**PokéMath: The Mathematics of Pokémon Go®**

**Math:1260**

Season 20XX

Note: Copyright and Trademark rights for Pokémon® and Pokémon Go® are owned by Nintendo of America Inc.

**Instructor: TBD**  
**Office:** TBD  
**Walk-in hours:** TBD Students are invited to drop by during these hours to discuss questions about the course material or concerns. I am also available by appointment if you are unable to attend my walk-in hours.  
  
**E-mail:**   
**DEO:**

**Prerequisites:** None

**Time and location:** Lectures 1:30-2:20 PM Mondays and Wednesdays in 213 MLH.

**Discussion sections:** Thursdays: 11:00-11:50 AM in 40 SH.

Have you ever wondered what makes Tyranitar so good for raids? Or what the appraisal of IVs means? Or if a razzberry really makes that Pokémon® easier to catch? In this course we will dig into these questions and more! Along the way, you will be exposed to the core practice of applied mathematics: identifying questions, developing mathematical models, and analyzing those models. We will learn how to use ideas from algebra, statistics, and precalculus to take your Pokémon Go® play to the next level.

The course is organized in three modules, “I choose you” where we learn about Pokémon® types, attributes and stats, “gotta catch ‘em all”® where we will learn about catching Pokémon® and modifiers such as berries, balls and throws, and “to be the very best” where we will learn about player vs player battles, damage and defense. Each module includes an introduction to related mathematical ideas, homework, and in-class group work to practice key techniques, and a capstone project where you will use examples and data from your own game play.

**Course Description:**

This course is built around three core themes:

**Mathematics is a language**: It is fundamentally a way to communicate complex ideas. We will focus on learning to use the language of mathematics to make convincing arguments. Students will learn to choose clear and concise notations, to write for a technical audience, and to incorporate mathematics into their discussions about complex questions.

**Mathematics is the art of problem solving**: It is more than a collection of tools we use to solve homework problems. Students will learn fundamental mathematical techniques in algebra, statistics and mathematical modeling and will learn to use these techniques to deepen their understanding of problems arising in the game.

**Mathematics is everywhere**. Yes, even in Pokémon Go®. Students will be encouraged to see mathematics all around them and explore the ways in which mathematical ideas impact their experiences.

**Learning Outcomes:** Students will be exposed to the core practice of applied mathematics: identifying questions, developing mathematical models, and analyzing those models. The first module focuses on sets and functions and includes set notation, Venn diagrams, unions and intersections, functions, representations of functions in tables and formulas, piecewise functions and invertible functions. The second module focuses on probability and statistics, including data collection and management, probability, conditional probability, discrete random variables, uniform distributions, independence, other distributions, and an introduction to basic statistics such as mean, median, mode and variance. The third module focuses on rates of change and game theory, including calculations of average rate of change and total change.

**Top Hat:** We will be using **Top Hat Pro** ([www.tophat.com](http://www.tophat.com)) for class participation. You will be able to submit answers to in-class questions using smartphones and tablets, computers, laptops, or through text message. For instructions on how to create a Top Hat account and enroll in our Top Hat Pro course, please refer to the invitation sent to your school email address or consult Top Hat's Getting Started Guide (<https://bit.ly/31TGMlw>).

**Textbook:** *Mathematics with Applications in the Management, Natural and Social Sciences*. Lial, Hungerford, Holcomb, and Mullins. 12th Edition. We will cover material from chapters 3, 4, 8, 9, 10, and 11.

**Online Resources:** Additional readings will be from online resources including

<https://gamepress.gg/pokemongo>

<https://pokemongohub.net>

<https://thesilphroad.com/science/>

<https://bulbapedia.bulbagarden.net/wiki/Main_Page>

<https://www.serebii.net/index2.shtml>

**Structure:** We will have two lectures and one discussion section each week. The semester is divided into three modules, each five weeks in length. Each module will be worth a total of 200 points spread across three homework assignments, four in class group work assignments, ten in class clicker questions, and a final project. The homework assignments will be due in weeks 1, 2, and 3 of the module. Each homework will be worth a total of 20 points and include a computational and an expository portion. The group work assignments, done in discussion, are each worth 15 points. The in class “clicker” questions using Top Hat are worth 2 points per lecture. And each module will culminate in a project worth a total of 60 points, subdivided among three assignments: proposal, data collection, and analysis. In week 3 students will submit a proposal, including their hypothesis and experimental design. In week 4 students will submit a summary of their data, including any changes in the experimental design. This stage focuses on data collection and data management using the software excel. In week 5, students will submit their full project with mathematical analysis.

