



Strategies

FOR
PERSONALIZED
LEARNING

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To my fellow educators:

The monotony of the traditional learning model was always difficult for me. As a student, I was constantly bored, and this boredom led to misbehavior and disruptions that further distanced me from school and learning. It was not until college that I began to understand how I actually learned—and that learning could be a positive piece of my daily life.

When I first entered teaching through Teach for America, I struggled to implement a traditional learning model in my own classroom and sought out every opportunity to break from it. Some of these attempts failed, but more importantly, some were successful and led me down the road of personalized and student-centered learning. I have seen it make the difference for students who did not fit in a traditional learning model—students who, like me, struggled to find their place in education.

Here, I outline five personalized learning strategies that have helped students find success in a setting that has too often felt like a failure. I think of students like Denyia, Samir, and Najah who never felt success in school before, but when given the opportunity to take ownership of their own learning, have thrived and found a place that feels both comfortable and successful to them.

When compiling these strategies, I thought a lot about cognitive lift. Cognitive lift refers to the amount of thinking and struggling with the content that is required of students during an activity. Within a traditional learning model, a substantial amount of the cognitive lift is on the teacher, which is counterproductive when we consider our goal as educators to effectively educate and enrich the lives of students. Students need to be doing the “heavy lifting” in the classroom, not the teacher, and these strategies help shift that weight. While advancing strategies that pass more of the work and more of the decision-making to students can be scary or difficult at first, it is incredibly beneficial, and with practice, leads to a strong learning environment and a culture centered around learning.

The strategies in this booklet take the ideas that have worked best for me and my colleagues in a school focused on personalized learning and break them down to approaches that should be easy to implement in any classroom. Effectively implementing student-centered learning can be quite daunting without support, but these strategies can provide a stepping stone. In addition to the basic how-to, I outline the potential miscues and areas of struggle that teachers and students may face—and what can be done to mitigate them.

I hope that you find these strategies as impactful and useful as I have, and I hope that you use them to increase the cognitive lift of the students in your classroom and enrich their experience in education.

In partnership,



CJ Ellsworth
High School Math & Physics Teacher



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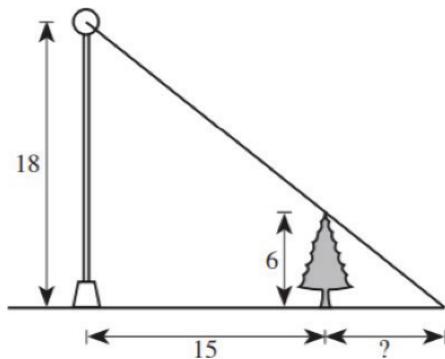
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Strategy #1 Problem-Based Approach

GRADE LEVEL: HIGH SCHOOL AND MIDDLE SCHOOL STUDENTS

How It Works

This is an easy-to-implement strategy for teachers who want to build self-directed learning into their classrooms. To get started, first reflect on the standards you aim to cover for the day. Then, develop a problem that will require students to work through these standards. For example:



Problem:

A 6-foot tree is planted 15 feet from a streetlight whose lamp is 18 feet above the ground. How many feet long is the shadow of that tree?

The problem should be difficult, but not so difficult that students cannot persevere and eventually succeed. Students may want to work in groups, which can be beneficial as long as there are checks in place to ensure all students play a role in the work. Students should do their own research to solve the problem, but you can get them started with Google search terms. At the end of the allotted time, students should present their solutions.

This strategy gives students the autonomy to pursue a problem in any way that they find beneficial. While allowing them to try their own strategies, students are allowed to struggle, which will help to increase their cognitive processing skills—particularly as they become more comfortable with it. The cognitive lift is on the students, which allows the teacher to circulate and identify areas of struggle, building a deeper understanding of each student’s gaps and strengths.

What It Looks Like

- **Quiet Work Time.** Students should be working quietly and independently or in small groups.
- **Problem-Solving.** Students should be writing down their questions and their thoughts and freely brainstorming as they begin to solve the problem.
- **Anchor Charts.** Students should be referencing anchor charts (reference charts or examples for students to use) in the room for

FEEDBACK

“It is really hard, but when you finally get it, you feel like you really accomplished something”
–K.W. (Student)

“I enjoy this because I like the challenge. Other classmates do not enjoy it as much, but I like learning things myself and using all of the resources available to solve the problem.”
–J. S. (Student)

Expectations Anchor Charts.

