DEPED - GENERAL SANTOS CITY
SIMPLIFIED
SELF-LEARNING MODULE
(S S L M)

GENSAN's ProTUNA
General Santos City's Pro-Active Response in Turbulent, Uncertain, New and Ambiguous Environment

GENERAL PHYSICS 1 - GRADE 12

Name: _____ Date: _____

Grade: _____ Section: _____

Quarter: 1 Week: 7 SSLM No. 7 MELC(s): 1.Differentiate geometric center and center of mass **(STEM_GP12MMICIh5**.) , 2. Relate center of mass of an object or system of object is related to its momentum. (**STEM_GP12MMIC-Ih57)**

Specific Objectives:

1. Define geometric center and center of mass
2. Determine the geometric center of any geometric shape.
3. Solve the center of mass of system of objects or group of objects.
4. Relate center of mass of an object or system of object is related to its velocity, acceleration & momentum.

- **Title of Textbook/LM to Study**: Exploring Life Through Science-Gen. Physics 1

Let Us Discover

Key Points

- The center of mass (COM) is a statement of spatial arrangement of mass (i.e. distribution of mass within the system).
- The experimental determination of the center of mass of a body uses gravity forces on the body and relies on the fact that in the parallel gravity field near the surface of the earth the center of mass is the same as the center of gravity.
- For a 2D object, an experimental method for locating the center of mass is to suspend the object from two locations and to drop plumb lines from the suspension points. The intersection of the two lines is the center of mass

The center of mass of an object or a system of objects may be used to represent the motions of interactions of the object or the systems of objects. Collision happens when a certain body have contact with another. It happens when you bump one another, vehicles collide with each other, it also happens in sports when a player accidentally hit one another. The concept of center of mass, impulse, and momentum play major roles in these situations.

Activity#1:

This activity can be done at home. By performing this activity, you need a partner. This activity would help you understand better the concept of center of mass.

1. Place a chair against the wall so that it cannot be slid back. Let your partner sit in the chair with her/his feet flat on the floor in front of the chair. Place your thumb on his/her forehead and ask him/her to standup. Why is it difficult for him to stand up?

Ans. _____

_____

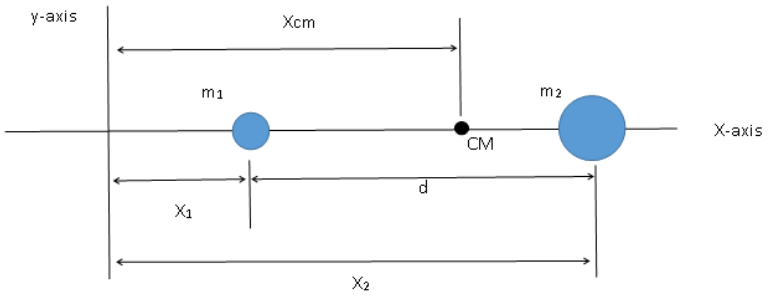
Activity 2: Ask again your partner to stand with his/her back against the wall. Place a coin in front of his/her foot and tell him to pick it up. What do you observe?

Ans. _____

_____

Extended Bodies or system of Bodies

Refer to this Figure: Let us locate the center of mass of the two bodies with respect to its x and y axes.



The center of mass(CM) of an extended body in three dimension may be computed as follows:

$$X_{CM} = \frac{x_1 m_1 + x_2 m_2 + \ldots\ldots\ldots}{m_1 + m_2 + \ldots\ldots\ldots} = \frac{\Sigma x_i}{\Sigma m_i} \quad \textit{Equation 1}$$

$$Y_{CM} = \frac{y_1 m_1 + y_2 m_2 + \ldots\ldots\ldots}{m_1 + m_2 + \ldots\ldots\ldots} = \frac{\sum_i y_i}{\sum_i m_i}$$ ***Equation 2***

$$Z_{CM} = \frac{Z_1 m_1 + Z_2 m_2 + \ldots\ldots\ldots}{m_1 + m_2 + \ldots\ldots\ldots} = \frac{\sum_i z_i}{\sum_i m_i}$$ ***Equation 3***

Where:

X_{cm}, Y_{cm}, Z_{cm} are the coordinates of the center of mass of the system; *x*, *y*, and *z.*

m_x, m_y, m_z represent the mass of each element making up the system.

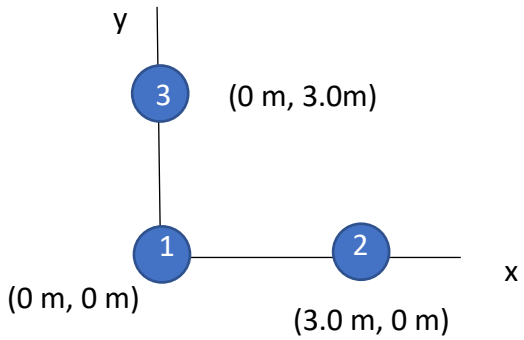
The ***motion*** of the ***center of mass*** characterizes that of the system as a whole. For computing the velocity of the center of mass of a system in three dimensions may be obtained by replacing *x, y,* and z in equation 1 to 3 by v_x, v_y, and v_z, respectively.

$$V_{cm} = \frac{v_1 m_1 + v_2 m_2 + v_3 m_3 + \ldots\ldots\ldots}{m_1 + m_2 + m_3 + \ldots\ldots\ldots} = \frac{\sum_i v_i x_i}{\sum_i m_i}$$ ***Equation 4***

Sample Problem 1:

Three 2.0 kg point particle are placed in the x-y coordinate system, as shown in the figure. Find the center of mass of this system.

