ROCKSIM 8.0 EDUCATIONAL GUIDE

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Introduction on how to use Rocksim 8.0

1. Overview of Rocksim 8.0

A. What is it?

RockSim is a powerful computer software tool that allows you to design any size rocket and then simulate its flight to see how high and how fast it will fly. You can also use it to find the best rocket motor combinations for your existing kits and to teach yourself and others about the physics of rocket flight. RockSim is a "Certified Educational Product," which is a special recognition given by the National Space Foundation to products used in educational environments that stimulate interest and knowledge about space. Over 900 schools throughout the USA are already using RockSim as part of their rocketry curriculum. It adds a level of safety, because the students can check to make sure their rockets are stable before they build them.

B. What Can It Do?

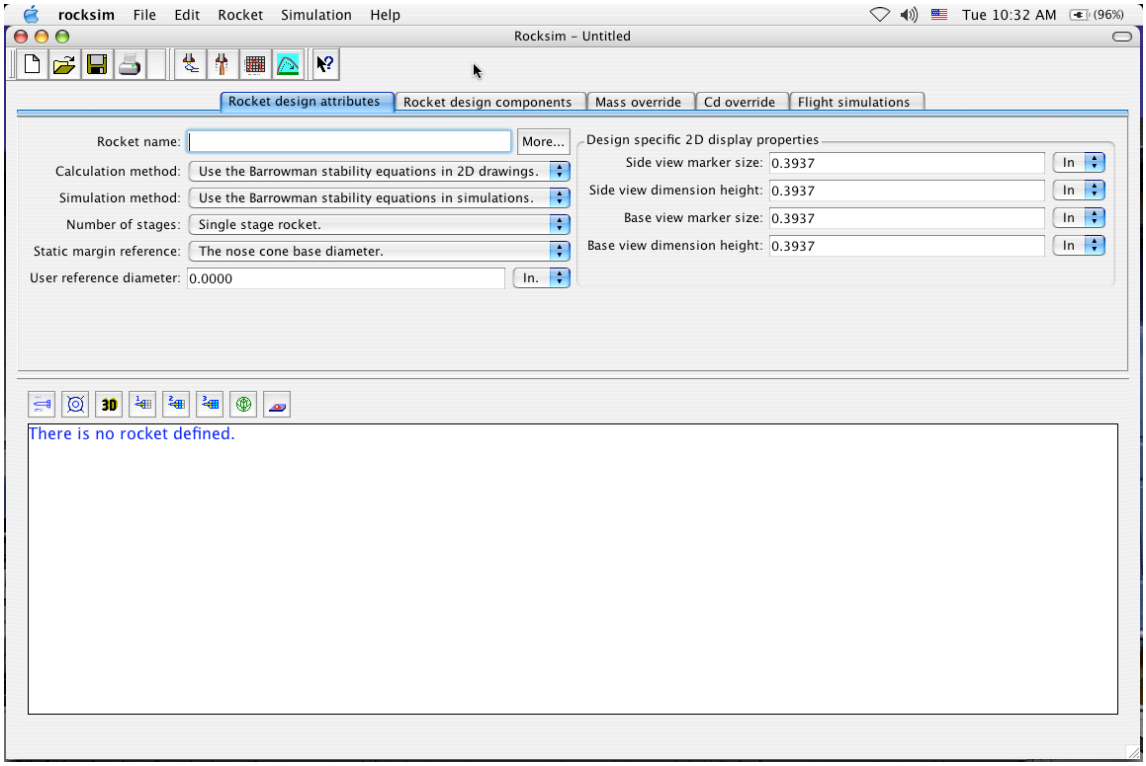
RockSim allows you to take your cool rocketry ideas, and flush out the concept to see if they'll be stable when you launch them. This is important, because you want to make sure all your homemade creations are safe. This process of selecting parts, and arranging them into a rocket to see if it will work is called "designing" a rocket. RockSim is for people that like to take control of the rocket design process. These are people, like you, that really want to know with certainty how their own rocket creations will fly. And you won't be limited to simple shapes and small rockets. You want it to have features that will allow you to try bigger, bolder, and more complex rockets. RockSim is a powerful tool from printing templates for parts and simulating flights to collecting and printing data.

C. How Versatile Is It?

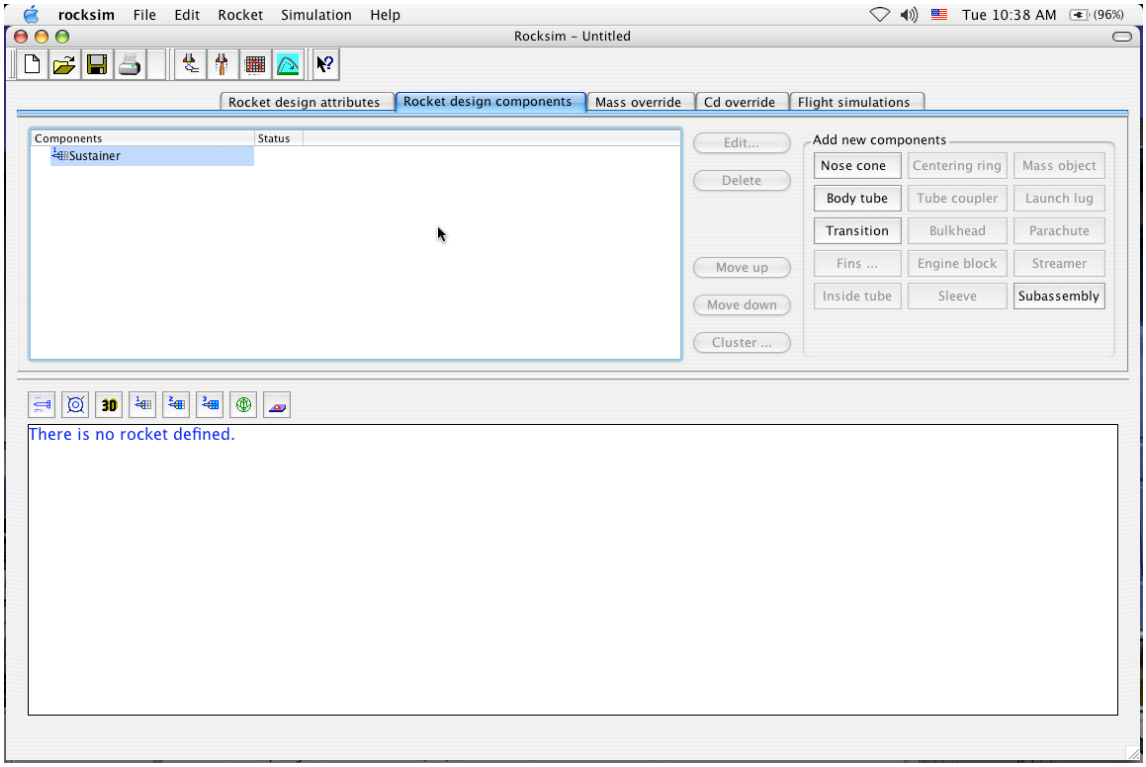
From the beginning, RockSim was created to be a true "Design Tool." With RockSim, you specify the components of the rocket (including all the rings and the recovery devices carried inside), and RockSim pre-calculates the weight of the rocket as you are in the process of designing it. At the same time, it is also calculating the CP location of the model and determining if the rocket will be stable. RockSim was the very first model rocket program to do this "on-the-fly" computation, and it revolutionized rocketry. Now you can make changes to your design, and see how the CP and CG are affected. But besides allowing you to design intricate rockets, RockSim will simulate the rocket's entire flight; from the launch trajectory to finding where they land. Besides being able to pick components, you can design your own custom parts.

D. The different screens

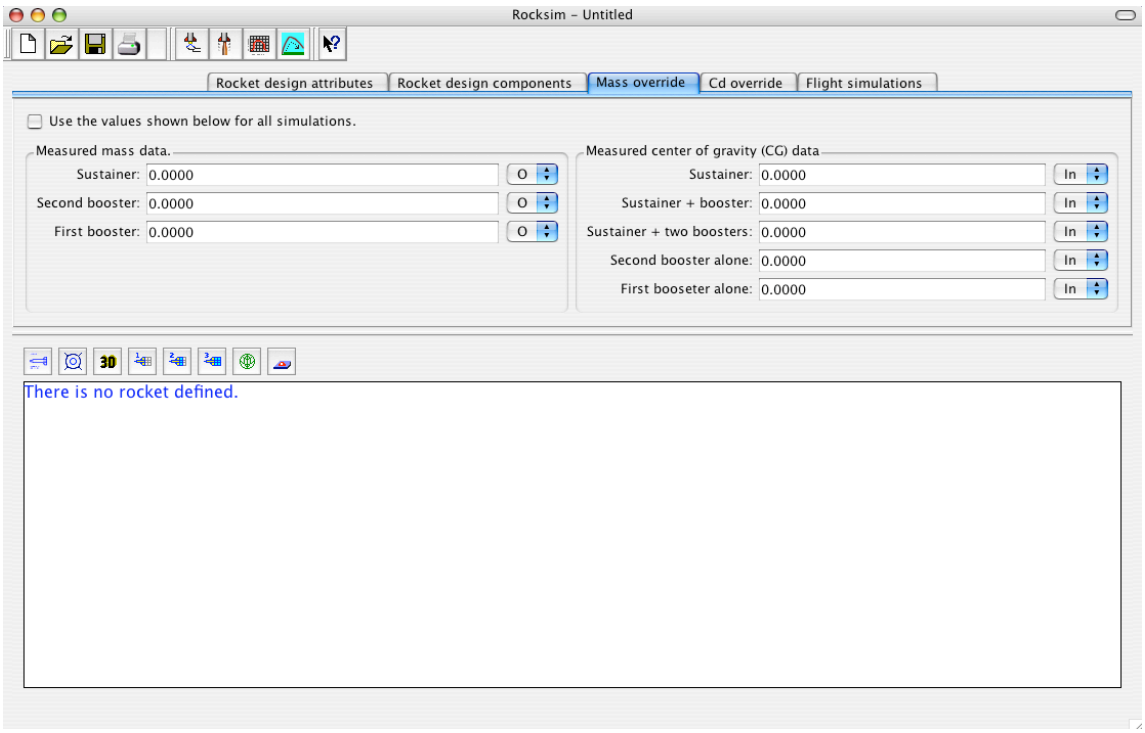
1. The main screen has a place where you may name the design; indicate whether you want to use the Barrowman or Rocksim equations, and how many stages there are.



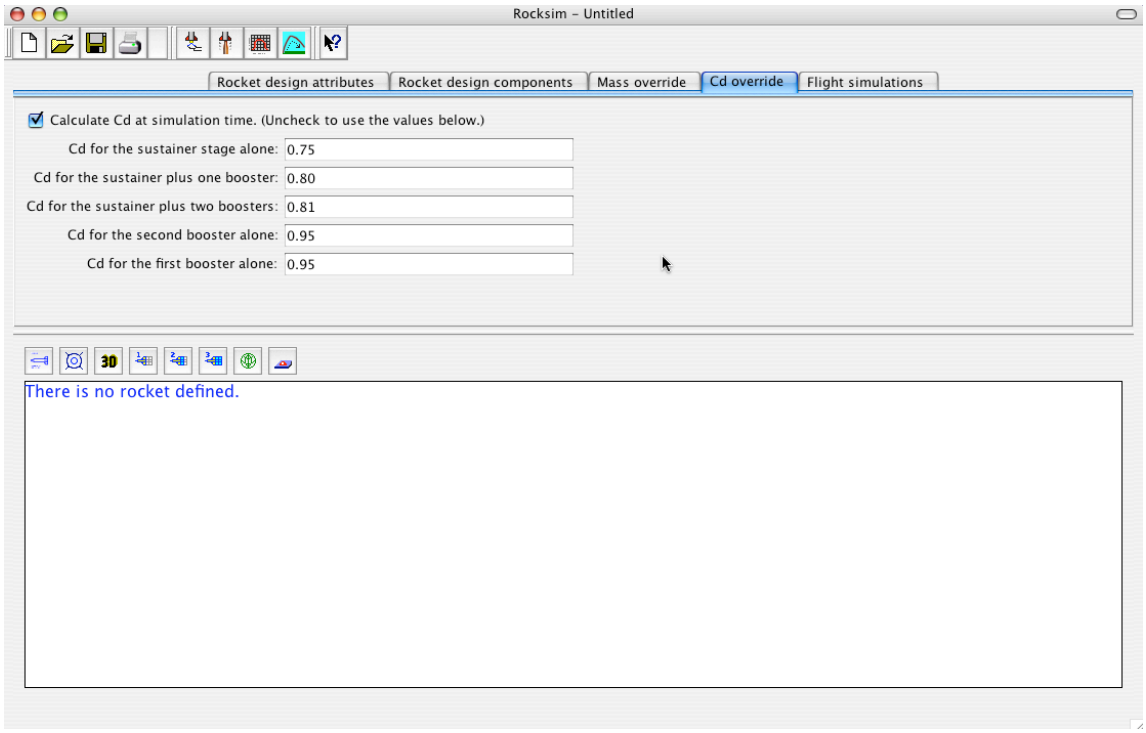
2. The rocket design components screen will constantly show you the different parts that make up your rocket and allow you to add new ones and edit existing ones.



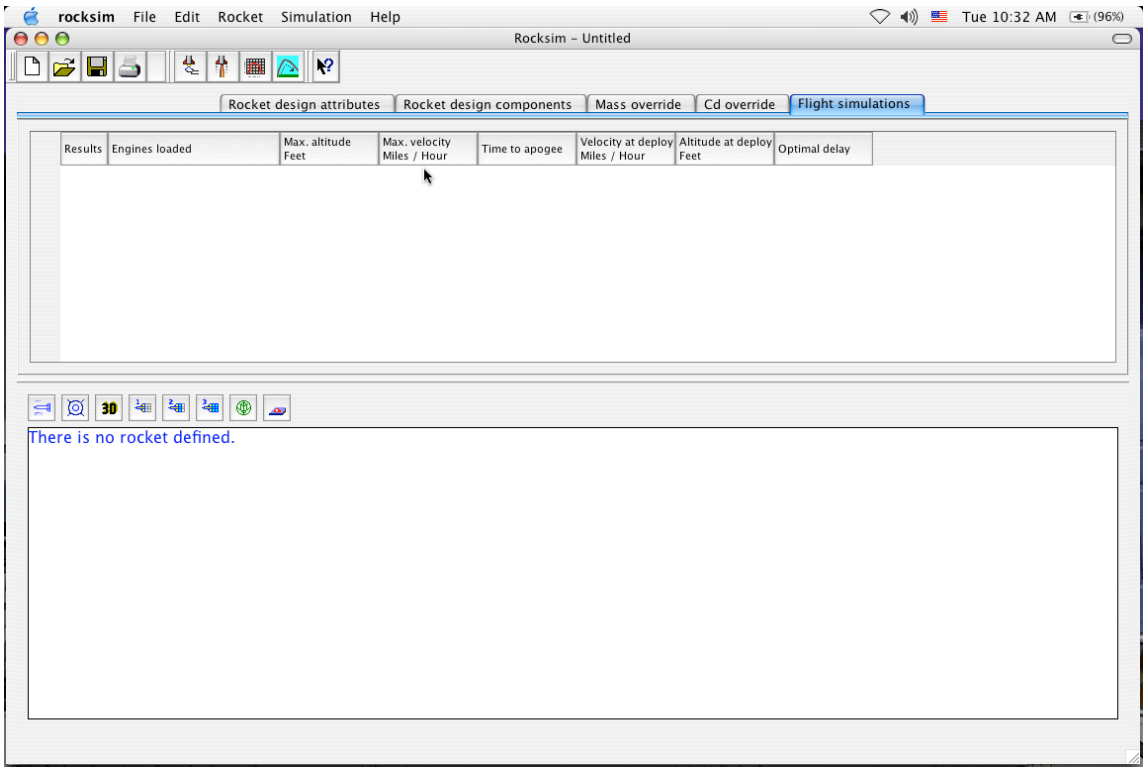
3. The "Mass Override" screen will, by default, attempt to calculate the mass and center of gravity for the rocket. If you wish to override these calculations, you can do so by selecting the "Use the values shown below for all simulations" option. This can be useful when you want to run a simulation against a partial rocket design, or to help find optimal engine configurations. The "Measured Center of Gravity" data is something that can be altered if you want to change where the actual CG is located by measurement in case it is different.



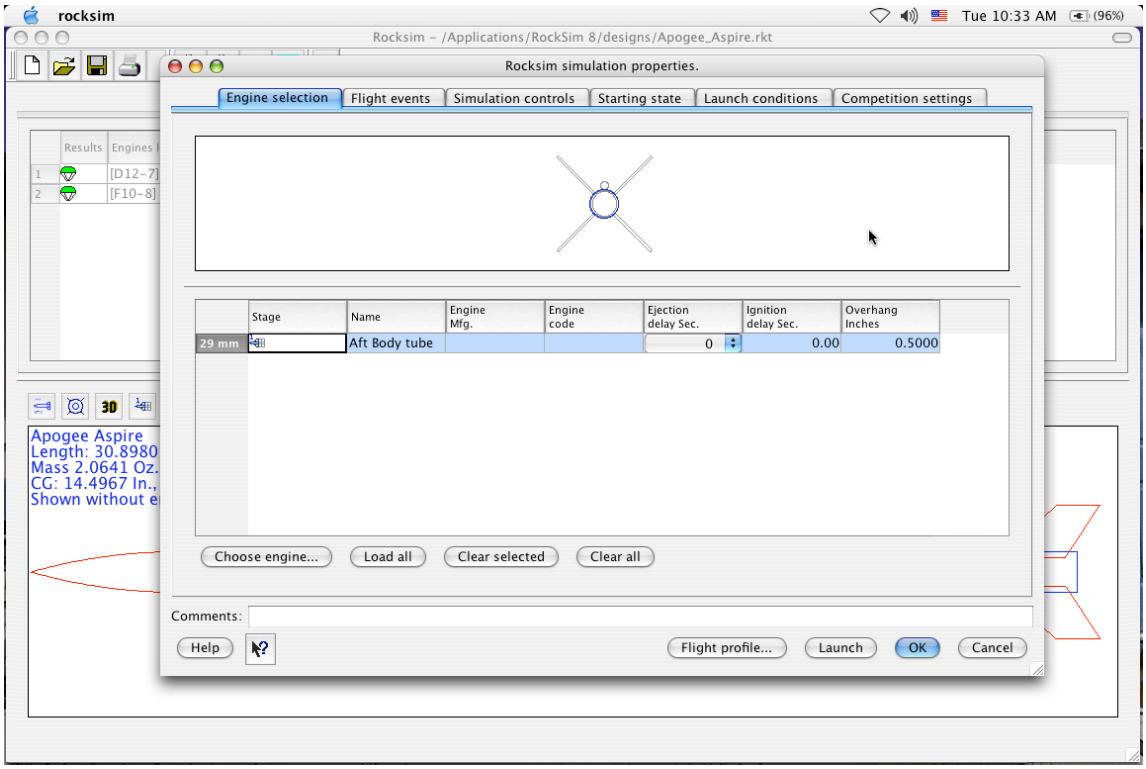
4. The "CD Override" screen is an option, if selected, which will enable the Cd prediction software in the simulator. The drag coefficient for the rocket design will be estimated at each iteration in the simulation. If you want to specify your own drag coefficient values, then you can uncheck this option.



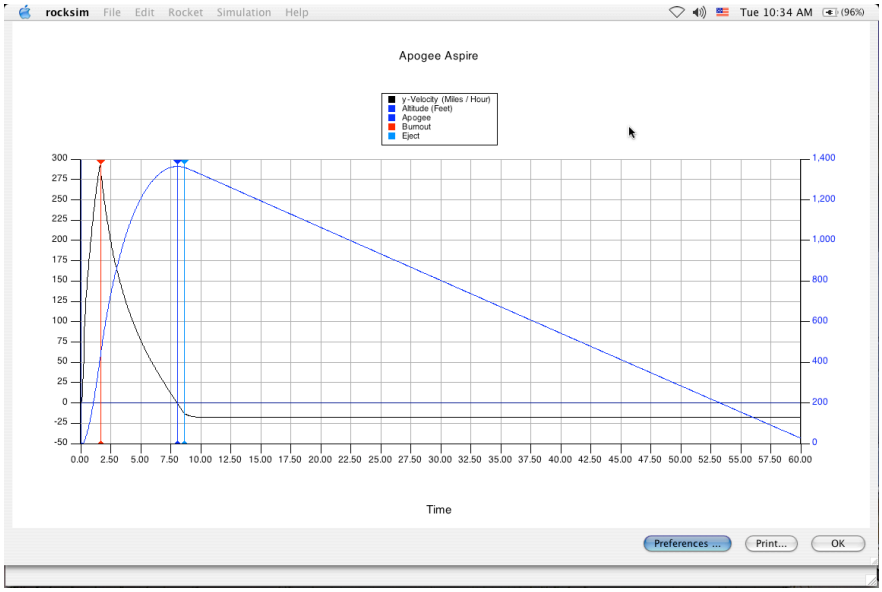
5. The flight simulations screen will show you the results of all the simulated flights that have been run.



6. The engine selection screen will indicate which motors can be loaded into the given design along with different delays. Also, controls such as launch angle, elevation, temperature, wind speed, and a variety of others can be set to suit your conditions.

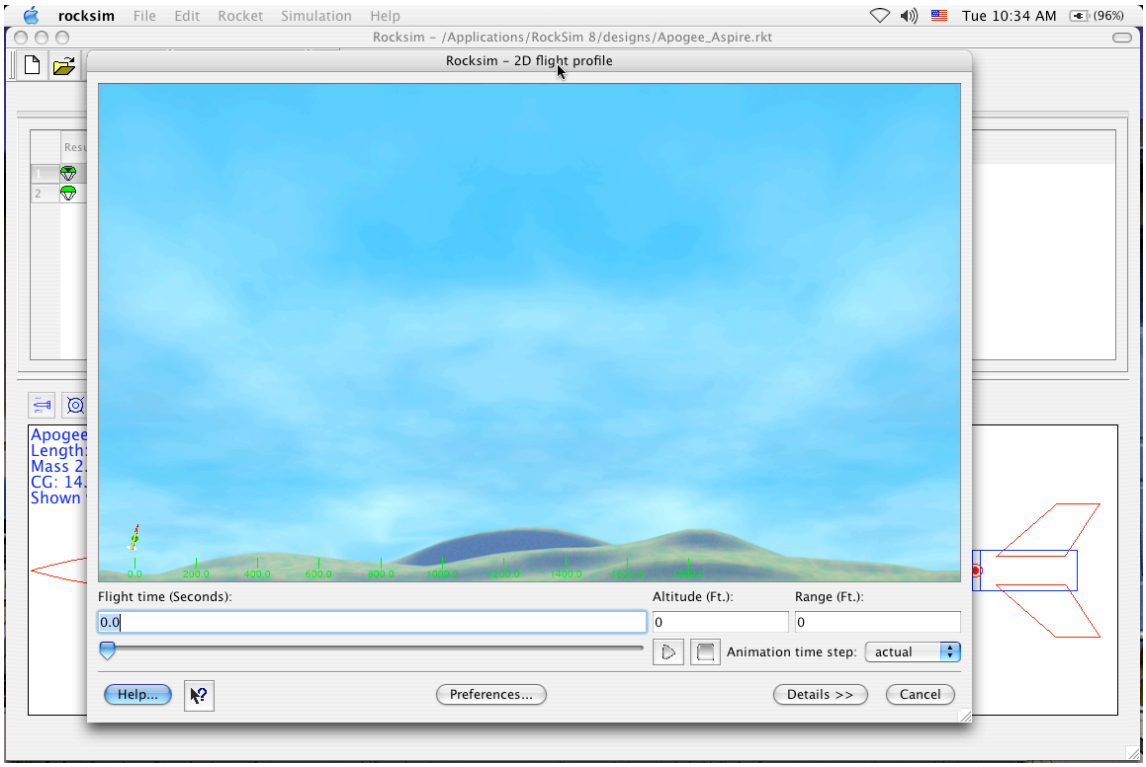


7. The graph screen will give you information on a variety of flight events such as peak altitude, speed, and time of deployment. Many types of graphs can be made and printed to suit you needs. Below on the right is only a partial list of the variables that can be used.

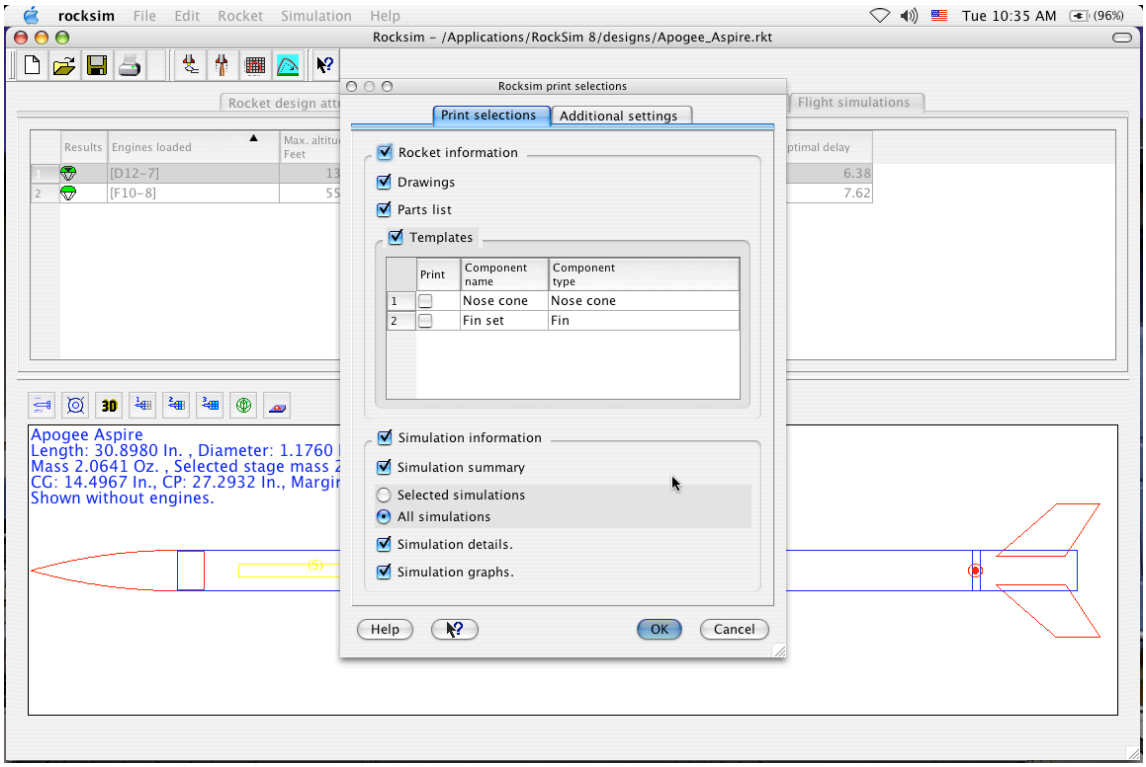


- ✔ Time
- Thrust
- x-Thrust
- y-Thrust
- Acceleration
- x-Acceleration
- y-Acceleration
- Acceleration Total
- x-Acceleration Total
- y-Acceleration Total
- Velocity
- x-Velocity
- y-Velocity
- Mach number
- Altitude
- Range
- Cd
- Drag force
- x-Drag force
- y-Drag force
- Longitudinal moment of inertia
- Radial moment of inertia
- Flight angle
- Gamma - Velocity tangent angle
- Wind angle of attack
- CG
- Mass
- CP
- CNa - normal force coefficient
- Static stability margin
- Angular acceleration
- Torque
- Pitch rate
- Pitch force
- x-Wind velocity
- Cross wind drag
- Cross wind lift

8. The 2D flight profile screen has some very nice features to it. It has the ability to create images of your particular rocket and then it will show you an animated flight of it. It is in this screen that you can turn on the details button that will bring up a sub-screen, which will display a running tally of many, many aspects of the rocket's flight.



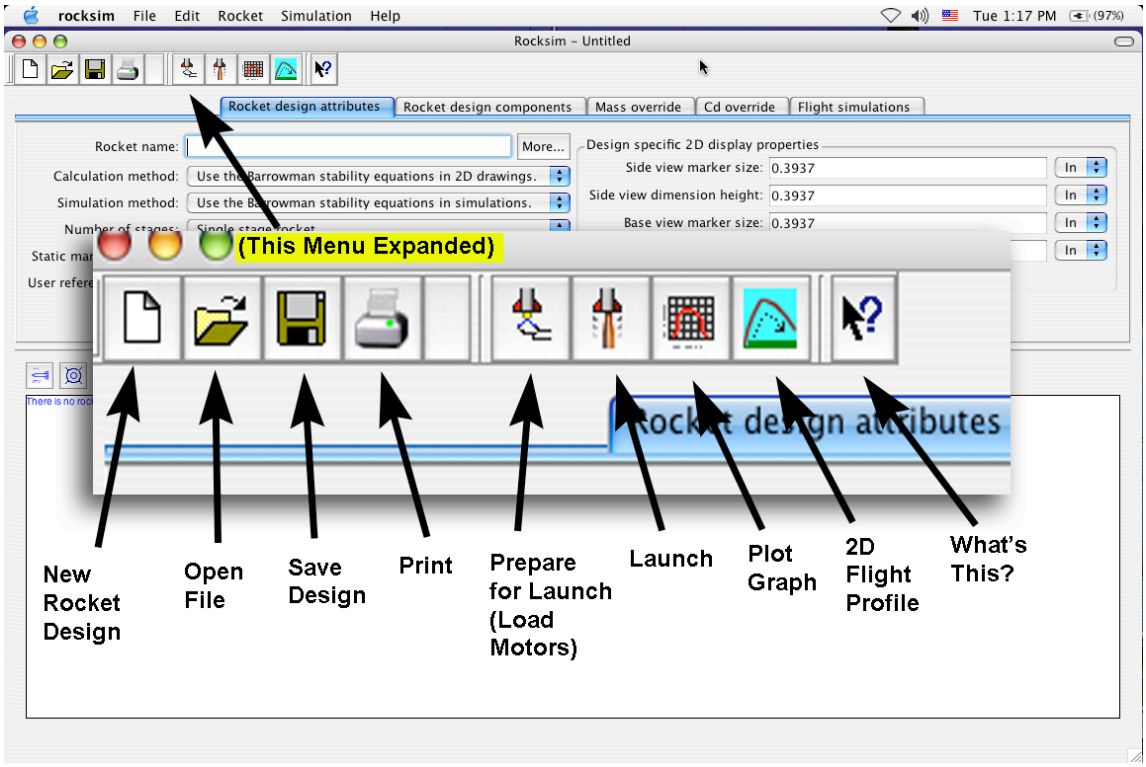
9. The print selections screen is where you have the ability to pick and choose which lists and/or components to print out. This would include templates of parts such as fins and centering rings, which can be used for cutting out parts.



