Lecture Demos Used By Dr. Masters

Engineering Science and Mechanics

Penn State University

E MCH 211: Statics

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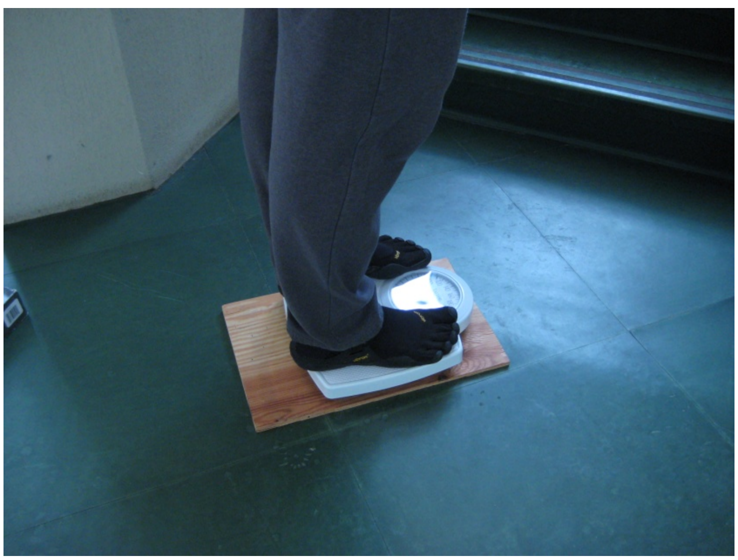
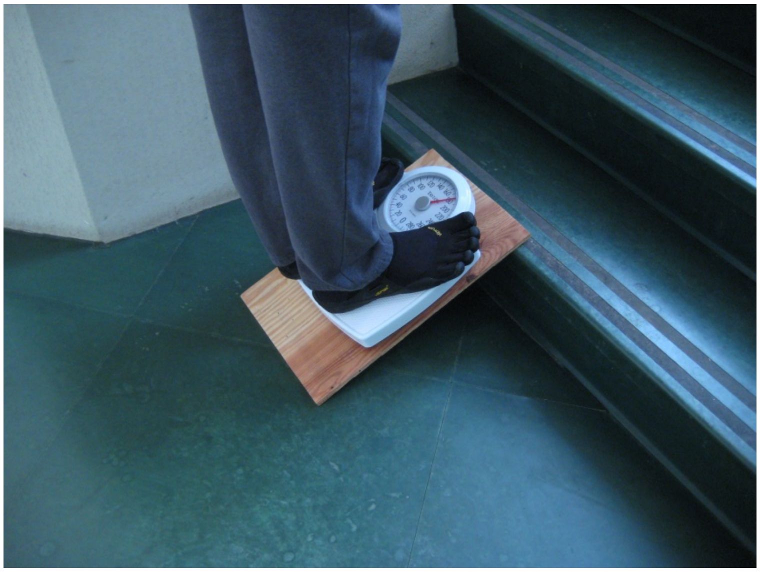
Demo #1 - Slanted Scale (Vector Components)

This demo gives an example of the relationship between normal force and object weight when a slant is introduced.

Part 1 - A student stands on a scale and his/her weight is measured.

