GreatHearts Irving

Remote Learning Packet

NB: Please keep all work produced this week. Details regarding how to turn in this work will be forthcoming.

April 6 - 9, 2020

Course: 11 Physics
Teacher: Miss Weisse natalie.weisse@greatheartsirving.org
Resource: *Miss Weisse's Own Physics Textbook* — pertinent pages found at the end of this packet

Weekly Plan Checklist:

Monday, April 6
- ☐ Read & Understand Notes on the Conservation of Momentum (pages 20-26)
- ☐ Perform the Conservation of Mass Experiment if Your Parents Give You a Thumbs Up
- ☐ Email Miss Weisse with Questions & to Get Solutions!

Tuesday, April 7
- ☐ Read & Understand Notes on the Conservation of Momentum (pages 27-30)
- ☐ Complete Unit 8 Worksheet 3 Problems #1-3
- ☐ Email Miss Weisse with Questions & to Get Solutions!

Wednesday, April 8
- ☐ Review Notes From Tuesday
- ☐ Complete Unit 8 Worksheet 3 Problem #4-6 (same sheet of paper as yesterday, please!)
- ☐ Email Miss Weisse with Questions & to Get Solutions!

Thursday, April 9
- ☐ Review Notes on Conservation of Momentum — page 27 will be especially helpful
- ☐ Complete Unit 8 Worksheet 4
- ☐ Email Miss Weisse with Questions & to Get Solutions!

Friday, April 10 — No School

Statement of Academic Honesty

I affirm that the work completed from the packet is mine and that I completed it independently.

I affirm that, to the best of my knowledge, my child completed this work independently

____
Student Signature

____
Parent Signature

DAILY PLANS

Monday, April 6

- Read Pages 20-26 of *Miss Weisse's Own Physics Textbook*
- Perform the Conservation of Mass Experiment if Your Parents Give You a Thumbs Up. Email me if you'd like instructions.
- Email Miss Weisse with Questions About the Notes!

Tuesday, April 7

- Read Pages 27-30 of *Miss Weisse's Own Physics Textbook*
- Complete the following problems on a sheet of paper with a full heading — Unit 8 Worksheet 3

1. Jude (m = 50.0 kg) and Alex (m = 65.0 kg) are at rest on frictionless in-line skates. The Jude pushes the Alex so that Alex rolls away at a speed of 10.0 m/s. What is Jude's final velocity?
2. In a railroad yard, an empty boxcar, coasting at 3.0 m/s, collides with a loaded car that is stationary. The two cars then move down the track together. Each of the boxcars has a mass of 9000 kg when empty, and the loaded car contains 55,000 kg of lumber. At what speed do the car move after the collision?
3. An astronaut of mass 80.0 kg is holding an empty oxygen tank of mass 10.0 kg. By pushing the tank away with a speed of 2.0 m/s, the astronaut recoils in the opposite direction. What is the velocity (including direction) of the astronaut?

- Email Miss Weisse with Questions & to Get Solutions!

Wednesday, April 8

- Review Pages 27-30 of *Miss Weisse's Own Physics Textbook*
- Complete the following problems on a sheet of paper with a full heading — Unit 8 Worksheet 3 (continued)

1. A 50.0 kg cart is moving across a frictionless floor at 2.0 m/s. A 70.0 kg boy, riding in the cart, jumps off so that he hits the floor with zero velocity. What is the velocity (including direction) of the cart after the boy jumps off?
2. A 2.0 kg melon is balanced on a circus performer's head. An archer shoots a 50.0 g arrow at the melon with a speed of 30 m/s. The arrow passes through the melon and emerges with a speed of 18 m/s. What is the velocity (including direction) of the melon after the arrow passes through?
3. Old cannons were built on wheeled carts, both to facilitate moving the cannon and to allow the cannon to recoil when fired. When a 150 kg cannon and cart recoils at 1.5 m/s, at what velocity would a 10.0 kg cannonball leave the cannon?

- Email Miss Weisse with Questions & to Get Solutions!