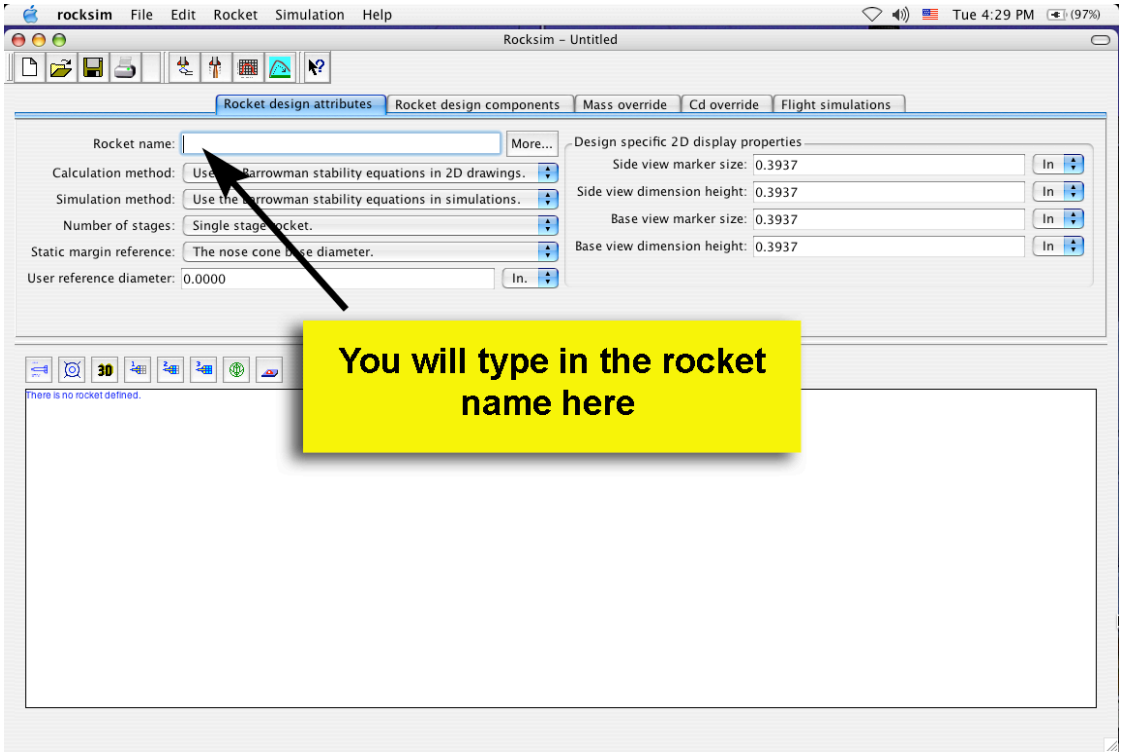
2. Creating a Rocket

A. Selecting a New Design

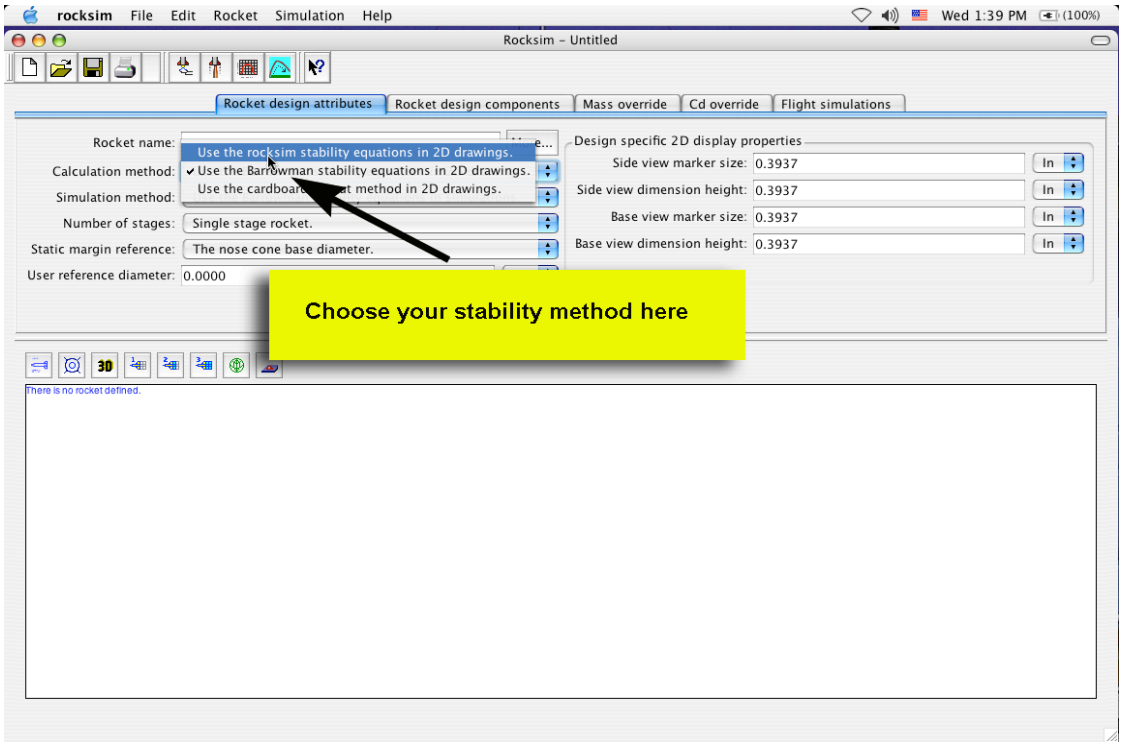
1. When RockSim opens up it will automatically begin in the "new design" screen where you can either create a rocket from scratch or open up an existing design from the RockSim database. On the main screen there are a variety of buttons and tabs to choose from. As you can see, they are labeled below:



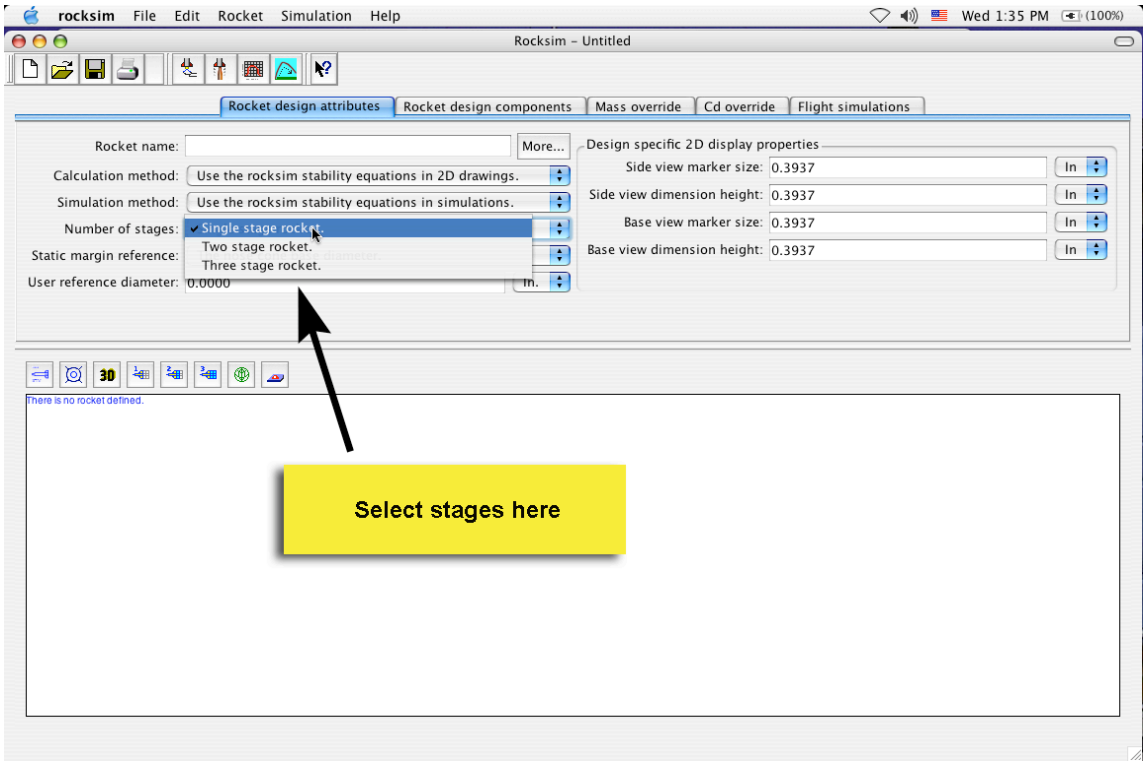
2. The first thing you will want to do is to name your rocket.



3. The next step is to choose the stability method that Rocksim will use for your design. It is recommended that you choose the "Rocksim" method due to the fact that the original Barrowman equations are figured by rounding off many figures where Rocksim uses the original equations, which makes it more accurate.

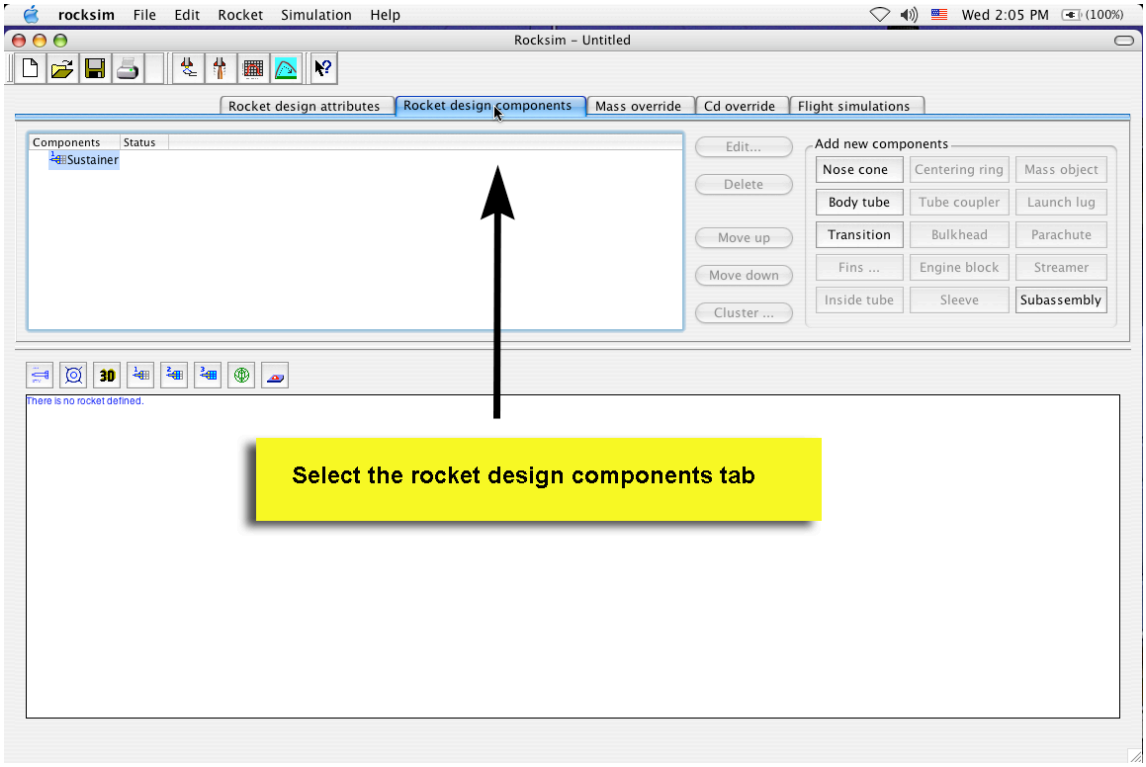


4. Next you will select how many stages your design will be. You are able to select up to three stages.

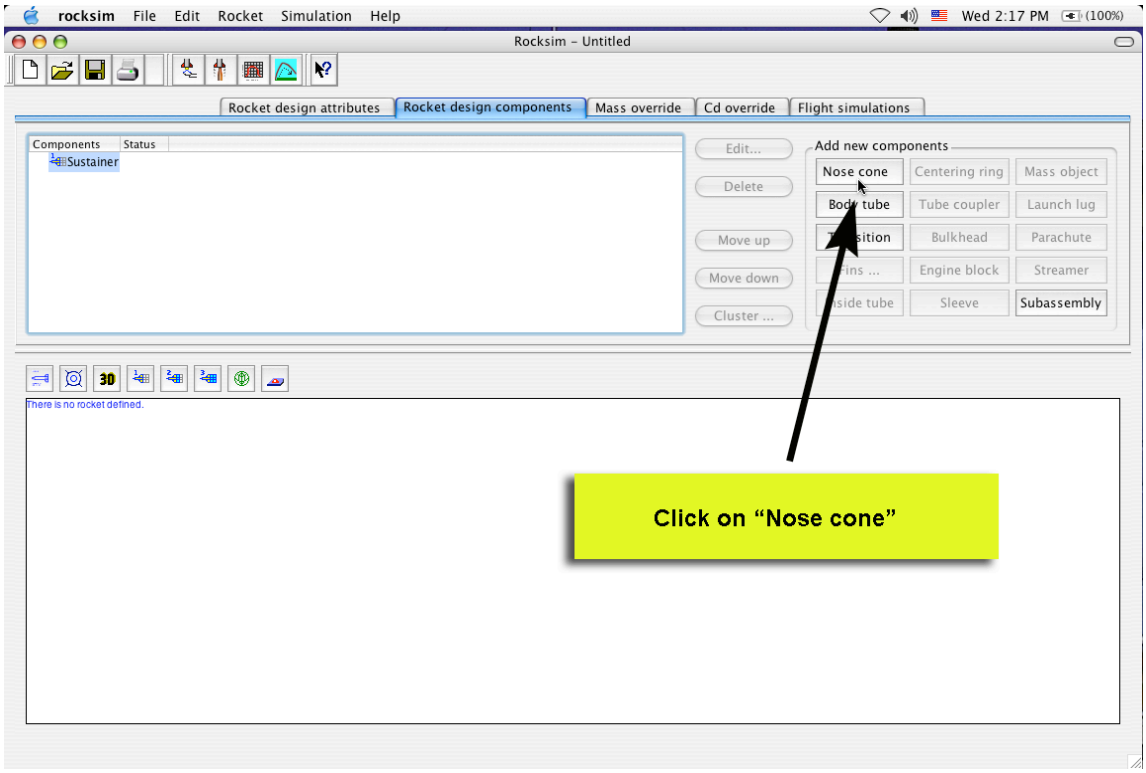


B. Selecting Parts

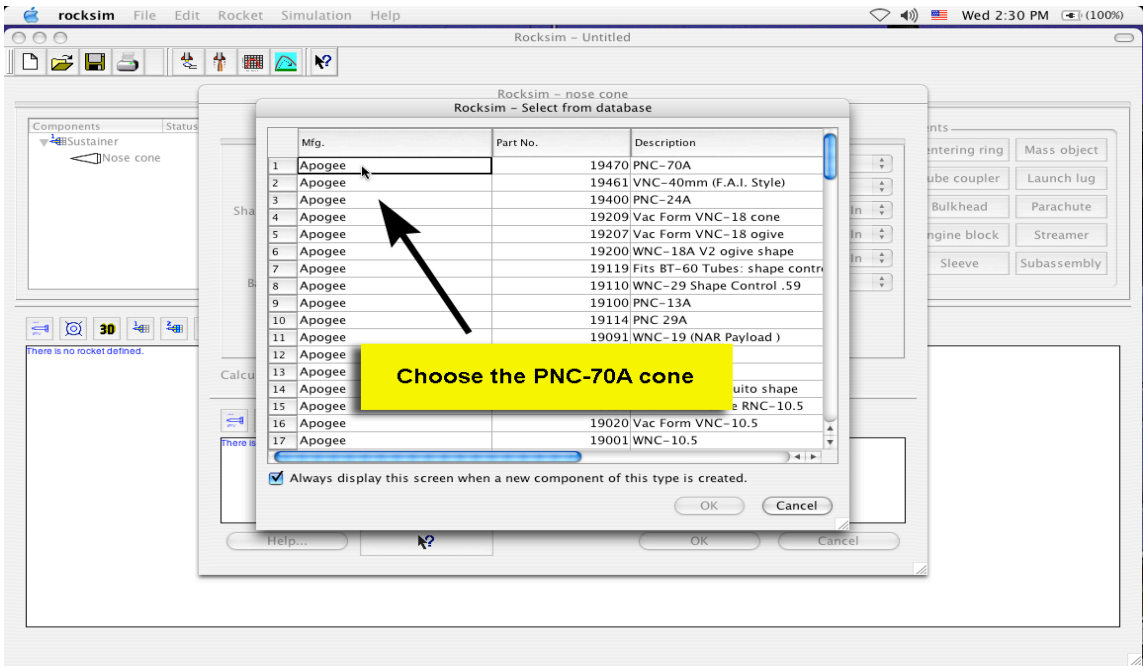
Now you are ready to start designing a rocket! Begin this process by clicking on the "rocket design components" tab. It's time to get creative!



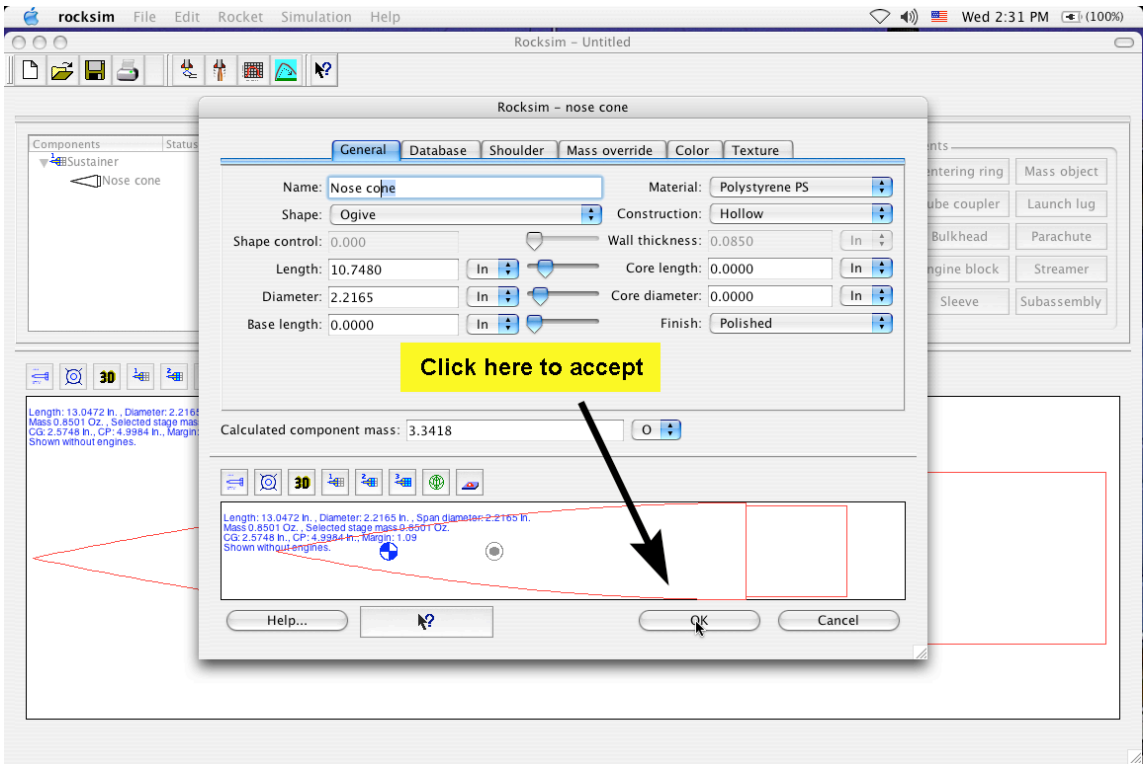
1. Nose Cone
   a. You will design your rocket from the top down, so start by selecting "Nose cone" from the "Add new components" menu.



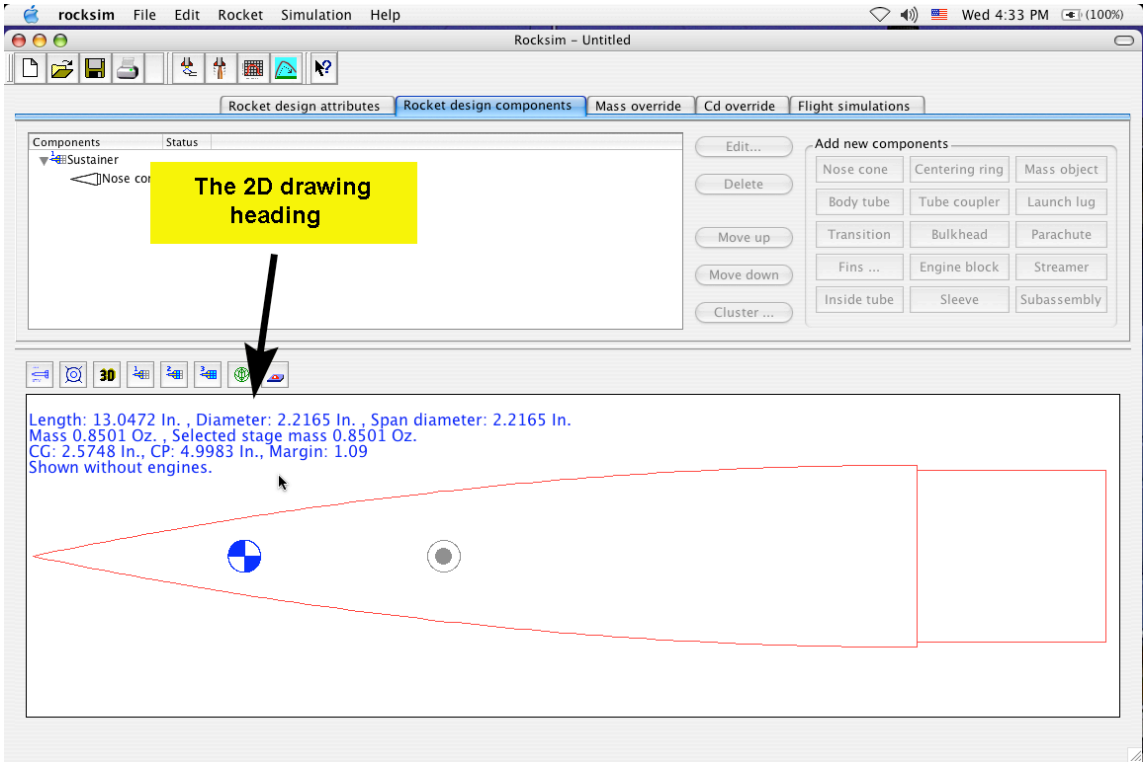
b. This will take you into a nose cone database screen. Let's choose the Apogee Components PNC-70A nose cone for simplicity's sake. Then you can click "OK" to accept the choice.



c. The next screen will show you the selected nose cone and includes such detail as length, diameter, shape, etc. You have the ability to edit these parts in order to customize them. For our purposes you will accept the selection fully by clicking as indicated below.

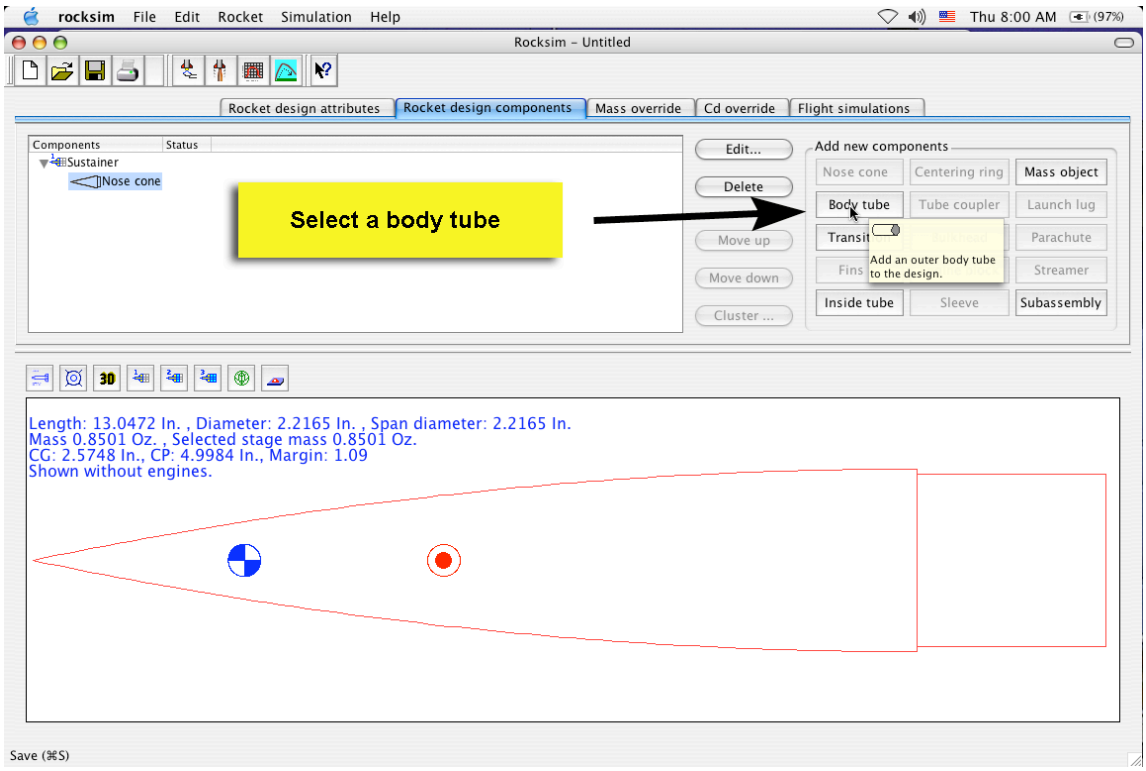


d. You now have a 2D drawing of the nose cone you selected. The 2D drawing heading has a variety of information regarding your rocket at all stages of the design process. It will show the length, diameter, span diameter (the distance from fin tip to fin tip), and mass. Also shown are the CG (center of gravity; the point at which the rocket balances) and the CP (center of pressure; the point at which all the aerodynamic forces concentrate). The margin defines how stable the rocket is. A stable rocket should have 1-2 body tube diameters between the CG and the CP. The CG should always be in front of the CP for the rocket to be stable. In this given design so far, the static margin is 1.09. The CG is always represented by the symbol and the CP by the symbol .

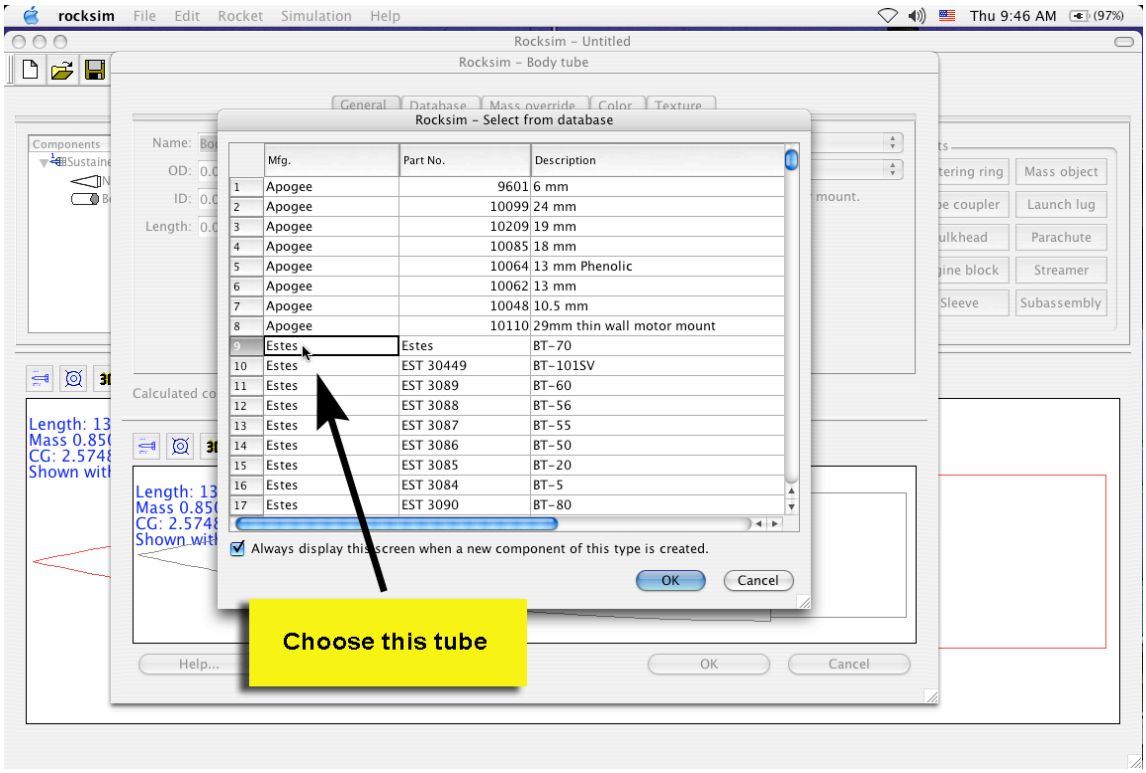


2. Body Tube

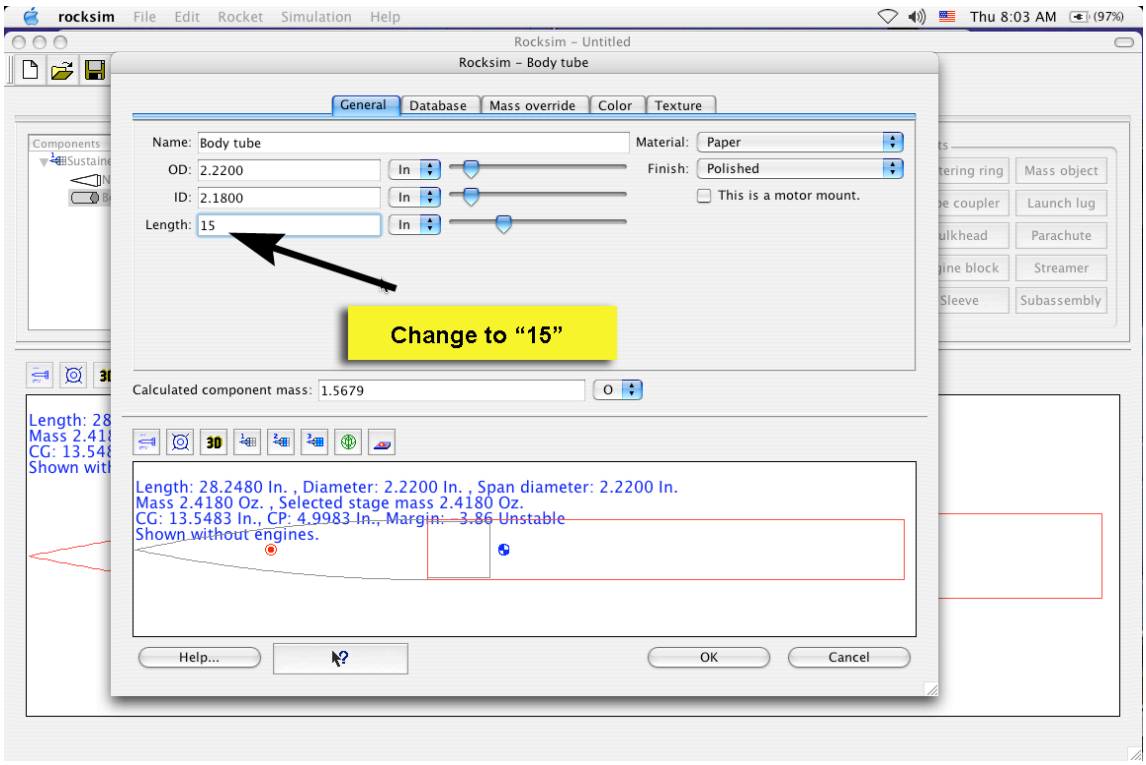
a. Start this process by clicking on the "body tube" button.



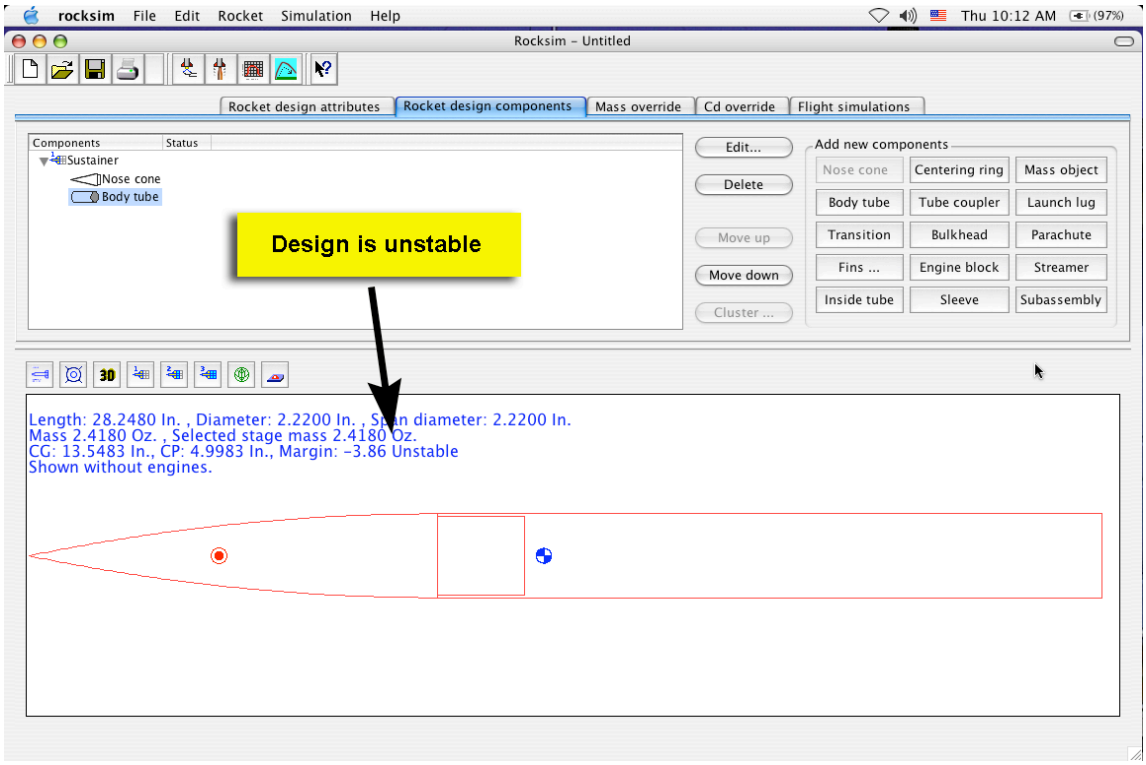
b. You will choose the body tube that is the appropriate size for the nose cone you chose. For our rocket, select the BT-70 tube. Then click on "OK."



c. Before finishing out this part, click the cursor on the length and change it from 17.5" to 15" because for our final design this length will make the rocket more stable. Shortening the length of the rocket moves the CG rearward and closer to the CP, thus making the rocket more stable. Then you can click "OK."

