**Model Rockets**

Model Rockets are usually simple. They have a set of fins, a body tube, a nosecone, a recovery system and a rocket motor to make it go. The motor burns and propels the rocket, the propellant in the motor burns out, the rocket coasts upwards and finally arcs over at the peak of its flight (apogee) where a small ejection charge pops the parachute out so the rocket can float back to earth safely. Model rockets are generally constructed of lightweight material such as cardboard, plastic, and balsa wood. Most are fueled by commercially manufactured single-use rocket motors.
Flight of a Model Rocket

PHASES OF A MODEL ROCKET'S FLIGHT

1. Ignition and Lift-off
2. Engine Burnout
3. Coasting Phase
4. Apogee and Ejection
5. Recovery
**Rocket Motors**

The most commonly used small model rocket engines are the black powder engines such as the one shown below. These are the "traditional" model rocket motor that have been in production since the 1950's.

Black powder model rocket engines are made of a paper tube with a clay nozzle, a solid pellet of black powder propellant, a smoke/delay charge, and an ejection charge as shown in this figure.

A model rocket engine is ignited by inserting an igniter in the clay nozzle putting it in contact with the propellant. At launch, an electric current is driven through the igniter, causing it to combust, igniting the propellant.
When the engine is ignited, the propellant burns, ejecting high-pressure gas out of the nozzle and producing thrust in the opposite direction.

![Thrust](image)

Thrust comes from burning the propellant.

When the propellant is completely consumed, the smoke/delay charge burns producing a smoke trail. The timer charge performs two tasks. First, it provides a smoke trail to help you follow the flight. Second, it lets the rocket coast to its maximum height before activating the ejection charge.

![Smoke](image)

A smoke/delay charge burns after the propellant is consumed.

When the smoke/timer charge is exhausted, the ejection charge fires, which pressurizes the rocket body and deploys a parachute, streamer, or other recovery device.

![Ejection](image)

When the burn reaches the ejection charge, a small explosion deploys the recovery system.
Rocket Motor Three Character Code

Model rocket engines are marked with a three character code that specifies the approximate operating characteristics of the motor. The code consists of a letter and two numbers such as D12-5, C6-5, B6-3, and A8-0.

Sport rocket motors approved for sale in the United States are stamped with a three-part code that gives the modeler some basic information about the motor's power and behavior:
Rocket Motor Total Impulse

Rocket motors come in many sizes. They are measured in "total impulse" and are designated by letters of the alphabet. Each letter designates a range of total impulse and each motor size contains twice the total impulse of the previous letter. For example a "B" motor has a potential total impulse twice that of the total impulse of an "A" motor; a "C" motor has twice the potential total impulse of a "B" motor, etc. Rocket motors larger than "G" are considered High Power; use of them requires certification by Tripoli and/or National Association of Rocketry. The chart below shows the impulse range according to letter.

Q. What does the "C" in "C6-5" mean?

A. The rocket has an impulse (power) of 5.01 -10 newton seconds.
Rocket Motor Average Thrust

Average thrust is a measure of how slowly or quickly the motor delivers its total energy, and is measured in Newtons. The "6" in our example motor tells us that the energy is delivered at a moderate rate (over about 1.7 seconds). A C4 would deliver weaker thrust over a longer time (about 2.5 seconds), while a C10 would deliver a strong thrust for a shorter time (about a second).

As a rule of thumb, the thrust duration of a motor can be approximated by dividing its total impulse by its average thrust.

Keep in mind that you cannot assume that the actual total impulse of a motor lies at the top end of its letter's power range -- an engine marked "C" might be engineered to deliver only 5.5 Newton-seconds, not 10.

Q. What does the "6" in "C6-5" mean?

A. This rocket engine produces an average thrust of 6 newtons.
Rocket Motor Delay Time

When the motor completes its burn the rocket is traveling extremely fast. The delay time allows the rocket to coast to its maximum altitude and slow down before the recovery system (such as a parachute or streamer) is activated by the ejection charge.

The delay time is indicated on our sample motor is 5 seconds. Other typical delay choices for C engines are 3 and 7. Longer delays are best for lighter rockets, which will coast upwards for a long time. Heavier rockets usually do better with shorter delays -- otherwise the rocket might fall back down to the ground during the delay time.

