

**PO 440**

1. **Performance:** Discuss Aerospace Structures
2. **Conditions:**
  - a. Given:
    - (1) Supervision, and
    - (2) Assistance as required.
  - b. Denied: Nil.
  - c. Environmental: Classroom or training area large enough to accommodate the entire group.
3. **Standard:** The cadet will discuss aerospace structures, to include:
  - a. aerospace materials, and
  - b. Canadian satellites.
4. **Remarks:** Nil.
5. **Complementary Material:**
  - a. Complementary material associated with PO 440 is designed to enhance the cadet's knowledge of aerospace structures, specifically:
    - (1) EO C440.01 (Describe Model Rocketry),
    - (2) EO C440.02 (Launch a Small Model Rocket),
    - (3) EO C440.03 (Discuss Characteristics of the Planets in the Solar System),
    - (4) EO C440.04 (Apply the Material Science of Trusses),
    - (5) EO C440.05 (Describe Robotics),
    - (6) EO C440.06 (Use Star Charts),
    - (7) EO C440.07 (Operate a Telescope),
    - (8) EO C440.08 (Watch *BLAST! [Balloon-Borne Large Aperture Sub-Millimetre Telescope]*).
    - (9) EO C440.09 (Describe the Relationship Between Gravity and Space-time),
    - (10) EO C440.10 (Discuss Kinetic and Potential Energy), and
    - (11) EO C440.11 (Watch *Einstein's Big Idea*).
  - b. EO C440.01 (Describe Model Rocketry) must be conducted before EO C440.02 (Launch a Small Rocket).
  - c. Complementary material from PO 340 that was not conducted in the previous year may be selected as complementary training in Proficiency Level Four.

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**EO M440.01**

1. **Performance:** Identify Aerospace Materials
2. **Conditions:**
  - a. Given:
    - (1) Supervision, and
    - (2) Assistance as required.
  - b. Denied: Nil.
  - c. Environmental: Classroom or training area large enough to accommodate the entire group.
3. **Standard:** The cadet shall identify various aerospace materials, to include:
  - a. aluminum,
  - b. magnesium,
  - c. titanium,
  - d. stainless steel,
  - e. fibreglass,
  - f. aramid,
  - g. carbon / graphite, and
  - h. ceramic.
4. **Teaching Points:**

TP	Description	Method	Time	Refs
TP1	Discuss: <ol style="list-style-type: none"> <li>a. metals used in aerospace construction, to include:               <ol style="list-style-type: none"> <li>(1) aluminum,</li> <li>(2) magnesium,</li> <li>(3) titanium, and</li> <li>(4) stainless steel;</li> </ol> </li> <li>b. material tests, and</li> <li>c. orbit environment.</li> </ol>	Interactive Lecture	15 min	C3-136 (pp. 2-1 to 2-15) C3-294
TP2	Discuss composite materials used in aerospace construction, to include: <ol style="list-style-type: none"> <li>a. fibreglass,</li> <li>b. aramid,</li> <li>c. carbon / graphite, and</li> <li>d. ceramic.</li> </ol>	Interactive Lecture	10 min	C3-136 (pp. 3-22 to 3-27)

5. **Time:**

- |    |                            |        |
|----|----------------------------|--------|
| a. | Introduction / Conclusion: | 5 min  |
| b. | Interactive Lecture:       | 25 min |
| c. | Total:                     | 30 min |

6. **Substantiation:** An interactive lecture was chosen for this lesson to introduce the cadets to aerospace materials and to generate interest in the subject.

7. **References:**

- a. C3-136 ISBN 0-88487-207-6 Sanderson Training Systems. (2001). *A&P technician airframe textbook*. Englewood, CO: Jeppesen Sanderson Inc.
- b. C3-294 Silverman, E. M. (1995). *Space environmental effects on spacecraft: LEO materials selection guide*. Hampton, VA: NASA Langley Research Center. Retrieved November 27, 2008, from <http://see.msfc.nasa.gov/mp/NASA-95-cr4661pt1.pdf>

8. **Training Aids:**

- a. Presentation aids (eg, whiteboard / flip chart / OHP / multimedia projector) appropriate for the classroom / training area.
- b. Samples of materials, to include:
  - (1) metals, to include:
    - (a) aluminum,
    - (b) magnesium steel,
    - (c) titanium steel, and
    - (d) stainless steel;
  - (2) composite cloth, to include:
    - (a) fibreglass,
    - (b) aramid,
    - (c) carbon / graphite, and
    - (d) ceramic.

9. **Learning Aids:** Nil.

10. **Test Details:** Nil.

11. **Remarks:** Cadets who are qualified Advanced Aerospace may assist with this instruction.