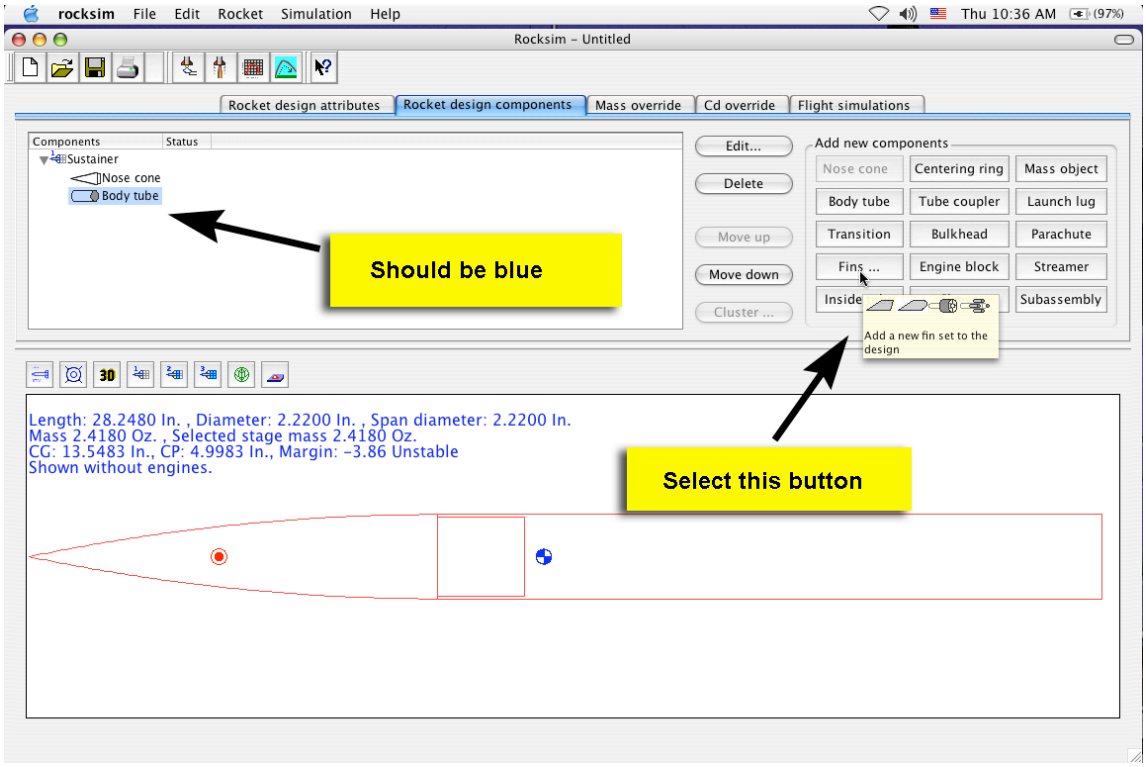


d. At this point, you can see that the rocket is unstable due to the fact that the CG is behind the CP.

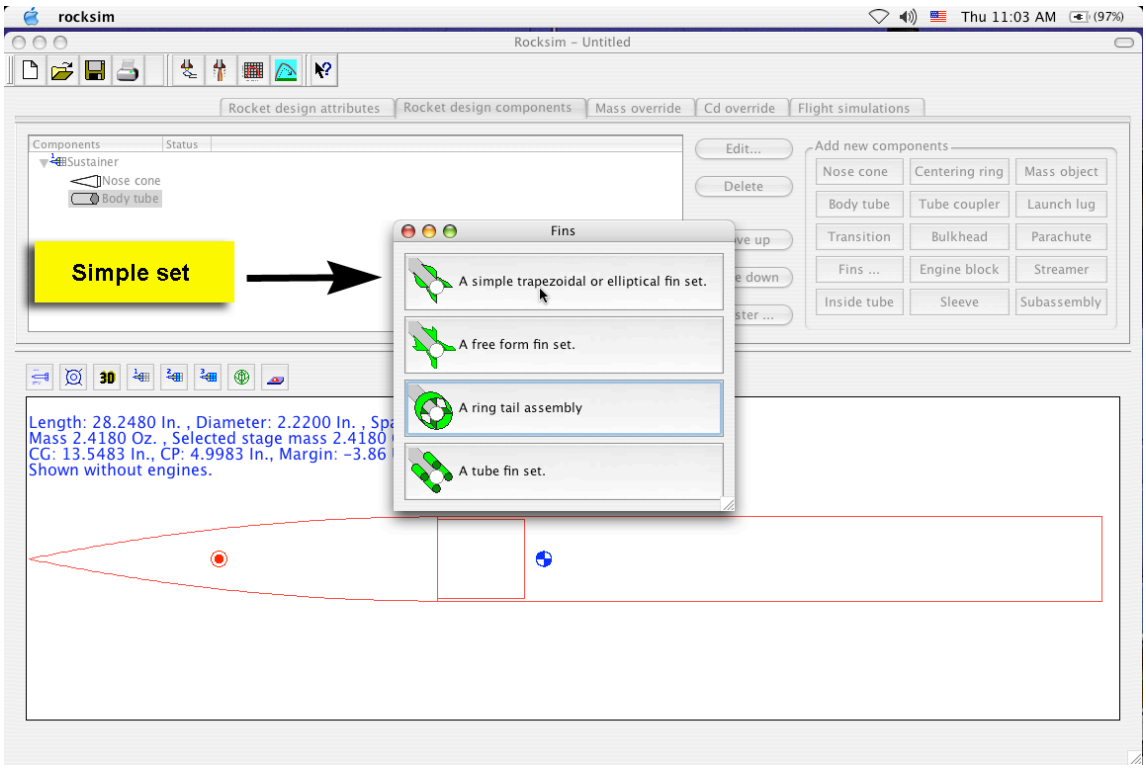


3. Fins

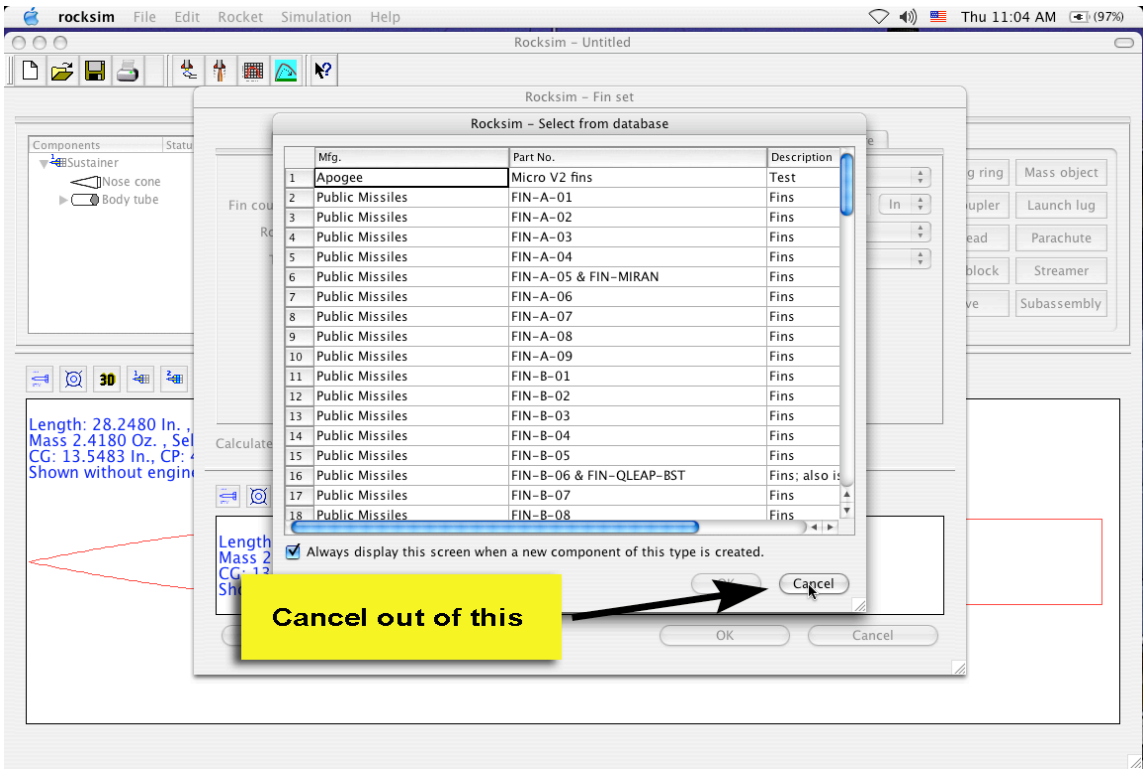
a. When adding a component to a design, make sure that the part you are attaching it to is highlighted. Now you may click on the "Fins" button to enter that part's screen.



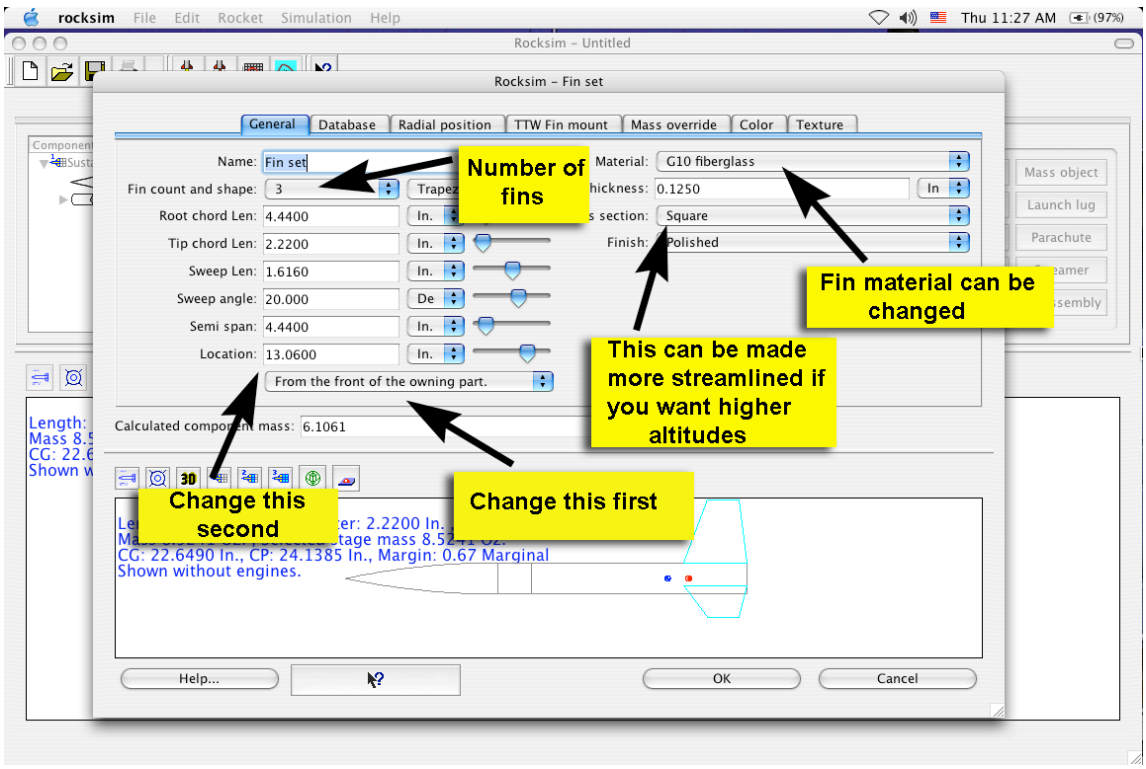
b. When learning to design fins, the best way to begin is the easiest route. Choose the simple fin set.



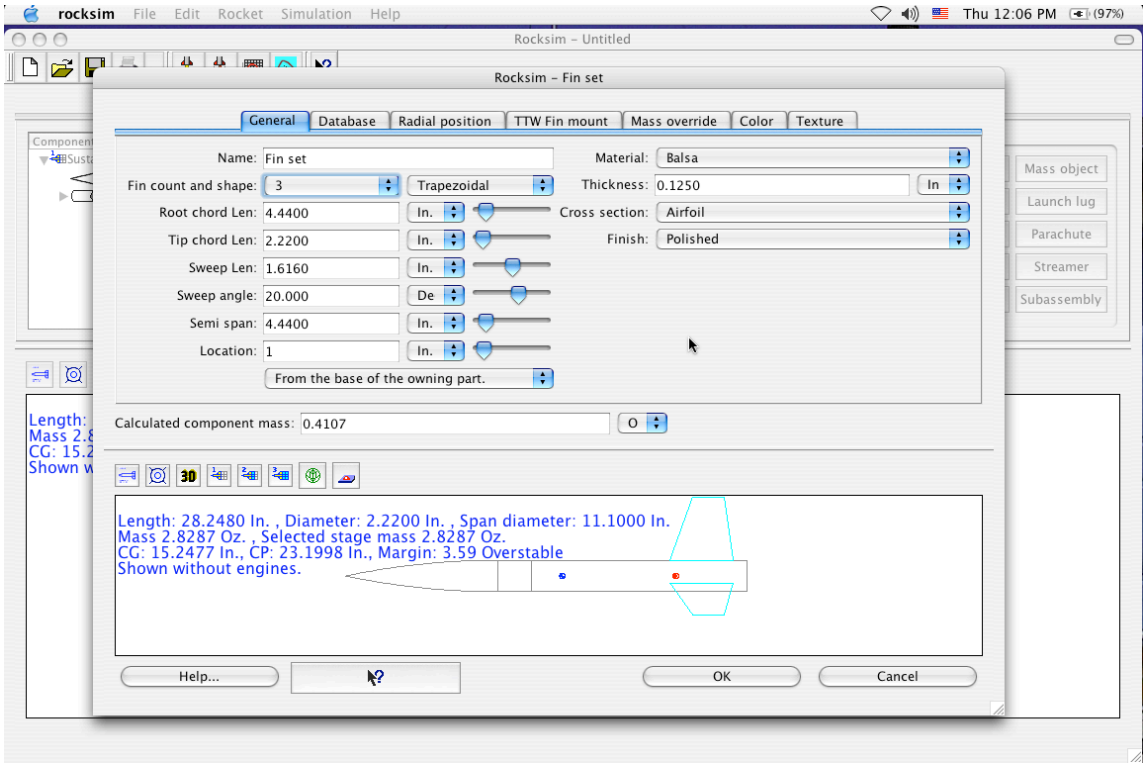
c. The next screen to appear will ask you what fins you would like. You may cancel this screen because you will be taking a default fin set and customizing it for yourself.



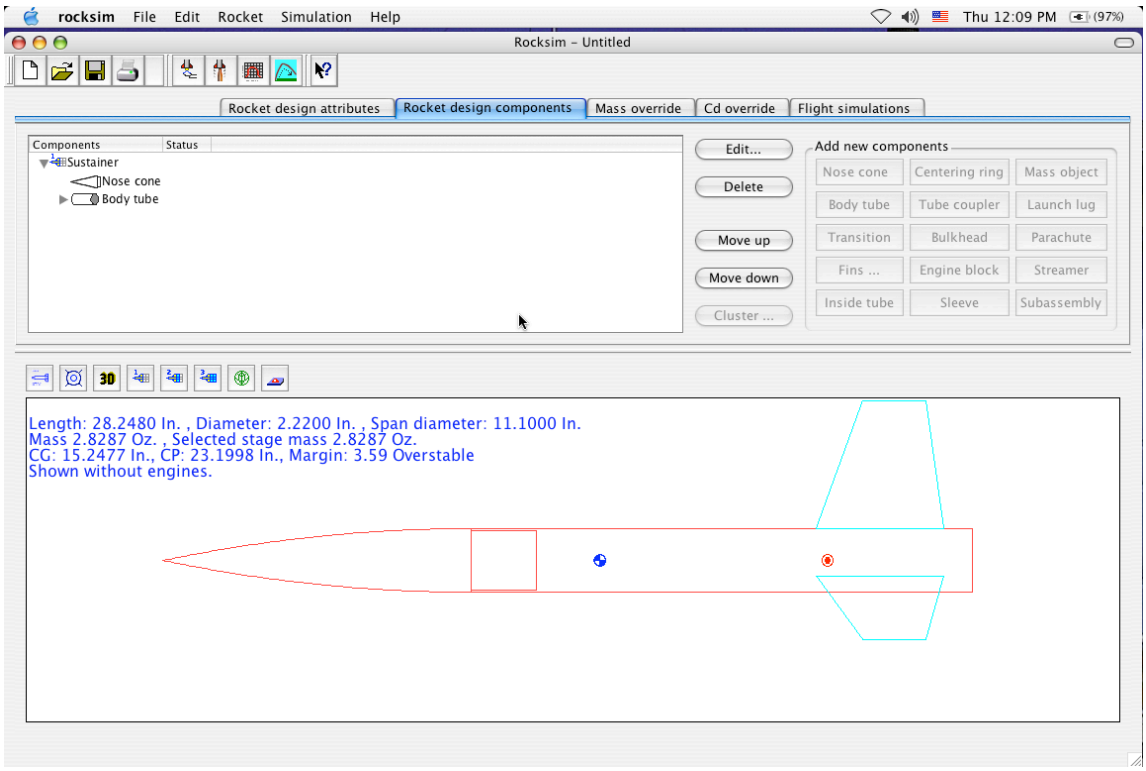
d. The main fin screen has a variety of information. The first thing you need to do is to select the fins' reference point on the part that owns it, namely, the body tube. You will need to change its reference to "From the base of the owning part." This way, if you decide to change the length of the body tube, the fins will always be the same distance from the base of the rocket. Second, change the location to 1" from the base. Now let's alter the fin material. Click on that area and select balsa instead. Last in line for changes will be the cross section, which by default is "square." Go ahead and click on it and change to "airfoil." If you want to, you may opt to put 4-8 fins on the design. For our purposes here, we will maintain 3 fins just to keep the design simple.



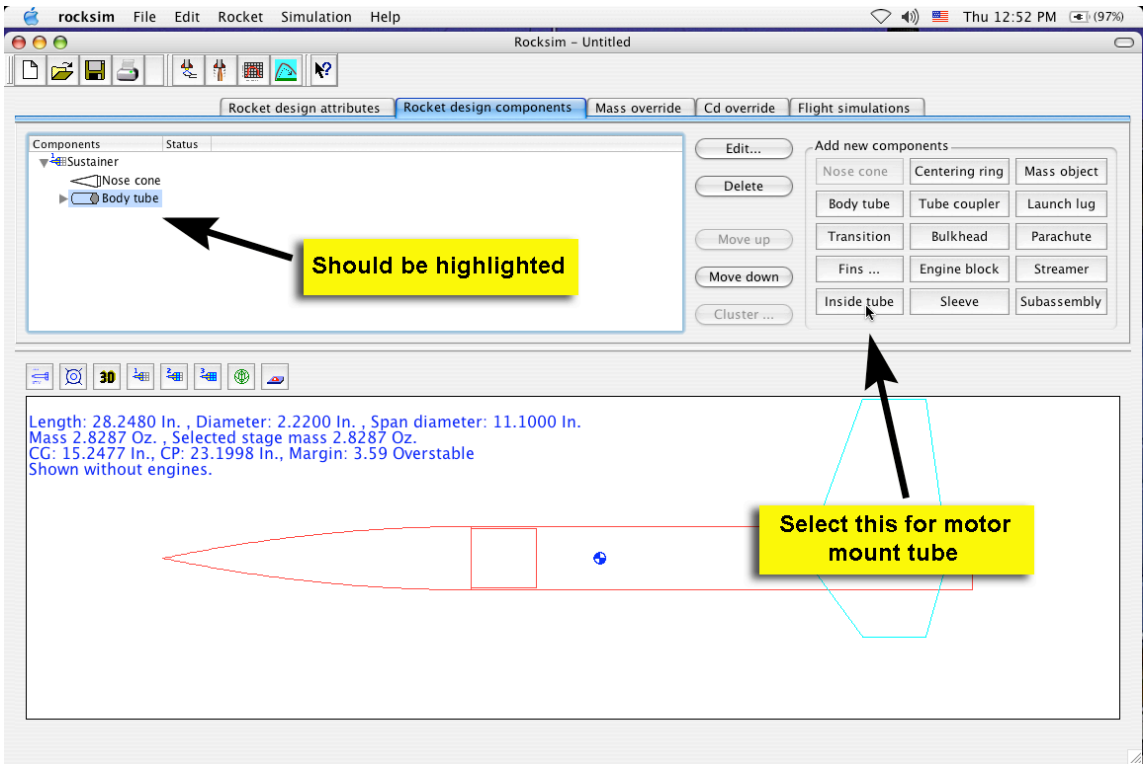
e. This is what the fin screen should look like now.



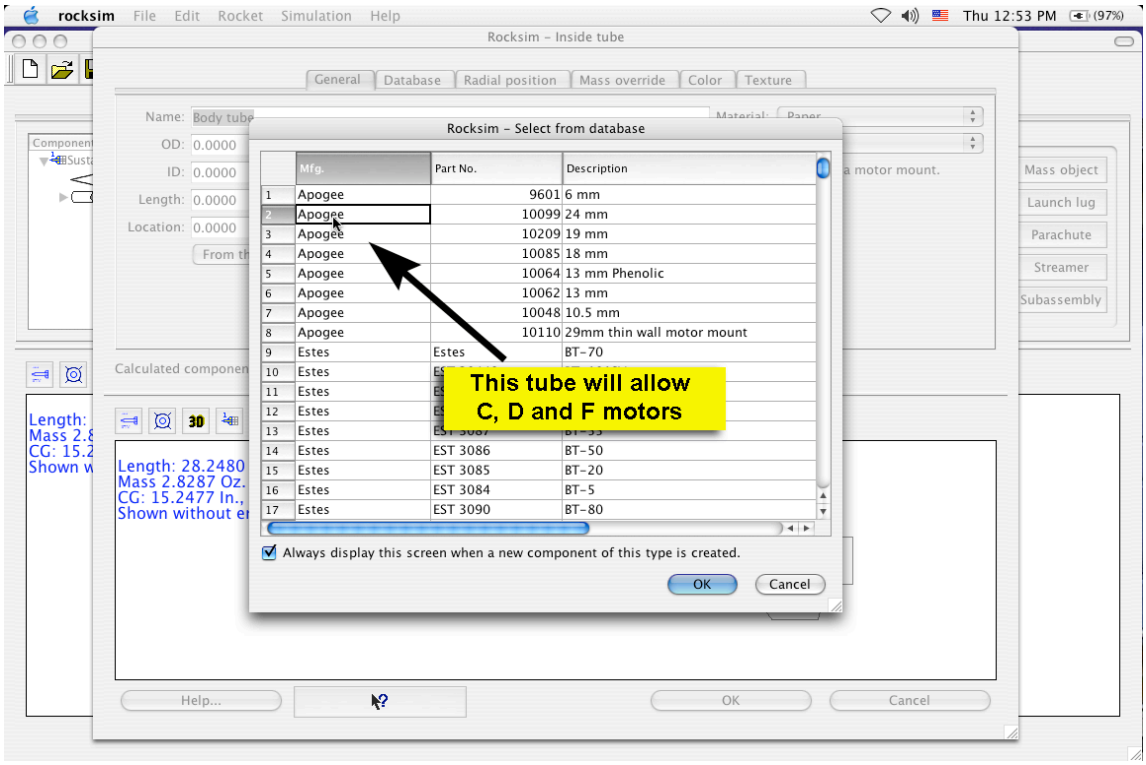
f. Select "OK" and that will lead you back to the main screen where the design should now appear as below:



4. Motor Mount Tube
   a. The next task is to design a motor mount tube to hold a motor in. Without it, this rocket isn't going anywhere! Start by confirming that the body tube will own the motor tube by clicking on the body tube to highlight it. Then click on "Inside tube" to create the part.

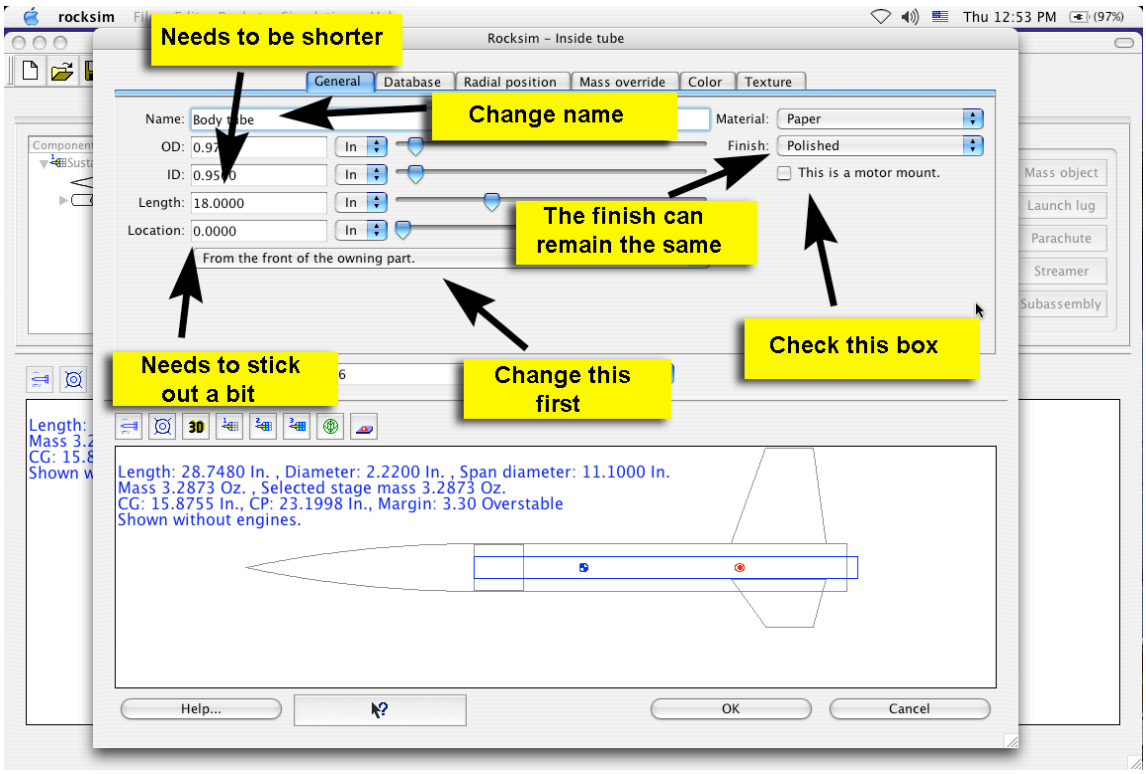


b. For our purpose here, you will choose the Apogee 24mm tube, which will give us a good variety of motors to select from in the "C", "D", "E", and "F" range.

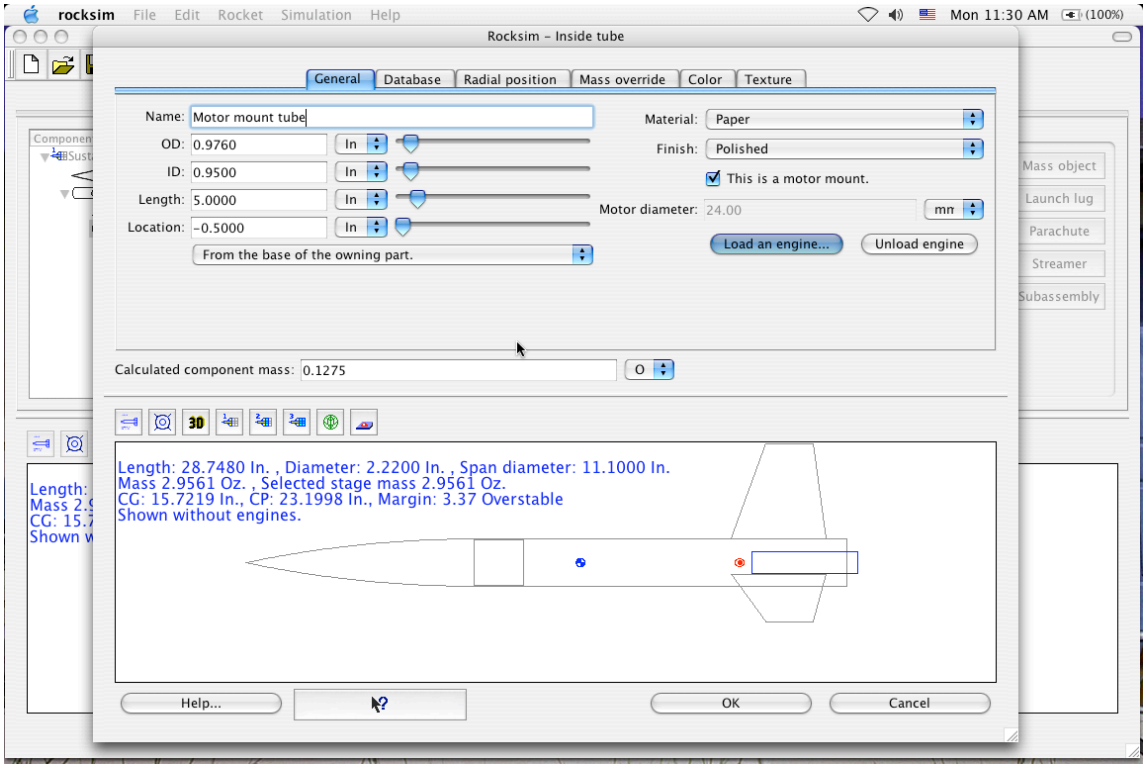


	Mfg.	Part No.	Description
1	Apogee	9601	6 mm
2	Apogee	10099	24 mm
3	Apogee	10209	19 mm
4	Apogee	10085	18 mm
5	Apogee	10064	13 mm Phenolic
6	Apogee	10062	13 mm
7	Apogee	10048	10.5 mm
8	Apogee	10110	29mm thin wall motor mount
9	Estes	Estes	BT-70
10	Estes		
11	Estes		
12	Estes		
13	Estes		
14	Estes	EST 3086	BT-50
15	Estes	EST 3085	BT-20
16	Estes	EST 3084	BT-5
17	Estes	EST 3090	BT-80

c. To start off, change the orientation to calculate from the base of the tube. Then you will need to change the length to 5". Next, the location should be minus (-) .5" that will allow the motor tube to stick out from the rocket for easier motor loading. The one thing that you will want to change is the name of the part. Make sure you rename the part "Motor mount tube." The more individual names there are for the different components, the less confusing it will be later on. Last, click on the box to produce a check mark, indicating that it is a motor mount tube.



