ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL FOUR

INSTRUCTIONAL GUIDE

SECTION 13

EO C440.11 – WATCH *EINSTEIN'S BIG IDEA*

Total Time: 150 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 cadet.

Photocopy the note template handout located at Attachment B.

Cue the DVD *Einstein's Big Idea*.

PRE-LESSON ASSIGNMENT

Nil.

APPROACH

An in-class activity was chosen for this lesson as it is an interactive way to provoke thought and stimulate interest among cadets about the development of the formula $E=mc^2$.

INTRODUCTION

REVIEW

Nil.

OBJECTIVES

By the end of this lesson the cadet shall be expected to discuss the history of the formula $E=mc^2$.

IMPORTANCE

It is important for cadets to be able to discuss the history of the formula $E=mc^2$ so that they recognize that science is a team effort, which transcends both national boundaries and the centuries.

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Teaching point 1 **Conduct an activity where the cadets to define energy and describe kinds of energy and differences between sources of energy.**

Time: 5 min Method: In-Class Activity



The term energy refers to the amount of work that can be performed by a system:

Potential energy. The energy an object has due to its position or condition.

Kinetic energy. The energy due to the motion of an object.

ACTIVITY

OBJECTIVE

The objective of this activity is to have the cadets brainstorm definitions of energy and to describe kinds of energy and differences between sources of energy.

RESOURCES

Nil.

ACTIVITY LAYOUT

Nil.

ACTIVITY INSTRUCTIONS

1. Have the cadets brainstorm definitions of energy.

2. Have the cadets list what kinds of energy they have used today.

3. Have the cadets list sources of energy (eg, sun, oil, natural gas, gasoline, wind, hydroelectric, nuclear, coal, wood, and food).

4. Point out that many of these are means of storing energy (eg, chemical storage such as natural gas) or forms of energy that are converted before becoming useful (eg, electrical energy converted to heat or mechanical energy).

SAFETY

Nil.

CONFIRMATION OF TEACHING POINT 1

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

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Teaching point 2 **Have the cadets determine that atoms of matter have mass.**

Time: 10 min Method: In-Class Activity



The nucleus of an atom is made up of protons and neutrons in a cluster. Virtually all the mass of the atom resides in the nucleus. The nucleus is held together by the tight pull of what is known to chemists and physicists as the "strong force". This force between the protons and neutrons overcomes the repulsive electrical force that would, according to the rules of electricity, otherwise push the positively-charged protons apart.

ACTIVITY

OBJECTIVE

The objective of this activity is to have the cadets determine that the atoms that constitute matter have mass.

RESOURCES

Handout located at Attachment A.

ACTIVITY LAYOUT

Nil.

ACTIVITY INSTRUCTIONS

1. Make a list of common materials on a flip chart or whiteboard, to include:
   a. air,
   b. water,
   c. living organisms,
   d. the sun, and
   e. jewellery
2. Have the cadets identify the primary elements in air (nitrogen, oxygen), water (hydrogen, oxygen), living organisms (carbon, nitrogen, oxygen, hydrogen), the sun (hydrogen, helium), and jewellery (nickel, silver, gold).
3. Have the cadets locate those elements in a periodic table and determine their atomic mass.

SAFETY

Nil.

CONFIRMATION OF TEACHING POINT 2

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

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Teaching point 3 **Have the cadets watch *Einstein's Big Idea* and make notes on topics assigned.**

Time: 110 min Method: In-Class Activity



Before watching *Einstein's Big Idea*, arrange for the cadets, singly or in groups, to make notes using the six handouts located at Attachment B.

The six note templates do not correspond to chapters in the motion picture. Information for the note templates will be found throughout the motion picture.

ACTIVITY

OBJECTIVE

The objective of this activity is to have the cadets take notes on their assigned topics while watching *Einstein's Big Idea*.

RESOURCES

- *Einstein's Big Idea* DVD,
- Note template handouts located at Attachment B, and
- Pens / pencils.

ACTIVITY LAYOUT

Nil.

ACTIVITY INSTRUCTIONS

1. Distribute the six note template handouts located at Attachment B. Each cadet should have one of the six note templates. If there are more than six cadets, they may form teams.
2. Ensure each template located at Attachment B has at least one cadet assigned to it.
3. Play *Einstein's Big Idea*.
4. Have the cadets, while watching *Einstein's Big Idea*, take notes on their assigned topics.

SAFETY

Nil.

CONFIRMATION OF TEACHING POINT 3

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

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Teaching point 4 **Conduct an activity to create a timeline of the development of the formula $E=mc^2$.**

Time: 15 min Method: In-Class Activity

ACTIVITY

OBJECTIVE

The objective of this activity is to have the cadets construct a timeline showing the development of the formula $E=mc^2$.

RESOURCES

- String,
- Paper clips,
- Pens / pencils, and
- Completed note templates from TP 3.

