Don’t Miscalculate Your Developmental Math Students

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Introduction

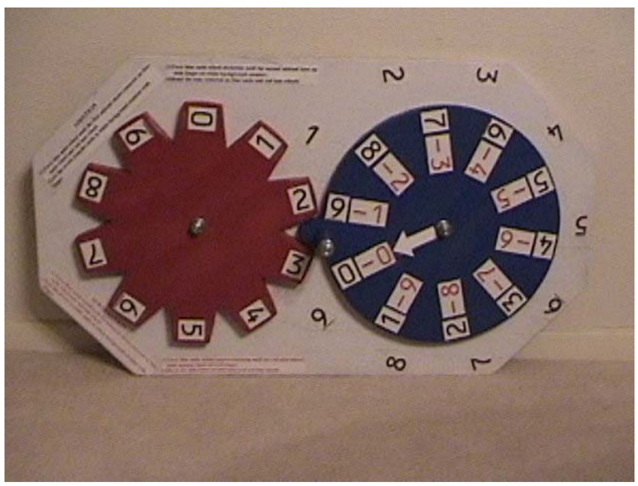
Making math interesting for our students is indeed one of our most challenging tasks and one that I can improve. This presentation discusses different learning styles to engage the interest of students by showing and building activities and project materials that provide real world applications into the classroom to increase student attention and provide greater understanding. How the applications of mathematics appear in everyday life is a part of my overall teaching philosophy. A significant problem for today’s faculty is that too many students have minimal skills in mathematics. The question is how to meet the needs of these students without ignoring those who are well prepared and highly motivated. Building projects is an important tool for engaging learners and addressing varied levels of math skills. Examples of two projects that were developed by students:

- Mechanical Calculators (Designed and Developed by Dr. Manshad and Warren Gray): Mathematicians and scientists wanted an accurate device that would compute automatically without much human intervention. Early pioneers in the development of automatic computation such as Wilhemlm Schickard (1592-1635), Blaise Pascal (1623-1662), Gottfried Leibnitz (1646-1716), and Samuel Moreland (1625-1695) used mechanical levers, gears, wheels, and cranks to replace the human element. These early calculating devices were essentially “automatic abacuses” where regrouping carrying were done mechanically. The system of two simple gears will be presented.
- Truss System Analysis (Designed and Developed by Dr. Manshad and Cipriano Duran): I want to build Corvettes, H-D Motorcycles, and High performance race engines, most likely creating a new model with different characteristics. Areas of evaluation will be as follows (tentatively and subject to additions).
    - The need for efficient truss form.
    - Numerical method of finding optimal truss form.
    - Applying the method of sections for truss system evaluations.
    - Mathematical analysis of all forces being exerted.

You can expect that I will most likely be constructing a truss in a bridge form consisting of a load bearing on the top of the truss system. The project will be constructed and worked on during Christmas break.

Mechanical Calculator-Operating Instructions (Warren Gray)

An opportunity was offered for extra credit for a project in my math 114 class (Beginning Algebra). Being from the machinist's trade, I started thinking about gears, diameter relationships, etc. Dr. Manshad then showed me the principals of mechanical counters as used in odometers from a book he had (Staszkow and Bradshaw 1995). I began working on the project that wound up being a wooden mechanical calculator. My wife helped me with the finishing touches, and my elementary aged children learned some concrete concepts of adding, subtracting, and multiplying. Also, Dr Manshad, who, lives and breathes teaching mathematics, received another tool to share his love of mathematics with others.



Addition

Step-1 Start with the zeros opposite each other in the center on both the blue units wheel and the red tens wheel.
Step-2 Turn the blue units wheel until the first number to be added shows in the center of both wheels.
Step-3 Mark the number found in the center of the blue units wheel with your finger on the white background. (It will be opposite the zeros on the Blue units wheel.)
Step-4 Turn the blue units wheel clockwise the number of tens and until the units number of your second number to be added lines up with your finger that is on the white background.
Step-5 Read the answer in the center of both wheels.

