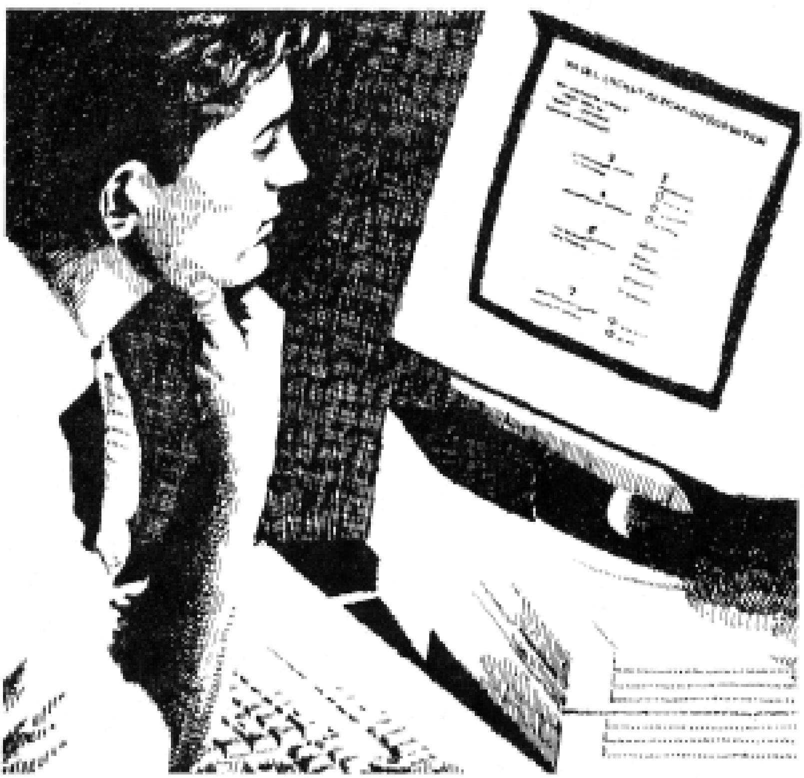
PC - ASTROCAD

Performance Analysis For Model Rockets

USER'S GUIDE



EST 9037

ESTES

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HARDWARE NEEDED

PC Astrocad is designed to run on any IBM™ or IBM™ compatible computer with a minimum of 128K of memory and a monitor.

It should be noted that Estes Industries cannot guarantee that the PC Astrocad program disk will operate on all home computers which are claimed by their manufacturer to be IBM compatible. For this reason, refunds on PC Astrocad disks will not be allowed unless it can be shown that the purchased disk is inoperative on a genuine IBM computer.

You will need your model rocket catalogs for the rocket weights, body tube diameters, nose cone dimensions, and rocket engine technical information. A ruler will be required for taking dimensions from rockets being used for program results.

GETTING STARTED

1. Make a backup copy of your **PC Astrocad** disk and label it.
1. Put your original **PC Astrocad** disk in a safe place.
2. Copy the DOS GWBASIC .EXE file from your system or system disk onto the backup **PC Astrocad** program disk.

DO NOT copy the GWBASIC .EXE file onto the original **PC Astrocad** program disk This voids all warranties that are provided upon purchase of the disk.

To start the **PC Astrocad** program from the backup copy, place the disk in drive A, be sure that you are logged onto drive A, then type: GWBASIC MENU .BAS (ENTER)

Once the menu appears, you may access a program by typing its number, then (RETURN).

To rerun the same program, simply type RUN.

When you are through using a program, exit from it by typing (CONTOL-C).

While your computer is in GWBASIC, you may access a program, including the menu, by typing:

RUN "(enter the name of the program, such as APOGEE.BAS or APOGEE)"
(ENTER)
Be sure to use the quote marks.
To list a program on the screen without printing it, type:

TYPE (the exact name of the program, as APOGEE.BAS)(ENTER)

You can print out a program. Turn on your printer. Type PRINT, then the full name of the program (as APOGEE.BAS). The APOGEE.BAS program should then be printed out on your printer. This permits you to see the program in detail in case you believe that you have a way to make it work faster or more accurately for you.

To return to normal use of your computer, type SYSTEM (ENTER)

PC ASTROCAD INTRODUCTION

The programs are written to help you. The results produced by these programs are not absolutes. Take each answer provided as a guide for comparison with other values. The programs permit you to consider the theoretical results of changing different features of your rockets.

Test the answers provided by the programs in the final laboratory, actual flights. Modify your rockets, and your expectations, based on both theoretical results and actual flight results. The programs permit you to test probable effects of changes to see if they should result in the performance you want before you actually build model rockets or modify existing model rockets. The programs can help you design and build better model rockets. Modify the programs to produce more reliable or more useful results or to make them more convenient for you to use.

Different programs may provide slightly different answers for center of pressure, etc., even when using the same data. This is because of slightly different assumptions and formulas used in different programs. Test the results of each program, and use those that best fit your actual flight performance data. After all, Mother Nature is doing it right!

To improve the performance of your model rockets you need to understand a number of things about them. It is possible to greatly improve the altitude performance of your model rocket by taking one or more of a number of separate steps. The programs on this disk will help you analyze the current performance of each of your model rockets and will help you modify your model rockets to improve their performance.

Take your time and try each program, one at a time. Read the proper portion of this User's Guide as appropriate. It is recommended that you print out the results of each program run. Try modifying one factor about your rocket and rerun the test. See the effect that the change made on the rocket's theoretical performance. Repeat the test, this time modifying one different factor only. Repeated tests let you analyze the effect of each change.

When you are satisfied that you have achieved an improved design, build or rebuild your rocket as indicated. Always check the design for stability <u>before flying it</u> by running a stability program <u>and</u> by using the swing test.

MENU

APOGEE DETERMINATION
STABILITY DETERMINATION
DYNAMIC STABILITY
DRAG PREDICTION
DRAG ESTIMATION
PERFORMANCE PREDICTION
OPTIMUM WEIGHT
FLIGHT SIMULATION
ELLIPTICAL FIN DESIGN
ROCKET DESIGN STORED DATA
ROCKET DESIGN INPUT VERSION

INTRODUCTION

The most easily observed feature of your model rocket's flight is the height it reaches.

The APOGEE DETERMINATION program quickly calculates the apogee (maximum height) reached by the flight of a model rocket.

A model rocket which is not stable will not fly straight. In addition to being dangerous, unstable rockets produce poor flights. Do not launch an unstable rocket!

The STABILITY DETERMINATION program will let you predict the degree of stability of your model rockets before you fly them. This program is easy to use but uses some approximations for determining the center of pressure.

The DYNAMIC STABILITY program permits you to use a more sophisticated program to provide a more accurate analysis of the probable stability of a model rocket. The results provided are more reliable than those from the STABILITY DETERMINATION program but the program requires the input of much more data.

