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FOR EXCELLENCE IN MIAMI-DADE PUBLIC SCHOOLS

2022-2023

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Science in Motion

ALGEBRATHLETICS

(Sports Math)

“Get your head in the game and ACE the EOC!”

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Background

As a longtime educator and administrator of the arts, I have always subscribed to the simple fact that students who care about and are interested in the subject matter will obviously do better than ones who are apathetic or exhibit negativity. When teaching music, oftentimes you encounter students who are already passionate about the material, but even still, it is a never ending challenge to find new and innovative ways to engage the students by presenting the topic at hand in relevant and meaningful approaches. Growing up, I always viewed math and music as two sides of the same coin and my passion was fueled for both disciplines the more I learned about each, and the more I discovered connections between the two. While I studied and pursued a career in the music industry, my interest and passion grew for both, and ultimately, my doctoral dissertation utilized advanced statistical analysis and modeling in an attempt to quantify the elusive topic of the jazz pianist's sense of "swing" and individual playing styles.

After 30+ years of directing musical ensembles and traveling the globe, I recently decided to pivot and rediscover my enthusiasm of teaching something different and new in the classroom, so I got certified and pivoted to becoming a "new" math teacher at Beach High. In the wake of Covid, these challenges of student engagement and interest were far more challenging than I was expecting! This past year, the students entering into this course came in with very low levels, many with very little understanding/ability of even basic math skills. Many in this particular demographic were already rated below grade level, even before the pandemic with little to no growth since 6th grade. The overwhelming sentiment that I observed was, unfortunately, an attitude of "I am no good at math." and "I hate math." I feel it is critical to reverse this permeating apathy and outlook.

The ONLY way I can see this being possible is to help make them realize two absolute truths: 1) that math CAN be relevant, meaningful, understandable, interesting, and (dare I say) "fun"! and 2) that if they actually DO apply themselves and are willing to work hard and put in the time AND effort, that they themselves will change their position believing they can not only be "good" at math, but actually excel! By getting students interested, excited, and involved in creating their own "real world" sports-related math problems, they take ownership of their learning and math self development. It is quite possible that if these profound changes in attitude about math take place while still in the 9th grade, they can potentially have a significant impact on their future academic career throughout the rest of high school and continue through their college studies and throughout the rest of their lives.

Goals and Objectives

The purpose of this project is to try to help you, as fellow math educators, (and me too!) make Algebra (or math in general) relevant, meaningful, understandable, and interesting for otherwise apathetic high school students, especially those in the stigmatized “lowest 25%”. If you are a teacher of Algebra you are painfully aware that our ultimate goal (as reflected in our own IPEGS end of year teacher evaluations) is for our students to achieve success on the FSA EOC assessment, required of all public school students to pass in order to graduate HS in the state of Florida.

This project addresses the age-old questions that nearly every teenager asks during math class… “How does this relate to the real world?” and “When are we ever going to use this in our daily lives?” By adapting the oftentimes challenging abstract Algebra 1 concepts and applying them to real world sports analogies, the students are able to visualize concrete examples by creating physical dioramas in one, two and three dimensional spaces within model playing fields. The first step is to discuss how many different sports arenas, when viewed from above, incorporate aspects of the simple number line and cartesian coordinate system. The football gridiron, soccer field, hockey rink, basketball, volleyball, and tennis courts, pool table, and even bowling alley can all be adapted to describe game play using x and y coordinates, most fittingly for descriptions of linear movement. When viewed from the perspective of the sports fan at ground level where the horizon becomes the x axis, by overlaying a graph behind the action, any throw, kick, serve, or jump shot becomes the tangible and visual path of a parabola, as described by its own quadratic equation. Even the “s” curve of a cubic function can be visualized using the path of an olympic ski jumper or accomplished skateboarder in your class.

In order for anything to be meaningful, it must be relevant. Therefore, while there is a plethora of resources available for examples of math and sports connections (some are provided in the resource section of this document) our main focus is to try to engage the students by first exploring the concepts and then having them create their own scenarios using themselves and their friends into the stories. In our new “Big Ideas” math textbooks, you may have notices that at the end of each concept the authors have the students do a self evaluation on how they feel they are grasping the idea: 1) “I do not understand yet.”, 2) “I can do with help.” 3) “I can do on my own.”, and 4) “I can teach someone else.” I propose that there is also a fifth level: 5) “I can create course material.” By engaging the students in considering actual sports scenarios, as teachers we can lead them towards constructing their own equations, word problems, and test questions that will hopefully sink in as true comprehension. (Imagine that!)

This project is innovative in that it will engage the students in the course material by making abstract concepts concrete in three dimensional spaces. Once the analogies are drawn to the sports arena, the students will gain a real-world understanding of linear and exponential equations, critical to success, and therefore be more open to accepting other application of algebraic functions. These "hands on" physical manifestations and graphing of gameplay will allow for full understanding and appreciation of the course material, thus providing for greater opportunity for success on the end of year FSA Algebra EOC.

By making math (or specifically Algebra in this case) relevant, concrete, understandable, interesting, and fun, this project has the potential to change the course of many young learners who will no longer be intimidated by math and who will no longer self proclaim, “I am no good in math.” Once someone becomes engaged, and is enjoying learning they can take charge of their own educational development and future, paving the way to success in all their subjects throughout high school and beyond.

We are hoping that, as teachers, you will benefit from this Expo workshop in five key areas:

1. As teachers, you will learn how to take abstract math concepts and present them in concrete, tangible, and visually appealing ways using sporting and/or gaming analogies.
2. You will learn how to capitalize on your students’ existing interest and passion for sports and gaming in order to inspire and engage them in both math in general, and specifically in algebra.
3. You will learn how to use your own creativity to develop your own ideas and expand on the practices and concepts presented.
4. You will learn how to engage your students so they can take ownership of their own education by creating inividualized math problems using the materials and concepts presented and available in the project.
5. As teachers, you will learn to collaborate among other math teachers, also doing the same project, as well as among your colleagues at your home school to brainstorm how these sports related tools, resources, and ideas can be expanded to the pedagogie of other subjects and disciplines

Florida Standards

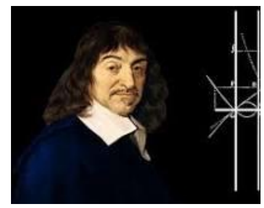
Note: Because this project can be presented in the various academic disciplines of math and PE, the following CPALMS Florida State Standards can be applied with slight variations across the grade levels and curriculum spectrum. As you develop your lesson plans you will come to realize that MANY more standards can equally be applied in these various educational endeavors.

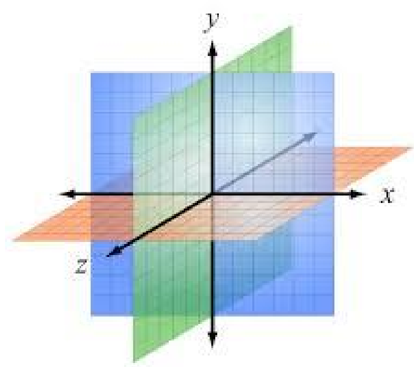
MAFS.912.C.1.1 Understand the concept of limit and estimate limits from graphs and tables of values.
MAFS.912.A-REI.3.6 Solve systems of linear equations exactly and approximately (e.g., with graphs), focusing on pairs of linear equations in two variables
MAFS.912.F-LE.1.1 Distinguish between situations that can be modeled with linear functions and with exponential functions.
MAFS.912.F-IF.3.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.
MAFS.912.A-REI.3.7 Solve a simple system consisting of a linear equation and a quadratic equation in two variables algebraically and graphically.