ACTIVITY LAYOUT

Place a 3-m string across a classroom wall. Create a timeline ranging from 1700 to 1950 from the string by hanging paper century markers on the string with paper clips.

ACTIVITY INSTRUCTIONS

1. Have a cadet describe an assigned topic and the scientist's challenges and accomplishments.

2. Have the cadet clip the notes about that scientist to the appropriate place on the string.

3. Repeat for each scientist or team of scientists.

4. Draw the cadets' attention to the way that scientific research crossed national frontiers over very long periods of time. Point out that although historic contributors such as Socrates, Aristotle, Leonardo da Vinci and Sir Isaac Newton are not shown on this short timeline, their ideas were essential to the discoveries in *Einstein's Big Idea*.

SAFETY

Nil.

CONFIRMATION OF TEACHING POINT 4

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

END OF LESSON CONFIRMATION

The cadets’ participation in the timeline construction activity will serve as the confirmation of this lesson.

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CONCLUSION

HOMEWORK / READING / PRACTICE

Nil.

METHOD OF EVALUATION

Nil.

CLOSING STATEMENT

Science is a team effort that transcends national boundaries and time. Our understanding of matter and energy are still very incomplete; while today we know more about light than Faraday and Maxwell, more about mass than the Lavoisiers and more about energy than du Châtelet, we have nevertheless scarcely begun. Science is teamwork in progress and it is not too late to join the team.

INSTRUCTOR NOTES / REMARKS

If EO C440.09 (Describe the Relationship Between Gravity and Space-Time) or EO C440.10 (Discuss Kinetic and Potential Energy) are also selected, they should be presented prior to this lesson to introduce concepts of energy.

It is recommended that Chapters 1–6 of Einstein's Big Idea be presented in three consecutive periods and Chapters 7–9 be presented in two consecutive periods, all on two consecutive training days.

REFERENCES

C3-319 NOVA. (2005). *Teacher's guide: Einstein's big idea*. Retrieved January 30, 2009 from http://www.pbs.org/wgbh/nova/einstein/

C3-320 Johnstone, G. (Producer & Director). (2005). *Einstein's big idea* [Motion picture]. United States: WBGH Educational Foundation.

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Table of Element Abbreviations and Names

Ac	Actinium	Ha	Hahnium	P	Phosphorus
Ag	Silver	He	Helium	Pr	Praseodymium
Al	Aluminum	Hf	Hafnium	Pt	Platinum
Am	Americium	Hg	Mercury	Pu	Plutonium
Ar	Argon	H	Hydrogen	Ra	Radium
As	Arsenic	Ho	Holmium	Rb	Rubidium
At	Astatine	Hs	Hassnium	Re	Rhenium
Au	Gold	I	Iodine	Rf	Rutherfordium
Ba	Barium	In	Indium	Rh	Rhodium
B	Boron	Ir	Iridium	Rn	Radon
Be	Beryllium	Kr	Krypton	Ru	Ruthenium
Bi	Bismuth	La	Lanthanum	Sb	Antimony
Bk	Berkelium	Li	Lithium	Sc	Scandium
Br	Bromine	Lr	Lawrencium	Se	Selenium
Ca	Calcium	Lu	Lutetium	Sg	Seaborgium
C	Carbon	Md	Mendelevium	Si	Silicon
Cd	Cadmium	Mg	Magnesium	Sm	Samarium
Ce	Cerium	Mn	Manganese	Sn	Tin
Cf	Californium	Mo	Molybdenum	Sr	Strontium
Cl	Chlorine	Mt	Meitnerium	S	Sulfur
Cm	Curium	Na	Sodium	Ta	Tantalum
Co	Cobalt	Nb	Niobium	Tb	Terbium
Cr	Chromium	Nd	Neodymium	Tc	Technetium
Cs	Cesium	Ne	Neon	Te	Tellurium
Cu	Copper	Ni	Nickel	Th	Thorium
Dy	Dysprosium	N	Nitrogen	Ti	Titanium
Er	Erbium	No	Nobelium	Tl	Thallium
Es	Einsteinium	Np	Neptunium	Tm	Thulium
Eu	Europium	Ns	Neilsborium	U	Uranium
Fe	Iron	O	Oxygen	V	Vanadium
F	Fluorine	Os	Osmium	W	Tungsten
Fm	Fermium	Pa	Protactinium	Xe	Xenon
Fr	Francium	Pb	Lead	Yb	Ytterbium
Ga	Gallium	Pd	Palladium	Y	Yttrium
Gd	Gadolinium	Pm	Promethium	Zn	Zinc
Ge	Germanium	Po	Polonium	Zr	Zirconium

Note: From "Los Alamos National Laboratory's Chemistry Division Presents", 2004, Periodic Table of the Elements: A Resource for Elementary, Middle School, and High School Students. Retrieved February 11, 2009, from http://periodic.lanl.gov/default.htm

