Hello, Science Teachers!

This is my interpretation of gravity using the Barbie Bungee Jump and a number of other resources. I love to use stories in class, so much of what I do is open discussion using the topics, videos,and questions students ask. I try to use a variety of media to enrich and break up what we do in class and play to the strengths of various learners. I also do not "lecture for notes". Instead, I give my kids coloring sheets with the big concepts and use my time doing experiments and demonstrations that cement the concepts for them. On the following pages you will find a selection of coloring sheets that I have made for my classroom and use for notes for my kids. Often I give the kids a sheet (or sheets) to color the night before we cover that topic in class the next day. For students that hate to color, I have them either summarize the information in their own way or do additional research with notes on the topic on the back. Happy Bungee Jumping!

Racheal

NGSS STANDARDS:

MS-PS2-2.
Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. [Clarification Statement: Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units.] [*Assessment Boundary: Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.*]
MS-PS2-5.
Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. [Clarification Statement: Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, and electrically-charged pith balls. Examples of investigations could include first-hand experiences or simulations.] [*Assessment Boundary: Assessment is limited to electric and magnetic fields, and limited to qualitative evidence for the existence of fields.*]

Unit Progression

- I begin this unit by giving out the FORCE coloring sheet the night before we do the PhET simulation in class. The PhET simulation lab helps students understand that only unbalanced forces can cause a change in motion. (This lab generally takes me about two days.) I've included a foldable on calculating net force that you can use in science notebooks or for a formative assessment if needed.

- We then move on to free body diagrams and use The Physics Classroom Interactive where students work together to determine which free body diagram goes with each scenario.

- Once we have these concepts down, I move on to gravity (usually give them the GRAVITY and FREE FALL AND TERMINAL VELOCITY coloring sheets as they finish up the PhET lab and have them finish for homework). I show the Felix Baumgartner video and facilitate a discussion about whether he is actually under the influence of gravity even though he is not touching Earth (have kids refer back to non-contact forces on FORCE coloring sheet if needed). We also analyze his speed in the video to discuss air resistance and terminal velocity. (Side note: As far as I understand it, the reason he goes so fast at the beginning of his fall is because the air is thinner. Fewer particles = less air resistance.)

- Kids are of course interested in free fall so I bring in the OK GO! Music video to discuss astronaut training and induced free fall and the lack of air resistance because the air is falling at the same speed as the people.

- Now that we are on the subject of thrill seeking, I move to bungee jumping as a sport. If you are interested in sharing the history behind bungee jumping, check this out for information. We analyze all the different parts of bungee jumping starting with the person standing on the platform (balanced forces) to the person leaving the platform (unbalanced forces) to the stretching of the bungee cord (elastic potential energy). We also discuss the net force and the free body diagram conceptually (no numbers but they need to understand that there is more force down than up).

- Finally, we move on to the Barbie Bungee jump lab. I give the kids the POTENTIAL ENERGY coloring sheet the night before I plan to begin this. I begin by showing the How It's Made video and Slow Mo Guys video so we can discuss why the bungee cord recoils to allow you to fall multiple times, focusing on the potential energy built up in the cord as it stretches. Before beginning the lab, I stress the importance of GOOD DATA. If they don't take good data, Barbie will not survive her fall. A stairwell is a great way to do this lab, but if you work in a building with no stairs, you can use a ladder and pop out one of the ceiling tiles in your room to have Barbie jump from ceiling to floor.

Resources for the Classroom

Balanced and Unbalanced Forces

- PhET: Force and Motion Basics: Net Force
  - This is an AWESOME interactive. If I have enough devices (we share a class set of iPads on the hall) then I have students complete this with partners. If not, I do one big class demo with all of us gathered around the board while I manipulate it. This is one of the best ways I have found to dispel some misconceptions about force and motion. Pages 8-10 of this document can be used with this interactive. (MS-PS2-2)
- The Physics Classroom Free Body Diagram Interactive
  - This interactive gives students the opportunity to consider various life scenarios and how forces play into them. From this we often draw our own free body diagrams as well. If you do not have technology for each student, you should be able to screenshot and print for a matching game.

