ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL FOUR

INSTRUCTIONAL GUIDE

SECTION 3

EO C440.01 – DESCRIBE MODEL ROCKETRY

Total Time: 60 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.

Create slides of the figures located at Attachments A.

Photocopy the handouts located at Attachments B and C for each cadet.

PRE-LESSON ASSIGNMENT

Nil.

APPROACH

An interactive lecture was chosen for this lesson to present basic information on model rocketry, and summarize the teaching points.

INTRODUCTION

REVIEW

Nil.

OBJECTIVES

By the end of this lesson the cadet shall be expected to describe the parts of a model rocket, the flight profile of a model rocket, and model rocket safety.

IMPORTANCE

It is important that the cadets know the parts of a model rocket, how a model rocket engine works, and model rocket safety, so they can plan the flight profile of their model rocket.

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Teaching point 1 **Describe the parts of a model rocket engine.**

Time: 15 min Method: Interactive Lecture

Model rocket engines are composed of six basic parts:

- engine case,
- clay nozzle,
- black powder propellant,
- delay composition,
- ejection charge, and
- igniter.



Show the cadets the slide of Figure A-1 located at Attachment A.

ENGINE CASE

The case keeps the engine together and under the correct pressure. Without pressure, the fuel will burn without producing efficient thrust. If the case is not strong enough and the pressure gets too high, the engine will explode. The engine case can be made of paper, cardboard, plastic or aluminum. Paper cases are rolled from paper to form a solid tube of cardboard.

CLAY NOZZLE

The nozzle directs the gas that is formed by the reaction of the oxidant out the back of the rocket. The nozzle is formed so the gasses are accelerated as they pass through the nozzle and provide efficient thrust. Nozzles can be made of clay, ceramic or metal.

PROPELLANT

The propellant is the substance that actually burns or oxidizes. This reaction between the oxidizer and fuel generates gas and heat, which provides the power for the rocket.

Model rocket engines use black powder as both the oxidizer and fuel. The black powder is mixed with other components and is packed or molded into a solid form inside the engine case. These engines are easy to use and safe to transport because the components do not require special containers and the engines are very unlikely to ignite accidentally.

The propellant burns at a prescribed rate and propels the rocket through the atmosphere. The propellant burns stronger at takeoff and has less force towards the end of the power stage. This can be represented in a time-to-thrust graph.



Show the cadets the slide of Figure A-2 located at Attachment A.

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Average thrust is calculated by dividing the total impulse by the duration of the propellant burning.

Depending on the depth of the igniter hole, rocket engines can burn two different ways. Shallow holes in the propellant result in end burn where the propellant burns from one end to the other. Engines requiring more lift use deep holes in the propellant causing the fuel to burn quickly resulting in extra lift earlier on in the flight.



Show the cadets the slide of Figure A-3 located at Attachment A.

Model rocket engines are labelled with a three-part classification code (B6-4) that describes the performance parameters of the engine. This code must be understood in order to choose the proper engine for the model rocket. The first part of the engine code is a letter designating the motor's total impulse class (the "B" in B6-4). Engine size is determined by the amount of propellant and case size. As engine size increases, the letter in the engine code changes to the next letter of the alphabet, and the engine is twice as powerful as the previous letter (eg, A series engines have 1.26 to 2.5 Newton seconds of force and B series engines 2.5 to 5 Newton seconds of force). Total impulse is the total power the engine produces. Total impulse is a measure of the momentum change the engine can impart to the rocket, measured in Newton-seconds. An engine with greater total impulse can lift a rocket higher and faster, and can lift heavier rockets, than an engine with lower total impulse. The table below gives the total impulse ranges and typical rocket performance for each class.



Show the cadets the slide of Figure A-4 located at Attachment A.

THE DELAY COMPOSITION

After the propellant has burned entirely the delay composition starts burning to allow the rocket to coast to the highest point in the flight or the apogee. As the delay composition burns, it emits smoke, allowing tracking of the rocket in its flight. Delay composition burn times can vary from 3–10 seconds and are linked to the weight and size characteristics of the rocket. A heavy and slow rocket would require a shorter burn time, as it would not be moving through the air as fast as a smaller lighter rocket with the same code engine. It is important to calculate the delay as deployment of the parachute or streamer during high speed before or after apogee can result in destruction of the parachute or streamer.

EJECTION CHARGE

The parachute or streamer is deployed by the ejection charge. This black powder charge ignites immediately after the delay composition has completed burning. It pushes the parachute or streamer and nose cone out of the front of the rocket.

IGNITER

The igniter uses an electrically activated fuse to ignite the propellant. An electrical source supplies power to the control panel and control switch. Switching on the power at the control switch causes the igniter to burn, which ignites the propellant.

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CONFIRMATION OF TEACHING POINT 1

QUESTIONS:

Q1. The engine case of a model rocket engine can be made from what materials?

Q2. Why does a model rocket require an ejection charge?

Q3. How does an igniter work?

ANTICIPATED ANSWERS:

A1. Paper, cardboard, plastic or aluminum.

A2. To deploy the parachute or streamer.

A3. Switching on the power at the control switch causes the igniter to burn, which ignites the propellant.

Teaching point 2 **Describe the parts of a model rocket.**

Time: 10 min Method: Interactive Lecture

A model rocket consists of the following parts:

- nose cone,
- body tube,
- fins,
- launch lug,
- engine stop,
- engine restraint,
- shock cord, and
- parachute.



Show the cadets the slide of Figure A-5 located at Attachment A.

NOSE CONE

The nose cone helps the rocket cut through the air during flight. It is important that the nose cone be aerodynamic to offer the least resistance when moving through the air. There are several different styles of nose cones, some for specific speeds. The nose cone is fitted to the body tube so that it can easily be ejected to deploy the parachute. It has an attachment point on one end for the shock cord and can be made from plastic, wood, Styrofoam™, fibreglass or carbon fibre.

BODY TUBE

All the parts of the rocket attach to or are contained within the body tube. The tube must be rigid to maintain its form during flight and can be made of cardboard, plastic, fibreglass or carbon fibre.

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FINS

The fins help stabilize the rocket during flight. They are usually placed near the engine and are usually made of balsa wood, plastic, cardboard, fibreglass or carbon fibre. They must be attached securely and accurately to the body tube as any misalignment will result in an unpredictable flight. Fins on a rocket should be handled with care to avoid damage and misalignment.

LAUNCH LUG

The launch lug guides the rocket off the launch pad for the first metre of flight until the rocket has reached enough speed for the fins to stabilize the rocket. In order to launch the rocket the launch lug is placed on the launch rod of the tower. The lug slides the rocket down the launch rod and is held there until launch. When the launch button is pressed, the rocket engine accelerates the rocket up the launch rod guided by the lug and can quickly achieve over 50 km / h before it leaves the launch rod. The lug can be made of cardboard or metal.

ENGINE STOP

The engine stop prevents the engine from being pushed through the body tube by the engine's thrust. The engine stop is usually made of cardboard.

ENGINE RESTRAINT

The restraint keeps the engine from being ejected out the tail of the rocket by the parachute deploying an explosive charge. Restraints can be a metal strap, screws or strong tape.

Both the engine stop and restraint prevent the effects of Newton's third law: for every action there is an equal and opposite reaction.

SHOCK CORD

The ejection of the parachute must happen when the rocket reaches apogee or the highest point in the flight. The shock cord, made from elastic webbing, absorbs the force of the explosion that ejects the parachute. One end of the shock cord is attached to the nose cone, the other end to the body tube and the parachute is attached to the nose cone or the middle of the shock cord.