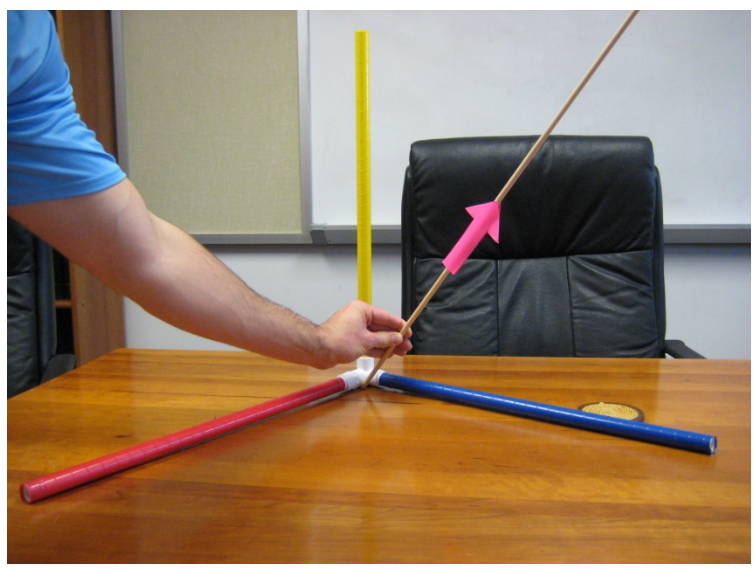


Part 2 - One side of the scale is propped on a stair or a similar rise so that when the student stands on the scale again, only the component of the student's weight perpendicular to the slanted scale is measured by the scale. The result is that the student appears to have "lost weight."



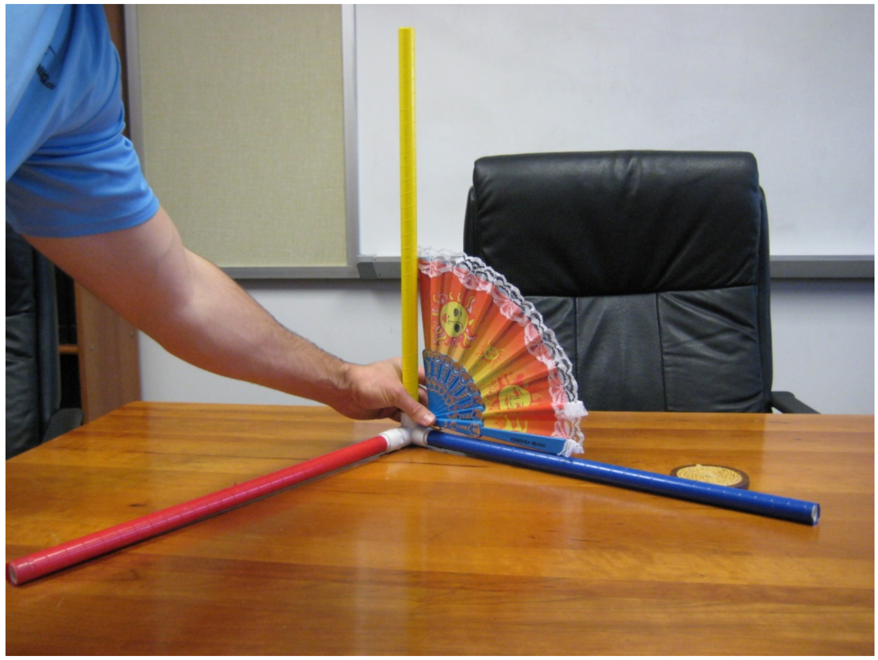
Demo #2 - Force-On-a-Stick (3D Vector and unit vector)

A force vector cut out of construction paper is taped to a small dowel rod. This tool is useful for demonstrating several points throughout the course. Aside from being a good way to show a physical vector in three dimensional space, it is also a good visual example of how two vectors - say a position vector (the dowel rod) and a force vector - can be in the exact same direction (have common unit vectors) but have different magnitudes.



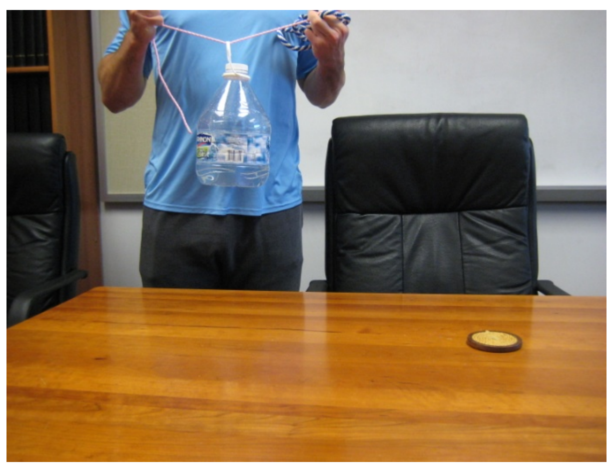
Demo #3 - 3 Dimensional Vector Demo (3D Direction Angles)

