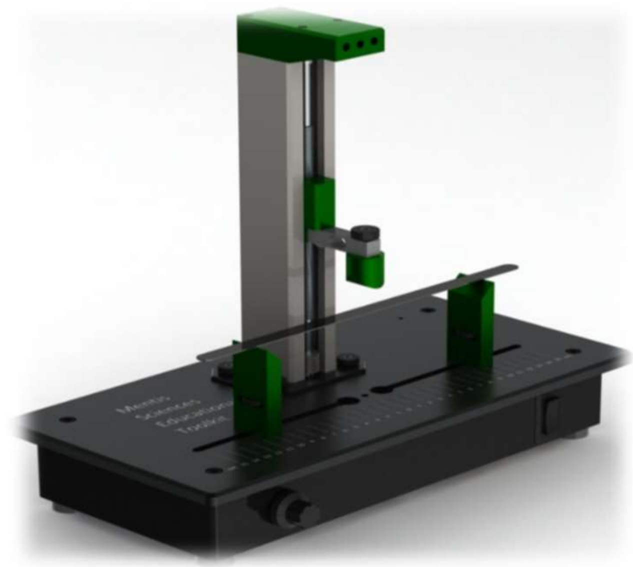
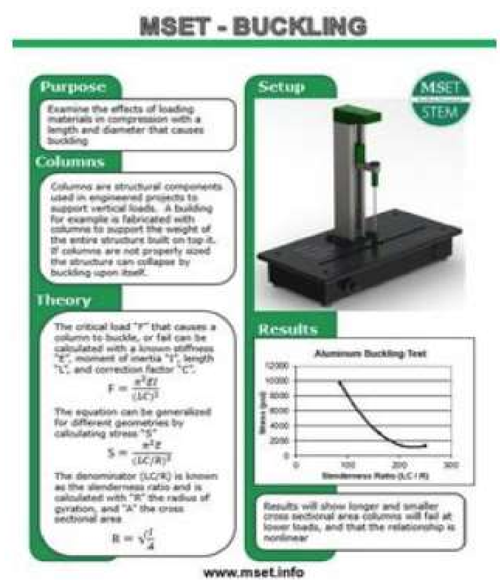
Mentis Sciences Engineering Toolkit

The MSET system is a small-scale portable testing apparatus that provides students a window into the world of science and engineering. With over 40 experiments available, the MSET system covers a wide range of engineering principles and real-world physical concepts, well suited for high school and college level engineering programs. Features include the following:



Mobile base unit can be easily reconfigured to prepare for multiple experiments in the classroom efficiently



MSET - BUCKLING

Purpose

Examine the effects of loading materials in compression with a length and diameter that causes buckling

Columns

Columns are structural components used in engineered projects to support vertical loads. A building for example is fabricated with columns to support the weight of the entire structure built on top it. If columns are not properly sized the structure can collapse by buckling upon itself.

Theory

The critical load "F" that causes a column to buckle, or fail can be calculated with a known stiffness "E", moment of inertia "I", length "L", and correction factor "C".

$$F = \frac{\pi^2 EI}{(LC)^2}$$

The equation can be generalized for different geometries by calculating stress "S"

$$S = \frac{\pi^2 E}{(LC/R)^2}$$

The denominator (LC/R) is known as the slenderness ratio and is calculated with "R" the radius of gyration, and "A" the cross sectional area

