. The bottom of the humerus bone should connect to the top of both the radius and ulna – this represents the elbow.
- Use a rubber band to bind the other end of the radius and ulna together – this represents the wrist.
- Members should blow air into a long balloon and force the air into the center of the balloon leaving the ends empty so they can be attached to the paper towel rolls.
- Members should tie one of the loose ends of the balloon to the top of the humerus and the other end to the bottom of the radius and ulna – this represents the biceps.
- Members should repeat the same process on the back of the cardboard rolls to create the triceps.
- Participants should flex and move their models to replicate how the arm moves as a lever in the human body.

Extension Activity #1 (20 minutes)

Members will explore physical science in their exploration of simple machines in the human body. In this activity participants will understand how muscles, joints and tendons serve as levers and fulcrums. They will also explore how scientific principles of force and motion can be applied through motion and dance by analyzing how Victor Cruz's celebratory touchdown dance uses properties of motion and simple machines.

- Using the chart below, participants will provide a description of the muscles that are necessary in Victor Cruz's salsa dance.
- Let members use a computer, their cell phones or tablet to search online for Victor Cruz's touchdown salsa. They should reenact his body movements and use the chart below to analyze the body movements involved in the dance.
- Members must provide a written analysis in their laboratory notebook of the body movements included in his touchdown celebration.

Describe the touchdown dance or motions	Which simple machines are used in the celebration?	What muscle groups are involved in the operation of the simple machine in the human body?

Extension Activity #2 (20 minutes)

Members will design a workout program to help them stretch the simple machines in their body that they studied in the module.

- Ask members to create a workout plan that focuses on the levers in the arms, legs and feet.
- The workout plan should help them stretch those muscle groups, tendons and bones so that they can prevent injury.
- The focus of their workout plan should be on conditioning the muscle groups included in stretches or strenuous physical activities.
- Ask members to write down this extension activity in their lab notebook.

Simple machine in the human body	Conditioning exercise	How long should the exercise last?	Why is the conditioning exercise beneficial to the simple machine?
Arm			
Leg			
Foot			

Extending Your Learning (5 minutes)

1. How does the human body use levers in dances like the salsa?
2. Why would types of dances like the salsa be an excellent activity to prepare players for football-related motions?

SOUND WAVES
(30 MINUTES)

Introduction: Sound waves are patterns of disturbances caused by energy moving away from sound through air, water, liquid or a solid. In sports, sound waves oftentimes travel from the voices of screaming fans or stadium speakers. Sound waves can be heard by humans as loud, sometimes deafening noises, or felt as strong vibrations. If you have ever participated in the "wave" at a football game, you have modeled what a real sound wave does. As you wait for the wave to flow across the stadium, you probably noticed that no one actually moved with the wave as it traveled longitudinally from left to right or right to left. Real sound waves operate in the same manner. The height of each part of the wave – when people are standing and raising their hands together – is called the crest. The lowest part – when people sit back down as the energy moves to the next section – is called the trough.

Objective: Participants will increase both their math and science skills by analyzing how sound waves produced by different items can be perceived at different distances; transmitted through solids, liquids and gases; and measured using digital tools.

NGSS Alignment:

Middle School, Energy

1. **4-MS2-2.** Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat and electric currents.

Middle School, Waves and their Applications in Technologies for Information Transfer

1. **MS-PS4-2.** Develop and use a model to describe that waves are reflected, absorbed or transmitted through various materials.