The drag experienced by your model rocket in flight is determined by the shape of your rocket; the number, size, and shape of structures attached to your rocket; the smoothness of the finish of your rocket; and the velocity of your rocket in flight. The drag which your model rocket will experience in flight can be estimated through analysis of the size and shape of the various parts of your rocket and the smoothness of the finish of the rocket.

The DRAG PREDICTION program enables you to estimate the theoretical drag which your rocket should experience.

To secure a good approximation of the drag actually experienced by your model rocket in flight, you need to know the apogee reached by the rocket on one flight with a known engine. The DRAG ESTIMATION program permits you to determine the approximate actual drag on your model rocket based on actual flight data.

The PERFORMANCE PREDICTION program enables you to estimate with reasonable accuracy the performance which your model rocket should deliver with any specified engine. Not only the total altitude reached but the altitude at engine burnout and the probable coasting time can be determined with this program.

Sometimes the performance of a model rocket can be improved by adding weight.

The OPTIMUM WEIGHT program calculates the effect of adding small amounts of weight to your rocket until the optimal weight for maximum performance is reached.

FLIGHT SIMULATION provides you with an analysis of the predicted performance of your model rocket in flight with most Estes engines. Allowance is made in the program for the effect of the air temperature. Output may be given in either English or metric units. Output is given in short time increments from lift-off through engine burnout, apogee, and activation of the ejection charge. The predicted acceleration in feet per second per second, velocity in feet per second, and altitude in feet (or their metric equivalents) is provided.

ELLIPTICAL FIN DESIGN lets you design elliptical fins to maximize altitude performance of your model rockets. You decide the root length, sweep angle, and span length you want for your fin. The ELLIPTICAL FIN DESIGN program yields output in columnar format. You must graph the results on X, Y coordinates on graph paper, then connect the dots and cut out the resulting shape to have a template for making your own elliptical fins.

Model rocket design programs analyze the drag on different parts of the rocket to allow you to modify the rocket for optimum performance. The center of gravity and center center of pressure and stability in calibers are computed. Two versions of the program are furnished.

ROCKET DESIGN STORED DATA program provides you with all data for a specific model rocket already written into the program. After running the program, you can print out the program. Then modify the information for the rocket one line at a time. After each change, rerun the program to see the effects of that one specific change. This provides an excellent way to optimize the performance of one basic design by slight alterations of dimensions.

ROCKET DESIGN INPUT VERSION program provides you with the same program, but requires you to supply the information on each measurement. This program is much faster and easier to use when analyzing a design. It is much slower to use when trying to maximize the performance of a single design since it requires the input of all measurements for each run rather than simply modifying one measurement for each run.

APOGEE DETERMINATION - INTRODUCTION

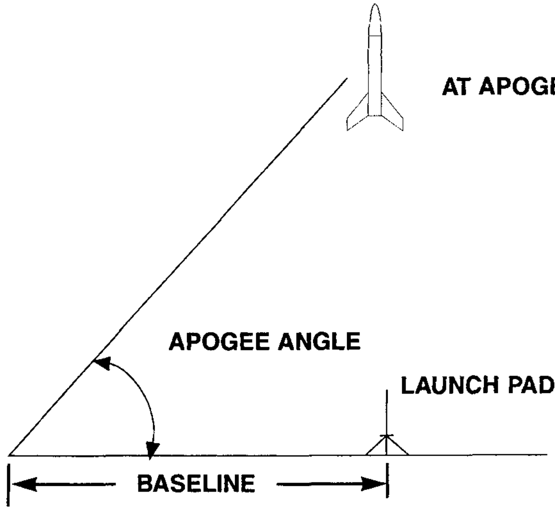
APOGEE-the highest point in the flight of a model rocket

Apogee occurs when the forces of drag and gravity cause the rocket to slow as it reaches its peak altitude before it starts to fall.

The most common method of determining the apogee of the model rocket uses a device to measure the angle between the rocket on the launch pad and at apogee.

The Estes AltiTrak™ can be used to measure this angle. The angular distance can be read directly from the degree scale on this special protractor.

Two measurements are needed to determine the apogee of a rocket. The “baseline”, the distance between the launch pad and the tracking station, must be measured.



This baseline distance is marked off and measured before the launch. It is easiest to make this distance a whole number, such as 150 feet or 100 meters. Record this number and the units used in measurement. The baseline should be about equal to the expected apogee of the highest flight. Having too long or too short a baseline can yield tracking results which are not reliable. The second number which must be determined is the apogee angle. The tracked angular height of the rocket should be close to 45° for the most accurate results. Record this number for each flight. Keep careful records.

Once these two numbers are determined, the height of the rocket at apogee can be easily determined.

Find the tangent of the apogee angle on a tangent table. Record this tangent value.

APOGEE = BASELINE X TANGENT OF APOGEE ANGLE

To determine the height reached by your model rocket on a flight, multiply the baseline distance times the tangent of the apogee angle. The number determined is the height at apogee. This number is in the same units as the units of measurement for the baseline (feet, meters, etc.).

This program performs the calculations for you after you supply the baseline and apogee reading.

APOGEE DETERMINATION EXAMPLE

```
APOGEE DETERMINATION PROGRAM
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WHAT WAS THE BASELINE DISTANCE IN FEET
?200
WHAT WAS THE APOGEE ANGLE IN DEGREES?
?61
APOGEE = 360.806 FEET
```

After this practice to become familiar with the program, type RUN and proceed to solve your own altitude determinations.

Be aware that the “answers” provided by your computer may not match exactly the examples given by this guide. This is primarily because the different ways in which different computers round off numbers in calculations.

STABILITY - INTRODUCTION

Stability for a model rocket is its ability to return to the original flight path if disturbed by some external force, as a gust of wind.

A model rocket must be stable. Never launch an unstable rocket.

If a rocket is unstable do not launch it.

If a rocket is extremely stable, it is very sensitive to small gusts of wind.

A rocket with adequate stability will fly straight and will not be overly sensitive to gusts of winds.

Stability for a model rocket depends upon having the proper relationship between its center of gravity and its center of pressure.

The center of gravity or CG (⊕) is the point at which half of the rocket’s total weight is forward (toward the rocket’s nose) and half is back of it.

This point can be determined by balancing the rocket.