Course Outline

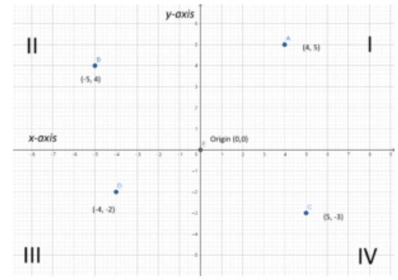
Dimensional Reality & Coordinate Systems

Before you can begin relating math to sports, it is important to explore with your students how we experience and describe the reality in which we exist. Every physical thing around us we can perceive and measure in terms of front/back, left/right, and up/down, which we now, without even thinking, call the three dimensional world (3D). While this may seem like an extremely obvious way of looking at the world around us, it wasn't until the early seventeenth century when French philosopher and mathematician Rene Descartes (yes that same dude who coined the term "I think, therefore I am.") developed a coordinate system envisioning a three dimensional model of three intersecting perpendicular x, y, and z axis lines to describe both the "real" physical world and the theoretical mathematical world: hence, the term we all know and love as math teachers… the "Cartesian Coordinate System". Any point in space existing around us can be plotted relative to the central zero point, and three dimensional objects measured and described in terms of the x, y, and z axis or horizontal position, vertical position and depth. It is important to understand however, that we are only talking about the physical world as a static snapshot or frozen picture of reality. As soon as we introduce any movement, that then must utilize the concept of a FOURTH dimension, which we call time. We exist in three dimensional space that ALSO moves through the fourth dimension of time, or the space-time continuum. At this point, without getting any deeper into the topic, suffice it to say you should reveal to your students that attempts at doing any calculations incorporating three dimensions, let alone four, get extremely complicated. Therefore, they should thank their lucky stars that in regular math class, most of the time you only deal with ONE dimension at a time (along a number line) where you are basically just using addition, subtraction, multiplication and division.



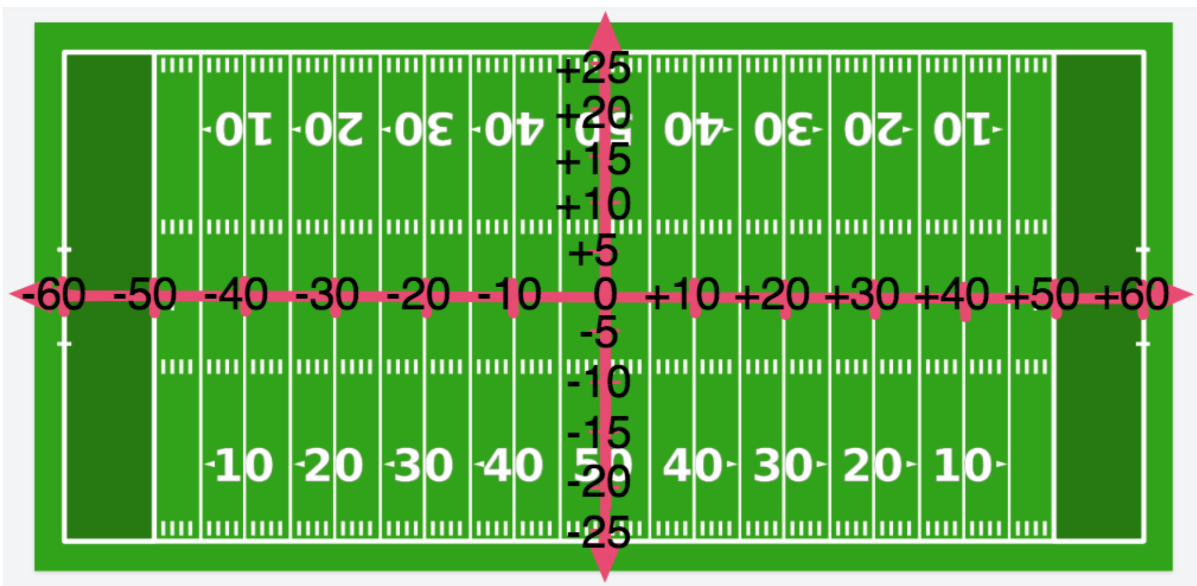


What makes Algebra class exciting, but a bit more challenging, is that you now can consider any two of the four dimensions and describe both along a flat 2

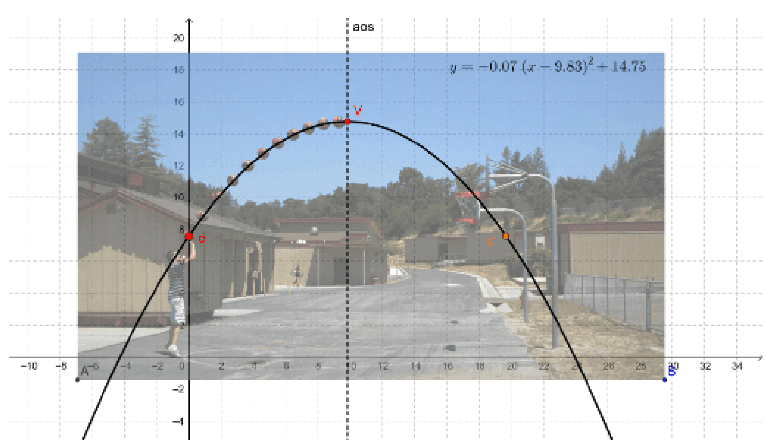


dimensional flat plane using the x and y axis. By looking at the world from above, we can picture left/right (or East/West on a map) along the the x axis and front/back (or North/South) measured along the y axis. This perspective can also be a simple and concrete method to describe movement along a playing field in sports.

When viewed from above, many fields of play already incorporate aspects of the cartesian coordinate system. The football gridiron, soccer field, hockey rink, basketball, volleyball, and tennis courts, pool table, and even bowling alley can all be adapted as a way to describe game play using x and y coordinates, most fittingly for descriptions of linear movement anywhere along the length or width of the field. Of course, in the case of football, you normally would ONLY be most concerned with the left/right movement along the marked yard lines, in which case you do not need the y axisand would utilize just the one dimensional x axis using very simple math.



While the example above is an overhead sky view of the game looking down on the field from above, you can also consider a side view from the perspective of the fan at ground level. In this case now the ground becomes the x axis measuring left to right as the ball and/or players move across the field of play, but now the y axis is measuring from the ground to how high the ball is thrown or kicked. By overlaying an x/y graph superimposed over the action,



any throw, kick, serve, or jump shot now becomes a visual path of a parabola, as described by its own quadratic equation.

Depending on classroom funds, these interactive playing surfaces can be presented as classroom models in a variety of medium - from a projector/smartboard, to inexpensive sports themed plastic tablecloths (with football gridiron printing for instance) or even actual gaming surfaces, such as a foosball or air hockey table. Students will examine each gaming surface and discuss/discover how nearly every sporting or game play area can be expressed as a real world depiction of the x and y coordinate system. They will soon come to realize that a two dimensional graph can be overlaid in order to represent player or ball movement using simple coordinates. Once measurements and units are determined for each activity's space, the students can use a cricut system (or markers) to apply the graphs to each for easy and concrete observation of movement represented by coordinate points. Note: using glow sticks to light the path diagram the scenario or the actual lines depicting player or ball movement should make

Once various graphs are applied to each game surface, different sports/gaming scenarios will be constructed with students applying concepts of point, line, and slope resulting in linear equations to describe the action. Conversely, given linear equations will be provided where the students would then have to show and construct the actual game play. Various sports/gaming scenarios will be used as analogies in this manner for all sorts of linear equations. Note: each game surface will need to be propped up vertically at the front of the room so that the students will have a "bird's eye" view of the action from the perspective of their classroom seats.

