ceemsmsp CINCINNATI ENGINEERING ENHANCED MATHEMATICS & SCIENCE PARTNERSHIP	**Activity**	RET is funded by the National Science Foundation, grant # EEC 0808696.

Fellow Name: Adam Miller	**Contact Info:** 513.253.6739	**Date:** 01/26/2016 – 01/29/2016
Teacher Name: Ms. Richmond	**School Name:** Scarlet Oaks	**Grade and Class:** 11th/12th Physics

Activity Title:	Egg Drop
Estimated Activity Duration:	~4 Class Periods

Setting:	Classroom and 2nd floor balcony of school.

Activity Objectives:

The student will be able to:

1) Identify the forces on objects in motion via a Free Body Diagram.
2) Describe the conservation and translation of energy in a system.
3) Calculate the potential and kinetic energy of a system in free-fall
4) Design a structure that absorbs the kinetic energy on a falling object.
5) Test their design and brainstorm improvements or alternatives.
6) Describe the process and reasoning for their design in the form of a presentation or a paper documentation.

Activity Guiding Questions:

1. What is the potential and kinetic energy prior to free fall? What is the potential and kinetic energy upon impact?
2. How do force, time, and velocity change with height? What equations can be used to describe their relationship?
3. When is energy conserved in a system? What are a few examples of energy being translated?
4. How can we reduce the force of impact? Can we affect the mass of the object? How about the acceleration? What about translating kinetic energy into a different form of energy?
5. How well did your design work? How can it be improved?
6. What did you find challenging in the Engineering Design Process?

Next Generation Science Standards (NGSS)	
Science and Engineering Practices (Check all that apply)	**Crosscutting Concepts (Check all that apply)**
☐ Asking questions (for science) and defining problems (for engineering)	☐ Patterns
☐ Developing and using models	☐ Cause and effect
☐ Planning and carrying out investigations	☐ Scale, proportion, and quantity
☐ Analyzing and interpreting data	☐ Systems and system models
☐ Using mathematics and computational thinking	☐ Energy and matter: Flows, cycles, and conservation

Next Generation Science Standards (NGSS)	
Science and Engineering Practices (Check all that apply)	**Crosscutting Concepts (Check all that apply)**
☐ Constructing explanations (for science) and designing solutions (for engineering)	☐ Structure and function.
☐ Engaging in argument from evidence	☐ Stability and change.
☐ Obtaining, evaluating, and communicating information	

Ohio's New Learning Standards for Science (ONLS)
Expectations for Learning - Cognitive Demands (Check all that apply)
X Designing Technological/Engineering Solutions Using Science concepts **(T)**
X Demonstrating Science Knowledge **(D)**
X Interpreting and Communicating Science Concepts **(C)**
X Recalling Accurate Science **(R)**

Common Core State Standards -- Mathematics (CCSS)	
Standards for Mathematical Practice (Check all that apply)	
X Make sense of problems and persevere in solving them	X Use appropriate tools strategically
☐ Reason abstractly and quantitatively	☐ Attend to precision
X Construct viable arguments and critique the reasoning of others	X Look for and make use of structure
X Model with mathematics	☐ Look for and express regularity in repeated reasoning

Unit Academic Standards (NGSS, ONLS and/or CCSS):

- Identify questions and concepts that guide scientific investigations
- Design and conduct scientific investigations
- Recognize and analyze explanations and models
- Motion
  - Uniform acceleration including free fall (initial velocity, final velocity, time, displacement, acceleration, average velocity)
  - Graph interpretations of position/velocity/acceleration vs. time.
- Forces
  - Air Resistance and drag
  - Elastic forces
  - Gravitational forces
- Energy
  - Gravitational potential energy
  - Conservation of energy

Source: http://education.ohio.gov/Topics/Ohio-s-New-Learning-Standards/Science

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Materials: (Link Handouts, Power Points, Resources, Websites, Supplies)

Handout:
- Pre/Post test
- Activity description and outline
- Rubric, supply list, design sheets, and reflection paper

Supplies:
- Materials (see below)
- Eggs
- Plastic Tarp for easy clean-up.

Teacher Advance Preparation:

Must section off drop area on drop days.
Gather building supplies
Bring eggs, measuring tape, and video camera.

