Name: **Key** Class: _____

Module 1.1: ARM STRENGTH: YOUTH VS FOAM FOOTBALL

Distance of Throws: Example data below.

	Mass	Throw 1	Throw 2	Throw 3	Throw 4	Average
Youth	0.32 kg	8 m	6.9 m	6.4 m	7.1 m	7.1 m
Foam	0.15 kg	6.3 m	7 m	4 m	2.8 m	5.0 m

Speed of Throws: Example data below.

	Throw 1	Throw 2	Throw 3	Throw 4	Average
Youth: Distance	6 m	3.1 m	2.9 m	8.3 m	
Youth: Time	2.8 s	2 s	1.4 s	3.5 s	
Youth: Velocity	2.1 m/s	1.6 m/s	2.1 m/s	2.5 m/s	2.0 m/s
Kinetic Energy (0.5 x mv^2					0.3 J
Foam: Distance	3.2 m	2.6 m	4.8 m	4 m	
Foam: Time	4.3 s	4 s	3.7 s	2.2 s	
Foam: Velocity	0.7 m/s	0.7 m/s	1.3 m/s	1.8 m/s	1.1 m/s
Kinetic Energy (0.5 x mv^2					0.1 J

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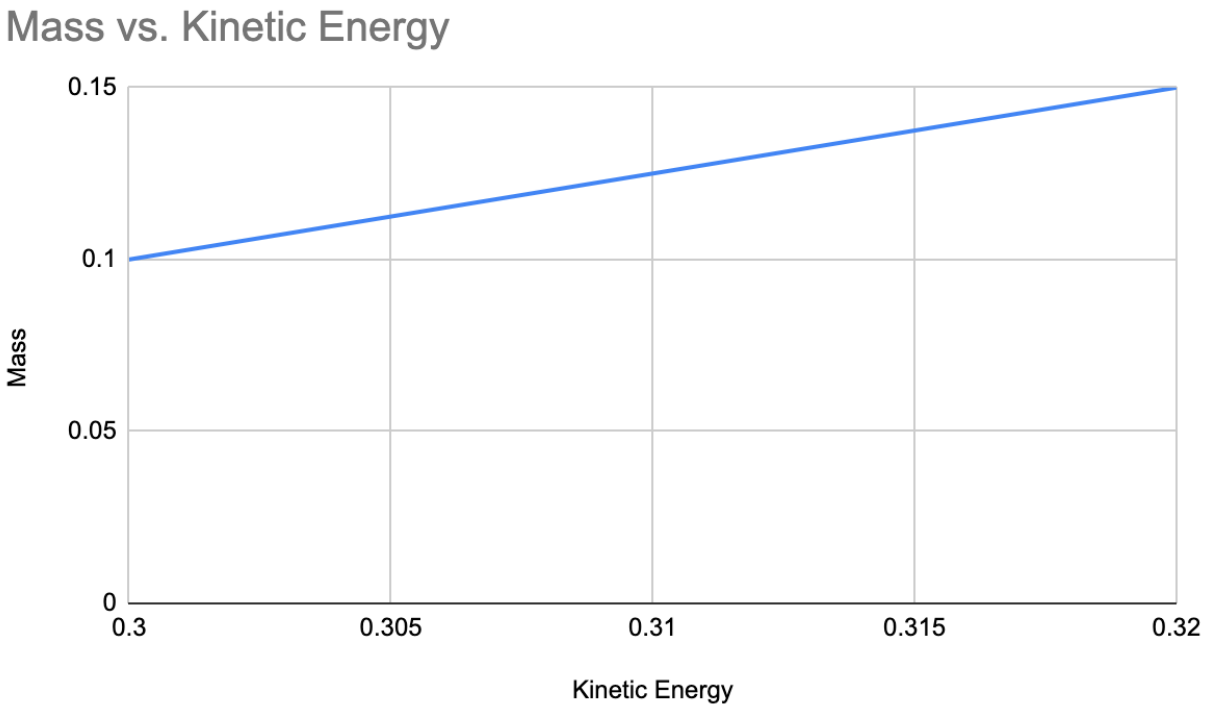

Make a claim about the relationship between mass and kinetic energy. Support your claim with evidence and reasoning.

Answers will vary.

Example: As mass increases, so does kinetic energy. In the graph and the data, the youth football with the higher mass and high kinetic energy, then the lighter foam ball. Since more mass is moving, more energy is created from the motion. Although, smaller objects tend to accelerate faster and heavier objects hold more energy at the same velocity than lighter objects.