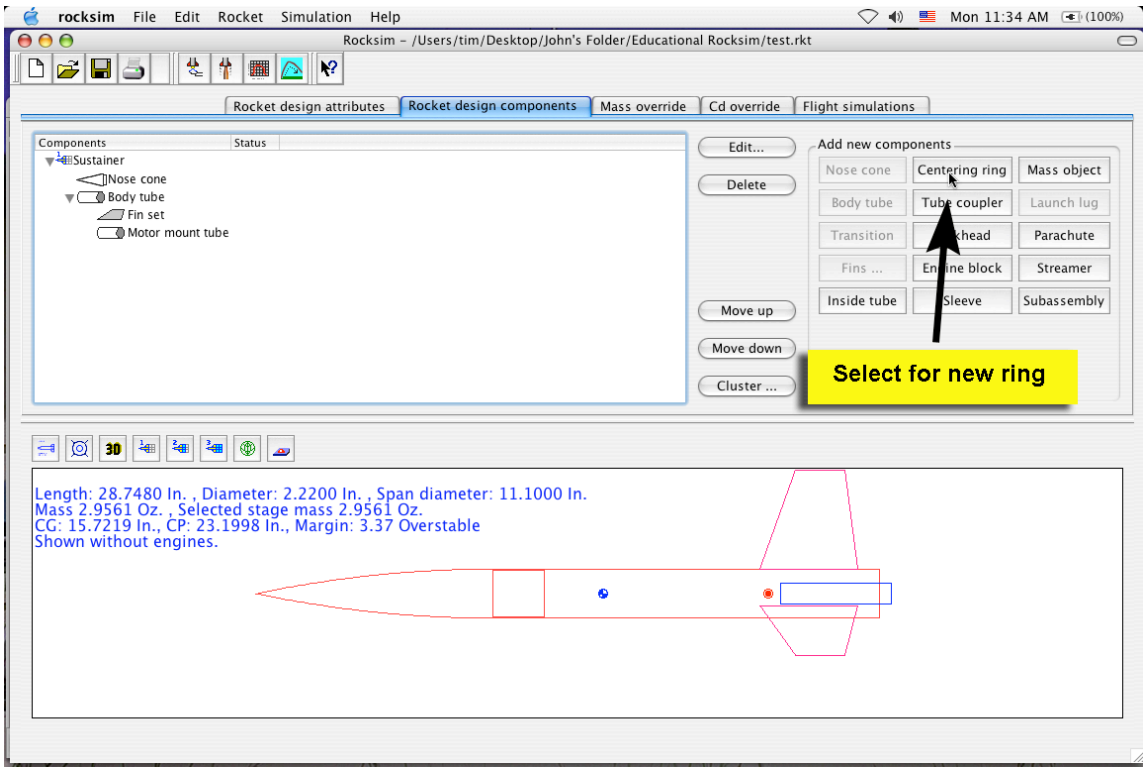
d. The screen should now look like this:



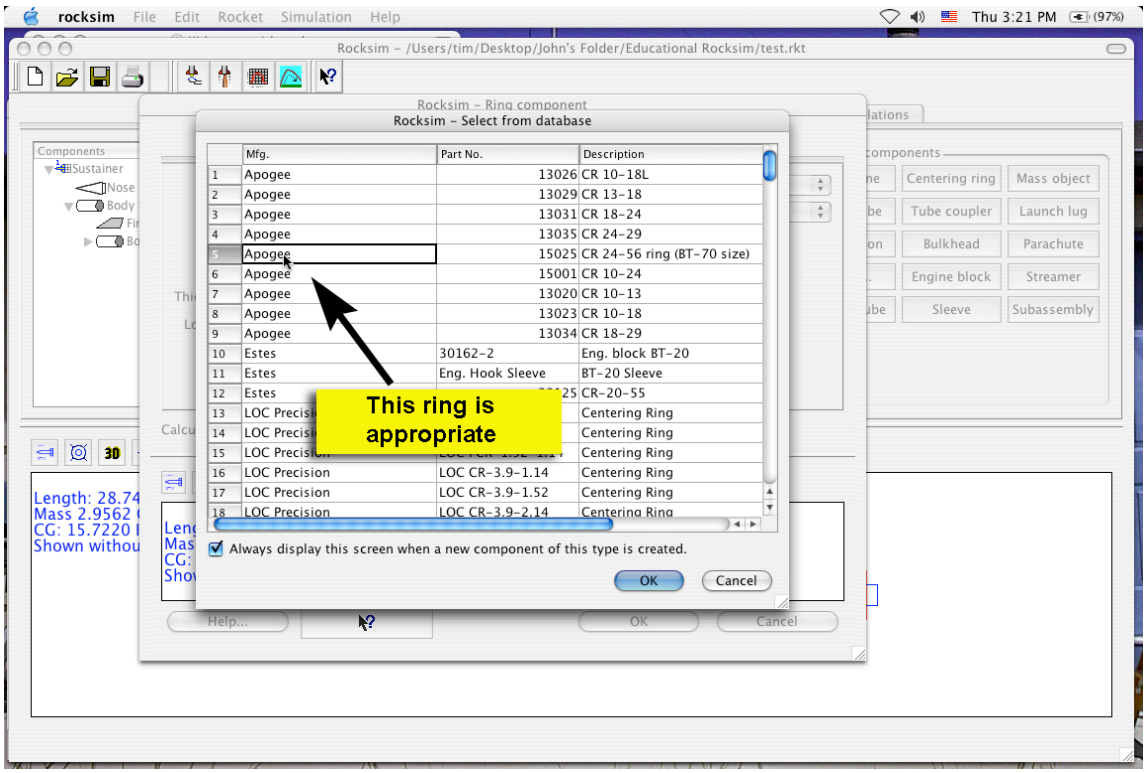
e. Click "OK" at this point.

5. Centering Rings

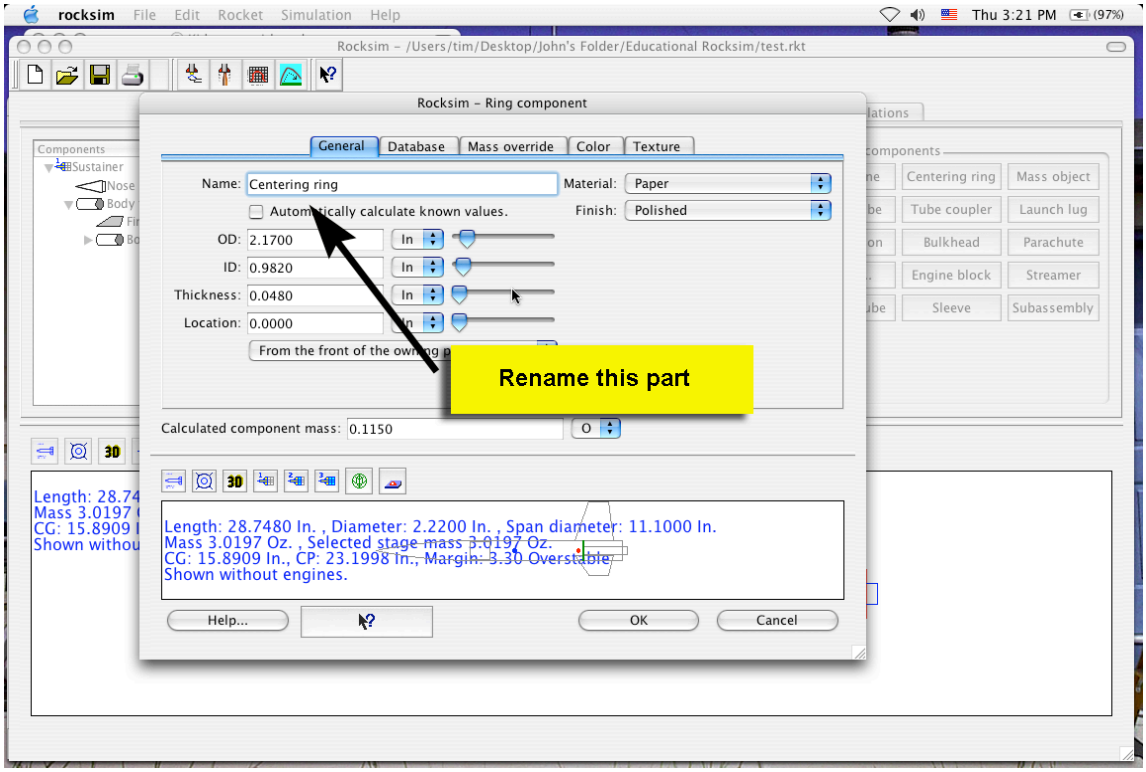
a. To begin, click on the "Centering ring" button.



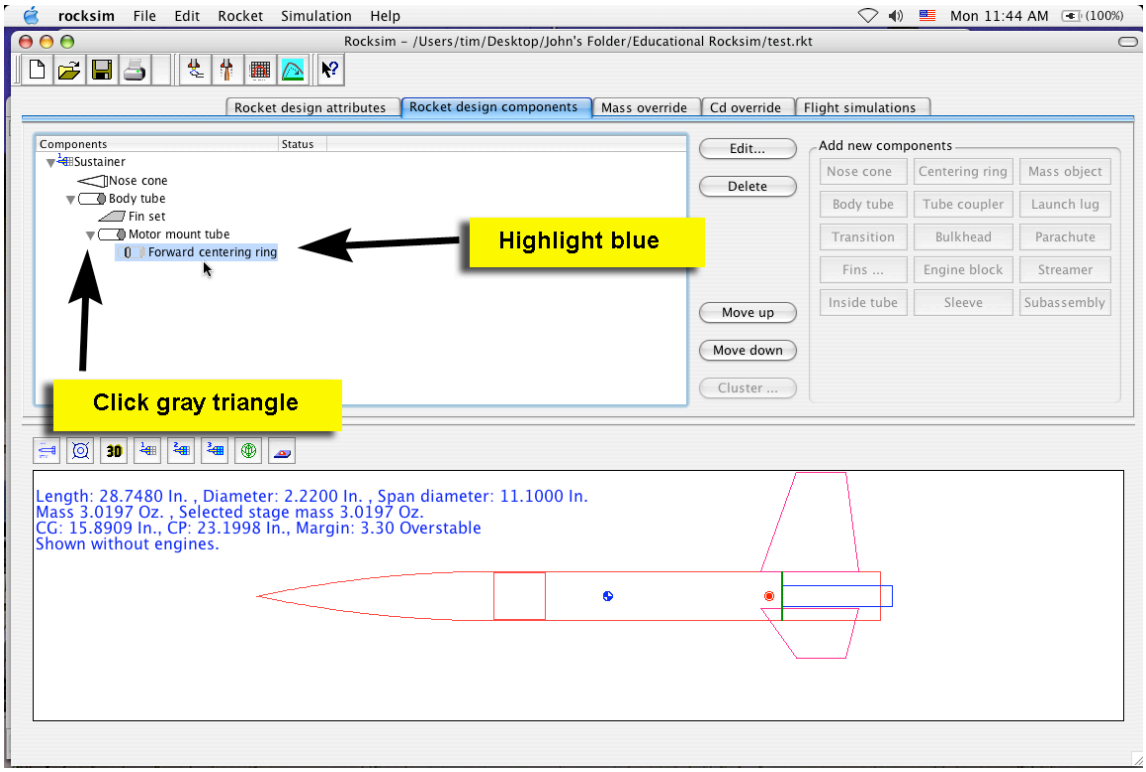
b. You will select the Apogee Components CR 24-56 ring as the inner diameter of the ring fits the motors that we want to use and the outer diameter is the same as the inside diameter of the body tube. Then click "OK."



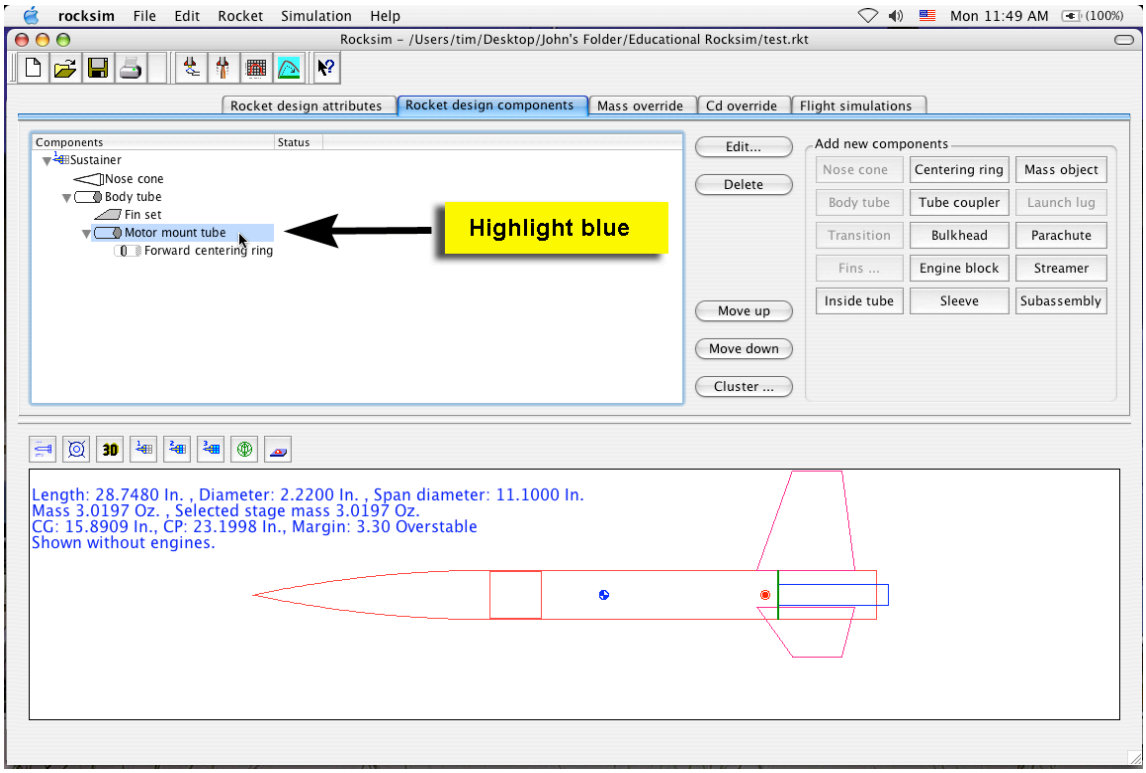
c. This is the screen that you will be on now. Almost everything will remain as it is due to the fact that we want the ring to be calculated from the front end of the owning part. Name this part "Forward centering ring." Also, the location will stay at zero because it needs to stay right up at the front of the motor mount tube. Now click "OK" to accept the designated part.



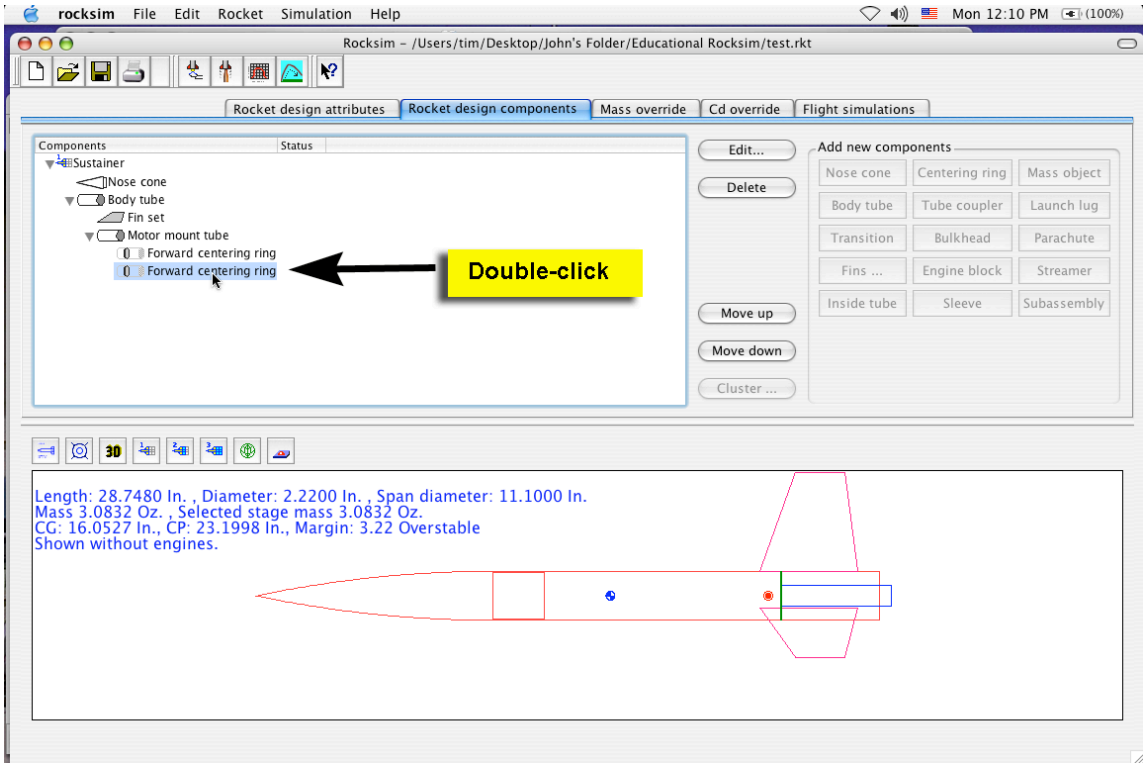
d. You, of course, need to create another centering ring identical to the one you already did. To do this, start by clicking on the gray triangle to the left of the body tube. This will show you what parts are associated with that piece. Next you will click on the "centering ring" to highlight it blue. For Mac users type the "Apple-C" at the same time to copy the part. For Windows users this is "Control-C."



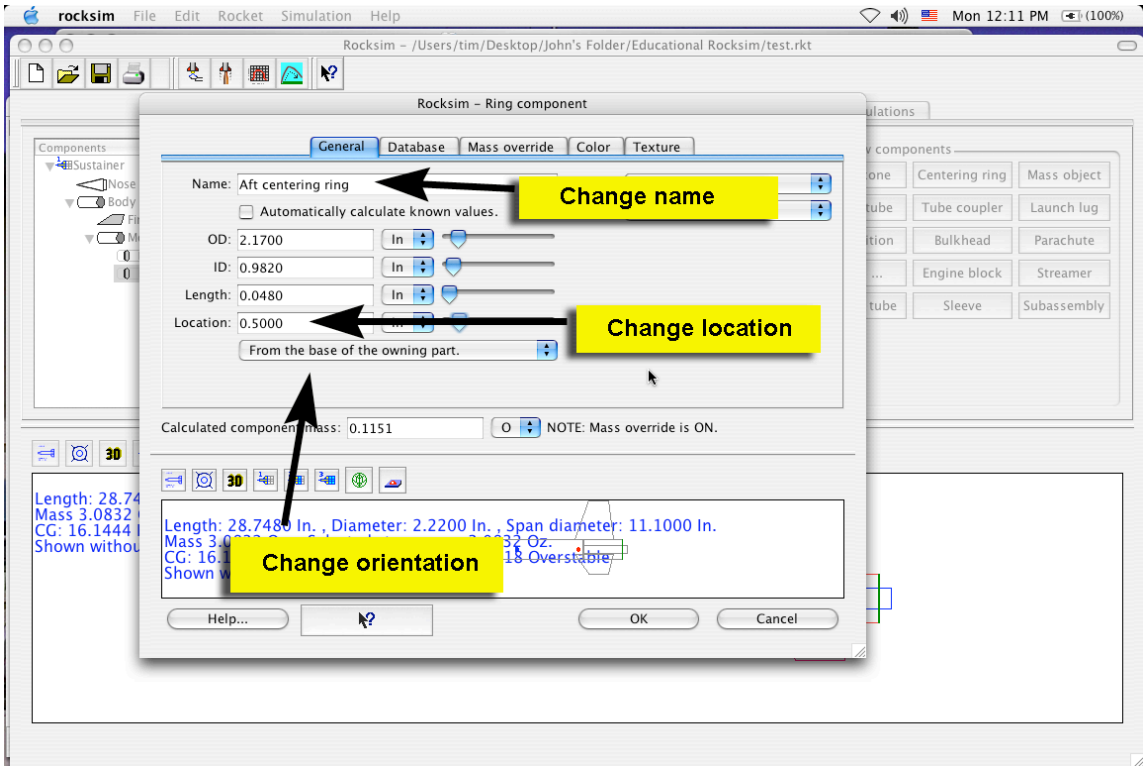
e. Now highlight the motor mount tube and type "Apple-V" at the same time to paste a duplicate centering ring in. For Windows users this is "Control-V."



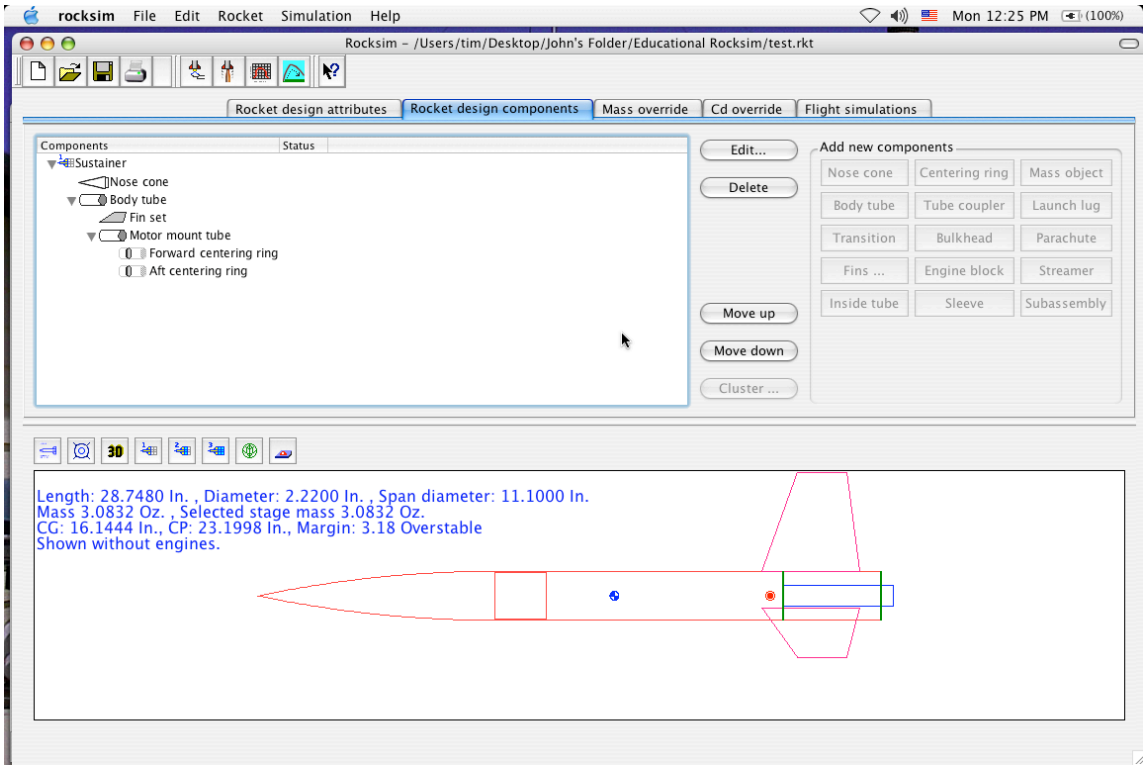
f. Next, double-click on the centering ring that you just pasted in.



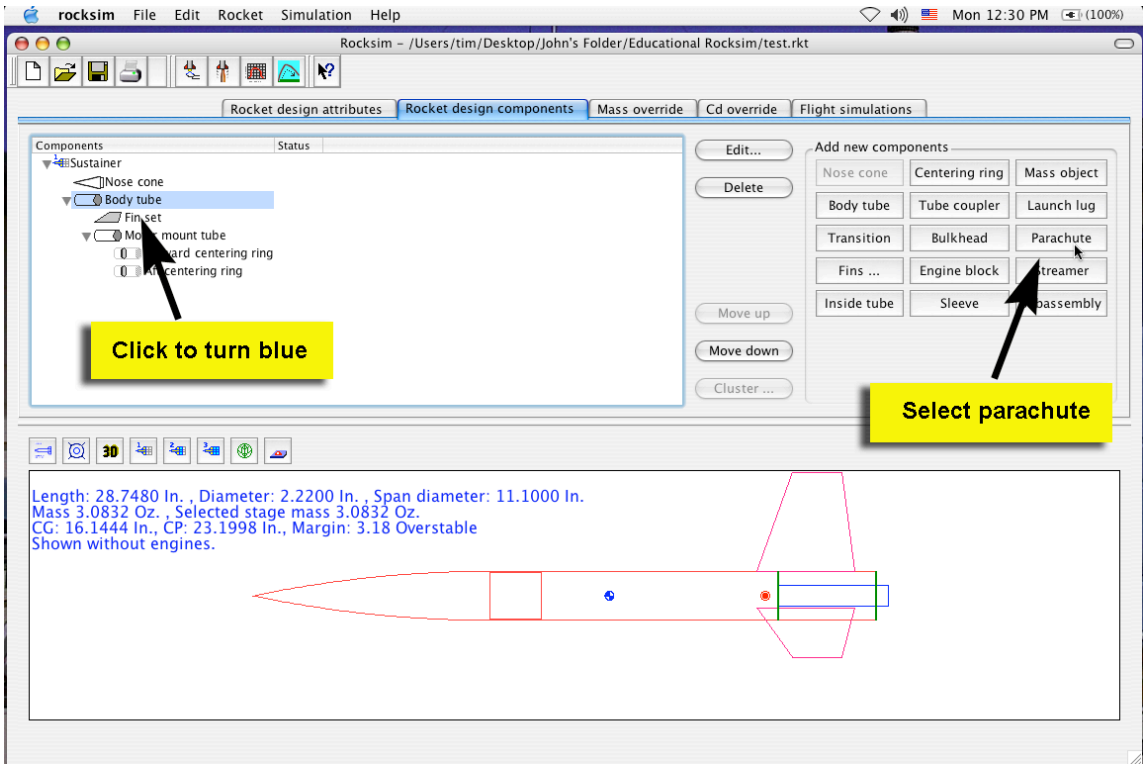
g. You will need to change the name of this ring to "Aft centering ring," change the location to 1/2", and make sure the orientation is "from the base." Then you will click "OK."



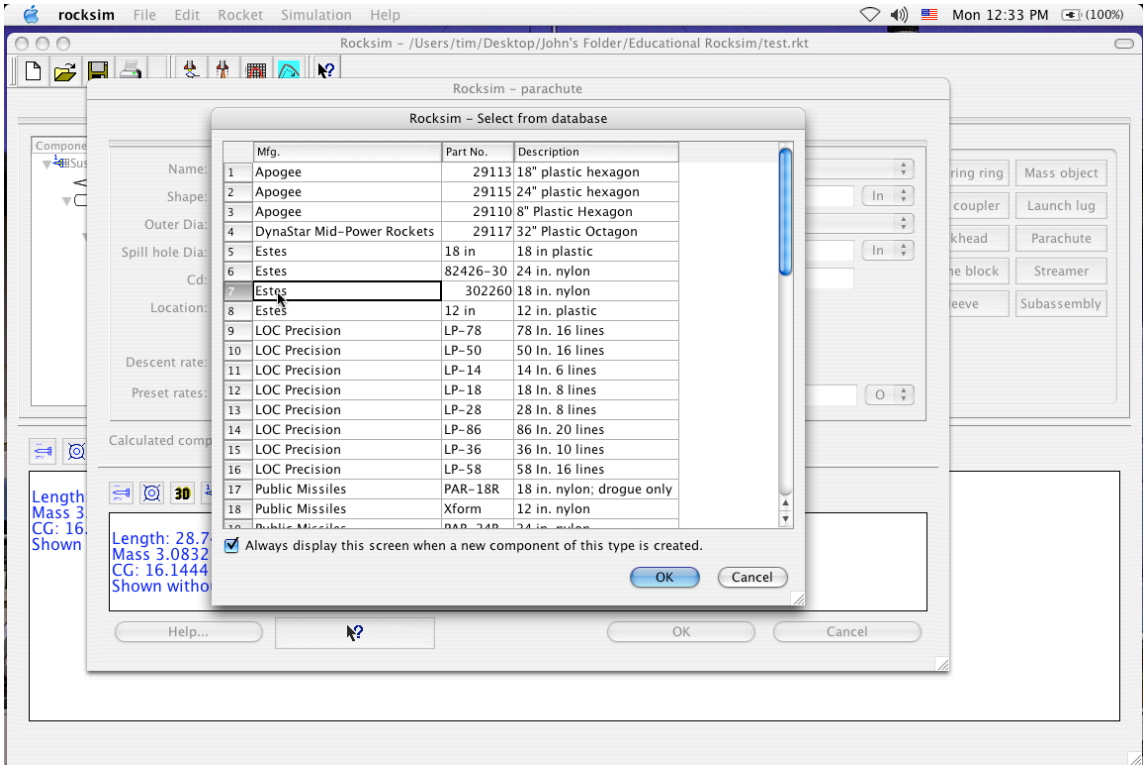
h. This is how your design should look to this point.



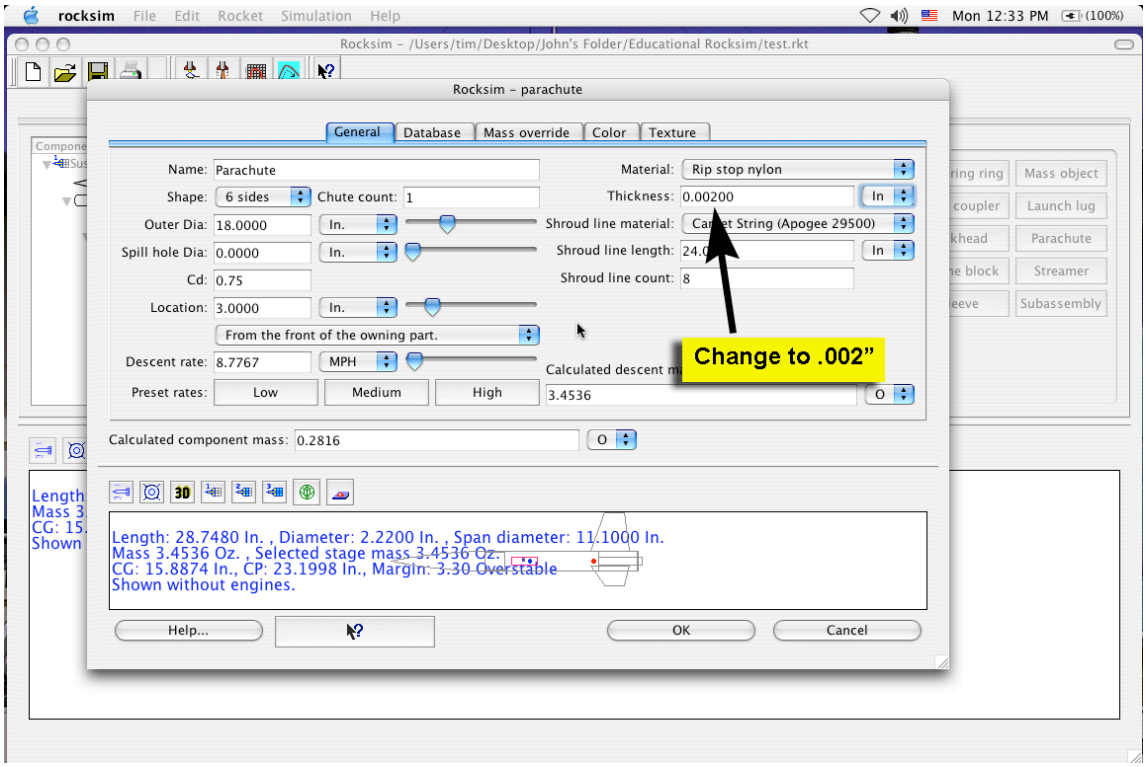
6. Parachute
   a. In order to put a recovery device in the design, you will either select a parachute or streamer. Typically, streamers are for lightweight rockets that weigh less than 1.05 oz. or for rockets that will fly quite high. This design will be heavy enough that you will need to use a parachute. Start by selecting the body tube since that is where the parachute will go. Then click on "Parachute" to enter the design screen.



b. When this screen appears, select the Estes 18" nylon parachute for this design and click "OK."

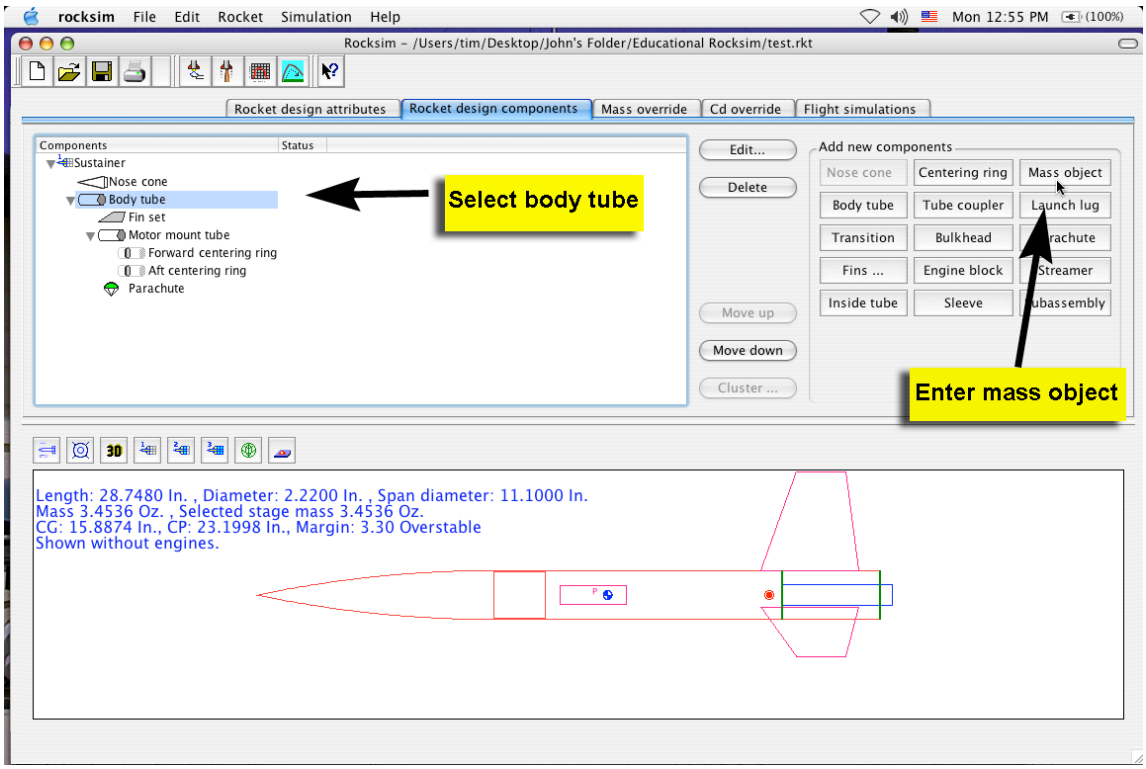


c. This will give you all the pre-set information for the parachute, except for the thickness. Enter this in as shown and then click "OK."