Activity Procedures:

Day 1: Pre-Test and Outline

1. Students are given pre-test to assess baseline knowledge and areas of focus.
2. I pass handouts and pose the hypothetical scenario of Amazon hiring their company to design an impact device for safe package delivery by air.
    a. Drop Constraints:
        i. Must be under “free fall” condition
        ii. Cannot have an “operator”
    b. Material Constraints:
        i. $100 material limit
            1. Popsicle Stick
            2. Straws
            3. Glue Stick
            4. String
            5. Cardboard
            6. Paper
            7. Paper Plates
            8. Film canister
            9. Balloons
            10. Ziplock bag
            11. Paper Towel
            12. Aluminum Foil
            13. Duct Tape
            14. Tubing
            15. Liquid Glue

16. Styrofoam Cup
17. Binder Clips
18. Scotch Tape
19. Paper clips
20. Cotton Balls
21. Popsicle
22. Paper Cups

ii. Additional material may be requested and pricing will be determined by teacher.

3. Students will brainstorm as a class different devices to: increase air friction, reduce kinetic energy translation, or absorb the force of impact.
4. Students will pick roles in their group and be assigned to have a finalized design by next class. They can begin researching designs and brainstorming ideas.

Day 2: Build Day

5. Upon approval of their design, students will have the class time to build their device and test it if it is ready.

Day 3: Re-build Day

6. Students modify their design for improvements and re-test their device. Results are recorded.

Day 4: Post-Test and Presentations

7. Students take their post-test and turn in their analysis/reflection on the activity.
8. I tally points and award prizes.

Formative Assessments: Link the items in the Activities that will be used as formative assessments.

As the class discusses devices (3.), I will be asking HOW such devices reduce the impact force (i.e. a parachute increase air drag).

Students will brainstorm designs as a group and settle on a final design that must be approved before continuing onto construction.

When approving their design (5.), I will pose thought-provoking questions like: What types of geometric structures are most effective as absorbing impact? Spheres? Cones? Pyramids? If a design is poorly thought out or needs improvement, the teacher will recommend some changes before moving onto the building phase.

After their first drop, I will ask students what failed in their last design, and/or how their design could be improved. Students will analyze their design and answer questions that guide them to improve upon their next device.

Students will answer reflective and assessment questions as they move through the process.

Summative Assessments: Prepare a Pre-Test and Post-Test with the input of the RET Teacher. This should be a simple 10-12 question assessment tool. These questions will cover the content related to the Standards. The Pre and Post Test will be identical. There may be several summative assessments at the end of this Activity. Besides the Pre and Post Tests, the students might create a product for which this is a rubric developed. The rubric is also a summative assessment tool. Link the assessment tools.

Pre/Post Test, and activity rubric.