Thursday, April 9

- ➔ Review Pages 20-30 of *Miss Weisse's Own Physics Textbook*
- ➔ Complete the following problems on a sheet of paper with a full heading — Unit 8 Worksheet 4

1. Airplanes maneuver on the ground by using thrust from their jets or propellers. A fully loaded, 396,900 kg Boeing 747-400 gets a total of 1100 kiloNewtons of thrust from its jet engines. Takeoff speed depends on a number of factors like air temperature, airplane weight, and airport elevation, but let us say that liftoff will occur at 170 mph.
    a. Determine the time the plane takes to go from 0 to 170 mph. (1 mile = 1600 meters)
    b. What is the momentum of the airplane at take-off?
    c. Calculate the impulse the plane receives from the engines during takeoff.
    d. What additional information would be needed to calculate the velocity of the exhaust gasses from the engines?

2. An apple (m = 100 g) falls from a tree. What is the recoil momentum of the branch it was hanging on?

3. a. Why is it difficult for a fire-fighter to hold a hose that ejects large amounts of high-speed water?

    b. Calculate the force needed to hold a 6.0 cm diameter fire hose in place when the water flow rate is 110 m^3/hour. (density of water: 1000 kg/m^3)

- ➔ Email Miss Weisse with Questions & to Get Solutions!

Friday, April 10 — No School

Well done! You've made it to the end of week 2 of distance learning,
and, what would have been the end of the 3rd Quarter!
I appreciate the work you are doing and
the effort you are putting into these assignments.
Have a wonderful, long weekend!

Warmly, Miss Weisse

Miss Weisse's Own Physics Textbook

An Introduction to the Conservation of Momentum

Conservation Laws

Hopefully, you remember learning a few conservation laws from your middle school years and, dare I say, Chemistry with me last year...

CONSERVATION OF MATTER (MASS)	CONSERVATION OF ENERGY	CONSERVATION OF MOMENTUM
No matter is created or destroyed during any physical or chemical change IN A CLOSED SYSTEM but can be rearranged and can change appearance.	No energy is created or destroyed IN A CLOSED SYSTEM but can be altered from one form to another (i.e. kinetic, potential, sound, etc.)	No momentum is created or destroyed (or gained or lost) IN A CLOSED SYSTEM but can be transferred between objects during a collision.

These 3 Conservation Laws have two statements in common

1) "nothing is created or destroyed" → Conservation

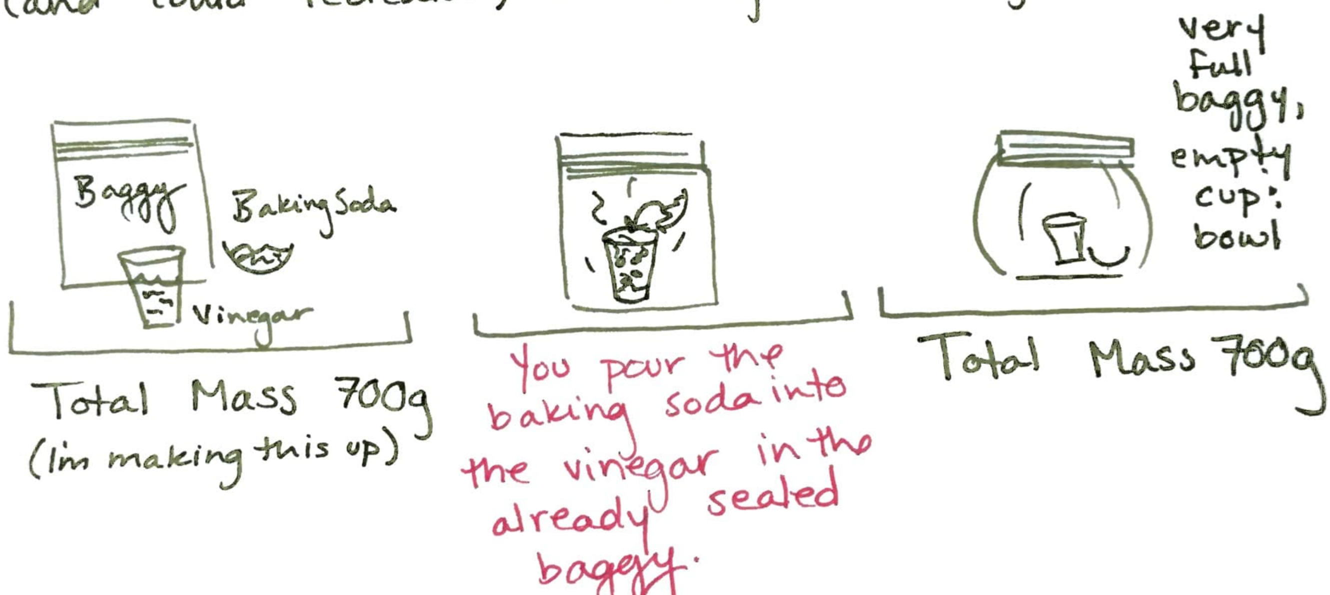
This is the Conservation (Latin "conservare" = to keep & preserve)