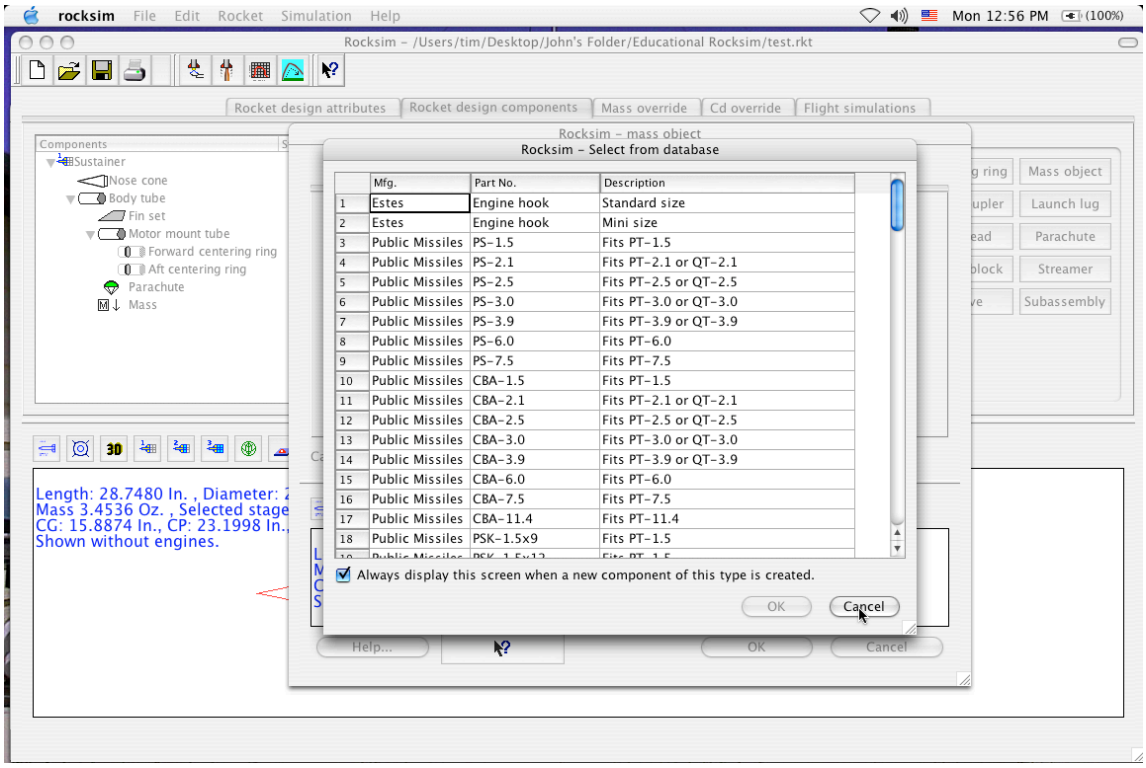


7. Shock Cord

a. For inserting a shock cord into the rocket, you must first highlight the body tube blue and then click on "Mass object" to enter the design screen.

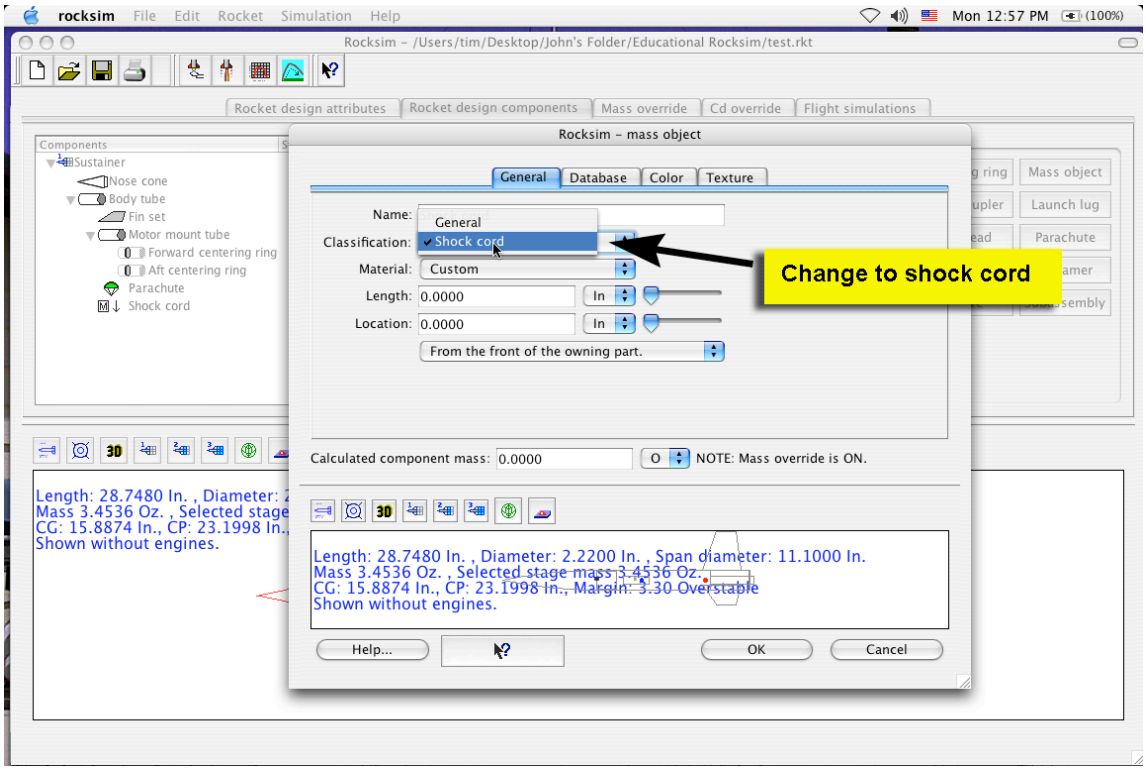


b. Cancel out of this screen.

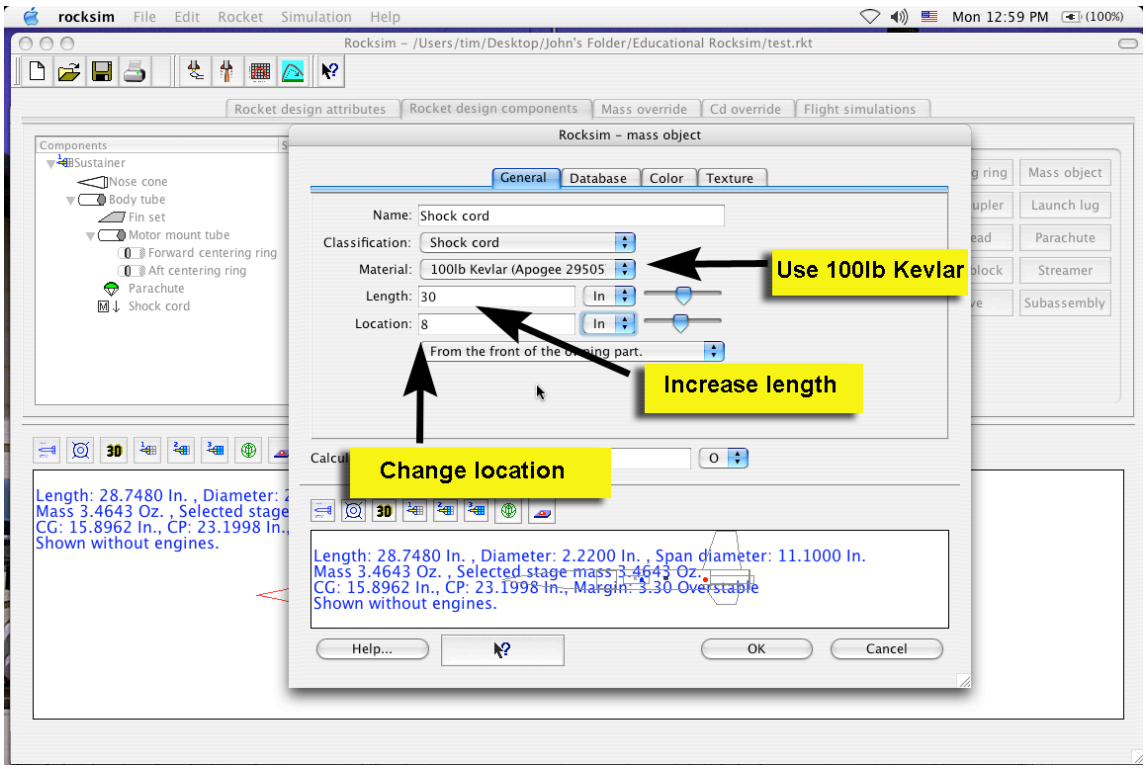


	Mfg.	Part No.	Description
1	Estes	Engine hook	Standard size
2	Estes	Engine hook	Mini size
3	Public Missiles	PS-1.5	Fits PT-1.5
4	Public Missiles	PS-2.1	Fits PT-2.1 or QT-2.1
5	Public Missiles	PS-2.5	Fits PT-2.5 or QT-2.5
6	Public Missiles	PS-3.0	Fits PT-3.0 or QT-3.0
7	Public Missiles	PS-3.9	Fits PT-3.9 or QT-3.9
8	Public Missiles	PS-6.0	Fits PT-6.0
9	Public Missiles	PS-7.5	Fits PT-7.5
10	Public Missiles	CBA-1.5	Fits PT-1.5
11	Public Missiles	CBA-2.1	Fits PT-2.1 or QT-2.1
12	Public Missiles	CBA-2.5	Fits PT-2.5 or QT-2.5
13	Public Missiles	CBA-3.0	Fits PT-3.0 or QT-3.0
14	Public Missiles	CBA-3.9	Fits PT-3.9 or QT-3.9
15	Public Missiles	CBA-6.0	Fits PT-6.0
16	Public Missiles	CBA-7.5	Fits PT-7.5
17	Public Missiles	CBA-11.4	Fits PT-11.4
18	Public Missiles	PSK-1.5x9	Fits PT-1.5

c. Change the classification heading to "Shock cord."

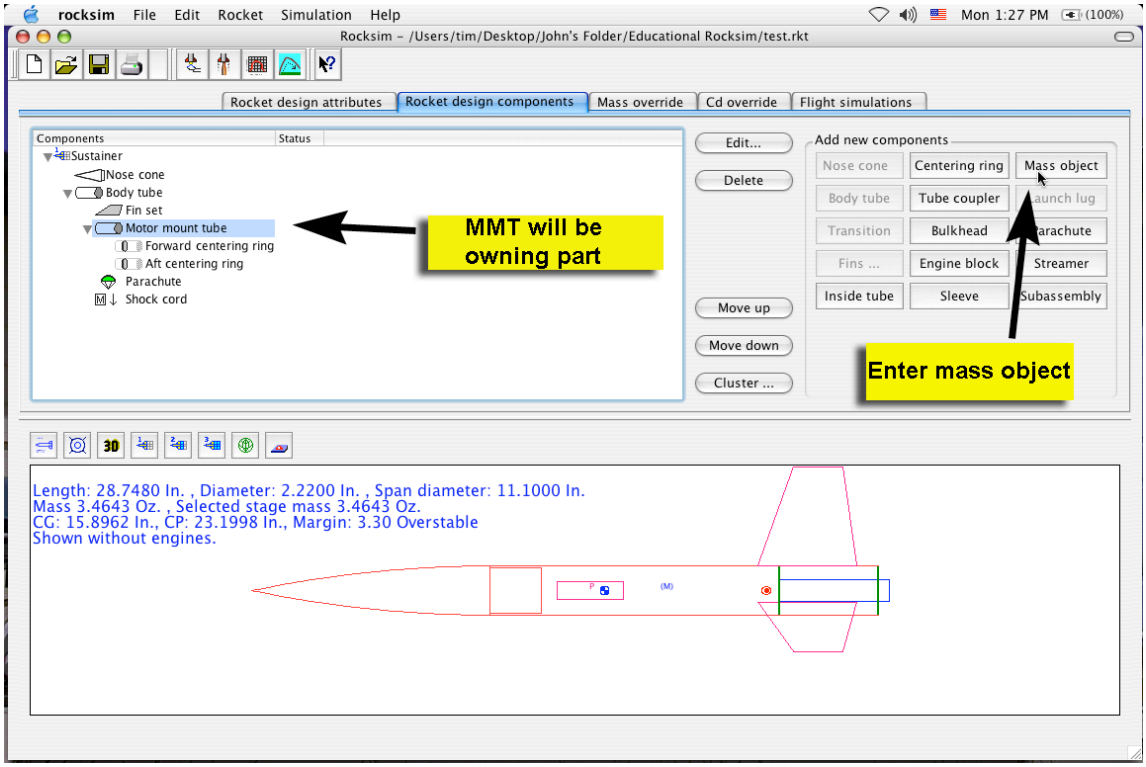


d. Then you will need to select the Apogee 100 lb. Kevlar cord, increase the length to 30 feet (due to the length of the rocket), and make the location 8" from the front of the body tube. After this is done click "OK."

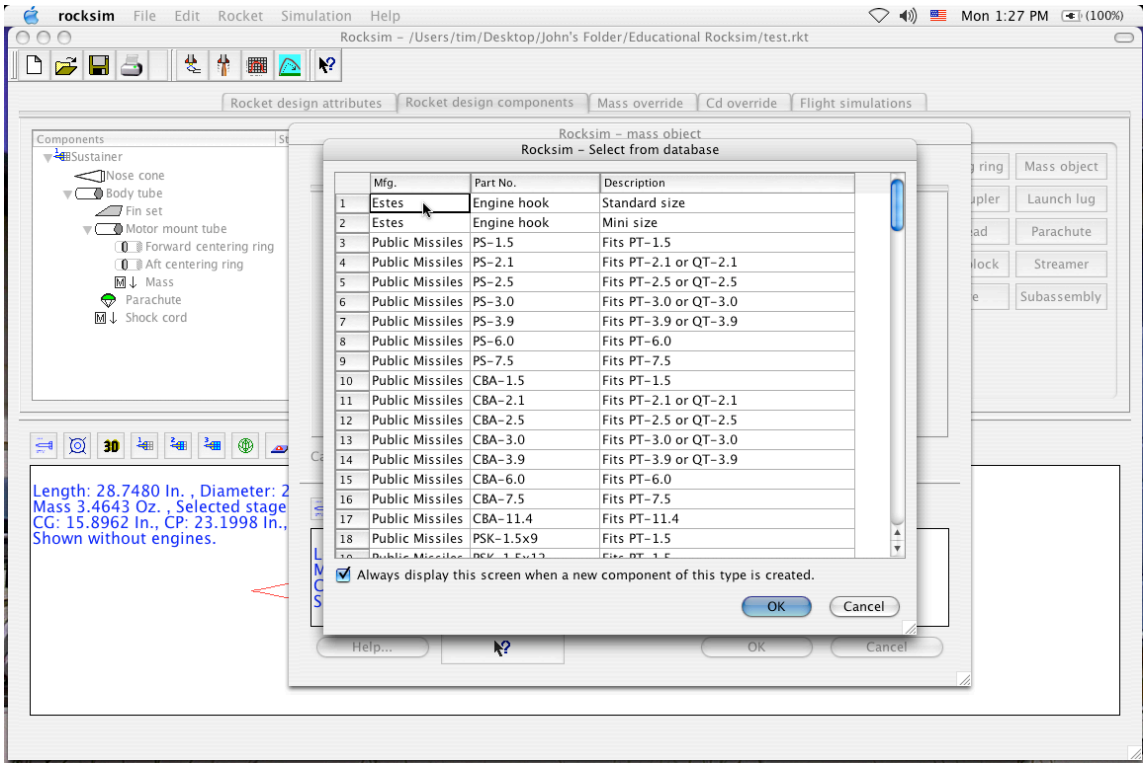


8. Engine Hook

a. To begin with, you will want to select the motor mount tube to be the owning part for the engine hook. Then click on "Mass object."

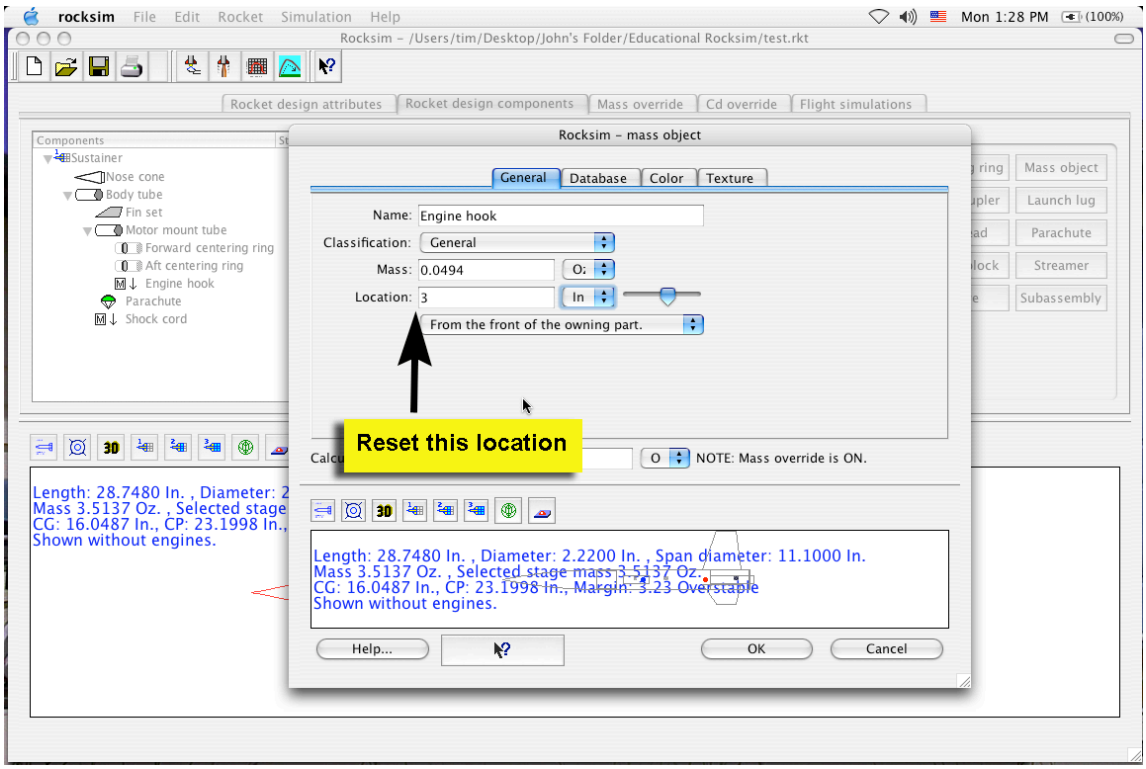


b. Select the Estes standard size engine hook and click "OK."



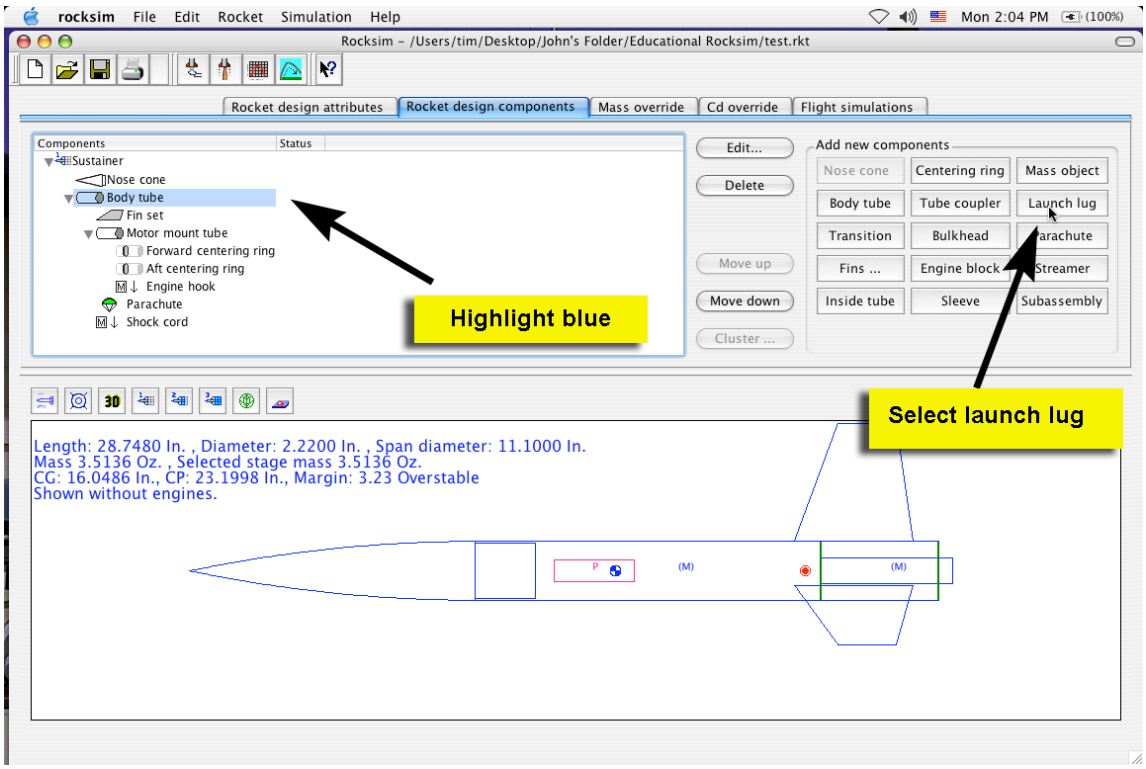
	Mfg.	Part No.	Description
1	Estes	Engine hook	Standard size
2	Estes	Engine hook	Mini size
3	Public Missiles	PS-1.5	Fits PT-1.5
4	Public Missiles	PS-2.1	Fits PT-2.1 or QT-2.1
5	Public Missiles	PS-2.5	Fits PT-2.5 or QT-2.5
6	Public Missiles	PS-3.0	Fits PT-3.0 or QT-3.0
7	Public Missiles	PS-3.9	Fits PT-3.9 or QT-3.9
8	Public Missiles	PS-6.0	Fits PT-6.0
9	Public Missiles	PS-7.5	Fits PT-7.5
10	Public Missiles	CBA-1.5	Fits PT-1.5
11	Public Missiles	CBA-2.1	Fits PT-2.1 or QT-2.1
12	Public Missiles	CBA-2.5	Fits PT-2.5 or QT-2.5
13	Public Missiles	CBA-3.0	Fits PT-3.0 or QT-3.0
14	Public Missiles	CBA-3.9	Fits PT-3.9 or QT-3.9
15	Public Missiles	CBA-6.0	Fits PT-6.0
16	Public Missiles	CBA-7.5	Fits PT-7.5
17	Public Missiles	CBA-11.4	Fits PT-11.4
18	Public Missiles	PSK-1.5x9	Fits PT-1.5

c. The only thing that you will need to change on this screen will be the location; which will be 3." This is done in order to center the weight of the hook where it will be located on the rocket. Then click "OK" to accept this.

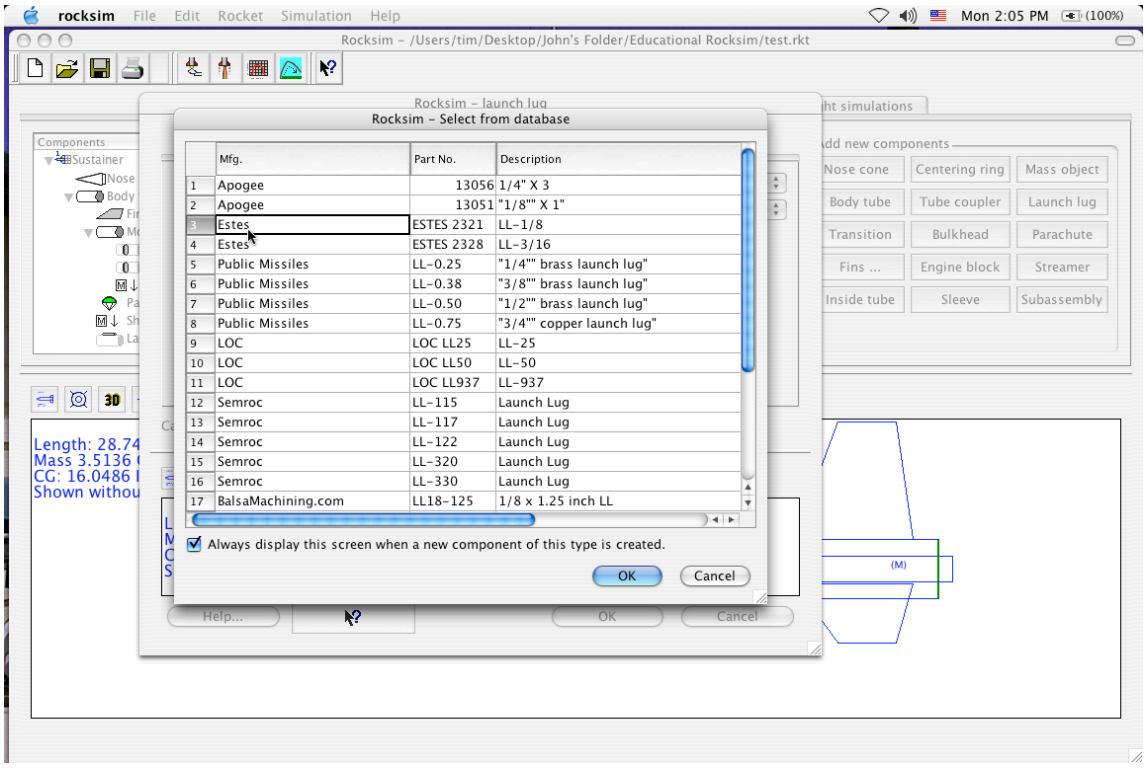


9. Launch Lugs

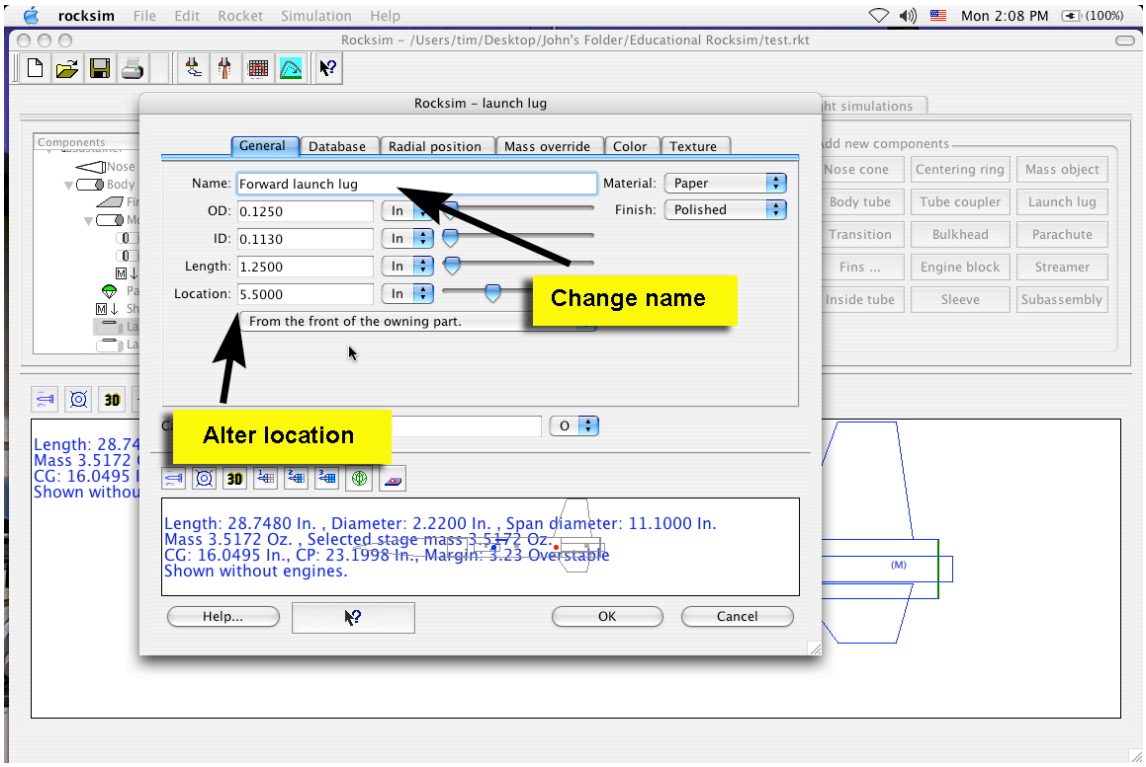
a. Begin this step by highlighting the body tube since this is the component that the launch lugs will be attached to. Then click on "Launch lug" to enter the design screen.



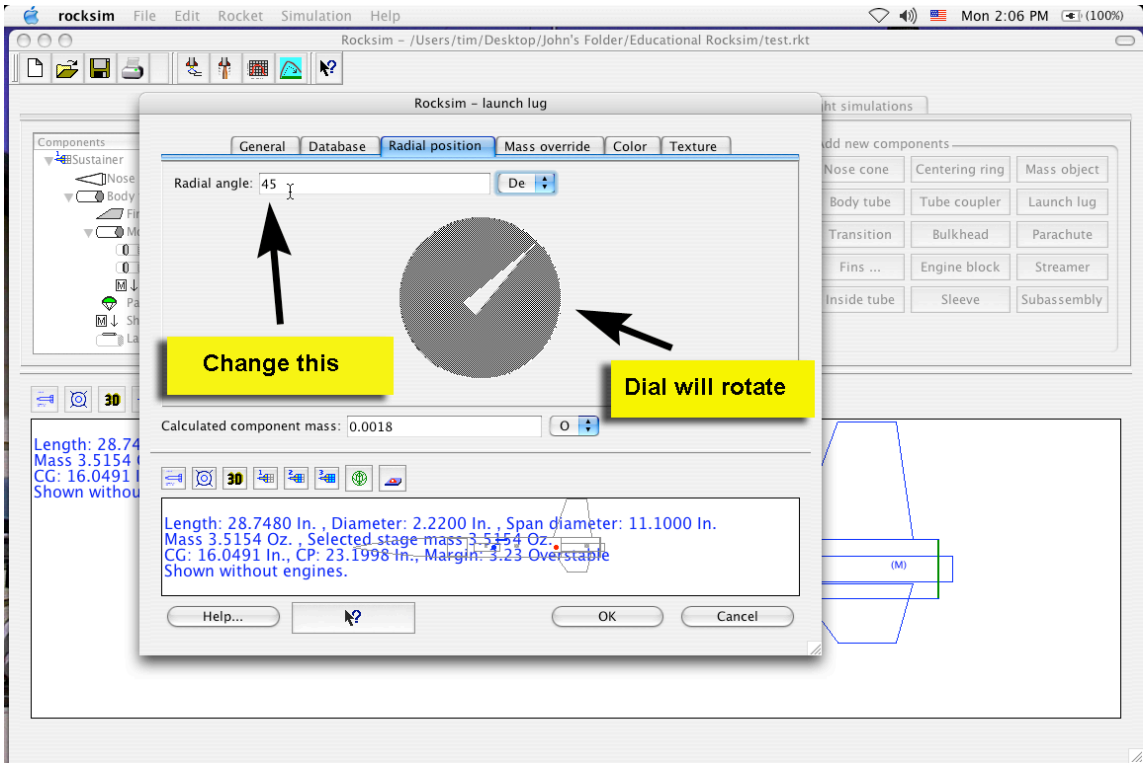
b. Select the Estes 1/8" lug and click "OK."