Facilitator's Notes: The focus of this experiment is to help members understand how sound waves move through solids, air and liquids. The results of the experiments will help them understand how well sound waves travel through different materials and how sound travels in an NFL stadium. Members will learn how to use technology to measure decibels of sounds produced from the human voice and other objects. This section is a continuation of what the members learned earlier about noise at NFL games. They

MATERIALS

- ☐ Large bowl (3)
- ☐ Roll of plastic wrap (1)
- ☐ Box of salt (1)
- ☐ Gallon of water (1)
- ☐ Whistle (3)
- ☐ Large metal pan (3)
- ☐ Measuring spoon (3)
- ☐ Plastic or glass measuring cup (3)
- ☐ Stereo (1)
- ☐ Large cardboard box (3)
- ☐ Apple or Android smartphone/tablet (3)
- ☐ Measuring tape or meter stick (3)

All of the materials for the module, except the smartphone or tablet, can be purchased at a supermarket, office supply or sporting goods store. Members can use their own smartphones, or they can use the Club's tablets for the experiments.

KEY VOCABULARY

Pitch – the highness or lowness of a tone

Frequency – the rate at which a sound vibration occurs that represents a sound wave

Decibel – a unit used to measure the sound of volume

Resonance – the length of sound reflecting off a surface

should develop a deeper understanding about why NFL stadiums have certain physical designs, and then use materials to increase the noise level of the crowd by reflecting sound waves.

EXPERIMENT #1 – Using Sound Waves to Move Salt (10 minutes)

The focus of the experiment is to determine if the sound waves make the grains of salt move. Members will experiment with sound waves and explore how these are visible through the movement of salt particles. You will need a large bowl and a supply of plastic wrap. You should use several types of noises, (e.g., a loud human voice, a whistle, a stereo playing music loudly, etc.) near the salt on the plastic wrap.

- Stretch the plastic wrap to make a tight seal around the edges of the bowl. Make sure you sprinkle two to three tablespoons of salt on the plastic wrap so members can see the grains of salt move when they interact with the sound waves.
- They will need to position the noise makers at least two feet away from the experiment to prevent the wind produced by yelling or blowing the whistle from moving the salt.
- Make sure that participants do not whistle or yell in another person's ears or stand too close to a loud speaker – this could damage the other person's or their own hearing.
- Explain that the sound waves are stronger and travel farther with bass notes. They may see the salt particles move more dramatically if they are using a stereo with strong bass in the speakers.
- Members should also determine how much the grains of salt move from different sound makers including clanging pans, a whistle or a loud stereo.
- Ask members to record their findings on their chart in their lab notebooks.

USING SOUND WAVES TO MOVE SALT PARTICLES	
Sound Wave Producer	**Movement of the Salt Particles** (Minimal, Significant, Drastic)
Whistle (2-3 ft. away)	
Whistle (4-5 ft. away)	
Whistle (6-8 ft. away)	
Stereo (2-3 ft. away)	
Stereo (4-5 ft. away)	
Stereo (6-8 ft. away)	
Yelling (2-3 ft. away)	
Yelling (4-5 ft. away)	
Yelling (6-8 ft. away)	

Experiment #2 – Using Sound Waves to Move Water (10 minutes)

The focus of the experiment is to determine if the sound waves make the water move on the plastic wrap. Members should also determine how much the water moves from different sound makers including the clanging pans, whistle and loud stereo.

- Once the salt experiments are complete, clear the salt off the covered bowl and sprinkle ½ cup of water on the top of the bowl.
- Members will repeat the experiment with ¼ cup of water on the top of the plastic wrap stretched across the bowl. You should try several types of noise makers like a loud human voice, a whistle and even a stereo playing music very loudly near the water on the plastic wrap.
- When the sounds are created or played, members should see visible waves in the water created by the sounds. They will need to position the noise makers at least two feet away from the experiment to reduce the amount of wind that they will produce by yelling or blowing the whistle from moving the water.
- Make sure that participants do not whistle or yell in another person's ears or stand too close to a loud speaker – this could damage the other person's or their own hearing. You may need to explain to participants that the sound waves are stronger and travel farther with bass notes. They may see the water move more dramatically if you are using a stereo with strong bass notes in the speakers.
- Ask members to record their findings on their chart in their lab notebooks.

