	High School	
	SUNHYDRALICS	[redacted]
	What's a Matter **Teacher Lesson Plan**	

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NATURE OF LESSON	GRADE LEVELS
Students are challenged to understand general properties of matter and the importance of the appropriate selection of a unit system in the design and manufacturing processes.	9-11
TARGETED SUBJECT AREA/S	**MANUFACTURING PHASE**
Science, Introduction to Science, Computer Technology, Math and Tech Ed	Test & Design
LEARNING OBJECTIVES	**TIME FRAME**
1. To understand the general properties of matter such as mass, volume, density, and weight. 2. To understand and compare concepts of mass and weight, and its relation to volume and density. 3. To manipulate variables and use the appropriate unit system towards desired computational outcomes. 4. To integrate and apply science, math, and technology.	2 class sessions (55 minutes each)

SUNSHINE STATE STANDARDS ADDRESSED

ITEEA: HTTP://WWW.ITEEA.ORG/TAA/PDFS/XSTND.PDF

NGSSS: HTTP://WWW.FLDOE.ORG/BII/CURRICULUM/SSS/

SC. 912.E.5.2, SC.912.E.7.1, SC.912.P.8.1, SC.912.P.8.2, MA.912.G.5.4, MA.912.G.2.2, MA.912.G.7.5, SC.912.L.17.1, MA.912.A.3.4, MA.912.A.3.5

MATERIALS

A plastic toy, four or more soda cans, a bag of cotton balls, a bag of sand enough to fill two soda cans, weight scale (optional), scissors, a piece of paper, an empty gallon of water, one liter bottle, golf ball, and beach ball.

LEARNING ACTIVITIES

1. Review theory

Matter can be described as the substance that all objects are made of, everything you can touch is made of matter. General properties of matter include: mass, volume, density, and weight.

Mass is the amount of matter in an object, it is constant and does not change from one place to another. In most modern scientific work, physical quantities are measured in the international systems of units (SI). The SI unit of mass is kilograms (kg); the English unit is the pound-mass (lb).

Volume is defined as the amount of three-dimensional space occupied by a liquid, solid, or gas. The SI unit of volume is a cubic meter; other common units include liters, gallons, milliliters, teaspoons and ounces.

Density can be explained as the measure of the relative "heaviness" of objects with a constant volume. The formal definition of density is mass per unit volume. Density can be changed by changing either the pressure or the temperature. Water upon freezing becomes ice, the density of the water decreases by about 9%. The SI unit of density is kilogram per cubic meter (kg/m^3), although grams per cubic centimeter (gr/cm^3), kilograms per liter (kg/l), and pounds per gallon (lb/gallon) are also used. In chemistry, is very common to compare the density of many substances to the density of water (1000 kilograms per cubic meter kg/m^3).

$$Density(kg/m^3) = \frac{mass(kg)}{volume(m^3)}$$

Regardless of size and shape, if the density of an object is less than that of a fluid, the object will float in the fluid. If the density of the object in the fluid is greater that the density of the fluid, the object will sink.

Weight is a measure of the heaviness of an object or the force which must be applied to support an object. It is explained by the force with which an object is attracted to Earth.

The gravitational field of earth exerts an attractive force on all objects and causes object near the earth to have weight. Weight is equal to the mass of the object multiplied by the acceleration of gravity of the gravitational field.

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$$Weight(kgm/s^2) = mass(kg) \cdot acceleration(m/s^2)$$

The acceleration of gravity is approximately constant everywhere on the surface of the earth (about 9.8 m/s² or 32.2 ft/sc). The (SI) unit of weight is the Newton (N) = 1 kgm / s $^{2.}$ Weight can be expressed in kilogram-force, which is a non-SI unit of force, defined as the force exerted by a one kilogram mass in standard Earth gravity (equal to 9.80665 Newton).