PVC pipes painted different colors are attached to a three-way perpendicular hub to represent a 3 dimensional set of axes. This tool is used in conjunction with the force-on-a-stick to give a visual demonstration of how a vector can have components in all three dimensions. In addition, one can use a flat object like a folder to represent xy, yz, or zx planes on the axes.



<u>Demo #4 - Tension vs. String Angle for a Suspended Object (Vector Components and Particle Equilibrium)</u>

A jug of water is suspended by two strings held loosely by the demonstrator (top picture). It can be shown that tension in the strings must be increased to decrease the angle between the string and the horizontal direction. In fact, using a sufficiently weak string and a large enough amount of water will enforce this point by snapping the string once tension has increased to a critical point.

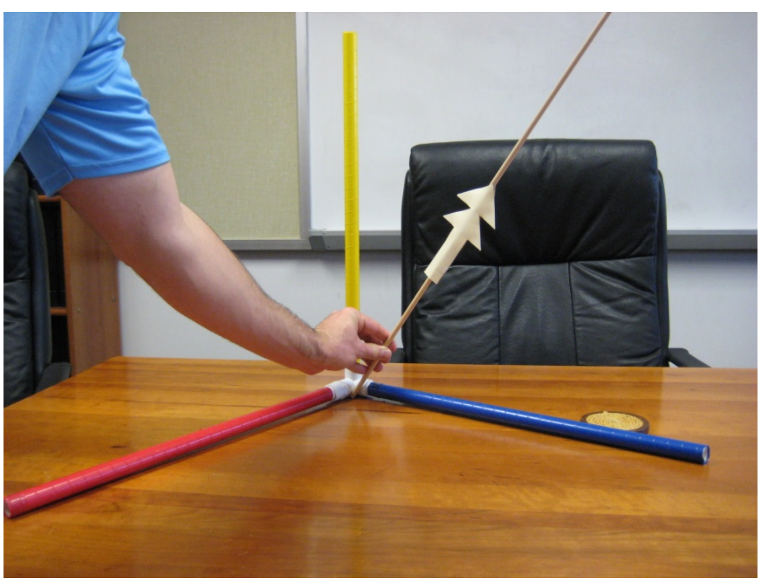


Demo #5 - Tension and Pulleys

A weight is hangs from a pulley suspended by a string which is held in a demonstrator's hand on one end and attached to a second pulley suspended by another string at the other end as shown in the picture to the left. The string ends of the second pulley can be manipulated to demonstrate the relationship between the tension in the two strings with two pulleys in the system. It can be shown that the tension in the second string is only half of that in the first string when the system is in equilibrium.

Demo #6 – Moment-on-a-Stick (3D Moments)

With the 3-D PVC axis system, a moment-on-a-stick is used to demonstrate the meaning of a 3-D moment vector. The physical action of the moment can be demonstrated by rotating the dowel rod along its axis to show how the moment would act on an object.

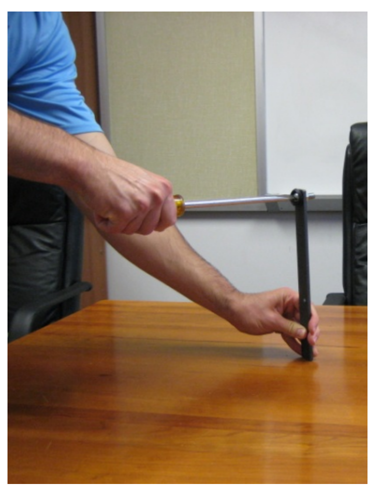


Demo #7 - Wrench and Lug Wrench (Moment vs. Couple)

These two tools are used to demonstrate the difference between a single force moment (the standard wrench) and a couple (the lug wrench).

