Milford Public Schools Curriculum

Department: Mathematics

Course Name: Mathematics of Sports and Game Theory

Course Description: Students will investigate the connection between mathematical models and sports. Students will apply concepts from physics including projectile motion and measurement, and also statistical concepts such as those used in tracking player performance. Students will apply laws of probability, statistics and game theory through the models of well-known games and sports. Fundamental laws of probability will be developed and applied to games.

UNIT #1

Unit Title: Probability

Unit Description: Students will explore how probability relates to games and sports of their choosing.

LEARNING GOALS

Enduring Understanding(s):

- Calculating probability is determined based on factors such as replacement, independence, and number of trials.
- Probability curves become closer to normal distributions the more trials you conduct

Essential Question(s):

- How is probability used to create fair games and predict outcomes?
- How is sample size used to create a normal distribution?

Content and Skills:

Students will be able to:

- Determine if two events are independent
- Calculate probabilities of dependent and independent events
- Calculate probabilities with and without replacement
- Determine the number of necessary trials to create a normal distribution

Standards Addressed:

CCSS.MATH.CONTENT.HSS.CP.A.2
Understand that two events A and B are independent if the probability of A and B occurring together is the product of their probabilities, and use this characterization to determine if they are independent.

CCSS.MATH.CONTENT.HSS.CP.A.5
Recognize and explain the concepts of conditional probability and independence in everyday language and situations.

CCSS.MATH.CONTENT.HSS.CP.B.6
Find the conditional probability of A given B as the fraction of B's outcomes that also belong to A, and interpret the answer in terms of the model.

CCSS.MATH.CONTENT.HSS.CP.B.7
Apply the Addition Rule, P(A or B) = P(A) + P(B) - P(A and B), and interpret the answer in terms of the model.

CCSS.MATH.CONTENT.HSS.CP.B.8
(+) Apply the general Multiplication Rule in a uniform probability model, P(A and B) = P(A)P(B|A) = P(B)P(A|B), and interpret the answer in terms of the model.

CCSS.MATH.CONTENT.HSS.CP.B.9
(+) Use permutations and combinations to compute probabilities of compound events and solve problems.

UNIT #2

Unit Title: Statistics

Unit Description: Students will explore how statistics are used to compare and rank players within the same and different sports, as well as how they are used to predict results of games.

LEARNING GOALS

Enduring Understanding(s):
- Z scores allow for comparing values on a non-equivalent scale.
- Statistics can be used to predict the outcomes of games and players.

Essential Question(s):
- How are statistics used to predict results and compare players?

Content and Skills:
Students will be able to:
- Calculate z-scores
- Predict outcomes using statistics
- Compare players based on z-scores
- Calculate weighted and unweighted averages
- Make and compare graphs (box-plots, dot plots, bar graphs)
- Calculate and interpret standard deviation
- Calculate curve of best fit using scatterplots

Standards Addressed:

CCSS.MATH.CONTENT.HSS.IC.A.1
Understand statistics as a process for making inferences about population parameters based on a random sample from that population.

CCSS.MATH.CONTENT.HSS.ID.B.6
Represent data on two quantitative variables on a scatter plot, and describe how the variables are related.

CCSS.MATH.CONTENT.HSS.ID.A.1
Represent data with plots on the real number line (dot plots, histograms, and box plots).

CCSS.MATH.CONTENT.HSS.ID.A.2
Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile

range, standard deviation) of two or more different data sets.

CCSS.MATH.CONTENT.HSS.ID.A.3
Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).

CCSS.MATH.CONTENT.HSS.ID.A.4
Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve.

UNIT #3

Unit Title: Algebra in Sports

Unit Description: Students will explore how quadratics are connected to different sports and affected by variables.

LEARNING GOALS

Enduring Understanding(s):	**Essential Question(s):**
● The path of a ball can be modeled using quadratics ● Quadratics can be used to find height, velocity, distance and time of a ball in motion	● How do quadratics relate to and impact sports?

Content and Skills:
Students will be able to:
- Use quadratics to calculate appropriate height and distance given specific variables
- Write quadratics to model a ball in motion
- Graph a quadratic to model a specific situation
- Define the coefficients within a quadratic
- Compare results when coefficients such as initial height are altered

Standards Addressed:

CCSS.MATH.CONTENT.HSA.CED.A.1
Create equations and inequalities in one variable and use them to solve problems.

CCSS.MATH.CONTENT.HSA.CED.A.2
Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.

CCSS.MATH.CONTENT.HSA.REI.B.4
Solve quadratic equations in one variable.

CCSS.MATH.CONTENT.HSF.IF.B.4
For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of

the quantities, and sketch graphs showing key features given a verbal description of the relationship.

CCSS.MATH.CONTENT.HSF.IF.B.5
Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes.

CCSS.MATH.CONTENT.HSF.IF.C.7
Graph functions expressed symbolically and show key features of the graph, by hand.

UNIT #4

Unit Title: Geometry in Stadiums, Fields and Courts

Unit Description: Students will explore the layouts of fields/courts, board games and stadiums to understand patterns of shapes, angles and sizes.

LEARNING GOALS

Enduring Understanding(s):
- Field/court designs and board games can be represented using different equations.
- The volume of stadiums impacts maximum capacity and profit.
- Patterns exist within angles and symmetry of fields.

Essential Question(s):
- Why are stadiums built the way they are?
- What shapes/angles are used most commonly in fields/courts and why?

Content and Skills:
Students will be able to:
- Write equations of lines, circles and quadratics
- Calculate distance
- Find area and perimeter
- Measure angles
- Calculate volume and surface area
- Calculate profit, revenue and expenses
- Determine optimal stadium size

Standards Addressed:
- **CCSS.MATH.CONTENT.HSG.GPE.B.7**
  Use coordinates to compute perimeters of polygons and areas of triangles and rectangles.
- **CCSS.MATH.CONTENT.HSG.SRT.C.8**
  Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems.
- **CCSS.MATH.CONTENT.HSG.SRT.B.5**
  Use congruence & similarity criteria for triangles to solve problems and prove relationships in geometric figures.
- **CCSS.MATH.CONTENT.HSG.MG.A.1**
  Use geometric shapes, their measures, and their properties to describe objects.

- **CCSS.MATH.CONTENT.HSG.MG.A.2**
  Apply concepts of density based on area and volume in modeling situations

- **CCSS.MATH.CONTENT.HSG.MG.A.3**
  Apply geometric methods to solve design problems