Forces acting on a rocket engineering essay

Rocketry can be dated back from 400 BCE, it comes from the writings of Aulus Gellius, a Roman. He wrote a book about a Greek individual who goes by the name Archytas. In this book Archytas uses a wooden pigeon propelled by steam and suspended by wires. This story can be related to rocket history because this is the first account of man using Newton’s Third Law of action and reaction as a means of propulsion, although Newton’s laws hadn’t been developed for another 20 more centuries.

100 to 0 BCE

In the first century BCE, a Greek inventor known as Hero of Alexandria invented a device known as the aeolipile. This is a steam driven device which was like Archytas’s wooden pigeon. Fire was used to heat a bank of water then converted to steam, this steam rose thorough tubes to a sphere, this collected the steam and became a pressure vessel. As the steam became pressured in the vessel, the steam escaped though small outlets and caused the sphere to rotate. Below is a picture of the aeolipile.

Figure 1. 1

Using Newton’s Third Law of action and reaction, Hero creates the aeolipile.

0 to 100 AD

The Chinese began to experiment with compound such as potassium nitrate, arsenic sulphide, sulphur and charcoal. Apart from arsenic sulphide, the other compounds makes gunpowder.

904 AD

The Chinese began using gunpowder as incendiary projectiles, they were used in different forms i. e. as arrows, catapults and grenades during warfare.

1132 to 1279 AD

The military began to expand on the idea of gunpowder and the Chinese used it as a propellant, the earliest record being mortars, they were fired from bamboo tubes.

The Mongols were reported to be the first users of a rocket. During the battle of Kai-Keng, a tube which contained gunpowder was capped at one end and lit from the open end was their weapon. The tube was ignited and the gunpowder created smoke, heat and other gases that created a thrust for the tube. During this time an English monk and alchemist Roger Bacon amended the range of the rockets.

1600-1800 AD

A Polish artillery expert by the name of Kasimiez Siemienowicz issued a number of designs for a single stage rocket. His design would offer a longer range, as well as more destructive capability. In 1696, Robert Anderson published papers detailing methods to build solid rockets. In these he explained how the propellants should be mixed and moulded.

In 1687 Sir Isaac Newton published a revised version of De Motu Corporum called Principia, which explained the laws of motion that gave Scientists and Engineers a better understanding of the whys and hows of rocket science. This knowledge was further expanded in the 1700s when Leonard Euler and

Daniel Bernoulli both developed a perception of the fluid dynamics of gas flow as well as the aerodynamics of flow and air within the interior and exterior of the rocket engine.

A Dutch Professor, Williem Gravesande constructed model cars in 1720, that were propelled by steam rockets. During this period Russian and German Scientists were conducting experiments that involved heavy rockets, which could lift about 45 kilograms. These rockets were so fierce that they burned deep holes in the ground where launched. It is to be noted that during this timeframe, rockets were used in military operations in India during war with the British.

In 1857 the Russian school teacher, Konstantin Tsiolkovsky, and the American Dr. Robert Hutchings Goddard founded modern rocket science.

1900-1930 AD

In 1903 Tsiolkovsky published what was to be considered the first true book on rocket science – The Exploration of Cosmic Space by Means of Reaction Devices. Over the years, he published hundreds of papers, mostly concentrating on multistage rockets for cosmic rocket trains. Due to his theories in this treatise, Tsiolkovsky became known as a father of modern astronautics.

In 1915, after a research fellowship at Princeton University, Dr Robert Goddard started experimenting with solid rockets. He became convinced that liquid rocket fuel would carry payload to higher altitudes. World War 1 helped fund his research leading him to print his findings in a book titled ‘ A

Method of Reaching Extreme Altitudes’. This book led Goddard to also become known as one of the fathers of astronautics.

Goddard launched his first successful flight using liquid engines on March 26, 1926. The flight distance was around 56 metres and lasted 2. 5 seconds but the rocket only peaked 12. 5 metres.

Another notable Scientist during this era was Hermann Oberth, a Romanian born in 1894. After reading Goddard’s findings in his book, he published his own research ‘ The Rocket in Planetary Space’ a year later. This research explained the prospect of a manned flight and what effects it would have on the human body. These findings led to clubs and organisations being formed all over the world.

In 1929 Goddard launched the first reconnaissance payload, which contained a camera, barometer and thermometer, into space.