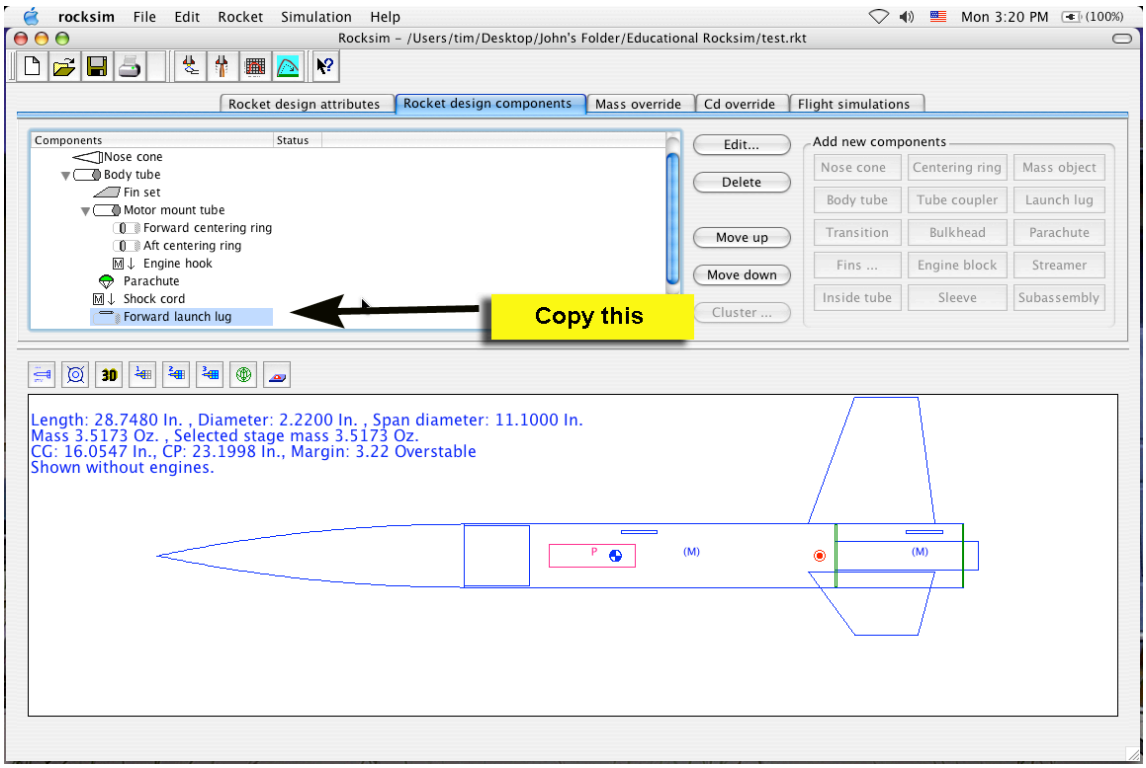
c. Change the name of the lug to "Forward" to distinguish it from the second lug that you will make. Make the location 5.5" from the front of the owning part.



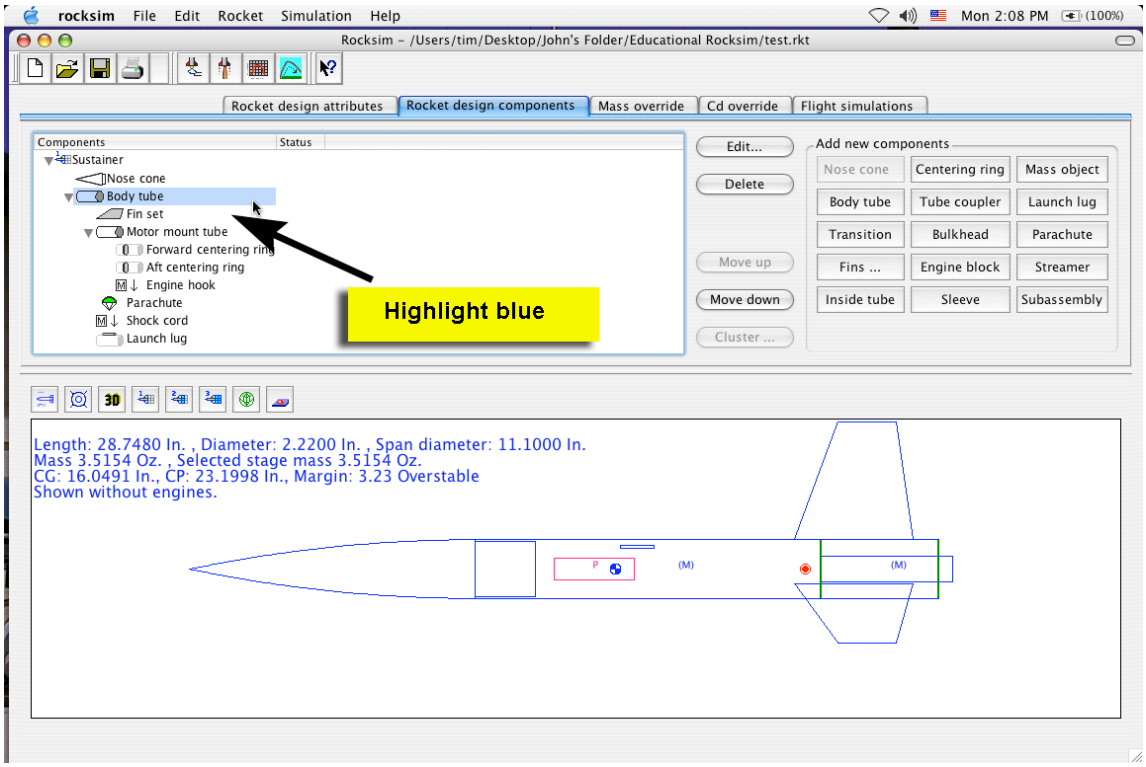
d. Next, click on the radial position tab and change the angle to "45 degrees." As you do this, you will notice the dial rotate to the right. Then you can click "OK."



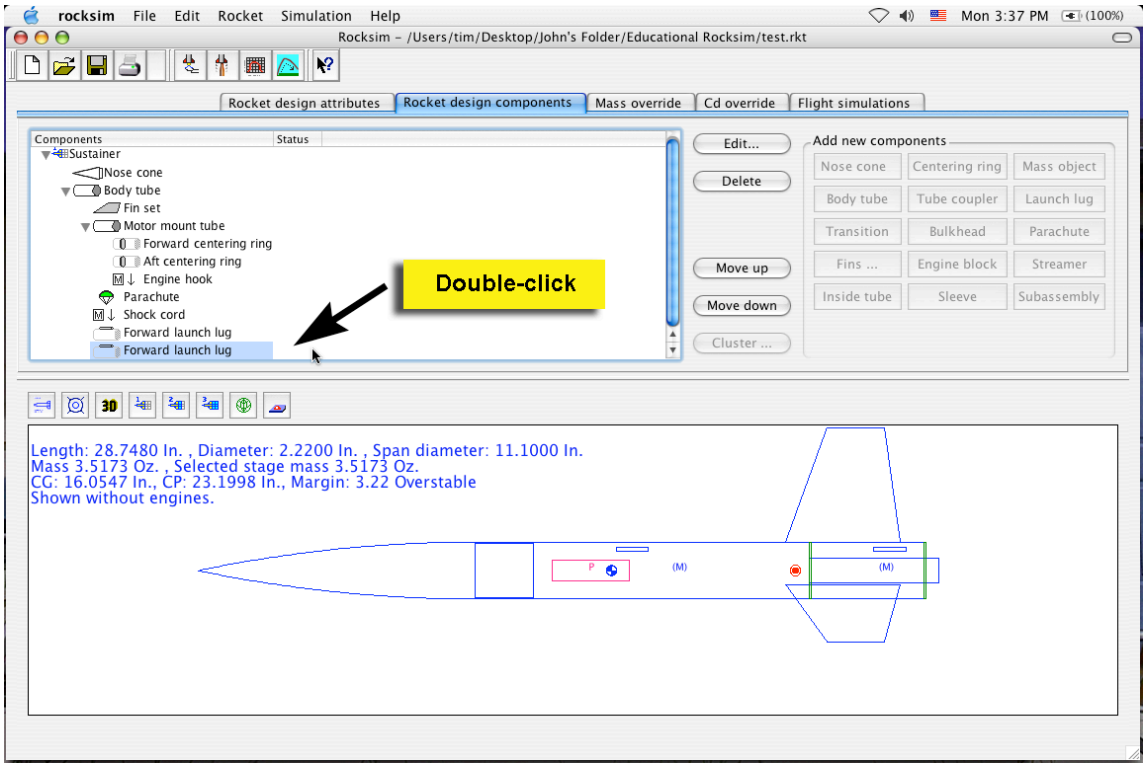
e. Now use the "Apple-C" keys together again to copy the lug. Windows users will use "Control-C."



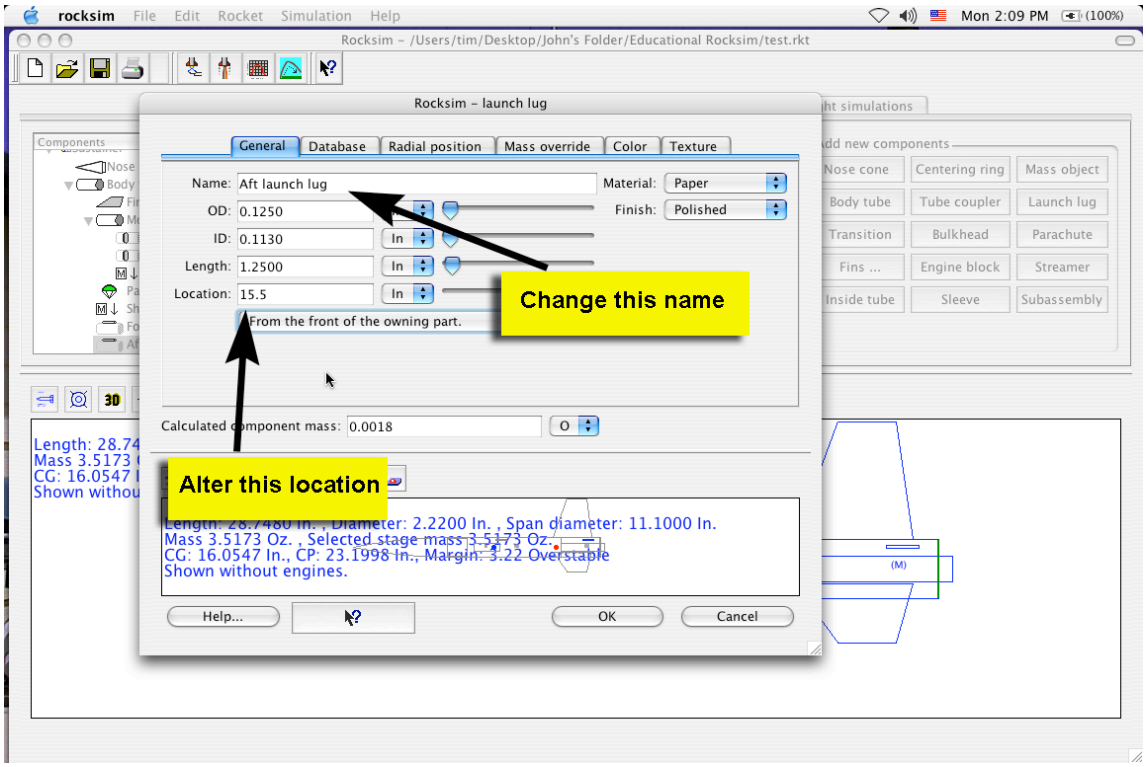
f. Next you will highlight the body tube since it will be the owning part and then use "Apple-V" keys together to duplicate in another lug. Windows users will use "Control-V."



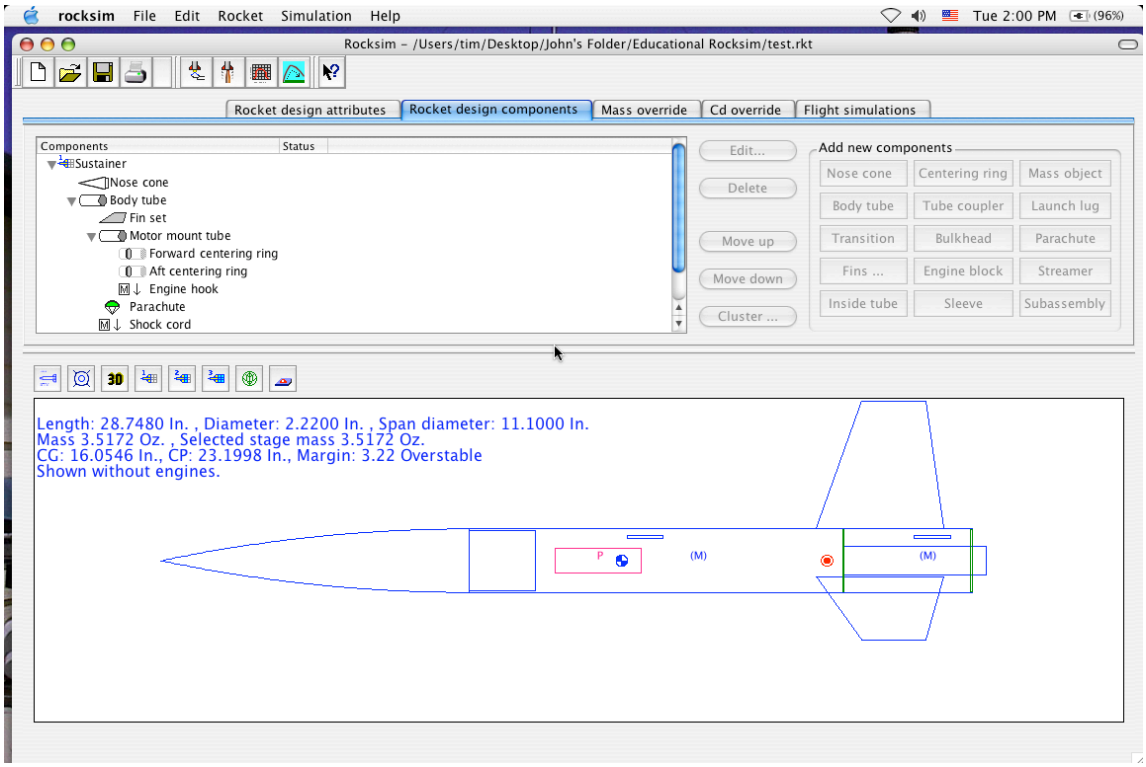
g. Double-click the duplicate lug to enter the design screen.



h. You may now change the name of the part to "Aft" and make the location 15.5" so that it is 1/2" from the end of the rocket. Then you can click "OK."



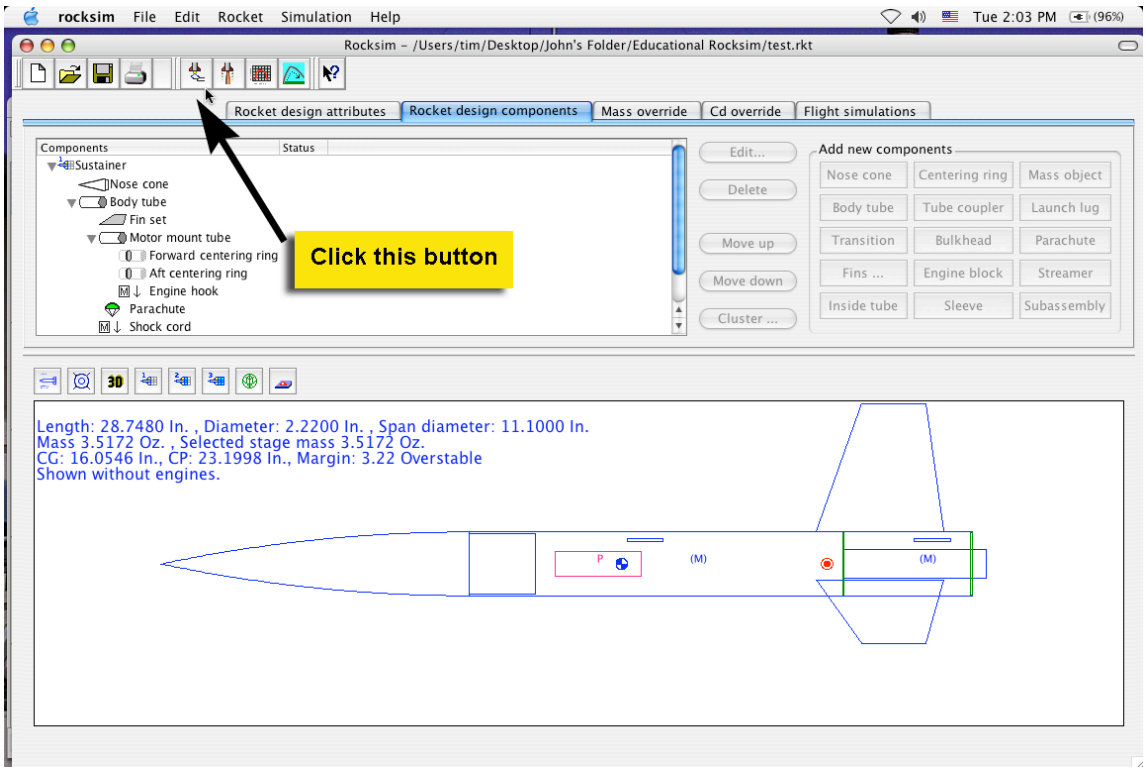
i. This is what your finished design should now look like.



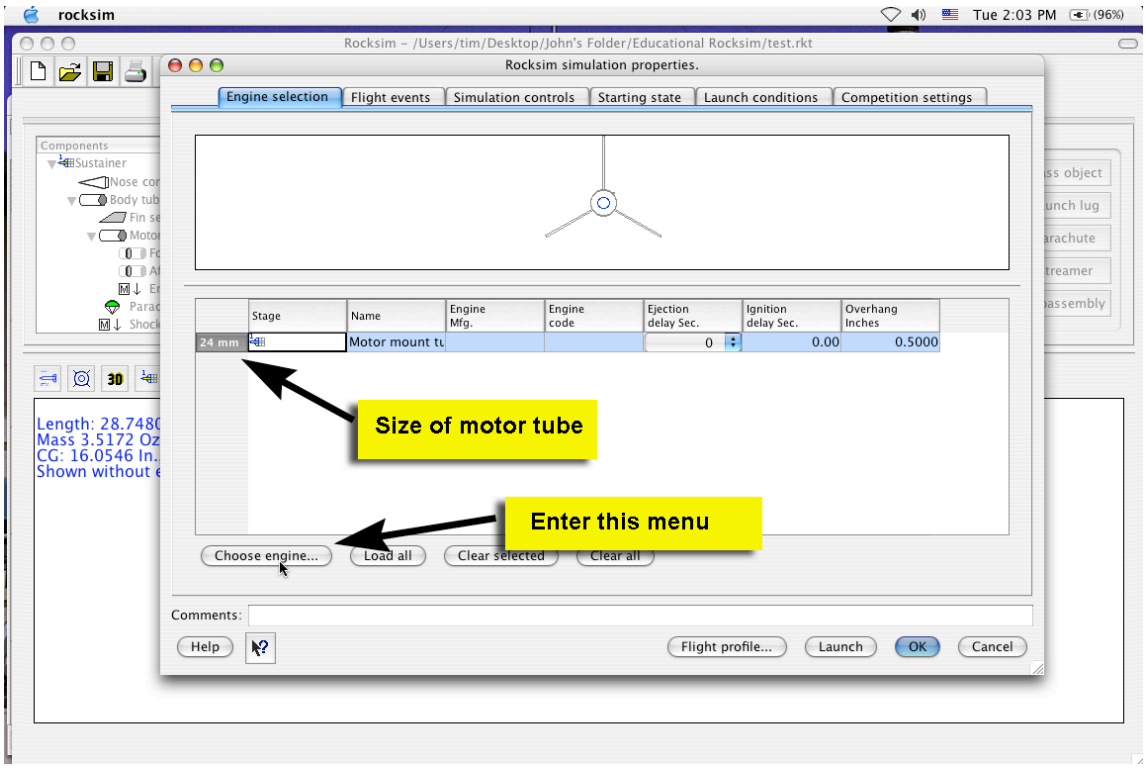
3. Simulating Flights

Loading a Motor and Launching

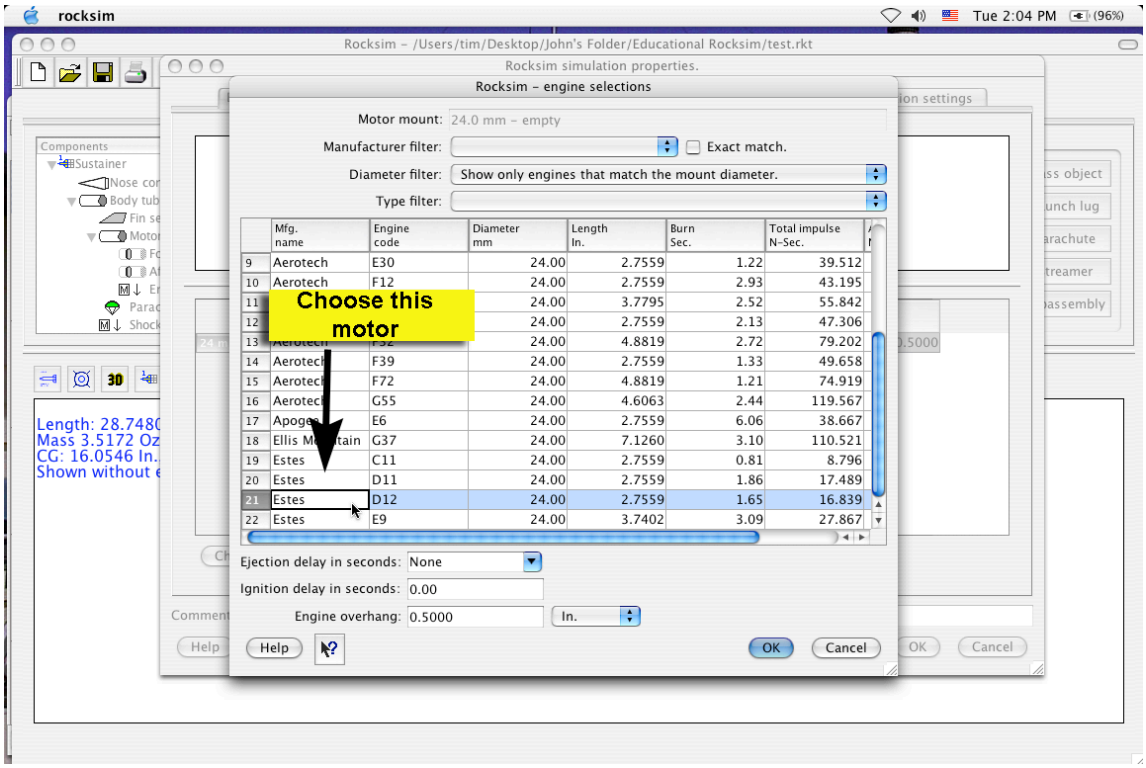
1. The first step in doing a flight simulation is to load a motor in the rocket, just like in real life. Click the "Prepare for launch" button.



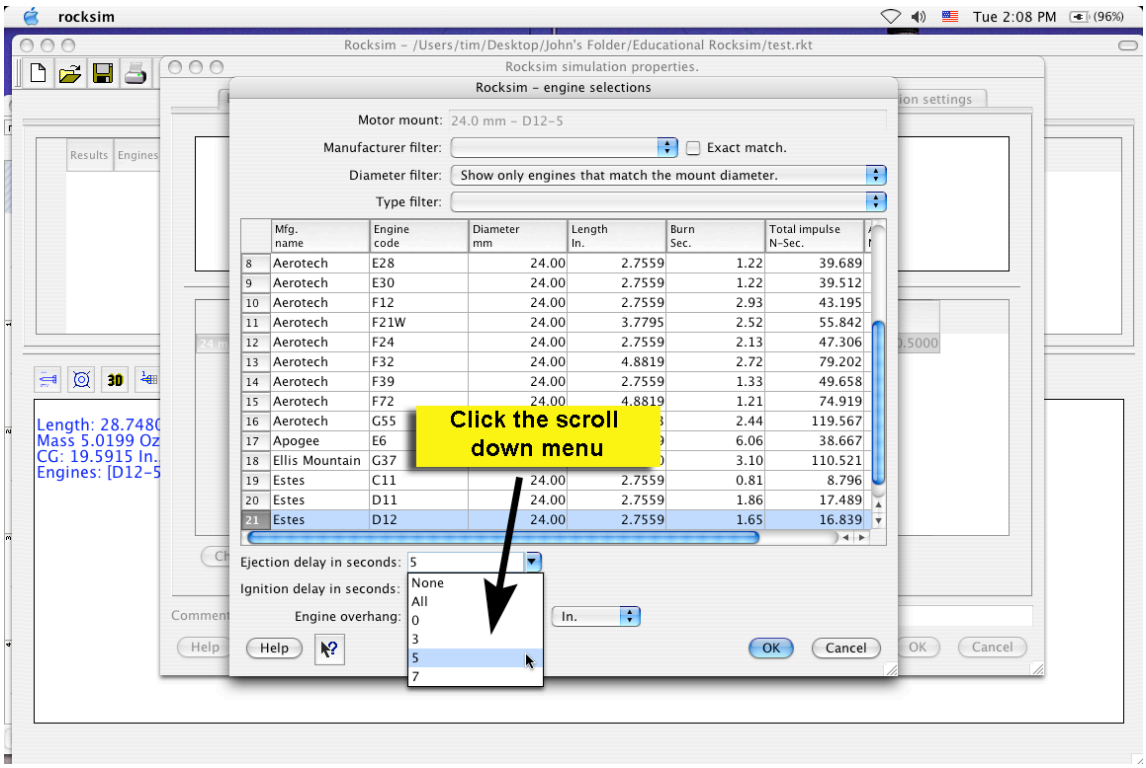
2. The next screen you will see will be the simulation properties screen. You will see what size motor tube you have so you know what size motor can be loaded. Choose a motor by entering the "Choose engine" screen.



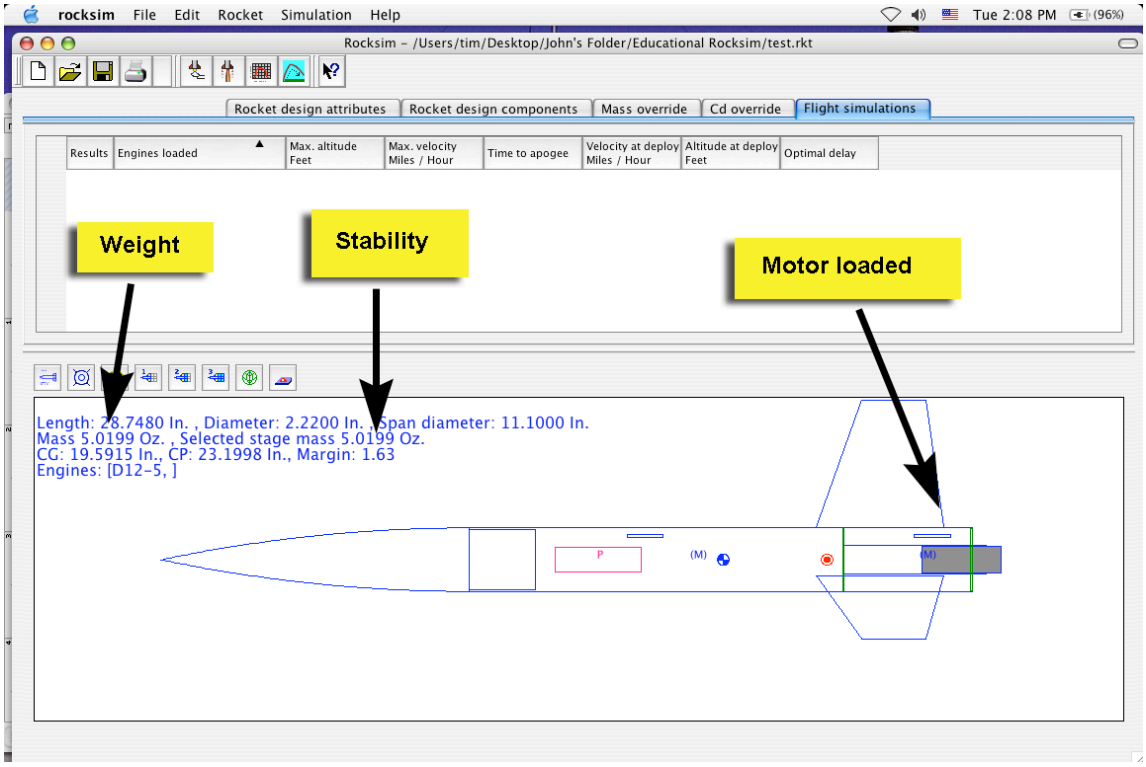
3. Let's start with an Estes D12 motor. Click on this to highlight it.



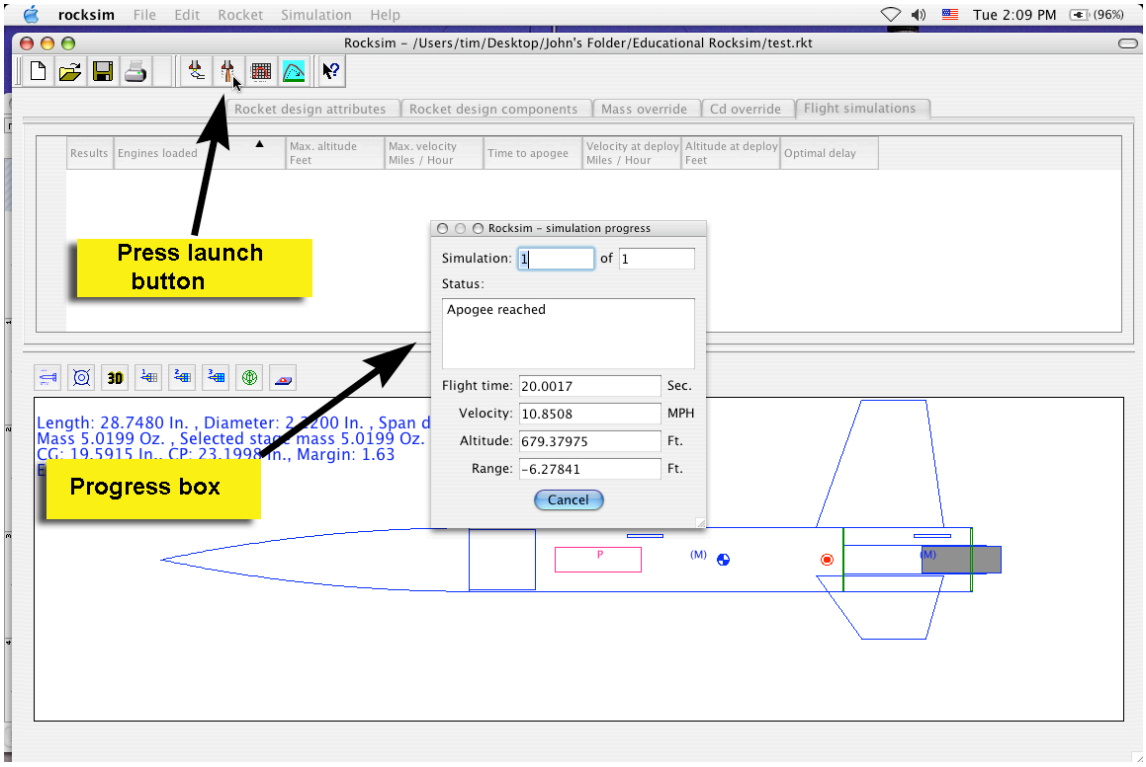
4. Now you may click the scroll down menu labeled "Ejection delay in seconds" and select a 5 second delay for this flight in particular. After this is done click "OK".



5. At this point, you will notice that the rocket's weight is displayed with the motor in. Also, the static margin is right in between 1-2 body tube diameters (calibers) and the motor is depicted being loaded into the rocket.

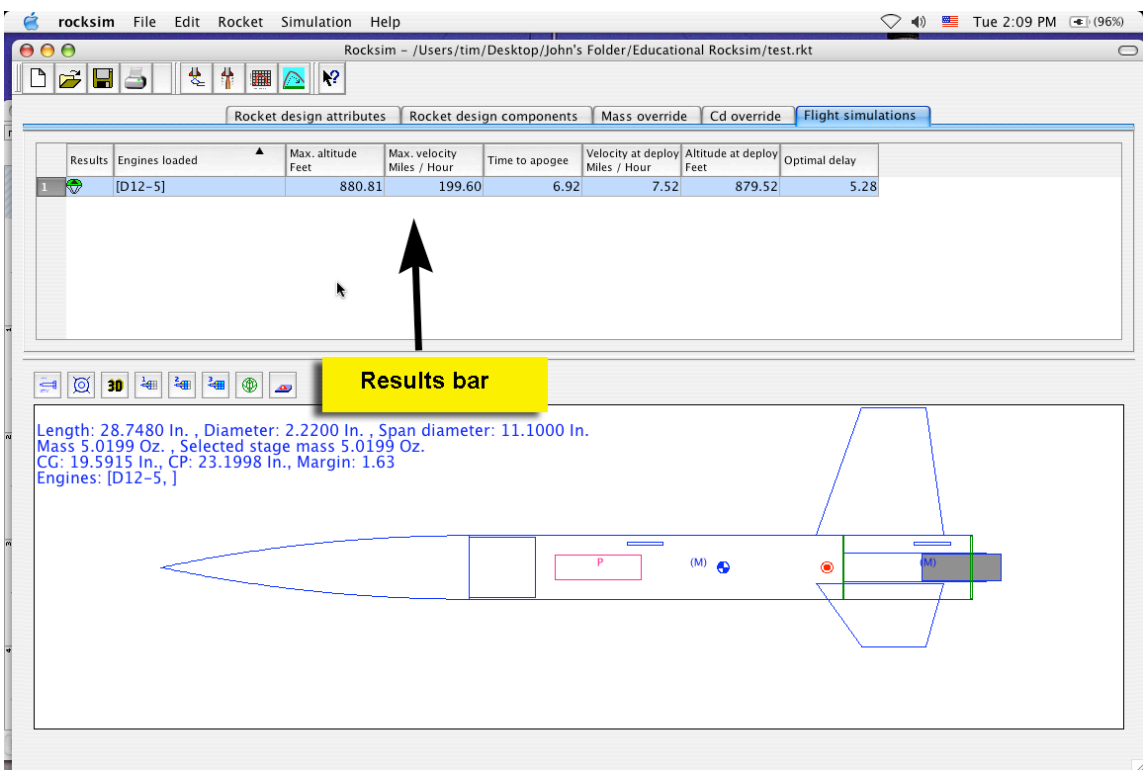


6. Now it's time to launch the rocket! Press the "Launch" icon and a simulation box will appear showing the rocket's progress.

