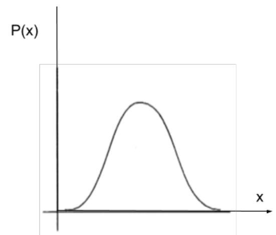
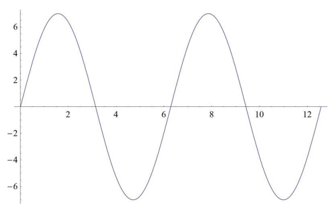
1 Physics

A very interesting area of physics is quantum mechanics. Probability is one of the most fundamentally used mathematical concepts in this area of physics. It all starts with finding the probability of a particle at some location; let's say the particle is on a one-dimensional line, and the probability of finding it at some point can be described as a function P(x). This is how the graph for our particle looks like:



The higher the probability of the object being on the x location, the higher the P(x) value and the higher the point is on the curve. This graph demonstrates a superposition of the particle, or a combination of all possible locations the particle can have. In quantum mechanics, an object is not only perceived as a particle, but also considered a wave, or something that instead of remaining at one point like a particle transfers energy through space. The wave looks like this:



Because our object, or a so-called "particle", can have different states, which can be represented by waves, the intersection of all the possible waves our object can represent creates the same curve as on the first graph.

2 Security

Prime numbers are largely used in security to protect the information. In order to secure your code, you first pick two prime numbers and keep them secret. Let's call these numbers **a** and **b**. However, when you multiply these numbers **a * b = D**, where **D** is a public number. Then you pick another public number which is also a prime. Let's call it **c**. And lastly, there is a secret number that is calculated from **a,b**, and **c**, which we'll call **f**. When you want to send a secret message, which is represented using numbers, you raise your secret-message-number to the power of **c**. In other words, you multiply your secret message by itself **c** times. Then you take the result and divide it by **D**. Your encrypted message is the remainder of that number, or a leftover from the division of the result by **D**. In order to decrypt the code, you multiply your final message by itself **f** times, divide by **N** and the remainder of that is your original message!

Example: let $a = 11$, and $b = 17$. Consequently $D = 187$. Let $c = 7$. Thus, based on a, b, and $c, f = 23$. Let's say, you secret message is a number 12. When you raise 12 to the power of 7, you get 35831808. Then 35831808 divided by D is 191613 with a remainder of 177. Now let's take 177 and multiply by itself 23 times, which will give us a very large number 5,051,090,226,898,791,218,777,976,549,737,850,514,424,116,332,442,833. Then you take this number and divide by 187, which will give you the remainder 12. This encryption technique is very effective, when dealing with very **large** prime numbers.

3 Computer Science

Computers are used in tandem with math to make computations much easier. For example, have you ever wondered how we made our Estimathon questions? We could always estimate the answer, but there is a way we were able to get the answer EXACT. Using computers to aid our computations, we were able to be as accurate as possible. However, the applications of math in computer science extends further than minor computations.

In math, we use graphs to represent objects that are connected. For example, friendships can be represented as graphs where where every friend is connected to each other. In graph theory, we call the objects being connected as nodes, and we call their connections edges. One of the most common applications of graphs is distances between places. In this case, each city or state can be connected to another one by a certain edge length or distance. This concept of graphs is used frequently by computers to help you find the shortest path between two places. You have probably used this when you get directions via Google Maps. Let us look at an example of a path finding algorithm in action.

Exercise 1. Let us consider 5 cities by drawing five circles and labeling them as A, B, C, D, and E. The following table lists the edges between cities and how far apart they are.

A	B	1
A	C	4
B	C	2
C	D	3
C	E	5
D	E	6

Now if we want to find a path from A to E, how can we do so? Well we have this cool thing called Djikstra's (Dike-struh) Algorithm which bridges together this math with computer science to solve this issue. Pretend you have a bucket that can store edges. Look at all the edges that come out of A and put them in your bucket. Now look in your bucket and choose the smallest edge (In our example, this is the edge that connects to B). Now we can label B with the distance it took to travel to it because this is the minimum distance to go from A to B (It is worth noting that the shortest path to E can be constructed by getting the shortest paths to the other nodes). Now we add all the edges coming out of B into our bucket and we repeat this process again. The shortest edge altogether is from B to C which is a length of 2. Now we can label C with 3, because it took 1 unit to get to B and 2 units to get to C. We then add all the edges coming out of C. After another repetition, we label D with 6. After the next repetition, we would have labeled C with 3, but since it is already labeled with a smaller number, we leave it unchanged. Finally, after a few repetitions, we can see that the minimum distance it takes to travel to E is 9. You can read up more about Djikstras online.