Online Classes

Online Classes Information and Notes

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Somewhere something incredible is waiting to be known - Carl Sagan

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Prologue

Chapter 0

Introduction to Online Classes

0.1 What is Online Classes / Purpose

Online classes were created because of the epidemic of COVID-19 in 2020. Because many clubs are unable to meet and therefore many students are unable to learn, online classes are for those that want to continue learning more regardless of what is going on the world.

0.2 Goals

The goal of these online classes is to spread knowledge regarding various academic topics. We will be focusing mostly on competitive science and math, but there exists a possibility for more in the future.

0.3 To the Teachers

Note: I originally wrote this for the ***teachers*** *to read, but this will also give you an idea of the layout of the classes.*

I've recommended this like 10,000 times, but learn LaTeX!!! It makes it a lot easier for the students to understand what you are doing if you use a typesetting code like this. It also has a great appearance / automatic neatness.

0.3.1 Requirements

1. Write a **handout** each week regarding the topic you will be teaching. I will likely give you all a list of topics to choose from, because teaching random things will only work if we have a very small number of classes. Now that we have more time, it is important that we use a list of topics rather than topics that are important.

    - A handout (again, in LaTeXplease!) does not mean a random test. It means something that teaches a specific portion of the subject you are teaching.

- For example, if you are teaching *polynomials*, you might write about a) solving polynomials, b) factoring polynomials and c) arithmetic with polynomials. Then you would give *problems* to summarize those subtopics.

2. Teach the class once a week. This may change, but it is pretty much a guarantee that we will each only be teaching once a week.
3. Send me your recordings / handouts for review. You are familiar with how it works by now, but just in case, I still want to see it. I'll probably just skim over it and check for length and presentability.

0.4 To the Students

If you would like to sign up for our classes, I will be providing a link here: https://tinyurl.com/onlineclasses123. Please be respectful to the other students.

0.4.1 Level of Our Classes

Before, we taught 24 lessons across six days for four levels (don't worry, the math checks out: $6 \times 4 = 24$) called **Level 1 Math, Level 2 Math, Level 1 Science,** and **Level 2 Science**. We had around 117 sign ups for our classes! For these next few, we will be calling them **Level 1.5 Math, Level 2.5 Math, Level 1.5 Science,** and **Level 2.5 Science** to avoid confusion. The classes will remain roughly the same level, but each lesson we expect you to understand more and more about the subjects we teach.

0.4.2 Notetaking

This isn't *too* important, especially since we will provide you with a) recordings and b) handouts, but it is scientifically proven writing things down helps you remember them better. So at least write something. You don't need to take your notes like this: But please don't take your notes like this: A healthy balance is best.

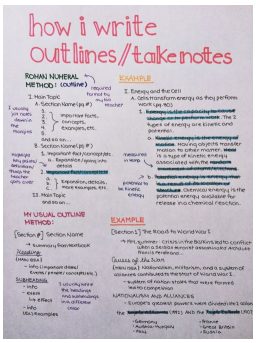


Figure 1: Amazing Notes!

0.4.3 Problems

We (the teachers) will likely have a few problems left by the end of it (depending on teacher, of course). If there are some left, do them!

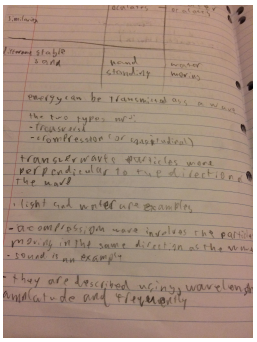


Figure 2: Bad Notes.

0.4.4 Asking Questions

Asking questions **during class** is great and you should do it. However, outside of class, it is important to remember that as high schoolers we are also very busy with our school work and our other extracurriculars. Therefore, we may not respond immediately. If after a couple days none of us has answered any of your questions, you may email us again. The email you should contact is: onlineclassesclub@gmail.com.

0.5 Class Information

0.5.1 Schedule

The following classes will be taught at these dates and times:

Class Dates & Times		
Math Level 1.5	Monday	6:00 p.m.-7:00 p.m.
Math Level 2.5	Wednesday	4:00 p.m.-5:00 p.m.
Science Level 1.5	Thursday	3:00 p.m.-4:00 p.m.
Science Level 2.5	Saturday	5:00 p.m.-6:00 p.m.