USING SOUND WAVES TO MOVE WATER	
Sound Wave Producer	**Movement of Water** (Minimal, Significant, Drastic)
Whistle (2-3 ft. away)	
Whistle (4-5 ft. away)	
Whistle (6-8 ft. away)	
Stereo (2-3 ft. away)	
Stereo (4-5 ft. away)	
Stereo (6-8 ft. away)	
Yelling (2-3 ft. away)	
Yelling (4-5 ft. away)	
Yelling (6-8 ft. away)	

Experiment #3 – Reflecting Sound Waves Off a Solid (10 minutes)

Members will use a large cardboard box and metal pan to study how sound waves from a human voice resonate off solid objects. The principle that they will study is similar to the way that sound echoes in large rooms when it bounces off walls or ceilings.

- Ask members to put the box and pan one foot from their mouths and yell or scream as loud as they can and blow a whistle.
- Ask members to record how they interpret the sound's reflection from the box and pan at that distance.
- Members should move the box and pan two to three feet from their mouths and repeat the same processes. Make sure that participants do not whistle or yell in another person's ears or stand too close to a loud speaker – this could damage the other person's or their own hearing.
- Finally, participants should move the box and pan four to five feet from their mouths and repeat the processes. Ask members to record their findings from the experiments in their lab notebooks.
- Participants will determine whether the sound waves resonated strongest off the cardboard box or pan. They should also discuss whether the hollow nature of the box with its four sides contributed to the sound it reflected and why metal is a good material to reflect sound waves.

SOUND WAVE RESONANCE		
Sound Wave Producer	**Resonance Strength on Box** (Minimal, Significant, Drastic)	**Resonance Strength on Metal Pan** (Minimal, Significant, Drastic)
Whistle (1 ft. away)		
Whistle (2-3 ft. away)		
Whistle (4-5 ft. away)		
Yelling (1 ft. away)		
Yelling (2-3 ft. away)		
Yelling (4-5 ft. away)		

Extension Activity Using Technology (20 minutes)

As an extension activity, participants can download a free app such as digital sound meter from the Android or Apple app market that will measure the decibels (dB) for sounds of their voice including whispering, talking or yelling using the microphone on their tablet or smartphone.

- Designate one member to operate the smartphone or tablet to ensure that they are receiving accurate measurements.
- Members should try recording the sounds from various sound makers at different distances from the tablet or phones.
- Members should attempt to generate sounds of 142 dB from a variety of distances from the smartphone or tablet using their voices and other objects to replicate the record-breaking noise level that the Kansas City Chiefs reached in the 2014 season.
- Make sure that participants do not whistle or yell in another person's ears or stand too close to a loud speaker – this could damage the other person's or their own hearing.
- Ask members to measure and record the different levels of sound made from various objects in their lab notebooks.

MEASURED SOUNDS IN DECIBELS (DB)			
Sound Maker	**2-3 Feet**	**5-6 Feet**	**8-10 Feet**
Whistle	Measure Sound (____dB)	Measure Sound (____dB)	Measure Sound (____dB)
Clanging Pans	Measure Sound (____dB)	Measure Sound (____dB)	Measure Sound (____dB)
Stereo	Measure Sound (____dB)	Measure Sound (____dB)	Measure Sound (____dB)
Screaming	Measure Sound (____dB)	Measure Sound (____dB)	Measure Sound (____dB)
Normal Talking	Measure Sound (____dB)	Measure Sound (____dB)	Measure Sound (____dB)

Extending Your Learning (5 minutes)

After the data has been recorded in their lab notebooks, members should evaluate the results of their experiment by answering the following questions:

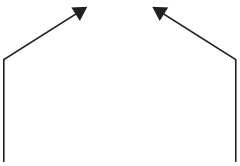
1. What did you notice about how sound waves affected the salt or water on the plastic wrap?
2. Based on your experiments, which sound maker produced the highest decibel readings?
3. In your opinion, how much higher would the decibel readings be if the NFL allowed all of its fans to blow whistles during the game?