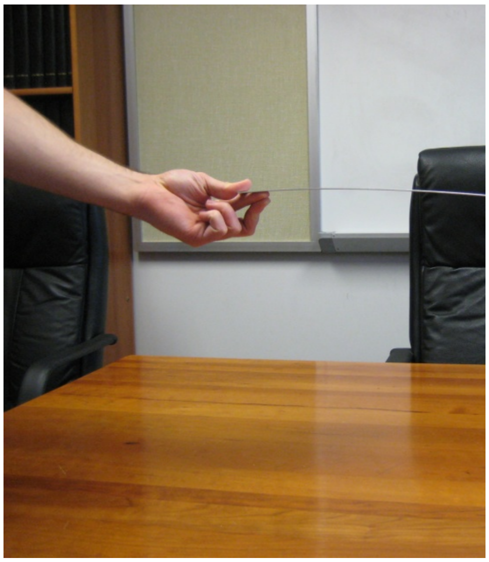
Demo # 8 - Wrench vs. Screwdriver (Moment arm)

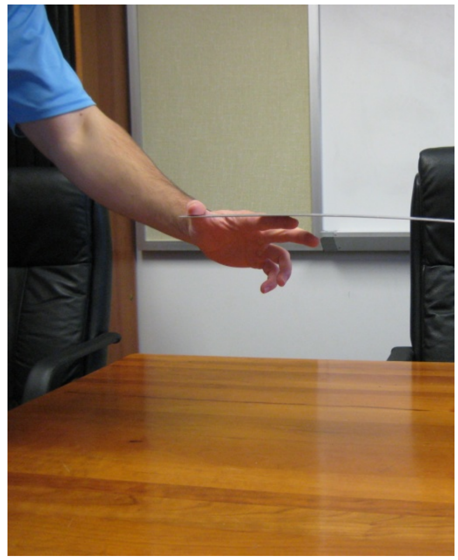
A comparison of these two tools shows that the standard wrench has a far superior moment arm but also produces a resultant force in the direction it is twisted that must be counteracted by whatever is supporting the object being wrenched. It can be shown that this resultant force is not present with the use of a screwdriver because a couple is applied instead of a single force moment.



Demo # 9 - Ruler Reaction Couples (Fixed support couple)

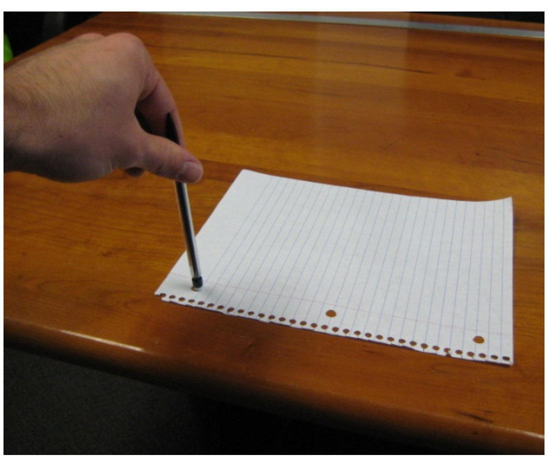
A long, flimsy ruler can be used to demonstrate how certain grips require less of a reaction couple to keep the ruler horizontal while grips closer to the edge require greater reaction couples to maintain this same equilibrium.

