ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL FOUR

INSTRUCTIONAL GUIDE

SECTION 12

EO C440.10 – DISCUSS KINETIC AND POTENTIAL ENERGY

Total Time: 30 min

PREPARATION

PRE-LESSON INSTRUCTIONS

Resources needed for the delivery of this lesson are listed in the lesson specification located in A-CR-CCP-804/PG-001, *Proficiency Level Four Qualification Standard and Plan*, Chapter 4. Specific uses for said resources are identified throughout the instructional guide within the TP for which they are required.

Review the lesson content and become familiar with the material prior to delivering the lesson.

Photocopy Attachment A for each group of four cadets for TP 3.

Gather materials needed for the activities in TPs 1–3.

PRE-LESSON ASSIGNMENT

Nil.

APPROACH

An in-class activity was chosen for this lesson as it is an interactive way to provoke thought about energy and stimulate interest in kinetic and potential energy among cadets.

INTRODUCTION

REVIEW

Nil.

OBJECTIVES

By the end of this lesson the cadet shall be expected to discuss kinetic and potential energy.

IMPORTANCE

It is important for cadets to understand the relationship between kinetic and potential energy so that they can recognize the requirements, applications and effects of propulsion systems, especially in a microgravity environment.

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Teaching point 1 **Explore the storage and conversion of kinetic and potential energy in a gravitational system.**

Time: 5 min Method: In-Class Activity

Kinetic energy. Energy of motion. A falling yo-yo has kinetic energy.

Potential energy. Energy that is stored in an object. A yo-yo held above the floor has potential energy because gravity pulls it down.

Kinetic energy can be converted into potential energy and potential energy can be converted back into kinetic energy. This can be seen in the repeated actions of a yo-yo as it goes through its cycles.

Before the yo-yo begins its fall, it has stored energy due to its position above the floor. At the top of its cycle it has its maximum potential energy. As it starts to fall the potential energy begins to be changed into the kinetic energy of falling—but the string, being wound around the yo-yo spindle, converts the kinetic energy of falling into kinetic energy of rotation.

At the bottom, the yo-yo's potential energy has been converted into, first, kinetic energy of falling, which was then converted to rotation. The yo-yo will now have its maximum kinetic energy of rotation. When the string is tightly extended at the bottom of the yo-yo's cycle, its kinetic energy of rotation can be used, by a competent yo-yo operator, to wind the string back around the yo-yo's spindle. It helps to add energy to each cycle of the yo-yo by speeding it on its downward leg. This is necessary due to energy losses from friction.

ACTIVITY

OBJECTIVE

The objective of this activity is to have the cadets explore the storage and conversion of kinetic and potential energy in a gravitational system by operating a yo-yo.

RESOURCES

Yo-yo (one per cadet).

ACTIVITY LAYOUT

Nil.

ACTIVITY INSTRUCTIONS

1. Distribute a yo-yo to each cadet.
2. Explain the following rules of this competition:
    a. Cadets shall stand to operate their yo-yos.
    b. Yo-yos shall be operated vertically only.
    c. Cadets shall return to their seats when their yo-yo stops.
    d. The last cadet standing wins the competition.
3. Have the cadets prepare by winding the string around the yo-yo spindle.
4. On command, have the cadets begin cycling their yo-yo.

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SAFETY

Cadets shall take care to not hit anyone or anything with their yo-yo.

CONFIRMATION OF TEACHING POINT 1

The cadets' participation in the yo-yo activity will serve as the confirmation of this TP.

Teaching point 2 **Explore the storage and conversion of kinetic and potential energy in an elastic system.**

Time: 5 min Method: In-Class Activity



An elastic band flying through the air has kinetic energy.

When an elastic band is stretched, it gains potential energy. As the elastic band is released, stored potential energy is changed to the kinetic energy of motion.

ACTIVITY

OBJECTIVE

The objective of this activity is to have the cadets explore the storage and conversion of kinetic and potential energy in an elastic system by using elastic bands in a target competition.

RESOURCES

Elastic bands (two different colours).

ACTIVITY LAYOUT

1. Clear an area at least 3 m on each side of a 2-m line on the floor.
2. Place an empty waste paper basket 3 m from the line.