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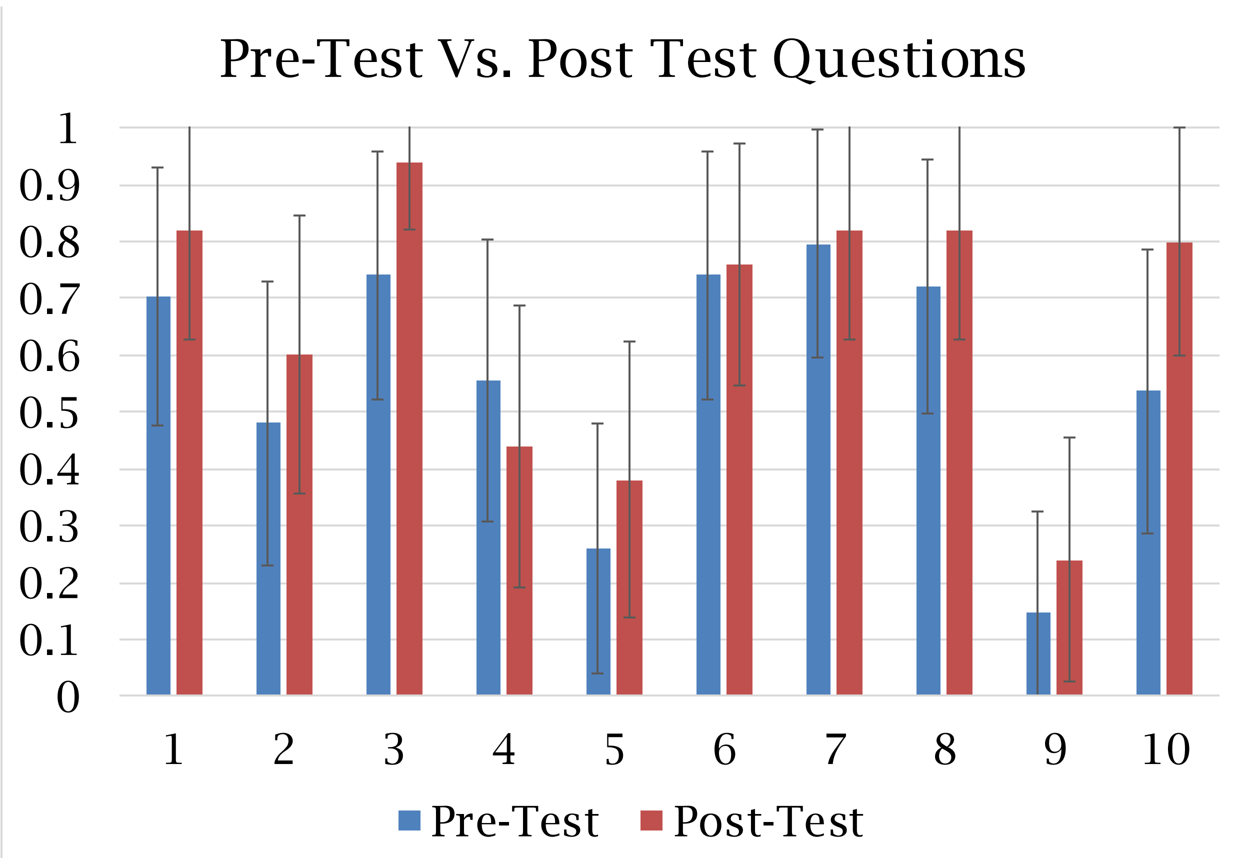
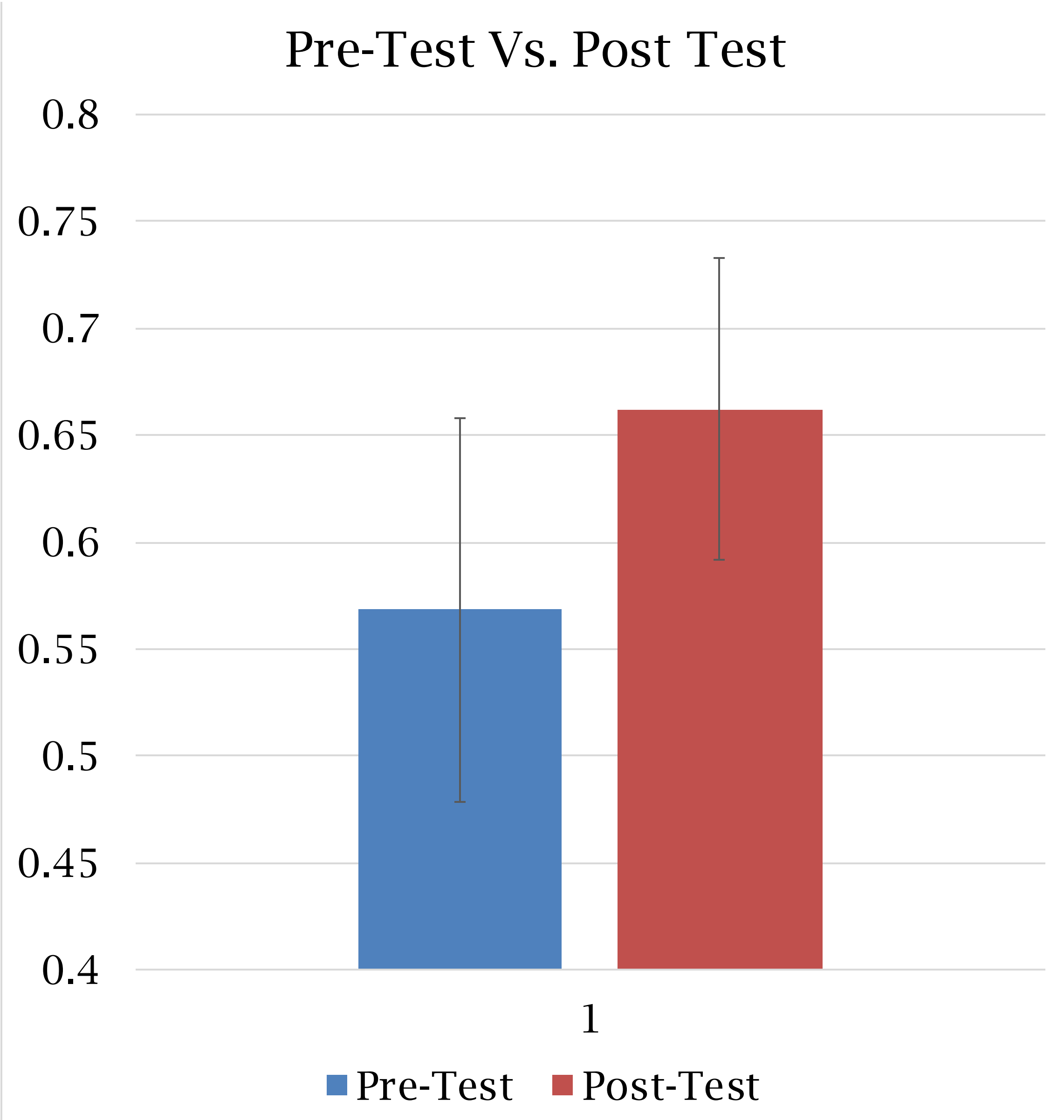
Question	Pre-test Mean	Pre-test StdDev	Post-test Mean	Post-test StdDev	Pre/Post ∆Mean	Pre/Post ∆StdDev
1	0.703704	0.456623	0.82	0.384187	0.116296	-0.07244
2	0.481481	0.499657	0.6	0.489898	0.118519	-0.00976
3	0.740741	0.438228	0.94	0.237487	0.199259	-0.20074
4	0.555556	0.496904	0.44	0.496387	-0.11556	-0.00052
5	0.259259	0.438228	0.38	0.485386	0.120741	0.047158
6	0.740741	0.438228	0.76	0.427083	0.019259	-0.01115
7	0.796296	0.402751	0.82	0.384187	0.023704	-0.01856
8	0.722222	0.447903	0.82	0.384187	0.097778	-0.06372
9	0.148148	0.355247	0.24	0.427083	0.091852	0.071836
10	0.537037	0.498626	0.8	0.4	0.262963	-0.09863
Total:	0.568519	0.179324	0.662	0.141266	0.093481	-0.03806