PARACHUTE

The descent of the rocket must be controlled to avoid damage to people, property or the rocket. There are several ways to slow the descent of the rocket. The most common is the parachute, which traps air in a canopy to slow the decent. Parachute canopies are made of light flexible sheet material, in the form of a cross or circle. Shroud lines are made of string or cord, with one end attached to the edges of the canopy and the other end of the shroud lines are attached together to the shock cord or nose cone. Parachute sizes and shroud line length are carefully calculated to control the descent. A large parachute will allow the wind to carry the rocket far from the launch tower. A parachute that is too small will cause the rocket to descend too quickly, possibly causing damage to the rocket.

Other forms of descent can be used on different rockets. Streamers can be used with lightweight rockets and act as a drag on the rocket. Free fall can only be used by the lightest rockets and has no additional equipment to slow the rocket. The drag from the rocket's body and fins will slow the rocket. Glide recovery involves attaching a wing to the rocket to allow the rocket to glide to the Earth.

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CONFIRMATION OF TEACHING POINT 2

QUESTIONS:

Q1. What purpose does the nose cone serve?

Q2. What does the launch lug do?

Q3. How do the fins affect the flight of the rocket?

ANTICIPATED ANSWERS:

A1. It helps the rocket cut through the air.

A2. It guides the rocket off the launch pad.

A3. The fins stabilize the rocket during flight.

Teaching point 3 **Describe the flight profile of a model rocket.**

Time: 10 min Method: Interactive Lecture

The burn stages of a model rockets engine allow one to predict the flight profile of the rocket. The flight profile of a model rocket consists of six stages:

1. ignition,
2. power,
3. coast / delay,
4. ejection,
5. descent, and
6. landing.

IGNITION

Ignition is the result of an electrical current lighting from the control panel and launch switch. The actual device that starts the engine burning is the igniter. It looks like a match head with wires coming from the tip. When the electrical current passes through the igniter, it heats up, causing it to burst into flame. This flame is what actually starts the propellant burning in the rocket engine.



Show the cadets the slide of Figure A-6 located at Attachment A.

After ignition, the rocket will leave the launch tower under thrust. The launch tower guides the rocket during low speed to ensure the rocket remains aligned on the prescribed course. The stabilizer fins on the rocket take over as it leaves the launch rod on the tower, usually at around 50 km / h.

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Show the cadets the slide of Figure A-7 located at Attachment A.

POWER

The propellant inside the engine burns quickly. In most engines, the propellant is consumed in less than three seconds, at which point burnout occurs. This means the engine is no longer producing a thrust force. By the time the engine burns out, the rocket has already reached its top speed and begins decelerating. While the rocket may reach hundreds of metres in the air, the burnout location on most rockets is about 15–25 m (50–80 feet) in the air.



Show the cadets the slide of Figure A-8 located at Attachment A.

COAST / DELAY

When the engine burns out, the rocket may be travelling hundreds of kilometres per hour. The parachute or streamer can be destroyed if it is ejected at this speed. The model will coast upward and lose airspeed as gravity and air friction slow it down. The period of time that starts at engine burnout and ends when the parachute is ejected out of the rocket is called the coast phase. The delay composition is now burning at a prescribed rate and produces smoke. The rocket moves so fast, that it is hard to follow visually and the smoke helps give a visual indication of the location of the rocket.



Show the cadets the slide of Figure A-9 located at Attachment A.

EJECTION

When the delay composition is done burning, the rocket should be at apogee. As the delay composition finishes burning it ignites the ejection charge. This ejection charge burns quickly, and is directed forward inside the rocket body tube. Its goal is to push off the nose cone, and eject the parachute out of the rocket. Ejection should occur right at apogee when the rocket has reached its slowest speed. Engine selection controls when the ejection charge pushes out the parachute. If the delay composition burns too long, the rocket will arc over, and will eject the chute while the rocket has begun accelerating in free fall descent. If the delay composition burns too quickly, the rocket may still be moving too fast as it has not coasted to its highest point. Ejection of the parachute at any point other than at apogee will result in the rocket and / or parachute being destroyed and the rocket free falling.



Show the cadets the slide of Figures A-10 and A-11 located at Attachment A.

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DESCENT

After the parachute has ejected, it fully inflates, and the rocket begins its descent phase. The rocket drifts slowly to the ground under the canopy of the parachute or drag of the streamer. The wind will affect the descent of the rocket and this will result in the model drifting away from the launch pad. Descent should not be more than 4.5 m / s (15 feet per second) or it is possible to damage the rocket. If the descent is too slow, the rocket will drift farther from the launch pad affecting recovery.

LANDING

After landing, the rocket should be fully inspected before the next launch. The engine case should be discarded.



Show the cadets the slide of Figure A-12 located at Attachment A.

CONFIRMATION OF TEACHING POINT 3

QUESTIONS:

Q1. How is a model rocket tracked during its flight?

Q2. When is the optimum time during a rocket's flight profile to deploy the parachute or streamer?

Q3. Why is there a delay or coast phase during the rocket's flight?

ANTICIPATED ANSWERS:

A1. The smoke emitted by the delay composition and parachute or streamer can track the flight of a rocket.

A2. At apogee.

A3. To allow the rocket to slow down enough to deploy the parachute without destroying it.

Teaching point 4 **Explain model rocketry safety rules.**

Time: 15 min Method: Interactive Lecture

The hobby of model rocketry originated at the dawn of the space age in the late 1950s. Seeing space boosters carry the first artificial satellites into Earth's orbit inspired many enthusiastic young people to try to emulate the rocket pioneers by building their own rockets. Unfortunately, these homemade rockets involved stuffing flammable chemicals into metal pipes, very often with tragic results. Newspapers told stories of fingers and eyes lost and all too frequently of lives lost.

What was needed was a safe alternative that would allow young people to experience constructing and launching their own rockets and provide them with the opportunity to explore the science of rocketry.

Several companies developed engines that did not explode and provided a safe flight for model rockets. This style of engine is still in use today.

Safety is important when flying model rockets. It is impossible to get out of the way of a rocket going over 400 km / h. The flame produced by the engine is extremely hot and capable of inflicting serious burns or setting objects on fire. Therefore, there are rules in place for launching rockets. The Canadian Aviation Regulations (CARs) and the Canadian Association of Rocketry (CAR) have rules for launching model rockets.

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Distribute photocopies of Attachments B and C to the cadets.

The CARs establish that a model rocket equipped with a model rocket engine will not have a total impulse exceeding 160 Newton-seconds and will not exceed 1500 grams, and will be equipped with a parachute or recovery device capable of retarding its descent. Anything above these parameters requires a high power model rocketry license and permission to fly from Transport Canada.

CAR model rocket rules cover launch site size, model rocket construction and launch procedures.

CONFIRMATION OF TEACHING POINT 4

QUESTIONS:

Q1. Why is safety important when launching model rockets?

Q2. Who establishes the rules for model rocketry in Canada?

Q3. What is the maximum weight of a model rocket?

ANTICIPATED ANSWERS:

A1. There are potential dangers from the rocket engine's flame and the high velocity of the rocket.

A2. Canadian Association of Rocketry.

A3. 1500 grams.

END OF LESSON CONFIRMATION

QUESTIONS:

Q1. When do the fins help guide the rocket during its flight?