Ground students in their work and the expectations using the sample anchor charts on **PAGES 14–17** of the appendix.

help with things like Google search terms and critical reference details (for example, the quadratic formula). See examples of anchor charts on **PAGES 14-17** of the appendix.

- **Sharing Out.** Near the end of the allotted time, students should be preparing to present their solutions and their reasoning.

What It Feels Like

For Students:

- Students should be cognitively tired at the end of this exercise, as they are putting in all of the cognitive lift. The more hands-off the teacher can be the better.
- Students will most likely struggle at the beginning with this strategy as it is not something that they are used to. Push past this and know that it is normal—with benefits in their cognitive development at the other end.

For Teachers:

- It will feel strange at first if you're not used to taking this big of a step back, and it requires patience as you teach students how to productively struggle.
- It may feel as though you have nothing to do. If so, refocus yourself on circulating the room looking for: common misconceptions to point out to the class, a strategy that is interesting, or opportunities to keep students motivated with scaffolds.

FEEDBACK

"Classroom management skills are paramount in this strategy. It will really help you to improve your skills in identifying and managing student behavior struggles."
—J.L. (Teacher)

"Even if you feel like you're not being productive, the lift should be on the students. Every time you give a hint, you take away their chance to learn something for themselves."
—L.B. (Teacher)



HELPFUL HINTS

WHEN USING THIS APPROACH:

Do: Have examples of similar topics on the walls.

Don't: Give exact examples of the problem.

Do: Appropriately group the students so that one student does not do all of the work and so that you can easily provide scaffolds for individual groups.

Don't: Start out by giving groups scaffolds. Let the struggle happen. This allows students to learn to ask the right questions.

Strategy #2

Point-Based Approach

GRADE LEVEL: HIGH SCHOOL AND STRONG MIDDLE SCHOOL STUDENTS

How It Works

In this strategy, students are presented with a menu of options for the week. The menu contains a list of possible assignments, projects, or deliverables that students may choose from. Each option is assigned a point-value based on difficulty or amount of work needed to complete the task. Students are told how many points they need to have by the end of the week and then allowed to “plan their own adventure.”

The options are endless, but here are some common types of work to include on your lists:

- **Checks for Understanding (CFUs).** These exercises allow students to practice the standards for the week. You can prepare worksheets like the example on [PAGES 18–19](#) of the appendix.
- **Lab/Application Activities.** These activities are more conceptual and ask students to apply the material to real-world scenarios. See the example of the marble launcher experiment on [PAGES 20–21](#) of the appendix.
- **Practice Summative Assessments.** These tasks should be similar to the summative assessment that students will be asked to complete at the end of the unit. See an example of the assessment on [PAGES 22–25](#) of the appendix.
- **Lecture/Class Notes.** Students who attend a lesson with the teacher may get points for their notes. In some cases, you might make attending a lecture a required component. It’s also up to you whether you want notes in a specific format, like Cornell, or whether they can be free-form.

This strategy is one of my personal favorites; it allows students not only personalize to their class period for a single day, but to plan their entire week. It tends to work best for high school students, but a strong middle school group may be able to handle it. The work in this strategy is best done independently, as students tend to be swayed by their classmates, and we want the work to be as self-directed as possible.

This strategy gives students autonomy while helping them build decision-making skills. Often what seems like an optimal course of action—completing the fewest activities—is not necessarily the easiest. When assigning points, it helps to think of the end-goal that you want from your students. If the goal is to be able to solve procedural math problems, make the procedural problems worth the most points. If the goal is to understand the conceptual basis behind the math, then the application should be worth the most points. My favorite part of this strategy is watching students opt into lectures, because they get to see the value associated with it.

What It Looks Like

- **Work Stations.** Students should be working at different stations based on their chosen activity.

FEEDBACK

“I like to choose what I work on. It makes it seem like I am getting the education that I want to get.”
–J.L. (Student)

“I like looking at the menu of options and figuring out how I can get the points I need without doing unnecessary work.”
–P.H. (Student)

Expectations Anchor Charts.

Ground students in their work and the expectations using the sample anchor charts on [PAGES 14–17](#) of the appendix.