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Module 2.1: TECHNOLOGICAL ADVANCEMENTS AND IMPROVED QUARTERBACK PLAY

Picking up the football: Put a checkmark if you were successful at picking up the ball with one hand.
Example data below.

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	P
No Gloves		x		x		x	x	x			0.5
Gloves	x	x	x	x	x		x	x	x		0.8

Pass completion: Put a checkmark if you and your partner completed a successful pass.
Example data below.

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	P
No Gloves	x		x	x	x			x		x	0.6
Gloves	x	x	x		x	x	x	x	x	x	0.9

1. What is your percent completion for passes without gloves? With gloves?
   Answers will vary based on student data.
   Example: 60%, 90%

2. Do you feel like players have an advantage when they wear gloves while playing?
   Answers will vary.
   Example: Players have an advantage when wearing gloves because the gloves have more traction

3. Using your probability, how many passes would you and your partner complete, if you were using gloves, in a season? (The average number of passes in a season is 552 or 34.5 attempts per game).
   Answers will vary:
   Example: 0.9 x 552 = 496.8 Passes

4. What are some arguments you could make against players wearing gloves?

Name: **Key** Class: _____

Answers will vary.
Example: Players may have an unfair advantage based on the glove they wear. Players use technology to improve play instead of natural ability.

5. Sometimes, in cold weather, quarterbacks wear gloves on their throwing hand. What advantages/disadvantages does the quarterback have?
   Answers will vary:
   Example: Players can keep their hands warm but may lose some dexterity based on the thickness of the glove.

6. What other on-field football equipment improvements have had major impacts on the game?
   Answers will vary based on knowledge of the sport and equipment.
   Examples: cleats, helmets, in-helmet radios.

Review and graph the data: https://stemsports.com/nfl-data-set or visit www.STEMSports.com "Resources", then "STEM Football". Review the graph and answer the below questions:

Based on your graph, answer the following questions:

Discuss the causes of any peaks and valleys in the graph.
Valleys could indicate variations in glove technology, popular plays, and improvement of player skills.

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What trends do you notice?
A general increase over time.

Using the graph and data, when do you think glove technology was mainstream? Support your answer using evidence.
Answers will vary. For full credit, look for evidence.
Example: In 1998, prior to 1980 - 1998, the data increases and decreases slightly, but it doesn't change overall. In 1998, the pass completion rate continues to increase without another major decrease.

Name: **Key** Class: _____

Module 3.1: ENGINEERING BETTER GAMEPLAY COMMUNICATION

Communication Tests: Put a check mark if the test was successful.
Example data below.

	Trial 1	Trial 2	Trial 3
No technology		x	
Walkie Talkie	x	x	x

Design better communication technology.
Example data below.

Criteria	Constraints
• Must work within 100 yards • Must be contained within the helmet • Must have battery life for the duration of the game	• Each offensive and defensive team is permitted no more than one player on the field with a speaker in his/her helmet. • Players who have speakers in their helmets must be identified in the Communication System section of the Game Day Administration Report that is submitted to the Referee or a member of his crew no later than one hour and 30 minutes prior to kickoff.

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Brainstorm ways to increase the success rate of communication:

Answers will vary.

Select a single design (draw in detail, label materials and provide measurements):

Answers will vary.

Write a procedure to test your new design. Think back to the walkie-talkie and non-technology tests for support. Answers will vary

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Module 4.1: THE EVOLUTION OF THE FOOTBALL HELMET

Examples data below.

Helmet	Observations	Advantages	Limitations	Prediction: Percent of concussions
No helmet	N/A	None	No protection	100%
	Leather, thin, worn out, two materials (inside and outside)	Provides warmth. Protects from abrasions. Protects ears.	No contact protection. No strap; easy to fall off in contact. Made of soft material.	98%
	Thicker than helmet 1, leather, smooth, wool or fabric lining, more shape.	Provides warmth. Protects from abrasions. Protects ears.	No contact protection. No strap- easy to fall off in contact. Made of soft material.	94%
	Hardened leather, shaped, black, chin strap.	A little contact protection. Absorbs some energy from contact. Chin strap to keep the helmet on.	Heavy No strap- easy to fall off in contact. Thin padding	85%

