611-0365 (40-510) Simple Form Truss

Additional Materials Needed, Not Included:

Calculator
Masking Tape
Protractor
2 of 250g/2.5N Spring Scale 29-1209
10 x 50g Slotted Weight Set with 50g weight hanger
Ring Stand with 1/2" dia. rod
30cm rope or twine

Warranty and Parts:

We replace all defective or missing parts free of charge. Additional replacement parts may be ordered toll-free. We accept MasterCard, Visa, checks and School P.O.s. All products warranted to be free from defect for 90 days. Does not apply to accident, misuse or normal wear and tear. Intended for children 13 years of age and up. This item is not a toy. It may contain small parts that can be choking hazards. Adult supervision is required.

How to Teach with the Simple Form Truss:

Concepts Taught: Roberval's Law of Composition of Forces; mathematical calculations (e.g. unit cancellation, algebra)
Curriculum Fit: Physics Sequence, Force and Motion. Grades 9-12 and up.

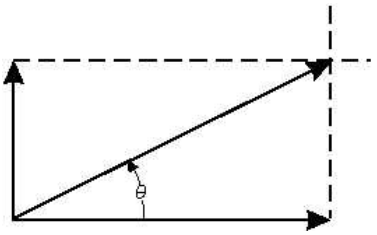
Theory:

Your Simple Form Truss Kit is designed to be set up as a way to demonstrate the Law of Composition of Forces (Discovered by Roberval (b.1602 d 1675). Among other things the Law of Composition of Forces is used for determining if there is enough tension and compression in components of a truss or derrick construction. Your Simple Form Truss is also able to help teach the Parallelogram of Forces (Discovered by Stevins (b.1548 d. 1620). Warren Truss Bridge over Little Manatee River


Warren Truss Bridge over Little Manatee River

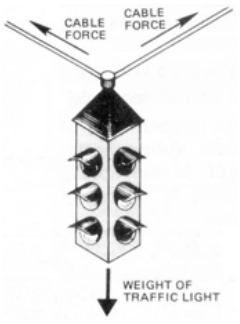
Law of Composition of Forces

If two or more forces are acting simultaneously at a point, the same effect can be produced by a single force of the proper size and direction. This single force which is equivalent to the action of two or more forces, is called the resultant. Putting component forces together to find the resultant force is called composition of forces.



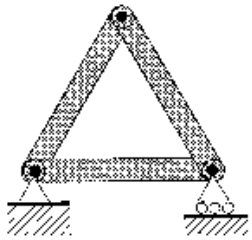
Questions:

1. Two soccer players kick a ball at the same instant. One strikes with a force of 66 N at 0° and the other 85 N at 90°. Find the resultant force on the ball.
2. Two children pull a wagon by exerting forces of 14 N and 20 N at the same point. If the angle between them is 30.0°, what is the magnitude of the resultant force on the wagon?
3. A boy and a girl carry a 11.0 kg bucket of water by holding the ends of a rope with the bucket attached at the middle. If there is an angle of 110.0° between the two segments of the rope, what is the tension in each part?
4. A woman and two men are pulling on ropes attached to a tree. The woman exerts a force of 70.0 N at 0°, the first man exerts a force of 40 N at 90°, and the second man 50 N at 140°.
   a. Find the resultant force on the tree by using the polygon method (with a scale drawing)
   b. What is the equilibrant force?
5. A traffic light is supported by two wires, which make an angle of 130.° to each other. If the maximum tension in each wire is 700 N, what is the maximum weight of the light they can support?