1957-1961 AD

In 1957 the ‘ Space Race’ between the Americans and the Soviets exploded into the public eye. The Soviet Sputnik 1 was launched into orbit on October 4th of the same year. It was the first orbital vehicle to be launched into space by mankind. Sputnik 1 generated enthusiasm as well as fear into the Americans. This was a worry because the launch of the spacecraft could provide means for the Soviets to launch nuclear weapons through space platforms.

The need to develop intercontinental ballistic missiles (ICBMs) that could transport nuclear payloads to the United States, was the economical driving force for the Soviet program.

In November of the same year, the Soviets launched Sputnik 2. This spacecraft carried the first animal into space, a dog name Laika.

Figure 1. 2 Laika

http://s3. amazonaws. com/readers/socyberty/2008/04/25/150792_2. jpg

During this time, the U. S were behind in their program and were even unsuccessful in their launching of Vanguard rocket. This failure encouraged the successful launch of Explorer 1 in 1958, which was the first of its kind in the U. S. Its mission was the study of radiation enveloping the Earth.

During the same year they also launched the Vanguard successfully.

Figure 1. 3 Vanguard Rocket

http://history. nasa. gov/SP-4202/p12-231b. jpg

This spacecraft is the oldest of its kind still in orbit. It enabled findings of the asymmetry of the Earth.

The National Aeronautic and Space Administration (NASA) was approved by Congress and became the central organisation for all space research, involving development and testing for the United States.

The Luna 1 spacecraft was launched by the Soviets in 1959. This was the first spacecraft to reach and escape the velocity of the Earth and travel forward into space to within 5995 kilometres of the moon, leading to a journey onwards into a heliocentric orbit between Earth and Mars. Luna 2 reached the moon, but crashed.

Luna 2 enabled the discovery of solar wind with the aid of sensors that were designed for detection of ions in space. It also confirmed the moon lacked a magnetic field of any magnitude.

Luna 3, after orbiting the moon, sent back images of the far side. Using the aid of a camera to take photographs, images were then developed on board, scanned, and then sent back to Earth using technology comparable to a facsimile machine.

In 1960 the first communication satellite Echo 1 was launched. The Soviets also launched sputnik 5 the same year carrying two cosmonauts, Stelka and Belka these where the first cosmonauts to return home from space safely.

In 1961 the first human travelled to space, this was Soviet cosmonaut Yuri Gagarin, his flight had a duration of 60 minutes using Vostok 1 rocket. It was fuelled by kerosene and propelled by liquid oxygen.

Less than a month later Alan Shepard was the first American to enter space in a suborbital flight. His spacecraft was derived from the German V2 rocket and burned alcohol and liquid oxygen under the leadership of the German rocket scientist Wernher von Braun.

On August 6th the Soviets orbited Gherman Titov. He travelled around the earth for more than 25 hours making him the first man to orbit longer than a day.

Figure 1. 4 Yuri Gagarin: First Man in Space

http://www. nasa. gov/images/content/146084main_yurig_516. jpg

1961-Present

From this point onwards, manned space program really kicked off. One of the main aims was to be the first to reach the moon The Americans and Soviets continuously launched flights into space via new technologies and experiments. The most significant improvements were on the magnitude of payload that could be carried into orbit, and the length of visit was also longer.

The Americans walked on the moon and the Russians orbited in space stations around the Earth.

From the 1970s the Americans created solid and liquid fuel systems and experimented with launch vehicles that could be used over and over again. There were a few setbacks to the American program. On January 28th 1986, the space shuttle challenger blew up moments after take-off and killed all of its crew members. Due to these and other setbacks, very little progress was made between the mid 70s and 2004. This was because of the requirements needed to keep the shuttle flying. Setbacks took major chunks of money for the NASA project.

During this time frame, the Chinese space program at joined the Russians and Americans by having their own manned space vehicles. On October 15th 2003, they had their own family of rockets called the Long March Rockets that propelled the Shenzhou 5 spacecraft which was carrying Yang Liwie into orbit. They also began unmanned exploration, this triggered new interest within the American space community and plans to return to the moon.

From here and beyond, other space agencies where born, amongst these include:

Irainian space Agency

Israeli Space Agency

Japan Aerospace exploration Agency

Centre National d’Etudes Spatiales (CNES- France)

Aim

The purpose of this report is to design a two stage rocket for a specific payload to be carried to a given height.