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	Looks like soft plastic; includes chin strap, smooth ear holes, leather inside material.	Some contact protection from the shape and material. Chin strap to keep the helmet on.	Heavy Thin padding	75%
	Made of hard plastic, little to no padding, smooth, no chin strap.	More contact absorption of the material and form.	Heavy No strap; easy to fall off with contact. No padding to absorb energy from collisions.	65%
	Face guard, hard plastic some inside padding.	More contact absorption of the material and form. Protection for chin and jaw. Chin strap to keep the helmet on/in place.	Eyes and neck injury from frontward collision.	45%

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	Full face guard, hard plastic, thick with foam padding inside.	Contact absorption of the material, padding and form. Face guard to protect face, frontward collisions/contact. Lightweight	Doesn't keep the head from rebounding. Doesn't absorb all the energy from a collision.	40%

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Module 5.1: INTRICACIES OF A FOOTBALL FIELD

Try calculating the following to determine the length of a scaled-down field.

1. $\frac{0.25 \text{ inch } (\frac{1}{4})}{1 \text{ yard}} = \frac{x \text{ inches}}{120 \text{ yards}}$ x = 30 inches

2. $\frac{0.5 \text{ inch } (\frac{1}{2})}{1 \text{ yard}} = \frac{x \text{ inches}}{120 \text{ yards}}$ x = 60 inches

3. $\frac{0.125 \text{ inch } (\frac{1}{8})}{1 \text{ yard}} = \frac{x \text{ inches}}{120 \text{ yards}}$ x = 15 inches

Which of the three scales would have a reasonable end length for a clipboard (12 x 18in) ?

1/8 inch would be the best scale to use on a clipboard.

Try calculating the following to determine the width of a scaled-down field.

3. $\frac{0.25 \text{ inch } (\frac{1}{4})}{1 \text{ yard}} = \frac{x \text{ inches}}{57.3 \text{ yards}}$ x = 14.3 inches

4. $\frac{0.5 \text{ inch } (\frac{1}{2})}{1 \text{ yard}} = \frac{x \text{ inches}}{57.3 \text{ yards}}$ x = 28.7 inches

5. $\frac{0.125 \text{ inch } (\frac{1}{8})}{1 \text{ yard}} = \frac{x \text{ inches}}{57.3 \text{ yards}}$ x = 7.2 inches

Which of the three scales would have a reasonable end width for a clipboard (12 x18in)?

1/8 inch would be the best scale to use on a clipboard.

Coaches have clipboards that are 8.5 x 11 inches. What scale would you need to use to ensure the field fits on a single sheet of paper? Don't forget that a football field has an additional 10 yards in each end zone.

The best scale to fit on an 8.5 x 11-inch clip board is 1/12. The length of the field on the board would be 9.9 inches and the width would be 4.8 inches. *Alternately: 1/11th would also work*.

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Module 6.1: EXTRA POINT VS TWO-POINT CONVERSION

Paper Football data collection: Put a checkmark when you make a "finger" kick.
Example data below.

	X	X		X		X		X	
X		X			X				
X	X	X	X		X		X	X	
X	X				X	X			
			X	X					
		X			X		X		
X	X			X	X				X
	X	X	X					X	
X			X		X		X	X	X
X	X								X

Total number of Extra-Point kicks made: 43/100 = 0.43

Using the probability calculated above, answer the following questions:

1. How many extra points will be scored if a team attempts 24 extra points in a season?
   Example: 0.43* 24 = 10 extra points

2. How many extra points will be scored if a kicker attempts 348 kicks in a career?
   Example: 0.43* 348 = 150 extra points

3. In 2016, the accuracy of any kick made at the 15-yard line is 93%. What is the probability of making a kick at the 15-yard line? How does it compare to your data?
   The probability of making a kick at the 15-yards line is 0.93. My probability is less than half of the NFL data at 0.43.

4. There is a second option for PATs, a two-point conversion. The NFL states that the probability of making a two-point conversion is .50 or 50%. How many extra points will be scored if a team attempts 24 two-point conversions?
   If the team attempts twenty-four (24) 2-point conversions, with a

Name: **Key** Class: _____

probability of 0.50, the team would make twelve (12) 2-point conversions or will score 24 points.

5. In 2016, the NFL used data to calculate a 94.2% chance of making any (extra point kick or two-point conversion) points after a touchdown, the lowest in almost 4 decades. Based on this data, can you make a claim about what option you would exercise?
   Answers will vary.
   Based on the probability of an extra-point kick (0.93) and a 2-point conversion (0.5), an extra-point kick is the better option for success.