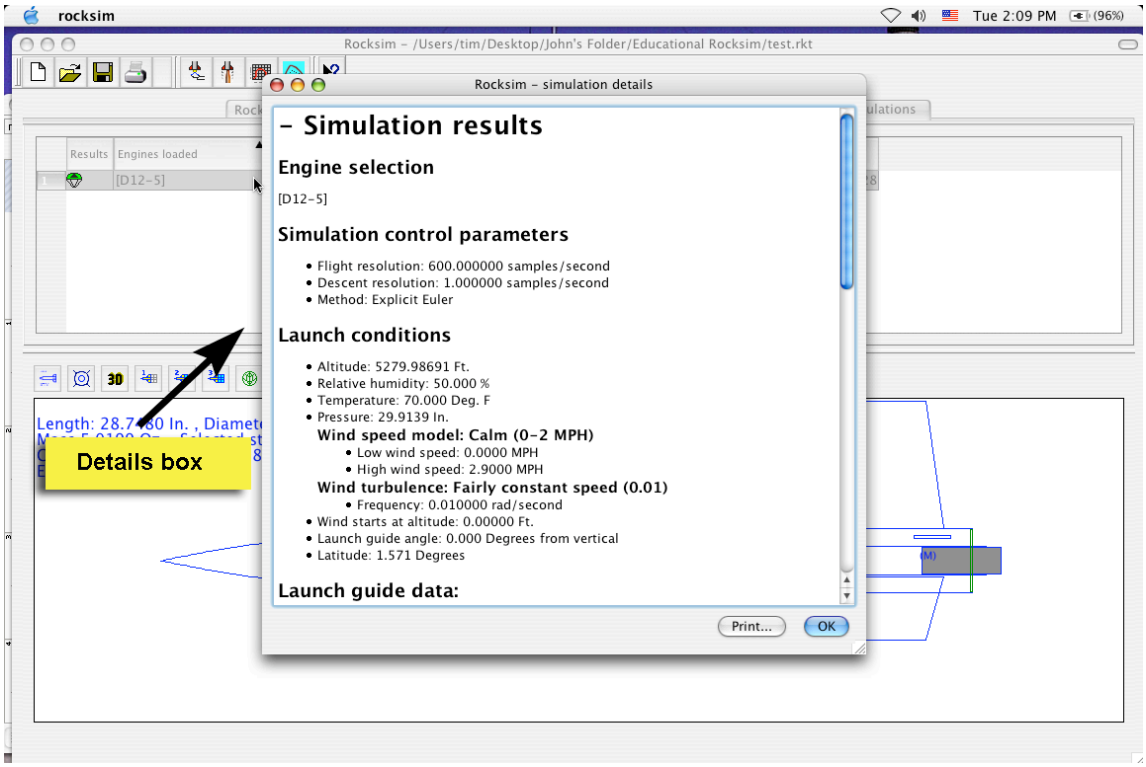


Reviewing Results

1. Once the simulation is finished running the results bar will appear which has quite a bit of information. The first thing you will see is the results box. This will have either a parachute with a triangle inside that is pointed up (deployment before apogee), one that is pointed down (deployment after apogee), a parachute without a triangle (deployment at apogee), or an icon of a crashed rocket (self explanatory). The next box shows what engine was loaded for that flight. This is followed by the maximum altitude reached, maximum speed, how long it took to reach apogee, the speed of the rocket at apogee, altitude at deployment, and the optimal delay for the motor. These boxes can be customized based on your need by going to the Rocksim pull-down menu, then to "preferences" and clicking on "simulation summary." You can add or delete summary boxes, as you like.

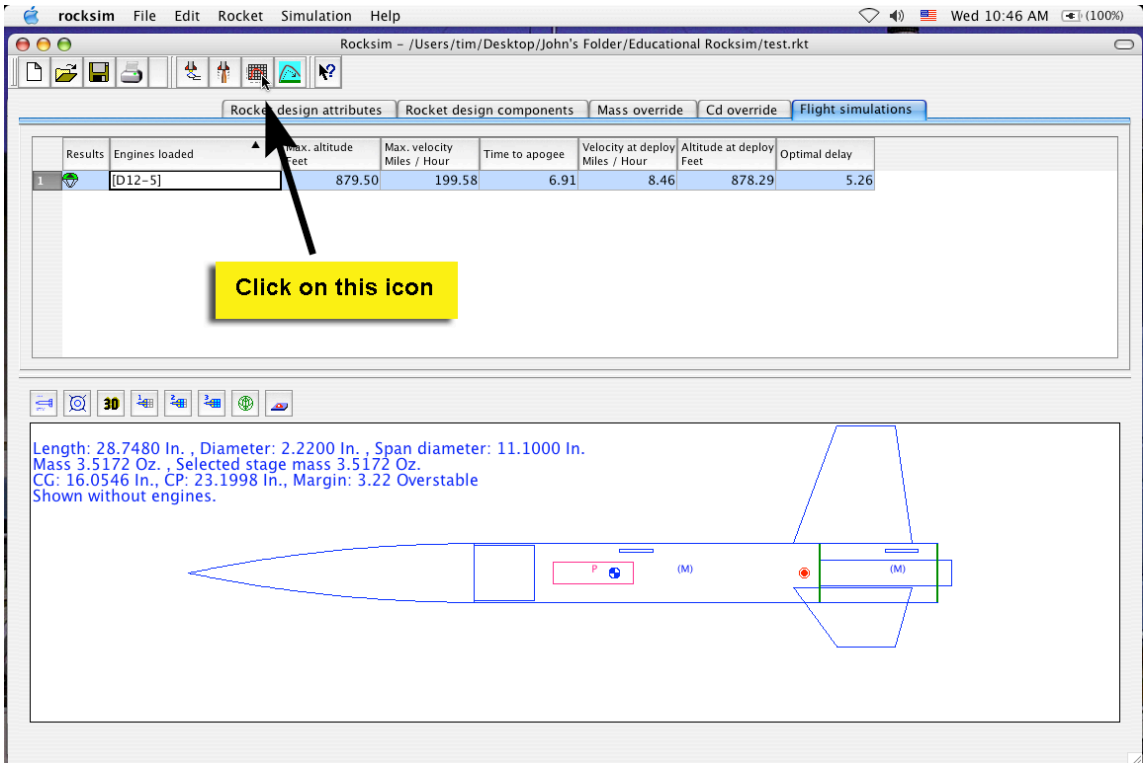


2. At this point, you can double-click on any simulation and a flight details box will appear, which you can scroll through and see all the details of the flight.

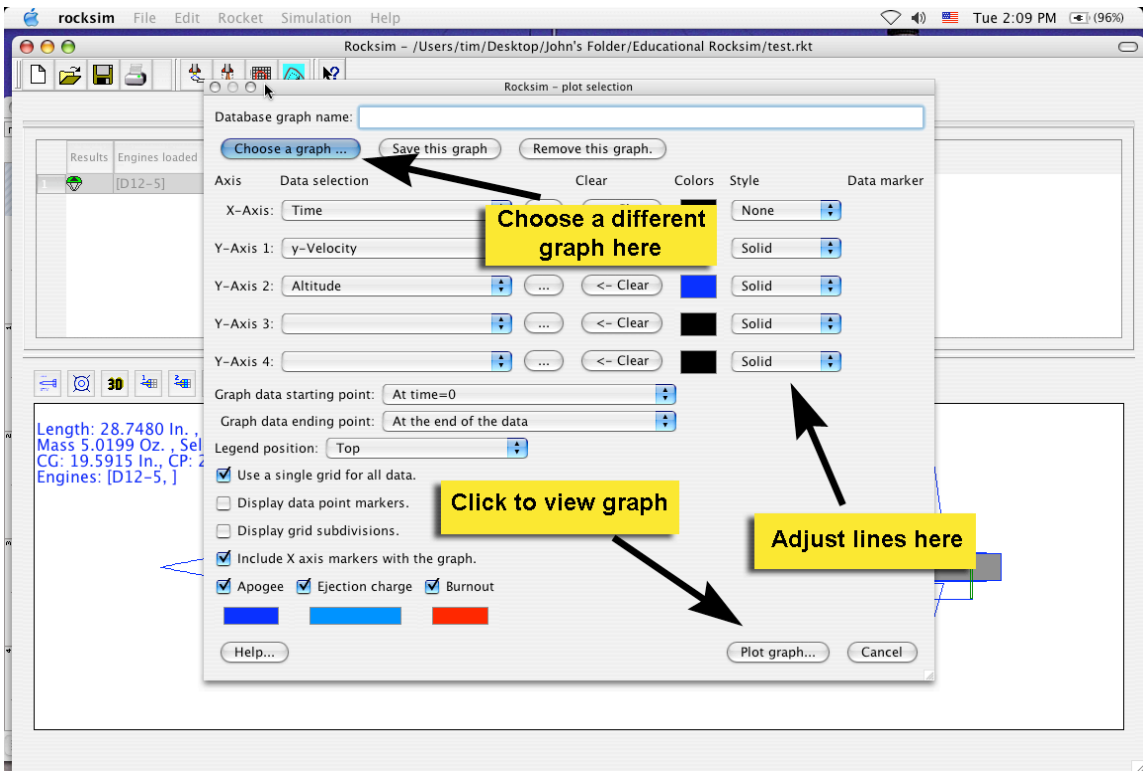


Using Graphs

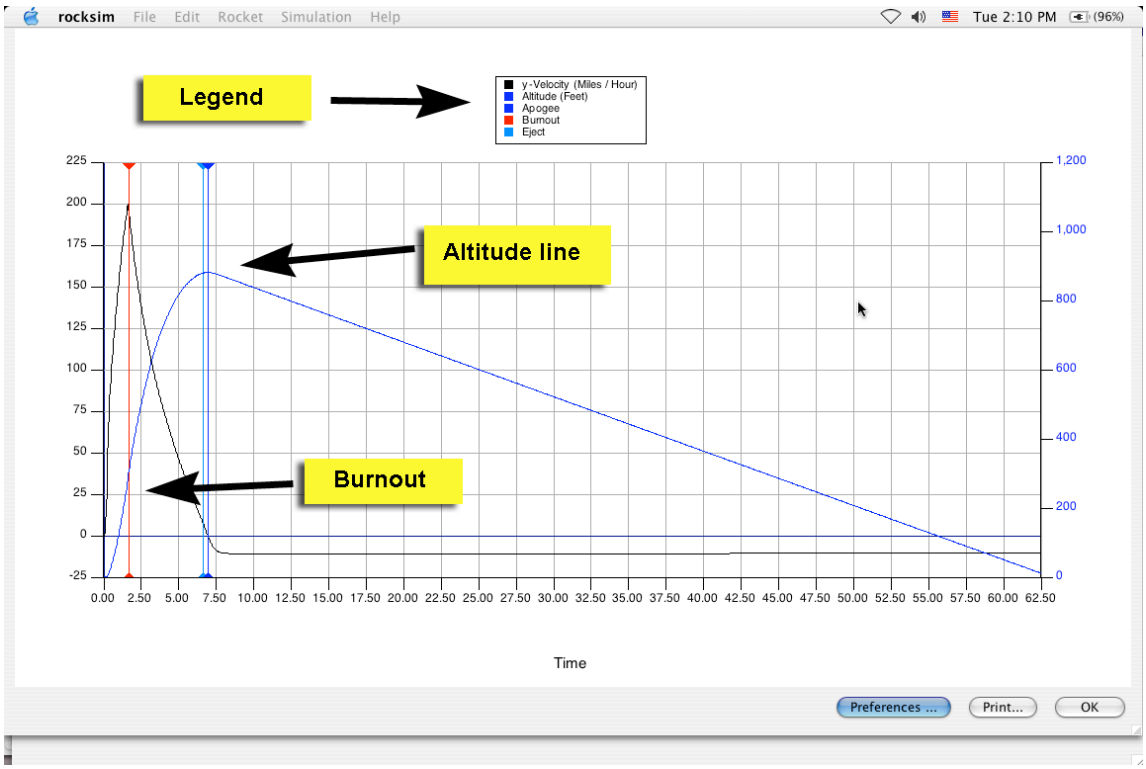
1. To create a graph, click on the "Graph" button.



2. This will be the screen that will appear. It is here that you can either use the default graph that gives you altitude, time and velocity, you may choose from other data or you can create your own graph. For our purposes, we will use the default setting, which is "time, velocity, and altitude." It gives some of the most useful information. You may also adjust the type of graph lines here. Then, just click "Plot graph" to get your results.

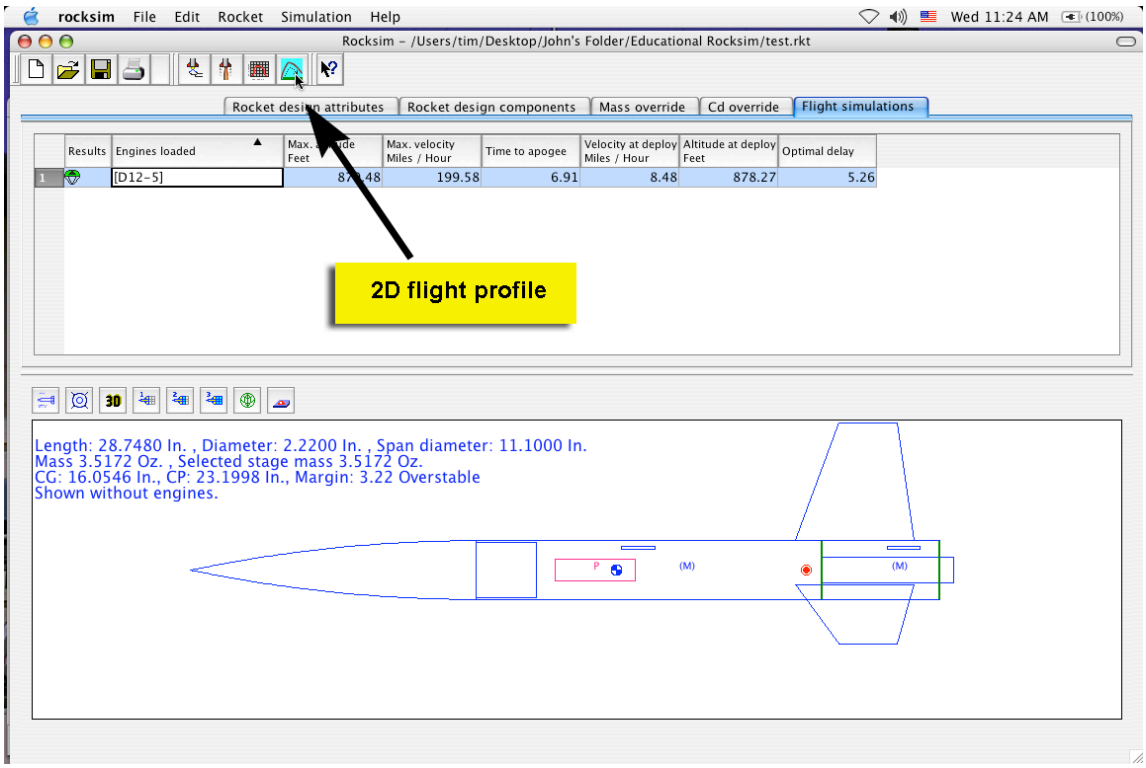


3. On the graph, you will find a legend that will help interpret the graph. As you can see, the motor burned out early and the rocket coasted for a while before the ejection charge went off. The altitude line gives a good visual aid to help you see where ejection occurred compared to apogee. On the left of the graph, there is the velocity; on the right is the altitude, and the time of the flight is on the bottom. If you would like to print the graph, simply press "Print" and you will have the option of printing and/or turning it into a PDF document.

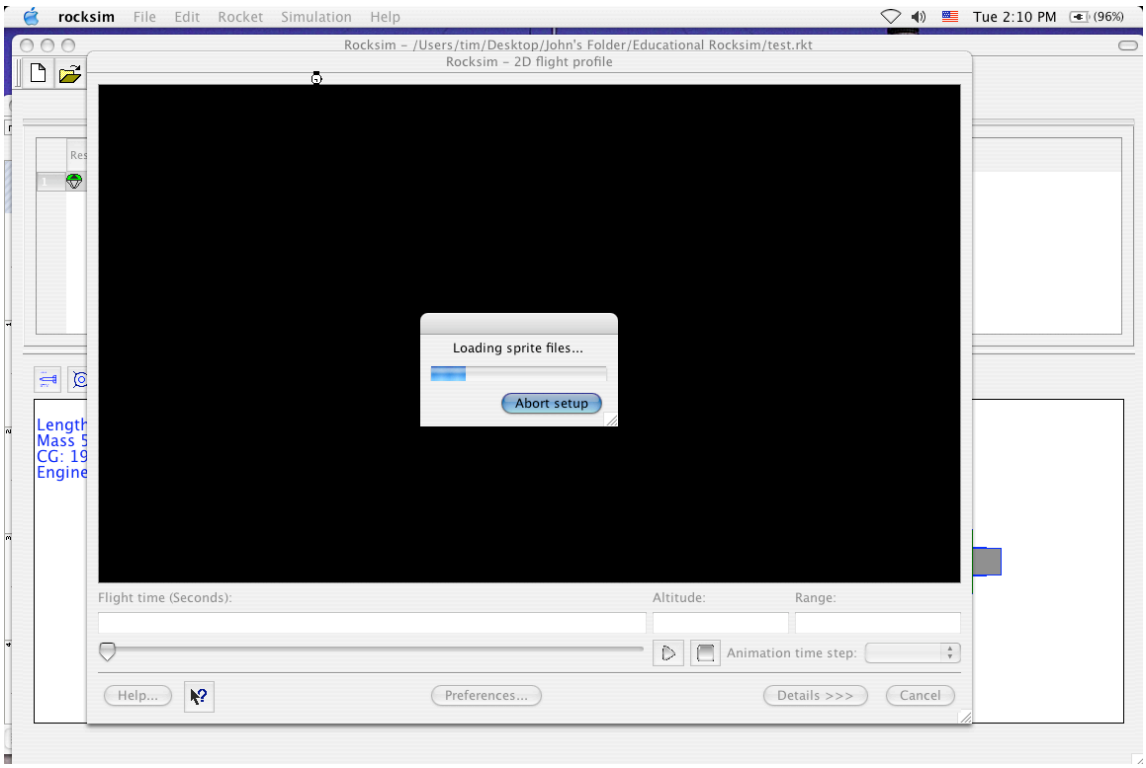


Running Animations

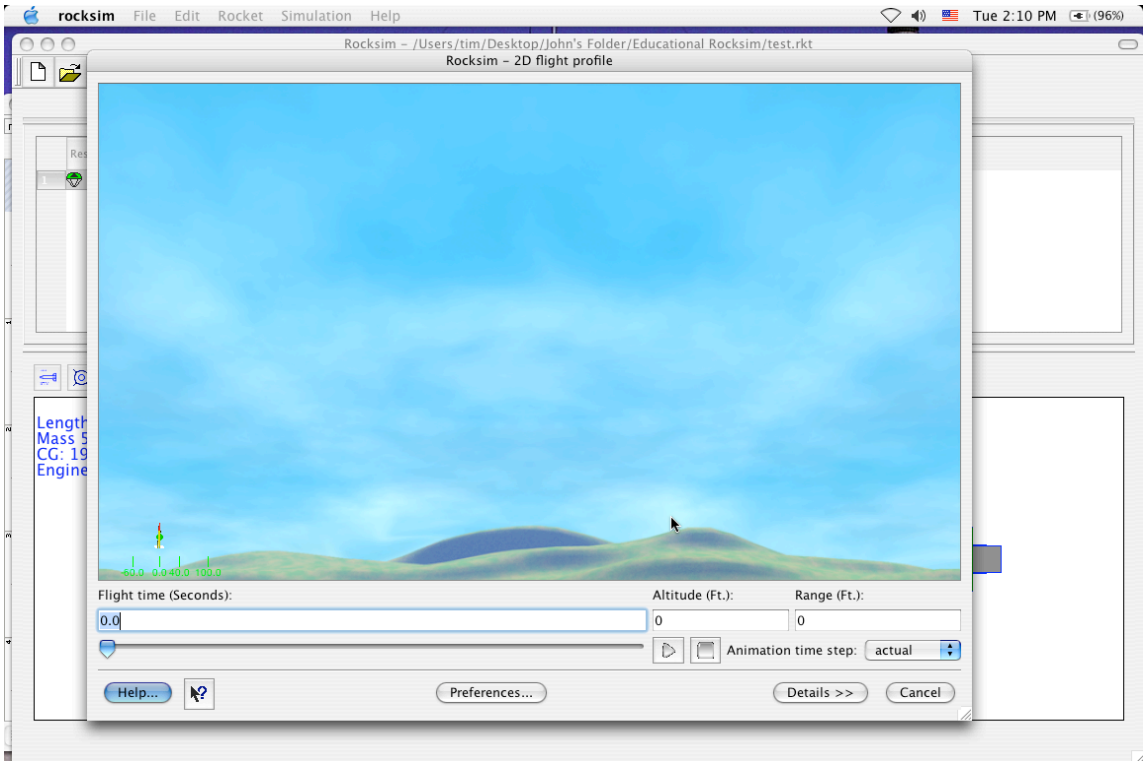
1. The first step in running a simulation is to click on the "2D flight profile" button.



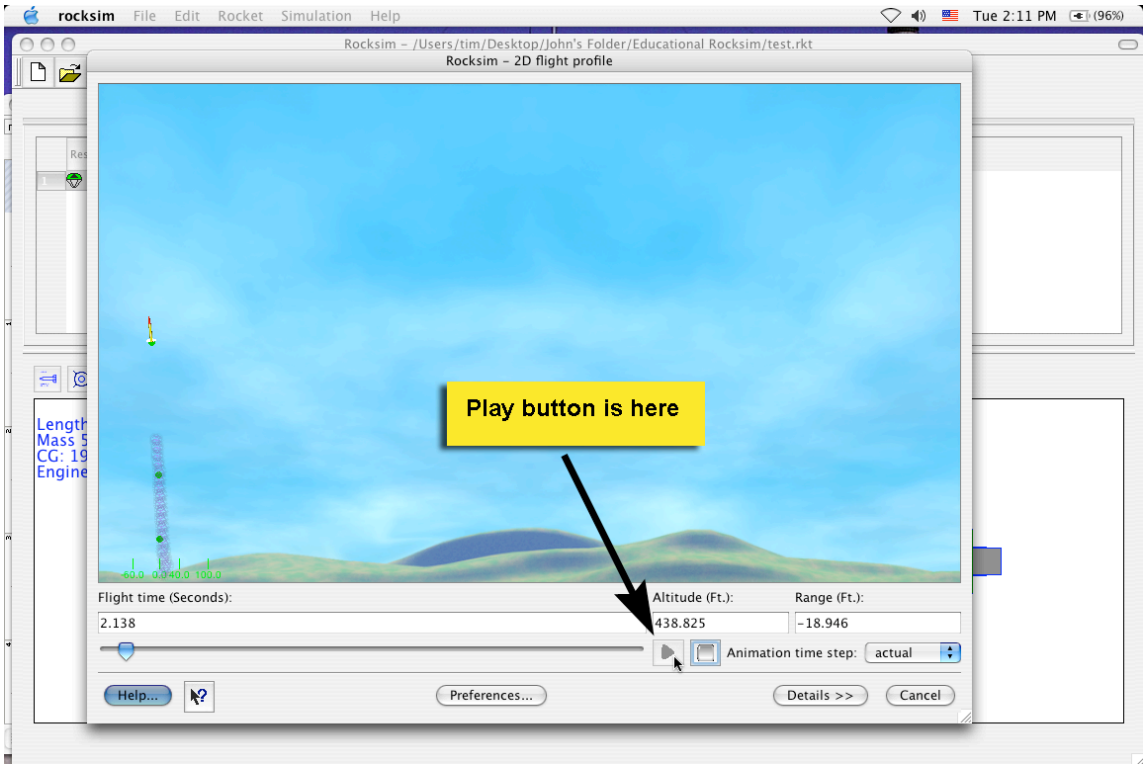
2. This will immediately start the process of loading sprite files, which are animated representations of rockets as well as the background and other files for the animation.



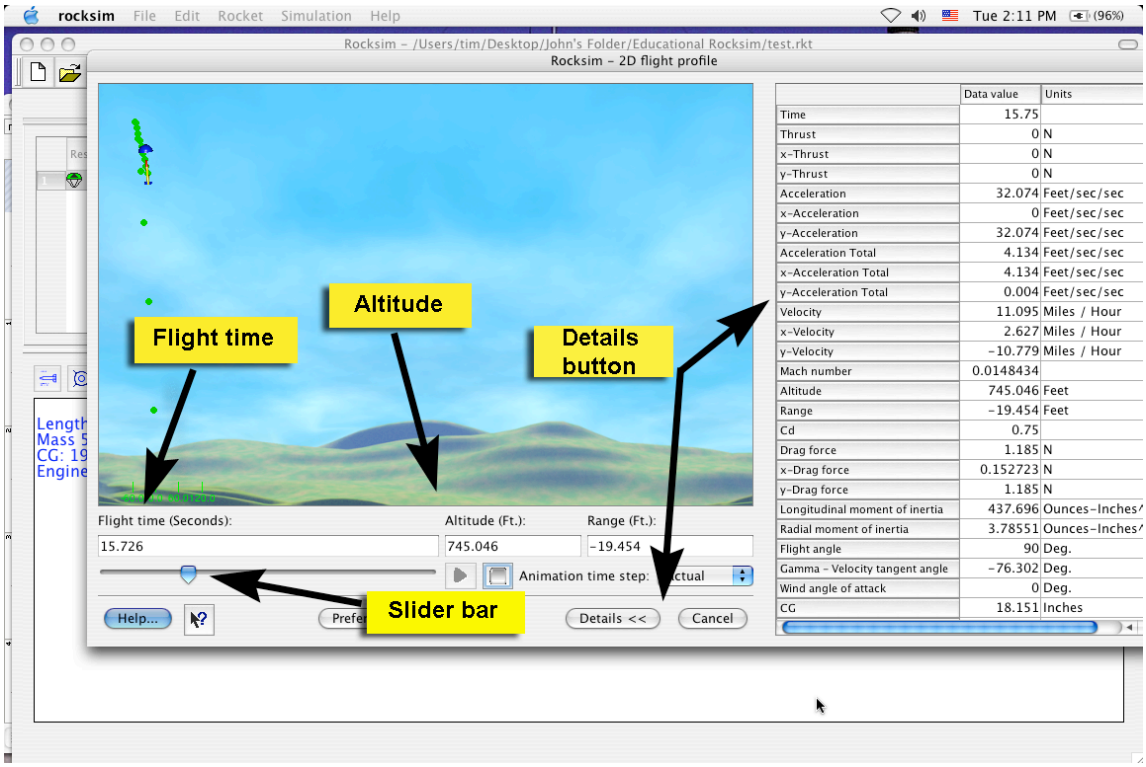
3. When this process is finished, the screen will appear as it does below.



4. To play the animation, just click on the play button and the rocket will take off.



5. Many things appear on the screen during the flight. The flight time is shown elapsing in real-time as well as altitude. If you would like to see the details of the flight, click on the "Details" button at the bottom of the screen and to the right of the animation you will be able to watch all of the details in real-time as they flash by. If you want to see certain aspects of the flight then, using the slider bar, simply click and drag it left or right to wherever you are trying to see in the sequence.



Teaching Science with Rocksim

Lesson 1
Introduction to Rocksim 8.0
Integrated Science and Technology Unit

John Manfredo

Apogee Components, Inc.

2006

Integrated Unit Plan Summary

This 2-week unit is designed for seventh through twelfth grade students to teach students how to use the rocketry design and simulation program, Rocksim 8.0. The lesson plans provided in this unit integrate science and technology. The science standards used within the lesson plans are taken from the National Education Technology Standards (NETS) and National Science Teacher Association (NSTA). The purpose of this unit is to teach students about the basic operations that can be performed using this program and the information that can be gleaned form it.

Throughout this unit, students will gain the knowledge they need to use Rocksim for other lesson plans relating to rockets and aerodynamics. The students will be required to graph their data from a simulation so that the teacher will know that they are able to use. In addition, they will be required to work in teams and assess themselves and others.

Integrated Lesson Plan

Name	John Manfredo	**National Model Content Standards**	*SCIENCE* STANDARD 1: Students understand the processes of scientific investigation and design, conduct, communicate about, and evaluate such investigations. **National Educational Technology Standard 4** *Technology Communications Tools:* Students use a variety of media and formats to communicate information and ideas effectively to multiple audiences. STANDARD 6: Students understand that science involves a particular way of knowing and understand the common connections among scientific disciplines.
Activity Title	Rocksim 8.0 Basics		
Lesson Completion Time	*Weeks: 2* *Days:* 2 days a week and 40 minutes a day.		
Intended Grade Level	7th-12th Grade		

Specific Objective:

Instructional (teacher) Objective	Behavioral (learner) Objective
1. The teacher will introduce the software program 2. The teacher will prepare and facilitate students into teams	1. The students will complete an overview of Rocksim 8.0. 3. The students will break out into groups to learn the basic operation of the program.

Materials Required:

- Computers for each student
- Rocksim 8.0 software on computers
- Science journals
- Pencils
- Rulers

Sequence of Lesson:

Introduction:

The teacher will conduct a short review and discussion of basic computer operation if needed. Then the teacher will either split students into groups or, if space and equipment allow, students will each have a computer to work with.

Activity:

DAY 1:

Students will click on the Rocksim icon on the desktop of the computer to start the program. They will then click on the "open folder" icon and a box will pop up which will show all the available rocket designs that can be opened up. Students will choose the Quest Payloader One by scrolling down to find it, highlighting it, and then clicking "open". When the rocket design appears in the window, they should take a moment to identify the different tabs, menus and data on the screen, including center of gravity (CG), center of pressure (CP), weight, dimensions, and margin. Next, students should select the "rocket design components" tab and familiarize themselves with how each part of the rocket is arranged. Have them select the main body tube and click on the edit button. This will bring up the details of the part such as dimensions and weight. Have them play with the slider bars a little and when they are finished they can click on "cancel". They should select "no" for saving changes. They will do the same for other parts so that they are familiar with each of the parts and how they can be altered. Students should then click on an existing simulation and then select "plot graph". Students can try viewing a graph that should have "time, velocity, and altitude" on it. If these are not selected, the students may go to the "choose a graph" menu where they can select the proper graph and click "ok". Students will then click on "plot graph" and the respective graph will appear. Pressing the print button will let them print out a graph. This is something that they will be printing out in future lessons.

DAY 2:

Students will begin this day by opening up the Payloader One again. Students will then click on the "prepare for launch" button to load a motor. Have them click on "choose engine" and then select a motor to load in the rocket as well as a delay. At this point it doesn't matter what motor or delay. After that they can click "ok". Now have the students select the "starting state" tab and make sure that the launch guide length is set at 36" and the launch angle is "0 degrees". Now they may select the launch conditions tab and set their current conditions to that which it is at their locale. They may then click "ok" which will take them back to the main screen. Students should then click on the launch button and let a simulation run. Once that simulation is finished, have them select the "flight simulation" tab and study the results of the launch. They should also try double-clicking on any of the simulations, as this will provide them with even more details of the launch. Next, each student shall click on one of the flight simulations and then select the "2D flight profile" button and play the animation that follows. From this screen they may also view the full flight details by clicking on the details button. They will be able to use the slider bar to see the details at any one moment of the flight.

Authentic Assessment (checking for understanding):

Through class discussions and observation the teacher will check students for understanding of the material. The students will complete a self-assessment of their own understanding and ability levels at the mid-point of the unit.

