Newton's Third Law 1 Name ___________________________

Part A: The Basics

There are 3 ways to define Newton's Third Law:

	Advantages	**Disadvantages**
The Poetic Definition For every action there is an equal and opposite reaction.	Beautiful, famous quote, Makes you sound smart	Not clear exactly what it means.
The Simple Definition If you push something, it pushes you back with the same force. This other force is called the *reaction force*.	Makes it very clear what Newton's Third Law is	Incomplete, Cannot use to solve advanced physics problems.
The Precise Definition Whenever A exerts a force on B, B also exerts a force on A of equal magnitude and opposite direction. These two forces are called an *action-reaction pair*.	Totally correct, Can use to solve advanced physics problems.	Hard to understand. (but so are advanced physics problems)

We will start out using the simple version, then move to the precise version. Only use the poetic version to sound smart when talking to people who don't know better.

A.1. If Mr. Kuncik punches the wall with a force of 200 N, what does the wall do to Mr. Kuncik? What will he feel?

A.2. If Mr. Kuncik punched the wall to the left, what is the direction of the reaction force?

A.3. If a very big linebacker punches Mr. Kuncik in the face with 800 N of force, what happens to the linebacker's first?

A.4. I truck is speeding down the highway, when it hits an innocent bug flying. SLAT! During this collision, which exerted more force:
a) the bug b) the windshield c) they exerted the same force

How do you know?

A.5. Write your own situation involving Newton's Third Law:

 Name ___________________________

Part B: Side by Side Free-Body Diagrams

For each example, you need to draw *two* free-body diagrams.
- for each force, you must write the a) name of the force and b) what causes the force
After you draw it, circle the action and reaction force pairs.
-find the net force on each object
If the object has so much mass that the force on it is meaningless, draw a the symbol ∅ next to the net force.

B.1. Rocky (the boxer) Punches Meat. Draw *two* free-body diagrams, one for Rocky and one for the meat. Label all forces A – G, and then write the name and cause of each force:
Note1: the meat is hanging from a rope.
Note2: One of the four forces on Rocky is the force which prevents him from *falling over* due to the reaction force.
After identifying all forces, circle the action-reaction pair.

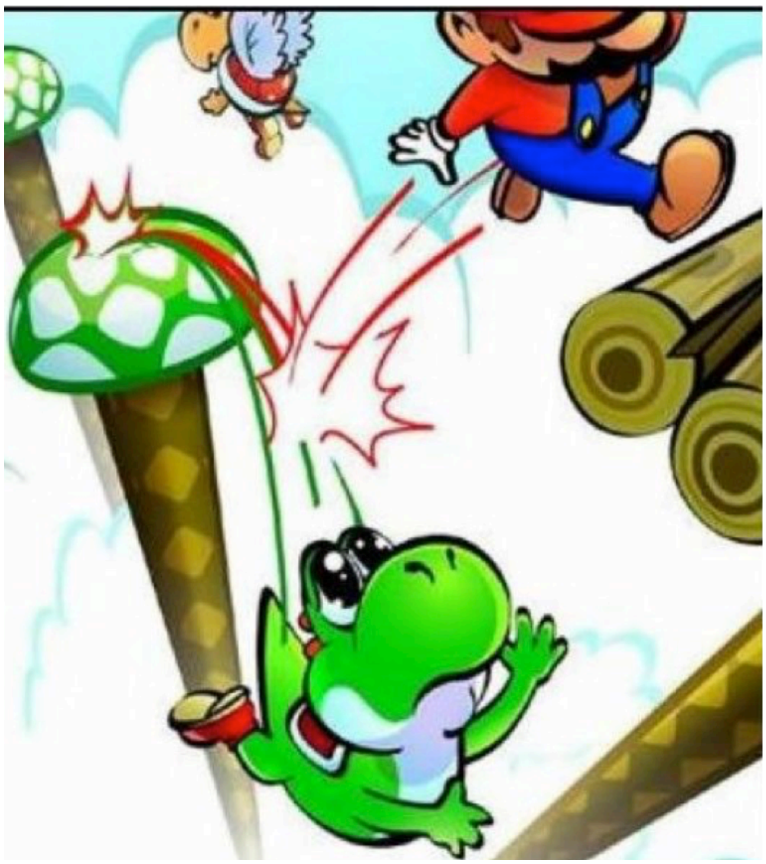
Free-Body Diagram of Rocky (4 Forces: A, B, C, and D)	Free-Body Diagram of Meat (3 Forces: E, F, and G)

Newton’s Third Law 1 Name ___________________________

Force A: Cause of A:	Force B: Cause of B:	Force E Cause of E:	Force F Cause of F:
Force C Cause of C:	Force D Cause of D:	Force G Cause of G:	

B.2.