0.5.2 Who are these Classes For?

Math Level 1.5 is for those starting Elementary TMSCA or Mathleague and want to either a) make their school's math club next year or b) reach higher levels of their school's math club/team. **Math Level 2.5** is for more experienced members to learn more advanced techniques. **Science Level 1.5** is for those with a curiosity about science, and also for those who want to improve in Elementary TMSCA Science. **Science Level 2.5** is for those who are doing well in Elementary TMSCA Science, or preparing for Middle School TMSCA Science, or interested in competing in Science Bowl.

0.5.3 Classroom Links

Here are the links to the classes:

1. **Math Level 1.5**: https://tinyurl.com/Math-Level-1-5
2. **Math Level 2.5**: https://tinyurl.com/Math-Level-2-5
3. **Science Level 1.5**: https://tinyurl.com/Science-Level-1-5
4. **Science Level 2.5**: https://tinyurl.com/Science-Level-2-5

Our **first class** will start the week of 4/13/20 - 4/19/20.

The **Mathematics of COVID-19** section was included just as a fun read. It obviously isn't mandatory.

Chapter 1

The Mathematics of COVID-19

1.1 Definition and History

COVID-19 is a disease caused by a type of coronavirus. It is an infectious disease that recently surfaced in late 2019 in China. The symptoms are similar to those of seasonal flu, so it is very difficult to distinguish from flu in the early stages.

There has been a misconception that someone ate bat soup in Wuhan and therefore caught coronavirus. This is **false**. In reality, a bat passed it on to an intermediate animal (we aren't sure what it is yet, but I believe we recently found a mammal with coronavirus) and it is our belief that this mammal passed it on to humans. This is why it's important to be certain you are getting the right information. Use Occam's Razor: the most direct answer is often the right one.

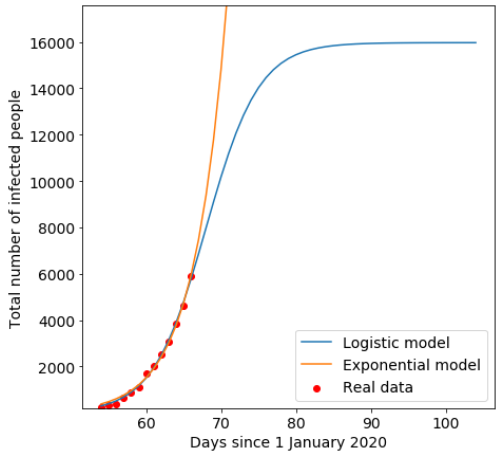
1.2 Math

1.2.1 Basics

Let's say we have a population in a grid. Obviously this doesn't happen in real life, but it will give you a simplified version of what is going on around the world. Let's say one the people of this population is infected. Then it is easy to see how simple spreading this virus would be. However, with **barriers**, the chance of survival increases drastically. Use this model as a resource for you to understand this: https://meltingasphalt.com/interactive/outbreak/.

1.2.2 Exponential Growth

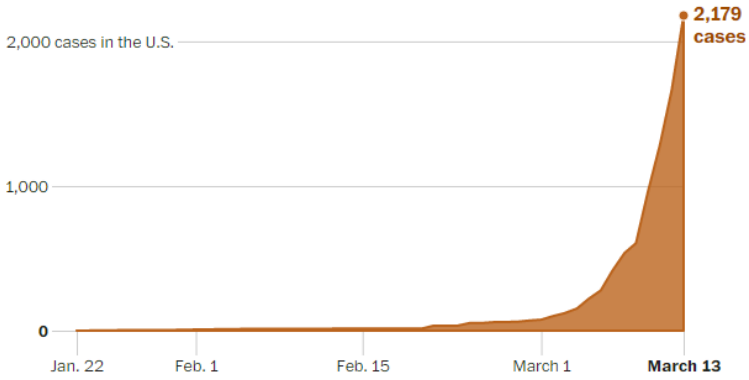
The growth is actually **not** exponential. In reality, it is **logistical**:



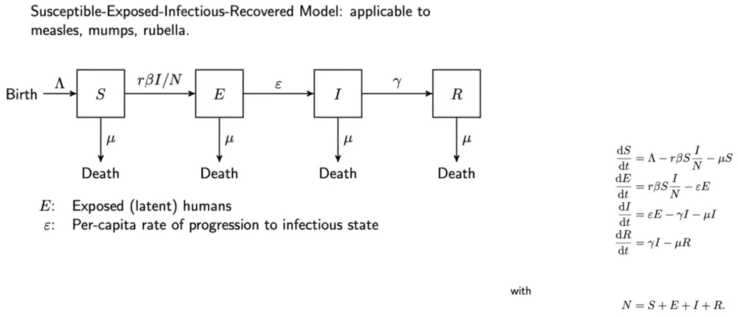
This is because after a while, there won't be anyone to infect, which means the number cannot increase.