Note that, repeating the addition process the number of times that you want the number to be multiplied by does Multiplication.

Subtraction

Step-1 Start with the zeros opposite each other in the center on both the blue units wheel and the red tens wheel.
Step-2 Turn the blue units wheel until the number to be subtracted from shows in the center of both wheels.
Step-3 Mark the number found in the center of the blue units wheel with your finger on the white background. (It will be opposite the zeros on the blue units wheel.)
Step-4 Turn the blue units wheel counterclockwise the number of tens and until the red negative number of the number to be subtracted lines up with your finger that is on the white background.
Step-5 read the answer in the center of both wheels.

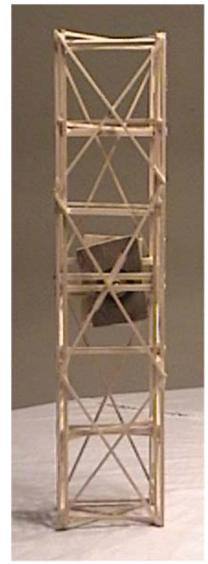
A Mathematical Analysis of a Truss-Origins and Basic Concepts (Cipriano Duran)

Trussing is simply the triangulating of a framework, and has been around for centuries. The idea has always been to use a truss as a stabilizing device spanning a structure. In prehistoric times trusses were built by latching together tree branches. Times have evolved and so have the materials; however, the basic concepts remain. Now we use the word "truss" but this fancy term simply means "tie-up or bind." This specifically relates to combining of diagonal forces to a rectilinear structure to distort the lateral effects, thus increasing the strength to guard against forces such as wind or earthquakes. As time passed, so did the evolution of trusses. The Eiffel Tower (1884) and the Washington Monument (1889) marked the emergence of a new generation of approaches. In the Industrial Revolution, structures were being built of heavy steel and meager approaches. Steel had replaced wood as a primary material for building. Today, we rely greatly on steel and a combination of wood and other materials both synthetic and natural. In the truss that I have provided, blossa wood was used as the material and the joints have been fixed with wood glue.

Strength of a Truss

Derived from a combination of forces the strength of a truss is altogether amazing. One of these is tension, which is the force or act of being pulled. It is important to note that the ability of a member of a truss to restrain force in tension depends on the material used in the construction of the truss. Alloy steel, for example will generally have more resistance to tension than wood. Compression is another force found in trusses. Compression is the act of pushing and is sometimes also referred to as a column. The ability of a member to withstand force in compression again depends on the materials used. Compression has a lower coefficient of strength than tension, which means that the compression forces are the forces most likely to cause damage, which can ultimately result in the failure of a member. Tension and compression both have coefficients of strength and for my for project I have included a coefficient schedule that relates directly to the truss provided.

Uses of a Truss



As previously stated trusses have been used in one form or another for centuries. Even prehistoric man might have originally used trusses to keep his cave from collapsing. This was similar in every fashion to the use of trusses today. Trusses are used on nearly every home here in the United States as well as in every other country. There are as many styles and varieties in these trusses as there are flavors of candy. For example, in the model presented, the candy of choice is a 6-panel flat-chorded truss. In addition to homes, trusses are used in the construction of bridges in order to maintain nearly all the structural integrity. Trusses are also used in fire truck ladders. Cranes also depend greatly on truss design to lift the incredible amount of weight required. Skyscrapers may be impossible to construct without truss technology. “You can always trust a truss.”

Mathematical Applications to Model Truss

There is a multitude of mathematical applications to a model truss. The following is the mathematical analysis of the model truss I have displayed with my project.