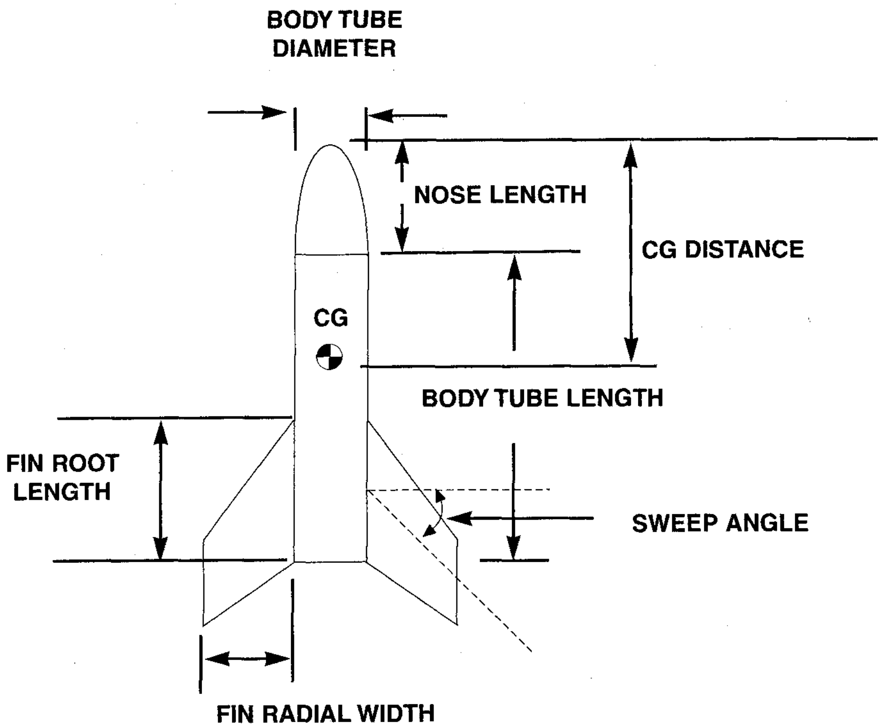
This point is determined after the rocket is ready for flight with recovery system packed and the engine and any payload in position.

The center of pressure is harder to determine.

This center of pressure or CP (⊙)can be approximated by balancing a flat cutout outline of the rocket.

This technique of balancing a cutout of the rocket’s profile is very conservative. The STABILITY DETERMINATION program calculates lateral areas and separation distances for the nose, body, and fins using this technique.

The center of gravity should always be in front (toward the nose) from the center of pressure. Ideally, the distance between the CG and the CP should be equal to one body diameter. The body diameter is sometimes referred to as “caliber”.
Learn the names of the measurements referred to here. You will need to know these terms and have their measurements for your rocket to operate this program.



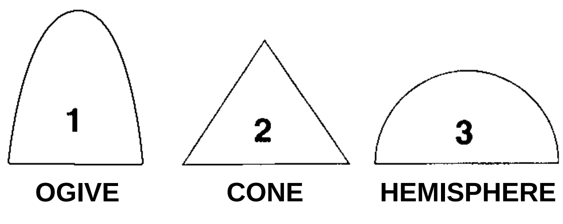
The sweep angle is measured in degrees. On a cutout of the fin, mark the midpoints of the root edge and the tip. Connect these two points with a straight line. The sweep angle is the angle between a line perpendicular to the rocket's long axis (Usually the body tube is parallel to the rocket's long axis.) and the line you just drew. Fins which are not swept will have 0 degrees of sweep. Fins will never have over 90 degrees of sweep.

The fin radial width is the distance from the tip edge of the fin to the body tube as measured perpendicular to the body tube.

The CG distance is the distance between the tip of the nose cone and the balance point of the rocket fully prepared for flight with payload, if any, and engine in place.

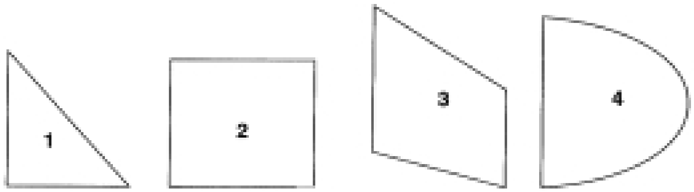
Remember the names of these basic nose cone shapes.

NOSE CONE SHAPES



FIN PROFILE SHAPES

Remember the names of these four basic fin shapes.



TRIANGLE RECTANGLE TAPERED ELLIPTICAL

STABILITY DETERMINATION EXAMPLE

Boot the disk. If you have been using another program on the disk, type NEW. This will clear the old program from the computers memory. Type RUN STABILITY DETERMINATION. As the program runs, supply the data as given in this example to see a test run of the program to help you become familiar with it.

STABILITY DETERMINATION PROGRAM
BY MICHAL L. GASPERI
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ENTER ALL DIMINSIONS IN INCHES
BODY TUBE DIAMETER
?.976
BODY TUBE LENGTH
?.7.75
NOSE SHAPE NUMBER
1)OGIVE 2)CONE 3)HEMISPHERE
?1
OGIVE NOSE LENGTH
?2.75
FIN ROOT LENGTH
?2.25
FIN RADIAL LENGTH
?1.6
NUMBER OF FINS (3 OR 4)
?3
FIN PROFILE SHAPE NUMBER
1) TRIANGLE 2)RECTANGLE 3)TAPERED 4)ELLIPTICAL
?3
TAPERED FIN LENGTH
?1.2
SWEEP ANGLE (DEGREES)
?35
CP IS 6.913974 INCHES DOWN FROM THE NOSE TIP
CG DISTANCE FROM NOSE TOP:
?6.2
STABILITY CRITERIA = .7315303 CALIBERS

The DYNAMIC STABILITY program permits you to make a more precise estimation of the rocket's Center of Pressure. To do this many more measurements must be entered. Some of these measurements are available from the Estes catalog. Others must be determined by you.

The output from this program provides you with very good approximations of the total length, total weight, center of gravity and center of pressure (as distances from the tip of the nose cone), stability in calibers, fin surface area, damping ratio, and coupled damping ratio.

A rocket which is disturbed from its flight path should return to this flight path if is it stable. It normally swings back and forth as it returns to its original flight path. This oscillation occurs about its Center of Gravity. The damping ratio is a measure of how well and how fast it returns to it's original flight path.

An underdamped rocket may return to its original vertical flight path too quickly and undershoot. An overdamped rocket will stabilize too slowly and may be flying in a new direction causing excessive weathercocking (flying into the wind). Overdamped rockets have the CG too far ahead of the CP.