1.2.3 Higher Math

The math of epidemics doesn't look like this:



That's simply the result of using statistics and equations. This is what it actually looks like:

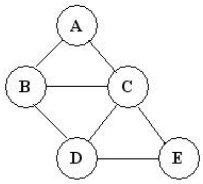


This is known as the **SEIR Model**, which stands for *Susceptible-Exposed-Infectious-Recovered* Model. By taking into account those who can still get the virus, those who have the virus with no symptoms, those

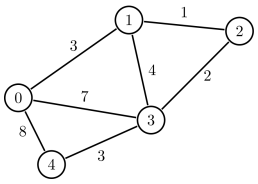
who have the virus with symptoms, and those who cannot get the virus (both those who recover and those who die from it), we are able to calculate exactly what will happen given what we are doing now. In fact, the diagram above is a **states diagram**, something actually very useful on the AIME! (Of course, this one uses calculus, not algebra.)

1.2.4 Separation

There exists a theory titled "Six Degrees of Separation" because it is believed that any two people are connected by a length of at most 6. For example, you know a person who knows a person who knows a person who knows a person who knows anyone else in the world. What does this mean for COVID-19? It means there's probably a 0.01% chance of getting COVID from that person, if the probability of infection is 10%. However, remember - it isn't just one person who you could get it from, it is all seven billion people on this planet! This is why **social distancing** is so important right now. Now for a little graph theory. A **graph** is basically just a collection of vertices, and edges leading from those vertices show connection. This is a graph:



And when we have **distances** in the graph, we have a **weighted graph**:



The reason we are using a *weighted graph* is because we are dealing with the **probability** of getting infected. There are a few ways to prevent the spread of COVID-19:

1. Reduce the Weight
2. Delete the Edges

If we **reduce the weight**, that means we reduce the probability of getting infected. To **delete the edges** is basically just making the probability 0 by distancing yourself from others.

1.3 Prevention

The World Health Organization has declared the COVID-19 a global epidemic. However, as long as we stay safe, and practice regular health protocols / social distancing, a majority of people should be fine. In

fact, the main concern is the **lack of concern** among country officials, especially those with a significant number of people already infected. To quote Grant Sanderson of 3Blue1Brown (Youtube Channel: https://www.youtube.com/channel/UCYO_jab_esuFRV4b17AJtAw),

> "If all people are sufficiently worried, then there is not much to worry about. The actual worry is the **lack of worry** among the masses."

So the conclusion of all of this is: be sufficiently worried, but don't go on Amazon and buy 100,000 bottles of hand sanitizer! In fact, Amazon banned this because the prices were rising too high (around $100 for one bottle!). In a video by 3Blue1Brown, it was found out that if washing your hands decreases your risk by half, the epidemic could stop twice as fast! What this means for you: wash your hands! For accurate information, go to https://ourworldindata.org/covid-testing. For information regarding specific states of the U.S. (I hope you don't live in New York!), go to https://github.com/aatishb/covid/blob/master/curvefit.ipynb.

1.4 Further Reading

For more information, go to

1. https://www.youtube.com/watch?v=MZ957qhzcjI
2. https://www.washingtonpost.com/graphics/2020/world/corona-simulator/
3. https://prajwalsouza.github.io/Experiments/Epidemic-Simulation.html
4. https://learningsim.itch.io/pandemic-spread-simulation
5. http://gabgoh.github.io/COVID/index.html
6. https://www.youtube.com/watch?v=gxAaO2rsdIs
7. https://www.youtube.com/watch?v=Kas0tIxDvrg

Stay safe everyone!