**EO M440.02**

1. **Performance:** Describe Canadian Satellites
2. **Conditions:**
  - a. Given:
    - (1) Supervision, and
    - (2) Assistance as required.
  - b. Denied: Nil.
  - c. Environmental: Classroom or training area large enough to accommodate the entire group.
3. **Standard:** The cadet shall describe Canadian satellites, to include:
  - a. Alouette,
  - b. Microvariability and Oscillation of Stars (MOST), and
  - c. Radarsat.
4. **Teaching Points:**

TP	Description	Method	Time	Refs
TP1	Identify aspects of the Alouette program, to include: <ol style="list-style-type: none"> <li>a. history,</li> <li>b. purpose, and</li> <li>c. accomplishments.</li> </ol>	Interactive Lecture	5 min	C3-253
TP2	Identify aspects of the MOST mission, to include: <ol style="list-style-type: none"> <li>a. history,</li> <li>b. purpose, and</li> <li>c. accomplishments.</li> </ol>	Interactive Lecture	10 min	C3-254
TP3	Identify aspects of the RADARSAT program, to include: <ol style="list-style-type: none"> <li>a. history,</li> <li>b. purpose, and</li> <li>c. accomplishments.</li> </ol>	Interactive Lecture	10 min	C3-255

5. **Time:**
  - a. Introduction / Conclusion: 5 min
  - b. Interactive Lecture: 25 min
  - c. Total: 30 min
6. **Substantiation:** An interactive lecture was chosen for this lesson to orient the cadets to Canadian satellites and to generate interest in the subject.

7. **References:**

- a. C3-253 Canadian Space Agency. (2008). *Alouette I and II*. Retrieved September 29, 2008, from <http://www.space.gc.ca/asc/eng/satellites/alouette.asp>
- b. C3-254 University of British Columbia. (2008). *MOST: Canada's first space telescope*. Retrieved September 29, 2008, from <http://www.astro.ubc.ca/MOST/overview.html#glance>
- c. C3-255 Natural Resources Canada. (2008). *Canada centre for remote sensing: RADARSAT*. Retrieved September 29, 2008, from [http://www.ccrs.nrcan.gc.ca/radar/spaceborne/radarsat1/index\\_e.php](http://www.ccrs.nrcan.gc.ca/radar/spaceborne/radarsat1/index_e.php)

8. **Training Aids:** Presentation aids (eg, whiteboard / flip chart / OHP / multimedia projector) appropriate for the classroom / training area.

9. **Learning Aids:** Nil.

10. **Test Details:** Nil.

11. **Remarks:** Cadets who are qualified Advanced Aerospace may assist with this instruction.

**EO C440.01**

1. **Performance:** Describe Model Rocketry
2. **Conditions:**
  - a. Given:
    - (1) Supervision, and
    - (2) Assistance as required.
  - b. Denied: Nil.
  - c. Environmental: Classroom or training area large enough to accommodate the entire group.
3. **Standard:** The cadet shall describe model rocketry, to include:
  - a. the parts of a model rocket engine,
  - b. the parts of a model rocket,
  - c. the flight profile of a model rocket, and
  - d. model rocketry safety rules.
4. **Teaching Points:**

TP	Description	Method	Time	Refs
TP1	Describe the parts of a model rocket engine, to include: <ol style="list-style-type: none"> <li>a. engine case,</li> <li>b. clay nozzle,</li> <li>c. black powder propellant,</li> <li>d. delay composition,</li> <li>e. ejection charge, and</li> <li>f. igniter.</li> </ol>	Interactive Lecture	15 min	C3-162 C3-259
TP2	Describe the parts of a model rocket, to include: <ol style="list-style-type: none"> <li>a. nose cone,</li> <li>b. body tube,</li> <li>c. fins,</li> <li>d. launch lug,</li> <li>e. engine stop,</li> <li>f. engine restraint,</li> <li>g. shock cord, and</li> <li>h. parachute.</li> </ol>	Interactive Lecture	10 min	C3-162 C3-259

TP	Description	Method	Time	Refs
TP3	Describe the flight profile of a model rocket, to include: a. ignition, b. power, c. coast / delay, d. ejection, e. descent, and f. landing.	Interactive Lecture	10 min	C3-162 C3-163 C3-259
TP4	Explain model rocketry safety rules.	Interactive Lecture	15 min	C3-162 C3-259

5. **Time:**

- |    |                            |        |
|----|----------------------------|--------|
| a. | Introduction / Conclusion: | 10 min |
| b. | Interactive Lecture:       | 50 min |
| c. | Total:                     | 60 min |

6. **Substantiation:** An interactive lecture was chosen for this lesson to present basic information on model rocketry and summarize the teaching points.7. **References:**

- C3-162 Beach, T. (1993). *Model rocketry technical manual*. Retrieved October 10, 2007, from <http://www.estesrockets.com/assets/downloads/roocketrytechniques.pdf>
- C3-163 Cannon, R. L. (1999). *A learning guide for model rocket launch systems*. Retrieved October 10, 2007, from <http://www.estesrockets.com/assets/downloads/launchsystemguide.pdf>
- C3-259 ISBN 978-0471472421 Stine, G. H. (2004). *Handbook of model rocketry*. Toronto, ON: John Wiley & Sons.

8. **Training Aids:**

- Presentation aids (eg, whiteboard / flip chart / OHP / multimedia projector) appropriate for the classroom / training area,
- Model rocket cutaway,
- Model rocket kit,
- Model rocket engine, and
- Digital scale.

9. **Learning Aids:** Nil.10. **Test Details:** Nil.11. **Remarks:** Cadets who are qualified Advanced Aerospace may assist with this instruction.