For concepts involving quadratic functions, the playing surfaces will be returned to their normal horizontal orientation and then placed in front of a whiteboard and/or promethean screen containing grid lines, whereby projectiles (such as a quarterback throw, volleyball serve, or jump shot) can be envisioned soaring above the game surface, once again using glow sticks connected, but this time bent to display the parabolic path. Concepts such as axis of symmetry, x and y intercepts, and max value will all be learned in a very concrete and tangible manner. Similar to the linear models, quadratic equations will be presented with having students construct the diorama, as well as the converse - where students build the model and then calculate the expressions depicting their home made scenarios.

In addition to the physical manifestation of both linear and quadratic equations plotted directly on (or above) the playing fields, sports analogies will be ALSO be implemented in many other Algebra 1 topic areas. For instance, various sports scoring practices can effectively be used to understand and solve 2 variable equations. For exploration of the concept of slope, simple examples can be revealed on the chess board. For instance, the restrictive movement of the knight on a chessboard (up two spaces and over one) can be shown as a real world representation of a linear slope of positive or negative 2 (or ½)... whereas the bishops must diagonally move along a slope of 1 (or -1) and the rooks movement must remain parallel to the x and y axis.

For remedial math exercises, the football yard markings will be used for adding positive and negative numbers, as the virtual players gain and/or lose yardage. Note: this particular skill of adding negative numbers (as the virtual quarterback keeps getting sacked) is of extreme value to the majority of my students who still struggle with addition and subtraction when dealing with negative numbers.

One Dimensional Math in Sports & Gaming

Most of the math used to describe sports can be performed using any 4 function calculator, and while the equations can get a bit complicated, you really are only dealing with addition, subtraction, multiplication and division. The following examples therefore can be visualized and plotted along a one dimensional number line. These include topics such as points/scoring, player and team stats, calculations of speed, and single dimensional left/right movement across a field of play.

It is important to remember that, as we introduce these sports math concepts, we are primarily concerned with getting the students involved in both envisioning the scenarios, and in creating/using their own data. By creating and describing situations, they can learn how to construct their own word problems with equations to match. These skills will be invaluable when they are later presented with other word problems on class assessments or standardized tests. By getting students involved in creating their own “real world” sports-related math problems, they take ownership of their learning and math development.IMPORTANT NOTE: While you may think that simple four function math problems may be too elementary in the study of algebra, my overwhelming observation with the math students I encounter, is that most of the obstruction in their learning lies in the fact that an alarming number of them have never learned to master the most basic math skills and their general integer and number awareness is severely lacking. A large contribution to this inability I believe can be attributed to the pandemic, where, when three years ago you may have had a sixth grader already struggling with perhaps a 2nd or 3rd grade math achievement level, and then for the next several years during lockdown, they did not progress. Unfortunately it is all too often the case that you encounter a large portion of struggling 9th graders who never learned their times tables and cannot even add or subtract single digit numbers without the help of a calculator. While this reality is sad beyond belief, still it is the reality we are faced with as math educators, and so, for ANY success in algebra, we will need to address these deficiencies head on. Please note that the scenarios below barely scratch the surface of what the kids can come up with, but are given here, merely as a jumping off point for their own creativity.

INTEGER AWARENESS WHEN ADDING NEGATIVE NUMBERS

1. **Scenario 1: Football 1st downs and QB sacks** - FYI - I am always astounded by the number of my 9-10 grade students who struggle with the concept of simply adding or subtracting when dealing with negative numbers. Even with the simplest attempts such as 3 - 6, or - 5 + 2 (or with a string of numbers like - 10 + 6 - 2 + 7) they will often be stuck dead in their tracks with a look of confusion. I have found that if they visualize a football game where the offense is trying to move down the field - this will oftentimes make much more sense to them. In the first term of 3 - 6, a simple question stating “If you gain 3 yards on one down, but your QB gets sacked and loses 6 yards on the next down, where do you end up with relation to where you started?“ (3 - 6 = - 3). Another scenario could be “You are on the 5 yard line (-5) hoping to score a touchdown and you only gain 2 yards (+2). Where are you now?” (- 5 + 2 = - 3). Or… “You begin your drive on the first down with 10 yards to go (-10) before you are granted another first down where you must cross the zero marker within 4 plays. On the first play you gain 6 yards (+ 6). On the 2nd down you lose 2 yards (- 2). On the 3rd down, you complete a short pass for a gain of 7 yards (+ 7). Where were you after each down? and… Have you successfully gained the 10 yards and passed the zero marker needed for another 1st down?” Answers: After 1st down gain of 4: - 10 + 6 = - 4 , After 2nd down loss of 2: - 4 - 2 = - 6 , After 3rd down gain of 7: - 6 + 7 = + 1 Yes you have earned a new 1st down!! Total yards gained of + 11 can be expressed as subtracting a negative number (normally a concept that makes their heads

spin!) or +1 - (-10) = + 11 (Difference between - 10 and +1) Note: you can also use this last equation to introduce the concept of absolute value as total distances - even though you are in the negative domain total distance traveled will always be positive. Student activity idea: have students go to a school football game and record data for some actual plays, and come back with examples of drives containing both yardage gains and losses, so that the data above could be actual real numbers with which they can create their own word problems incorporating themselves or their friends on the team.

INTEGER AWARENESS WHEN MULTIPLYING NEGATIVE NUMBERS

2. **Scenario #2: Hockey Penalty Box times a player is removed from the game** - Within the sport of hockey your students can formulate real world problems dealing with multiplying negative numbers with regard to a player's penalties he earns. Within a 60 minute game, when rules are broken a player can get temporarily ejected and sent to a penalty box for… 2 min in the case of a minor penalty (p = - 2) (which can also be doubled or tripled as multiple minors) OR 5 minute removal for a major penalty infraction (m = - 5), OR 10 min penalty (u = - 10) for unsportsmanlike misconduct such as fighting or disrespect to the ref.

Using this rubric, students can come up with all sorts of variations of word problems incorporating multiplying negatives such as "If a player is scheduled to play the full 60 min of a game and receives 4 minor penalties removing him for 2 min each (p = - 2), and also gets 3 major penalties where he loses 5 min each (m = - 5) and then gets in a fight and is kicked out another 10 min (u = - 10) how many total min T were subtracting from the time he should have been helping his team? One possible equation might be

T = 4(-2) + 3(-5) + 1(-10)   T = - 33 minutes

Or…   4p + 3m + 1u = T   "Solve for T when p = - 2, m = - 5 and u = - 10"

A follow up question could be "How many total minutes did he actually play?"