Gravity

- Felix Baumgartner Stratosphere Jump (8:17)
  - It should be noted that this video contains the phrase "I'm hauling ass!". I discuss this with my 8th graders before showing the video because I think what you get out of the video is more important than just this phrase, but this may not be appropriate for younger viewers. This video is a great introduction to the concept of free fall, terminal velocity, and air resistance. If you need a refresher on these concepts, check out The Physics Classroom. This is also a great way to show that even though he is not touching the Earth, he is still under the influence of gravity because he is pulled back to Earth. (MS-PS2-5)
- OK GO! Upside Down and Inside Out (3:21)
  - You can find a little bit of background on the Vomit Comet here. This video does a good job of explaining how a parabolic flight works. Both of these videos and the concept of the zero g flight give me an opportunity to address induced free fall.

Elasticity

- How It's Made: Rubber Bands (5:04)
  - My kids (although they don't like to admit it) love to watch how things are made. This is a "just for fun" video that gives them perspective into where rubber bands come from.
- Slow-Mo Guys: Rubber band vs Watermelon (4:33)
  - This video shows the power of elastic potential energy. The Slow Mo guys do a great job of showcasing the power produced. Plus, who doesn't love videos in slow motion? When I show this video, I ask the kids to journal or discuss what would happen if they continued to use the same rubber bands around different watermelons so we can discuss hysteresis.

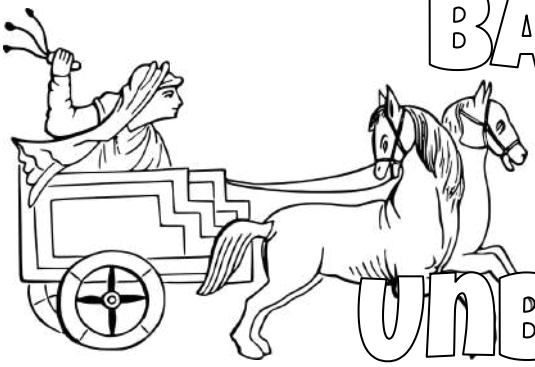
A PUSH OR A PULL

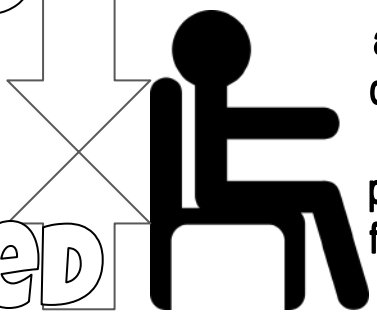
Work occurs when a FORCE moves an object some distance in the direction that the force is pushing or pulling

$W = f \times d$

work = force x distance

BALANCED VS. UNBALANCED





When you sit in a chair, you push down on the chair and the chair pushes with equal force back at you!

Unbalanced forces are not equal.
These DO cause a change in motion!
Some also cause WORK!

Balanced forces result when two objects push or pull on one another with equal amounts of force.
There is NO change in motion or direction.