Mario jumps off of Yoshi. Draw two free-body diagrams for Mario and Yoshi at the *moment* that Mario jumps off. There are 4 total forces. Label the forces A- D.
After identifying all forces, circle the action-reaction pair.

<table>
<tr><td rowspan="4"></td><td rowspan="2">Free-Body Diagram of Mario (2 forces: A and B)</td><td>Force A:

Cause of A:</td></tr>
<tr><td>Force B:

Cause of B</td></tr>
<tr><td rowspan="2">Free-Body Diagram of Yoshi (2 forces: C and D)</td><td>Force C:

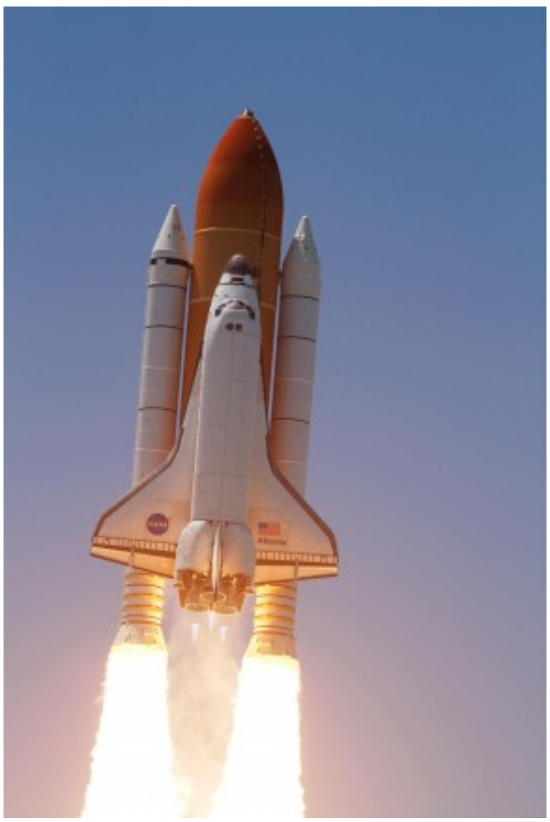
Cause of C:</td></tr>
<tr><td>Force D:

Cause of D:</td></tr>
</table>

B.3.

As a rocket flies upward (outward from the earth), it releases a hot gas (to rocket fuel). Draw the forces acting on the rocket and on the rocket fuel expelled from the bottom. There are 5 total forces, label them A – E.

After identifying all forces, circle the action-reaction pair.

	Free-Body Diagram of Rocket (3 forces: A, B, and C)	Force A: Cause of A:	Force C: Cause of C:
		Force B: Cause of B:	
	Free-Body Diagram of Rock Fuel (2 forces: D and E)	Force D: Cause of D:	
		Force E: Cause of E:	

Name ___________________________

B.4

Identify the action and reaction forces on a cannon and a cannonball at the moment a cannon is fired.

Note 1: A civil war cannon such as this one typically flew backward *ten feet* every time it was fired.

Note 2: In this situation, the reaction-force is often called the *recoil*.

After identifying all forces, circle the action and reaction force.

<table>
<tr><td colspan="4"></td></tr>
<tr><td colspan="2">Free-Body Diagram of Cannonball
(3 Forces: A, B, and C)</td><td colspan="2">Free-Body Diagram of Cannon
(3 Forces: D, E, and F)</td></tr>
<tr><td>Force A:

Cause of A:</td><td>Force B

Cause of B:</td><td>Force D

Cause of D:</td><td>Force E:

Cause of E:</td></tr>
</table>

Force C Cause of C:		Force F: Cause of F:	

B.4 Climbing the stairs.
Identify the forces.
Circle the *action-reaction pair*.
Which force is the same force that’s always been there, but is now *stronger* than before?

<table>
<tr><td rowspan="3"></td><td rowspan="2">Free-Body Diagram of Runner (2 forces: A and B)</td><td>Force A:

Cause of A:</td><td></td></tr>
<tr><td>Force B:

Cause of B:</td><td></td></tr>
<tr><td>Free-Body Diagram of Stairs (3 forces: C, D, and E – note that one force is the earth holding up the staircase]</td><td>Force C:

Cause of C:</td><td>Force E:

Cause of E:</td></tr>
</table>

		Force D: Cause of D:	

B.5
A person is walking on the ground.
Note these:
- There are many many forces acting on the ground, but you should only include the one relevant to the walking person.
- There are *diagonal* forces in this problem. Think carefully about it.