- **Noise Levels.** Students should abide by the noise level that is set for that station. For example, students working on CFUs will be silent, while those working on lab activities will engage in on-task conversation.
- **Answer Sheets.** After finishing the task, students should be able to consult answer sheets. Since you will often be lecturing to another group of students, students should know where to find these. Answer sheets could be exemplars or final answers (this is most appropriate for math and science activities where students will also show their work).

What It Feels Like

For Students:

- Students may feel like they can take advantage of the system at first. This may cause them to fall behind and get discouraged. To mitigate this, you may want to allow students to finish the work over the weekend during the first few attempts at this system.
- Students may get off-task in this system. You can mitigate this by providing enough scaffolding to keep students engaged, as well as providing timelines for students who struggle with planning.

For Teachers:

- It may feel strange to give students as much freedom as this strategy allows, but this is to teach the importance of time management and allow students to feel the impact of their decisions.
- It may feel like students are wasting time, and this may happen at the beginning. If you positively narrate behavior, make expectations clear, and are transparent about grading for each activity, eventually, students will buy in and adapt to the system.

FEEDBACK

"Positive narration is your friend."
—C.E.L. (Teacher)

"It is a lot of planning upfront, but it makes the week feel structured. Every activity is leading students to the end goal."
—A.B. (Teacher)



HELPFUL HINTS

WHEN USING THIS APPROACH:

When students inevitably say, "I do not know what to work on," make sure you give them all of the options and then make a recommendation. The recommendation should sound something like this: "You have options A, B, and C, but I think that you would be most successful with option ____." It makes the recommendation feel personal to a student.

Be transparent about the work with students. Let them know that you are allowing them to choose what they work on, but if they do not complete the work, they are making the choice to deny themselves the chance to learn the material.

Strategy #3

Students as Teachers Approach

GRADE LEVEL: HIGH SCHOOL STUDENTS

How It Works

This is a strategy that teachers have implemented for years, elevating students to the role of teacher. Under this strategy, you ask students to prepare a lesson and teach the class a certain topic. ***This allows them to dig deeper into the content than they normally would, often looking at the theory behind it in order to explain concepts, answer key questions, and address misconceptions.***

This strategy is ideal for high school students and can be used in most subjects, from humanities to math to physics. I use this strategy for students of all levels and have found that even students who struggle with other learning methods can rise to the occasion and succeed when given this type of leadership. While it can seem like less work for the teacher, is actually quite labor-intensive to provide students the coaching and support to ensure they are prepared to teach a lesson on a particular day.

What It Looks Like

- **Small Groups.** Students should work in small groups of 3-4. Ideally, the groups should be mixed skill level. You can decide whether you trust students to self-select or whether you want the groups to be predetermined.
- **Clear Guidelines.** Groups should start from clear guidelines. I like to give students a well-designed and standards-aligned exit ticket so that they know what the end-goal of their lesson should be.
- **Curated Resources.** Students can also be given resources, such as textbooks and useful websites to help them learn and prepare materials on the topic.
- **Lesson Planning.** Group work should focus on writing a lesson plan, including:
 - A whole-group lesson that teaches the key points of the topic
 - Independent practice problems/activities where they will circulate to answer questions and observe challenges
 - Responses to misconceptions that they think will arise in the lesson
 - Formative assessment questions to see if the class has understood the material
 - A "Do Now" (or pre-assessment) with answers that are well scripted
 - A well-structured and standards-aligned exit ticket (if not provided by you)
- **Students as Teachers.** The whole class should have clear expectations around behavior during student presentations—along with consequences for misbehavior.
- **Room to Fail.** Students should be given room to fail. Let students finish their lesson, even if isn't going well and you need to re-teach the topic

FEEDBACK

"Getting to teach the class is fun, but it makes you feel bad for teachers sometimes."
—P.H. (Student)

"Teaching is hard, but I will never forget how to solve systems of equations."
—S.P. (Student)

another day. Strong reflection and coaching can ensure students learn and grow from their mistakes.

- **Reflection.** Once the lesson is given, the group should reflect on the experience and give specifics on what went well, and what did not. Possible reflection questions include:
 - What do you think went well?
 - What do you think could have gone better?
 - What does your data from exit ticket results say about your lesson?
 - Did you know the topic well enough to teach it?
 - Were there any questions that surprised you?

What It Feels Like

For Students:

- Students should feel challenged as they take on the vast majority of the work in this strategy. With less teacher direction than they are used to, students may feel uncomfortable, but ultimately the learning will be deep and authentic, as they have to know the material well enough to teach others.