Q2. How are rocket engines classified?

Q3. How do we slow a rocket's descent?

Q4. What purpose does the nose cone serve?

Q5. What is apogee?

ANTICIPATED ANSWERS:

A1. When the rocket achieves over 50 km / h or when it leaves the launch rod.

A2. By letter, each successive letter doubles the force of the engine.

A3. By using a parachute or streamer.

A4. It helps the rocket cut through the air.

A5. The highest point of a flight.

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CONCLUSION

HOMEWORK / READING / PRACTICE

Nil.

METHOD OF EVALUATION

Nil.

CLOSING STATEMENT

Model rocketry is a fun and exciting sport. It is important to know the parts of a model rocket, how a model rocket engine works, model rocket safety, and how to plan the flight profile of a model rocket, to be able to fly model rockets safely.

INSTRUCTOR NOTES / REMARKS

Cadets who have completed Advanced Aerospace summer training may assist with this instruction.

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

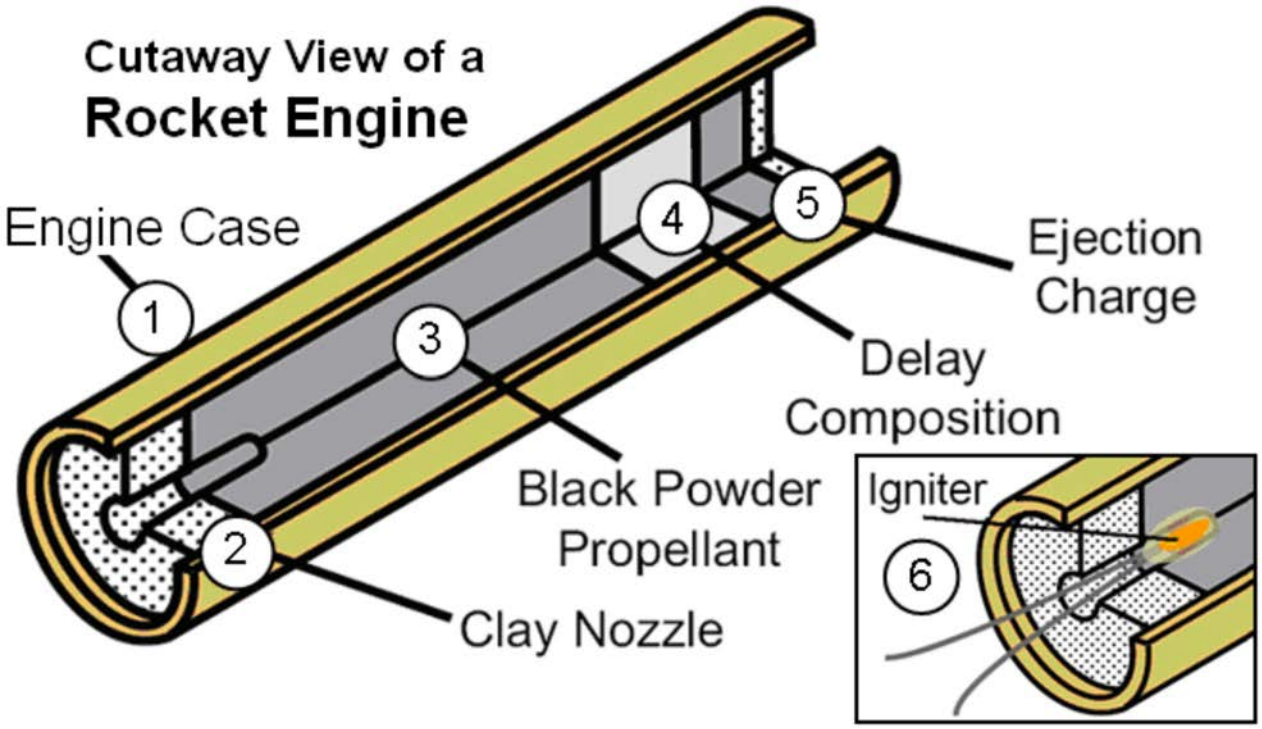
REFERENCES

C3-162 Beach, T. (1993). *Model rocketry technical manual*. Retrieved October 10, 2007, from http://www.estesrockets.com/assets/downloads/roecketrytechniques.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

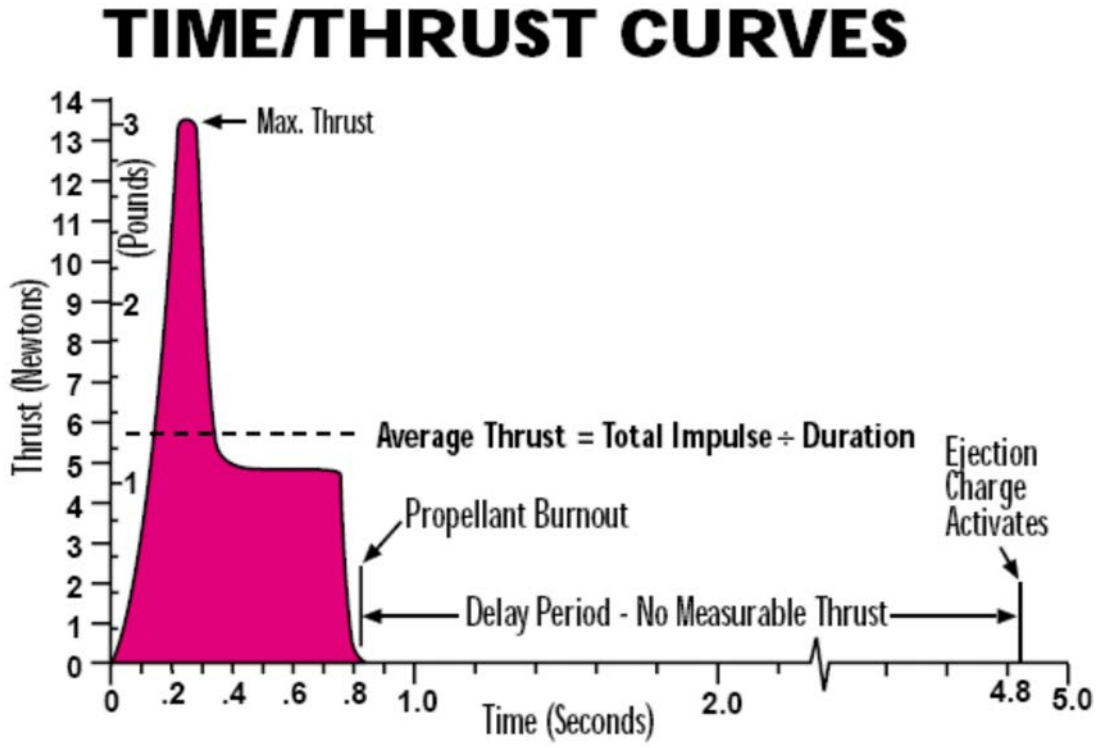
C3-259 ISBN 978-0471472421 Stine, G. H. (2004). *Handbook of model rocketry*. Toronto, ON: John Wiley & Sons.