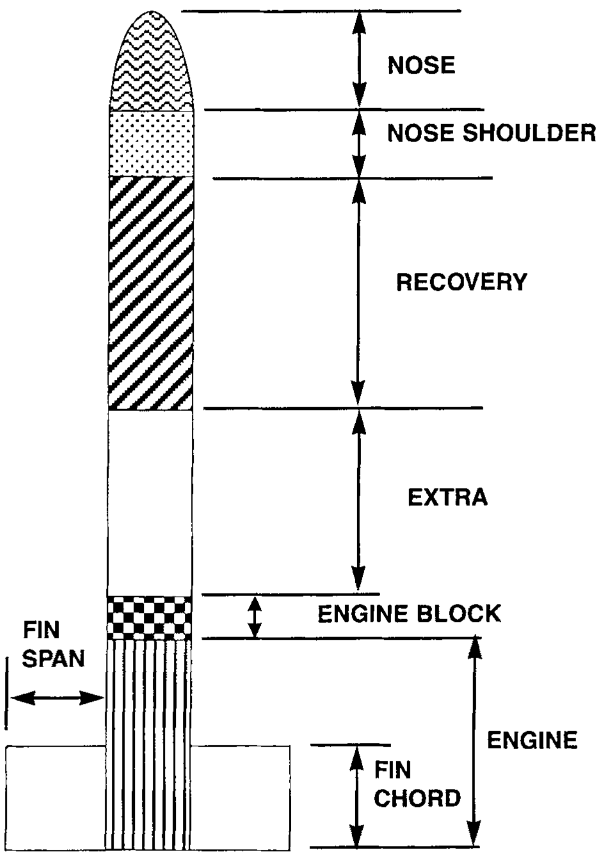
The damping ratio should be less than .3, and the coupled damping ration should be more than .05.

A rocket may be statically stable but may be underdamped to stop oscillations quickly. Oscillations mean that the rocket is flying at an angle of attack much of the time, producing high drag.

The DYNAMIC STABILITY program permits you to adjust fins or extra length easily to rerun the program.

WT/LEN OF BT is weight per length of body tube.

Location of Various Dynamic Stability Input Variables



No example run is provided for the DYNAMIC STABILITY program. Type RUN “DSTABLE”. Enter the variables as called for by the screen prompts to run the program for your rocket. The program will calculate for you the stability of your rocket as measured by the distance between the rocket’s CG and CP. The ideal is + 1.0 caliber of stability. Since this program’s results are not always precise because of the assumptions made, your rocket will usually be safe if the stability is anywhere from + 1 to - 1.

DRAG - INTRODUCTION

Drag is a force which resists the movement of the object past the molecules of the air.

Drag is created by the movement of the object past the molecules of the air.

All objects experience drag as they move through fluids. The drag force opposes the forward motion of the object.

Gases, like air, and liquids are fluids.

The amount of drag created by the movement of an object through the air depends mainly upon:

1. Shape of the object
2. Size of the object
3. Smoothness of the surface of the object
4. Velocity or speed of the object
5. Structures attached to the object

The PERFORMANCE PREDICTION program and the OPTIMUM WEIGHT PROGRAM require that you know the coefficient of drag of your model rocket. You can calculate an estimate of the coefficient. This calculation is tedious and provides only a “best estimate”.

You can use this estimate as the drag coefficient, but you can secure a more accurate value if you can provide the apogee from a tracked flight with a known engine.

The DRAG PREDICTION program uses the information you provide about your model rocket to calculate an estimated drag coefficient. This program works well with simple models, but some models have too many irregular structures to permit this program to work with high reliability.

If you can provide an accurate apogee from a tracked flight with a known engine, then the DRAG ESTIMATION program will use this data to provide a reliable estimate of the drag coefficient. The program does this by starting with a very low drag coefficient and repeating the calculations over and over with slightly higher drag coefficients until the estimated height equals the measured height.

Basic information about nose cone shapes, fin profile shapes, fin edge shapes, rocket measurements, etc. are presented here. Study the drawings carefully as you will need this information to successfully use the DRAG PREDICTION program.

You will also need an Estes catalog with the specifications for the model rocket engines you will use or have used.

SPECIAL SECTION

VARIABLES USED IN THE PROGRAM

These definitions are provided for the convenience of those who wish to understand the programs and how they work. The listings provide identification for most of the factors used in the programs. You do not need to learn these symbols unless you TYPE or PRINT the programs and want to try to understand the formulas written in the program. You will not even see these symbols during normal use of the programs.

Please refer to Technical Report TR-10 Altitude Prediction Charts (EST 2842) or Technical Report TR-11 Aerodynamic Drag of Model Rockets (EST 2843) published by Estes Industries and similar publications for more information about formulas. Please do not write or call asking for help in interpreting formulas.

Apogee Determination

D	Baseline distance in feet
A	Apogee angle in degrees

Stability Determination

A	Sweep angle of fins in degrees
C	CP (center of pressure) distances from nose tip
D	Body tube diameter
G	CG (center of gravity) distance from nose tip
I	Nose shape number or fin profile shape number
J	Number of fins
L	Body tube length
M(1)	Body mass
M(2)	Nose mass
M(3)	Fin mass
N	Nose length
R(1)	Body moment distance
R(2)	Nose moment distance
R(3)	Fin moment distance
S	Stability criteria in calibers (body diameters)
W	Fin radial width
X	Tapered fin tip length
Y	Fin root length

Dynamic Stability

A	Fin chord length
B	Fin span length
BO	Body tube length
C1	Corrective moment coefficient
C2	Damping moment coefficient
CA	Aerodynamic damping moment coefficient
CD	Coupled damping ratio
CF	Fin aerodynamic force coefficient
CG	Center of gravity location
CN	Nose cone aerodynamic force coefficient
CR	Jet damping moment coefficient
CS	Calibers (body diameters) of stability
CT	Total aerodynamic force coefficient
D	Damping ratio
DE	Engine block inside diameter
DI	Body tube inside diameter
DT	Body tube outside diameter
EX	Extra tube length
FD	Fin material density
FT	Fin thickness

GB	Engine block CG(center of gravity)
GE	Engine CG
GF	Fin CG
GG	Recovery system CG
GN	Nose cone shoulder CG
GP	Propellant CG
GS	Nose cone shoulder CG
GY	Body tube CG
I	Total radial inertia
IB	Engine block radial inertia
IE	Engine radial inertia
II	Fin radial inertia
IN	Nose cone radial inertia
IR	Recovery system radial inertia
IS	Nose cone shoulder radial inertia
IY	Body tube radial inertia
K	Density of air *.5 *PI
RE	Engine block inside radius
RT	Body tube outside radius
TB	Engine burn time
TL	Total length
TW	Total weight
V	Velocity
WB	Engine block weight
WE	Engine Weight
WF	Weight of fins
WI	Engine initial weight
WN	Nose cone weight
WP	Propellant weight
WR	Recovery system weight
WS	Nose cone shoulder weight
WT	Body tube weight/length
WY	Total body tube length
XB	Engine block length
XE	Engine length
XN	Nose cone length
XR	Recovery system length
XS	Nose cone shoulder length
Y	Total longitudinal inertia
YB	Engine block longitudinal inertia
YE	Engine longitudinal inertia
YF	Fin longitudinal inertia
YN	Nose cone longitudinal inertia
YR	Recovery system longitudinal inertia
YS	Nose cone shoulder longitudinal inertia
YY	Body tube longitudinal inertia
Z	Center of pressure location
ZF	Fin aerodynamic force location
ZN	Nose cone aerodynamic force location