After drawing all forces, circle the action-reaction pair.

 Name ___________________________

Free-Body Diagram of the Ground (One force: A)		Free-Body Diagram of Walker (Two forces: B and C)	
Force A: Cause of A:		Force B: Cause of B:	Force C: Cause of C:

Part C: Real Life Questions

Answer each question in at least two sentences. Drawing pictures and diagrams to help answer is encouraged.

C.1 Explain how Newton's Third Law is necessary to jump:

C.2 Explain how Newton's Third Law is necessary to walk:

 Name ___________________________

C.3 If a fly hits a truck, on the highway, they each exert the same force. How is it possible that the fly is crushed, but the windshield is not?

C.4 While a car is driving slowly in a parking lot, a pebble hits the car and does no damage. While the car is driving on the highly, a pebble hits the car and cracks the windshield. Why the difference?

C.5 Why do swimmers need Newton's third law when turning inside the pool?

 Name ___________________________

C.6 How do rockets need Newton's Third Law?

C.7 Using Newton's third Law, explain why it hurts when you fall and hit the ground.

C.8 In the Civil War, every cannon, after being fired, needed to be carefully moved back into place and re-aimed (in fact, they typically moved up to 10 feet backward). Why?

C.9 Explain the following statement using Newton's Third Law:
"You cannot touch anything without being touched."

 Name ___________________________

Part D: The Lazy Donkey Paradox

A **paradox** is statement that seems perfectly logical, but is obviously wrong. In this case, we have a paradox in which somebody tries to use Newton's Third Law in a way that is obviously false, but seems perfectly logically.

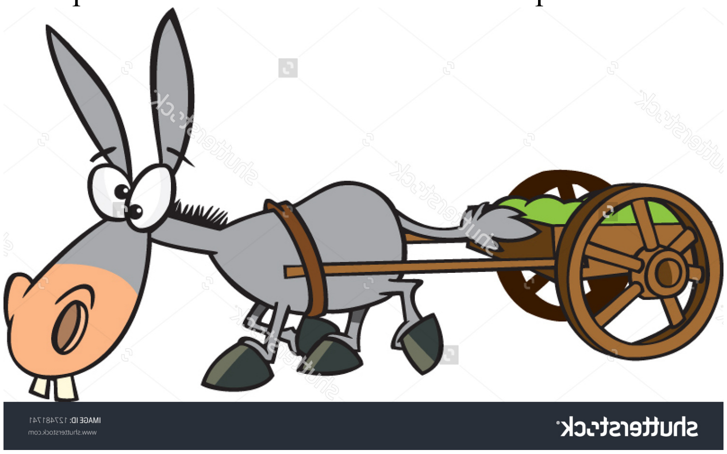
A settler on the Oregon Trail has a donkey pulling his Conestoga wagon. Unfortunately, he has the laziest, sassiest, donkey in the world who also claims to know physics. He tells the donkey to move, and the donkey says "NO!" The settler, very confused, says, "Why not?" The donkey responds:

"According to Newton's Third Law, if I pull the wagon, the wagon pulls back on me with an equal force. Thus, we won't move anywhere. So, why bother?"

What can the driver say back to the donkey to convince him that, yes, even within the laws of physics, it is possible to pull the cart?

Newton’s Third Law 1 Name ___________________________

D.1. Draw a free-body diagram of the donkey, the wagon, and the ground. (ignore the force of friction in this case). Hints: The Donkey is very similar to the walking person from a previous example. Circle all of the action-reaction pairs.



<table>
<tr><td>Free-Body Diagram of Donkey (3 forces: A, B, and C)</td><td>Free-Body Diagram of the car (3 forces: D, E, and F)</td></tr>
<tr><td colspan="2">Free-Body Diagram of the ground (2 forces: G and H --- many more forces exist on the ground, but are not included)</td></tr>
</table>

Force A: Cause of A:	Force B: Cause of B:	Force D: Cause of D:	Force E: Cause of D:

Force C Cause of C:	Force G: Cause of G:	Force H Cause of H:	Force F: Cause of F:

D.2. What is the net force on the wagon? Will it move forward?

D.3. What is the net force on the donkey? Will he move forward?

D.4. Using your knowledge from **1-3**, how can the driver of the wagon address the donkey's paradox?