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Note. From "Apogee Peak of Flight Newsletter", 2003, How Black Powder Rocket Motors Work. Retrieved November 16, 2007, from http://www.apogeerockets.com/educator/downloads/newsletter114.pdf

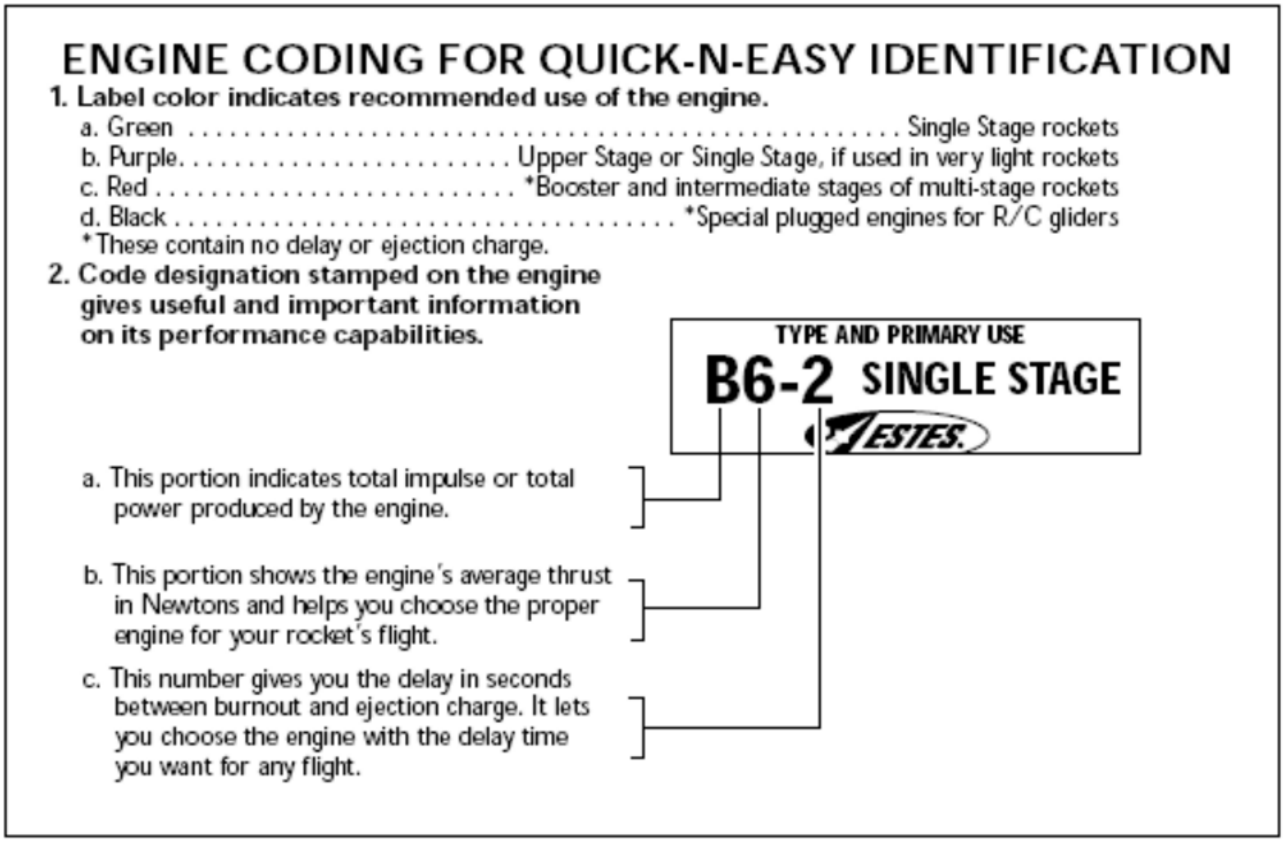
Figure A-1 Cutaway View of a Rocket Engine



Note. From "Estes Rocketry", 1993, by T. Beach, 2003, Model Rocketry Technical Manual. Retrieved October 10, 2007, from http://www.estesrockets.com/assets/downloads/roecketrytechniques.pdf

Figure A-2 Time / Thrust Curves

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Figure A-3 Model Rocket Engine Codes

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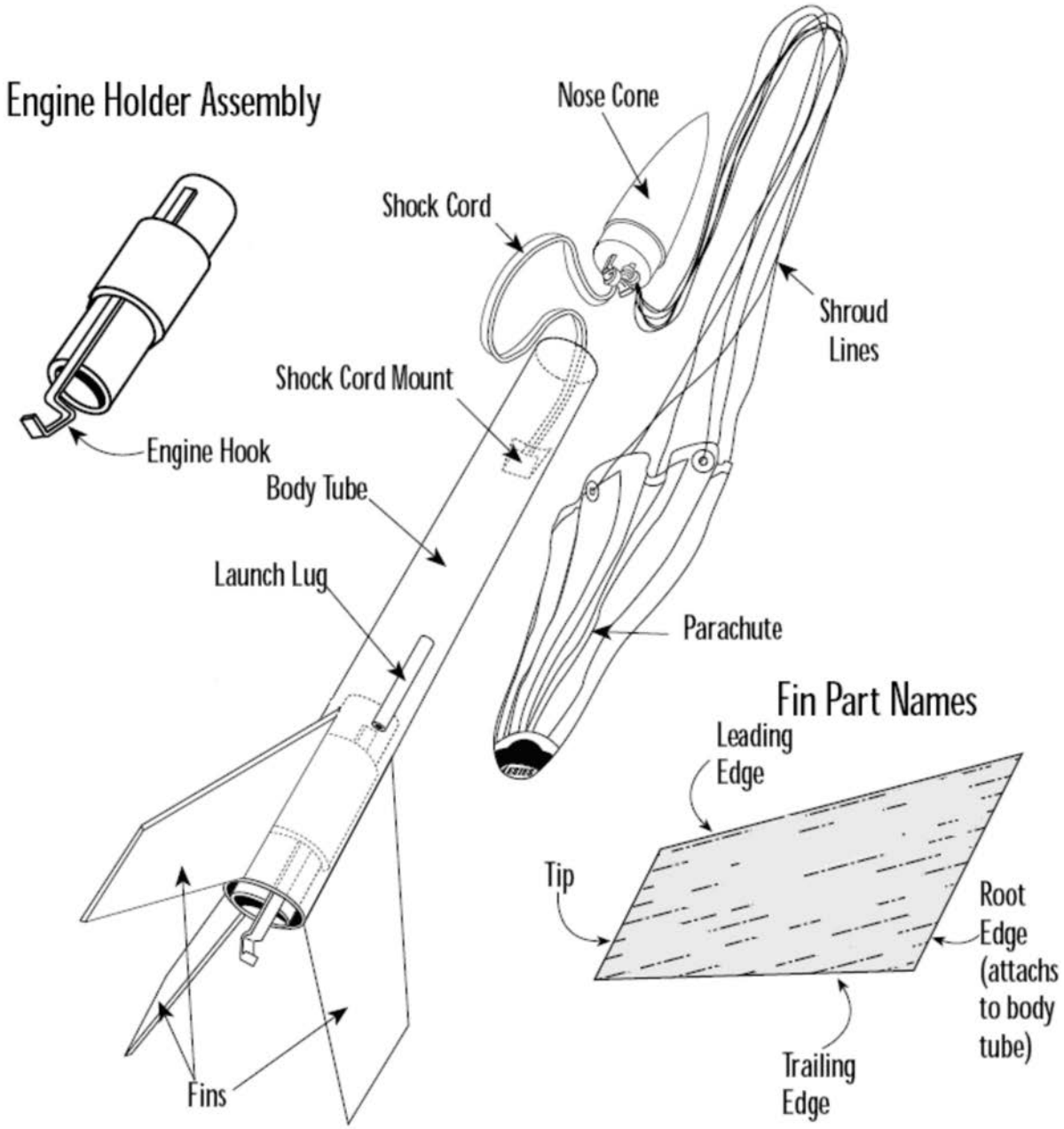
TOTAL IMPULSE CLASSIFICATION