For Teachers:

- Teachers, at times, are uncomfortable releasing the control of the room, so classroom culture needs to be strong before implementing this strategy. You should feel comfortable in your classroom management skills, knowing that students can take direction, and have a strong handle on classroom dynamics and peer relationships. Know that at the same time, this strategy will help increase the sense of community in your classroom and make students more comfortable asking questions of their peers.

FEEDBACK

"Kids learn better from each other than they will ever learn from me."
 –L.Y. (Teacher)



HELPFUL HINTS

WHEN USING THIS APPROACH:

- It is ok to teach a quick lesson to the group before they begin planning their lesson.
- Raise the stakes by turning it into a competition where the best exit ticket scores win.
- Before assigning topics, make sure that the students have all of the prerequisite knowledge.
- Intro lessons are usually the best for this strategy. Intro lessons are typically broader and allow students to teach less in-depth material. This also makes it easier to fix any misconceptions later in the unit, if the student lesson does not go well.

Strategy #4

Project-Based Approach

GRADE LEVEL: HIGH SCHOOL

How It Works

The Project-Based Approach is a longer-term strategy—usually an entire unit or more. To really allow students to be creative and work through the entire scope of creating and implementing a project, a solid amount of time needs to be allotted. In this strategy, **students design a project which hits all of the necessary standards but does so in a way that is more interesting and aligned to students' passions.** Teachers provide a framework of student-facing objectives in the form of project goals that students can easily understand.

For example, a student passionate about theater could write a one-act play explaining the role of slaves in fighting the American Civil War. The topic becomes more engaging for the student when tackled through a lens that is interesting to them. Because this approach requires a heavy creative lift from students, I find it helpful to have some project examples that students can choose from, making sure the initial stage isn't too overwhelming. I also like to provide a list of ways students might consider sharing their projects back with the class, such as: PowerPoints, posters, videos, animations, student teaches (see Strategy #3), or even speeches.

Once students get used to the expectations—and to the wide-open nature of this approach—they begin to take ownership over their projects and start to focus more and more on their passions and how they can be applied to many different subject areas.

What It Looks Like

- **Clear Objectives.** To get started, it is critical to clearly outline the project objectives. I always create a handout for students that they can reference throughout the project. I also model an exemplar with students; typically, a screencast style video as this is easy to pause and explain how objectives are reached. It is also easy to produce and can be shared with students to reference later.
- **Planning Time.** Students should have designated time to develop with their project idea. This process typically takes two hour-long class periods.
- **Project Proposals.** Students should submit a written project proposal for teacher feedback and approval. The proposal should include:
 - A clear project description
 - An outline of project objectives, in their own words to demonstrate understanding, with details on how the project meets each objective
 - A summary of potential sources/research tools
 - A timeline with key milestones
 - A plan for presenting their project
- **Working on a Timeline.** Once the project proposal has been approved, students should work toward the goals that they set for themselves in the project timeline. If a student does not meet a goal on a certain day, allow

FEEDBACK

**"I like making my own project. If I had to do something that I was not interested in, it would not turn out well."
—O.W. (Student)**

them to adjust their timeline, but ensure they keep the goal. The timeline should be a part of their grade, so they must update it if they fall behind.

- **Holding Students Accountable.** Students should check daily on their progress and timeline. I ask students to bring their timeline to me when they think they have accomplished their daily goal, or before the end of the period. If they have, I initial the timeline; if not, I provide feedback. If students do not bring me their timeline, they will not get initialed and will not receive credit for that day.
- **Office Hours.** I hold “office hours” to help students that need specific help with their projects. I compile resources that might help students along the way and ask other teachers to help with particular projects if it is in their area of expertise.
- **Presentations.** When it comes time to present projects, make a calendar of presentation times so that students know when to be prepared.

What It Feels Like

For Students:

- Students may get overwhelmed by the scope of their project. It is important that you encourage them and help them appropriately schedule out their work into manageable goals.

For Teachers:

- As a teacher, you may worry that some projects aren’t fully capturing each objective. To address this, you can also ask students to pass an assessment at the end of the unit. This will allow you to identify and address any gaps.
- At times, it may feel like students are off task. Your job will likely involve some redirection and pushing, along with helping students set manageable goals.