60 - 33 = 28 minutes of actual play

3. **Scenario #3: Multiplied negatives equal a positive by reversing penalties**

Here's a real world problem I came up with that will demonstrate how multiplying a negative times a negative will result in a positive - a concept that students know to follow but may not truly comprehend WHY this is the case. Imagine a football game where a referee (who is

biased towards the visiting team) unjustly calls multiple five yard penalties (p = -5) against the home team a total of 6 times within the last quarter of the game, causing the home team to be pushed back a total amount of 30 yards from the 50 yard line to the opponent's 20 yard line.
This is expressed as 6p = - 30 yards where p = - 5 Now imagine with only 2 minutes left in the game, they review the tapes and discover that the ref was, in fact, cheating to benefit his preferred visiting team. In this situation you would have to "undo" the 6 penalties (- 6) where each penalty was worth negative five yards (- 5) and of course the home team would have to gain back all 30 yards that were unjustly taken away from them. Hence, the equation (- 6) (- 5) = + 30 - a real world example proving that two negative numbers multiplied together must result in a positive number!!

WORKING WITH UNKNOWN VARIABLES IN WORD PROBLEMS

4. **Scenario #4: Working with variables to calculate basketball scoring**
Consider a basketball game where "Alex" in your 1st period class imagines himself playing for the Heat and makes 12 three point shots (t), and sinks 15 other various 2 point jump shots (j) to score a total of 66 points (P) Try to guide your students to construct this equation… 12(3) + 15(2) = 66 Next tell your students we want THEM to come up with several versions of the problem. First have them pretend that they DON'T know the total points and make that the unknown. Let the variable P be the unknown total points and now the equation reads 12(3) + 15(2) = P If the number of 3 pointers (t) is unknown then, it could read t(3) + 2(15) = 66 and conversely if the number of 2 point jump shots (j) is the unknown then 12(3) + j(2) = 66 For a problem with TWO unknown variables, you may know you will need two equations to solve. Here you could say "The number of 2 point jump shots is three more than the number of 3 pointers. AND the total points is 66
The two given equations are j = t + 3 and j(2) + t(3) = 66
By substituting t + 3 for j in the second equation will solve for t = 12 and plugging that back in the first equation will solve j = 15 Another variation of the same could be "Michael Jordan makes 12 shots in a row using a combination of 2 and 3 pointers to single handedly score 28 pts leading the Bulls to victory. Let x equal the number of 2 pointers and y equal the number of 3 pointers. Therefore, x + y = 12 shots and 2x +3y = 28 pts. (x = 8 and y =4) (He shot 8 two pointers and 4 three pointers scoring 28 pts)TIP: for personal relevance, do a variation of the above using actual real game stats from your students who play on the basketball team!! If you don't have any

students on the team, assign your students to go watch their friends and collect the “real world” data. Note: have your students come up with variations of scenario 4 above, but with other sports. - They can imagine all sorts of football scoring scenarios using field goals (3 pts), touchdowns (6 pts), 1 point TD extra points (1 pt), safeties (2 pts) and/or two point conversions.

As a challenge for some advanced students: have them try to create an equation which describes the totally crazy point system in tennis. If memory “serves” (pun intended) the scoring goes from 0 (“love”) to 1st point counting as 15, 2nd point as 15 more to equal 30, the third point as 10 more to give 40, and then either a win (if more than two points ahead) or switches to “duece” where one point each is given if tied called “advantage” - alternating back and forth until a two point lead (but only when serving!) yields a win.

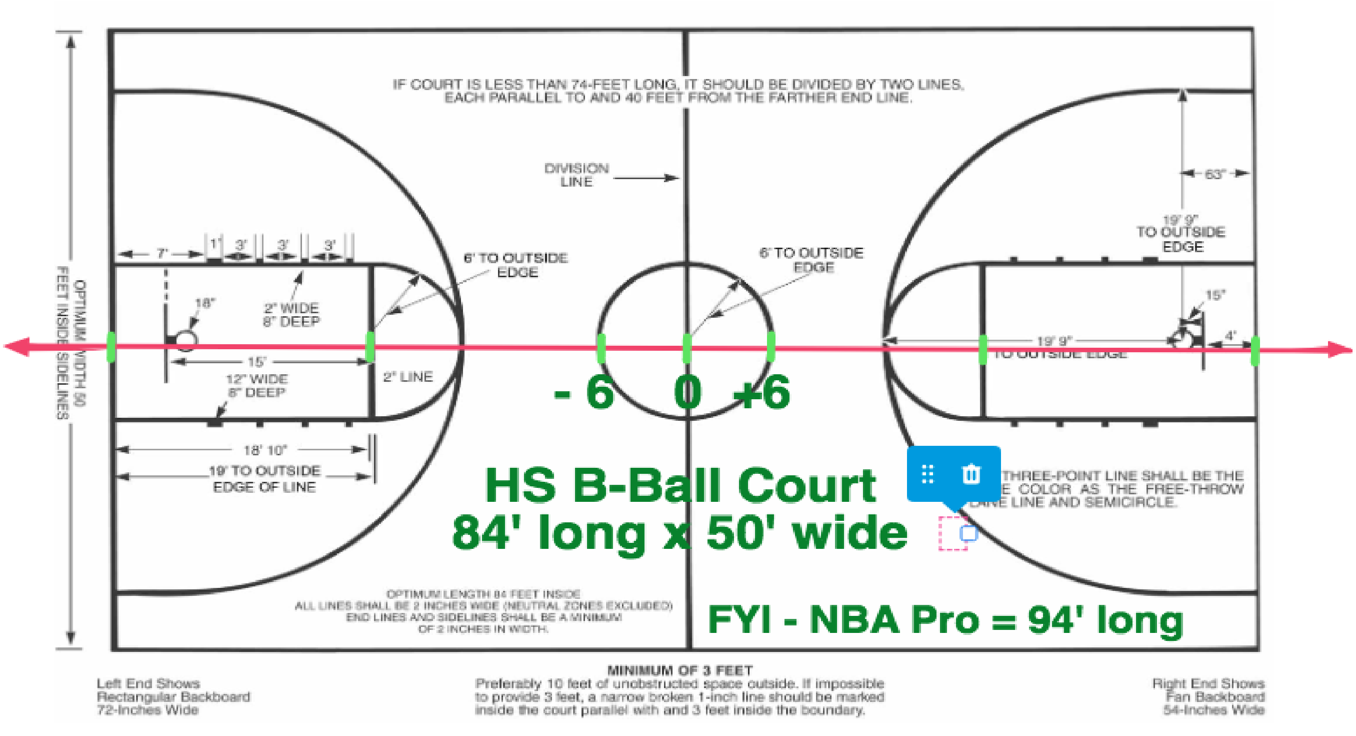
WORKING WITH ABSOLUTE VALUES

5. **Scenario #6: Deflategate Word Problem (Using Absolute Value Formula)**
   In 2014 there was a big scandal with the NFL during the AFC Championship game between the New England Patriots and Indianapolis Colts. Tom Brady, QB of the Pats, was accused of deliberately deflating the footballs giving them

a distinct advantage. According to league rules, the game footballs should be inflated to a pressure of 13 pounds per square inch (psi) with allowable variation of plus or minus .5 psi. Investigations revealed that 5 of 11 footballs were underinflated beyond acceptable levels and the team was fined $1M, while Brady was suspended for 4 games. Create an absolute value equation to determine the minimum and maximum allowable psi and solve for both.
   Answer. $|p - 13.0| = .5$ Minimum acceptable inflation p = 13.5 psi
   Maximum acceptable inflation p = 14.5 psi

6. **Scenario #5: Basketball “suicide drills” computation.** Here’s another fun number line challenge incorporating both positive and negative domains (and absolute values). In basketball there is a extremely grueling running drill called “suicide drills”. (Pardon the political incorrectness of the term, but that is what they have always been called.) In this drill, the runners start on the baseline and run to the nearest free throw line 19 ft away, back to the baseline, then to the half court (at 42’), back to the start, then the far free throw (19 ft from the far baseline), back again, all the way to the far bassline (84’) and finally return to the beginning to complete one rep. Thus, it is a total of four round trips, each of differing lengths. The students will use the diagram

of a HS B-ball court (shown below) - which is 84 ft long, and with the superimposed number line where half court is at 0.