Code	Pound-Seconds	Newton-Seconds
1/2A	0.14 - 0.28	0.625 - 1.25
A	0.28 - 0.56	1.26 - 2.50
B	0.56 - 1.12	2.51 - 5.00
C	1.12 - 2.24	5.01 - 10.00
D	2.24 - 5.00	10.01 - 20.00

Note. From "Estes Rocketry", 1993, by T. Beach, 2003, Model Rocketry Technical Manual. Retrieved October 10, 2007, from http://www.estesrockets.com/assets/downloads/roecketrytechniques.pdf

Figure A-4 Impulse Classification for Model Rocket Engines

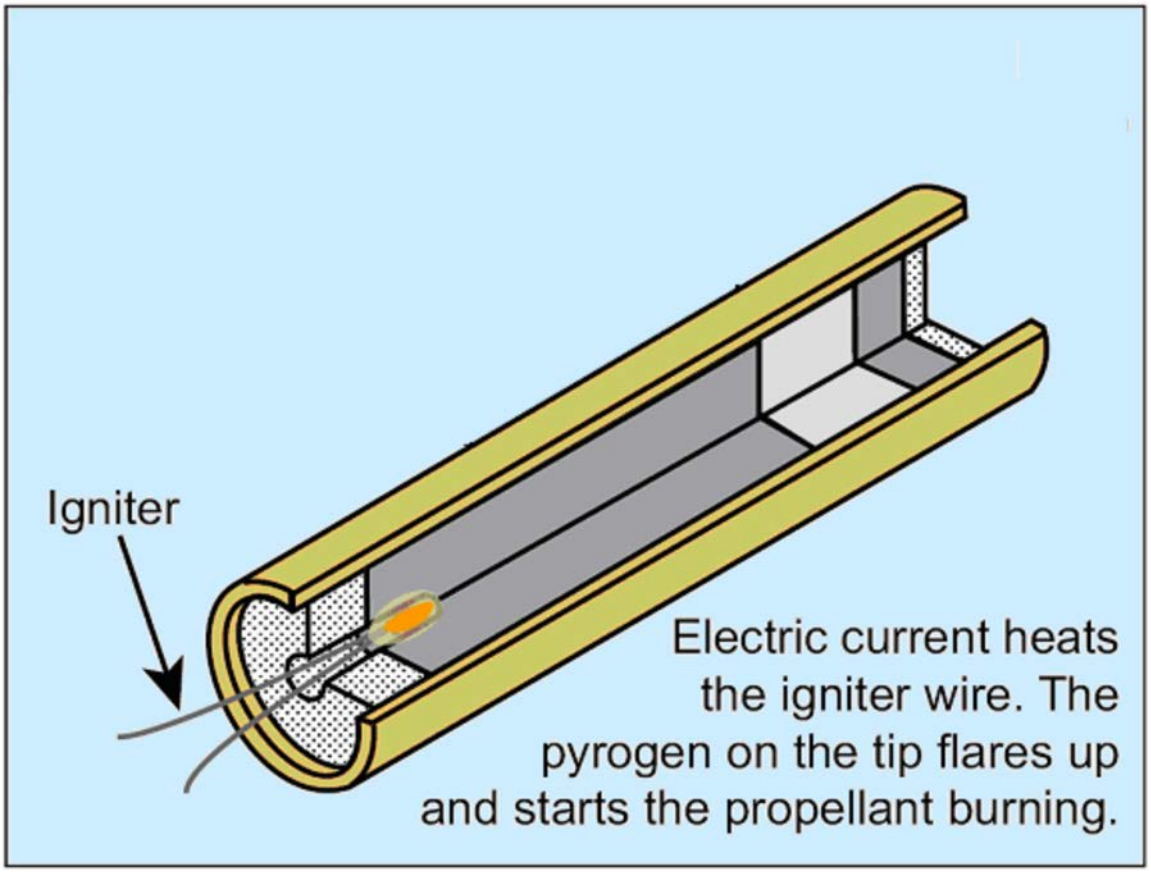
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Note. From "Estes Rocketry", 1993, by T. Beach, 2003, Model Rocketry Technical Manual. Retrieved October 10, 2007, from http://www.estesrockets.com/assets/downloads/roecketrytechniques.pdf

Figure A-5 Parts of a Model Rocket

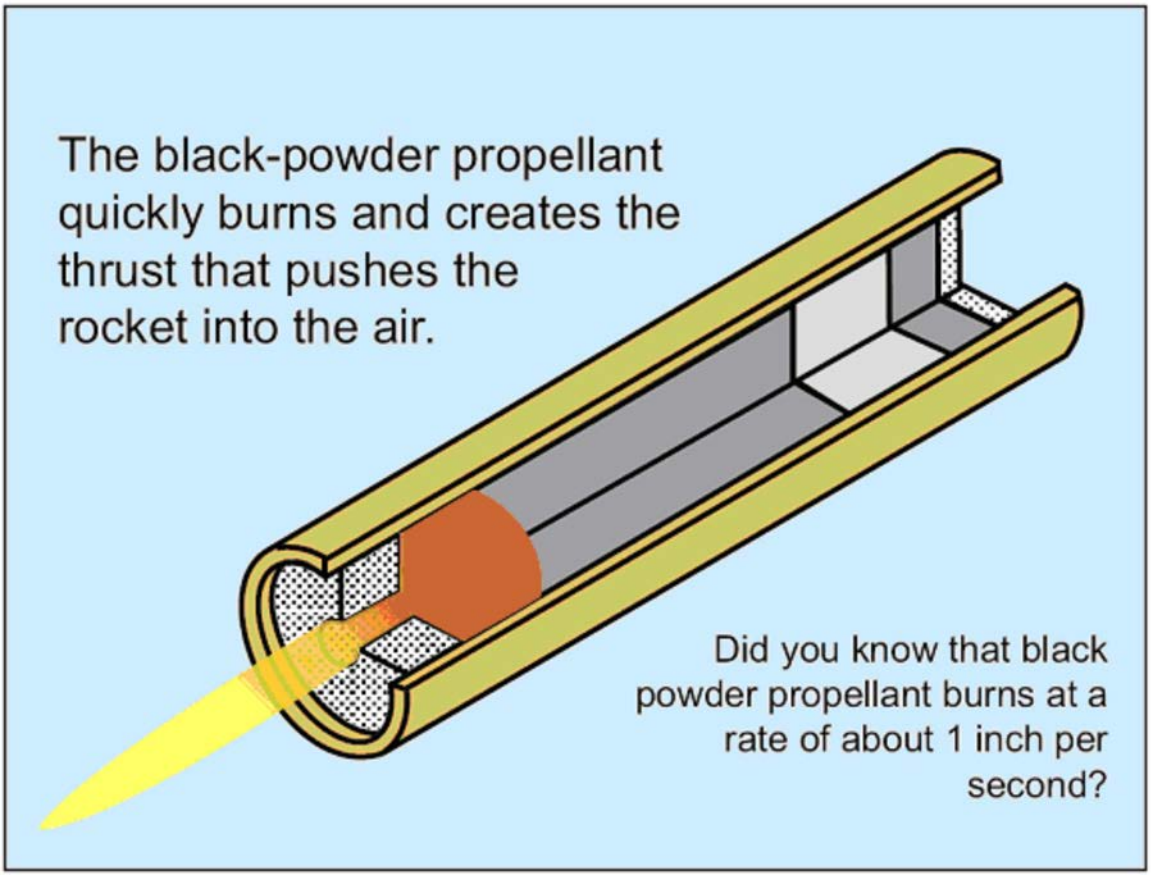
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Note. From "Apogee Peak of Flight Newsletter", 2003, How Black Powder Rocket Motors Work. Retrieved November 16, 2007, from http://www.apogeerockets.com/educator/downloads/newsletter114.pdf