Contact and Non-Contact Forces

Forces that exist even when objects don't touch

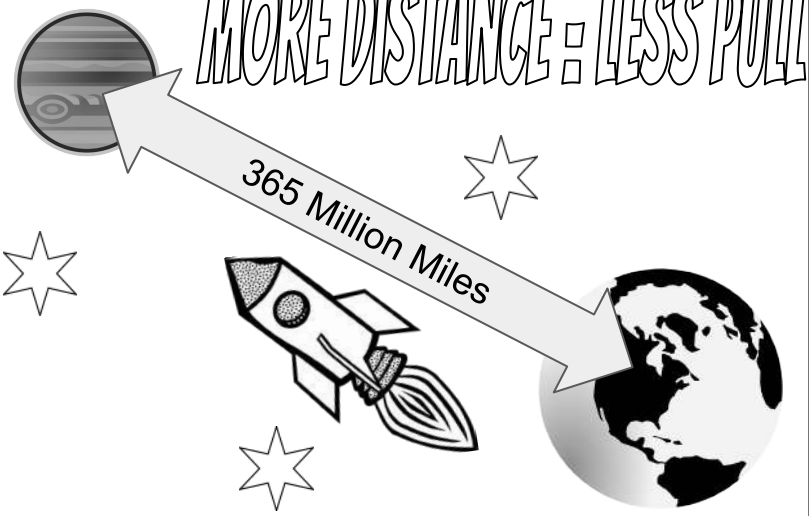
- GRAVITATIONAL
- ELECTRICAL
- Magnetic

Forces that result from objects making physical contact

- TENSION
- Applied
- Normal Force
- AIR RESISTANCE
- FRICTION
- Spring

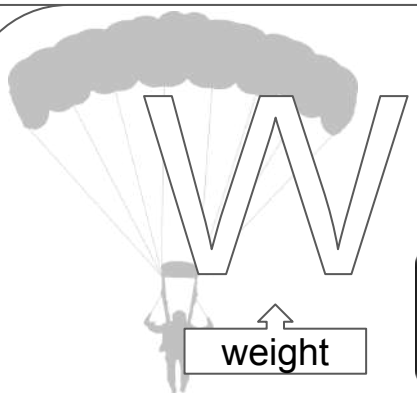
GRAVITY

GRAVITY IS A NATURAL PHENOMENON BY WHICH ALL PHYSICAL BODIES ATTRACT EACH OTHER



THE AMOUNT OF ATTRACTION IS DIRECTLY RELATED TO THE MASS OF THE OBJECTS AND THE DISTANCE THEY ARE FROM ONE ANOTHER

WEIGHT



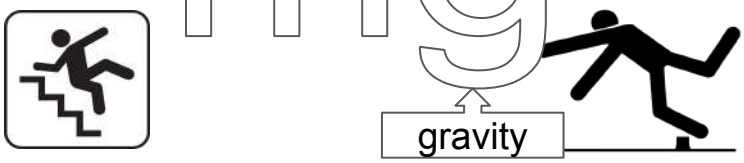
$$W = mg$$

mass

$9.8\ m/s^2$

weight

gravity

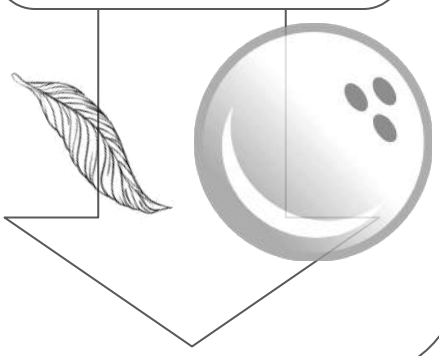


GRAVITY GIVES OBJECTS ON EARTH WEIGHT BY PULLING ON THEIR MASS AND CAUSING THEM TO FALL TOWARD EARTH WHEN DROPPED

FREE FALL and Terminal Velocity

Free fall occurs when the only force acting on an object is gravity. This means that their either is no air resistance or that air resistance is negligible.

All object fall and accelerate at the same rate, regardless of their mass. (9.8 m/s^2)



Air Resistance

Air resistance occurs when objects fall through air due to the collision of the object with air particles on it's way down.

The faster an object falls (and objects do accelerate as they fall), the more collisions it has. The more collisions there are, the more air resistance!

TERMINAL Velocity

Once an object has reached the point at which the air resistance it experiences is equal to the force of gravity, it will no longer accelerate. This is called terminal velocity.

POTENTIAL ENERGY

"STORED ENERGY DUE TO POSITION, SHAPE, OR CHEMICAL COMPOSITION."

Gravitational Potential Energy

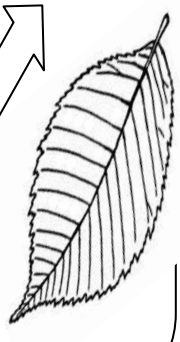
Energy due to an object's position above Earth's surface

Height (m)

Mass (kg)

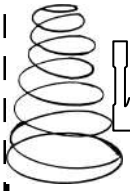
$$GPE = mgh$$

The force of gravity ($9.8\ m/s^2$)



Elastic Potential Energy

ENERGY STORED IN ELASTIC MATERIALS, LIKE RUBBER BANDS OR SPRINGS, DUE TO THEIR STRETCHING OR COMPRESSING.



MORE STRETCH = MORE ENERGY!

RUBBER BANDS ARE SPECIAL!

Stretching a rubber band uncoils the kinks and tangles in the molecules that make it so the rubber band cannot return to it's original shape. This is called "hysteresis".

PhET Force and Motion Lab: Balanced and Unbalanced Forces

NAME:_____

Trial	Predict which way the cart will move. If you think it will not move, write "no movement"	Explain your prediction
		
		
		
		
		

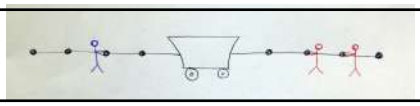
Forces and Motion: Graphic Organizer

Which way do you think the cart will move in each of the pictures below? Explain your predictions using drawings and words.