$$R = \sqrt{\frac{I}{A}}$$

Setup

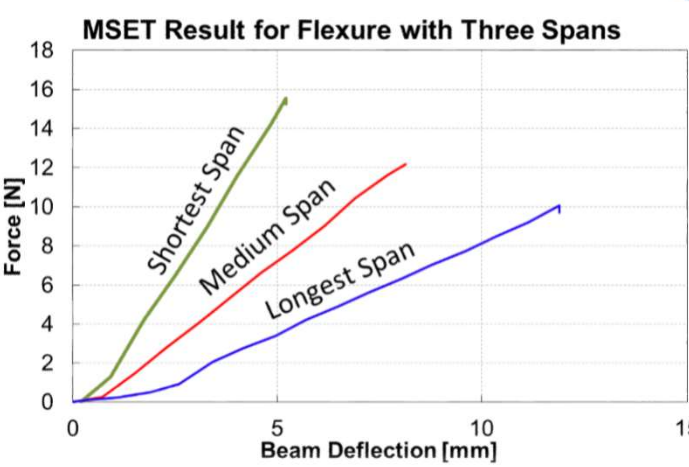
Results

Aluminum Buckling Test

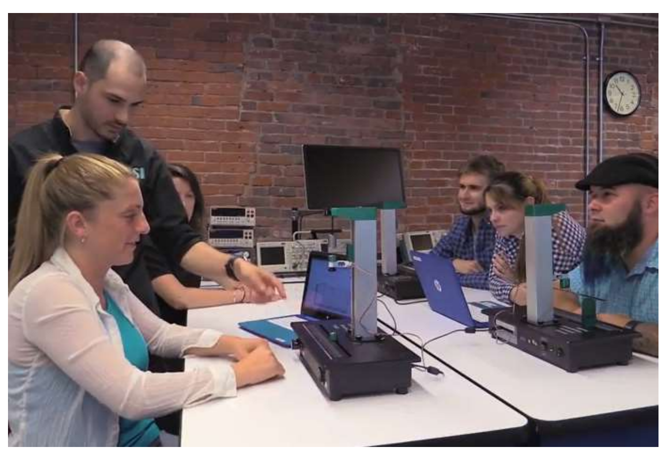
Results will show longer and smaller cross sectional area columns will fail at lower loads, and that the relationship is nonlinear

www.mset.info

Over 40 experiments available including tutorials, instructor class notes, instructions and video lesson



Bluetooth enabled, data acquisition is used on most experiments, giving users graphing capabilities for comparing important engineering parameters.



Affordable design provides a platform for performing all experiments, offering greater accessibility to all students

Sampling of Experiments

MSET "Endless Potential" STEM

MSET - THREE POINT FLEXURE

Purpose

Develop an understanding of geometry, material properties, and problem formulation.

Beams

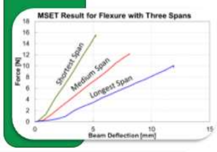
Beams are one of the fundamental components used in engineering. A bridge for example is fabricated with a number of beams configured, and sized to support vehicles.

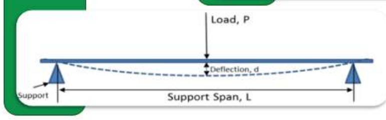
Theory

A beam loaded at its center will deflect a distance "d". The amount of deflection depends on the magnitude of force "P", beam span "L", stiffness "E", and beam combined geometric shape "I"

$$d = \frac{PL^3}{48EI}$$

Setup





MSET – BUOYANCY FORCES

Purpose

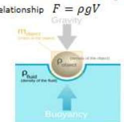
Evaluate the effects of submerging an object in a body of liquid that imparts a force on the body helping the body afloat.

Buoyancy

Buoyancy forces are useful in keeping an object from sinking in water. An example of this type of force can be seen when a boat is launched into water. Without the buoyancy force the vessel would sink.

Theory

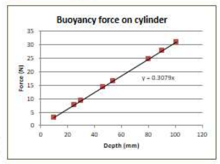
Buoyancy is a force "F" that works in the opposite direction of gravity "g" and is proportional to the volume "V" of water displaced by a body. The upward buoyancy force can be calculated using the relationship $F = \rho g V$



Setup

Results

The linear relationship between the buoyancy force and volume of water displaced will be plotted and compared to theory for a vessel of constant cross-sectional area. This relationship may also be studied for geometries that vary as a function of depth.



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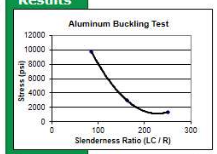
Setup

Results



Results will show longer and smaller cross sectional area columns will fail at lower loads, and that the relationship is nonlinear

MSET - CALIBRATION

Purpose

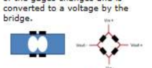
Introduce sensors and transducers to quantify physical inputs such as force, and rotational speeds. Develop a basic skill set used to determine conversion coefficients.

Sensors

Sensors are electro-mechanical devices commonly attached to materials and placed in an environment to be measured. The sensor produces an electrical output of voltage, current, and or resistance as the input changes

Theory

Load cells convert force to a signal with strain gages and a wheat stone bridge. Resistance of the gages changes and is converted to a voltage by the bridge.

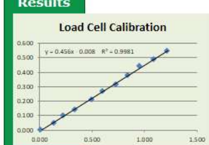


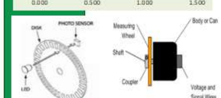
Encoders are used to measure rotational and linear movement using a light source (LED) and optical sensor. The sensor generates electric pulses that are counted when the light source passes a slots in a disk that is attached to a shaft

Setup

$$SF = \frac{gms.}{volt}$$

Results





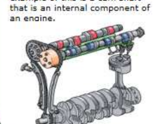
M – CAMS

Purpose

Introduce a method of converting rotary motion to variable linear motions using a cam.

Cams

Cams are used in a variety of applications for the purpose of controlling movement of a link or other object in contact with it. An example of this is a cam shaft that is an internal component of an engine.



Theory

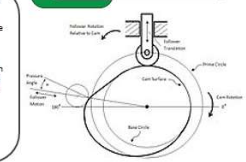
A simple cam that is rotated on a shaft with a follower that rolls along the surface of it. As the diameter of the cam changes, the follower moves up and down. The travel of the follower "Y" is calculated as a function of rotation angle "Ø ", net change in follower travel "H", and the angle "β" causeing follower movement.

$$Y = \frac{1}{2}H\left(1 - \cos\left(\frac{\pi Ø}{\beta}\right)\right)$$

Setup

Results

Measurements of

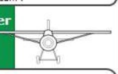


MSET – CANTILEVER FLEXURE

Purpose

Perform a strain gage system calibration that will be used to determine the flexural stiffness of a cantilever beam .