2) "IN A CLOSED SYSTEM"

A <u>Closed System</u> limits the scope of what objects, space, forces we are considering.

A few examples:

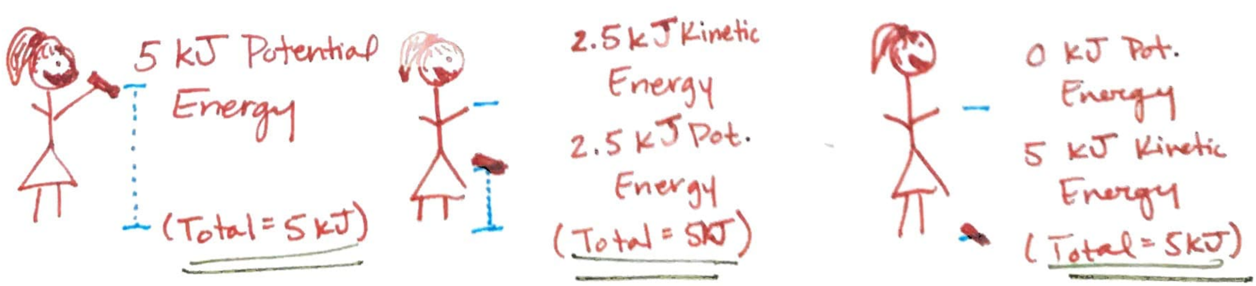
Ex.1 <u>Conservation of Matter</u> - You might remember (and could recreate...) the vinegar - baking soda lab.



Initial Total Mass = Final Total Mass

∴ Matter (via the mass) is CONSERVED!

Ex. 2 <u>Conservation of Energy</u> - You might remember me holding up marker and saying "Potential Energy..." then dropping the marker and saying "Kinetic Energy!"



In [Ex. 1] the baggy is our closed system.

- The initial mass included the baggy, cup, bowl, vinegar, and baking soda.
- The chemical reaction (mixing of vinegar and baking soda) was done in the SEALED baggy so <u>NO MASS</u> could escape in the form of gas.

* If the baggy were open, the gas created by the rearrangement of the atoms that make up the vinegar and baking soda would ESCAPE! This would not be a closed system, but an OPEN SYSTEM! <u>And</u>, the final mass would be less than the initial mass.

In [Ex. 2], as the marker falls the potential energy it had when being held above the ground continuously transforms into kinetic energy. So the sum of potential energy and kinetic energy always add to the same total. Well... until a new force is introduced! The "closed system" ends when the marker hits the floor.

* We could expand our closed system so the floor is included, but things get complicated. We'd say something like the kinetic energy becomes sound energy (the thud we hear), and those sound waves are vibrating air particles (kinetic again) then interacts with a wall, and... you get the point.

Note - A closed system is also called an isolated system. You will see both in these notes and in problems.

Now to the point of the lesson -

Conservation of Momentum

Conservation of Momentum is mostly used to describe collisions between objects.