**EO C440.02**

1. **Performance:** Launch a Small Model Rocket
2. **Conditions:**
  - a. Given:
    - (1) Cement for plastic models,
    - (2) No. 11 hobby knife,
    - (3) Pencil,
    - (4) Scissors,
    - (5) Small model rocket kit,
    - (6) Supervision, and
    - (7) Assistance as required.
  - b. Denied: Nil.
  - c. Environmental:
    - (1) Classroom or training area large enough to accommodate the entire group, and
    - (2) Outdoor training area IAW Canadian Association of Rocketry (CAR) standards.
3. **Standard:** The cadet shall:
  - a. construct a small model rocket;
  - b. assist in the set-up of the rocket launch site; and
  - c. launch a small model rocket.
4. **Teaching Points:** Have the cadet, as a member of a pair:
  - a. assemble a small model rocket;
  - b. assist in the set-up of the rocket launch site; and
  - c. launch a small model rocket.
5. **Time:**

a. Introduction / Conclusion:	10 min
b. Practical Activity:	80 min
c. Total:	90 min
6. **Substantiation:** A practical activity was chosen for this lesson as it is an interactive way to introduce the cadets to constructing and launching model rockets in a safe, controlled environment.
7. **References:**
  - a. C3-162 Beach, T. (1993). *Model rocketry technical manual*. Retrieved October 10, 2007, from <http://www.estesrockets.com/assets/downloads/rocketrytechniques.pdf>

- b. C3-163 Cannon, R. L. (1999). *A learning guide for model rocket launch systems*. Retrieved October 10, 2007, from <http://www.estesrockets.com/assets/downloads/launchsystemguide.pdf>
- c. C3-259 ISBN 978-0-471-47242-1 Stine, G. H. (2004). *Handbook of model rocketry*. Toronto, ON: John Wiley & Sons.

8. **Training Aids:**

- a. Launch tower for a model rocket,
- b. Launch controller for a model rocket,
- c. 80 m of safety tape,
- d. 18 modular tent pegs or a suitable substitute,
- e. Safety glasses,
- f. Voltmeter,
- g. Pliers,
- h. Screwdriver, and
- i. Electrical tape.

9. **Learning Aids:**

- a. Safety glasses,
- b. Cement for plastic models,
- c. No. 11 hobby knife,
- d. Pencil, Scissors, and
- e. Small model rocket kit.

10. **Test Details:** Nil.

11. **Remarks:**

- a. EO C440.01 (Describe Model Rocketry) must also be selected and delivered prior to this lesson.
- b. Cadets who are qualified Advanced Aerospace may assist with this instruction.

**EO C440.03**

1. **Performance:** Discuss Characteristics of the Planets in the Solar System
2. **Conditions:**
  - a. Given:
    - (1) Supervision, and
    - (2) Assistance as required.
  - b. Denied: Nil.
  - c. Environmental: Classroom or training area large enough to accommodate the entire group.
3. **Standard:** The cadet shall discuss the characteristics of the planets in the solar system, to include:
  - a. mean distance from the sun,
  - b. size,
  - c. mass,
  - d. rotation,
  - e. inclination, and
  - f. orbit characteristics.
4. **Teaching Points:**

TP	Description	Method	Time	Refs
TP1	Discuss the planet Mercury, to include: <ol style="list-style-type: none"> <li>a. mean distance from the sun,</li> <li>b. size,</li> <li>c. mass,</li> <li>d. rotation,</li> <li>e. inclination, and</li> <li>f. orbit characteristics.</li> </ol>	Interactive Lecture	5 min	C3-170 C3-288 C3-289
TP2	Discuss the planet Venus, to include: <ol style="list-style-type: none"> <li>a. mean distance from the sun,</li> <li>b. size,</li> <li>c. mass,</li> <li>d. rotation,</li> <li>e. inclination, and</li> <li>f. orbit characteristics.</li> </ol>	Interactive Lecture	5 min	C3-170 C3-288 C3-289

TP	Description	Method	Time	Refs
TP3	Discuss the planet Earth, to include: <ol style="list-style-type: none"> <li>a. mean distance from the sun,</li> <li>b. size,</li> <li>c. mass,</li> <li>d. rotation,</li> <li>e. inclination, and</li> <li>f. orbit characteristics.</li> </ol>	Interactive Lecture	10 min	C3-170 C3-288 C3-289
TP4	Discuss the planet Mars, to include: <ol style="list-style-type: none"> <li>a. mean distance from the sun,</li> <li>b. size,</li> <li>c. mass,</li> <li>d. rotation,</li> <li>e. inclination, and</li> <li>f. orbit characteristics.</li> </ol>	Interactive Lecture	5 min	C3-170 C3-288 C3-289
TP5	Discuss the planet Jupiter, to include: <ol style="list-style-type: none"> <li>a. mean distance from the sun,</li> <li>b. size,</li> <li>c. mass,</li> <li>d. rotation,</li> <li>e. inclination, and</li> <li>f. orbit characteristics.</li> </ol>	Interactive Lecture	10 min	C3-170 C3-288 C3-289
TP6	Discuss the planet Saturn, to include: <ol style="list-style-type: none"> <li>a. mean distance from the sun,</li> <li>b. size,</li> <li>c. mass,</li> <li>d. rotation,</li> <li>e. inclination, and</li> <li>f. orbit characteristics.</li> </ol>	Interactive Lecture	5 min	C3-170 C3-288 C3-289
TP7	Discuss the planet Uranus, to include: <ol style="list-style-type: none"> <li>a. mean distance from the sun,</li> <li>b. size,</li> <li>c. mass,</li> <li>d. rotation,</li> <li>e. inclination, and</li> <li>f. orbit characteristics.</li> </ol>	Interactive Lecture	5 min	C3-170 C3-288 C3-289

TP	Description	Method	Time	Refs
TP8	Discuss the planet Neptune, to include: a. mean distance from the sun, b. size, c. mass, d. rotation, e. inclination, and f. orbit characteristics.	Interactive Lecture	5 min	C3-170 C3-288 C3-289

5. **Time:**

- |    |                            |        |
|----|----------------------------|--------|
| a. | Introduction / Conclusion: | 10 min |
| b. | Interactive Lecture:       | 50 min |
| c. | Total:                     | 60 min |

6. **Substantiation:** An interactive lecture was chosen for this lesson to introduce the cadets to the characteristics of the planets in the solar system and to generate interest in the subject.