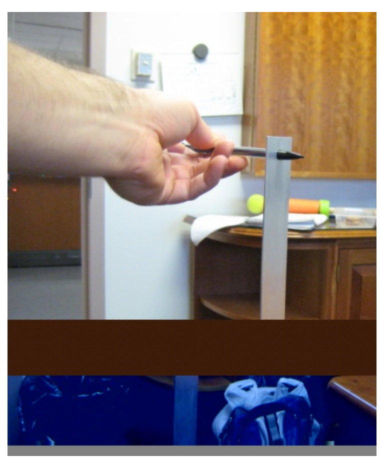




Demo # 10 - Pin Reactions with Pencils

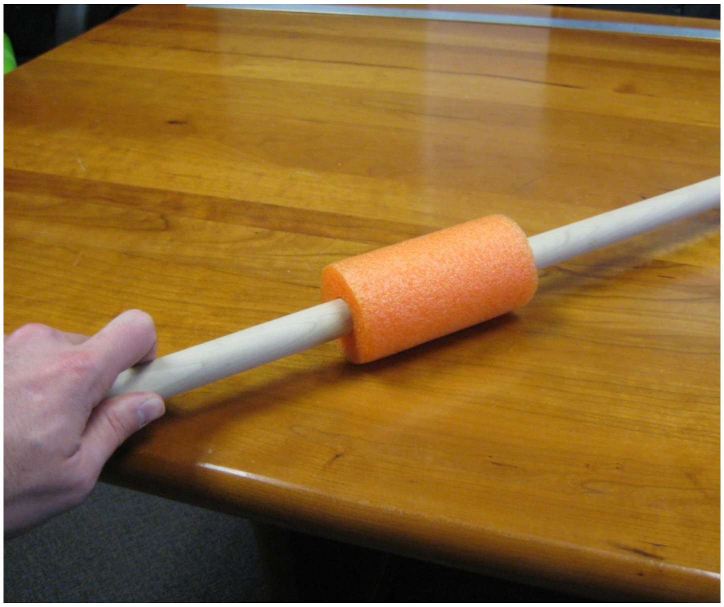
A pencil can be placed in the hole of a piece of notebook paper or in the hole at the end of a ruler to demonstrate the reaction forces of a pin support: the object is free to rotate about the axis of the pencil's length but is unable to move against the pencil horizontally or vertically.





Demo # 11 - Roller Reactions

A dowel rod surrounded by a layer of foam represents a roller and shows that the roller can only exert a single direction reaction force.

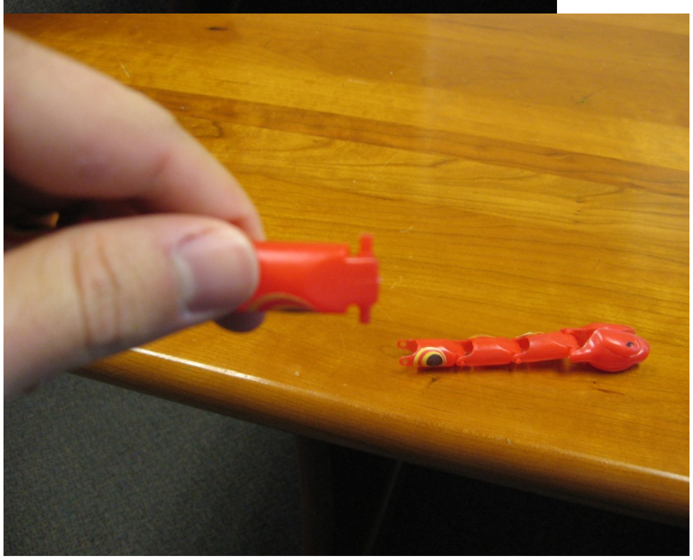


Demo # 12 - Collar Reactions/Ball-and-Socket Reactions

A dowel rod with two foam collars (one representing a collar and another representing a self aligning bearing) and a ball on the end can be used to demonstrate reactions of collars and ball-and-socket joints. The ball can simply be held in the hand while the rod is moved to demonstrate the three reaction force directions but lack of reaction couples. The foam collar can demonstrate that the only freedom a rod in a collar has is to slide and rotate along the axis of the rod. Lastly, the more flexible foam piece is used to demonstrate how a self aligning bearing is flexible enough to avoid exerting the reaction couples that a normal collar would. Note: the collar and self aligning bearing pieces are not pictured.