FEEDBACK

“Organization is key, if you seem disorganized, so will the students. It’s not easy, but it is worth it. Having students manage their own project is helping them gain a skill that can change their lives.”
–K.G. (Teacher)



HELPFUL HINTS

WHEN USING THIS APPROACH:

- Make sure that you have a system in place for students to ask questions and get help. You do not want a big line of students waiting for help, since this can lead them off-task.
- If a student asks for feedback, give it. Then, allow them to revise. This feedback loop allows students to see improvement and the fruits of their labor.
- If possible, develop your own project! It allows students to see your interests and passions, while also providing an example.

Strategy #5

Standards-Based Approach

GRADE LEVEL: MIDDLE SCHOOL/HIGH SCHOOL

How it Works

The Standards-Based Approach is a great place to start with self-directed learning. ***This strategy is popular and it is a fairly simple way to let students work at their own pace while still moving forward on content and standards.*** It is a perfect balance between self-directed learning and the traditional teaching model.

The Standards-Based Approach starts with a lesson on the standard that you want students to master. Just like in a traditional model, you teach the lesson, use appropriate formative assessments and exit tickets, and assign homework or other independent practice. After that, you put in place a “Standards Assessment,” which students take when they feel they have mastered the standard.

If they don’t pass, they need to study more and attempt the assessment again. This assessment will cover the same standards, but be slightly different (different texts for an English or History standard, different numbers for a Math standard, slightly different scenario in Science). The teacher can decide how to handle students who have not passed the assessment by a certain deadline. I typically give another lesson on the topic with smaller groups and more individualized strategies linked to the areas where they’re struggling.

What It Looks Like

- **Traditional Elements.** This approach starts with a traditional classroom model, including a teacher-led lesson, formative assessment, exit ticket, and homework/independent practice.
- **Practice Time.** Students should have time to practice and study the standard. The amount of time depends on the difficulty or amount of material the standard covers. Students should be given resources to use when studying as well as the option to attend teacher office hours for more individualized help.
- **Standards Assessment.** Students must demonstrate mastery of the standard. This could be in the form of a traditional test, a conversation with the teacher where they explain key topics (I have seen this work extremely well for history), a project that meets the requirements of the standard, or a Socratic Seminar (which also works well with literature or history). Once a student passes, they are done! If a student does not master the standard, they must keep working on it.
- **Next Steps.** Once a student masters a standard, they can work on an extension activity that will push them to gain further knowledge of this standard. If you’re ready for them to do so, you can also allow students to begin working on the next standard.

FEEDBACK

“Getting to study by myself helps me learn what works and what I need to work on.”
–S.R. (Student)

“Sometimes, I get stuck when I don’t know where to start. It helps when I can work with the teacher on a plan.”
–C.R. (Student)

- **Additional Support.** If students have not mastered the standard by the deadline, prescriptive measures must be taken by the teacher. This could involve:
 - Small group lessons
 - Individual lessons with a student
 - Feedback on where/how to improve
 - Alternative assignments when necessary

What It Feels Like

For Students:

- It will feel pretty familiar at the beginning, which could make it easier to implement.
- Students may struggle with the idea of possible failure in the beginning. Ensure that you frontload expectations by telling students that you care more about their growth than their current abilities.
- Students may struggle with time management, pacing out their work, and knowing what learning strategies work for them, but these are skills that this approach is attempting to build in students.

For Teachers:

- In the beginning, students will ask for a lot of help. It will be uncomfortable to turn them down, but it will be better in the long run for them to learn the skills to teach themselves.
- While you may not be teaching a large group lesson every day, you should be prepared to provide students with resources, example problems and, potentially, assessments for them to demonstrate mastery—so the workload does not necessarily decrease from traditional teaching.

FEEDBACK

“It is easy to get started, and it does not take a lot of convincing kids to make it work.”
–P.B. (Teacher)

“You need to be prepared with the “Second Chance Assessments” so that students can try again.”
–P.H. (Teacher)



HELPFUL HINTS

WHEN USING THIS APPROACH:

It is best to be prepared with multiple assessments so that students can attempt to master a standard multiple time:

- I like to have different versions with different question formats.
- Pinpoint where a student slipped up the first time and give them an assessment with more questions like the ones they messed up on. This helps me to know if they’ve learned the material.
- Try to predict where students will slip up and use that to inform your instruction.