7. **References:**

- a. C3-170 Ottewell, G. The National Optical Observatory. (1998). *Thousand-yard model: Or, Earth as a peppercorn*. Retrieved October 16, 2007, from <http://www.noao.edu/education/peppercorn/pcmain.html>
- b. C3-288 Williams, D. NASA. (2008). *Planetary fact sheet–metric*. Retrieved October 14, 2008, from <http://nssdc.gsfc.nasa.gov/planetary/factsheet/index.html>
- c. C3-289 Williams, D. NASA. (2008). *Planetary fact sheet–ratio to earth values*. Retrieved October 14, 2008, from [http://nssdc.gsfc.nasa.gov/planetary/factsheet/planet\\_table\\_ratio.html](http://nssdc.gsfc.nasa.gov/planetary/factsheet/planet_table_ratio.html)

8. **Training Aids:** Nil.

9. **Learning Aids:** Planet specification sheet.

10. **Test Details:** Nil.

11. **Remarks:**

- a. Planetary data is provided in detail at <http://solarsystem.nasa.gov/planets/index.cfm>
- b. Cadets who are qualified Advanced Aerospace may assist with this instruction.

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**EO C440.04**

1. **Performance:** Apply the Material Science of Trusses
2. **Conditions:**
  - a. Given:
    - (1) Legal-size graph paper,
    - (2) Mechanical pencils,
    - (3) Eraser,
    - (4) 30-cm ruler,
    - (5) Plastic protractor,
    - (6) Marbles,
    - (7) Suspended container mount,
    - (8) Hot glue gun,
    - (9) Hot glue sticks,
    - (10) Hobby knife,
    - (11) Uncooked spaghetti,
    - (12) Supervision, and
    - (13) Assistance as required.
  - b. Denied: Nil.
  - c. Environmental: Classroom or training area large enough to accommodate the entire group.
3. **Standard:** The cadet, in pairs, shall apply the material science of trusses by:
  - a. designing a truss;
  - b. constructing a truss; and
  - c. testing a truss.
4. **Teaching Points:**

TP	Description	Method	Time	Refs
TP1	Explain the material science of trusses.	Interactive Lecture	15 min	C3-331
TP2	Have the cadets, in pairs, design a truss.	Practical Activity	15 min	
TP3	Have the cadets, in pairs, construct and test a truss.	Practical Activity	50 min	

5. **Time:**

- |                               |        |
|-------------------------------|--------|
| a. Introduction / Conclusion: | 10 min |
| b. Interactive Lecture:       | 15 min |
| c. Practical Activity:        | 65 min |
| d. Total:                     | 90 min |

6. **Substantiation:**

- An interactive lecture was chosen for TP 1 to generate interest in the material science of trusses and summarize the teaching point.
- A practical activity was chosen for TPs 2 and 3 as it is an interactive way to allow the cadets to design and test a truss in a safe and controlled environment.

7. **References:** C3-331 McMaster University YES I Can! Science Team. (2009). *How forces act on structures*. Retrieved February 19, 2009, from <http://resources.yesican-science.ca/sts115/aboutforces.html>

8. **Training Aids:**

- Presentation aids (eg, whiteboard / flip chart / OHP / multimedia projector) appropriate for the classroom / training area.
- Marbles, and
- Suspended container.

9. **Learning Aids:**

- Legal-size graph paper,
- Mechanical pencils,
- Eraser,
- 30-cm ruler,
- Plastic protractor,
- Marbles,
- Suspended container mount,
- Hot glue gun,
- Hot glue sticks,
- Hobby knife, and
- Uncooked spaghetti.

10. **Test Details:** Nil.

11. **Remarks:**

- This lesson should be taught in three consecutive periods.
- Cadets who are qualified Advanced Aerospace may assist with this instruction.



**EO C440.05**

1. **Performance:** Describe Robotics
2. **Conditions:**
  - a. Given:
    - (1) Supervision, and
    - (2) Assistance as required.
  - b. Denied: Nil.
  - c. Environmental: Classroom or training area large enough to accommodate the entire group.
3. **Standard:** The cadet shall describe robotics, to include:
  - a. types of robots, and
  - b. robotic applications.
4. **Teaching Points:**

TP	Description	Method	Time	Refs
TP1	Describe types of robots, to include: <ol style="list-style-type: none"> <li>a. autonomous systems, and</li> <li>b. remote-controlled systems.</li> </ol>	Interactive Lecture	10 min	C3-292
TP2	Describe robotic applications, to include: <ol style="list-style-type: none"> <li>a. industrial fabrication, to include:               <ol style="list-style-type: none"> <li>(1) machining,</li> <li>(2) cutting,</li> <li>(3) assembling, and</li> <li>(4) welding,</li> </ol> </li> <li>b. exploration,</li> <li>c. space,</li> <li>d. emergency services, and</li> <li>e. military.</li> </ol>	Interactive Lecture	15 min	C3-292