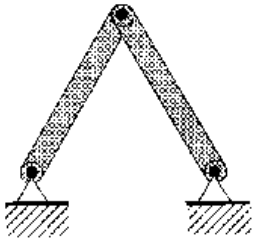


Stability and Trusses

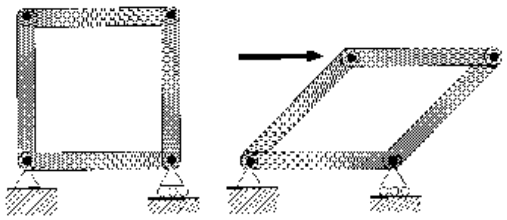
There is an important characteristic of a useful truss: it must be stable, which is to say that it should not move freely in any direction. Below are some configurations of members joined at the ends. The first shown is the most basic triangular truss. The left support only allows connected members to rotate. The right support additionally allows horizontal movement. This configuration is stable, because there is no motion which can freely occur.



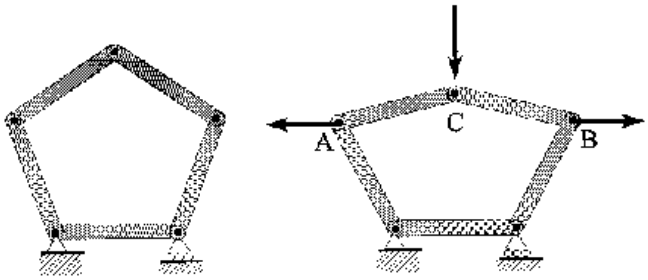
Two members connected at a joint form a hinged arch, as shown below. A hinged arch may be added to any stable truss to form another stable truss, as long as the angle of the arch is other than 180º. A truss which can be assembled in this manner is called a simple truss.

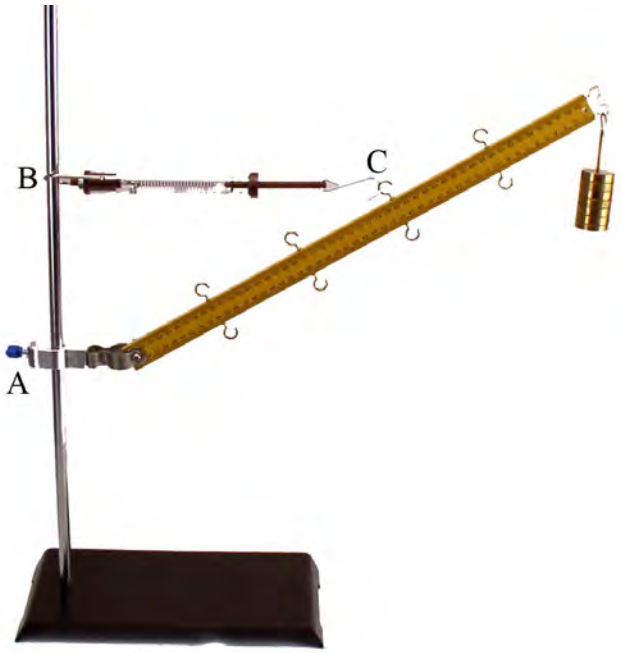


Shown next is a square configuration. This is unstable, because the side pieces will lean over freely as the top is pushed horizontally. How would this be stabilized?



Lastly, we see that a pentagonal configuration is also unstable, because as points A and B move apart, point C is free to move down. What is the smallest number of members required to make this stable? In a similar fashion, all but the triangle will be unstable, so the triangle is basic unit of any truss structure.





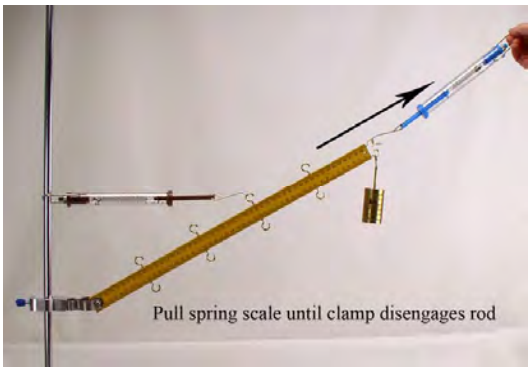
Setup:
Using the picture above as a guide, attach the right angle clamp to the ring stand. Slide the closed loop of the spring scale down from the top of the ring stand. Attach the hooked end of the spring scale to one of the cup hooks on the top side of the ½ meter stick. Using a loop of string, or just the weight hanger itself, hang the slotted weight hanger from one of the hooks. The weights can be attached anywhere along the lower set of hooks, however easiest computations are made when the weights are attached to the hook that is directly opposite the hook which the spring scale is attached to. Attach 2 weights to the weight hanger. You may need to affix some masking tape to keep the spring scale in place on the ring stand. Please use caution and make
sure the device is positioned so that the ring stand will not fall over. All of the following experiments can be performed using any set of hooks. It may be necessary, however, have someone hold the horizontal spring scale as the distance from the hook to the upright bar may not be long enough to fit some types of spring scales.