Imagine the chaos as they navigate both positive and negative domains along with the integer math used to compute the entire rep!!! Hint: they begin on the baseline at negative 42. Be sure they can identify where on the number line each turning point is.

HInt: total distance for a HS court is 420 ft = 2(19) + 2(42) + 2(65) + 2(84)
THEN… as an added challenge have them calculate the same for an NBA court where the total length is 94 ft (but the free throw lines remain at 19 ft from the basslines). One NBA rep here would be…

470 ft = 2(19) + 2(47) + 2(75) + 2(94)

Lastly, have your students try to explain why the NBA full rep of 470 ft is 50 ft more than the HS rep of 420 ft, when the NBA court is only 10 ft longer?? Answer: 1st RT to nearby free throw is the same for both courts since FT line is measured the same from starting baseline; 2nd RT to half court adds **10 ft** since the halfway difference is 5 ft each way; 3rd RT adds **20 ft** since that free throw line is measured from the far baseline adding the full 10 ft difference each way; last RT also adds **20 ft** (the full 10 ft difference both ways).

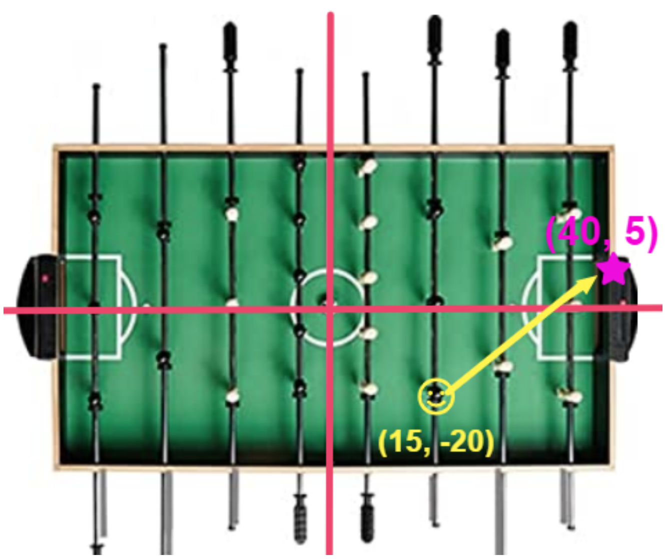
OTHER INTEGER BASED SPORTS CALCULATIONS

As you can imagine, we have only scratched the surface in just a few examples of integer based calculations found in sports. Many websites and books are devoted to the subject (see extensive resource list). If you think about it, really most sports stats numbers are really just a result of averages and/or percentages expressed as oftentimes one or two step single variable equations. These include win/loss percentage, shooting percentage, batting Average, ERA, and a myriad of Speed, Distance, and Time Calculations. Remember for batting averages, to calculate your proportion extended to the 3rd (thousandths) place. For the unit on exponential decay, use the March Madness bracket to describe the number of remaining teams after each round $f(x) = 64(.5)^2$.

Two Dimensional Math in Sports & Gaming

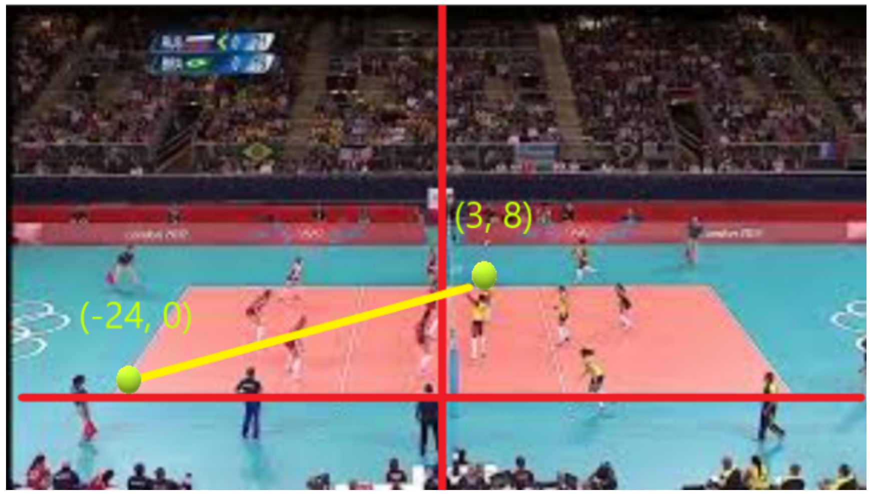
WORKING WITH LINEAR EQUATIONS

7. **Scenario 7: Soccer (Foosball) shots on goal expressed as coordinate points, line, and slope.**



In this scenario we will engage the students in a live 3D diorama of a soccer game, by either using a picture of a soccer field, or (if budget is available), an actual foosball table in the classroom. We overlay an xy coordinate system on top of a playing field using tape or markers (shown in red below) and will show the path (shown in yellow below) of a ball that is kicked across the field from a yellow player who is at the coordinate point of (15, -20) into the corner of the goal (shown in purple) to the point of (40, 5) For our live demonstration, the path of the ball represented in a yellow line with arrow below will actually be glow sticks affixed together. Using these two given points, the students will have to calculate the equation for the line, the slope of the line, and finally, the distance between these two points, in order to determine how far the player has to kick the ball.

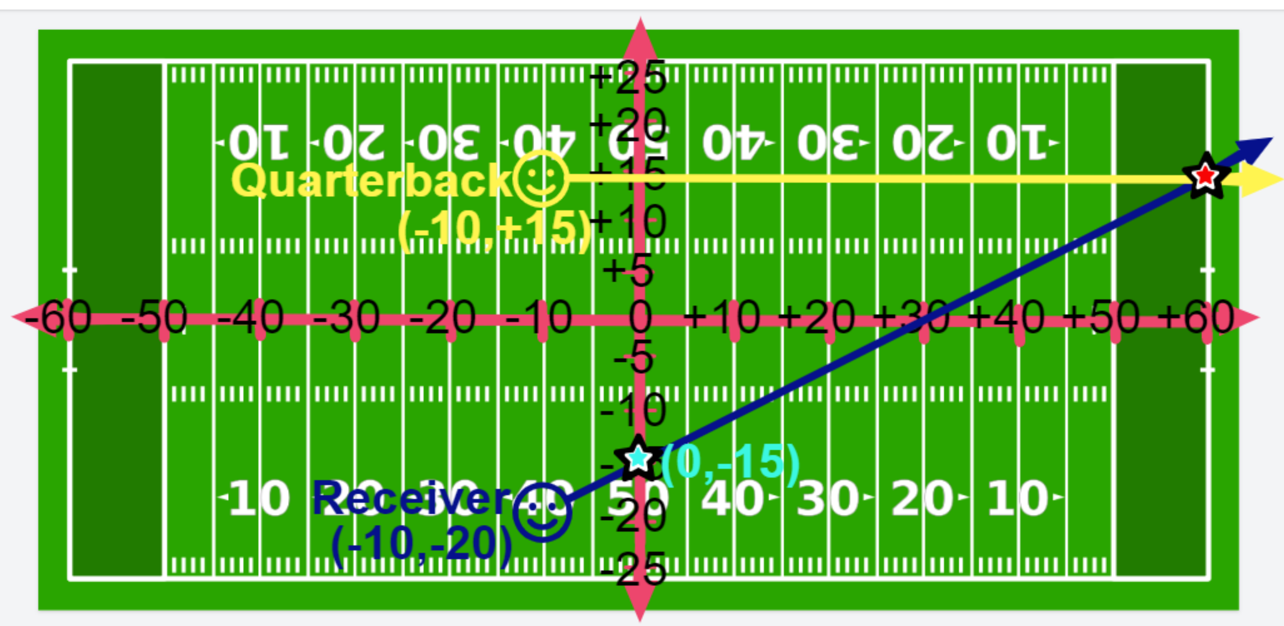
8. **Scenario 8: Line describing a Volleyball spike from above the net**



