Fantastic formulas A (brick or digital) classroom-ready mini-project

Ella Sitkin,
Mathematics Faculty
School of Mathematics, Science and Engineering
Central New Mexico Community College
Albuquerque, New Mexico
esitkin@cnm.edu

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Themed Session T2E Classroom-Ready Career Applications

Fantastic Formulas

A classroom-ready mini-project that can demonstrate many career "applications"

Used in Gen Ed Problem Solving courses but can apply to other math courses – algebra, trigonometry, calculus

Gen Ed Problem Solving is four short courses. Students take 3 out of 4

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Math 1211 Problem Solving with Algebraic Modeling	Proportional reasoning, basic algebra, percentage, measurement, formula use and manipulation, dimensional analysis (units conversion).
Math 1212 Problem Solving with Probability and Statistics	Introductory statistics: mean, median, mode, range, standard deviation, graphical analysis of data. Probability of single and compound events
Math 1213 Problem Solving with Geometry and Right Triangle Trigonometry	Plane and solid geometry (area, perimeter, volume, surface area), right-triangle trigonometry
Math 1214 Problem Solving with Consumer Mathematics	Constructing personal budgets, investigating the effects of compound interest on loans (such as mortgages, cars, credit cards) and savings (such as bank savings, mutual funds), analysis of financial options based on interest

A mini-project: Fantastic Formulas

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Math 1211
Problem Solving with Algebraic Modeling

Formulas are a big deal for many students - dosage calculations, electrical loads, HVAC throughput, and so on.

Seeing how formulas work on the job makes a link between textbook math and the world they will be working in.

The “Essential Skills” of communication, quantitative reasoning and critical thinking are used as students research, discover, articulate and demonstrate their formulas.

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Formulas are Fantastic!

Formulas can be found in almost every career field, from cosmetology to cooking to carpentry to nursing to filmmaking to…well…everywhere!

Your assignment is to bring a formula that you would use on the job in your chosen profession. It may take a little research to find an interesting formula. Try asking someone who is in the profession or do some digging on the internet of all things. Always give credit to your sources.

You must

1. Give us the actual formula and describe how the formula works.
2. Tell us how the formula is used on the job (who would use it, how and why).
3. Show an example with realistic numbers, work it all the way through, explaining each step clearly. Just like you'd do if you were training someone on the job.

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For online formats, this could be a

- Required graded discussion post

For face-to-face formats, some possibilities are

- A “poster” session
- A short presentation to the entire class
- Presentations within smaller groups (more opportunities for question and answers)
- Written paper turned in

Giving them an example helps (sometimes)

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On a film crew, the person responsible for lighting a set is called the Chief Lighting Officer (or Gaffer). His/her crew are called grip-electrics. This department needs to know about electricity and how to calculate electrical loads. If you plug too many of those big movie lights into the same circuit…oops. The director and producers will get awfully upset if there is a blackout during filming.

The formula used to approximate an electrical load is Amps = Watts / Volts.
AKA My **A**unt Sally **Lives** in **W**est **V**irginia. Grip-electrics use this formula to calculate the electrical load to make sure they don't blow a circuit.

By the way, this works at home too. Most circuits in homes these days are rated at 20 amps. Really old homes might only have 15 amp circuits. One circuit breaker in your electrical panel usually governs all the outlets in one area of your home.

One day, I plugged an iron and a space heater into the same circuit. Darkness fell! If you look at the electrical tag on your iron, you can see the wattage and voltage the iron will draw. Divide and you have an estimate of the number of amps required. Do the same thing with the space-heater. Add the amps together. They may add up to more than 15-20 amps so the lesson here is DON'T plug them into the same outlet or even two outlets that share the same circuit and then turn them on. You may find yourself in the midst of a mini-blackout.

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Excerpts from students' work

Secret's in the Sauce

"When I had an interest in BBQ and decided to build a food truck, I knew I would need a signature BBQ sauce. I experimented in small batches using ingredients that would make servicing for 12. My recipe calls for ½ cup ketchup, 1/6 cup molasses, 2-1/4 Tbl of black pepper, among other ingredients that would have to kill for if I told.

Before I knew, I had gigs for 300 people. I was ever so thankful but had to figure out how to make that much sauce. How do I convert 12 serving to 100?"

Student goes on to demonstrate the conversions.

Air Traffic Control (ATC)

"As an Air Traffic Controller, I am responsible for monitoring the distance between aircraft. The distance between aircrafts must be larger than the minimum separation allowed, all the time. The Haversine Fomula is used for the calculation…"

Dosage Calculation for a child

"In the healthcare field, many times you have to calculate the dosage for a certain medication for a child. For example, say you need to calculate the dosage for an antibiotic for an ear infection. For a child, you first convert the weight in pounds to kilograms and then…" Student gives detailed instructions.

The Right Dosage

“In the field of medicine, it is of the utmost importance in knowing the medication one has to administer to a certain individual. Depending on the career choice, you have a certain scope of practice which allows you to only administer certain types of medicine. Regardless of your scope you will still have to administer medicine that requires one to understand dosage”.

Student goes on to describe the Want vs Have dosage calculations.

Radiology Technician Sammy, “had to take a chest x-ray on a patient. Her boss wanted her to find the exposures using different distances.