Homework: Each assignment has problems asking you to make calculations using the mathematical ideas and notation introduced. Each also has a writing question where you will give an explanation using mathematical themes and notations from that week.

Group work: Each week in discussion, you will work in small groups on problems related to the recent lecture content. These are designed to give you further opportunities to practice key problem-solving skills and to gain experience in explaining your calculations to classmates.

Top Hat: During lecture, you will have a chance to put your new knowledge to work immediately. For Top Hat questions, you will earn points for participation and for a correct answer.

Projects: See outlines below for the projects which provide the capstone for each module. The first stage of the project will be worth 10 points and will be graded for clarity and for the degree to which the proposed project makes use of the mathematical topics from that module. Because we want you to be creative while still ensuring that your proposals are feasible and use the techniques you are learning, the initial proposal may be revised. You will have the opportunity to resubmit your proposal with the second stage and recoup any points lost up to the total of five. The second stage will be worth 20 points and will be graded for complete and organized data collection. The third stage is the final project report. It will be worth 30 points. The reports will be graded on each section: Introduction (6 points), Methods (6 points), Results (10 points), and Discussion (8 points). The later sections must include the application of the mathematical ideas and techniques from that module to address the hypothesis.

**Grading:** 600 total points are possible for the semester. Grades will be assigned with a standard scale. That is 90-100% or 540-600 points is A- to A, 80-90% or 480-540 points is B- to B+, 70-80% or 420-480 points is C- to C+, 60-70% or 360-420 points is D- to D+, and 0-60% or 0-360 points is F.

30% Weekly homework: 9 x 20 points = 180 points total

30% In class group exercises: 12 x 15 points = 180 points total

30% Projects: Focus on hypothesis, data collection, analysis: 3 x 60 points = 180 points total

10% Top Hat in class questions: 2 x 30 = 60 points

**Attendance:** You are expected to attend class and a portion of the final grade is directly related to your attendance since you must be in class to receive credit for the Top Hat questions and group exercises. If you will miss class, you must email me an absence form before the absence in order to make up work. Missed work will not be accepted except for approved excused absences.

**Module 1: I choose you!**

In this module, you will learn about Pokémon® including Types, Stats, IVs and CP.

Week 1: Organization of course, basic game play. Pokémon® types and attributes.

Mathematical ideas: Sets, set notation, union, intersection, complements, Venn diagrams.

Week 2: Stats, base stats and IVs.

Mathematical ideas: Order of operations, functions, functions defined by formulas and functions defined by tables.

Week 3: Combat Power, CP.

Mathematical ideas: Functions defined piecewise (CPM), square roots, power functions.

Week 4: Levels and leveling up.

Mathematical ideas: Invertible and non-invertible functions.

Week 5: Pokécoins and Pokénomics. Earn and spend.

Mathematical ideas: Ratios, units and dimensional analysis, optimal strategies and balancing your Pokémon® budget.

Project 1: Catch a cohort of one Pokémon® species to compare and contrast.

Stage 1 (10 points): Proposal. Describe your catch method and commit to catching at least twenty of your target Pokémon®. Pick two attributes or stats you will focus on and suggest a hypothesis for how they may be related.

Stage 2 (20 points): Data collection and data management. Organize and submit the data that you collected.

Stage 3 (30 points): Final project report, an analysis of your catch method and your cohort. This analysis will include at a minimum: Venn diagrams for attributes, an evaluation of all stats for the highest and lowest CP Pokémon® you caught, and a bar or line graph.

**Module 2: Gotta Catch ‘em all®**

In this module you will learn about catching Pokémon®, including modifiers such as berries, balls, throws.

Week 6: Three shakes and a click.

Mathematical ideas: Discrete probability, independence.

Week 7: Pokéballs.

Mathematical ideas: Discrete random variables, uniform random variables, conditional probability.

Week 8: Where to search.

Mathematical ideas: Continuous probability. Pdf and cdf.

Week 9: Berries.

Mathematical ideas: Mean, median, mode.

Week 10: Curveballs, nice/great/excellent throws.

Mathematical ideas: variance, standard deviation, correlation.

Project 2: Correlation is not causation

Stage 1 (10 points): Proposal. Choose two “conditions” that may affect Pokémon spawn rates. Examples: Day-night, Rainy-Sunny, Lure-no lure, etc. Explain how you will catch Pokémon during these two conditions without any confounding variables.