I like to use “My Favorite No” to front-load common misconceptions. This strategy allows teachers to reteach or to clear up misconceptions without singling out students, or letting the misconception go on for too long. This video provides a fantastic example of how to use this strategy: [BIT.LY/MYFAVORITENO](https://bit.ly/myfavoriteno).

Appendix

- 14-17** **Expectations Anchor Charts**
- 18-19** **Checks for Understanding (CFU) Worksheet**
- 20-21** **Marble Launcher Experiment Worksheet**
- 22-25** **Summative Assessment Example**

Practice Group Problems

You may work on Objective #1 or Objective #2.
Each objective is worth 1 point toward this weeks goal.

EXPECTATIONS



Make sure
no other groups
can hear you!



No phones



Working on
Objective #1 or
Objective #2

HOW TO GET HELP



These are example
problems in the
Exemplar Project.



To check your
answer, look at the
Answer Packet.



Need more help?
Watch the Kahn
Academy video(s)
(links on your papers).

WHAT TO DO WHEN FINISHED



Move on to the
next Objective.



Try the Content
Assessment.



Try the Lab.

DON'T FORGET TO GET YOUR POINTS!

Independent Study

You are studying for the Content Assessment

EXPECTATIONS



Silent



No phones



You are studying
for the Content
Assessment

HOW TO GET HELP



Take a look at
the resources
in the PLP.



Take a look at
your notes from
the lesson.



Need more help?
Watch the Kahn
Academy video(s)
(links on your papers).

WHAT TO DO WHEN FINISHED



Try the Content
Assessment.



Move on to
Objective #1.



Move on to
Objective #2.

**DON'T FORGET
TO GET YOUR POINTS!**

Lab

You are working on the Lab for this week.

EXPECTATIONS



Make sure
no other groups
can hear you!



No phones



Working on
the Lab

HOW TO GET HELP



There are example
problems in the
Example Packet.



To check your
answer, look at the
Answer Packet.



Need more help?
Watch the Kahn
Academy video(s)
(links on your papers).

WHAT TO DO WHEN FINISHED



Move on to
Objective #1.



Move on to
Objective #2.



Try the Content
Assessment.

**DON'T FORGET
TO GET YOUR POINTS!**

Practice Problems Silent

You may work on Objective #1 or Objective #2.
Each objective is worth 1 point toward this weeks goal.

EXPECTATIONS



Silent



No phones



Working on
Objective #1 or
Objective #2

HOW TO GET HELP



There are example
problems in the
Example Packet.



To check your
answer, look at the
Answer Packet.



Need more help?
Watch the Kahn
Academy video(s)
(links on your papers).

WHAT TO DO WHEN FINISHED



Move on to the
next Objective.



Try the Content
Assessment.



Try the Lab.

DON'T FORGET TO GET YOUR POINTS!

Name: _____

Step 6: CFU Special Cases of Systems of Equations

Due Date: Friday, January 29th, 2016

Content Focus

- Forms of Linear Functions
- Systems of Equations

Cog Skill Focus

- Modeling
- Justifying/Constructing Explanation

Purpose: Sometimes a system of equations doesn't have a solution, or has many solutions, when do those systems occur? Why do they occur? These are important questions when understanding systems of linear equations.

Part 1: Sketch an example of each of the following.

One Solution	No Solutions	Many Solutions
One solution occurs when:	No solution occurs when:	Many solutions occur when:
<hr/> <hr/> <hr/>	<hr/> <hr/> <hr/>	<hr/> <hr/> <hr/>

Part 2: Determine *algebraically* how many solutions each system has, and if it has a solution, state the solution.

$y = -2x + 2$ $4x + 2y = -2$	$y = -2x + 3$ $4x + 2y = 6$
<p>How many solutions does this system of equations have? _____</p> <p>How do you know?</p> <hr/> <hr/>	<p>How many solutions does this system of equations have? _____</p> <p>How do you know?</p> <hr/> <hr/>

Part 3: Critique the Reasoning of Others

<p>Given System: $\begin{cases} y = -2x + 3 \\ 6x + 3y = 9 \end{cases}$</p> $6x + 3(-2x + 3) = 9$ $6x - 6x + 9 = 9$ $\quad \quad -9 \quad -9$ $6x - 6x = 0$ $0 = 0$	<p>Samantha is trying to solve the system of equations below. She is doing all of her work correctly, but when she solves the problem, she is not sure what the answer means. She believes since she got $0=0$ that there is no solution to this system.</p> <p>Is she correct?</p> <p>Why or why not?</p>
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Activity: Rubber Band Investigation Lab Guide

Experiment: Rubber Band Stretch and Distance

Overview

For this lab you will see how the length that you stretch a rubber band affects how far it rolls. If you remember from the Skate Park simulation, we found that when objects have more energy, they take longer to stop rolling. In this lab, we will measure the distance the marble travels, rather than the time until the marble stops, to measure energy.