1. Go to PhET Force and Motion Basics and click "Net Force" to test your predictions using a series of trials. Try new combinations!

2. Compare the predictions that you made in the table above to what happens to the cart of candy in each trial. If some of your predictions are not right, correct them

Try more trials using different combinations of people from the red and blue teams. Be sure to return the carts to the center before beginning a new trial. Draw or talk about what you discover. You can use the data table below to keep track of your observations.

Trial	Which way did the cart move?	Explain why
		

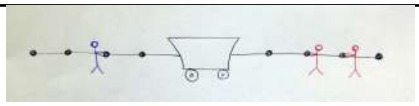
Look at your tables. What are some "rules" that you can use to make predictions about which way the cart will move? You might ask yourself questions like:

a. Does it matter that the people are red or blue? Explain your answer.

b. Does a large person always win each competition? Provide evidence to support your answer.

c. If two people are pulling on opposite sides, does the cart always stay still? Elaborate on your ideas.

d. Does it matter what part of the rope a person holds? Provide evidence to support your answer.

Trial	Draw the forces	Net force and how it was found
		

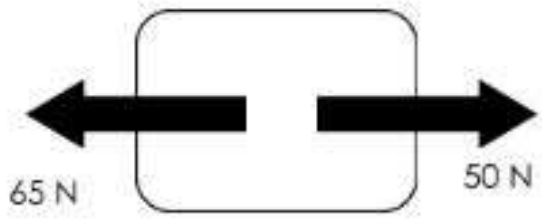
Part II: Finding the Net Force on an object

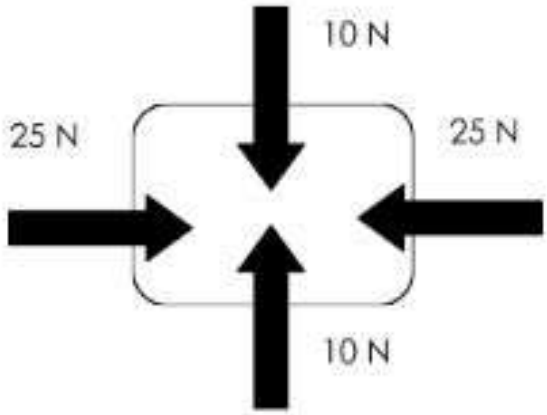
Open the PhET simulation for Net Forces. In the top right corner, make sure that "Sum of Forces" and "Values" both have a check mark next to them. Use the simulation to try different combinations of people. For each trial, draw the arrows of force and state the net force (sum of forces). Using the information given, figure out how they find the "sum of forces".

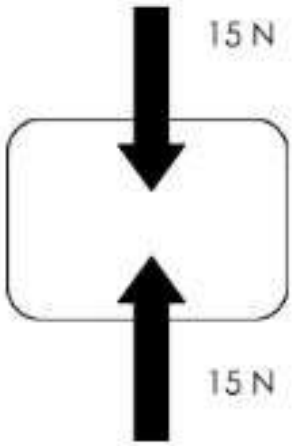
A. The simulation calls the net force the "sum of forces". Sum implies that the forces will be added together. Is this always the case? Explain your answer.

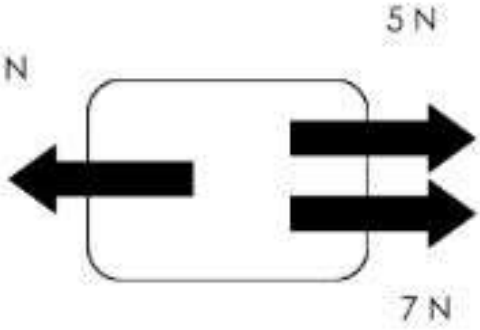
B. What has to happen in order for the sum of forces to be zero?

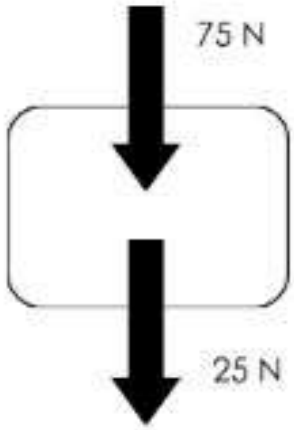
C. What happens to the motion as you increase the force on one side of the cart? What would happen if you kept increasing the force?