Differentiation: Describe how you modified parts of the Lesson to support the needs of different learners.Refer to Activity Template for details.

I hope to support the needs of various learners by verbally explaining the idea and concepts, giving students a visual sample and outline of the activity, and by allowing hands-on interactions with design and building on their device. I believe this accommodates audio, visual, and kinesthetic learners. Furthermore, students are welcome and encouraged to spend time outside the classroom researching comparative devices and even building their device outside of class.

Reflection: Reflect upon the successes and shortcomings of the Activity. This is done after the Activity is implemented.

Reflecting on the implementation of my activity, I saw the benefit of framing the problem in a real-world context. Students saw the importance and application, and were better able to visualize the scenario where their design would be utilized. This led to very diverse and creative problem solving as students created various parachutes, tunnels, and cushions. I was surprised when students were asking me if they had to pay for water from the sink to use in their design, something I had not even considered.

Having a challenging Pre-test and Post-test help obtain a wide range of values. I believe it also challenged their current knowledge on the subject and help address some pre-conceived notions on energy. The team structure and documentation practices served to not only simulate real-life, but also to help students collaborate on ideas and communicate to one another. This forced cooperation led to some healthy, but sometimes heated, arguments. Overall, I believe the greatest take-away the students got from this activity was the hands-on learning and fun. By experimenting with the different materials and testing different designs, they were learning about air drag, surface area:volume ratio, elasticity, cost-benefit analysis, symmetry, and a whole host of other principles. I asked students why they have cushioning overtop the egg if they are only dropping it down. Some gave reasonable answers such as they didn't want it to fall out or turn over. However, some simply said that they just know they need it. This activity was meant to supplement their lessons and build a stronger understanding of the material. I believe it did just that in a fun and impactful way.

The activity was not without its struggles and shortcomings however. The pre/post-tests tried to gauge student's understanding of a broad scope of material and the relationship between potential energy, kinetic energy, force, and free-fall motion. While they have a foundation in all these concepts, I believe connecting them was difficult. Students would mix up force and velocity or potential and kinetic energy. I believe this was in part due to the manipulation of the conservation of energy equation. This could easily be resolved with more time to practice example problems and review some of the concepts.

While 4 days may seem like a lot, it went by really quickly. I would have liked this to be a quarter-project in which groups meet up on their own time to do the research, design, and building, and only have 1 or 2 class periods dedicated to testing. However, this was not a very viable option for the classes I had, so all this had to be done in a matter of days. Additionally, the constraints were meant to be moderately challenging in which not too many students would fail and not too many would succeed. However, some students struggled on both drops to get a successful prototype while others found it too easy. Additional time would allow for tougher constraints and therefore a more challenging activity. Lastly, I wish I had more time to discuss student's opinions and reflections on the activity. There was certainly a lot of changes that occurred in student designs from their 1st drop to their 2nd drop and I believe a lot of that was seeing what other students did to succeed and communicating with their group as to how they can improve their design. It would also give me a chance to talk about the reasons WHY certain designs were more successful. It is in this discussion, as students design, build, and reflect that the greatest degree of learning occurs. Despite these factors, I believe my activity went very well for its first iteration. Each subsequent day I felt more comfortable leading and daily activities went by more smoothly. In conclusion, this activity was a wonderful learning experience for both myself and the students and offered a range of benefits for both parties, while allowing room for growth and development.