5. **Time:**
  - a. Introduction: 5 min
  - b. Interactive Lecture: 25 min
  - c. Total: 30 min
6. **Substantiation:** An interactive lecture was chosen for this lesson to give the cadets an overview of robotics and to generate interest in the subject.
7. **References:** C3-292 NASA. (2003). *Rover ranch: K-12 experiments in robotic software*. Retrieved November 20, 2008, from <http://prime.jsc.nasa.gov/ROV/>

8. **Training Aids:** Presentation aids (eg, whiteboard / flip chart / OHP / multimedia projector) appropriate for the classroom / training area.
9. **Learning Aids:** Nil.
10. **Test Details:** Nil.
11. **Remarks:** Cadets who are qualified Advanced Aerospace may assist with this instruction.

**EO C440.06**

1. **Performance:** Use Star Charts
2. **Conditions:**
  - a. Given:
    - (1) Planisphere,
    - (2) Red-filtered flashlight,
    - (3) Star charts,
    - (4) Supervision, and
    - (5) Assistance as required.
  - b. Denied: Nil.
  - c. Environmental:
    - (1) Classroom or training area large enough to accommodate the entire group, and
    - (2) An open outdoor area with clear sky, at night, away from light pollution.
3. **Standard:** The cadet shall use star charts to identify elements of the night sky.
4. **Teaching Points:**

TP	Description	Method	Time	Refs
TP1	Explain how the celestial sphere is divided, to include: <ol style="list-style-type: none"> <li>a. how earth and sky are assumed to be concentric,</li> <li>b. celestial poles, and</li> <li>c. celestial equator.</li> </ol>	Interactive Lecture	5 min	C3-176 (p. 168) C3-179 (pp. 28–29)
TP2	Explain how the sphere of the sky is represented on star charts, to include: <ol style="list-style-type: none"> <li>a. declination,</li> <li>b. right ascension, and</li> <li>c. the plane of the ecliptic.</li> </ol>	Interactive Lecture	5 min	C3-176 (pp. 212–217) C3-179 (pp. 99–119)
TP3	Explain how to interpret a star chart, to include: <ol style="list-style-type: none"> <li>a. date,</li> <li>b. time,</li> <li>c. latitude,</li> <li>d. orientation, and</li> <li>e. planets.</li> </ol>	Interactive Lecture	5 min	C3-176 (pp. 212–217) C3-179 (pp. 99–119)

TP	Description	Method	Time	Refs
TP4	<p>Explain, demonstrate and have the cadets identify elements of the night sky by exploring aspects of a planisphere, to include:</p> <ul style="list-style-type: none"> <li>a. planisphere design,</li> <li>b. the lack of planetary data on a planisphere,</li> <li>c. date,</li> <li>d. time,</li> <li>e. midnight time mark,</li> <li>f. latitude,</li> <li>g. orientation,</li> <li>h. horizon,</li> <li>i. constellations, and</li> <li>j. stars.</li> </ul>	Demonstration and Performance	40 min	C3-180 (p. 1) C3-221

5. **Time:**

a.	Introduction / Conclusion:	5 min
b.	Interactive Lecture:	15 min
c.	Demonstration and Performance:	40 min
d.	Total:	60 min

6. **Substantiation:**

- a. An interactive lecture was chosen for TPs 1–3 to introduce the cadets to star charts and give an overview of the subject.
- b. A demonstration and performance was chosen for TP 4 as it allows the instructor to explain and demonstrate planisphere use while providing an opportunity for the cadets to practice the skill under supervision.

7. **References:**

- a. C3-176 ISBN 1-55407-071-6 Moore, P. (2005). *Atlas of the universe*. Richmond Hill, ON: Firefly Books.
- b. C3-179 ISBN 1-55209-302-6 Dickenson, T. (2001). *Night watch: A practical guide to viewing the universe*. Willowdale, ON: Firefly Books.
- c. C3-180 ISBN 1-55297-853-2 Scagell, R. (2004). *Firefly planisphere: Latitude 42 deg N*. Willowdale, ON: Firefly Books.
- d. C3-221 National Research Council of Canada. (2007). *Explore the night sky*. Retrieved December 3, 2007, from <http://www.nrc-cnrc.gc.ca/eng/education/astronomy/constellations/html.html>

**8. Training Aids:**

- a. Presentation aids (eg, whiteboard / flip chart / OHP / multimedia projector) appropriate for the classroom / training area,
- b. Planisphere star chart,
- c. Red-filtered flashlight,
- d. Star charts and
- e. Desktop globe.

**9. Learning Aids:**

- a. Planisphere star chart,
- b. Red-filtered flashlight, and
- c. Star charts.

**10. Test Details:** Nil.**11. Remarks:**

- a. TPs 1–3 may be taught in the classroom or in the field, as appropriate.
- b. Cadets who are qualified Advanced Aerospace may assist with this instruction.