Objectives:

To be able to reach my aim, detailed analysis will be carried out into the following:

Mission

Payload

Necessary rocket equations

Thrust

Specific impulse

Rocket dynamics and control

Basic rocket engine

Thermodynamic Expansion and rocket Nozzle

Types of rocket engines

Materials suitable for engine design

Final design of rocket

Missions

There are three main types of mission. These include military, commercial and science.

Military Missions

This involves the need for a payload to target a craft, for example a spy satellite, to be placed into a particular orbit in space. There could also be a need for telecommunications satellite.

Commercial Missions

This involves telecommunications for television broadcast which can be for global use or space tourism. For this kind of mission it is important to devise a way or means of making money. For example, deep space expeditions. This mission will orbit around the moon for some one hundred million dollars each.

Science Missions

This type of mission can be used for the advancement and understanding of our Universe and satisfaction of scientific curiosity. For example, the study of the availability of water or ice on the moon. Once requirements for the mission have been established and resources are available, a suitable payload can be designed to execute the mission.

Payload

This is the fundamental reason for the need to build a rocket. The payload can vary from an instrument to a communication device.

Definition of payload:

The book Space Mission Analysis and Design, Third Edition by James R. Wertz and Wiley J. Larson explains;

“ The term payload includes all hardware above the launch-vehicle-to-spacecraft interface, excluding the payload protective fairing, which is usually part of the launch system. The payload consists of the entire spacecraft above the booster adapter interface. For the shuttle, it is customary to speak of the payload as the spacecraft to be deployed or a sortie mission payload to be operated from the payload bay.”

For this project I will be designing a hobby rocket in place of an actual rocket. This is due to limited time and expenses.

My mission

The mission of my project is to carry a specific weight of 0. 25kg up to a height of 1000 metres

Rocket fundamentals

To be able to achieve a successful mission it is important to understand the fundamental forces that govern a rocket.

http://www. grc. nasa. gov/WWW/K-12/rocket/Images/rktfor. gif

Rocket fundamentals

Forces acting on a Rocket

Thrust: through a suitable propulsion system and the application of Newton's Third law of motion; For every action there is an equal and opposite reaction. Thrust can be defined as a force that propels the rocket through the air and even through space. This propulsion system can either be gas, liquid or solid. The reaction to the propulsion system produces the force on the engine.

Weight: Due to the gravitational attraction present on the earth, a force is generated by the rocket.

Lift: When the rocket moves through a fluid i. e. air, the body exerts a surface force on it. Lift can be seen as the component of the surface force that is perpendicular to the oncoming flow direction.

Drag: This can be seen as air resistance, its a force that counterbalances the relative motion of the rocket through a fluid. It acts in a direction that is opposite to the oncoming flow.

Model rocket parts

Below are the different parts of a hubby rocket.

Parts of a rocket http://www. grc. nasa. gov/WWW/K-12/rocket/Images/rktparts. gif

FLIGHT PATH OF A MODEL ROCKET

http://www. grc. nasa. gov/WWW/K-12/rocket/Images/rktflight. gif

the picture above shows the flight path of a single stage rocket, the weight of the model rocket is constant as small amount of the propellant is used compared to the weight of the rocket. Although this is a lot different from a full scale rocket of which its propellant weight is a lot bigger compared to the craft’s weight. During launch, the rocket’s thrust is greater when compared to the weight of the rocket, this accelerates the rocket away from the pad. Model rockets reply on the aerodynamics for its stability. After leaving the pad the rocket starts with a powered accent, the thrust produced is greater than its weight permitting the lift and drag (aerodynamic forces) to work on the rocket. As the rocket’s fuel runs out it starts its coasting flight. Due to the lack of thrust the weight and drag causes the rocket to slow down. After this a maximum altitude is reached and the law of gravity causes the rocket to fall back to earth.

During coasting a delay charge slowly burns, although it doesn’t yield anymore thrust smoke is produced this is for a better visibility from the ground. After the delay charge, ejection charge pressurizes the body tube which blows off the nose cap and the parachute becomes active. At this point the rocket starts to descend slowly, the descend is slow because of the weight and drag forces of the parachute.

The flight path should be straight up and down as this provides the maximum altitude but hubby rockets are often affected by the wind due to weather cocking. This causes the maximum altitude to be less than its optimum.

Rocket dynamics

SPECIFIC IMPULSE

Thrust is the directing force of a rocket through the air, as discussed earlier thrust is created by the engine with the aid of reaction of an accelerating mass of gas.