SIDE NOTE

(this is the moment we realize our momentum labs would have been colliding objects, and that would have been great fun... alas)

So the total momentum of all objects before the collision must be equal to the total momentum of all objects after the collion - in an isolated system.

momentum before a collision = momentum after a collision

$$\vec{p}_{i,\,total} = \vec{p}_{f,\,total}$$

$$\underbrace{\vec{p}_{1,i} + \vec{p}_{2,i} + \vec{p}_{3,i}}_{\text{the SUM of the intial momentum of all objects in the system}} = \underbrace{\vec{p}_{1,f} + \vec{p}_{2,f} + \vec{p}_{3,f}}_{\text{the SUM of the final momentum of all objects in the system}}$$

NOTICE! I've added vector hats to momentum now.

Since $\vec{p} = m \cdot \vec{v}$

$\uparrow$ scalar · vector $\uparrow$

a # scales the vector, it makes the value bigger or smaller but doesn't affect the DIRECTION.

$\therefore$ the momentum of an object has the same direction as its velocity.

This was true for force and acceleration as well. Acceleration was always in the same

$$\vec{F}_{net} = m \cdot \vec{a}$$

direction as the net force.

Another way to think about the conservation of momentum is to say there is NO IMPULSE or NO CHANGE IN MOMENTUM IN A COLLISION.

$$J = 0 \text{ N·s}$$

$$\Delta\vec{p} = 0 \text{ N·s}$$

This is simple to show. We've already said

$$\vec{p}_{total,intial} = \vec{p}_{total,final}$$

If you substract the total, initial momentum from both sides we get

$$\Delta\vec{p} = \vec{p}_{total,final} - \vec{p}_{total,initial}$$

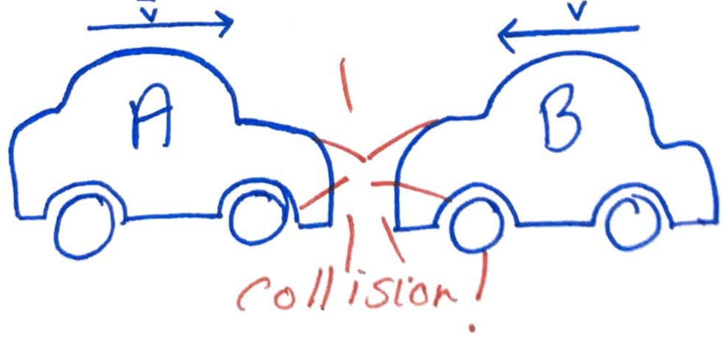
$$\Delta\vec{p} = 0\ N\cdot s \quad \underline{OR} \quad J = 0\ N\cdot s$$

Because $\vec{p}_f$ and $\vec{p}_i$ are equal if we subtract one from the other the result is zero.

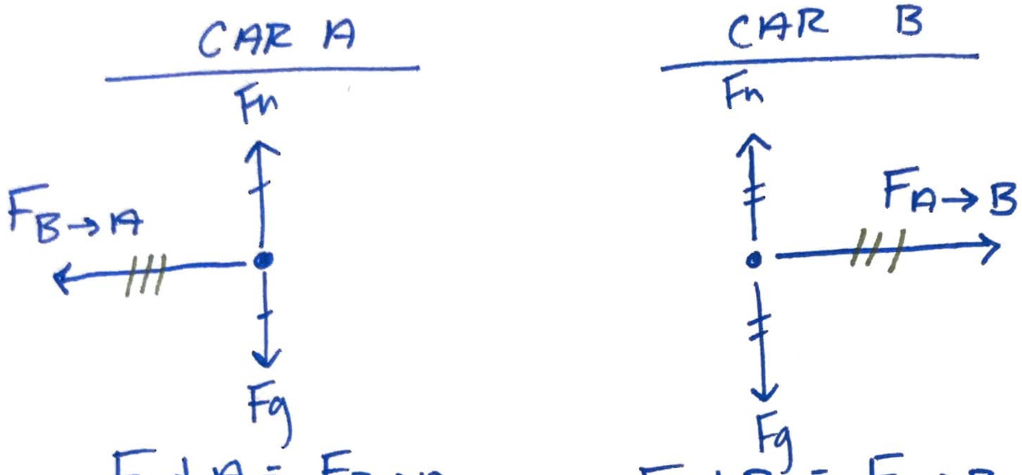
Now that we are thinking about $\Delta\vec{p}$ and Impulse (J), I hope your mind has jumped to the definition of these.

$$J = \Delta\vec{p} = \underline{\underline{F_{net}}} \cdot \Delta t$$

Let's think about a collision (and let's go ahead and assume there's no friction...)