Figure:



Solution: Eq. 1 and Eq. 2 will be used to locate the center of mass of the three -point particle since the problem requires only x and y axes.

Point Particle	Mass(kg)	x-coordinate(m)	y-coordinate(m)
1	m_1=2.0	x_1=0	y_1=0
2	m_2=2.0	x_1=3.0	y_2=0
3	m_3=2.0	x_1=0	y_3=3.0

$$X_{cm} = \frac{x_1 m_1 + x_2 m_2 + x_3 m_3}{m_1 + m_2 + m_3} \quad \frac{0(2.0kg) + 3.0m(2.0kg) + 0(2.0kg)}{(2+2+2)kg} = \frac{6.0\ kg.m}{6kg}$$

Xcm =1.0 m

$$Y_{cm} = \frac{y_1m_1 + y_2m_2 + y_3m_3}{m_1 + m_2 + m_3} \qquad \frac{0(2.0kg) + 3.0m(2.0kg) + 3.0\ m(2.0kg)}{(2+2+2)kg} \qquad \frac{6.0\ \cancel{kg}.m}{6\ \cancel{kg}}$$

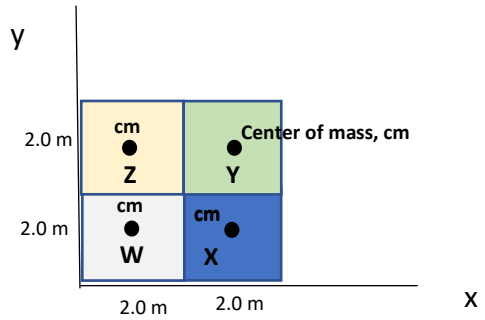
Ycm =1.0 m

Therefore, the center of mass of this 3-point particle system is at (1.0m, 1.0m)

Let Us Try

Activity 2 :*(using problem #1 as your reference, try to solve for the center of mass of the system of objects in figure below)*

Four squares, with equal side length of 2.0m, are arranged based on the rectangular coordinate shown in the figure. The masses of **W, X, Y** and **Z** are 2.0 kg , 3.0 kg, 4.0 kg and 5.0 kg, respectively. Find the center of mass of the system of four squares with respect to the x and y-axes.



Solution: First, determine the center of mass of the squares with respect to the x and y-axes. Note that the center of mass of its mass is at its geometric center.

Square	Mass(kg)	x-coordinate(m)	y-coordinate(m)
W	m_W=	x_w=	y_w=
X	m_X=	x_x=	y_x=
Y	m_Y=	x_y=	y_y=
Z	m_Z=	x_z=	y_z=

Using Eq. 1 and Eq. 2,

$$X_{cm} = \frac{X_w m_w + x_x m_x + x_y m_y + x_z m_z}{m_w + m_x + m_y + m_z} \qquad Y_{cm} = \frac{y_w m_w + y_x m_x + y_y m_y + y_z m_z}{m_w + m_x + m_y + m_z}$$

Therefore the center of mass of the four square system is at ***(_____m, _____ m)***

Let Us Do

Activity 3:

Problem: Particle A of mass 2 kg is moving to the East. Particle B of mass 3.0 kg is also moving to the east at 10 m/s. Find the velocity of the center of mass of the two particles.

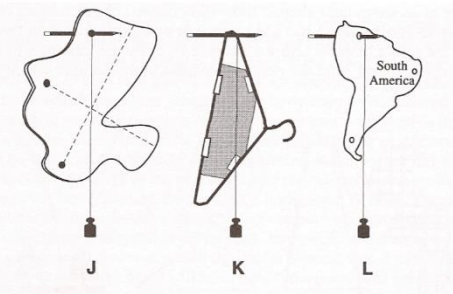
(Note: since the system of particles are in motion, you may use equation 4)

Let Us Apply

Activity 4: *From the given irregular objects shown, simulate similar activity. if materials are not available you may improvise it, then find their center of mass.*

Center of mass of irregularly shaped objects

1. From a cardboard box, cut an irregular shape such as shown in figure J. Be creative, use your own irregular shape.
2. Use a nail or pencil to carefully punch three holes in the perimeter of the cardboard. Enlarge the holes so that board can swing freely.
3. Place a nail or pencil in one of the holes and hang a weighted string from it. If you don't have a small mass to hang from the string, tie a small object to the end of the string. With a mass at the end of the string, the string should hang vertically straight down. If the string gets caught on your irregularly shaped object, swing the string until it hangs straight down.
4. Swing the cardboard and when it comes to rest, draw a line on the cardboard.
5. Repeat step 4 for the other two holes.
6. The center of mass of the object is where the lines intersect. Try to balance your object from that location.
7. Tape a pencil to your irregularly shaped object (tape it to one side, not in the center). Now, you have an irregular shape and also an irregular mass. Find the new center of mass.
8. Tape a piece of paper to the hanger as shown in figure K. Using the same steps as for the irregular shape, find the center of mass for the hanger.
9. Using the cut out of California, find the center of mass of the state.
10. Draw the four objects (irregular shape, irregular shape + pencil, hanger, CA) carefully on your paper and record where the center of mass is for each.



Questions:

1. The method works well for finding the center of mass of the irregularly shaped cardboard and hanger. Do you think this method works well for finding the center of mass of California? Why or why not?
   Ans. _____

2. If you are in a space station and move from one side to the other, do you change the position of the center of mass about which the space station rotates? Explain.
   Ans. _____

3. Why does a hardboiled egg spin nicely while a raw egg will wobble when it is spun? (Use center of mass in your explanation.)
   Ans. _____

References

Conceptual Physics By Paul Hewitt
Exploring Life Through Science (Gen. Physics 1- By Angelina A. Silverio

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