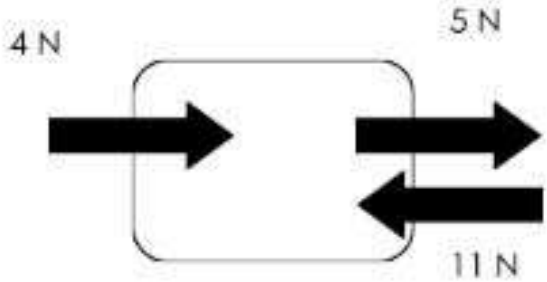

65 N
50 N

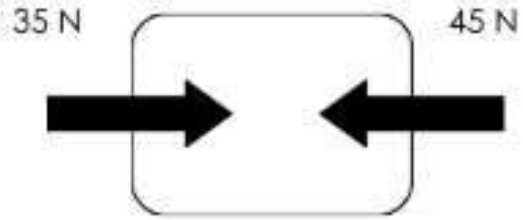

10 N
25 N
25 N
10 N

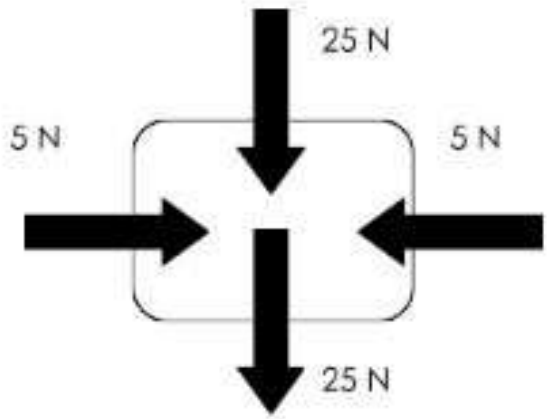

15 N
15 N


5 N
10 N
7 N


75 N
25 N


4 N
5 N
11 N


35 N
45 N


25 N
5 N
5 N
25 N

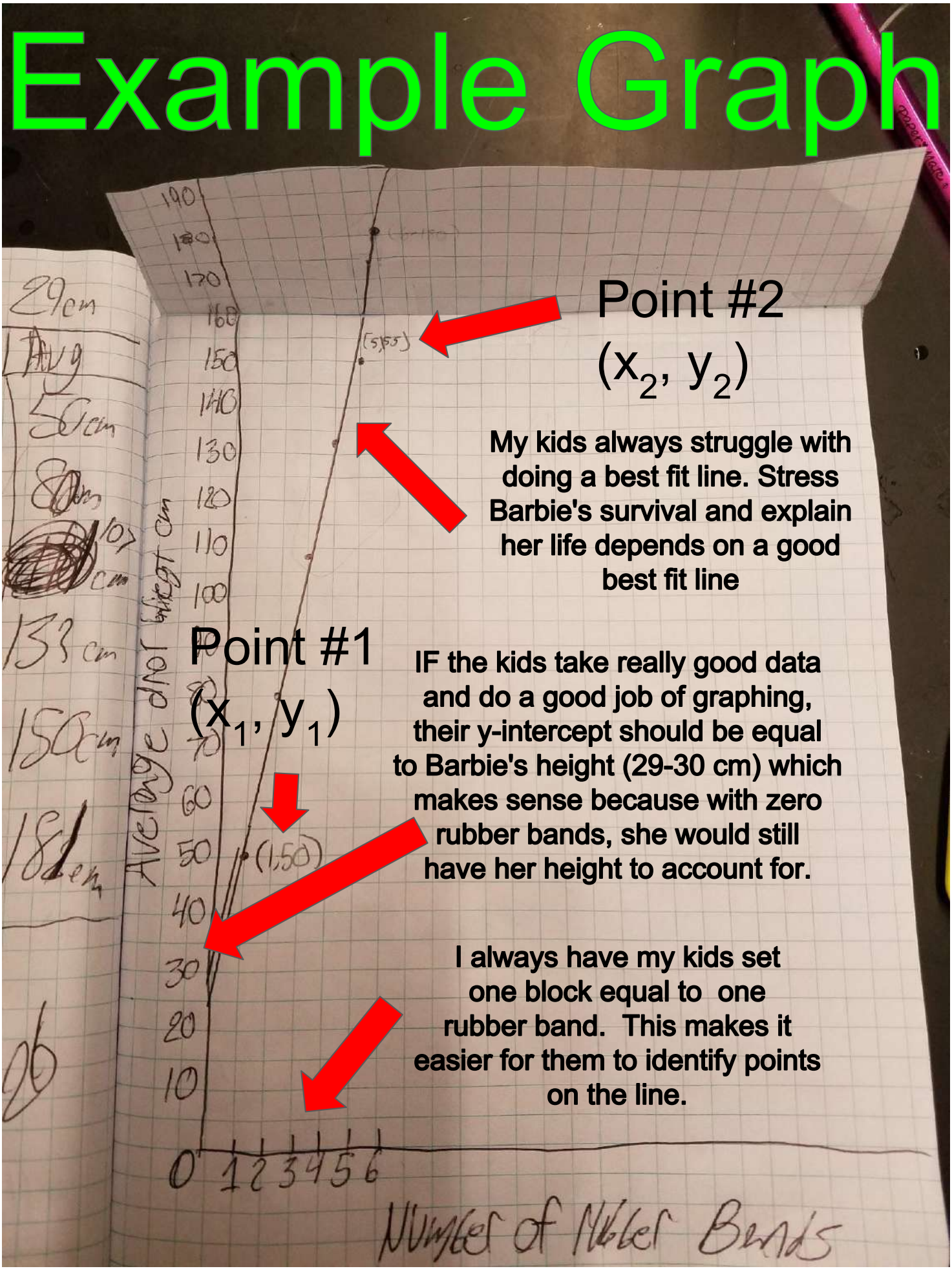
Barbie™ Bungee Jump

Teacher Notes

- Many people believe that this lab should be done in a math class due to the calculations and analysis. While it is a bit intensive in the math area, it provides a great opportunity to link elastic potential energy, free fall, gravity, and a lot of other science concepts. Above all, it is a lesson in taking GOOD data and analyzing it for next steps in the scientific process.
- Barbie is an expensive gal! I ask for my 8th graders to donate any Barbies they no longer use as well as clothes. If you are in a pinch and find a bunch of naked Barbies at a yard sale, BUY THEM! Masking tape works wonders for clothing.
- Instead of giving my kids a table to copy, I begin by setting the stage for them. You can the included newspaper provided below. I also facilitate a discussion about the type of table needed to record the information based on Barbie's interview (up to 6 rubber bands, multiple trials, and an average) and we develop a table for information as a class. We also develop a table for the class predictions and height from the floor during the drop. If needed, you can supply the tables listed after the Barbie Times to students to record their data.
- For testing purposes, I have kids tape 2 meter sticks to the wall, one on top of the other. Make sure that zero is at the top so that they can measure from zero down. If you don't have meter sticks available, you can get a printable one here and have kids or group leaders cut and tape these to the wall the day before the lab.