Let's draw a force diagram for each car.



$F_{net,A} = F_{B \to A}$ $\quad$ $F_{net,B} = F_{A \to B}$

According to Newton's 3rd Law, the forces of car A hitting B and car B hitting A are EQUAL but OPPOSITE. They are force pairs!

$$F_{A \to B} = -F_{B \to A}$$

Also, the two cars are in contact for the SAME AMOUNT OF TIME, Δt.

$$(\Delta t)(F_{A \to B}) = (-F_{B \to A})(\Delta t)$$

$$(\Delta t)(F_{net,B}) = (-F_{net,A})(\Delta t)$$

Remembering that $(F_{net})(\Delta t) = J = \Delta p$

$$J_B = -J_A$$

$$\Delta \vec{p}_B = -\Delta \vec{p}_A$$

∴ The Sum of $\Delta \vec{p}$ of the system $(\Delta \vec{p}_B + -\Delta \vec{p}_A) = 0$.
There is no Δmomentum, momentum is conserved.

Solving Problems Using the Conservation of Momentum

Review of What We Know

→ momentum is mass in motion

$$\vec{p} = m \times \vec{v}$$

→ momentum is a vector quantity (it has both magnitude and direction) and its direction will always be the same as the direction of velocity

→ Impulse is a Change in Motion

$$J = \Delta\vec{p}$$

It is also the net force acting on an object time the time the force is acting

$$J = F_{net} \times \Delta t = \Delta\vec{p}$$

→ In a closed (isolated) system, No momentum is created or destroyed.

$$\text{total } \vec{p}_{intial} = \text{total } \vec{p}_{Final}$$

This also means there is no change in $\vec{p}$.

$$\Delta\vec{p} = 0 \frac{kg \cdot m}{s} \therefore J = 0 \, N \cdot s$$

This last fact is the most important for the following problems. We're just going to jump in and explain as we go.

Example 1: While playing a game of pool, you aim to hit the 3-ball straight into the corner pocket. To do so you hit the cue ball ($m = 2.0$ kg) so it travels at a velocity of 2 m/s just before it hits the 3-ball. After the collision the 3-ball travels with a velocity of 2 m/s. The 3-ball has a mass of 1.6 kg. What is the final velocity of the cue ball?

① To begin, we're going to draw a dotted line down the middle the represents the collision and separates the initial and final values.

Initial Values: cue ball	Initial Values: 3-ball	COLLISION	Final Values: cue ball	Final Values: 3-ball
$m = 2.0$ kg	$m = 1.6$ kg		$m = 2.0$ kg	$m = 1.6$ kg
$\vec{v}_i = 2$ m/s	$\vec{v}_i = 0$ m/s		$v_f = ?$	$v_f = 2$ m/s
$\vec{p}_i = 2 \times 2 = 4\ \frac{kg \cdot m}{s}$	$\vec{p}_i = 1.6 \times 0 = 0$		$p_f = 0.8$	$p_f = 1.6 \times 2 = 3.2\ \frac{kg \cdot m}{s}$

$$\text{total } \vec{p}_{initial} = p_{cue} + p_3 = \text{total } \vec{p}_{final} = \vec{p}_{cue} + \vec{p}_3$$

$$4 + 0 = p_{f,cue} + 3.2$$

$$4 = p_{f,cue} + 3.2$$

$$-3.2 \qquad\qquad -3.2$$

$$\vec{p}_{f,cue} = 0.8$$

$$p = mv$$

$$\frac{0.8}{2} = \frac{2 \cdot v}{2}$$

$$\boxed{0.4\ m/s = \vec{v}_f}$$

② We list the given information.

