**Archaeological Imaging**

**Subject area/course**: Science, Physics

**Grade level/band**: 11­–12

**INSTRUCTOR PROCEDURES**

1. **Task overview**:

In this task, students imagine that they are joining an expedition to explore one of the Egyptian pyramids. As the physicists in the group, they have been tasked with the job of getting a Ground Penetrating Radar (GPR) unit up the side of a pyramid. After choosing a pyramid to explore, performing research on the exterior surface of the pyramid, and calculating various dimensions of the pyramid, students propose a method to move the GPR unit to the top of the pyramid. Students will justify their method in a 3-page paper. Alternatively, students may choose to present their finding to the class, choosing several of the most feasible options and then model and design the structures to prove their validity.

1. **Prior knowledge required:**

Students should be able to:

* Analyze real world situations using data in the literature and examining the results.
* Solve Newton’s Second Law problems, evaluating the credibility and accuracy of the data collected, and propose a solution to moving a large mass up a steep incline.
* Analyze motion using Newton’s Laws of Motion.
* Utilize trigonometry and find solutions to linear equations.
1. **Common Core State Standards aligned to this task:**

[CCSS.Math.Content.HSN.VM.A.3](http://www.corestandards.org/Math/Content/HSN/VM/A/3/) Solve problems involving velocity and other quantities that can be represented by vectors.

[CCSS.ELA-Literacy.RST.11-12.3](http://www.corestandards.org/ELA-Literacy/RST/11-12/3/) Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

[CCSS.Math.Content.HSA.SSE.A.1](http://www.corestandards.org/Math/Content/HSA/SSE/A/1/) Interpret expressions that represent a quantity in terms of its context.

[CCSS.Math.Content.HSA.REI.C.5](http://www.corestandards.org/Math/Content/HSA/REI/C/5/) Prove that, given a system of two equations in two variables, replacing one equation by the sum of that equation and a multiple of the other produces a system with the same solutions.

[CCSS.ELA-Literacy.RST.11-12.7](http://www.corestandards.org/ELA-Literacy/RST/11-12/7/) Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

**Next Generation Science Standards**

HS-PS2-1. Analyze data to support the claim that Newton’s second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration**.**

1. **Time requirements:**

Students will need 3 to 4 hours to complete this task. Approximately half the time should be spent analyzing the data, formulating a plan to move the imaging equipment, and solving Newton’s Equations of Motion. The remainder of the time should be spent writing the paper. All of this may be done in or out of class.

1. **Instructor materials to use during administration**:
* Access the Internet
* Introductory physics texts
* Presentation software (if students choose or are permitted to present their findings in this way)
1. **Instructor procedures during administration:**
* This exercise would be most appropriate for students to work on after the presentation of Newton’s Second Law.
* At the beginning of the task, you may want to review with students the motion of an object on an inclined plane, emphasizing the difference between static and kinetic friction.
* Students should work independently throughout this task.
* Although many GPR systems found through an Internet search show the systems with wheels attached, students should be informed that the GPR unit secured through the grant does not have wheels.
* Students will have to research the composition of the exterior of the pyramid they have chosen. They will need this information to choose another substance to house the GPR so that they can calculate the coefficient of friction between the two surfaces. Coefficients of friction may be found online in a limited fashion or in tabulated research books. The angle of incline of the sides of the pyramid must be calculated. The student will have to research the width of the pyramid as well as the height of the pyramid to calculate the angle of incline.
* Students will then have to propose a method to move the GPR unit utilizing force considerations. Complete free body diagrams should be expected for each proposed solution to move the GPR unit. Students should support their proposed method of moving the GPR unit with detailed consideration of Newton’s Second Law.
* As a final activity, you could encourage students to share some interesting facts about the pyramid they chose to investigate and then have the students share their method for getting the imaging equipment to the top of the pyramid. Sharing the plan to move the

equipment that students decided on in the reports will be useful in furthering the understanding of Newton’s Laws of Motion. This exercise will provide students with feedback on their thought process.

1. **Student support:**

The following suggestions are examples of scaffolding that can be used to meet the diverse student needs within the classroom.

* Provide class time for research on students’ topics.
* Provide definitions of new vocabulary words ahead of time.
* For the final product, all learners will benefit from peer assistance while brainstorming their topics, as well as a peer or teacher review of their papers before final submission.
* Some students will have good research skills, but some will need guidance in the determination of appropriate sources and where to look for them. It is important to spend class time in review of what constitutes an appropriate source in advance of students’ independent work time.
* Students may need additional support on application if a free body diagram and application of Newton’s Second Law in solving this problem.
* Group collaboration may be useful at the start of the problem such that struggling students can see various ideas modeled.
1. **Extensions or variations:**
* This task was designed to be completed independently, but students could work collaboratively on the task.
* Students could present the results of their research to the class via an oral or multimedia presentation.
* A panel could be organized where students share their research hypotheses and debate the benefits and limitations of each other’s proposals.
1. **Scoring and assessment considerations:**

EPIC developed the *College and Career Ready (CCR) Task Bank Scoring Rubric* to accompany this task. If your school or department uses a standardized rubric that would fit the content and requirements of this task, you may choose to use your existing rubric. The following notes and suggestions are meant to clarify the intent of the rubric and include considerations for the assessment of student work.

* When assigning the task, provide students with the rubric that will be used to score their final product and discuss it as a class.
* Unlike some rubrics, the *CCR Task Bank Rubric* does not predetermine “point values” for the scoring criteria. The rubric thus allows for flexibility with different instructors’ scoring systems and individual determination of the “weight” of each criterion.
* Student work that scores at the *Accomplished* level is considered to be entry-level college work.
* The *Exceeds* category on the rubric provides an example of how a student can go above and beyond the *Accomplished* level. These examples are intended to be only ONE way a work product can exceed expectations, thus allowing room for your professional judgment.
* If needed, consider including task-specific criteria as an additional scoring category to the rubric or providing a checklist of requirements for the task.