Experiment One (Using your brain)
The figure drawn by connecting A to B to C with straight lines is a right triangle. The Square of the hypotenuse (longest side) is therefore equal to the sums of the squares of the two adjacent sides. The hypotenuse (1/2 meter stick) is the compression (thrust) factor.

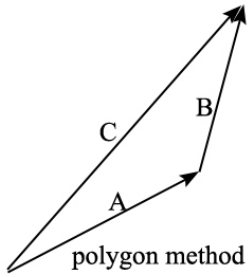
$$c^2 = a^2 + b^2$$

By examining the angles set up and the force displayed on the spring scale, the compression force on the meter stick can be easily determined.

Experiment Two (Using your hands)
Attach a second spring scale to either of the hooks at the end of the halfmeter stick. Loosen the right angle clamp and pull the second spring scale away from the support rod in the direction the ½ meter stick is oriented. Do this until the clamp end of the ½ meter stick moves. This signifies that the weight of the ½ meter stick is fully lifted. While making sure that the first spring scale reading and angle remain constant with the same values in experiment One, have a second person record the spring scale reading. This second spring scale reading minus the weight of the ½ meter stick (you determine this) is the compression (thrust) factor.



Experiment Three (using Polygon method)
The polygon method: In Fig. 1a, the vectors are placed head to tail. The resultant vector goes from the tail of the first vector A to the head of the second vector B to give C = A + B.



polygon method

For this experiment it is necessary to use graph paper and a protractor to plot the lengths and angles of the (magnitude and angle) of the two sides, as shown in the diagram above, in order to find the resultant.

Experiment Four (using Parallelogram of Forces method)
Stevin's principle of Parallelogram of Forces says that the resultant (1/2 meter stick) of two forces acting at any angle may be represented by a diagonal of a parallelogram constructed of arrows representing the two forces.

Again, using graph paper and a protractor, draw a rectangle with the adjacent sides representing (in length) the forces of the tension members (spring scale reading BC and the hooked weight CD). A combined weight of 500gms for example, might be represented by a line 5cm long in which 1cm equals 100gms. Draw the diagonal of this rectangle and measure it. Convert this dimension to grams. This is the compression (thrust) factor.

Benchmarks and Standards

This investigation provides support for the *Benchmarks for Science Literacy* and *National Science Education Standards* shown in the table below.

Benchmarks for Science Literacy				*National Science Education Standard*
Grades 6 – 8 **The Physical Setting**	**4B.3**	"An unbalanced force acting on an object changes its speed or direction of motion, or both.	Grades 5 -8 **Physical Science Content Standard B.3** – Motions and Forces	"If more than one force acts on an object along a straight line, then the forces will reinforce or cancel one another, depending on their direction and magnitude. Unbalanced forces will cause changes in speed or direction of an object's motion." (p. 154)
Grades 9 – 12 **The Physical Setting**	**4B.1**	"The change in motion of an object is proportional to the applied force and inversely proportional to the mass."	Grades 9-12 **Physical Science Content Standard B.1** – Motions and Forces	"Objects change their motion only when a net force is applied. Laws of motion are used to calculate precisely the effects of forces on the motion of objects. The magnitude of the change in motion can be calculated using the relationship F = ma, which is independent of the nature of the force. Whenever one object exerts a force on another, a force equal in magnitude and opposite in direction is exerted on the first object." (p. 179)