Part E: Counterintuitive Points and Misconceptions

E1. Someone is standing, there are two forces on them. What two forces Draw them:

Many many times people tell me that gravity and normal force are an action/reaction pair. But they aren’t! Let ‘s look at it:

<table>
<tr><td rowspan="6">Draw a picture of a person standing:</td><td rowspan="2">Free-Body Diagram of Person standing (2 Forces: A and B)</td><td>Force A:</td><td>Force B:</td></tr>
<tr><td>Cause of A:</td><td>Cause of B:</td></tr>
<tr><td rowspan="2">Free-Body Diagram of the ground (only one force included: C)</td><td>Force C:</td><td rowspan="2"></td></tr>
<tr><td>Cause of C:</td></tr>
<tr><td rowspan="2">Free-Body Diagram of the whole earth (only one force: D)***</td><td>Force D:</td><td rowspan="2"></td></tr>
<tr><td>Cause of D:</td></tr>
</table>

*** Note that many many many more forces affect the earth, and that, because of the huge mass of the earth, this force is completely insignificant to the earth.

 Name ___________________________

Draw a free-body diagram for each of objects forces in the system: you, the ground, and the whole earth.
What is the *reaction force* of gravity?

What is the *reaction force* of the normal force?

DO YOU FEEL POWERFUL? Why might this example make someone feel powerful?

Part F: Newton's Third Law and Electrons
(Imagination Question)

F.1:

	Positive and Positive	Positive and Negative	Negative and negative
Attract or Repel			

F2:
An atom looks like a positive charge in the center of a large cloud of negative charge:

(picture)

When two atoms come near each other, do they attract or repel? How do you know?

F3: When two electrons are near each other, do they repel with the same force or different forces? What LAW tells you the answer?

F4. Remember the problem where Mr. Kuncik punches the wall? The wall exerts back the same force.

IMAGINE that Mr. Kuncik's hand is made totally of atoms, and the wall is made totally of atoms:
(picture here)

The force pushing the wall, and the force pushing Mr. Kuncik back, are really just the forces of electrons in atoms repelling!

As Mr. Kuncik moves his hand near the wall, does the repulsive force get stronger or weaker?

As Mr. Kuncik moves his hand near the wall, do the atoms ever actually *touch*?

F5. Imagine this situation very carefully.
Then, use all the previous questions to explain *why* Newton's Third Law makes sense:

F6: Breaking a board:

The board is held together by chemical bonds between atoms.

When a master slaps tbe board, the bonds between these atoms break.

(pictures showing a hand breaking a board)

Review of question **E.3:**
“Many students tell me that, if you break through a board, then surely the board exerts *less* force on you then you put on the board. However, this is false: the forces are still the same:

When this person whacks the wooden boards, he exerts a force on the boards called the *shear*. The *shear strength* of the boards is the maximum force the boards can break before they are split.

If the shear strength of the wood is 500 N, and the person is strong enough to hit it with 1000 N, they will still only ever exert 500 N, because after it reaches that load, the board will break before it can take more force.”

By thinking about the how your hand and the board are really made of atoms, see if you can better *understand* and *explain* the statement from **E.3.**

Part D: Common Questions, Mistakes, and Counterintuitive Points

E1. If I have a weight of 550 Newtons, this mean the earth pulls me *down* with a force of 550 Newtons. What is the *reaction* to this force?

E2. Someone is standing, there are two forces on them: Draw them:

Many many times people tell me that gravity and normal force are an action/reaction pair? Is this true?

Draw a free-body diagram for each of objects forces in the system: you, the ground, and the whole earth.
What is the *reaction force* of gravity?
What is the *reaction force* of the normal force?

Are the kids who say gravity and normal force are an action/reaction pair?

(Extra: if we’ve done a lab on this by now, can you think of a time that the normal force is *not* equal to gravity.

E3. The most common question I get is, what happens if you hit something and you break it?

[I need to do more research on this…include a picture of someone breaking a board]

Many students tell me that, if you break through a board, then surely the board exerts *less* force on you then you put on the board. However, this is false: the forces are still the same:
When this person whacks the wooden boards, he exerts a force on the boards called the *shear*.
The *shear strength* of the boards is the maximum force the boards can break before they are split.

If the shear strength of the wood is 500 N, and the person is strong enough to hit it with 1000 N, they will still only ever exert 500 N, because after it reaches that load, the board will break before it can take more force.

This makes *more sense* after you have done **Section F: Newton’s Third Law And Electrons**.