Newton’s second law of motion defines force as change in momentum of an object with change in time. In this scenario, momentum is the mass X velocity. If dealing with gas, the basic thrust equation can be defined as:

F thrust= mdot e * Ve – mdot 0 * V0 + (pe – p0) * Ae

Where P= pressure, V= Velocity, A= Area, mdot= mass flow rate.

Where liquid or solid engines are involved, the propellants (fuel and oxidizer) there is no free stream air within the propulsion system therefore the thrust equation can be simplified to:

Fthrust = mdot * Ve + (pe – p0) * Ae

Using algebra, we can divide by mdot:

F / modt = Ve + (pe – p0) * Ae / mdot

By defining a new velocity called equivalent velocity Veq which is the velocity on the right hand side of the above equation:

Veq = Ve + (pe – p0) * Ae / mdot

Now the thrust equation becomes:

F = mdot * Veq

Total impulse (I) can be defined as the average thrust X thrust duration.

I = F * Î” t

Due to the thrust being able to change with time, an integral equation for the total impulse can be defined as:

I = âˆ« F dt

Substituting the equation for thrust given above:

I = âˆ« (mdot * Veq) dt

If the velocity remains constant, we can integrate the equation to get:

I = m * Veq

Where m = mass of propellant. I can divide the equation by the propellant’s weight as this will define the specific impulse. Therefore the specific impulse (Isp) becomes:

Isp = Veq / g0

g0 = gravitational acceleration which is 9. 81m/s2

Now, if we substitute for the equivalent velocity in terms of the thrust:

Isp = F / (mdot * g0)

We can check our units mathematically as Isp is a ratio of the thrust produced to the weight flow of the propellants.

Isp = m/sec / m/sec2 = sec

The specific impulse is a quick way to determine the thrust of the rocket. It is also an indication of the rocket engine’s efficiency. The higher the specific impulse the more efficient its engine is going to be. It also makes the analysis of the rocket’s thermodynamics easier as it gives an easy way to specify the size of engine needed during preliminary analysis.

IDEAL ROCKET EQUATION

During a typical flight there are a few changes of forces, for example during the powered flight, the propellants within the propulsion system is always depleted through the nozzle. This affects the mass and weight of the rocket as they are constantly changing. Due to this change the standard Newton’s second law of motion cannot be used to find the acceleration and velocity of the rocket. By neglecting the aerodynamic effects of lift and drag, we can derive the change in velocity during the first stage of flight taking in consideration the changing mass of the hobby rocket.

The change in rocket momentum

M (u + du) – M u = M du

Where M= mass of rocket, u= velocity of rocket, v= exhaust velocity.

To determine the change in momentum of dm which is exits at velocity v, this can be written as:

$$dm\ (u - v) - dm\ u = - dm\ v$$

So the total change in momentum of the system (rocket + exhaust) is

$$\text{change in system momentum} = M\ du - dm\ v$$

if taken into account the forces acting on the rocket's system, neglecting drag, the weight of the rocket is Mg. Pressure force will be $(p-p0)A$ acting in a positive direction. Leaving the total force on te system to be:

$$\text{force on the system} = (p - p0)\ A - M\ g \cos (a)$$

where p = exhaust pressure, $p0$ = atmospheric pressure, A= exhaust area

the impulse on the system is equal to the change in momentum, this is equal to the force on the system X the change in time.

Combining the two equations to be:

$$M\ du - dm\ v = [(p - p0)\ A - M\ g \cos (a)]\ dt$$

Ignoring the weight force and using algebra this can be simplified to

$$M\ du = [(p - p0)\ A\ ]\ dt + dm\ v$$

This leaves the exhaust mass dm equal the mass flow rate X dt. Resulting in the last equation being:

$$M\ du = [(p - p0)\ A + \text{mdot}\ v\ ]\ dt$$

By including the equivalent exit velocity and substituting it into the momentum equation we have

Veq = v + (p – p0) * A / mdot

M du = Veq mdot dt

mdot dt is the amount of change within the mass of the rocket, as the rocket is losing mass due to the propellant being exhausted the sign becomes negative

mdot dt = – dM

Substituting into the momentum equation:

M du = – Veq d M

du = – Veq dM / M

by integrating this equation:

Î” u = – Veq ln (M)

Where Î” u = change in velocity, ln is the natural logarithmic function. The inital mass and final mass of the rocket are the limits of the integration.