Independent Variable: In each trial, you will pull back the rubber band to a different stretch length (displacement) to see how the displacement affects the stored elastic potential energy

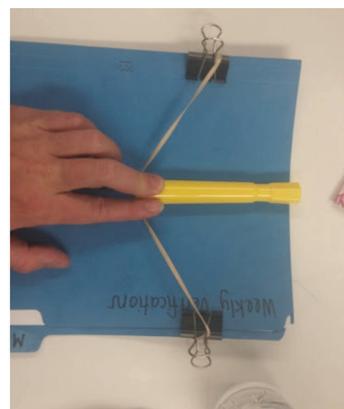
Dependent Variable: In each trial, you will measure the distance the marble travels.

Materials

- 1 Marble Launcher
 - 8"x11" sturdy surface (ex. piece of cardboard or sturdy folder)
 - 2 binder clips
 - Rubber band
- Marble
- 1 Yardstick
- Tape

Procedure

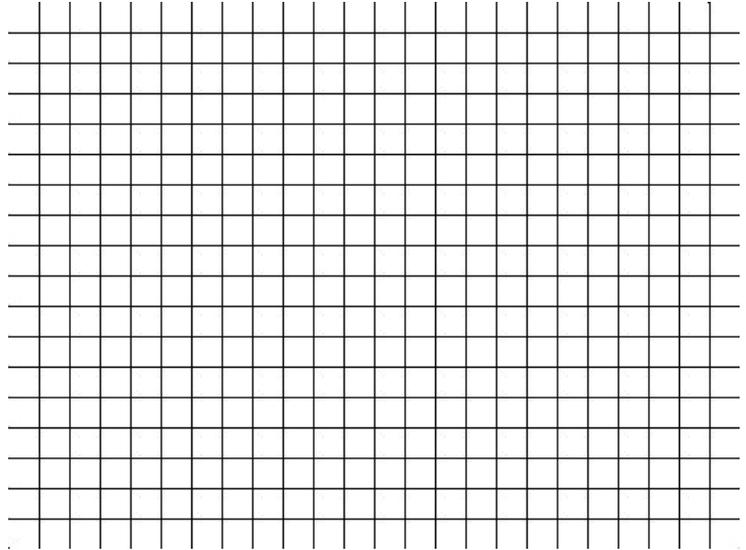
- Construct your **Marble Launcher**:
 - For the marble launcher, take a sturdy surface (such as a piece of cardboard) and place binder clips on each side. The binder clips will anchor the rubber band. Stretch the rubber band across the metal ends of the binder clips, making sure the rubber band is taut. To measure the displacement, you can either draw marks on the cardboard or tape a ruler to the cardboard and launch marbles off the ruler. This launcher goes on the ground; there should be no projectile motion in this lab.



Note: The image uses a marker instead of a marble to make it easier to see how this setup will be used to launch an object.

- Move to an open space to make sure the marble will not collide with anything while rolling
- Place the Marble Launcher on the ground and place a piece of tape on the ground at one foot intervals from the end of the launcher to 15 feet.
- For this experiment, you will pull the rubber band back to the 0.5, 1, 1.5, 2, 2.5, 3, 3.5, and 4 inch marks, launching the marble at that position from rest. Record these measurements in the **Displacement Column** of your data table.
- Pull the rubber band back to these positions, place the marble at the measured positions and launch the marble
- Measure the distance from the front of the Marble Launcher to the place where the marble stops moving. Record these measurements in the **Distance Column** of your data table.