Here we have a volleyball court where the x axis is the ground depicting how far the players are from the net and the y axis is located center court meauring height above the ground. The player is located 3 feet from the net and jumps to spike a ball at 8 ft in the air (3, 8). She spikes the ball so hard the path, for our purposes, isa straight line and lands at the ground in the opponent's court 24 feet from the net in the very corner at (-24, 0). Calculate the height of the ball as it travels over a 6 foot net (ie. the y intercept). How high above the net did the ball clear the net? Where is the x intercept? (A: At zero where it hits the ground at -24 ft) How far did the ball travel? Hint: must use the value of the hypotenuse of the created right triangle.

9. **Scenario #9: "Hail Mary Pass" (TD yes or no?)**

The scenario below depicts two intersecting lines showing the path of a thrown football (yellow) vs. the running path of a receiver (blue).

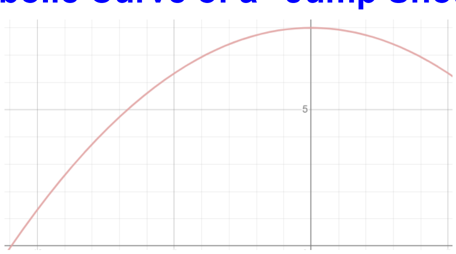


Both teammates begin at the line of scrimmage on the opponents 40 yard line (x = -10 for our purposes). Using our superimposed grid, you can see the QB (yellow smiley face) is located on the left part of the field at point (-10, 15) while the receiver (blue smiley face) begins running from near the right sideline (-10, -20). The QB throws a “Hail Mary” pass directly straight across the field towards the end zone. After some class discussion, the students SHOULD conclude that the equation representing the path of the football would be $y = 15$ and would have a slope of 0 since it is a horizontal line. Meanwhile,the receiver begins running on a diagonal across the field and crosses the 50 yard line, or y axis, exactly 15 yards to the right of center (0 , -15), marked by the light blue star. (At this point you must make the obligatory “dad joke” about the defense ALSO crossing the 50 yard line, but closer to the QB as they attempt to make a “y intercept-ion”!!) Now once two points of the receiver’s path line is known, the students should be able to equate both the equation $y = \frac{1}{2} x - 15$ and the slope $m = \frac{1}{2}$ Next have the students calculate where the two lines intersect (i.e. Where on the field is the ball caught - as shown in the diagram as the red star?) The reception location calculates to the point (60, 15) . Now is the time for a fun class debate.. Since this point is EXACTLY on the out-of-bounds line in the back of the end zone, will this be considered a touchdown or not? (My understanding of the NFL rules is that, as long as both player’s feet are still in bounds when the ball is caught, the ball itself can be over the line, but it will still be good. Note: these rules MAY be different for NFL, College and HS??) Lastly, have the students calculate the total distance our QB had to throw the ball 60 - (-10) = 70 yards as well as the total distance the receiver ran. Hint: lead your students into realizing this path is the hypotenuse of a triangle created and so will need to remember the Pythagorean Theorem $a^2 + b^2 = c^2$ Answer: d = 78.262379 total yards ran

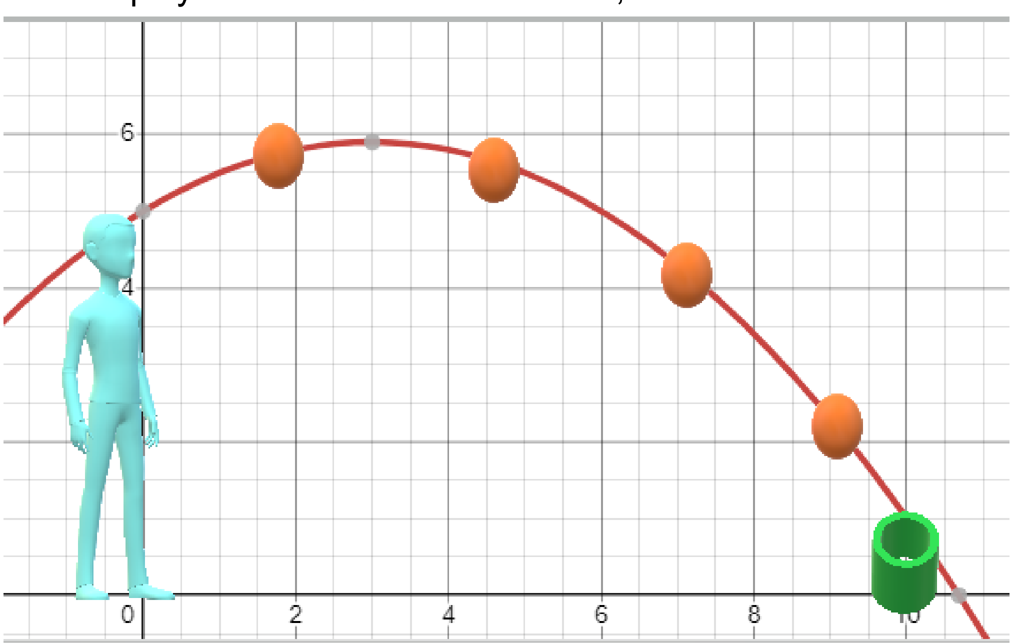
For: $(X_1, Y_1) = (-10, -20)$ and $(X_2, Y_2) = (60, 15)$ $d = \sqrt{(60-(-10))^2 + (15-(-20))^2}$

WORKING WITH QUADRATIC EQUATIONS

10. The Parabolic Curve of a “Jump Shot”



This exercise can be used to describe many different sports scenarios where ANY projectile is thrown, shot or kicked. Once the students realize this, have them come up with as many examples as possible. Now to get the students fully engaged, they can re-create this scenario live in the classroom with students taking turns shooting “jump shots” as they throw a paper wad across the front of the classroom into waste basket (or if available, using a small game hoop set that attaches to the back of a door). Have other students in the back take a video and then review the projectile's path so that another team of students build a lifesize parabola made out of connected glow sticks. Have them experiment with different distances and heights of the shot, to then hypothesize which approach might give the best results, a flat shot, a super high shot, or medium arch. Note: sports research has shown the most successful shots will have the ball enter the rim at a 45 degree angle. By using screen shots of various glow stick parabolas, the students can share and display on the classroom's smart board, superimpose a coordinate system graph, and try to calculate the various quadratic functions displayed. An alternate approach would be to utilize a projection of the the desmos graphing calculator and hold up the glow sticks in front of it. Or simply by looking at the desmos display and try to recreate the path, even if it is thru trial and error. While there are many ways to look at this, one visualization might be to imagine the shooter standing at the y axis and throwing the wad of paper into a waste paper basket sitting on the floor 10 feet away. Help them realize that the path of the "ball" in this situation actually begins not on the ground but perhaps 5 feet up (or the height of the participant). This would be the y intercept (0 , 5) and so the constant in our quadratic function would be 5. Also at the 10 ft mark the "rim" in this also is not at the floor (x axis) but the wastebasket might be 1 ft tall. Lastly, the parabola should cross this target point (10 , 1) at approximately a 45 degree angle (or slope of -1). If the shot has the correct distance, but he misses it should hit the ground (x intercept) at approximately (11 , 0). Using these guidelines, and through some trial and error, I came up with the equation $y = -.1x^2 + .6x + 5$ and the graphed parabola is displayed below. Once determined, then ask them the vertex!