ACTIVITY INSTRUCTIONS

1. Divide the cadets into two teams.
2. Give each team three elastic bands per cadet, with different colours for each team.
3. Have one member of each team advance to the line and attempt to shoot one elastic band into the waste paper basket by stretching and releasing it.
4. Have each cadet repeat Step 3 three times.
5. Declare the winner based on the team that has the most elastic bands in the waste paper basket.

SAFETY

Cadets shall not aim an elastic band at another person.

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CONFIRMATION OF TEACHING POINT 2

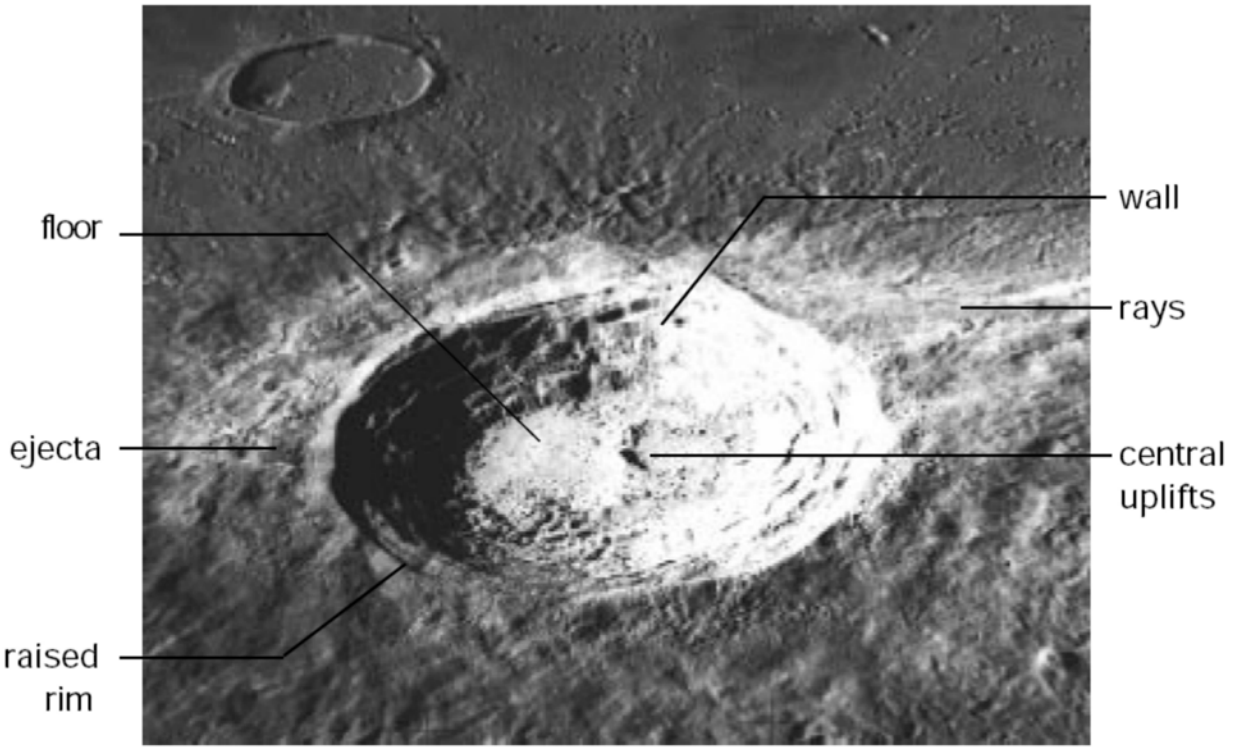
The cadets' participation in the elastic band activity will serve as the confirmation of this TP.

Teaching point 3 **Explore the effects of velocity and mass in the expenditure of energy.**

Time: 15 min Method: In-Class Activity



This TP consists of making a series of craters of various sizes. Point out to the cadets the features of the craters they create as shown in Figure 1 (Lunar crater Aristarchus, 42 km in diameter, located west of Mare Imbrium).



Note: From NASA, 1997, Exploring the Moon: A Teacher's Guide With Activities. Retrieved September 30, 2008, from http://lunar.arc.nasa.gov/education/pdf/expmoon.pdf

Figure 1 Parts of a Crater



The energy of a moving object is equal to its mass (weight) multiplied by the square of its velocity, or $E = mv^2$. An object travelling twice as fast will therefore deliver four times the energy at impact, and an object travelling three times as fast results in nine times the energy at impact.