Cantilever Beam



Cantilever beams are used in a variety of engineering applications. As an example, aircraft are designed with complex geometric cantilever beams called wings.

Theory

A cantilever beam has clamped - free boundary conditions. When a force "P" is applied to the free end of the beam it deflects an amount " δ", that depends on the beam length "L", stiffness "E", and the moment of inertia "I".

$$\delta = \frac{PL^3}{3EI}$$

A beam of thickness "h" is strained an amount "e" as the load is applied at a point from the location of interest "X".

$$\varepsilon = \frac{3hx}{2L^3}\delta$$

The stress "S" carried by the beam is given as

$$\sigma = \frac{Px(C)}{I}$$

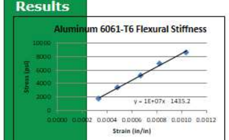
Setup

Theory

Where "C" is the distance from the neutral axis to the surface of the beam, simplified as "h/2". The flexural stiffness is obtained by determining the slope of the stress and strain data expressed as:

$$E = \sigma/\varepsilon$$

Results



MSET – DENSITY

Purpose

Develop an understanding of how the density of different materials varies, introduce basic volumetric calculations, weight measurements, and how they are used to calculate density, and specific gravity

Density

The density of liquids varies with their molecular structure, temperature, and atmospheric pressure. If two liquids such as vinegar and water are mixed together they will separate with the denser liquid settling to the bottom substances varies with less dense materials

Theory

The density of a material can be determined by measuring the mass "M", and volume "V" equated as follows:

$$\rho = M/V$$

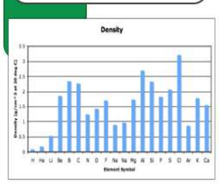
Specific gravity "Sg" is used to define the relative density of materials and is the ratio of the density of material "X" to that of water.

$$Sg = \rho^X/\rho^{Water}$$

Setup

Results

A number of MSET components will be weighed and volumetrically quantified to allow for the density to be determined. Results will be converted to specific gravities and then used to hypothesize what the material is.



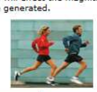
MSET – DYNAMIC IMPACT

Purpose

Examine the effects of impacting materials of different composition, and how the impact force varies as a function of event duration.

Impacts

Dynamic impacts are a common result of daily activities. As an example a person walking or running experiences dynamic forces to their body. The weight of the person, and type of shoes worn will effect the magnitude of force generated.



Theory

The amount of potential energy "PE", that an object of mass "M" has is a function of height "H", and gravitational constant "G".

$$PE = MGH$$

As it falls, the height decreases, and velocity "V" increases. The potential energy is converted to kinetic energy "KE".

$$KE = \sqrt{2GH}$$

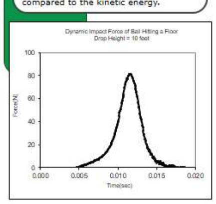
The force of impact "F" is defined by Newton's second law with "A" being the deacceleration.

$$F = MA$$

Setup

Results

A number of materials with various energy absorbing characteristics will be measured and compared to each other. The impact magnitude, and duration time will be compared. Energy absorption of each will calculated and compared to the kinetic energy.



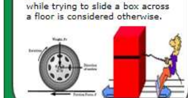
MSET – FRICTION

Purpose

Determine the coefficients of static and dynamic friction of different materials sets.

Friction

Friction is a result of materials in contact with each other and subjected to a bonding force. The adhesion of car tires to pavement is considered a benefit of friction while trying to slide a box across a floor is considered otherwise.



Theory

The coefficient of static friction μ_s is used to quantify the force F_s needed to slide two surfaces relative to each other when connected by a normal force N and is expressed as:

$$\mu_s = {}^{F_s}/_{N}$$

Once movement occurs the dynamic coefficient of friction μ_K replaces the static coefficient and the force F_k needed to maintain motion is calculated as:

$$F_k = \mu_k N$$

Setup

Results

The measured normal force and angled height that causes sliding will be used to calculate the coefficient of static friction. The dynamic coefficient will be determined by measuring the force after motion begins. Values obtained will be compared to those published. Coefficients will be used to predict forces required to move masses of varying magnitudes and composition

Approximate Coefficients of Friction

	Kinetic	Static
Rubber on concrete (dry)	0.68	0.90
Rubber on concrete (wet)	0.58	
Rubber on asphalt (dry)	0.67	0.85
Rubber on asphalt (wet)	0.53	
Rubber on ice	0.15	
Waxed ski on snow	0.05	0.14
Wood on wood	0.30	0.42
Steel on steel	0.57	0.74
Copper on steel	0.36	0.53
Teflon on Teflon	0.04	