Figure A-1 Element Abbreviations and Names

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Simplified Periodic Table of the Elements

1 H 1.008																	2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.47	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La* 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 190.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.5	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (210)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac~ (227)	104 Rf (257)	105 Db (260)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 --- ()	111 --- ()	112 --- ()		114 --- ()		116 --- ()		118 --- ()

58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (147)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
90 Th 232.0	91 Pa (231)	92 U (238)	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (249)	99 Es (254)	100 Fm (253)	101 Md (256)	102 No (254)	103 Lr (257)

Template

Atomic Number

Atomic Symbol

Atomic Mass

Note: From "Los Alamos National Laboratory's Chemistry Division Presents", 2004, Periodic Table of the Elements: A Resource for Elementary, Middle School, and High School Students. Retrieved February 11, 2009, from http://periodic.lanl.gov/default.htm

Figure A-2 Simplified Periodic Table

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Energy

Scientists

Nationality

Concept

Experiment

Time Period

Challenges Faced

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Mass

Scientists

Nationality

Concept

Experiment

Time Period

Challenges Faced

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Light

Scientists

Nationality

Concept

Experiment

Time Period

Challenges Faced

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Velocity (Speed of Light Squared)

Scientists

Nationality

Concept

Experiment

Time Period

Challenges Faced

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Development of the Equation $E=mc^2$

Scientists

Nationality

Concept

Experiment

Time Period

Challenges Faced

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Confirmation of the Equation $E=mc^2$

Scientists

Nationality

Concept

Experiment

Time Period

Challenges Faced

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Energy

Scientist

Michael Faraday.

Nationality

English.

Concept

Invisible lines of force flow around electricity and magnets; electricity and magnetism are linked.

Experiment

Faraday placed a magnet beside a copper wire suspended in mercury and passed an electric current through the wire. The wire spun in a circle around the magnet, thus demonstrating the interaction of lines of electric and magnetic force.

Time Period

Early 1800s.

Challenges Faced

Accused of plagiarism by Sir Humphry Davy; refuted claim and was later elected to the Royal Society.

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Mass

Scientists

Antoine-Laurent and Marie Anne Lavoisier.

Nationality

French.

Concept

Matter is always conserved in a chemical reaction regardless of how it is transformed.

Experiment

Lavoisier transformed a number of different substances. He carefully measured all the products of the reactions to show that matter is conserved.

Time Period

Late 1700s.

Challenges Faced

The French Revolution; Antoine-Laurent Lavoisier was captured and executed by guillotine.

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Light

Scientists

Michael Faraday and James Clerk Maxwell.

Nationality

English (Faraday) and Scottish (Maxwell).

Concept

Electromagnetism can be described mathematically; Maxwell's equations supported Faraday's long-held claims that light was just one form of electromagnetism.

Experiment

Maxwell's ideas were theoretical.

Time Period

Mid-1800s.

Challenges Faced

Scientists did not agree with Faraday's belief that light was an electromagnetic wave.

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Velocity (Speed of Light Squared)

Scientists

Emilie du Châtelet and Gottfried von Leibniz.

Nationality

French (du Châtelet) and German (Leibniz).

Concept

The energy of an object is a function of the square of its speed, rather than its speed.

Experiment

Du Châtelet analyzed experiments in which brass balls were dropped into clay; measuring their impacts demonstrated that an object's energy is a function of its velocity squared. She corrected Newton and clarified Leibniz's original ideas about velocity.

Time Period

Early to mid-1700s.

Challenges Faced

Scientists discounted Leibniz' ideas; du Châtelet died during childbirth when she was 43.

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Development of the Equation $E=mc^2$

Scientist

Albert Einstein.

Nationality

German, Swiss, and American.

Concept

Mass and energy are the same and can be converted from one to the other using the speed of light squared.

Experiment

Einstein's ideas were theoretical.

Time Period

Early 1900s.

Challenges Faced

At first no one responded to Einstein's ideas; he patiently answered letters for four years. His genius began to be recognized when his work gained the endorsement of German physicist Max Planck.

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Confirmation of the Equation $E=mc^2$

Scientists

Otto Hahn, Fritz Strassmann, Lise Meitner, and Otto Robert Frisch.

Nationality

German (Hahn, Strassmann) and Austrian (Meitner, Frisch).

Concept

The confirmation of $E=mc^2$.

Experiment

Hahn and Strassmann bombarded uranium with neutrons and discovered barium in the resulting products; Meitner and Frisch realized the results indicated that Hahn and Strassmann had split the uranium nucleus.

Time Period

Mid-1900s.

Challenges Faced

Since she was Jewish, Meitner was forced to flee Germany and compelled to collaborate by mail with Hahn and Strassmann, but Hahn never acknowledged Meitner's work.

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