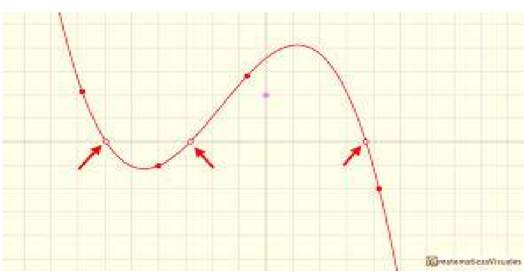
11. Parabolas created by snapshots of jump ropers, as rope rotates.

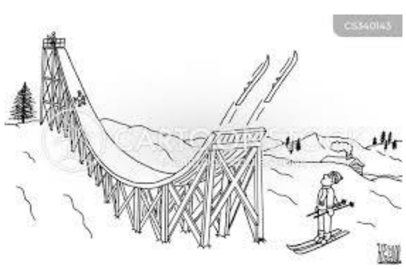
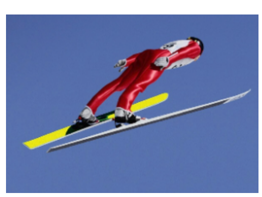
Using these same math concepts of parabolas and manipulation of quadratic functions, another fun activity would be to have your students try to jump rope and consider what shapes are viewed by an observer as the rope rotates. The students can even try to use the glow sticks as the rope to use with various snapshots along its path to be analyzed.(see below). When the “rope” is in the bottom half of its journey, this is a nice “real world” example of a quadratic function showing an upward facing parabola defined by a quadratic function with a **positive** leading coefficient!! (Doesn’t it seem like 99% of the real world examples are always projectiles, so we always have the negative x^2 !) They should realize that as the rope rotates, the parabola flattens out and at the midway point becomes a straight line along the x axis. Again, use desmos to help with immediate feedback to help them truly understand how we manipulate our parabolic friends!

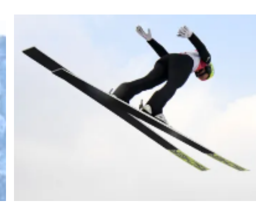
WORKING WITH CUBIC EQUATIONS

12. Scenario 12: Path of ski jumper expressed as a cubic function

Finally we have one last example of a real world sports scenario that is, from my imagination, the only representation I can come up with of a cubic function, although admittedly this MAY be a bit of a stretch! Here we imagine the Olympic ski jumper starting at the top of our graph, traveling down the ramp, jumping off at the middle arrow, shooting up, flying through the air and landing at the right arrow. You can do your own math here! This reminds me of the old sports announcer, as he shouts his ageless wisdom to all math teachers of the world….. “The thrill of victory! The agony of defeat!”





Resource List

http://www.projectglobalawakening.com/cartesian-coordinate-system/

https://www.mathgoodies.com/Webquests/sports

https://www.hunter.cuny.edu/dolciani/Images%20and%20Files/files/workshop-powerpoints/Mathematics%20In%20Sports%20adaptation%202020%20edits.pdf

http://jwilson.coe.uga.edu/EMAT6680/Huffman/Mathematics%20in%20Sports/MathematicsSports.html

https://www.mathgoodies.com/Webquests/sports

https://hellothinkster.com/blog/algebra-help-summer-sports/

https://youtu.be/lepXR9mBRb0

https://youtu.be/66ko_cWSHBU

https://youtu.be/AqDxrj8K480

https://www.teacherspayteachers.com/Product/4th-Grade-Math-Word-Problem-Task-Cards-Sports-Theme-Print-and-Digital-1212575?st=4fd6baa60f19fbca08298c35f6ed8a3b

https://www.teacherspayteachers.com/Product/5th-Grade-Math-Madness-All-STAAR-TEKS-Games-3055985?st=4fd6baa60f19fbca08298c35f6ed8a3b

Optional Materials/Costs/Amazon Links

1) Triumph 13-in-1 Combo Game Table (qty=1) $161.99
https://www.amazon.com/Triumph-Basketball-Billiards-Football-Tic-Tac-Toe/dp/B01MQD7TSR/ref=sr_1_11?crid=63G40TLZ7VCR&keywords=combo+game+table+set+for+home&qid=1655220570&s=sporting-goods&sprefix=%2Csporting%2C73&sr=1-11

2) Best Choice Products 2x4ft 10-in-1 Combo Game Table Set (qty=1) $169.99
https://www.amazon.com/Best-Choice-Products-Foosball-Shuffleboard/dp/B07PK672WW/ref=pd_lpo_1?pd_rd_i=B07PK672WW&psc=1

3) 300 Glow Sticks Bulk $25
https://www.amazon.com/Glow-Sticks-Bulk-Party-Supplies/dp/B07D4LLMGL/ref=sr_1_3_sspa?crid=10AMPJLO9QRU1&keywords=glow%2Bsticks&qid=1655221327&s=sporting-goods&sprefix=Glow%2Csporting%2C89&sr=1-3-spons&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEzSlRNU0Y3MTJNQlY3JmVuY3J5cHRlZElkPUEwNzc1NzE1MVVQRlRETVY1RUNSRCZlbmNyeXB0ZWRBZElkPUEwODc1MDU2M0hKUjFMUEpQU1NZOSZ3aWRnZXROYW1lPXNwX2F0ZiZhY3Rpb249Y2xpY2tSZWRpcmVjdCZkb05vdExvZ0NsaWNrPXRydWU&th=1

4) Sports Balls with Hand Pump 4 Pack $12.89
https://www.amazon.com/Sports-Balls-Hand-Pump-Toddlers/dp/B09CBZL8JB/ref=sr_1_7?crid=7V5UHD1C6DCN&keywords=sports+ball+set&qid=1655222010&s=sporting-goods&sprefix=sports+ball+set%2Csporting%2C82&sr=1-7

5) TREYWELL Indoor Basketball Hoop $33.14
https://www.amazon.com/TREYWELL-Indoor-Basketball-Electronic-Scoreboard/dp/B08HJYGV2G/ref=sr_1_2?crid=1UIN6NDH2LKY8&keywords=indoor%2Bbasketball&qid=1655222252&s=sporting-goods&sprefix=indoor%2Bbasketball%2B%2Csporting%2C83&sr=1-2&th=1