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ACTIVITY

OBJECTIVE

The objective of this activity is to have the cadets explore the effects of velocity and mass in the expenditure of energy through the creation of a series of craters.

RESOURCES

- Impact Crater Data Chart located at Attachment A,
- Plastic tubs approximately 10 cm deep, 20 cm wide and 30 cm long,
- Ruler marked in millimetres,
- Sand (half tub),
- Cornstarch (half tub), and
- Impactors, to include:
  - marbles of various sizes,
  - ball bearings of various sizes,
  - wooden balls of various sizes, and
  - golf balls.

ACTIVITY LAYOUT

1. Place a tub of mixed dry sand and cornstarch in the centre of an area that is clear at least 3 m on each side.

2. During this activity, the sand mixture may fall onto the floor and the cornstarch may even be dispersed into the air. Spread newspaper under the pan(s) to catch spills or conduct the activity outside.

ACTIVITY INSTRUCTIONS

1. Divide the cadets into groups of no more than four.

2. Distribute one Impact Crater Data Chart located at Attachment A to each group.

3. Have the cadets drop impactors of various sizes into the tub of mixed sand and cornstarch from a height of 30 cm as per Attachment A.

4. Have the cadets measure the resulting craters and then select an effective impactor for the following exercise (an effective impactor will produce maximum rays, crater walls, a raised rim, and ejecta as shown in Figure 1, but it may not be possible to create a central uplift).

5. Have the cadets smooth and resurface the material in the pan before each impact. The material does not need to be packed down.



Shaking or tilting the pan back and forth produces a smooth surface. Better experimental control is achieved with consistent handling of the materials. For instance, cratering results may vary if the material is packed down for some trials and not for others.

6. Explain to the cadets that because of the low velocity of the experimental impactors compared with the velocity of real impactors, the experimental impact craters may not have significantly raised rims or central uplifts.

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7. Have the cadets drop the impactor from increasing heights and record their data as per Attachment A.

8. Have the cadets analyze their results. They should observe that the higher drop height and resulting increase in velocity of the impactor creates a larger crater and spreads the ejecta out further.

SAFETY

Nil.

CONFIRMATION OF TEACHING POINT 3

The cadets' participation in the crater activity will serve as the confirmation of this TP.

END OF LESSON CONFIRMATION

The cadets' participation in exploring the storage and conversion of kinetic and potential energy in a gravitational system, the conversion of kinetic and potential energy in an elastic system, and the effects of velocity and mass in the expenditure of energy will serve as the confirmation of this lesson.

CONCLUSION

HOMEWORK / READING / PRACTICE

Nil.

METHOD OF EVALUATION

Nil.

CLOSING STATEMENT

A coasting spaceship has kinetic energy that was gained from the potential energy stored in its fuel. A good understanding of the relationship between kinetic and potential energy helps to recognize the requirements, applications and effects of propulsion systems.

INSTRUCTOR NOTES / REMARKS

Cadets who are qualified Advanced Aerospace may assist with this instruction.

REFERENCES

C3-262 Canadian Space Agency. (2003). *Orbital mechanics: Energy*. Retrieved September 30, 2008, from http://www.space.gc.ca/eng/educators/resources/orbital/energy.asp

C3-263 EG-1997-10-116-HQ NASA. (1997). *Exploring the moon: A teacher's guide with activities*. Retrieved September 30, 2008, from http://lunar.arc.nasa.gov/education/pdf/expmoon.pdf

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Impact Craters - Data Chart

		trial 1	trial 2	trial 3	total	average
drop height = 30 cm velocity = 242 cm/s	crater diameter					
	crater depth					
	average length of all rays					
drop height = 60 cm velocity = 343 cm/s	crater diameter					
	crater depth					
	average length of all rays					
drop height = 90 cm velocity = 420 cm/s	crater diameter					
	crater depth					
	average length of all rays					
drop height = 2 m velocity = 626 cm/s	crater diameter					
	crater depth					
	average length of all rays					

Note: From NASA, 1997, Exploring the Moon: A Teacher's Guide With Activities. Retrieved September 30, 2008, from http://lunar.arc.nasa.gov/education/pdf/expmoon.pdf

Figure A-1 Impact Crater Data Chart

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