Drag Prediction

A	Body cross-sectional area
B	Body tube length
C(1)	Body plus nose drag coefficient
C(2)	Base drag coefficient
C(3)	Lug drag coefficient for 5/32 inch diameter lug
C(4)	Fin surface drag coefficient
C(5)	Fin interference drag coefficient
C(6)	Total drag coefficient
D	Body tube diameter
E	Fin drag coefficient, 0 lift

F	Flow friction factor
H	Fin chord
I	Nose shape, base shape, or fin profile shape number
J	Loop counter
K	Total area ratio
L	Total length
M	Number of fins
N	Nose length
O	Nose area ratio
P	Body area ratio
Q	Finish quality number
R	Reynolds number at 100 ft/sec, sea level, 70° F
S	Fin surface area
T	Fin thickness
U	Launch lug length
W	Fin radial width
X	Tapered fin length
Y	Fin root length
Z	Base diameter of boattail, narrow end

Drag Estimation, Performance Prediction, and Optimum Weight

A	Drag free acceleration
B	Ballistic coefficient thrusting or coasting
C	Estimated drag coefficient
D	Rocket diameter
E	Engine total impulse in lb-sec
H	Total altitude in feet
I	Engine initial weight in oz
K	Coast time in sec
L	Engine thrust duration in sec
M	Cross-sectional area of rocket
P	Engine propellant weight in oz
Q	Measured apogee altitude in feet
R	Rocket weight without engine in oz
S	Burnout altitude in feet
T	Average thrust in oz
V	Burnout velocity in ft/sec
W	Average weight during thrusting or coasting
Z	Coasting distance in feet
FN S(X)	Hyperbolic sine function
FN C(X)	Hyperbolic cosine function
FN T(X)	Hyperbolic tangent function

Flight Simulation

AF	Apogee flag
BT	Burn time in time intervals
CD	Coefficient of drag
CM	Casing and nozzle mass in grams
CT	Coast time in time intervals
DM	Delay material mass for 1 second delay in grams
DT	Time step size in seconds
EM	Total engine mass
ET	Total burn and coast time in time intervals
F(I)	Force of engine at time interval I Burnout is indicated by 0.0 thrust
FM	Conversion factor from metric to English
FR	Length of sustained burn in time intervals
G	Force of gravity
I	A loop counter
J	A derived variable, used as a marker
K	Drag parameter
M	Total mass of rocket

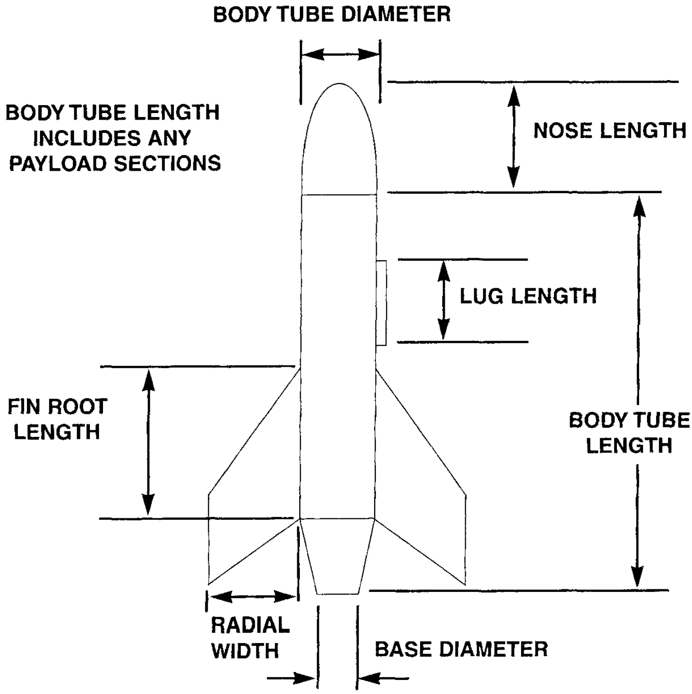
N$	Engine type entered as a “string”
PM	Propellant mass in grams
RD	Rocket’s maximum diameter in inches
RH	Density of air
RM	Rocket mass
RW	Rocket weight without engine in ounces
T	Launch site temperature
TD	Ejection time delay
TI	Total impulse
V	Velocity
Z	Instantaneous altitude

Elliptical Fin Design

A	Span length
R	Root length
T	Sweep angle in degrees
FN R(Z)	Round-off function

Model Rocket Design, both versions

A	Cross-sectional area of body tube
B	Reynolds number
BT	Body tube type
C(1)	Drag, nose and body
C(2)	Drag, base
C(3)	Drag, launch lug
C(4)	Drag, fin surface
C(5)	Drag, fin interference
C(6)	Total coefficient of drag
D	Outside diameter of body tube
F	Turbulent flow friction factor
G(1)	Weight of nose cone
G(2)	Weight of payload section
G(3)	Payload weight
G(4)	Weight of nose cone block separating payload section from body
G(5)	Weight of Body
G(6)	Weight of engine mount for regular engine in large body tube
G(7)	Engine weight
G(8)	Weight of fins
G(9)	Total weight of rocket
I	Nose number
J	Number of fins
K	Total area ratio
L	Total length
M	Cross-sectional area of parts as a cardboard cutout
MR	Sum of the moments
N	Nose cone length
O	Nose area ratio
P	Body area ratio
Q	Fin sweep angle in degrees
R(1)	Distance from nose tip to CG of hose as cardboard cutout
R(2)	Distance from nose tip to CG of payload section as cardboard cutout
R(5)	Distance from nose tip to CG of body as cardboard cutout
R(8)	Distance from nose tip to CG of fins as cardboard cutout
R(9)	Distance from nose tip of CG of nose center of pressure as cardboard cutout
S	Fin surface area
T	Fin thickness
U	Payload tube length
V	Body tube length
W	Fin radial width
Y	Fin root length
Z	Location of CG relative to tip of nose cone



You will also need to know the maximum thickness of the fins on your model rocket.

If you use tapered fins, you will need to know the length of the tip of the fin.

The DRAG PREDICTION program will provide you with a list of the drag coefficients of five different parts of the rocket as well as with the total drag coefficient and the coefficient of drag times in the area. This permits you to determine which factors in the drag are the largest so that you can concentrate your efforts in reducing drag on these factors.

DRAG PREDICTION EXAMPLE

Run the program. Supply the numbers involved after the question marks for a sample run of the program. Then rerun the program with figures for your model rocket to predict its drag.