Demo #13 - Plastic Snakes and Pins (3D Pin reactions)

Plastic snake toys which feature segments held together by two pins each are passed around to the students to allow them to interact with an example of pins and feel the reaction forces for themselves.

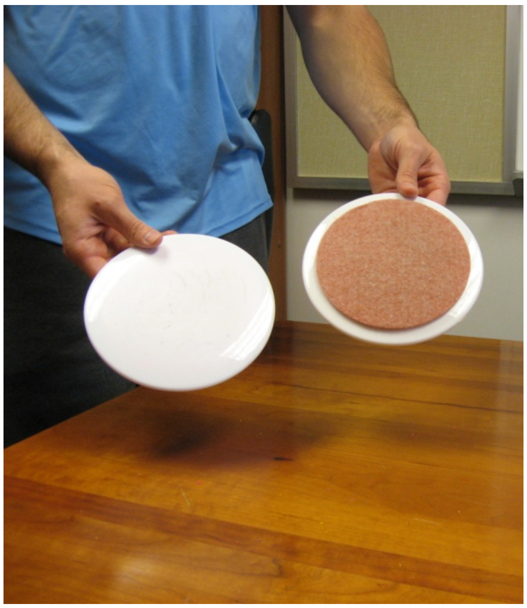


Demo #14 – Scissors (Machine analysis)

A regular pair of scissors is used as a demonstration of a simple machine and a basis for discussing the application of external forces to a machine and the resulting internal forces that occur.

Demo #15 - Slider Pads and Friction

"As seen on TV," slider pads demonstrate how different materials have different coefficients of friction relative to different materials. For example, the plastic pads work well for sliding on carpet, but carpet pads work better for sliding on a linoleum floor.

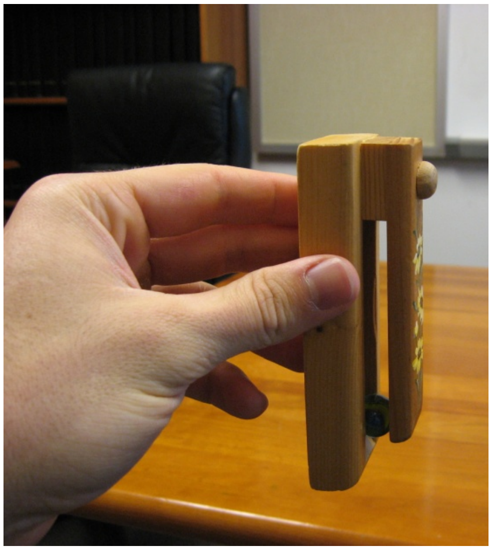


Demo #16 - Velcro and Friction

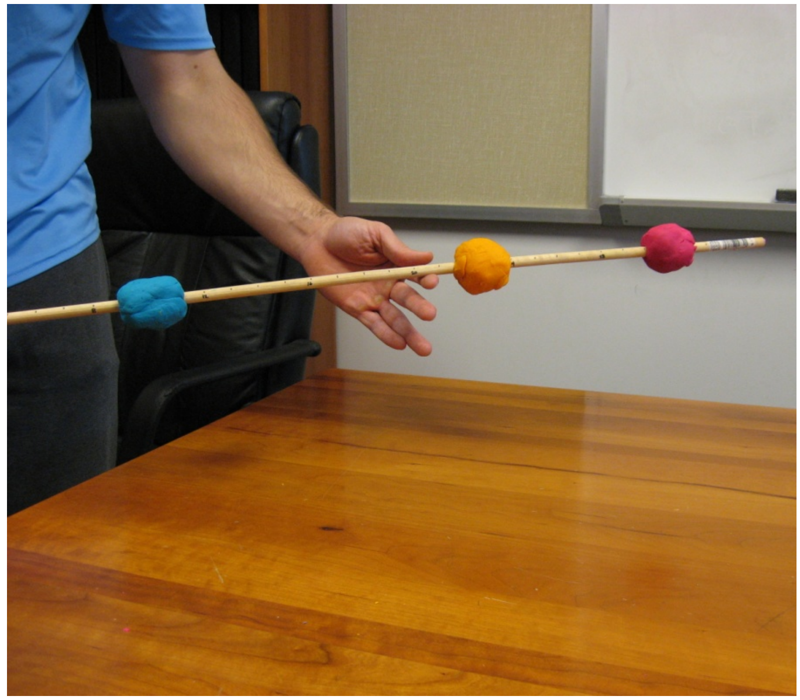
Velcro is used as an example of a case in which the coefficient of friction between two materials can be greater than one.