- Don't allow the kids to tie knots in the rubber bands unless you want to go through several bags of them during the experiment. I am providing a video that shows you how to attach them that allows them the be easily undone. Have students pay attention to how they tie them. Tying them tightly makes her go lower and tying them loosely makes her not fall as far! This will affect the overall results.
- For graphing purposes, have students graph on graph paper. This is really important because the data they get and the best fit line they draw predicts the number of rubber bands they need to use.
- Calculations generally take an entire day for students who are not in advanced classes. I work with my math teacher to ensure that they have been over graphing lines, identifying the coordinates of specific points, finding slope using two points, and using the equation of a line (y=mx + b). I have included a math teaching sheet that can help you if you are fuzzy on the details.
- Drop Day usually takes about 20-25 minutes for 9 groups (in my experience). I allow students to start on their write up after we finish the drop and have all data recorded.

Happy Jumping!

Example Graph



Barbie™ Bungee Jump

Math Calculations

$$y = mx + b$$

Begin by having students find the slope of their best fit line

Graphing, drawing the best fit line, and doing the calculations to find the number of rubber bands to use usually takes me one 50 minute class period so plan for it!

$$\frac{y_2 - y_1}{x_2 - x_1} = \text{slope of the line}$$

Move the line equation to get x by itself (x is the number of rubber bands)

$$x = \frac{y - b}{m}$$

Where:
y is the height of the drop in cm (I measure this the day before we do calculations)
b is their y-intercept from their graph
m is their calculated slope from above

x is equal to the number of rubber bands that group should use in the full drop

It is possible that all students in the same group will come up with a different number of rubber bands to use because their best fit lines will not be exactly the same. Have them make an informed decision based on all of the numbers to use in the actual drop.