The instantaneous mass of the rocket M is divided into two parts, empty mass me and propellant mass mp. The empty mass remains the same with time while the propellant mass will change with time.

M(t) = me + mp (t)

Mf contains the empty mass and all of the propellant before lift-off, after all the propellant has burned, the mass of the rocket will only be that of the empty mass:

M initial = mf = me + mp

M final = me

Substituting for these values we obtain:

Î” u = Veq ln (mf / me)

This equation is the ideal rocket equation. There are a few additions to this equation which is listed below:

Propellant mass ratio MR can be defined as

MR = mf / me

Î” u = Veq * ln (MR)

Veq is related to the specific impulse Isp:

Veq = Isp * g

where g is the gravitational constant.

The change in velocity can be written in terms of the specific impulse of the engine:

Î” u = Isp * g * ln (MR)

Having a desired Î” u, by inverting this equation we can easily work out the amount of propellant that will be required for this given velocity.

MR = exp (delta u / (Isp * g))

where exp = exponential function.

Taking into consideration the effect of gravity, the rocket equation will now become:

Î” u = Veq ln (MR) – g0 * tb

where tb = time for the burn

VELOCITIES AND HEIGHTS

Stage 1

Velocity

V= V0 – gt + ulog

At burn out t = tbo v= vbo m= mbo , = r

The initial velocity at this stage V01= 0

Vb01 = V01 – gt + ulog r1

Where V01 = initial velocity, Vb01 = Velocity at stage 1, g = gravity, u = relative velocity of exhaust

Height at end of stage 1

S = ut + 0. 5at2

$Hcl = Vbo1 + t2 – 0. 5at22$

Stage 2

Velocity at stage 2 burn out

$Vbo2 = Vo2 – gt + ulogr2$

Height gained at end of stage 2

$V2 = u + 2as$

$Vbo2 = Vo2 + 2gh2$

Velocity gained at end of the stage 2 coasting is V3 which is at the maximum height 0

$V3 = 0$

$V = u + at$

$V3 = Vbo2 + gt$

Calculating the burn-out Velocity

Mp – Payload Mass

Ms – Structural Mass

Mf – Propellant Mass

mg

Mbo – Burnout

Mo – Total Mass

Ve

From the equation of motion

F =

Î£F = mv + m(v-ve)

= mv + mu

Î£F = -mg

This can be combined to

mv + mu = -mg

v = -g- u

dv = -g dt – u dt

= -g dt – dt

v – v0 = -gt – u log

Therefore

v = v0 – gt – u log

let r =

where v = vbo , m = mbo, t at burnout = tbo

Restoring Forces and stability of Rocket

Center of Pressure

All the forces that act on the rocket has impact which affects the flight dynamics.

these forces sum up the vectors with a total of

Î£F = Fthrust + mg + L + D

where mg = gravitational force, L = lift , D = drag

the angle of displacement also proves vital to the equation above. Centre of pressure and cL affect the stability of the rocket. This is due to cg being:

a representation of centre mass in correspondence to two bodies

the typical geometry centroid of an object

The sum of weight of each component within the system (payload, engine, structure, oxidizer, fuel) can be seen as the total weight times the centre of gravity location. This is usually measured from distances from the reference line.

The procedure used to calculate the center of pressure is a very complicated one its a three dimensional problem. The aerodynamic forces acting on the rocket are the result of pressure vibrations around the surface of the rocket. due to the symmetric ability of a model rocket i. e. its very symmetric about its axis, its reduces a three dimensional problem into a simple two dimensional problem. the magnitude of pressure variation for a model rocket is rather small.

the center of pressure can be calculated by

A * cp = (a*d nose) + (a*dtube)+ (a*d fins)

where A = area, cp = center of pressure, d= diameter

to determine the center of pressure of each component i. e. the tube, its projected area is a rectangle and its center of pressure is on the axis, half of the end planes.

The center of gravity

The flight of a rocket consist of translation and rotation. The center of gravity is where the rotation takes place. The center of gravity can be seen as the average location of weight relevant to the rocket. In a model rocket there are a lot of different part, it is important to know the distribution of mass and weight throughout the entire system.

w = m*g

where w = weight, m = mass and g = gravitational constant

To determine the center of gravity a reference line should be chosen. The cg can now be calculated relative to the reference line. The rocket’s total weight can be seen as all the individual weights of all components.