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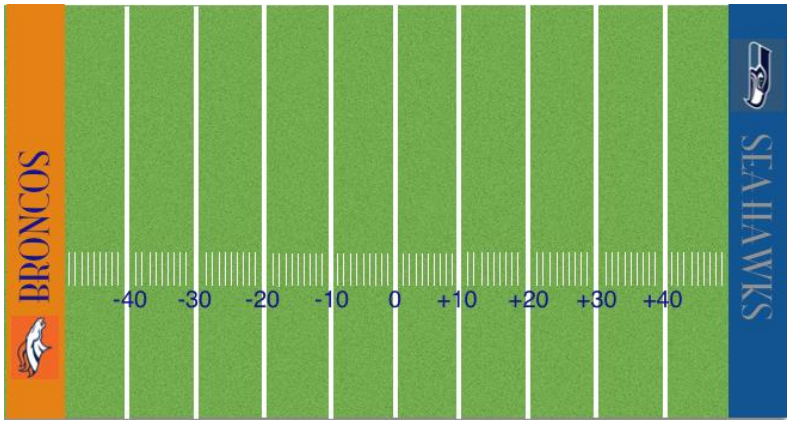
Module 7.1: INTEGERS OF PLAY

Kick Practice: Example data below.

	Actual (measured kick)	**To Goal Post**
10 feet (representing 5 yards)	12 feet	-2 feet
17 feet (representing 10 yards)	14 feet	3 feet
20 feet (representing 12 yards)	11 feet	9 feet
27 feet (representing 17 yards)	18 feet	9 feet



Model the following problems using a football; write each problem as an equation:

1. Team A is moving to the left; they are on the 42-yard line to start. Once the play is finished, they are at the -23-yard line. How far did they travel?
   65 yards

2. Team B is moving to the right; they are on the -14-yard line to start. Once the play is finished, they are at the 16-yard line. How far did they travel?
   30 yards

3. Team A's kicker kicks at the 8-yard line. If they make the field goal, will they beat the NFL record of 64 yards?
   They would only have made the field goal at 58 yards; not enough to beat the NFL record.

4. Team B kicks-off at the -40-yard line and the ball bounces at the 15-yard line. How far did the ball travel?

Name: **Key** Class: _____

55 yards

5. Team A ended on the -48 yard line. They traveled 11 yards in their last play. Where did they start?

-37-yard line

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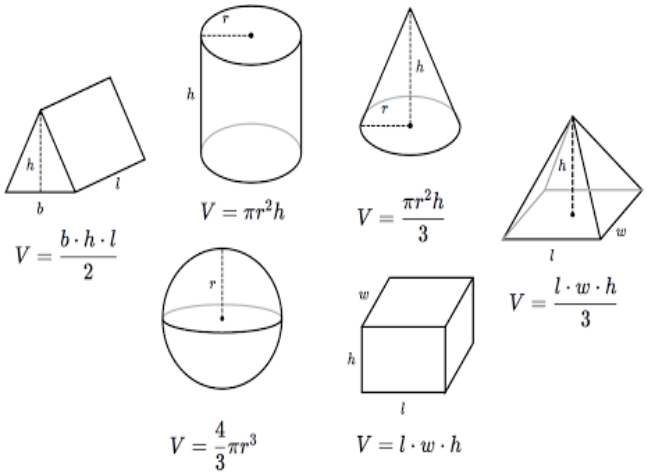
Module 8.1: PROPERTIES AND BEHAVIOR OF FOOTBALLS

Formulas:



Volume of object 1: Will vary based on the object.

Volume of object 2: Will vary based on the object.

Volume of object 3: Will vary based on the object.

Volume of object 4: Will vary based on the object.

	Volume of the center cylinder	Volume of the end cone	Approximate volume of the football	Mass of the football	Density of the football D= M/V
Youth football	Will vary based student measurements	Will vary based student measurements	= 280 in^3	320 g	1.14 g/in^3
Foam Football	Will vary based student measurements	Will vary based student measurements	= 262 in^3	150 g	1.75 g/in^3

Claim: How does the density of a football affect its behavior? Use evidence to support your answer.

Answers will vary.

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Example: A higher density object bounces less than a lower density object. A foam football has a higher density (1.75 g/in^3) and when observing the differences in bounce-ability of balls, it bounced less than the youth football. The youth football has a density of 1.14 g/in^3 and bounces almost double the height of the foam ball.