Stage 2 (20 points): Data collection and data management. Go out and catch Pokémon during your two chosen “conditions”. Organize and submit the data that you collected.

Stage 3 (30 points): Final project report, an analysis of your experiment. This analysis will include at a minimum: discussion of mean, standard deviation and correlation.

**Module 3: To be the very best**

In this module you will learn about Player vs Player Pokémon® battles, including damage and defense.

Week 11: Moves and move types.

Mathematical ideas: Introduction to game theory.

Week 12: Fast moves, damage per second and energy per second.

Mathematical ideas: Rate of change, average rate of change

Week 13: Charge moves, total damage output.

Mathematical ideas: Total change

Week 14: Tankiness.

Mathematical ideas: percentages and percentiles

Week 15: Other types of battles, Team Rocket and Gym battles.

Project 3: Build your battle team.

Stage 1 (10 points): Proposal. Select your battle team and an explanation of your choices.

Stage 2 (20 points): Data collection and data management. You will participate in battles with classmates and submit the data that you collected with battle outcomes.

Stage 3 (30 points): Final project report, an analysis of the battle data. This analysis will include at a minimum: calculations of damage per second as well as total damage for each Pokémon® pair in the battle (up to 6).

**Changes to the Syllabus:**

What follows is **tentative**, I am certain we will make changes as we go based on the needs of the class. Therefore, the instructor reserves the right to make adjustments to this syllabus. Any changes will be announced in class and posted on ICON.