The formula to find the distance is Inverse Square Law:

$$\frac{l_1}{l_2} = \frac{D_2}{D_1}$$

Samantha took two radiographic images of the patients chest. If the first exposure of the chest was taken at a distance of 64" using 10 mAs and had an exposure of 50 mR. What would the exposure be at a distance of 80"?

This formula is used in the daily work life of a rad tech. They use different exposure on each patient and need plug in what distance they need to be at to get the correct exposure.”

Precision Machining

“In machining we use several different types of formulas and equations. One of the most important is to calculate *SFPM (surface feet per minute)* in order to cut different types of metals with different cutters without causing damage to tooling or materials.

The formula for this is SFPM=RPM x part or cutter diameter/3.82. 3.82 is derived from pi and is a constant. Since we are working with a circle (diameter) we need pi. RPM needed for the formula is provided from the tooling manufacturer for the type of cutter you are using and calculating SFPM for.

So if we have a .500 diameter tool with a recommended RPM of 800 we would multiply .5 x 800=400 and them divide the 400 by 3.82 so SFPM = .5 x 800 = 400 / 3.82 = 104.71. 104.71 is the amount of surface feet we can cut per minute and would be programmed into the CNC. ”

Fantastic Formulas in Fire Fighting

”In the Fire Department there are many specialty job classes and within each job class you could probably find multiple mathematical formulas. The formula that I want to show you is used within the Engineer job class. An engineer is the person who drives the fire truck! More specifically though, they are the one who operates the water pump that is built into the truck. You probably wouldn't realize it, but when you see a fire truck spraying a lot of water on a fire and a bunch of hoses everywhere a lot of math formulas are being used by the person responsible for that fire truck. Before I show you one of the formulas being used I want to explain something. When you flow water through a hose a certain amount of friction is created depending on the size of the hose. in other words, as water flows through a house under pressure the place where the water is touching the hose creates friction and slows down the water. Now imagine how much area of hose the water is touching in an entire hose! It can cause a lot of friction loss! That is what Firefighters call the slowing of the water, Friction Loss.

One more thing to consider is that different hose materials can cause different amounts of friction loss as well as a few other variables. Because of these different variables, including the type of material used to build the hose you may see multiple different formulas that are very simular. Now lets look at a very simple Friction loss formula used for flowing water through a standard small hose that is typically held by one or two Firefighters.

One very important fact needs to be learned before getting to the formula. At the end of a fire hose you have a device called a nozzle. nozzles are found even on garden hoses so I'm sure you have seen one and get the idea. Nozzles in the fire service are rated for a certain amount of water to flow through them. Nozzles are normally labelled with these numbers. the numbers will read like this (150 GPM@100psi). GPM means gallons per minute and psi is pounds per sq in. In other words, If the pump is making 100 psi at the nozzle than it will flow 150 gallons per minute. With that understood lets move on to the formula.”

Firefighting, continued.

$FL=CQ^2L$

FL= Friction Loss in psi(lb/sq in) C = Coefficient Q = quantity of water in GPM^2 (gallons per minute/100^2) L = Length of hose in ft/100

The " C" Coefficient is the number that is constant in the formula and is different for each size hose. For our example we will be using the coefficient for a hose that is 1.75" (inches) in diameter. For the 1.75" hose the coefficient is the number 10. As a general rule, the smaller in diameter the hose the higher the coefficient will be and the same is true for the opposite. So in this example the Coefficient will be 10.

The "Q^2" is the GPM (gallons of water / minute) that that particular hose will be flowing divided by 100. This number is determined by the nozzle at the end of the hose. For our example we will be using a nozzle that flows 150 GPM@100psi.

The "L" is the length of hose in ft. divided by 100. 1.75" diameter hose typically comes in 50 ft. long sections. In this example we will be using 3 sections of hose which will total 150 ft. so "L" will be 150 ft/100

So lets plug these numbers into our formula.

$FL= 10(1.5^2)(1.5)$

Now solve, $FL= 10(2.25)(1.5)$

$FL= 22.5(1.5)$

FL= 33.75 psi

Rounded up to the nearest 5 psi you get 35 psi.

answer : FL = 35 psi.

Firefighting, continued.

$FL=CQ^2L$

That is the friction loss that is happening in a 150 ft long hose that is 1.75" (inches) in diameter and is flowing 150 GPM (gallons per minute). Because the nozzle being used in this example requires 100 psi to flow 150GPM you must add the friction loss that the hose creates (35psi) to the 100psi that the nozzle requires. The pump must be creating 135 psi in order to flow 150 GPM (gallons per minute).

Lets look at one more example to try to help you understand.

a.) You have a hose that is 1.75" in diameter and 200 ft in length. The nozzle flows 150 GPM (gallons per minute) @ 100 psi. What pressure in (psi) must you create at the pump to flow 150GPM ?

First find the friction loss.

$FL=CQ^2L$

$FL = 10 (1.5^2)(2)$

FL = 45 psi

Now add the pressure the nozzle requires (100 psi) and the Friction loss of the hose (45psi) and you get 145psi.

Answer : You must create 145 psi at the pump to flow 150 GPM (gallons per minute) @ 100psi

A mini-project: Fantastic Formulas

- Requires active participation
- Enables the students to learn a little something more about their chosen field as well as being exposed to other fields
- Demonstrates a link between classroom/textbook mathematics skills and skills required on the job
- Provides a way for student to demonstrate essential skills such as critical thinking and communicating quantitatively
- Some of the formulas are SO fantastic that you could develop them into modeling examples for other classes.