Motors marked with a time delay of 0 (e.g., "C6-0") are booster engines. They are not designed to activate recovery systems. They are intended for use as lower-stage engines in multi-stage rockets. They are designed to ignite the next stage engine immediately once their own thrust is finished. Often their labels are printed in a different color to help prevent you from using them in a typical rocket. In a multi-stage rocket, you would usually select a very long delay for your topmost engine.

Q: What does the “5” in “C6-5” mean?

A: 5 second delay before blowing an ejection charge
NAR Model Rocket Safety Code

1. **Materials.** I will use only lightweight, non-metal parts for the nose, body, and fins of my rocket.

2. **Motors.** I will use only certified, commercially-made model rocket motors, and will not tamper with these motors or use them for any purposes except those recommended by the manufacturer.

3. **Ignition System.** I will launch my rockets with an electrical launch system and electrical motor igniters. My launch system will have a safety interlock in series with the launch switch, and will use a launch switch that returns to the "off" position when released.

4. **Misfires.** If my rocket does not launch when I press the button of my electrical launch system, I will remove the launcher's safety interlock or disconnect its battery, and will wait 30 seconds after the last launch attempt before allowing anyone to approach the rocket.

5. **Launch Safety.** I will use a countdown before launch, and will ensure that everyone is paying attention and is a safe distance of at least 15 feet away when I launch rockets with D motors or smaller, and 30 feet when I launch larger rockets. If I am uncertain about the safety or stability of an untested rocket, I will check the stability before flight and will fly it only after warning spectators and clearing them away to a safe distance.

6. **Launcher.** I will launch my rocket from a launch rod, tower, or rail that is pointed to within 30 degrees of the vertical to ensure that the rocket flies nearly straight up, and I will use a blast deflector to prevent the motor's exhaust from hitting the ground. To prevent accidental eye injury, I will place launchers so that the end of the launch rod is above eye level or will cap the end of the rod when it is not in use.

7. **Size.** My model rocket will not weigh more than 1,500 grams (53 ounces) at liftoff and will not contain more than 125 grams (4.4 ounces) of propellant or 320 N-sec (71.9 pound-seconds) of total impulse. If my model rocket weighs more than one pound (453 grams) at liftoff or has more than four ounces (113 grams) of propellant, I will check and comply with Federal Aviation Administration regulations before flying.

8. **Flight Safety.** I will not launch my rocket at targets, into clouds, or near airplanes, and will not put any flammable or explosive payload in my rocket.
9. **Launch Site.** I will launch my rocket outdoors, in an open area at least as large as shown in the accompanying table, and in safe weather conditions with wind speeds no greater than 20 miles per hour. I will ensure that there is no dry grass close to the launch pad, and that the launch site does not present risk of grass fires.

10. **Recovery System.** I will use a recovery system such as a streamer or parachute in my rocket so that it returns safely and undamaged and can be flown again, and I will use only flame-resistant or fireproof recovery system wadding in my rocket.

11. **Recovery Safety.** I will not attempt to recover my rocket from power lines, tall trees, or other dangerous places.

<table>
<thead>
<tr>
<th>Installed Total Impulse (N-sec)</th>
<th>Equivalent Motor Type</th>
<th>Minimum Site Dimensions (ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00 -- 1.25</td>
<td>1/4A, 1/2A</td>
<td>50</td>
</tr>
<tr>
<td>1.26 -- 2.50</td>
<td>A</td>
<td>100</td>
</tr>
<tr>
<td>2.51 -- 5.00</td>
<td>B</td>
<td>200</td>
</tr>
<tr>
<td>5.01 -- 10.00</td>
<td>C</td>
<td>400</td>
</tr>
<tr>
<td>10.01 -- 20.00</td>
<td>D</td>
<td>500</td>
</tr>
<tr>
<td>20.01 -- 40.00</td>
<td>E</td>
<td>1,000</td>
</tr>
<tr>
<td>40.01 -- 80.00</td>
<td>F</td>
<td>1,000</td>
</tr>
<tr>
<td>80.01 -- 160.00</td>
<td>G</td>
<td>1,000</td>
</tr>
<tr>
<td>160.01 -- 320.00</td>
<td>Two Gs</td>
<td>1,500</td>
</tr>
</tbody>
</table>