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**EO C440.07**

1. **Performance:** Operate a Telescope
2. **Conditions:**
  - a. Given:
    - (1) Telescope,
    - (2) Supervision, and
    - (3) Assistance as required.
  - b. Denied: Nil.
  - c. Environmental: Classroom or training area large enough to accommodate the entire group.
3. **Standard:** The cadet shall operate a telescope by:
  - a. setting up a telescope;
  - b. operating a telescope; and
  - c. dismantling a telescope.
4. **Teaching Points:**

TP	Description	Method	Time	Refs
TP1	Identify the parts of a telescope, to include: <ol style="list-style-type: none"> <li>a. optical tube,</li> <li>b. optical tube mounts, to include:               <ol style="list-style-type: none"> <li>(1) equatorial (one axis of movement) mount, and</li> <li>(2) altazimuth (two axes of movement) mount;</li> </ol> </li> <li>c. finderscope,</li> <li>d. eyepiece,</li> <li>e. lens cover,</li> <li>f. mirrors,</li> <li>g. lenses,</li> <li>h. focus knob,</li> <li>i. tripod, and</li> <li>j. specialty computerized telescope parts, to include:               <ol style="list-style-type: none"> <li>(1) control panel,</li> <li>(2) on / off switch,</li> <li>(3) computer interface port, and</li> <li>(4) power cord.</li> </ol> </li> </ol>	Interactive Lecture	10 min	C3-286 (pp. 5–14)

TP	Description	Method	Time	Refs
TP2	<p>Describe telescope theory, to include:</p> <ul style="list-style-type: none"> <li>a. safety, to include:               <ul style="list-style-type: none"> <li>(1) never looking at the sun through a lens; and</li> <li>(2) careful handling of fragile equipment;</li> </ul> </li> <li>b. what the numbers represent, to include:               <ul style="list-style-type: none"> <li>(1) light gathering of main lens or mirror (aperture),</li> <li>(2) focal length, and</li> <li>(3) focal ratio;</li> </ul> </li> <li>c. seeing, to include:               <ul style="list-style-type: none"> <li>(1) image shaking, and</li> <li>(2) shimmering (atmospheric turbulence); and</li> </ul> </li> <li>d. the three main types of telescope optical systems, to include:               <ul style="list-style-type: none"> <li>(1) refractors,</li> <li>(2) Newtonian reflectors, and</li> <li>(3) Schmidt-Cassegrains.</li> </ul> </li> </ul>	Interactive Lecture	10 min	C3-179 (pp. 60–81) C3-286 (p. 4, pp. 30–37)
TP3	<p>Explain, demonstrate and have the cadets:</p> <ul style="list-style-type: none"> <li>a. set up a telescope by:               <ul style="list-style-type: none"> <li>(1) removing all parts from their containers, ensuring that the optical tube is placed on a sturdy level surface;</li> <li>(2) setting up the tripod;</li> <li>(3) attaching the telescope to the tripod;</li> <li>(4) attaching the finderscope (if required);</li> <li>(5) attaching the eyepiece (if required);</li> <li>(6) aligning the finderscope; and</li> <li>(7) aligning the telescope; and</li> </ul> </li> <li>b. operate and dismantle a telescope by:               <ul style="list-style-type: none"> <li>(1) adjusting the right ascension;</li> <li>(2) adjusting the declination;</li> <li>(3) removing the eyepiece (if required);</li> <li>(4) removing the finderscope (if required);</li> <li>(5) removing the telescope from its tripod;</li> </ul> </li> </ul>	Demonstration and Performance	30 min	C3-286 (pp. 6–14)



TP	Description	Method	Time	Refs
	(6) collapsing the tripod; and (7) returning all parts to their containers.			

5. **Time:**

- |    |                                |        |
|----|--------------------------------|--------|
| a. | Introduction / Conclusion:     | 10 min |
| b. | Interactive Lecture:           | 20 min |
| c. | Demonstration and Performance: | 30 min |
| d. | Total:                         | 60 min |

6. **Substantiation:**

- a. An interactive lecture was chosen for TPs 1 and 2 to orient the cadets to telescope theory and generate interest in the subject.
- b. A demonstration and performance was chosen for TP 3 as it allows the instructor to explain and demonstrate the telescope-handling skills the cadets are expected to acquire while providing an opportunity for the cadets to practice the skill under supervision.

7. **References:**

- a. C3-179 ISBN 1-55209-302-6 Dickenson, T. (2001). *Night watch: A practical guide to viewing the universe*. Willowdale, ON: Firefly Books.
- b. C3-286 11073-INST. Celestron. (2006). *CPC series instructional manual*. Torrance, CA: Celestron.

8. **Training Aids:**

- a. Presentation aids (eg, whiteboard / flip chart / OHP / multimedia projector) appropriate for the classroom / training area, and
- b. Telescope.

9. **Learning Aids:** Telescope.10. **Test Details:** Nil.11. **Remarks:** Cadets who are qualified Advanced Aerospace may assist with this instruction.

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**EO C440.08**

1. **Performance:** Watch *BLAST! (Balloon-Borne Large Aperture Sub- Millimetre Telescope)*
2. **Conditions:**
  - a. Given:
    - (1) *BLAST!* DVD
    - (2) Supervision, and
    - (3) Assistance as required.
  - b. Denied: Nil.
  - c. Environmental: Classroom or training area large enough to accommodate the entire group.
3. **Standard:** The cadet shall watch *BLAST!* and discuss the BLAST mission, to include:
  - a. galactic cosmology,
  - b. extragalactic cosmology, and
  - c. BLAST mission design.