DRAG PREDICTION
BY MICHAEL L. GASPERI
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ENTER ALL DIMENSIONS IN INCHES.
BODY TUBE DIAMETER
?.976
NOSE SHAPE NUMBER
1) OGIVE 2) CONE 3) HEMISPHERE
?1

OGIVE NOSE LENGTH
?2.75
BODY TUBE LENGTH
?7.75
FINISH QUALITY NUMBER
1) NONE 2) GOOD 3) EXCELLENT
?2
BASE SHAPE NUMBER
1) BLUNT 2) BOAT TAIL
?1
LAUNCH LUG LENGTH
?1.5
FIN THICKNESS
?.093
FIN ROOT LENGTH
?2.25
FIN RADIAL WIDTH
?1.6
NUMBER OF FINS
?3
FIN PROFILE SHAPE NUMBER
1) TRIANGLE 2) RECTANGLE 3) TAPERED 4) ELLIPTICAL
?3
TAPERED FIN LENGTH
?1.2
FIN EDGE SHAPE NUMBER
1) SQUARE 2) ROUNDED 3)STREAMLINED
?1

COMPONENT	DRAG COEFFICIENT
NOSE + BODY	.2016076
BASE	6.458691E-02
FIN SURFACE	.4002668
FIN INTERF.	.1592366
LAUNCH LUG	1.704202E-02
TOTAL CD	.84274
CD* AREA	.6304967

DRAG ESTIMATION EXAMPLE

DRAG ESTIMATION PROGRAM
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ENTER ENGINE TOTAL IMPULSE (LB-S)
?.56
ENTER ENGINE THRUST DURATION (S)
?.32
ENTER ENGINE INITIAL WEIGHT (OZ)
?.57
ENTER ENGINE PROPELLANT WEIGHT (OZ)
?.11
ENTER ROCKET WEIGHT W/O ENGINE (OZ)
?.80

ENTER ROCKET DIAMETER (IN)
?.976
ENTER MEASURED APOGEE ALTITUDE (FT)
?354

At this point the program iterates (repeats with small changes) until the solution sought is reached. Then the program stops with the correct answers appearing last.

ESTIMATED DRAG COEF. = 0.7500001
BURNOUT ALTITUDE = 32.77386 FT
BURNOUT VELOCITY = 200.8701 FT/S
COASTING DISTANCE = 321.2101 FT
TOTAL ALTITUDE =353.9839 FT
COASTING TIME = 4.032285 S
FINAL ESTIMATED DRAG COEF. = 0.7500001

PERFORMANCE PREDICTION - INTRODUCTION

This program predicts the performance which your model rocket should deliver.

You will be asked to supply information about the performance of the model rocket engine (total impulse, thrust duration in seconds, initial weight, and propellant weight), so have your catalog or technical specifications (as Estes Technical Note TN-1, “Model Rocket Engines” from The Classic Collection) handy.

You will be asked to give the drag coefficient for your model rocket. Other programs on this disk help you to supply an accurate drag coefficient.

You will also be asked to give the rocket’s body diameter in inches.

This program also tells you the estimated coasting time so that you may pick an engine with the appropriate delay.

As in the other programs, the formulas used in this program assume a number of things about flight conditions and aerodynamic drag. Some of these assumptions limit the usefulness of the programs. For example, in this program the predictions are not accurate for burnout velocities above 700 FT/S. The engine thrust is treated as a constant over the entire burn time, so the program may predict that a heavy rocket would not leave the launch rod while it actually would.

PERFORMANCE PREDICTION EXAMPLE

Use the same procedure as described earlier to run this example program. The data is based on an Alpha to be launched with an A8-3 engine.

PERFORMANCE PREDICTION
BY MICHAEL L. GASPERI
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ENTER ENGINE TOTAL IMPULSE (LB-S)
?.56
ENTER ENGINE THRUST DURATION (S)
?.32
ENTER ENGINE INITIAL WEIGHT (OZ)
?.57
ENTER ENGINE PROPELLANT WEIGHT (OZ)
?.11
ENTER ROCKET WEIGHT W/O ENGINE (OZ)
?.80
ENTER ROCKET DIAMETER (IN)
?.976
ENTER ROCKET DRAG COEF. (.75 IS TYPICAL)
?.75
BURNOUT ALTITUDE = 32.77387 FT

BURNOUT VELOCITY = 200.8701 FT/S
COASTING DISTANCE = 321.2101 FT
TOTAL ALTITUDE = 353.984 FT
COASTING TIME = 4.032286 S

OPTIMUM WEIGHT - INTRODUCTION

The height achieved by a model rocket may sometimes be increased by making the rocket weigh more!

This is possible because a ‘heavy’ rocket may have more momentum at burnout to compensate for the drag it will experience during coasting. In other words, a heavier rocket will sometimes outperform a rocket which is identical except that it is lighter.

Have your Estes catalog and/or other reference handy when you run this program because you will be asked for information about the model rocket engine (total impulse, thrust duration, initial weight, and propellant weight).

You will also need to know the diameter of your rocket and the drag coefficient of your rocket. Other programs on this disk are useful in accurate calculation of the drag of your model rocket.

This program works by calculating the height which your rocket should reach if it weighed 0 ounces. Then the program repeatedly calculates the height the rocket should reach if it weighed .1 ounce more, etc. The “answer” provided is the “answer” calculated just before adding weight causes the total height reached by the rocket to decrease.

For many rockets the optimum weight will be zero because the engine weight alone is greater than the total optimum value.

OPTIMUM WEIGHT PROGRAM EXAMPLE

OPTIMUM WEIGHT PROGRAM
BY MICHAEL L. GASPERI
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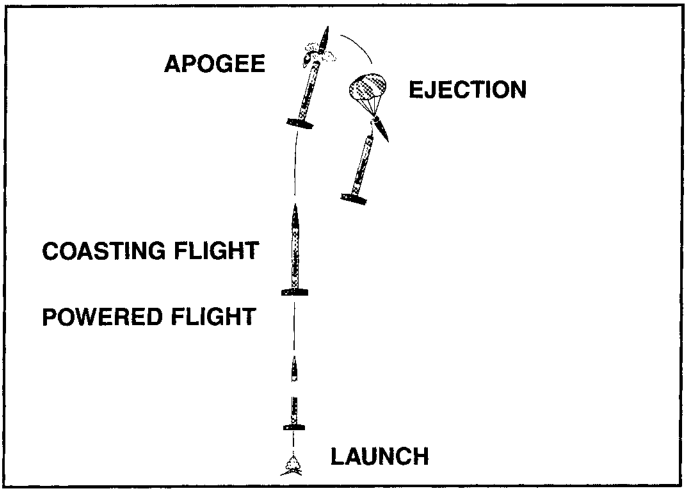
ENTER ENGINE TOTAL IMPULSE (LB-S)
?1.12
ENTER ENGINE THRUST DURATION (S)
?.6
ENTER ENGINE INITIAL WEIGHT (OZ)
?.68
ENTER ENGINE PROPELLANT WEIGHT (OZ)
?.22
ENTER ROCKET DIAMETER (IN)
?.976
ENTER ROCKET DRAG COEF. (.75 IS TYPICAL)
?.75
ROCKET WEIGHT W/O ENGINE = .6 OZ
BURNOUT ALTITUDE = 130.1376 FT
BURNOUT VELOCITY = 399.2259 FT/S
COASTING DISTANCE = 554.872 FT
TOTAL ALTITUDE = 685.0096 FT
COASTING TIME = 4.756476 S
THE OPTIMUM ROCKET WEIGHT W/O ENGINE = 0.5 OZ.