VELOCITY

(45-65 MINUTES)

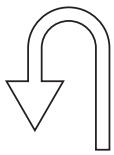
Introduction: In the NFL, players must maintain their physical fitness to compete with some of the best athletes in the world. One of the key characteristics of effective wide receivers or defensive backs is their ability to use speed to either free themselves from another player or maintain pace with quick offensive players. Quarterbacks must develop timing with their receivers to know the proper distance and force to apply as they throw the ball to the receiver at an appropriate velocity and angle. Defensive backs must determine the appropriate distance to give a receiver so they are in position to either intercept or deflect the football from the receiver. The principles of science and mathematics are very important in offensive or defensive plays during football games.

Slant Route:



Go Route:

Curl Route:



Objective: Participants will increase both their math and science skills by calculating the speed, time and distance that players take to complete football plays, along with determining the appropriate velocity for a football thrown in simulated football plays.

MATERIALS

- ☐ Stopwatch (2)
- ☐ NFL or NCAA sized football (2)
- ☐ Roll of masking tape (1)
- ☐ Measuring tape (2)
- ☐ Lab notebook (1 per member)
- ☐ Apple or Android smartphone (2)

All of the materials for the module, except the smartphone or tablet, can be purchased at a supermarket, office supply or sporting goods store. Members can use their own smartphones, or they can use the Club's tablets for the experiments.

KEY VOCABULARY

Velocity – the speed an object is traveling in a given direction

NGSS Alignment:

Grades 3-5:

1. **1. 3-PS2-2.** Make observations and/or measurements to produce data to serve as the basis for evidence that a pattern can be used to predict future motion.

Middle School, Energy (MS-PS3-1):

1. **Scales, Proportions and Quantities.** Proportional relationships, (i.e. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.

Facilitator's Notes: To reduce the risk of injuries, make sure that participants complete some warm-up throws and stretches to loosen their muscles prior to running the routes and throwing the passes required in the experiments.

Experiment #1a (10-15 minutes)

This activity will require participants to use a stopwatch and their lab notebooks to record the speed their peers run both designated football routes and the 40-yard dash. This activity works best in an area where you can clearly mark distances such as football fields or parking lots. You should use tape or another marker to mark 10-yard increments for a total of 50 yards. Members will use technology – a speedometer and a radar gun app – to calculate speed and distance.

- Put members into groups and ask them to use the stopwatch to record how fast each member can run the 40-yard dash.
- Ask members to record their data on the chart listed below.

Experiment #1b (10-15 minutes)

- Ask two of the group members to line up beside one another. One member will act as a wide receiver, and the other member will act as a defensive back.
- Ask another group member to record how far the wide receiver can run in five seconds on a go route, with the defensive back following the receiver straight up the field.
- Have members record their data on the chart listed below.

Experiment #2 (10-15 minutes)

Participants will use technology to calculate the velocity they need to throw a football and then complete a pass for one of the assigned routes. Participants can download a radar gun from the Apple or Android app market for their smartphone or tablet.

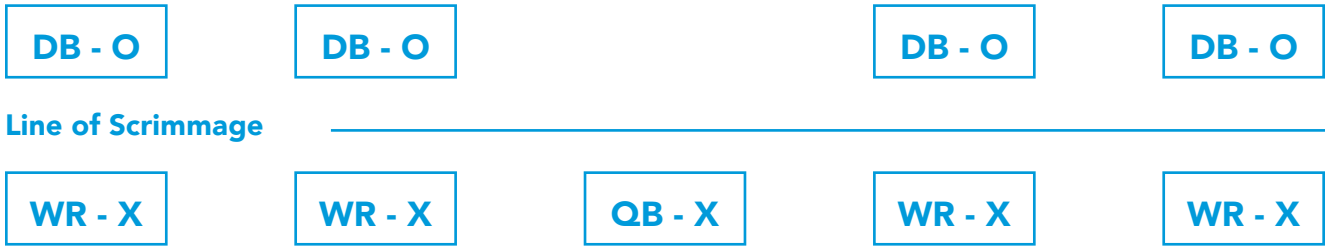
- Ask one member of the group to use the radar gun app to calculate and record the appropriate velocity of a football thrown in the assigned football routes.
- Ask members to record whether or not the football has low, medium or high velocity on the chart below.
- Have a second group member use a stopwatch to calculate the time it took for the receiver to run a 10-yard curl route and catch the football from the quarterback. The route will require the receiver and quarterback to have appropriate timing, and the quarterback must use the correct velocity on his throw to the receiver.
- Ask members to record their data on the chart listed below.