Difference between mass and weight: mass is a property of matter, whereas weight is a force that results from the action of gravity on matter: it measures how strongly gravity pulls on the matter. For example, on the surface of the Moon, gravity is much less (1/6 as strong as on the surface of the Earth). That is why astronauts weight less in the moon and look like they float; the downward force due to gravity is only 1/6 of the gravity on Earth. An astronaut's mass is still the same in earth or in the moon. Since mass is constant and does not change and earth's acceleration of gravity can also be considered constant, it can be implied that the weight of an object is proportional to its mass. That is why the standard weights used with balances are often labeled in mass units. For example, your weight is also known as body mass and is measured in kilograms (kg) or pounds (lb). Scales are usually the measuring instrument for determining the weight or mass of an object (if possible show a scale and ask students to check their weigh). The appropriate selection of the scale depends on the desired precision and how heavy the object is. Medical scales and bathroom scales are usually used to measure the body weight of human beings (figure 1). The spring scale is a simple system that uses a spring fixed at one end with a hook to attach an object at the other (figure 2). The traditional balance is a pivoted horizontal lever of equal length arms, called the beam, with a weighting pan, also called scale. It compares the mass of an unknown object in one scale pan to the mass of standard objects in the other. An example is a beam balance shown in figure 3. An analytical balance (figure 4), is used to measure mass to a very high degree of accuracy. The weighing pan(s) of a high precision (0.01 mg or better) analytical balance are inside a transparent enclosure with doors so that dust does not collect and so any air currents in the room do not affect the balance's operation.

Bell work

Have students brainstorm with examples describing matter and some general properties (if possible pass the objects). Examples: a toy and a plastic container are made of plastic, have a solid mass, weight, volume, and other properties such as flexibility, etc. A soda can, is made of aluminum metal, it is strong and soft material. A drinking glass is made of glass, can be transparent and fragile. If possible show some of the mentioned objects.

Volume: ask students to identify which one has the largest or smallest volume i.e.; one gallon of milk vs. one liter of water? Answer: one gallon (3.785 liters) is larger than one liter. If possible show gallon of water and a bottle of one liter.

If possible show a golf ball and a beach ball, pass them around and ask students which one has the largest volume.

Answer: a beach balloon has larger volume, which one is the heaviest and why? Answer: even though the beach ball has a larger volume, a golf ball is heavier because of its density; it has more mass (kg) "packed" in smaller volume. Ask students how to calculate the volume of a cylinder and a box?

Answer: $cylinder, volume = \Pi \cdot radius^2 \cdot h$, and $box, volume = lenght \cdot width \cdot high$

Density: Which one has more density, a can filled with sand vs. the same can fill with cotton, why?
Answer: the can filled with sand has more density because there is more mass of sand (kg), which weights more than the cotton, "packed" in the same volume. Review the formula:

$$Density(kg/m^3) = \frac{sand, mass(kg)}{can, volume(m^3)} > \frac{\cot ton, mass(kg)}{can, volume(m^3)}$$

"Oil and water don't mix" is an old saying. Ask students to use what they have learned about density to explain the reasons for this saying.
Answer: due to the densities of oil and water.

A cork is dropped in a plastic container with water (density of cork 240 k g/m^3), it is going to float or sink?

Answer: a cork will float in the water because its density is less than the density of the water (figure 5).
A ring made of gold has a density of 19300 kg/m^3 will sink or float in water? It will sink, because its density is greater than the density of the water.

Measuring weight & mass: *Weigh*t, the force of gravity on an object, is measured using a scale, whereas mass is measured using a balance. Photographs of two types of scales used to measure the force of gravity, an objects weight, are shown in Figure 1 and Figure 2.

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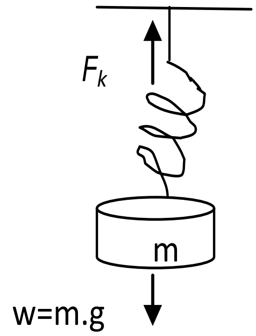
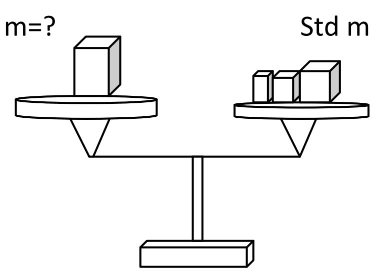