Part II

Appendix

Appendix A

Beginner's List of Topics for Math

A.1 General

1. Use of logic in problems
2. Developing imagination

A.2 Algebra

1. Multiplying polynomials
2. Factoring
3. Ratios and proportions
4. Direct and indirect variation
5. Distance-rate-time problems
6. Simon's favorite factoring trick
7. Quadratic equations and Vieta's formulas
8. Substitution and elimination
9. Percents
10. Function notation and operations
11. Newly-defined operators
12. Mean, median, and mode
13. Composing functions
14. Recursively-defined functions
15. Clever algebraic manipulations
16. Word problems

17. Pattern recognition
18. Finite arithmetic sequences
19. Finite arithmetic series
20. Finite geometric sequences
21. Finite geometric series
22. Infinite geometric series
23. Telescopic series/products

A.3 Number Theory

1. Introduction to primes
2. Fundamental Theorem of Arithmetic
3. Divisibility rules
4. GCDs and relative primeness
5. Euclidean algorithm
6. Counting divisors of a number
7. Diophantine equations
8. Chicken McNugget Theorem
9. Sequences in number theory

A.4 Combinatorics

1. Patterns
2. Venn diagrams
3. The Multiplication Principle
4. Overcounting
5. Complementary counting and casework
6. Independent/dependent events
7. Complementary probability
8. Geometric probability

A.5 Geometry

1. Angles
2. Triangles and lengths
3. Right triangles
4. Circles and quadrilaterals
5. Finding wacky areas
6. Inscribed angle theorem for circles
7. External tangents to circles
8. 3D solids

Appendix B

Beginner's List of Topics for Science

B.1 General

1. Scientists
2. Laboratories
3. Experiments
4. Fields of Science
5. History of Science

B.2 Biology

1. Cellular Biology
    - Structure
    - Function
    - Mitosis & Meiosis
    - DNA Structure and Replication
    - Organic Compounds
2. Molecular Biology
3. Ecology
    - Ecological Roles and Niches
    - Ecological Succession
4. Botany
    - Plant Parts
    - Gymnosperms and Angiosperms
    - Plant Reproduction
5. Taxonomy

6. Anatomy
    - Different Systems
    - System Connections
    - Evolutionary Biology
7. Biochemistry

B.3 Chemistry

1. Elements
2. Atoms, Molecules, and Compounds
    - Atomic Structure and Properties
    - Interactions
3. Periodic Table
4. Periodicity
5. Ideal Gases
    - Kinetic Theory
    - Avogadro's Law
    - Boyle's Law
    - Charles' Law
    - Ideal Gas Law

B.4 Physics

1. Classical Mechanics
    - Newton's Laws
    - Work, Energy, Power
    - Simple Machines
    - Friction
    - Gravity
    - Rotational Motion
    - Torque
    - Springs
2. Electromagnetism
    - Maxwell's Laws
    - Conductors and Insulators
    - Parts of a Circuit
3. Optics and Acoustics
4. Thermodynamics
5. General / Special Relativity (Modern Physics)

B.5 Earth Science

1. The Earth
    - Parts and Layers
    - Geosphere
    - Biosphere
    - Hydrosphere
    - Atmosphere
2. History
    - Dating
    - Geologic Time
3. Geographic Features
    - Plate Tectonics
    - Geographic Features
    - Soil and Ground Structures
4. Natural Disasters
    - Earthquakes
    - Volcanoes
    - Landslides
    - etc.
5. Weather and Atmosphere
    - Parts of the Atmosphere
    - Clouds
    - Weather Measurements
    - Weather Systems
6. Rocks and Minerals
    - Mohs Scale
    - Erosion and Weathering
    - Glaciers (and Other Landforms)
7. The Ocean
    - Parts of the Ocean
    - Water Systems
    - Organisms in the Ocean

B.6 Space Science

1. The Planets
    - General Characteristics
    - Groupings
    - Beyond the Solar System
2. The Moon
    - Phases
    - Composition
    - Evolution
3. The Sun
    - Parts of the sun
4. Other Celestial Objects
    - Dwarf Planets
    - Black Holes
    - Hertzsprung-Russell Diagram & Types of Stars
    - Stellar Evolution
    - Celestial Phenomena
5. Cosmology
6. Heliocentrism and Geocentrism

B.7 Energy

1. Forms of Energy
2. Energy Units
3. Energy Sources
    - Biomass
    - Coal
    - Geothermal
    - Hydropower
    - Natural Gas
    - Petroleum
    - Propane
    - Solar
    - Nuclear
    - Wind
4. Statistics