Figure A-6 The Igniter

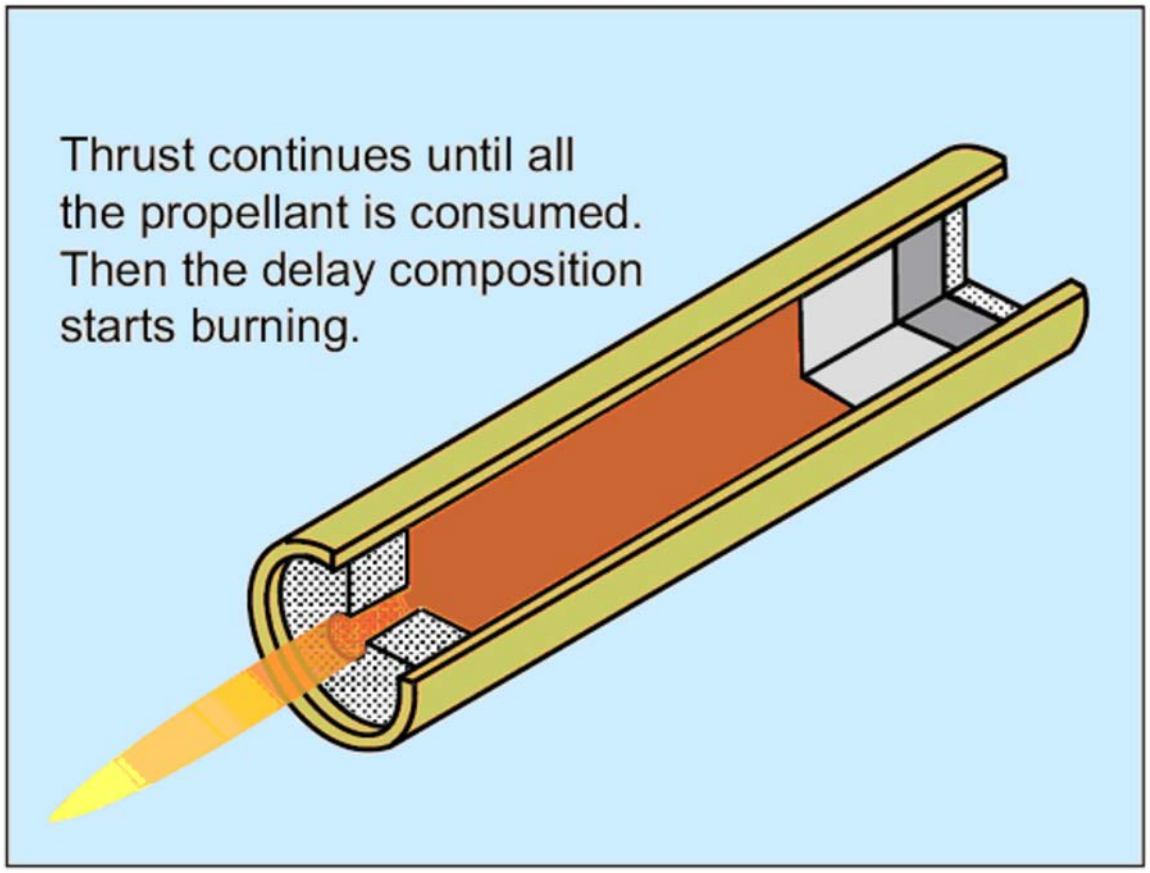
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Note. From "Apogee Peak of Flight Newsletter", 2003, How Black Powder Rocket Motors Work. Retrieved November 16, 2007, from http://www.apogeerockets.com/educator/downloads/newsletter114.pdf

Figure A-7 The Propellant Ignited

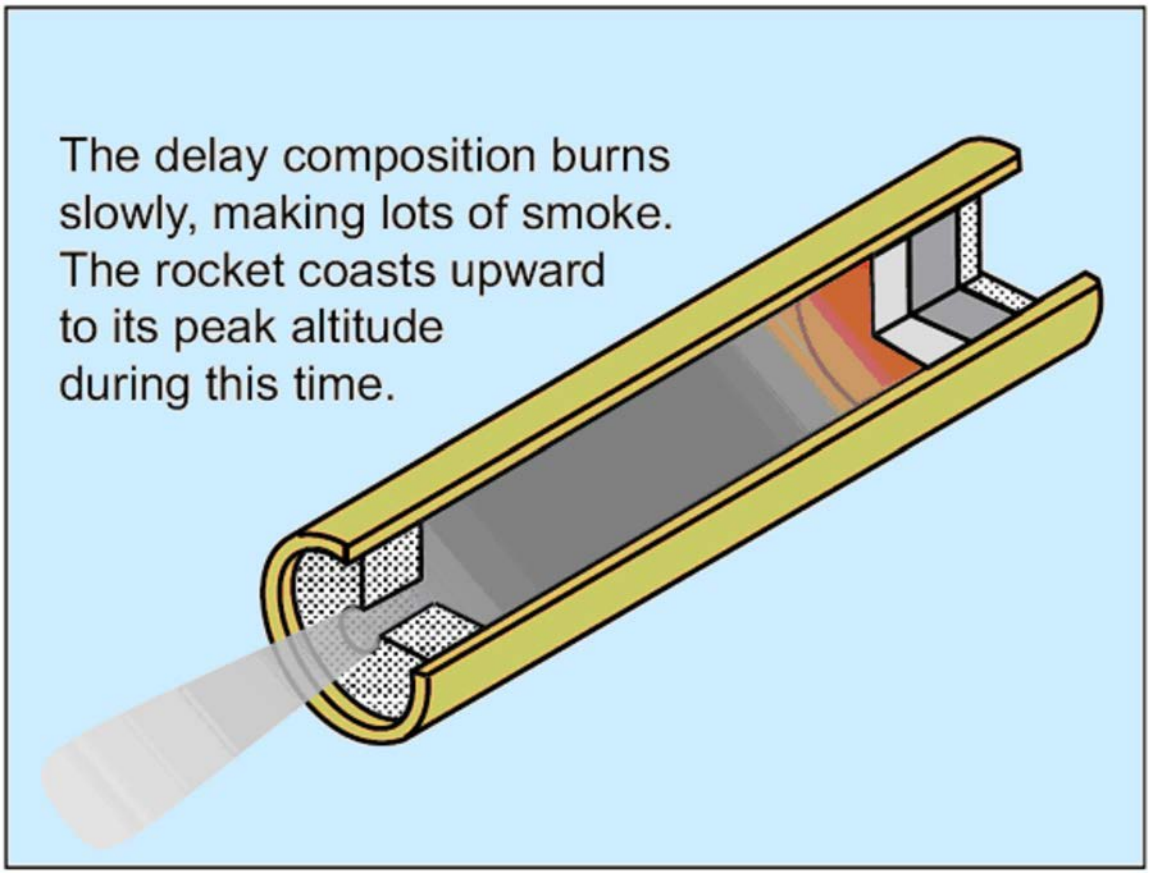
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Figure A-8 Thrust Phase