Experiment #3 (10-20 minutes)

Members will create their own football play in their notebooks using Xs and Os and an Apple or Android app to determine the distance that a wide receiver would have to run to be free from the defensive player. They should calculate a player's speed for a specific distance on a football play, along with the velocity of a football thrown from a quarterback to a wide receiver.

- Participants can download the free apps from the Android or Apple stores on a tablet or smartphone.
- In teams of six to eight participants, members will create their own slant, curl or go route using their own requirements for timing, distance, speed and appropriate velocity for the football.
- Participants should use Xs and Os to design and record the play and the elements of force they believe they will need to complete the play in their notebook.
- The receivers should continue to use the speedometer app on the Apple or Android phone to calculate their running speed during the play.

Type of Route	Speed the Receiver Will Have to Run to Complete the Play	Velocity Required to Complete the Pass (High – 50-75mph, Medium – 26-49mph, Low – 0-25mph)	Time to Complete the Play
40-Yard Dash			
Go Route			
Slant Route			
Curl Route			



Type of Route	Speed the Receiver Will Have to Run to Complete the Play	What level of Velocity Will Be Required to Complete the Pass (High – 50-75mph, Medium – 26-49mph, Low – 0-25mph)	Time to Complete the Play

Extending Your Learning (5 minutes)

1. Based on your experiments, how close was your speed to the 40-yard dash record set by Chris Johnson in 2008?

2. Which of the three routes that you used in this experiment is dependent the least on a player's overall speed?

MATERIALS SCIENCE

(30-45 MINUTES)

Introduction: Great National Football League (NFL) quarterbacks such as Tom Brady, Peyton Manning and Aaron Rogers have been successful partially because they have excellent throwing mechanics. Their throwing motion incorporates a number of scientific properties such as velocity, angles, trajectories, force, etc. While the mass of the NFL football is standard, the way quarterbacks hold their football, position their bodies to throw the football and release the football at the appropriate angle and desired velocity differs with each quarterback. The statistics and the quality of their plays as quarterbacks demonstrate the importance of velocity, angle, trajectory and throwing motions in the success of an NFL quarterback.

Objective: Participants will increase both their math and science skills by measuring angles and trajectories, along with calculating the distance an object is thrown from a point using different angles.

MATERIALS

- ☐ **Measuring tape (1)**
- ☐ **NFL or NCAA sized football (2)**
- ☐ **Lab notebook (1 per member)**
- ☐ **Masking tape (2 rolls)**

All of the materials for the module can be purchased at a supercenter, office supply store or sporting goods store.

KEY VOCABULARY

Trajectory – the path that an object follows when it is launched or thrown

Velocity – the speed an object is traveling in a given direction

NGSS Alignment:

1. **3-PS2-2.** Make observations and/or measurements to produce data to serve as the basis for evidence that a pattern can be used to predict future motion.
2. **PS2-A. Forces and Motion.** The patterns of an object's motion in various situations can be observed and measured. When past motion exhibits a regular pattern, future motion can be predicted from it.

Facilitator's Notes: It is important that you use the steps below to teach members proper throwing posture, ball positioning and finger placement before they conduct the experiment. These factors impact the trajectory of the football and the distance it travels. Give members a few minutes to throw some practice passes so they can loosen the muscles in their arm and shoulder and reduce the risk of injury before they attempt to throw the ball.