③ Solve for momentums you have enough info to know.

④ Determine total $\vec{p}_{initial}$ and $\vec{p}_{final}$.

* THIS IS THE CONSERVATION STEP!

⑤ Solve for missing momentum values

⑥ Solve for the cue ball's final velocity

Let's think about how we solved that —

1) Identified all info before and after the collision

2) Found missing info that we could easily solve for with info already known (solve for $\vec{p}$!)

3) Wrote conservation of momentum equations

sum of all $\vec{p}$ before collision = sum of all $\vec{p}$ after collision

4) Used the conservation of ~~m~~momentum eqn. to find missing momentum(s)

5) Solved for all unknown values.

Example 2: On an icy road (no friction!) a 5,000 kg truck rear-ends a 1,200 kg car that had been traveling at 13 m/s. The collision caused the car to speed up and the truck to slow from 14 m/s to 12 m/s. What is the final velocity of the car?

FOLLOWING THE COLOR-CODED STEPS ABOVE...

before

truck
$m = 5000\ kg$
$v = 14\ m/s$
$p = (5000)(14) = 70{,}000\ \frac{kg \cdot m}{s}$

car
$m = 1200\ kg$
$v = 13\ m/s$
$p = (1200)(13) = 15{,}600\ \frac{kg \cdot m}{s}$

collision

after

truck
$m = 5000\ kg$
$v = 12\ m/s$
$p = (5000)(12) = 60{,}000\ \frac{kg \cdot m}{s}$

car
$m = 1200\ kg$
$v = ? = 21.3\ m/s$
$p = ? = 25{,}600\ \frac{kg \cdot m}{s}$
$\frac{p}{m} = v = \frac{25{,}600}{1200}$

$$\text{total } \vec{p}_{intial} = \vec{p}_{truck} + \vec{p}_{car} = \text{total } \vec{p}_{final} = \vec{p}_{truck} + \vec{p}_{car} = 21.3\ m/s$$

$$70{,}000 + 15{,}600 = 60{,}000 + \vec{p}_{car,\ final}$$

$$85{,}600 = 60{,}000 + \vec{p}_{car,\ final}$$

$$-60{,}000 \qquad -60{,}000$$

$$25{,}600\ \frac{kg \cdot m}{s} = \vec{p}_{car,\ final}$$

Example 8: A 10,000 kg railroad car, A, traveling at a speed of 24.0 m/s strikes an identical car, B, at rest. The cars lock together as a result of the collision. What is the speed of the two trains together just after the collision? NOTICE! Because the two objects are now moving as 1, we can treat them like one!

Before

train A	train B
$m = 10{,}000\,kg$	$m = 10{,}000\,kg$
$\vec{v} = 24.0\,m/s$	$\vec{v} = 0\,m/s$
$p = (24)(10{,}000) = 240{,}000\,\frac{kg \cdot m}{s}$	$p = 0\,\frac{kg \cdot m}{s}$

After

train A & B

$m = (10{,}000)2 = 20{,}000\,kg$

$\vec{v} = ?$

$p = 240{,}000\,\frac{kg \cdot m}{s}$

$$\text{total } \vec{p}_{initial} = \vec{p}_{A,i} + \vec{p}_{B,i} = \text{total } \vec{p}_{final} = \vec{p}_{A+B}$$

$$240{,}000 + 0 = \vec{p}_{A+B}$$

$$240{,}000 = \vec{p}_{A+B}$$

$$\vec{v}_{A+B,\,final} = \frac{p_{AB}}{m_{AB}}$$

$$= \frac{240{,}000\,\frac{kg \cdot m}{s}}{20{,}000\,kg}$$

$$\boxed{\vec{v}_{A+B,\,final} = 12\,m/s}$$

This makes sense!

$p \propto m\vec{v}$

if $\uparrow m$, $\downarrow \vec{v}$ or more specifically

if $2m$, $\frac{1}{2}\vec{v}$

HELPFUL NOTE

* You will also see problems where you treat two objects as one to begin with the treat them as two after a collision (or other event.