Barbie TIMES

Barbie Bungee To Open Soon!

Thrillseeker Barbie is interested in opening her own bungee jumping business. Although she has no formal physics training, she feels that this would be a great job to have. A recent interview with the entrepreneur helped us gain insight into this new adventure:

Barbie, what type of bungee cord do you plan to use?

Because I'm a small doll, we are experimenting with high quality 1.5 mm rubber bands. Rubber bands store _____ _____ _____ when they are stretched, and this provides us the ability to spring back into the air.

Are you worried at all about the integrity of your rubber bands?

I know that when I stretch a rubber band, it will not fully return to its original shape. This is a property known as _____. Therefore, we plan to replace bungee cords on a regular basis.

What forces will influence you during this activity?

The force of _____ will pull me toward the Earth even though we are not touching. This will create an _____ _____ force because I will not have a stable platform below me and this will cause my motion to change as I start to fall down toward Earth. There will also be a negligible amount of _____ _____ as I push the the particles of air on my way toward the ground.

$$y = mx + b$$

Doctor, Lawyer, Veterinarian, Pilot, Astronaut, and Supermodel? What next? BARBIE BUNGEE!

Barbie, how will you determine the length of the rope needed to keep your patrons safe during their fall?

I will be doing my own testing for this. To determine the length of the rope I need for a person my size, I will begin with small jumps. Using a short test rope and building up will ensure that I don't hurt myself. I will start with 1 rubber band and measure the length of my fall. I will then use 2, then 3, and eventually work my way up to 6 rubber bands, recording my data as I go. I will use _____ trials and take an _____ of my falls so that one piece of data does not over-influence my results.

If you are only doing a short jump, how will you know how many rubber bands to use for the actual jump?

I will graph and use the equation of a line to determine the number of rubber bands to use.

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Barbie, what type of bungee cord do you plan to use?

Because I'm a small doll, we are experimenting with high quality 1.5 mm rubber bands. Rubber bands are _elastic_ _potential energy_ _____ when they are stretched, and this provides us the ability to spring back into the air.

Are you worried at all about the integrity of your rubber bands?

I know that when I stretch a rubber band, it will not fully return to its original shape. This is a property known as _hysteresis_ Therefore, we plan to replace bungee cords on a regular basis.

What forces will influence you during this activity?

The force of _gravity_ will pull me toward the Earth even though we are not touching. This will create an _unbalanced_ _force_ because I will not have a stable platform below me and this will cause my motion to change as I start to fall down toward Earth. There will also be a negligible amount of _air_ _resistance_ as I push the the particles of air on my way toward the ground.

y coordinate x coordinate

$$y = mx + b$$

slope y intercept

Doctor, Lawyer, Veterinarian, Pilot, Astronaut, and Supermodel? What next? BARBIE BUNGEE!

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If you are only doing a short jump, how will you know how many rubber bands to use for the actual jump?

I will graph and use the equation of a line to determine the number of rubber bands to use.

Number of Rubber Bands	Height (cm) Trial 1	Height (cm) Trial 2	Height (cm) Trial 3	Average Height (cm)
1				
2				
3				
4				
5				
6				

Group Name	Prediction (Number of Rubber Bands)	Height from Floor (cm)

Barbie Bungee Jump

Write Up Instructions

Using the format below to write up the Barbie Bungee Jump experiment and what you learned. Use this sheet to guide you as write because this is how I will grade it.

I. Experiment

A. Explain what you did in the experiment from the first step to the last step.

B. 10 points

II. Data

A. Record your data tables (including UNITS) for the six rubber band jumps that you did in the room.

B. 10 points

III. Graph and Calculations

A. Draw your graph and your best fit line. Show the calculations you used to help you determine the number of rubber bands you needed to use for the big drop.

B. 20 points

IV. Conclusion

A. Discuss the outcome of your experiment in paragraph form using the following questions to help you answer it.:

1. Explain the difference between balanced and unbalanced forces and how it relates to this experiment.
2. Explain what gravity is and how it relates to this experiment.
3. How did your Barbie do compared to other Barbies in the class? (Use specific data [numbers] and refer to your graph to support your answer.)
4. Why do you think this happened?
5. How would you change this experiment to get as close to the floor as possible without touching?
6. Draw a free body diagram of Barbie before the fall (on the platform), during the fall, and at the bottom of the rope.

B. 30 Points