Demo #17 - Friction-based Towel Holder (Self Locking Mechanism)

This unique towel holder makes use of a marble in a slotted track to hold a towel that is placed between the wood and the marble. This is a good example of a system that is capable of producing higher frictional forces when one pulls harder on the towel. It can be shown that the towel can be removed from the holder by simply pulling it up instead of down.



Demo #18 - Play Dough Balls and Centers of Gravity (Equivalent System review leading to CG equation)



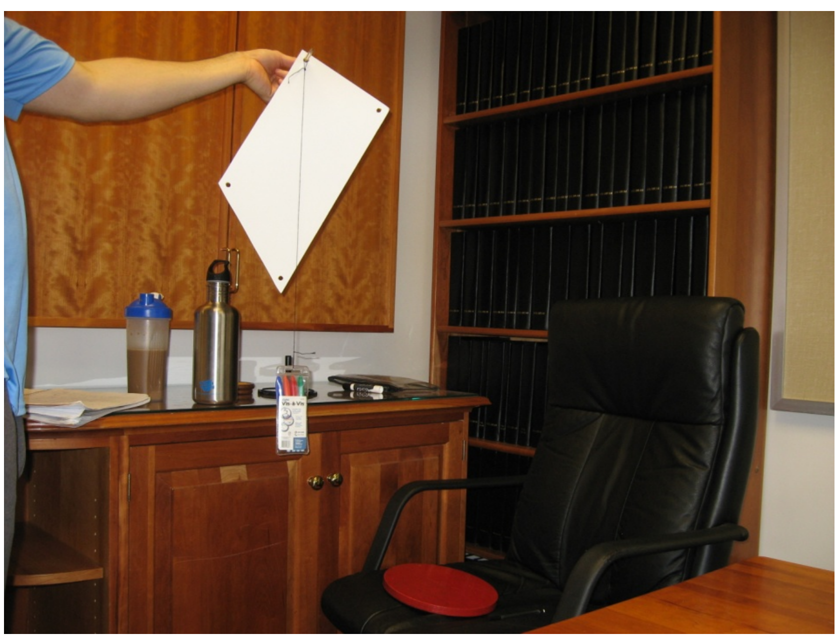
Three play dough balls are placed at random positions on a dowel rod marked with increments of length. From these positions and the fact that the balls are all approximately equal in weight, the center of gravity can be calculated. It can then be shown that the entire system can be balanced at the calculated position, its center of gravity, to validate the calculation.

Demo #19 - Center of Gravity Wheel Trick (CG vs. Centroid)

A wheel with one half constructed of wood and the other of metal is painted uniformly red. When placed with the metal half on the bottom, it remains in place, but when placed with the line separating the halves vertical, the wheel will roll towards its center of gravity. NOTE: The separation in the picture lies horizontally, but it is hard to see.

Demo #20 - Finding Centers of Gravity with a Plumb Bob

A plumb bob (consisting of a pack of markers) is dangled from a pencil that is slipped through a hole in a piece of dry erase board and a marker is used to trace the first center line. The process is repeated using a different hole in the board to get the second center line. The center of gravity is then the intersection of these two lines. The center of gravity can then be calculated and shown to be the same location as the one that was found.



Demo #21 - Moments of Inertia and Axes of Rotation

A foam tube with various holes can be fitted onto a dowel rod through its center, through its end, or along its length to show that the moment of inertia changes when the foam tube is rotated about each different axis.