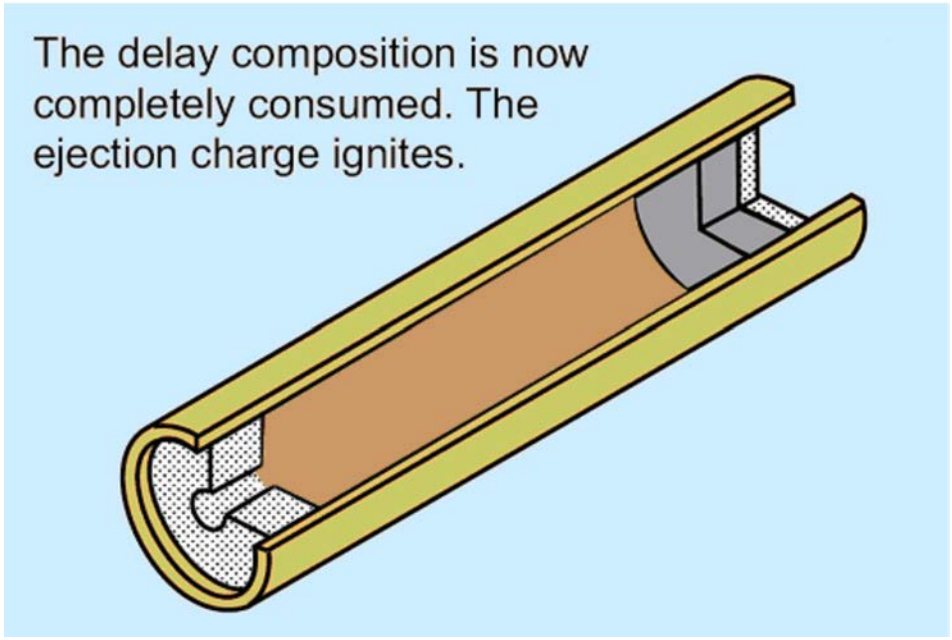
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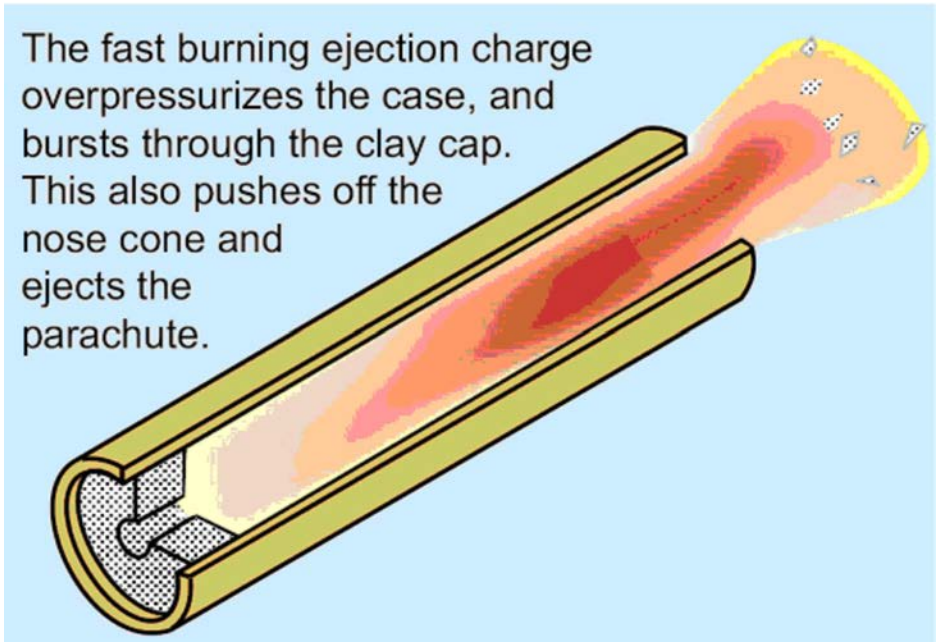
Figure A-9 Delay or Coast Phase

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Note. From "Apogee Peak of Flight Newsletter", 2003, How Black Powder Rocket Motors Work. Retrieved November 16, 2007, from http://www.apogeerockets.com/educator/downloads/newsletter114.pdf

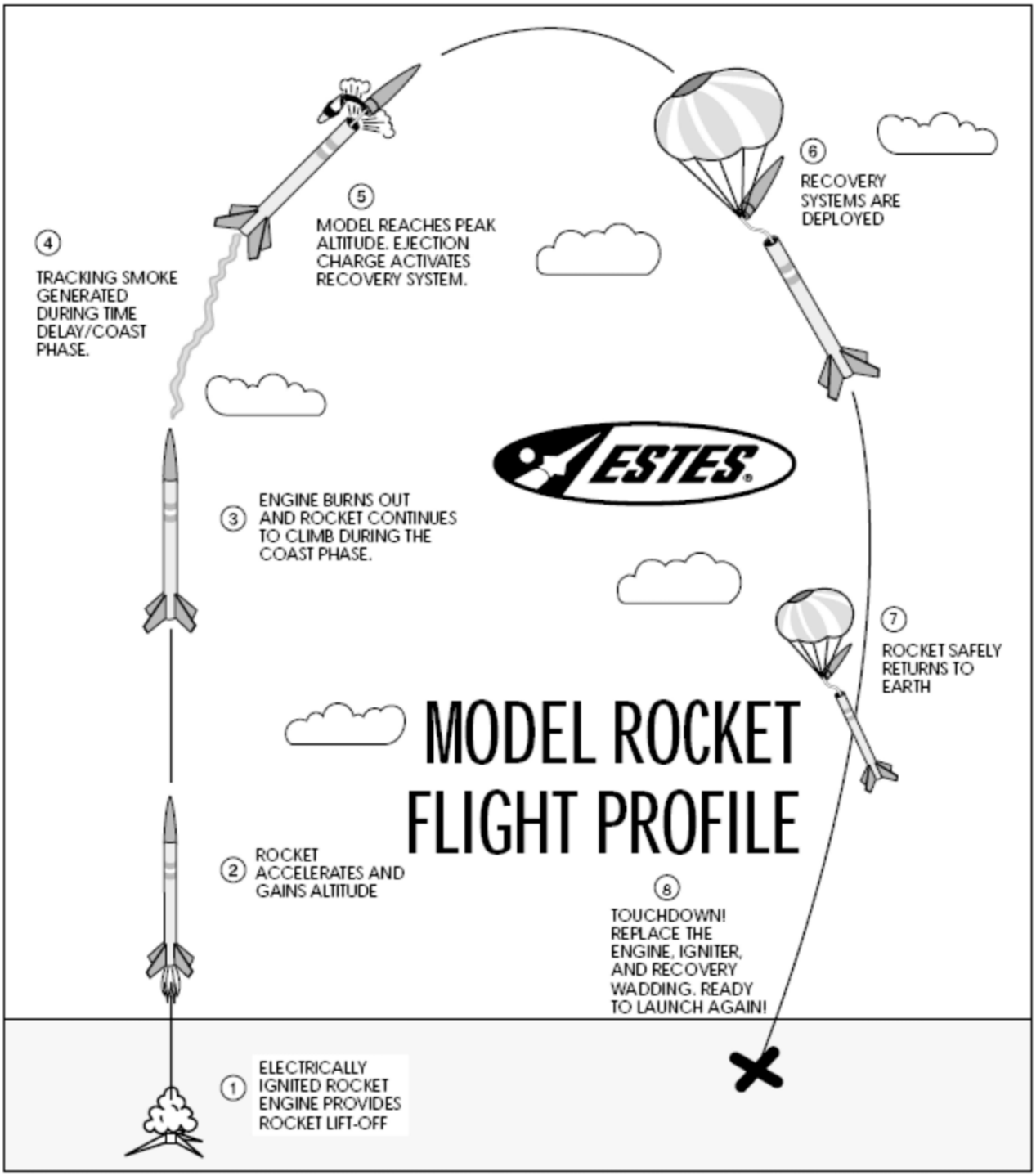
Figure A-10 Beginning of the Ejection Phase