**Calendar for Spring 2023:**

|  |  |  |  |
| --- | --- | --- | --- |
| Day | Date | Topic | Assignments |
| Module 1: I Choose You! | | | |
| Wk1 Mon | 1/15 | No class, |  |
| Wk1  Wed | 1/17 | Syllabus,  Pokémon® Types and Set Theory | Read 8.1-8.2 |
| Wk1 Thur\* | 1/18 | Venn Diagrams, Union, Intersection, Complement | GW 1 |
| Wk2 Mon | 1/22 | Stats, functions, order of operations | HW 1  Read 3.1  <https://gamepress.gg/pokemongo/cp-multiplier> |
| Wk2 Wed | 1/24 | Base stats,IVs and functions from tables and formulas | Read 3.2  https://www.eurogamer.net/articles/2017-06-30-pokemon-go-cp-meaning-explained-how-to-get-the-highest-cp-values-create-the-most-powerful-team-6002 |
| Wk2 Thur\* | 1/25 | Comparison of base stats,  Discuss Project 1 | GW 2 |
| Wk3 Mon | 1/29 | Combat Power (CP) and piecewise functions | HW 2  Read 3.4-5  <https://gamepress.gg/pokemongo/pokemon-stats-advanced> |
| Wk3 Wed | 1/31 | Exponential and power functions | <https://pokemon.fandom.com/wiki/Eeveelution> |
| Wk3 Thur\* | 2/1 | Eevee® evolutions.  Feedback on Proposals | Project 1 Stage 1: Proposal  GW 3 |
| Wk4 Mon | 2/5 | Levels, cost/benefit analysis of leveling up | HW 3  Read 4.1-4.2  <https://pokeassistant.com/stardust>  <https://igeekout.net/pokemon-levels-in-pokemon-go/> |
| Wk4 Wed | 2/7 | Functions and their inverses, non-invertible functions | Read 4.3  <https://gamepress.gg/pokemongo/power-up-costs> |
| Wk4 Thur\* | 2/8 | Units and Dimensional Analysis | Project 1 stage 2: Data  GW 4 |
| Wk5 Mon | 2/12 | PokeCoins and Ratios | Read  <https://progameguides.com/pokemon/pokemon-go-how-to-get-coins-guide> |
| Wk5 Wed | 2/14 | Optimal Strategies for earning, purchasing, and spending | Read <https://www.forbes.com/sites/timworstall/2016/10/21/when-is-a-virtual-currency-a-currency-when-its-a-prepayment-in-pokemon-go/#4e618cc27764>  <https://www.bustle.com/articles/174043-how-much-is-a-pokecoin-worth-the-pokemon-go-currency-costs-actual-money-so-heres-what> |
| Wk5 Thur\* | 2/15 | Share Final Projects | Project 1 Phase3: Final Report |
| Module 2: Gotta Catch ‘Em All® | | | |
| Wk6 Mon | 2/19 | Catching Pokémon®, discrete probability | Read 8.3  <https://gamepress.gg/pokemongo/catch-mechanics> |
| Wk6 Wed | 2/21 | Independent events, Bernoulli Random Variables | Read 8.4  <https://www.eurogamer.net/articles/2017-03-23-we-used-to-catch-pokemon-wrong> |
| Wk6  Thur\* | 2/22 | Three Shakes  And a Click | GW 5 |
| Wk7 Mon | 2/26 | Discrete Random Variables, uniform random variables | HW 4  Read 9.4 |
| Wk7 Wed | 2/28 | Pokéballs and conditional probability | Read 8.5-8.6  <https://bulbapedia.bulbagarden.net/wiki/Catch_rate> |
| Wk7 Thur\* | 2/29 | Pokéball, Great Ball, Ultra Ball  Discuss Project 2 | GW 6 |
| Wk8 Mon | 3/4 | Where to search, Continuous Random Variables | HW 5  Read 9.1-9.2 |
| Wk8 Wed | 3/6 | Probability Density Function, Cumulative Distribution Function | <https://www.skyparksecure.com/blog/pokemon-go-tips/> |
| Wk8 Thur\* | 3/7 | Pokémon® Height distribution  Feedback on Proposals | Project 2 Stage 1: Proposal  GW 7 |
| Wk9 Mon | 3/18 | Berries, The mean, median and mode | HW 6  Read 10.1  https://pokemongohub.net/post/wiki/berries-pokemon-go/ |
| Wk9 Wed | 3/20 | Data fitting, least squares | Read 10.2  https://www.makeuseof.com/tag/excel-basic-statistics/ |
| Wk9 Thur\* | 3/21 | Analyzing your data in Excel-mean, median, mode | Project 2 stage 2: data  GW 8 |
| Wk10Mon | 3/25 | Nice/Great/Excellent Throws and the standard deviation | Read 10.3  <https://www.eurogamer.net/articles/2016-08-17-pokemon-go-curveball--throws-nice-great-excellent-throws> |
| Wk10Wed | 3/27 | Curveballs and correlation | Read 10.4  https://www.vg247.com/2018/09/28/pokemon-go-how-to-excellent-throw-curveball-throw |
| Wk10Thur\* | 3/28 | Share Final Projects | Project 2 stage 3: final report |
| Module 3: To be the very best | | | |
| Wk11Mon | 4/1 | Battle basics, Moves and move types | Read: 9.5  https://www.eurogamer.net/articles/2019-01-08-pokemon-go-pvp-trainer-battles-rewards-5392 |
| Wk11Wed | 4/3 | Fire-water-grass, graphs and game theory | Read: 9.6  <https://www.quantamagazine.org/the-game-theory-math-behind-rock-paper-scissors-20180402/> |
| Wk11Thur\* | 4/4 | balanced triples in the battle chart | GW 9 |
| Wk12  Mon | 4/8 | Fast moves and rates of change | HW 7  Read 11.3-4 |
| Wk12Wed | 4/10 | Average rate of change | <https://gamepress.gg/pokemongo/pvp-fast-moves>  <https://thesilphroad.com/pokemon-go-moves> |
| Wk12Thur\* | 4/11 | DPS, EPS, dimensional analysis, Discuss Project 3 | GW 10 |
| Wk13Mon | 4/15 | Charge moves, total damage output | HW 8  Read 13.3  https://gamepress.gg/pokemongo/damage-mechanics |
| Wk13Wed | 4/17 | Move sets and total damage. | https://pokemongohub.net/post/guide/understanding-dps-vs-tdo-in-pokemon-go/ |
| Wk13Thur\* | 4/18 | Gym battles and PVP battles,  Feedback on Proposals | Project 3 stage 1: Proposal  GW 11 |
| Wk14Mon | 4/22 | Defensive strategies, percentages and percentiles | HW 9  Read 9.1 |
| Wk14Wed | 4/24 | Tankiness, computing the winner | Read  <https://pokemongohub.net/post/questions-and-answers/move-damage-output-actually-calculated/>  You can also try your team here: https://www.pokebattler.com |
| Wk14Thur\* | 4/25 | Battle Time! | Project 3 stage 2: data  GW 12 |
| Wk15Mon | 4/29 | How to defeat Team Rocket. Best teams and move sets | Read  <http://www.stutzcreative.com/pokemon>  https://www.eurogamer.net/articles/2019-11-06-pokemon-go-unleashes-next-big-team-rocket-update |
| Wk15Wed | 5/1 | Wrap up and ACE forms |  |
| Wk15Thur\* | 5/2 | Share Final Projects | Project 3 stage 3: final report |