4. **Teaching Points:**

TP	Description	Method	Time	Refs
TP1	Describe the BLAST mission, to include: <ol style="list-style-type: none"> <li>a. observation of star formation;</li> <li>b. observation of galaxy formation; and</li> <li>c. the BLAST mission design.</li> </ol>	Interactive Lecture	10 min	C3-298
TP2	Have the cadets watch <i>BLAST!</i>	In-Class Activity	55 min	C3-295
TP3	Discuss the science and the design of the BLAST mission.	Group Discussion	15 min	

5. **Time:**

- |                         |        |
|-------------------------|--------|
| a. Introduction:        | 10 min |
| b. Interactive Lecture: | 10 min |
| c. In-Class Activity:   | 55 min |
| d. Group Discussion:    | 15 min |
| e. Total:               | 90 min |

6. **Substantiation:**

- a. An interactive lecture was chosen for TP 1 to introduce the cadets to cosmology and give an overview of the BLAST mission.
- b. An in-class activity was chosen for TP 2 as it as it is an interactive way to reinforce cosmology, provoke thought and stimulate interest among cadets.
- c. A group discussion was chosen for TP 3 as it allows the cadets to interact with their peers and share their knowledge, experiences, opinions, and feelings about cosmology using a balloon-borne large aperture sub-millimetre telescope.

7. **References:**

- a. C3-295 Devlin, P. (Producer & Director). (2008). *BLAST!* [Motion picture]. United States: The ArtistShare Project.
- b. C3-298 *BLAST (Balloon-Borne Large Aperture Sub-Millimetre Telescope)*. University of Pennsylvania Department of Physics and Astronomy. Retrieved January 30, 2009, from <http://blastexperiment.info/>

8. **Training Aids:**

- a. Presentation aids (eg, whiteboard / flip chart / OHP / multimedia projector) appropriate for the classroom / training area, and
- b. *BLAST!* DVD.

9. **Learning Aids:** Nil.

10. **Test Details:** Nil.

11. **Remarks:**

- a. It is recommended that this EO be presented in three consecutive periods.
- b. If EO C440.07 (Operate a Telescope) is selected, it is recommended that it be presented prior to this lesson.

**EO C440.09**

1. **Performance:** Describe the Relationship Between Gravity and Space-Time
2. **Conditions:**
  - a. Given:
    - (1) Supervision, and
    - (2) Assistance as required.
  - b. Denied: Nil.
  - c. Environmental: Classroom or training area large enough to accommodate the entire group.
3. **Standard:** The cadet shall describe the relationship between gravity and space-time, to include:
  - a. classical explanations of gravity, and
  - b. relativistic explanations of gravity and space-time.
4. **Teaching Points:**

TP	Description	Method	Time	Refs
TP1	Compare early ideas of gravity to gravitation under the theory of relativity, to include: <ol style="list-style-type: none"> <li>a. Newton's Universal Law of Gravitation,</li> <li>b. gravity as a force between masses,</li> <li>c. instantaneous transmission of gravity,</li> <li>d. the interdependence of space and time, and</li> <li>e. curvature of space-time.</li> </ol>	Interactive Lecture	10 min	C3-310 C3-312
TP2	Describe the Gravity Probe B (GP-B) mission, to include: <ol style="list-style-type: none"> <li>a. gyroscope operation,</li> <li>b. the spin-axis of a gyroscope,</li> <li>c. geodetic effect,</li> <li>d. frame-dragging effect,</li> <li>e. spacecraft components, and</li> <li>f. Canada's contribution to orientation control.</li> </ol>	Interactive Lecture	10 min	C3-310 C3-312
TP3	Have the cadets watch <i>Testing Einstein's Universe</i> while finding answers to assigned questions, to include: <ol style="list-style-type: none"> <li>a. tests of the 20<sup>th</sup> century,</li> <li>b. the concept of GP-B,</li> </ol>	In-Class Activity	25 min	C3-311

TP	Description	Method	Time	Refs
	c. mechanics of GP-B, and d. components of the GP-B spacecraft.			
TP4	Conduct an activity to correct answers to the assigned questions.	In-Class Activity	5 min	C3-310

5. **Time:**

- |    |                      |        |
|----|----------------------|--------|
| a. | Introduction:        | 10 min |
| b. | Interactive Lecture: | 20 min |
| c. | In-Class Activity:   | 30 min |
| d. | Total:               | 60 min |

6. **Substantiation:**

- An interactive lecture was chosen for TPs 1 and 2 to introduce theories of gravitation and give an overview of the Gravity Probe B mission.
- An in-class activity was chosen for TPs 3 and 4 as it is an interactive way to reinforce the relationship between gravity and space-time, provoke thought, and stimulate interest among cadets.