Note. From "Apogee Peak of Flight Newsletter", 2003, How Black Powder Rocket Motors Work. Retrieved November 16, 2007, from http://www.apogeerockets.com/educator/downloads/newsletter114.pdf

Figure A-11 Ejection Phase

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Note. From "Estes Rocketry", 1993, by T. Beach, 2003, Model Rocketry Technical Manual. Retrieved October 10, 2007, from http://www.estesrockets.com/assets/downloads/roecketrytechniques.pdf

Figure A-12 Model Rocket Flight Profile

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CANADIAN ASSOCIATION OF ROCKETRY: CANADA MODEL ROCKET SAFETY CODE

1. CONSTRUCTION: I will always build my model rocket using only lightweight materials such as paper, wood, plastics and rubber without any metal airframe components. My model shall include aerodynamic surfaces or a mechanism to assure a safe, stable flight.

2. ENGINES: I will use only pre-loaded, commercially available model rocket engines approved safe by Energy, Mines and Resources Canada. I will never subject these engines to excessive shock, extremes of temperature, nor will I ever attempt their reloading or alteration. I shall always employ recommended manufacturer handling and ignition procedures.

3. RECOVERY: My model rocket will always utilize a recovery system to return it safely to the ground so that my model rocket may be reflown. I shall prepare the recovery system with due care to assure that it will properly deploy.

4. WEIGHT LIMITS: My model rocket will not weigh more than 1500 grams at liftoff and the model rocket engine(s) will contain no more than 125 grams of propellant.

5. FIRING SYSTEM: I will always use a remote, electrical system to ignite the model rocket engine(s). My firing system will include an ignition switch that will return to "OFF" when released, and a safety interlock key switch to prevent accidental ignition. I will never leave the safety interlock key in my firing system between launches.

6. LAUNCH SYSTEM: My model rocket will always be launched from a stable platform having a device to initially guide its motion. My launch system will have a jet deflector to prevent the engine exhaust from directly contacting the ground, or inflammable launcher components. To protect others and myself from eye injury, I will position the launch rod or rail so that the upper end is above eye level, or else I will place a large guard on the upper end between launches. I will never place my body or hand directly over my loaded model rocket mounted on the launch system.

7. LAUNCH SITE: I will never launch my model rocket near buildings, power lines or within 9.1 kilometres from the centre of an airport. The area immediately around the launch system will be cleared of any flammable materials. I will always obtain the permission of the launch site owner prior to using the launch site for my model rocket activities.

8. LAUNCH CONDITIONS: I will never launch my model rocket in high winds or under conditions of low visibility that may impair the observation of my model rocket in flight, or in a direction below 30 degrees from the vertical.

9. LAUNCH SAFETY: I will remain at least five metres away from any model rocket about to be launched. I will always announce to persons within the launch site that I am about to launch my model rocket, and I shall give a loud countdown of at least five seconds duration. I shall immediately remove the safety interlock key from my firing system after the launch of my model rocket.

10. MISFIRE: In the event of an ignition misfire, I shall not immediately approach my model rocket, but remove the safety interlock key and remain back for a safe period until assured that no ignition will occur.

11. ANIMAL PAYLOADS: I will never endanger live animals by launching them in my model rocket.

12. TARGETS: I will never launch my model rocket so that it will fall on or strike ground or air targets, nor will I include any explosive or incendiary payload.

13. HAZARDOUS RECOVERY: I will never attempt to recover my model rocket from a power line, high place or other dangerous location.

14. PRE-FLIGHT TESTS: Whenever possible, I will, always test the stability, operation and reliability of my model rocket designs prior to flight. I will launch unproven designs in complete isolation from other persons.

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15. PERSONAL CONDUCT: I will always conduct myself in a responsible manner, conscious that the maintenance of safety for others and myself rests with my ability to design and construct sound, working models, and to enthusiastically abide by the Canada Model rocket Safety Code.

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2. CANADIAN ASSOCIATION OF ROCKETRY: MODEL ROCKET STANDARDS

2.1 A "model rocket" is defined as a heavier-than-air flying rocket having a substantially non-metallic airframe, employing the reaction force of a model rocket engine as its sole source of lift and incorporating an automatically initiated system that will assure a safe descent and model reusability.

2.2 The model rocket shall be constructed of wood, paper, plastic or similar lightweight materials. No substantial metal components shall be incorporated in the model rocket airframe.

2.3 The model rocket shall embody aerodynamic surfaces and / or a guidance system, which will develop the necessary stabilizing and restoring forces to produce and maintain a safe, predictable and substantially vertical flight path. Model rockets, which employ an internally or externally controlled guidance system, shall incorporate sufficient inherent stability to fail safe any malfunction or disabling of the guidance system.

2.4 The model rocket shall incorporate a reliable and effective means, of retarding its descent so that no hazard shall be presented to 'persons or property on the ground, and to prevent model damage upon touchdown so as to enable reflight. All engine casings and / or portions of the model jettisoned from the model rocket during flight shall descend with a fully deployed streamer or parachute, or by aerodynamic surfaces, which will induce rapid tumbling or a shallow glide. Minimum loading requirements shall be five (5) square centimetres per gram for parachutes, and ten (10) square centimetres per gram for streamers.

2.5 A model rocket shall utilize no more than three powered stages. A "powered stage" shall be defined as a unit of the whole model rocket airframe which contains one or more model rocket engines, and which is designed to and / or actually separates as a unit in flight after the burnout of its contained engine(s). The number of powered stages used shall be assessed from the staged model configuration at the instant of its first motion on the launcher.

2.6 A model rocket incorporating a self-energized firing system shall contain a safety interlock switch that will disable the firing circuit when "OFF". Activation of the firing system shall occur only immediately prior to launch. The self-energized firing system shall include a safe and reliable provision to test circuit continuity.

2.7 All combustible materials subject to high temperature developed by the function of any model rocket engine, burning-wick dethermalizer or other auxiliary devices operating at higher than 200 degrees Celsius shall be flame proofed or similarly protected to prevent their ignition. Any on-board device, which initiates ignition and / or employs combustion, shall be self-extinguishing upon termination of actual or intended function.

2.8 A model rocket shall never contain an explosive or pyrotechnic payload, nor shall it be used to launch a living animal.

2.9 The maximum or gross mass of a model rocket at launch shall not exceed 1500 grams.

2.10 The model rocket shall contain no more than 125 grams of propellant grain.

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