(http://www. grc. nasa. gov/WWW/K-12/rocket/rktcg. html)

Staging

There are three types of staging

Serial staging: In this system the stages are on top of each other.

Stage 2

Stage 1

1st Stage

Upper Stage

Serial staging in a Serial stage system

Parallel staging: In this system boosters are straped beside each other

Stage 1

Stage 2

Parallel staging in a Parallel stage system

Hybrid staging: In this system, a combination of the two method mentioned above can be used. for example the Delta IV family

Basic solid motor components

Igniter

Propellant Grain

Thermal Insulation

Burning Surface

Casting

Throat

Nozzle

Schematic of the solid rocket motor

Solid rocket motors are very simple machines with no moving parts apart from the use of a thrust vectoring control system which is an option. Propellants used in a solid motor have a long shelf life. The picture diagram above shows a the basic components. The igniter is used to start the engine, once this has been done the engine can not be turned off because it start to burn the propellant. Igniters have different form, this ranges from eletrical activated components to fuses in bottle rockets. The propellant is the same as the grain witch makes up to 85% of the solid rocket motor. The grain consist of a burning surface, this is where the propellant is burnt during operation of the motor.

A number of motors come with a cylindrical channel which is along the central axis, other confiurations like the open cylindrical channel has a wall which is the burning surface.

The outer shell of the grain is a thermal insulating barrier, this protects the outer casting from the extreme pressure and temperature of the motor. This part is the only resuable part in a solid rocket motor. In space travel, the space shuttle’s SRBs casting is usually recovered from the ocean after launch, this casting can them be renovated and then used again.

Solid rocket motors can take different shapes and sizes due to the need of optimization of the combustion chamber and the need of efficiency when burning the propellant to achieve the relevant thrust profile.

Geometry of the burning channel is also called perforation, this has a burning surface area and this determines the thrust’s profile i. e. does the thrust increase with burn or decrease, it could just remain constant. there are three different modes of burn.

Progressive: As burn time increases, thrust, pressure and burning surface area increases

Regressive: As the burning time increases, the thrust, pressure and burning surface area decreases.

Neutral: As the burning time increases, the thrust pressure and burning surface remains constant.

Configuration for a solid motor

There are 4 main types of configuration a solid motor can adapt to, these include:

Cylindrical

Sperical

Finocyl

Conocyl

Propellant Composition

The grain of the solid rocket motor is mixure of oxidizer, catalyst, fuel, elastomer binder compound, curing agents, plasticizer and addictives. The most and commonly used fuel is an elastomer binder and fuel combination. These are hydroxyl-terminated polybutandiene (HTPB) and polybutanience acrylonitrile (PBAN). HTPB is a visously clear polymer whilst PBAN is a copolymer, the binder is mixed with the oxidizer, this is commonly known to be ammonium perchlorate. The catalyst an additives are mixed in to result the propellant.

A large scale solid propellant like the SRBs of the space shuttle has a composition of the following:

PBAN(Binder and fuel) = 12%

Ammonium perchlorate (Oxiderzer) = 69. 8%

Atomized aliminum powder (Fuel) = 16%

Epoxy curing agent = 2%

Iron oxide powder (Catalyst) = 0. 2%

The Rocket Engine

http://www. grc. nasa. gov/WWW/K-12/rocket/Images/rktengine. gif

Above is a drawing of the different parts of a model rocket engine, hubby rocket nozzle are usually made of ceramic or clay due to the high temperature of its exhaust. The gases are produced using solid propellant highlighted in the green. The rocket is launched with the aid of an electrical igniter. When ignited the propellant burns and the rocket starts its powered flight, after the propellant is burnt the engine produces no more thrust, the delay charge highlighted in blue burns and the rocket reaches its maximum altitude. This delay charge can be between 2-8 seconds depending on the engine used.

The ejection charge shown in red is after the delay charge and this makes an explosion which discharges hot gases through the engine mount, ejecting the nose cone and starts the recovery process of the rocket.

Rocket Engine performance

Rocket engine performance is always a reliable factor which can tell one how high, far and fast the rocket will perform. Hubby rocket come in various size and weights each with different size of propellant containing different burn patterns which has an effect on the thrust profile.

(http://www. grc. nasa. gov/WWW/K-12/rocket/Images/rktengperf. gif)

The graph above shows different performance curves for different rocket engines. The graph shows a plot of the thrust(engine) against the time. The graph shows differences between shapes and level