7. **References:**

- C3-310 Range, S. K. (2004). *Gravity Probe B: An educator's guide*. Washington, DC: NASA. Retrieved February 6, 2009, from <http://einstein.stanford.edu/RESOURCES/education-index.html#guide>
- C3-311 Bartel, N. (Producer & Director). (2003). *Testing Einstein's universe* [Motion picture]. Canada: York University.
- C3-312 Range, S. K. (2008). *Gravity Probe B: Testing Einstein's universe*. Retrieved February 6, 2009, from <http://einstein.stanford.edu/index.html>

8. **Training Aids:**

- Presentation aids (eg, whiteboard / flip chart / OHP / multimedia projector) appropriate for the classroom / training area,
- WMV video file *Newtons\_Universe\_Anima* from Reference C3-312,
- WMV video file *Einsteins\_Universe\_Anima* from Reference C3-312,
- WMV video file *Rel\_gyro\_expt-anima* from Reference C3-312,
- WMV video file *Simple\_expt\_anima* from Reference C3-312,
- WMV video file *DF-Satellite* from Reference C3-312,
- WMV video file *SConSquid* from Reference C3-312, and
- Testing Einstein's Universe* DVD.

9. **Learning Aids:** Nil.

10. **Test Details:** Nil.
11. **Remarks:** Nil.

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**EO C440.10**

1. **Performance:** Discuss Kinetic and Potential Energy
2. **Conditions:**
  - a. Given:
    - (1) Supervision, and
    - (2) Assistance as required.
  - b. Denied: Nil.
  - c. Environmental: Classroom or training area large enough to accommodate the entire group.
3. **Standard:** The cadet shall discuss kinetic and potential energy, to include:
  - a. storage and conversion of energy, to include:
    - (1) gravitational potential energy, and
    - (2) elastic potential energy; and
  - b. expenditure of energy, to include the effects of:
    - (1) velocity, and
    - (2) mass.

4. **Teaching Points:**

TP	Description	Method	Time	Refs
TP1	Explore the storage and conversion of kinetic and potential energy in a gravitational system.	In-Class Activity	5 min	C3-262
TP2	Explore the storage and conversion of kinetic and potential energy in an elastic system.	In-Class Activity	5 min	C3-262
TP3	Explore the effects of velocity and mass in the expenditure of energy.	In-Class Activity	15 min	C3-263

5. **Time:**
  - a. Introduction / Conclusion: 5 min
  - b. In-Class Activity: 25 min
  - c. Total: 30 min
6. **Substantiation:** 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.
7. **References:**
  - a. 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>

- b. 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>

8. **Training Aids:**

- a. Elastic bands,
- b. Yo-yos,
- c. Plastic tub approximately 7.5 cm deep, 25 cm wide and 30 cm long,
- d. Sand (1 / 2 tub),
- e. Cornstarch (1 / 2 tub),
- f. Ruler marked in millimetres, and
- g. Impacters, to include:
  - (1) marbles of various sizes,
  - (2) ball bearings of various sizes,
  - (3) wooden balls of various sizes, and
  - (4) golf balls.

9. **Learning Aids:**

- a. Elastic bands, and
- b. Yo-yo.

10. **Test Details:** Nil.

11. **Remarks:** Cadets who are qualified Advanced Aerospace may assist with this instruction.

**EO C440.11**

1. **Performance:** Watch *Einstein's Big Idea*
2. **Conditions:**
  - a. Given:
    - (1) Supervision, and
    - (2) Assistance as required.
  - b. Denied: Nil.
  - c. Environmental: Classroom or training area large enough to accommodate the entire group.
3. **Standard:** The cadet shall watch *Einstein's Big Idea* and discuss the history of the formula  $E=mc^2$ , to include:
  - a. development of physics,
  - b. applications of nuclear physics, and
  - c. history of the principle investigators.
4. **Teaching Points:**

TP	Description	Method	Time	Refs
TP1	Conduct an activity where the cadets: <ol style="list-style-type: none"> <li>a. define the word "energy";</li> <li>b. describe what kinds of energy they have used today; and</li> <li>c. describe the difference between sources of energy (eg, sun, wood, oil, wind, or food) and energy itself (eg, light, heat, electrical or mechanical action).</li> </ol>	In-Class Activity	5 min	C3-319 (p. 3)
TP2	Have the cadets determine that atoms of matter have mass by: <ol style="list-style-type: none"> <li>a. examining a list of common materials;</li> <li>b. determining what elements are in those materials;</li> <li>c. locating the elements in a periodic table; and</li> <li>d. determining the mass of those elements' atoms.</li> </ol>	In-Class Activity	10 min	C3-319 (p. 3)
TP3	Have the cadets watch <i>Einstein's Big Idea</i> and make notes on topics assigned, to include: <ol style="list-style-type: none"> <li>a. energy,</li> <li>b. mass,</li> <li>c. light,</li> </ol>	In-Class Activity	110 min	C3-320

TP	Description	Method	Time	Refs
	d. velocity, e. development of the equation $E=mc^2$ , and f. confirmation of the equation $E=mc^2$ .			
TP4	Conduct an activity to create a timeline of the development of the formula $E=mc^2$ .	In-Class Activity	15 min	C3-319 (pp. 4–5)

5. **Time:**

- |    |                            |         |
|----|----------------------------|---------|
| a. | Introduction / Conclusion: | 10 min  |
| b. | In-Class Activity:         | 140 min |
| c. | Total:                     | 150 min |

6. **Substantiation:** 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  $E=mc^2$ .7. **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.

8. **Training Aids:**

- Presentation aids (eg, whiteboard / flip chart / OHP / multimedia projector) appropriate for the classroom / training area, and
- Einstein's Big Idea* DVD.

9. **Learning Aids:**

- Periodic table, and
- Note template handout.

10. **Test Details:** Nil.11. **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.