Both of these scales have a spring mechanism. The bathroom scale, Figure 1, has its spring located under the platform that you stand on. The hook scale, Figure 2, has its spring on its back side. The spring in a scale stretches (as in a hanging scale of a grocery store) or compresses (as in a simple bathroom scale) in proportion to how much the Earth pulls down on the object on the scale. The spring's displacement, the change of the spring's length, is directly proportional to the gravitational force applied by the object attached to the spring. Spring scales were first studied by Robert Hooke in the 17th Century and the following formula known as a "Hooke's law", $F_k = -k \cdot x$, is used to calculate the pulling force caused by the force of gravity on the object connected to the hook. In this equation *x* is the letter used to represent displacement, length change, of the spring from its starting position before the object was attached to the hook. This displacement is often measured in meters, the SI units for distance. The weight of the object, F_k, exerted by the object on the hook has Newton, N, units in the SI unit system. The letter *k* in the equation is a proportionality constant that is also called a spring constant. The units of a spring constant, N/m, make sure that the units on both sides of the equal sign are the same. The spring constant is unique for every spring and depends on the material it is made of and other properties. If the value of the spring constant is known the weight of the object can be calculated using Hooke's equation for that spring. For example, in the cartoon above, if the spring constant is 16 N/m and the attached object displaces the spring 0.25 meters the weight of the object is 16 Newton/meter multiplied by 0.25 meters, (16 N/m) (0.25m). This means that the weight of the object is 4 Newton, (16 N/m)(0.25m)= 4 N.

Mass is measured using a balance. This change in measurement device reflects the difference in mass and weight. Mass is determined by comparing the mass of an unknown object to masses of known standard masses. The photograph of a beam-balance is presented in Figure 3. Since this balance only compares the object's mass with a set of known masses, when the balance pans are in the horizontal position shown in the balance cartoon to the left, the object has the same mass as the sum of the standard masses. In practice, the object with the unknown mass is placed in one pan, and the standard masses are added to the other pan until the beam is as close to equilibrium as possible. In the case shown in the cartoon, the unknown mass on the left pan is equal to the sum of the three masses on the right pan. Balances can be used for accurate mass measurement. If the mass of the standard masses placed in the pan on the right are exactly known, the mass of the object on the left pan is also exactly known. The balance shown in Figure 4 is used to measure mass to very high degree of accuracy. These balances are made with the best materials and are carefully assembled so that if you put the same object on the pan over and over again the balance gives the exact same answer over and over again. This type of balance is known as an analytical balance because the mass measurement is accurate, gives the correct answer, and precise, give the same answer over and over again.



1. What's a Matter?

Draw on the blackboard table 1 shown below. Have students form 5 groups of 2. Assign an item per group and ask students to complete the requested information. Results should be presented using at least the first decimal.

	Item	Type of material (made of)	Volume	Mass/weight	Density
Example	One quarter (25 cents)	Metals: nickel plated copper (8.33% Ni with the remainder Cu),	Data: diameter 24.26 mm (0.955 in), thickness 1.75 mm (0.069 in). What is the volume in mm^3 and in^3? *Answer:* $volume = \frac{\Pi}{4} \cdot diameter^2 \cdot thickness$ $= \frac{\Pi}{4} \cdot (24.26mm)^2 \cdot 1.75mm$	Mass of the 25 cents: 5.67 g	What would be the density in g/cm^3 and lb/in^3? If the coin is thrown to a pond, it will sink or float, explain? *Answer:* $Density(g/cm^3) = \frac{mass(g)}{volume(cm^3)}$ $= \frac{5.670(g)}{809.1mm^3 \cdot \frac{1cm^3}{1000mm^3}}$

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		=809.1 mm^3 or (0.049 in^3)		=7.01g/cm^3 If the coin is thrown to a pond, it will sink or float, explain? *Answer:* the coin will sink because its density is 7. 01 g/cm^3, is greater that the density of water 1 g/cm^3
Block of ice		Data: width 1 m, length 2.5 m, high 3.0 m. What is the volume in m^3 and in^3 units? *Answer:* $volume = \cdot 1m \cdot 2.5m \cdot 3m$ =7.5 m^3	The block of ice is transported to the moon. What is the weight of the cube on Earth and on the moon (kg . m / s ^{2})? Ice's density: 0.92 g/mL, Moon's gravity: 1/6 of the gravity on Earth 9.8 m/s² *Answer:* $Mass(kg) = 920kg/m^3 \cdot 7.5m^3$ = 69,00 kg, mass is constant Weight $= 69,00(kg) \cdot 9.8(m/sc^2)$ = 67,620 kg.m / s ^{2}	A block of common ice floats in liquid water, why? *Answer:* because its density is less than water. Ice's density: 0.92 g/mL Water's density: 1 g/mL