Rectangular Solid

 Volume (V) = (L) (W) (H)

 Length (L) = 41 cm

 Width (W) = 9 cm

 Height (H) = 7 cm

 (V) = (41 cm) x (9 cm) x (7 cm) = 2583 cm^3

Surface Area

 Surface area of a rectangular solid (A) = 2 (H) (W) + 2 (L) (W) + 2 (L) (H)

 (L) = 41 cm

 (W) = 9 cm

 (H) = 7 cm

 (A) = 2 (7 cm x 9 cm)+ 2 (41 cm x 9 cm) + 2 (41 cm x 7 cm) = 1438 cm^2

Perimeter

 Perimeter of one side of the truss (P) = 2 (L) + 2 (W)

 (L) = 41 cm

 (W) = 7 cm

 (P) = 2 (41 cm) + 2 (7 cm) = 96 cm

Area of One Side of the Truss
 (A) = (L) (W)
 (L) = 41 cm
 (W) = 7 cm
 (A) = 41 cm x 7 cm = 287 cm^2

Pythagorean Theorem
 Each member (B, C, D, E, F, G, J, L, N, Q, S, U) = 6.8 cm ( 7 cm)
 (A) = 7 cm

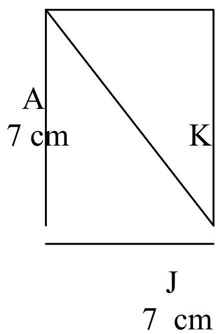


Figure 1 above is a diagram of one section with sides A, J, K to help demonstrate theorem.

The Pythagorean Theorem states $a^2 + b^2 = c^2$ or all right triangles with c being the hypotenuse and, as shown in the diagram above, would be the value of K.

 $A^2 + J^2 = C^2$
 $72 + 72 = K^2$
 $49 + 49 = K^2$
 $98 = K^2$
 K  9.9
 Value of K calculated above would be equal in all members M, O, P, R, T

Other Mathematical Notes and Applications

Note the outer vertical members A and T both have a load value of W/2. This is because they support only half as much weight as the other vertical members. Notice that all other vertical members have a load value of W. This is due to the fact that they are under a full load from both the left and right sides of the vertical member. The outer member receives a load from only one side or the other thus equaling ½ W for load.

Also, in addition to A/P = 1, I have also included A/P = ¾. This would represent a ratio in size since vertical member A is 75% the size of horizontal member P, which would be represented as 3:4. The same multiplication ratio rules still apply; only the coefficient of force has changed.

Evaluating the Coefficient of Force

In a 6 panel flat-chorded truss, coefficients of force have been predetermined for us already by the text, Design of Building Trusses (Ambrose, J.1994). These coefficients express what to multiply the load by in order to arrive at the force. Force is represented in units of compression or tension. There are 2 coefficients used. The first is A/P = 1 which represents the relationship of the truss members A and P where A is a vertical and P is a horizontal member. In the truss provided the measure is A = 7 cm and P = 6.8 cm ( 7 cm). The division looks like this: 7 / 6.83 = 1.02, which will round to 1. Then we can use the coefficient chart to multiply the coefficient of 2.5 by the load, which in this case is 4.166 lbs. This would give us the result of 10.4 lbs. of force

Newtons

Because a large part of the mathematical analysis of a truss is measured in Newton's of force, I have included all values of the forces in Newton. To arrive at this is simple; just use the conversion formula from pounds to Newton's, the conversion factor is 4.448. For example to convert 10.4 pounds to Newton's, simply multiply 10.4 lbs. x 4.448 = 46.2592 Newton's of force. In addition to this it is interesting to note that the weight to strength ratio for the truss provided is 1 ounce (1/16 pound) to 25 lbs or 1:400.

Conclusion

Trussing offers an efficiency of materials unattainable with any other type framing system. The practical applications have an enormous potential. Everywhere you look you find trusses. When a structure is being built in most cases a truss system will be required. Knowing the mathematical analysis of a truss is important when determining the needs of the structure in question. Without which failure of the truss may be inevitable. Although a multitude of other considerations need be taken into account when constructing framing systems, presented here is an elementary understanding of one aspect of application. Industry is ever evolving; however, the mathematical principles presented here will not change and are only subject further study.

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