Displacement	Distance



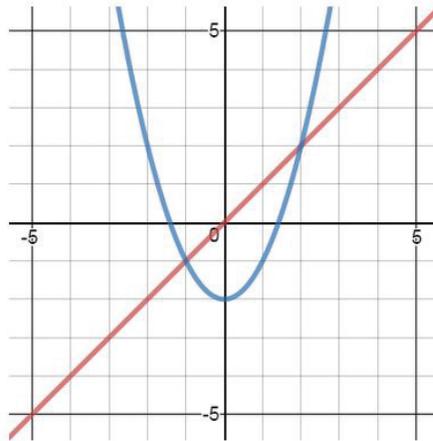
1. Describe the shape of the graph
2. What type of mathematical relationship (linear, quadratic, exponential, etc) does this graph represent?
3. What is the relationship between displacement and energy?
4. What is the slope of this graph? What does the slope represent?
5. *Advanced: Put your data into [Desmos](#) and determine the mathematical equation between Displacement and Distance*

Name: _____

You must show work to get credit! (Except for questions: 1, 8 and 10)

1.

Which of the following coordinate points is a solution to the system of equations?



- a. (0,-2)
- b. (0,0)
- c. (0,1)
- d. (2,2)

2.

How many solutions does the system of equations below have?

$$y = 2x + 2$$

$$y = x - 1$$

- a. None
- b. One, (-3, -4)
- c. Infinite
- d. One, (2, 1)

Name: _____

You must show work to get credit! (Except for questions: 1, 8 and 10)

3.

At a portrait studio, three 8-inch-by-10-inch pictures and two 5-inch-by-7-inch pictures cost a total of \$52. Two 8-inch-by-10-inch pictures and two 5-inch-by-7-inch pictures cost a total of \$40. This situation can be represented by the system of equations, where x is the cost in dollars of each 8-inch-by-10-inch picture and y is the cost in dollars of each 5-inch-by-7-inch picture.

$$3x + 2y = 52$$

$$2x + 2y = 40$$

What is the cost of one 5-inch-by-7-inch picture?

- a. \$12
- b. \$8
- c. \$16
- d. \$10

4.

At the school store, 3 pens and 2 notebooks cost a total of \$12, while 1 pen and 3 notebooks cost a total of \$11. This can be represented by the system of equations, where x stands for the cost, in dollars, of pens, and y stands for the cost, in dollars, of notebooks.

$$3x + 2y = 12$$

$$x + 3y = 11$$

What is the cost of one notebook?

-
- a. \$3.00
 - b. \$2.75
 - c. \$2.00
 - d. \$2.40

Name: _____

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5.

What is the value of x in the solution to the system of equations below?

$$2x + y = 1$$

$$2x + 3y = 11$$

- a. $x = 5$
- b. $x = -1$
- c. $x = 3$
- d. $x = -2$

6.

How many solutions will the following system of equations have?

$$2x + y = 4$$

$$2x + y = 8$$

- a. One
- b. Infinite
- c. Zero

7.

Look at the system of equations shown.

$$y = 3x + 7$$

$$y = 2x + 8$$

What is the x -coordinate of the solution to the system?

- a. -1
- b. 10
- c. -10
- d. 1

Name: _____

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8.

A factory has 161 workers. There are 92 more males than females. Let x represent the number of males and let y represent the number of females. Which system of equations represents this situation?

Select One of the Systems below:

$$\begin{aligned}x + y &= 161 \\ y &= 92x\end{aligned}$$

$$\begin{aligned}x + y &= 161 \\ x &= 92y\end{aligned}$$

$$\begin{aligned}x + y &= 161 \\ y &= x + 92\end{aligned}$$

$$\begin{aligned}x + y &= 161 \\ x &= y + 92\end{aligned}$$

9.

What is the y -coordinate of the solution to this system of equations?

$$\begin{aligned}5x - 8y &= 1 \\ 3x + 6y &= -21\end{aligned}$$

- a. $y = -2$
- b. $y = 2$
- c. $y = 3$
- d. $y = -3$

10.

David is solving a system of linear equations by graphing. First, he graphed both equations on a coordinate plane. What should be his next step in solving the system of linear equations?

- a. Find the location of the point where the lines intersect.
- b. Find the measure of the angles where the lines intersect.
- c. Find the x -intercept of each line
- d. Find the y -intercept of each line

Thank You!

This is an EdFellows project. EdAllies' EdFellows program gives educators and parent advocates the chance to get hands-on policy experience and to develop leadership skills—taking on a project that will inform local education debates and strengthen Minnesota schools.

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