FLIGHT SIMULATION - INTRODUCTION

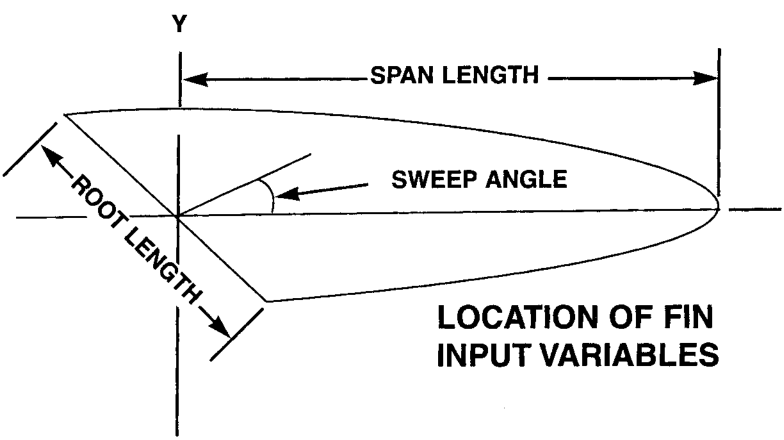


TYPICAL FLIGHT PROFILE

The FLIGHT SIMULATION program asks you for some basic data about your model rocket. Then the program calculates the probable performance of the rocket. The probable altitude of the rocket, its velocity, and its acceleration are provided at fraction of a second intervals for the entire flight from lift-off to ejection.

These predictions are provided for you in the form of a table. These predictions can be provided in either English or metric units, as you select.

Be ready to provide the engine type, it's time delay, the weight of the rocket without engine, the maximum diameter (body tube) of the rocket, it's drag coefficient (C_D), the air temperature at the launch site, and whether you want the results displayed in English or metric units at the appropriate prompts.



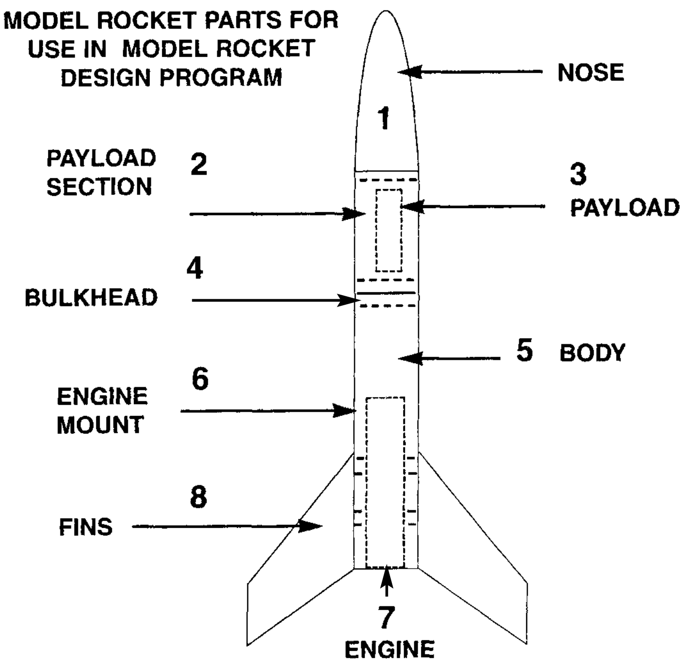
LOCATION OF FIN INPUT VARIABLES

ELLIPTICAL FIN DESIGN - INTRODUCTION

Elliptical fins are harder to make than fins with corners and square edges. Elliptical fins have lower aerodynamic drag than rectangular or tapered fins of the same size. They also look “fast”.

This program asks you to supply the root length in inches, sweep angle, and span length in inches of the elliptical fin you wish to design. Supply these three numbers and the computer provides you with the X and Y axis coordinates needed to plot the fin you want on the graph paper. Then connect these points with a smooth curve for the fin and a straight line for the root edge. You now have a pattern to cut out and use to make your own high-performance elliptical fins.

MODEL ROCKET DESIGN - INTRODUCTION



The ROCKET DESIGN STORED DATA or the ROCKET DESIGN INPUT VERSION programs enable you to determine the approximate performance of a model rocket you have not yet built. These programs can be used to predict the effect of changes to an existing model rocket.

Please read this entire introduction before attempting to use either program.

The programs require that you supply a great deal of information. Some of this information is available in the Estes catalog. Some of this information is available through making simple measurements. Some of the information is only through some careful measurements or estimates.

Either program requires extensive input of data. To make it easier for you to use, two versions of this program are available on this disk. Both utilize the same data, but one stores all of the information so that the program can be run repeatedly.

The version of this program which stores the data about your rocket is called ROCKET DESIGN STORED DATA. To see the effect of a change on the performance of the rocket, you need to list the program. Then reenter a new line for the line which you want to replace.