2. Rolling your weight

An amusement park wants to build the fastest rolling coaster, in the shortest possible time, using a hydraulic power system. A fast acceleration is reached by powerful hydraulic pumps. At launch, hydraulic oil pumps from a reservoir into storage cylinders filled with nitrogen. The nitrogen compresses and acts like a spring, when pressure has built up, the train is ready to launch. Most of the valves and mechanical devices used to build rolling coasters are manufactured of aluminum. Because of its characteristics, aluminum is widely used in aerospace, building, and medicine. Aluminum is remarkable for the metal's low density and for its ability to resist corrosion. Figures 6 and 7show examples of aluminum blocks used for hydraulic valves and manifolds.

Since there is not much time to build the roller coaster, the manufacture (the students) should plan the most efficient way of transport 56 blocks of aluminum to a warehouse using 5 carts. There are two types of blocks available B_1 and B_2, these blocks will be transformed in small components of the rolling coaster's hydraulic system. In order to start the production, the manufacturer (the students) should calculate the following information:

a) Maximum number of aluminum blocks B_1 that can be transported per cart
b) Maximum number of aluminum blocks B_2 that can be transported per car
c) Design the optimal distribution of the total aluminum blocks to be transported using 5 carts
d) The designer informs that each aluminum block B_2 needs to have 10 holes (radius: 1 in, depth 2.5 in), see figure 7. Calculate the new weight of the block B_2.

Data:

Density of aluminum 0.098 lb/in^3 or 2.7 g/cm^3
Aluminum block 1: 21 blocks of 8.0 in x 8.0 in x 15 in
Aluminum block 2: 35 blocks of 5.5 in x 7.20 in x 10.0 in
Dimensions of the storage cart tray: 17 in x 40 in with a 10 in high support lip
Number of carts available: 5 units, maximum weight capacity: 775 lb
*For safety reasons, aluminum blocks cannot be placed on top of one another

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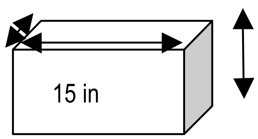
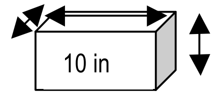
Aluminum block B_1	Aluminum block B_2
8 in  15 in, 8 in	7.2 in  10 in, 5.5 in

NOW figure this out! How many of these can be carried on one cart?

Answers:

a) Maximum number of aluminum blocks B1 that can be transported per cart: 8 units (see calculation analysis in next page)

Even though one cart can physically transport 10 units of block B1, by weight only 8 units are recommended to be transported.

b) Maximum number of aluminum blocks B2 that can be transported per cart: 14 units (see calculation analysis in next page)

In the case of block B2, one cart can transport the weight of 19 units, however only 14 units of block B2 can be fitted in the cart.

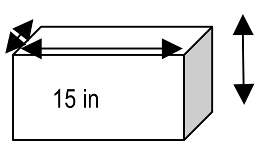
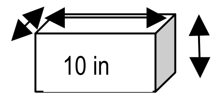
c). Optimal distribution of the 56 aluminum blocks using 5 carts:
16 units of blocks B2 transported in two carts, 28 units of blocks B1 transported in two carts. In the remaining cart: 7 units of blocks B2 and 5 units of blocks B1.

d).The new weight of the block B2=36.36 lb

CALCULATION ANALYSIS FOR PROBLEMS A) AND B)

The number of blocks that can be transported in each cart is limited by 2 conditions: i) maximum cart's weight capacity and ii) the number of aluminum blocks that can be accommodated in one cart.