6) Football Tablecloth Plastic | 3 Pcs $9.79
https://www.amazon.com/dp/B08Q1LK8YP/ref=sspa_dk_detail_1?psc=1&pd_rd_i=B08Q1LK8YP&pd_rd_w=0Y54H&content-id=amzn1.sym.81235241-515c-4d38-b71a-0a05c42c47dd&pf_rd_p=81235241-515c-4d38-b71a-0a05c42c47dd&pf_rd_r=T2SSERV8GNRWES80NCN5&pd_rd_wg=m9BtR&pd_rd_r=f5df3c0e-81c8-44f1-b54a-d0a50bb3ff3c&s=sporting-goods&smid=A14SZFZ97ROYVQ&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUExVklIVExZQUc5VVRZJmVuY3J5cHRlZElkPUEwMDQwNzM0MVMwMUVUNE80WFRGOSZlbmNyeXB0ZWRBZElkPUExMDA5MzYwSlFGMVRSTVExTkFUJndpZGdldE5hbWU9c3BfZGV0YWlsX3RoZW1hdGljJmFjdGlvbj1jbGlja1JlZGlyZWN0JmRvTm90TG9nQ2xpY2s9dHJ1ZQ==

7) 4 Pieces Sports Theme Banners $9.99
https://www.amazon.com/Basketball-Football-Baseball-Birthday-Decorations/dp/B085VY281K/ref=pd_day0fbt_img_sccl_1/145-1865319-5042257?pd_rd_w=RN9Gt&content-id=amzn1.sym.0a3d352f-2699-4ba2-810c-59dcb4abfa1b&pf_rd_p=0a3d352f-2699-4ba2-810c-59dcb4abfa1b&pf_rd_r=2TKVAM2S2ZD46WG0QCJR&pd_rd_wg=gpGun&pd_rd_r=a6deb719-a343-4700-8027-177fd206383d&pd_rd_i=B085VY281K&psc=1

8) Cricut Maker - Smart Cutting Machine $228.98
https://www.amazon.com/Cricut-2005464-Maker-Blue/dp/B07KWBLNHM?tag=offersamzn-20&ascsubtag=05W7oaaYbHanZx97HsJSFGB

9) Cricut Cutting Mat 3 pack $17.48
https://www.amazon.com/Cricut-Variety-Mat-Mats-2003546/dp/B00HVIXC22/ref=pd_day0fbt_img_sccl_1/145-1865319-5042257?pd_rd_w=BWGU1&content-id=amzn1.sym.134f9fe5-f651-42b4-bca3-da68afd012fb&pf_rd_p=134f9fe5-f651-42b4-bca3-da68afd012fb&pf_rd_r=EXZ3VN5XWX0R9WX3PREZ&pd_rd_wg=yXdGi&pd_rd_r=5ade73ca-c509-4c91-8415-3fcc4ff75d2c&pd_rd_i=B00HVIXC22&psc=1

10) Cricut Basic Tool Set $9.89
https://www.amazon.com/Cricut-Basic-Tool-Core-Colors/dp/B07STGLY6J/ref=pd_day0fbt_img_sccl_1/145-1865319-5042257?pd_rd_w=ZPTib&content-id=amzn1.sym.134f9fe5-f651-42b4-bca3-da68afd012fb&pf_rd_p=134f9fe5-f651-42b4-bca3-da68afd012fb&pf_rd_r=YNSRX8ET2R3CAJK4QTJ3&pd_rd_wg=WasPe&pd_rd_r=976ba337-effd-4e88-9f0e-3d0b76a6f991&pd_rd_i=B07STGLY6J&th=1

11) Cricut Kassa Permanent Vinyl Sheets pack $24.95
https://www.amazon.com/Kassa-Permanent-Adhesive-Vinyl-Sheets/dp/B078XL6J8F/ref=sr_1_2_sspa?crid=3JPCKQ7UXZ9RM&keywords=cricut+paper&qid=1655229093&sprefix=cricut+paper%2Caps%2C105&sr=8-2-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEzOVlFTjkzODZNM1ZYJmVuY3J5cHRlZElkPUEwNDA4NzE4MVJPOE9GNURZMzlMQSZlbmNyeXB0ZWRBZElkPUEwNjMwOTA1MVBRMVlNQTdDTEFKOSZ3aWRnZXROYW1lPXNwX2F0ZiZhY3Rpb249Y2xpY2tSZWRpcmVjdCZkb05vdExvZ0NsaWNrPXRydWU=

12) ROBDAE Portable Desktop Scoreboard $40.89
https://www.amazon.com/ROBDAE-Scoreboard-Competition-Basketball-Scoreboards/dp/B07ZJ4YKB8/ref=sr_1_33?crid=AS9SICCRWDZS&keywords=desktop+scoreboard&qid=1655240326&s=sporting-goods&sprefix=desktop+scoreboard%2Csporting%2C75&sr=1-33

13) JL497 Algebra Dominoes $12.99
https://www.amazon.com/Junior-Learning-Algebra-Dominoes-Educational/dp/B077BYMBX2/ref=asc_df_B077BYMBX2/?tag=hyprod-20&linkCode=df0&hvadid=241894971494&hvpos=&hvnetw=g&hvrand=5934025047325329211&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9052220&hvtargid=pla-654710200708&psc=1

14) Baseball: The Math of the Game (Sports Math) Paperback $8.19
https://www.amazon.com/Baseball-Math-Game-Sports/dp/142967315X/ref=asc_df_142967315X/?tag=hyprod-20&linkCode=df0&hvadid=312087669297&hvpos=&hvnetw=g&hvrand=5934025047325329211&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9052220&hvtargid=pla-492761746543&psc=1

15) 24 Game 96-Card Deck: Algebra/Exponents Math Card Game $20.04
https://www.amazon.com/24-Game-Algebra-Exponents-Ages/dp/B0006U2OFS/ref=asc_df_B0006U2OFS/?tag=hyprod-20&linkCode=df0&hvadid=312133084246&hvpos=&hvnetw=g&hvrand=5934025047325329211&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9052220&hvtargid=pla-571158782116&th=1

16) 24 Game Multiply/Divide Primer $17.96
https://www.amazon.com/24-Game-Algebra-Exponents-Ages/dp/B0009GD084/ref=asc_df_B0006U2OFS/?tag=hyprod-20&linkCode=df0&hvadid=312133084246&hvpos=&hvnetw=g&hvrand=5934025047325329211&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9052220&hvtargid=pla-571158782116&th=1

17) 24 Game Factors/Multiples $24.99
https://www.amazon.com/24-Game-Algebra-Exponents-Ages/dp/B0009GU294/ref=asc_df_B0006U2OFS/?tag=hyprod-20&linkCode=df0&hvadid=312133084246&hvpos=&hvnetw=g&hvrand=5934025047325329211&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9052220&hvtargid=pla-571158782116&th=1

18) The Secret Science of Sports: Paperback $14.97
https://www.amazon.com/Secret-Science-Sports-Mechanical-Engineering/dp/0762473037/ref=sr_1_1?crid=3SVCJOEC6NU4E&keywords=algebra+sports&qid=1655269063&sprefix=algebra+sports%2Caps%2C74&sr=8-1

19) Mathletics: Paperback 18.99
https://www.amazon.com/Mathletics-Gamblers-Managers-Mathematics-Sports/dp/0691177627/ref=sr_1_6?crid=3SVCJOEC6NU4E&keywords=algebra+sports&qid=1655269349&sprefix=algebra+sports%2Caps%2C74&sr=8-6

20) Pre-Algebra Word Problems For Sports Fans: Paperback $11.99
https://www.amazon.com/Pre-Algebra-Word-Problems-Sports-Fans/dp/B09Q6SZFJW/ref=sr_1_8?crid=3SVCJOEC6NU4E&keywords=algebra+sports&qid=1655269349&sprefix=algebra+sports%2Caps%2C74&sr=8-8