Gripping the Football

1. Place their hands on the football with their index finger close to the rear tip of the football.
2. Their middle finger should touch the laces of the football.
3. Their ring finger should touch the middle laces of the football, and their pinky finger should land on the final laces.
4. Their thumb should fall in the middle of the underside of the football to provide stability when throwing.

Body Position for the Throw

1. Both feet should be spread apart with the left foot slightly in front of the body.
2. The body should be turned slightly sideways with the throwing shoulder behind and the other shoulder pointed toward the target.

Releasing the Football

1. Release the non-throwing hand from the football and step forward into a throwing position.
2. Raise the ball above the head with the throwing hand and bring the arm forward.
3. Select the best angle for the throw. (A higher angle on the throw will produce a higher trajectory, but less distance. A medium angle will produce a slightly lower trajectory, but greater distance.)
4. Release the football at the height of the selected throwing angle with the appropriate amount of force.
5. Bring the throwing arm completely through the throwing motion and release the football with a slight twist of the hands to form a spiral on the football.

Note: If a member's grip is not properly placed on the laces, the ball will not travel in a spiral, which will impact its trajectory.

Experiment #1 (30-45 minutes)

Members will throw a football at varying angles and measure which angle creates the greatest distance from the launch point. Members' individual hand grip on the football, force of their throw and velocity of the football factor into the distance the football travels. Before members begin their throwing motion, review the steps of an accurate throw as well as the angle heights that they will attempt for each of their three throws.

- Place a strip of masking tape across the floor to mark where members should stop their forward motion during their throw. If members step over the mark during their throw, they should repeat their attempt, using the same angle to ensure the distance the football travels is measured accurately.
- Each member will take three opportunities to throw the football at varying angles and trajectories. The members will record the distance their football travels. Using the diagram provided, members should throw the football at a 75˚ steep angle, a 45˚ medium angle and a 15˚ shallow angle to replicate some of the most widely used angles for common passes in the NFL.
- Mark where the football initially lands as the ending point for the members' throw.
- After each throw, measure the distance the football travels using the measuring tape.
- Members should create the chart listed below to record the distance the football traveled for each throw for the specified angles in their lab notebooks.

BCGA Member	Selected Angle (Shallow-15˚, Medium-45˚, Steep-75˚)	Height (feet and inches)
Throw #1		
Throw #2		
Throw #3		

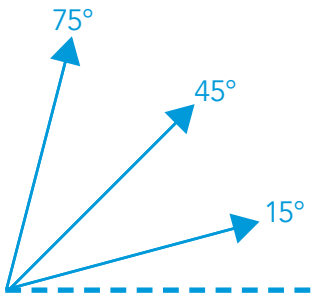


Figure above - A diagram of 15° (shallow), 45° (medium) and 75° (steep) launch angles.

Extending Your Learning (10 minutes)

After the data has been recorded in their lab notebooks, members should evaluate their experiment by answering the following questions:

1. Which angle produced the greatest trajectory?
2. What variables could have impacted the distance the football traveled including your stance, grip and throwing motion?
3. Which angle would produce the most appropriate trajectory for a "Hail Mary" pass to the number one or number two receiver at the end of half a football field? Why would it be the most effective?
4. Which throwing angle would be most appropriate for a quick 15-20 yard slant across the middle of the field to the tight end or slot receiver? Based on your experiments, why would it be the best throwing trajectory?
5. Which throwing angle would be most appropriate for a 30-40 yard pass across the field, (e.g., seam route, go route, etc.) so the football would sail over the heads of the linebackers? Based on your experiments, why would it be the best throwing trajectory?

[1]Science Buddies Staff. "How Far Can You Throw (or Kick) a Ball?" Science Buddies. Science Buddies, 17 Dec. 2014. Web. 2 July 2015