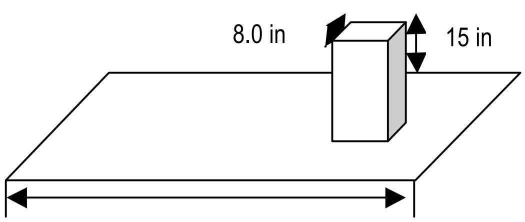
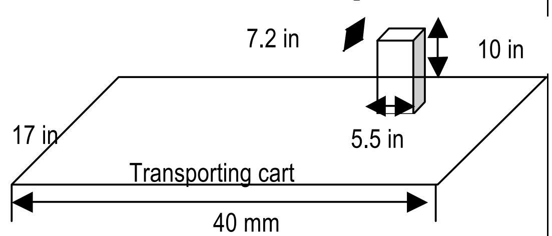
- Volume and weight of aluminum blocks

Aluminum block B1	Aluminum block B1
8 in  15 in, 8 in	7.2 in  10 in, 5.5 in
Volume B1: $= 8in \cdot 8in \cdot 15in$ = 960 in3	Volume B2: $= 5.5in \cdot 7.2in \cdot 10in$ = 396 in3
Weight B1: $= volume \cdot density$ $= 960in^3 \cdot 0.098 \, lb/in^3$ = 94.08 lb	Weight B2: $= 396in^3 \cdot 0.098 \, lb/in^3$ = 38.81 lb

- Let's evaluate condition i: calculate number of units per cart based upon the maximum weight capacity:

Number of aluminum blocks per cart:	
Number of aluminum blocks B_1 per cart: $=\frac{MaxCartCapacity(lb)}{WeightB_1(lb)}$ $=\frac{775(lb)}{94.08(lb)}$ = *8.23 units* *Based upon its weight capacity, one cart is able to transport maximum 8 units of blocks B_1*	*Number of aluminum blocks B_2 per cart* $=\frac{MaxCartCapacity(lb)}{WeightB_2(lb)}$ $=\frac{775(lb)}{38.81(lb)}$ = *19.97 units* *Based upon its weight capacity, one cart is able to transport maximum19 units of blocks B_2*

- *Condition ii: calculate the maximum number of aluminum blocks that can be accommodated in one cart based upon dimensions*

Aluminum block B_1	*Aluminum block B_2*
	
By the length: $=\frac{40(in)}{8(in)}$ = *5.0 units* *By the width* $=\frac{17(in)}{8(in)}$ = *2.1 units* *Total* $=5\cdot 2$ = *10 units B_1 per cart*	*By the length:* $=\frac{40(in)}{5.5(in)}$ = *7.3 units* *By the width* $=\frac{17(in)}{7.2(in)}$ = *2.4 units* *Total* $=7\cdot 2$ = *14 units B_2 per cart*

- *Maximum number of aluminum blocks to be transported per cart by weight and dimension capacity*

	Units of aluminum blocks B_1 per cart	*Units of aluminum blocks B_2 per cart*
Condition i, by weight capacity	***8***	*19*
Condition ii, by dimension capacity	*10*	***14***

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Extensions & Additional Resources

These sites are useful and can be applied at any point(s) during this lesson.

- http://en.wikipedia.org/wiki/Matter
- http://en.wikipedia.org/wiki/Weight
- Learning Challenges: http://flate.pbwiki.com
- Educational Pathways: http://www.madeinflorida.org/Pathways.html
- http://www.educationalrap.com/son/weight-mass-volume-density.html
- http://www.floridastandards.org/Standards/FLStandardSearch.aspx
- http://www.wikihow.com/Design-a-Roller-Coaster-Model
- http://www.sunhydraulics.com/cmsnet/sun_homepage.aspx?lang_id=1

Figure 1. Bathroom Scales

Figure 2. Spring

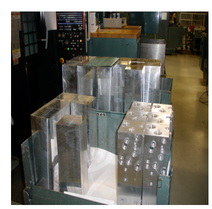
Figure 3. Traditional Scale-Beam Balance

Figure 4. Analytical Balance

Figure 5. Cork Floating in Water

Figure 6. Aluminum Blocs transported in carts

Figure7. Aluminum Blocks used to build valves



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