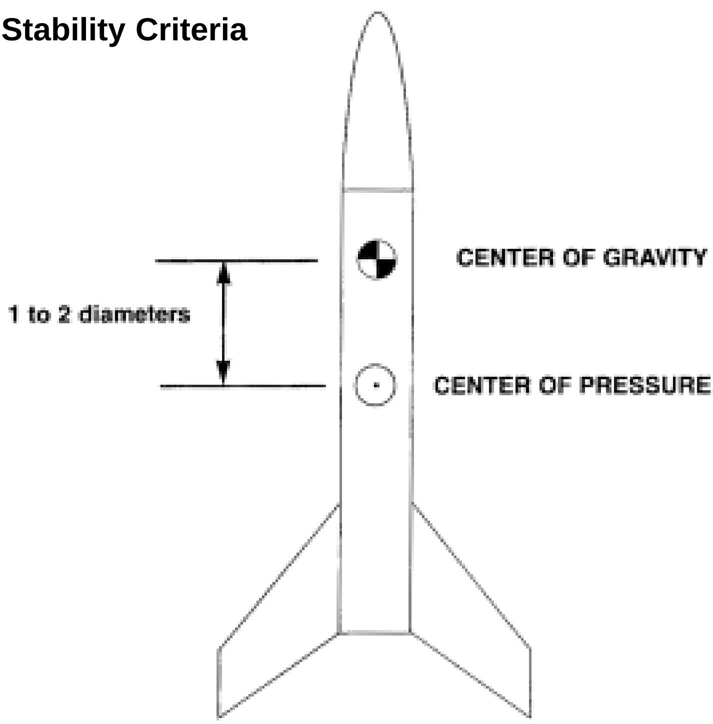
For example, type EDLIN MRDSD.BAS to edit ROCKET DESIGN STORED DATA, then use the usual EDLIN commands to alter the appropriate line to examine the effect of changing the body tube length of your rocket, then list the program. You will find that line 130 deals with V, the new length of your body tube. Save this change and exit EDLIN.

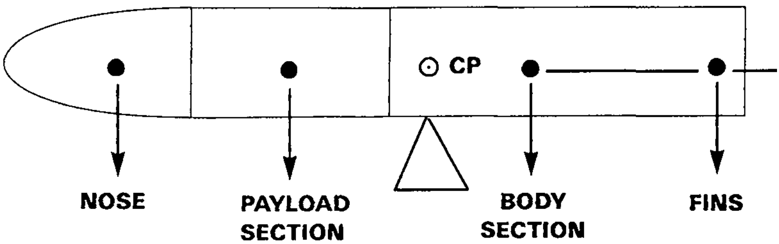
Now type RUN "MRDSD.BAS" and (RETURN). The program will run again, this time with new body tube length. The output will be altered to allow for the new body tube length. This method enables you to examine carefully the probable effect of making one change in the construction of your rocket.

This procedure can be repeated with different parts of the rocket to attempt to modify the design for maximum performance. Since the output identifies the drag for different components of the rocket, it is fairly easy to test the results of changes before you actually modify the model rocket.

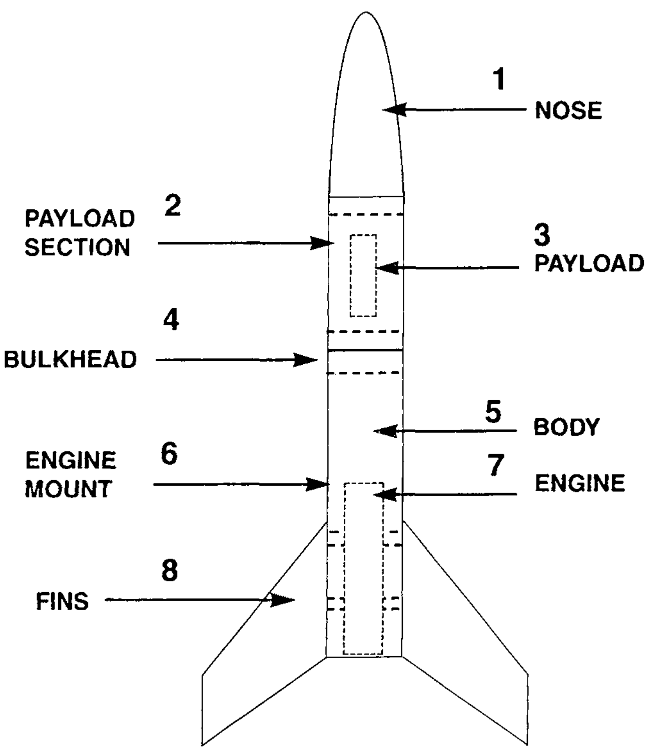
The other version of the program is called ROCKET DESIGN INPUT VERSION. The computations in this program are the same as those in the original version. This version requires that you type in over ten variables each time you run the program. Since there are no measurements stored from one run of this version to the next run, you do not need to worry about having to rewrite part of the program each time you use it.

Stability Criteria

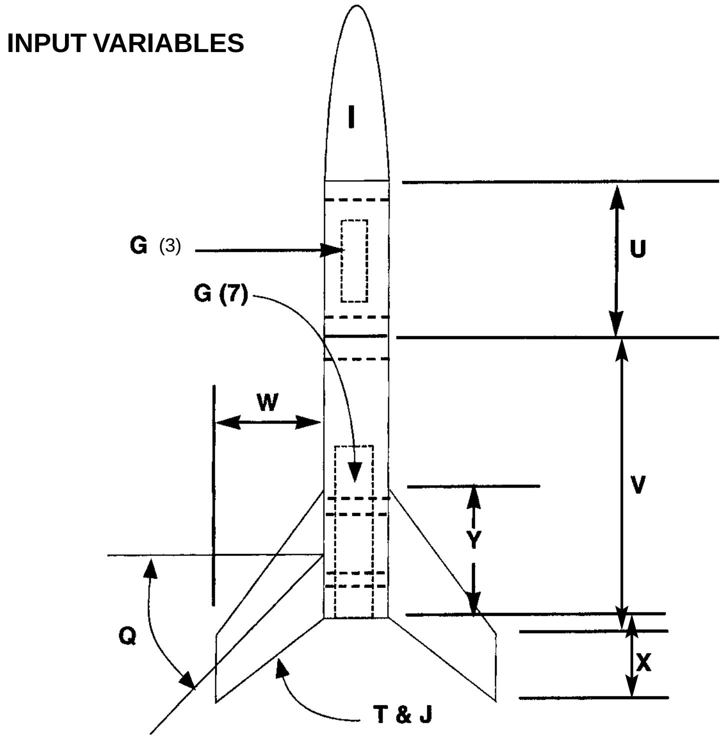




BALANCE OF LATERAL AREA TO ESTIMATE ROCKET'S CENTER OF PRESSURE



COMPONENTS AND THEIR NUMBERS AS USED IN THE PROGRAM



NOSE CONE REFERRED TO BY "I" NUMBERS:

1 = 20B	7 = 50Y
2 = 20R	8 = 55AC
3 = 20N	9 = 55AD
4 = 20Y	10 = 60MS
5 = 50J	11 = 60AH
6 = 50K	

If you wish to use the other version of the program, type "MRDIV.BAS" and (RETURN). You may now use the version of the program which requires you to reinput information each time the program is run.

Both programs provide excellent guidance in helping you with the theoretical design of your rocket. Find the best design, then build it. Then take it outdoors and launch it in the ultimate testing grounds-Mother Nature's Lab!

VARIABLES

If you TYPE or PRINT a program to help you understand how it operates, you will find the table of variables to be of great help. It is not necessary to TYPE or PRINT the programs unless you want to examine them in detail.