Evaluation:

Each student will be required to submit his or her science journal and Venn Diagram. An automated Venn diagram site may be found at: http://teachers.teachnology.com/web_tools/graphic_org/venn_diagrams/. The teacher for understanding and accuracy of the material will review them. The teacher will collect the students' science journals, specifically evaluating the data collection process and how the scientific method was used. Suggested resources are: http://teach-nology.com/web_tools/rubrics/lab_report/ and http://teach-nology.com/web_tools/rubrics/research/.

Scaffolding Activities for At-Risk Students:

The teacher will help children who are having difficulty with the science experiment. Students will be paired with other students so that they may use each other's knowledge to complete their individual science journals.

Extension Activities for Gifted and Talented Students:

Students may also create a graph that represents the specific data collected throughout the experimentation process.

Rocksim Lesson 1 Quiz

1. In order to open a design in Rocksim, you must:

A) Click on the "New design" icon.
B) Select the print button.
C) Left click on the "Open" button.
D) Right click on the "Open" button.

2. Which of the following is not shown on the main design screen?

A) The CG
B) Altitude
C) The Static Margin
D) The CP

3. On the "Rocket Design Components" tab, the following items can be found:

A) Motor used
B) Nose cone
C) Fins
D) B and C

4. To plot a graph you need to:

A) Select a simulation, click on the graph button, plot the graph, and print it.
B) Click on the graph button and print it.
C) Select a simulation, plot the graph, and print it.
D) None of the above.

5. Some of the information that can be learned from running the "details" on the 2D flight profile is:

A) Velocity at any one point within the rocket's flight.
B) Wind angle of attack
C) Drag force
D) A, B, and C

Lesson 2
Rocket Stability
Integrated Science and Technology Unit

John Manfredo

Apogee Components, Inc.

2006

Integrated Unit Plan Summary

This 2-week unit is designed for seventh through twelfth grade students to teach the stability of rockets. The lesson plans provided in this unit integrate science and technology. The science standards used within the lesson plans are taken from the National Education Technology Standards (NETS) and National Science Teacher Association (NSTA). The purpose of this unit is to teach students about rocket stability, data collection, graphing, and presentation of results using computer media.

Throughout this unit, students will use the scientific method to complete a variety of experiments. The experiments will provide students with the knowledge they need to explain where to find a rocket's center of gravity, the center of pressure, and explain the necessity of having both of these in the proper orientation in order for a rocket to be stable for flight. Also, this helps the students answer the question "Why can't we put the fins at the front of the rocket?" The students will be required to complete observations, journal their findings, and graph their data. In addition, they will be required to work in teams, assess themselves and others, and submit their science journals for teacher review.

Integrated Lesson Plan

Name	John Manfredo	**National Model Content Standards**	*SCIENCE* STANDARD 1: Students understand the processes of scientific investigation and design, conduct, communicate about, and evaluate such investigations. **National Educational Technology Standard 4** *Technology Communications Tools:* Students use a variety of media and formats to communicate information and ideas effectively to multiple audiences. STANDARD 6: Students understand that science involves a particular way of knowing and understand the common connections among scientific disciplines.
Activity Title	Center of Gravity		
Lesson Completion Time	*Weeks: 1* *Days:* 2 days a week and 40 minutes a day.		
Intended Grade Level	7th-12th Grade		

Specific Objective:

Instructional (teacher) Objective	Behavioral (learner) Objective
1. The teacher will introduce the scientific method. 2. Each week the teacher will introduce the theme for the week. 3. The teacher will prepare and facilitate an integrated technology and science experiment.	1. The students will complete a review of the scientific method. 2. The students will discuss the weekly theme to gain an understanding of the unit. 3. The students will complete an integrated technology and science experiment.

Materials Required:

- Computers for teams of 4 students each
- Rocksim 8.0 software on computers
- Handouts from Appendix A
- Science journals
- Pencils
- Rulers
- Clay

Sequence of Lesson:

Introduction:

The teacher will conduct a short review and discussion of the scientific method. The scientific method consists of five steps: identifying a problem, making a hypothesis, deciding on a procedure, collecting and analyzing data, and deriving a conclusion. See Appendix A for scientific method worksheet. The teacher will explain to the students what the center of gravity and the center of pressure on an object is. (See Appendix B). The students should already have been shown the basics on how to use the different Rocksim screens. The teacher will then pose the question "Why is the location of the center of gravity important for the stability of a rocket?" and a short classroom discussion will be held. The students will identify the basic parts of a rocket, the nose cone, body tube, fins, motor mount, etc.

Day 1 Activity:

The teacher will divide the class up into groups of 4 students each. Each student will take a pencil and find the balance point on a ruler, which is the center of gravity (CG). They will then randomly affix small amounts of clay weight to different parts of the pencil, finding the CG for each location, and recording each finding in their journals (i.e.-measurements from the tip of the pencil to the CG for each finding).

Day 2 Activity:

Each student will take a turn using Rocksim to find the CG on a rocket. To begin, the student will start Rocksim and open the Quest Astra rocket kit. Students will take turns identifying and noting the location of the rocket's center of CG. Each student will then load a C6-7 motor into the rocket to find out what happens to the CG when weight is added to the aft end of the rocket. Students will then take turns adding weight to the nose cone and aft end of the rocket to see the shift of the CG as the weight changes on different parts of the rocket.

Authentic Assessment (checking for understanding):

Through class discussions and observation the teacher will check students for understanding of the material. The students will complete a self-assessment of their own understanding and ability levels at the mid-point of the unit.

Evaluation:

The teacher will collect the students' science journals, specifically evaluating the data collection process and how the scientific method was used. Suggested resources are: http://teach-nology.com/web_tools/rubrics/lab_report/ and http://teach-nology.com/web_tools/rubrics/research/.

Scaffolding Activities for At-Risk Students:

The teacher will help children who are having difficulty with the science experiment. Students will be paired with other students so that they may use each other's knowledge to complete their individual science journals.

Extension Activities for Gifted and Talented Students:

Students will create a short power point presentation that discusses their findings from the experiment. Students may also create a graph that represents the specific data collected throughout the experimentation process.

Cooperative Lesson Plan

Name	John Manfredo	**National Model Content Standards**	*SCIENCE* STANDARD 1: Students understand the processes of scientific investigation and design, conduct, communicate about, and evaluate such investigations. **National Educational Technology Standard 4** *Technology Communications Tools:* Students use a variety of media and formats to communicate information and ideas effectively to multiple audiences.
Activity Title	Center of Pressure		
Lesson Completion Time	*Weeks: 1* *Days:* 2 days a week and 40 minutes a day.		
Intended Grade Level	7th-12th Grade		

Specific Objective:

Instructional (teacher) Objective	Behavioral (learner) Objective
1. The teacher will facilitate a classroom discussion using a series of questions. 2. The teacher will explain what "center of pressure" is and how to find it.	1. The students will participate in a classroom discussion based on a series of questions posed by the teacher. 2. The students will work in a team to using cardboard cutouts and Rocksim to find center of pressure.

Materials Required:

- Computers for teams of 4 students each
- Rocksim 8.0 software on computers
- Science journals
- Pencils
- Cardboard
- Rulers

Sequence of Lesson:

Introduction:

The teacher will discuss with the class what center of pressure (CP) is in rocketry, what it does, how to find it, and why it is important. Information can be found at http://www.info-central.org/index.cgi?construction.

Day 1 Activity:
Students will be divided into groups of 4. Each student will take turns drawing the shape of a rocket on a piece of cardboard and cutting it out. They will find the balance point by placing it on the ruler. This will be the CP of the rocket. Each student will record his or her findings in their science journal.

Day 2 Activity:
Students will be divided into groups of 4. Each student will take a turn using Rocksim to find the CP on a rocket. To begin, the student will start Rocksim and open the Quest Astra rocket kit. Students will take turns identifying and noting the location of the rocket's center of CP. Each student will then load a C6-7 motor into the rocket to find out what happens to the CP when weight is added to the aft end of the rocket. Students will then take turns adding weight to the nose cone and aft end of the rocket to see if the CP shifts as the weight changes on different parts of the rocket.

Authentic Assessment (checking for understanding):

The team presentation will be used to evaluate their understanding of the activity. Each team member will also submit a team assessment survey indicating the performance and participation of all other team members. Each student will also be required to submit an assessment of his or her performance on the project.

Evaluation:

The teacher will collect the students' science journals, specifically evaluating the data collection process and how the scientific method was used. Suggested resources are: http://teach-nology.com/web_tools/rubrics/lab_report/ and http://teach-nology.com/web_tools/rubrics/research/.

Scaffolding Activities for At-Risk Students:

Teams will have individual students with a variety of different ability levels. The team will work together on all parts of the assignment. The teacher will assure that each team is actively working together and will assist when asked.

Extension Activities for Gifted and Talented Students:

Students will create a short power point presentation that discusses their findings from the experiment. Students may also create a graph that represents the specific data collected throughout the experimentation process.

Problem Solving Lesson Plan

Name	John Manfredo	**Colorado Model Content Standards**	*SCIENCE* STANDARD 1: Students understand the processes of scientific investigation and design, conduct, communicate about, and evaluate such investigations. STANDARD 3: Life Science: Students know and understand the characteristics and structure of living things, the processes of life, and how living things interact with each other and their environment. **National Educational Technology Standard 4** *Technology Communications Tools:* Students use a variety of media and formats to communicate information and ideas effectively to multiple audiences.
Activity Title	Stable Designs for Flight		
Lesson Completion Time	*Weeks: 2* *2 times weekly; 40 minutes per day*		
Intended Grade Level	7th-12th Grade		

Specific Objective:

Instructional (teacher) Objective	Behavioral (learner) Objective
1. The teacher will relay the importance of CG and CP related to the stability of a rocket's flight. 2. The teacher will provide examples of Venn Diagrams to the class.	1. The students will understand the importance of CG and CP in the in relation to the stability of rockets. 2. The students will create Venn Diagrams to indicate the interrelationships of CG and CP related to rocket stability.

Materials Required:

- Computers for teams of 4 students each
- Rocksim 8.0 software on computers
- Science journals

Sequence of Lesson:

Introduction:

The teacher will briefly discuss Center of Gravity (CG) and Center of Pressure (CP) in relation to rocket stability, and explain that the class will create 3 different configurations in Rocksim to prove why they are important. The teacher will instruct the student about the minimum and maximum static margins for a rocket to be stable.

Activity:

Day 1

Students will be divided into groups of 4. Each student will take a turn using Rocksim to test the stability of a rocket. To begin, the student will start Rocksim and open the Quest Astra rocket kit. Students will take turns identifying and noting the location of the rocket's center of CP and CG. Each student will then load a C6-7 motor into the rocket to find out what happens to the CP and CG when the weight of the motor is added to the rocket. Next, each student will run generate a graph and run a 2D flight profile of the rocket (Students should set the launch conditions to have no wind for consistency with their simulations; graphs chosen should be "time/velocity/altitude").

Day 2

To begin, the student will start Rocksim and open the Quest Astra rocket kit. Each student will then load a C6-7 motor into the rocket. Each student will take a turn moving the fin location forward until the CP is in front of the CG and the rocket becomes unstable. With each configuration the student will create a graph and run a 2D flight profile of the rocket, observe what occurs, and record their findings in their science journal (see Appendix B).

Day 3

To begin, the student will start Rocksim and open the Quest Astra rocket kit. Each student will then load a C6-7 motor into the rocket. Students will take turns adding enough weight to the rear of the rocket to cause the CG to move behind the CP again. Next, each student will run generate a graph and run a 2D flight profile of the rocket. The results should be noted in their science journals.

Day 4

To begin, the student will start Rocksim and open the Quest Astra rocket kit. Each student will then load a C6-7 motor into the rocket. The students will then modify their rockets' body tubes by shortening them until the CG is once again behind the CP. Next, each student will run generate a graph and run a 2D flight profile of the rocket. The results should be noted in their science journals.

Authentic Assessment (checking for understanding):

The teacher will ask questions to check for understanding throughout the class discussion. The students will be required to answer questions using thorough explanations.

Evaluation:

Each student will be required to submit his or her science journal and Venn Diagram. An automated Venn diagram site may be found at http://teachers.teach-nology.com/web_tools/graphic_org/venn_diagrams/. The teacher will collect the students' science journals, specifically evaluating the data collection process and how the scientific method was used. Suggested resources are: http://teach-nology.com/web_tools/rubrics/lab_report/ and http://teach-nology.com/web_tools/rubrics/research/.

Scaffolding Activities for At-Risk Students:

Students will work with the teacher during the observation period, as well as during journaling. Students may use pictures to help complete their science journals and their Venn Diagrams.

Extension Activities for Gifted and Talented Students:

Students will create a PowerPoint presentation to show different rocket configurations and how they relate to stability. . They will then present their show to the other members of the class.

Rocksim Lesson 2 Quiz

1. For a rocket to be stable which of the following statements is true?

A) The center of pressure (CP) must be behind the center of gravity (CG).
B) The center of pressure (CP) must be in front of the center of gravity (CG).
C) The rocket must have fins.
D) The length of the body tube must be at least 5 times the model diameter.

2. An unstable rocket can be made stable by:

A) Adding weight to the nose
B) Removing weight from the nosecone
C) Moving the fins forward towards the nosecone
D) Making the rocket shorter

3. Rocket stability can be estimated by:

A) Center of pressure" Barrowman" equations
B)"Cardboard cutout" method
C) Determining the relative positions of the center of pressure and center of gravity
D) Stability cannot be estimated before a test flight.

4. An unstable rocket can usually be made more stable by:

A) Using a shorter nosecone
B) Increasing the size of the aft fins
C) Using a larger, heavier rocket motor
D) Increasing the rocket diameter

5. Which of the following is true of an unstable rocket?

A) The center of pressure (CP) is behind the center of gravity (CG).
B) The center of pressure (CP) is in front of the center of gravity (CG).
C) The rocket has more than 6 fins.
D) The length of the body tube is less than 5 times the model diameter.

Lesson 3
Newton's Laws of Motion
Integrated Science and Technology Unit

John Manfredo

Apogee Components, Inc.

2006

Integrated Unit Plan Summary

This 3-week unit is designed for seventh through twelfth grade students to teach Newton's Laws of Motion. The lesson plans provided in this unit integrate science and technology. The technology and science standards used within the lesson plans are taken from the National Education Technology Standards (NETS) and National Science Teacher Association (NSTA). The purpose of this unit is to teach students about Newton's Laws of Motion, data collection, graphing, and presentation of results using computer media.

Throughout this unit, students will use the scientific method to complete a variety of experiments. The experiments will provide students with the knowledge they need to explain what Newton's Laws of Motion are and how they relate to rocketry. The students will be required to complete observations, journal their findings, and graph their data. In addition, they will be required to work in teams, assess themselves and others, and submit their science journals for teacher review.

Integrated Lesson Plan

Name	John Manfredo	**National Model Content Standards**	*SCIENCE* STANDARD 1: Students understand the processes of scientific investigation and design, conduct, communicate about, and evaluate such investigations. **National Educational Technology Standard 4** *Technology Communications Tools:* Students use a variety of media and formats to communicate information and ideas effectively to multiple audiences. STANDARD 6: Students understand that science involves a particular way of knowing and understand the common connections among scientific disciplines.
Activity Title	Newton's First Law of Motion "Law of Inertia"		
Lesson Completion Time	*Weeks: 1* *Days:* 2 days a week and 40 minutes a day.		
Intended Grade Level	7th-12th Grade		

Specific Objective:

Instructional (teacher) Objective	Behavioral (learner) Objective
1. The teacher will introduce the scientific method. 2. Each week the teacher will introduce the theme for the week. 3.The teacher will prepare and facilitate an integrated technology and science experiment. 3. The teacher will explain the law of inertia	1. The students will complete a review of the scientific method. 2. The students will discuss the weekly theme to gain an understanding of the unit. 3. The students will complete an integrated technology and science experiment.

Materials Required:

- Computers for each student
- Rocksim 8.0 software on computers
- Handouts from Appendix A
- Science journals
- Pencils
- Rulers

Sequence of Lesson:

Introduction:

The teacher will conduct a short review and discussion of the scientific method. The scientific method consists of five steps: identifying a problem, making a hypothesis, deciding on a procedure, collecting and analyzing data, and deriving a conclusion. See Appendix A for scientific method worksheet. The teacher will explain to the students what Newton's Laws of Motion are: that these three laws state how any object moves; so with them we can accurately determine how a model rocket works. For assistance with Newton's Laws see: http://www.grc.nasa.gov/WWW/K-12/airplane/newton.html. Newton's first law of motion is often stated, as "every object will remain at rest or in uniform motion in a straight line unless compelled to change its state by the action of an external force". The students should already have been shown the basics on how to use the different Rocksim screens. Students should come up with a hypothesis stating why the law of inertia is related to a rocket's motion. The teacher will then pose the question "What makes a rocket's motion stay the same or change?" and a short discussion will be held.

Activity:

Each student will open up the Quest Payloader One rocket in Rocksim. They will then select the "flight simulations" tab and click on the "A6Q-4" simulation. Students will then click on the "2D flight profile" button at the top of the screen. Once the simulation is loaded, they should note that as in Newton's First Law, the object (rocket) is at rest and stays that way. Next, students will click on the "start animation playback" button and notice how the rocket stays in motion for a time once it is set in motion by the rocket motor. They should think about and answer questions such as, "What changes the rocket's motion once it is in the air and what changes the rocket's state of equilibrium when it is on the ground?"

Upon completion of the experiment, students will compile data and compare the results to their hypothesis. They may print out a graph of 'Time/Velocity/Altitude' from Rocksim to aid their results. After participating in a classroom discussion, they will write a conclusion in their science journal answering addressing their hypothesis and answering the question, "What makes a rocket's motion stay the same or change?"

Authentic Assessment (checking for understanding):

Through class discussions and observation the teacher will check students for understanding of the material. The students will complete a self-assessment of their own understanding and ability levels at the mid-point of the unit.

Evaluation:

Each student will be required to submit his or her science journal and Venn Diagram. An automated Venn diagram site may be found at: http://teachers.teachnology.com/web_tools/graphic_org/venn_diagrams/. The teacher for understanding and accuracy of the material will review them. The teacher will collect the students' science journals, specifically evaluating the data collection process and how the scientific method was used. Suggested resources are: http://teach-nology.com/web_tools/rubrics/lab_report/ and http://teach-nology.com/web_tools/rubrics/research/.

Scaffolding Activities for At-Risk Students:

The teacher will help children who are having difficulty with the science experiment. Students will be paired with other students so that they may use each other's knowledge to complete their individual science journals.

Extension Activities for Gifted and Talented Students:

Students may also create a graph that represents the specific data collected throughout the experimentation process.

Cooperative Lesson Plan

Name	John Manfredo	**National Model** **Content Standards**	*SCIENCE* STANDARD 1: Students understand the processes of scientific investigation and design, conduct, communicate about, and evaluate such investigations. **National Educational Technology Standard 4** *Technology Communications Tools:* Students use a variety of media and formats to communicate information and ideas effectively to multiple audiences.
Activity Title	Newton's 2nd Law of Motion "Acceleration of an Object"		
Lesson Completion Time	*Weeks: 1* *Days:* 2 days a week and 40 minutes a day.		
Intended Grade Level	7th-12th Grade		

Specific Objective:

Instructional (teacher) Objective	Behavioral (learner) Objective
1. The teacher will facilitate a classroom discussion using a series of questions. 2. The teacher will explain what the acceleration of an object is. 3. The teacher will explain Newton's Laws to the class.	1. The students will participate in a classroom discussion based on a series of questions posed by the teacher. 2. The students will work in a team to using cardboard cutouts and Rocksim to find center of pressure.

Materials Required:

- Computers for each student
- Rocksim 8.0 software on computers
- Science journals
- Pencils
- Rulers

Sequence of Lesson:

Introduction:

The teacher will introduce Newton's Second Law of Motion. Newton's second law of motion explains how the velocity of an object changes when it is subjected to an external force and has three planks: 1. If you do place a force on an object, it will accelerate and change its velocity in the direction of the force, 2. This acceleration is directly proportional to the force, and 3. This acceleration is inversely proportional to the mass of the object." Students should come up with a hypothesis why the law of acceleration is related to the motion of a rocket. The teacher will then pose the question, "What affects the acceleration of an object?"

Activity:
Each student will open up the Quest Payloader One rocket in Rocksim. Students will load a B6Q-4 and click on "flight profile" at the bottom of the screen. Once the simulation is loaded the students will click the "play" button and take note about how the motion of the rocket relates to the first plank of Newton's second law. Next, the students will cancel out of this screen and note the altitude of this flight on the "flight simulations" screen. Now students will load a C6Q-5 into the rocket and click on the "launch" button. Students will note the difference in maximum velocity and how this relates to the second plank of the second law of motion. Last, each student will add a mass object of 1.8 oz. to the model, positioned at the center of gravity of the rocket. They will then launch the rocket again and record their findings of maximum velocity difference and how this relates to the third plank of the second law of motion.

Upon completion of the experiment, students will compile data and compare the results to their hypothesis. They may print out a graph of 'Time/Velocity/Altitude' from Rocksim to aid their results. After participating in a classroom discussion, they will write a conclusion in their science journal answering addressing their hypothesis and answering the question, "What makes a rocket's motion stay the same or change?"

Authentic Assessment (checking for understanding):

Through class discussions and observation the teacher will check students for understanding of the material. The students will complete a self-assessment of their own understanding and ability levels at the mid-point of the unit.

Evaluation:

Each student will be required to submit his or her science journal and Venn Diagram. An automated Venn diagram site may be found at: http://teachers.teachnology.com/web_tools/graphic_org/venn_diagrams/. The teacher for understanding and accuracy of the material will review them. The teacher will collect the students' science journals, specifically evaluating the data collection process and how the scientific method was used. Suggested resources are: http://teach-nology.com/web_tools/rubrics/lab_report/ and http://teach-nology.com/web_tools/rubrics/research/.

Scaffolding Activities for At-Risk Students:

The teacher will help children who are having difficulty with the science experiment. Students will be paired with other students so that they may use each other's knowledge to complete their individual science journals.

Extension Activities for Gifted and Talented Students:

Students may also create a graph that represents the specific data collected throughout the experimentation process.

Problem Solving Lesson Plan

Name	John Manfredo	**Colorado Model Content Standards**	*SCIENCE* STANDARD 1: Students understand the processes of scientific investigation and design, conduct, communicate about, and evaluate such investigations. STANDARD 3: Life Science: Students know and understand the characteristics and structure of living things, the processes of life, and how living things interact with each other and their environment. **National Educational Technology Standard 4** *Technology Communications Tools:* Students use a variety of media and formats to communicate information and ideas effectively to multiple audiences.
Activity Title	Newton's 3rd Law of Motion "Action-Reaction"		
Lesson Completion Time	*Weeks: 1* *2 times weekly; 40 minutes per day*		
Intended Grade Level	7th-12th Grade		

Specific Objective:

Instructional (teacher) Objective	Behavioral (learner) Objective
1. The teacher will relay the importance of CG and CP related to the stability of a rocket's flight. 2. The teacher will provide examples of Venn Diagrams to the class. 3. The teacher will explain the law of action-reaction.	1. The students will understand the importance of CG and CP in the in relation to the stability of rockets. 2. The students will create Venn Diagrams to indicate the interrelationships of CG and CP related to rocket stability.

Materials Required:

- Computers for each student
- Rocksim 8.0 software on computers
- Science journals
- Pencils
- Rulers

Sequence of Lesson:

Introduction:

The teacher will introduce Newton's Third Law of Motion. Newton's third law of motion states that for every action (force) in nature there is an equal and opposite reaction. Students should come up with a hypothesis as to why the action of the rocket motor makes the rocket react. The teacher will then pose the question, "What action occurs to make the rocket motion occur?" Students will enter into a discussion on the subject.

Activity: Each student will open up the Quest Payloader One rocket in Rocksim. Students will load a B6Q-4 into the rocket and click on "flight profile" at the bottom of the screen. Once the simulation is loaded the students will click the "play" button and take note about how the motion of the rocket relates to the third law of motion. Students should answer the question, "What forces and actions are present?"

Upon completion of the experiment, students will compile data and compare the results to their hypothesis. They may print out a graph of 'Time/Velocity/Altitude' from Rocksim to aid their results. After participating in a classroom discussion, they will write a conclusion in their science journal addressing their hypothesis and answering the question, " What action occurs to make the rocket motion occur?"

Authentic Assessment (checking for understanding):

Through class discussions and observation the teacher will check students for understanding of the material. The students will complete a self-assessment of their own understanding and ability levels at the mid-point of the unit.

Evaluation:

Each student will be required to submit his or her science journal and Venn Diagram. An automated Venn diagram site may be found at: http://teachers.teachnology.com/web_tools/graphic_org/venn_diagrams/. The teacher for understanding and accuracy of the material will review them. The teacher will collect the students' science journals, specifically evaluating the data collection process and how the scientific method was used. Suggested resources are: http://teach-nology.com/web_tools/rubrics/lab_report/ and http://teach-nology.com/web_tools/rubrics/research/.

Scaffolding Activities for At-Risk Students:

Students will work with the teacher during the observation period, as well as during journaling. Students may use pictures to help complete their science journals and their Venn Diagrams.

Extension Activities for Gifted and Talented Students:

Students will create a PowerPoint presentation to show different rocket configurations and how they relate to stability. . They will then present their show to the other members of the class.

Rocksim Lesson 3 Quiz

1. Newton's first law can be stated as:

A) To every action there is an equal and opposite reaction.
B) Every object will remain at rest or in uniform motion in a straight line unless compelled to change its state by the action of an external force.
C) What goes up must come down.
D) A and C

2. Newton's second law of motion explains how the velocity of an object changes when it is subjected to an external force. Which of the following is <u>not</u> one of its three planks?

A) If you do place a force on an object, it will accelerate and change its velocity in the direction of the force.
B) This acceleration is directly proportional to the force.
C) The proportional force of an object is related to the inverse mass of the object.
D) This acceleration is inversely proportional to the mass of the object.

3. How does Newton's Third Law "To every action there is always an equal and opposite reaction" relate to rocketry?

A) That the blast deflector must be strong enough to push the rocket off the launch pad at ignition.
B) That a rocket flies because the rocket motor "pushes" the rocket in a direction opposite of the exhaust jet.
C) That the thrust of a rocket motor is proportional to the air density at the launch site.
D) The thrust of the rocket motor is inverse to the barometric pressure of the launch site.

4. The change in the flight path of a rocket due to wind demonstrates which one of Newton's Laws?

A) Newton's First Law
B) Newton's Second Law
C) Newton's Third Law
D) All of the Above

5. How is Newton's First Law demonstrated by a rocket sitting on the launch pad?

A) A body in motion will cease to move when the force on it changes.
B) Increasing the motion of the rocket will change its vector.
C) Shorter rockets will stay motionless longer than a rocket which is longer.
D) A body at rest stays at rest, unless acted upon by an external force.

Lesson 4
Rocketry Aerodynamics
Integrated Science and Technology Unit

John Manfredo

Apogee Components, Inc.

2006

Integrated Unit Plan Summary

This 3 - week unit is designed for seventh through twelfth grade students to teach rocketry aerodynamics and drag reduction. The lesson plans provided in this unit integrate science and technology. The technology and science standards used within the lesson plans are taken from the National Education Technology Standards (NETS) and National Science Teacher Association (NSTA). The purpose of this unit is to teach students about rocket stability, data collection, graphing, and presentation of results using computer media.

Throughout this unit, students will use the scientific method to complete a variety of experiments. The experiments will provide students with the knowledge they need to explain what structural aspects of a rocket affect the speed and maximum altitude of a rocket and how one can optimize the design for maximum performance. The students will be required to complete observations, journal their findings, and graph their data. In addition, they will be required to work in teams, assess themselves and others, and submit their science journals for teacher review.

Integrated Lesson Plan

Name	John Manfredo	**National Model Content Standards**	*SCIENCE* STANDARD 1: Students understand the processes of scientific investigation and design, conduct, communicate about, and evaluate such investigations. **National Educational Technology Standard 4** *Technology Communications Tools:* Students use a variety of media and formats to communicate information and ideas effectively to multiple audiences. STANDARD 6: Students understand that science involves a particular way of knowing and understand the common connections among scientific disciplines.
Activity Title	Nose Cone Shape		
Lesson Completion Time	*Weeks: 1* *Days:* 2 days a week and 40 minutes a day.		
Intended Grade Level	7th-12th Grade		

Specific Objective:

Instructional (teacher) Objective	Behavioral (learner) Objective
1. The teacher will introduce the scientific method. 2. Each week the teacher will introduce the theme for the week. 3. The teacher will prepare and facilitate an integrated technology and science experiment.	1. The students will complete a review of the scientific method. 2. The students will discuss the weekly theme to gain an understanding of the unit. 3. The students will complete an integrated technology and science experiment.

Materials Required:

- Computers for teams of 4 students each
- Rocksim 8.0 software on computers
- Handouts from Appendix A and B
- Science journals
- Pencils
- Rulers

Sequence of Lesson:

Introduction:

The teacher will conduct a short review and discussion of the scientific method. The scientific method consists of five steps: identifying a problem, making a hypothesis, deciding on a procedure, collecting and analyzing data, and deriving a conclusion. See Appendix A for scientific method worksheet. The teacher will explain to the students what the center of gravity on an object is. The students should already have been shown the basics on how to use the different Rocksim screens. The teacher will then pose the question "Why is the shape of the nose cone important for the maximum performance of a rocket?" and a short classroom discussion will be held. The students will identify shapes and sizes of the nose cones that they think will give the rocket the maximum performance.

Day 1 Activity:

The teacher will divide the class up into groups of 4 students each. Each student will open up the Quest Astra rocket. They will then load a Quest C6-5 motor in and launch the rocket. All simulations will use the C6-5 motor for consistency. They will record the flight details for all simulations that they perform. Next, each student will change the shape of their nose cone from ogive to parabolic and run the simulation again. After each change, simulations will be run and data recorded. Also, graphs should be generated with altitude, time, and velocity. The same will be done for the elliptical, power series, parabolic series, Sears Haack, and the conical nose cones, respectively.

Day 2 Activity:

Upon completion of the experiment, students will compile data and compare the results to their hypothesis. After participating in a classroom discussion, they will write a conclusion in their science journal answering the question, "Why is the shape of the nose cone important for the maximum performance of a rocket?"

Authentic Assessment (checking for understanding):

Through class discussions and observation the teacher will check students for understanding of the material. The students will complete a self-assessment of their own understanding and ability levels at the mid-point of the unit.

Evaluation:

The teacher will collect the students' science journals, specifically evaluating the data collection process and how the scientific method was used.

Scaffolding Activities for At-Risk Students:

The teacher will help children who are having difficulty with the science experiment. Students will be paired with other students so that they may use each other's knowledge to complete their individual science journals.

Extension Activities for Gifted and Talented Students:

Students will create a short power point presentation that discusses their findings from the experiment. Students may also create a graph that represents the specific data collected throughout the experimentation process.

Cooperative Lesson Plan

Name	John Manfredo	**National Model** **Content Standards**	*SCIENCE* STANDARD 1: Students understand the processes of scientific investigation and design, conduct, communicate about, and evaluate such investigations. **National Educational Technology Standard 4** *Technology Communications Tools:* Students use a variety of media and formats to communicate information and ideas effectively to multiple audiences. STANDARD 6: Students understand that science involves a particular way of knowing and understand the common connections among scientific disciplines.
Activity Title	Fin Geometry		
Lesson Completion Time	*Weeks: 2* *Days:* 2 days a week and 40 minutes a day.		
Intended Grade Level	7th-12th Grade		

Specific Objective:

Instructional (teacher) Objective	Behavioral (learner) Objective
1. The teacher will facilitate a classroom discussion using a series of questions. 2. The teacher will prepare and facilitate an integrated technology and science experiment.	1. The students will participate in a classroom discussion based on a series of questions posed by the teacher. 2. The students will work in a team to using Rocksim to find which fin shape is the most efficient for the altitude of a rocket.

Materials Required:

- Computers for teams of 4 students each
- Rocksim 8.0 software on computers
- Science journals
- Pencils

Sequence of Lesson:

Introduction:

The teacher will conduct a short review and discussion of the scientific method. The scientific method consists of five steps: identifying a problem, making a hypothesis, deciding on a procedure, collecting and analyzing data, and deriving a conclusion. See Appendix A for scientific method worksheet. The teacher will explain to the students what aerodynamics is. The students should already have been shown the basics on how to use the different Rocksim screens. The teacher will then pose the question, "Why are the shapes, sizes, and number of the fins important for the maximum performance of a rocket?" and a short classroom discussion will be held. The students will identify shapes and sizes of the fins that they think will give the rocket the maximum performance.

Day 1 Activity:
The teacher will divide the class up into groups of 4 students each. Each student will open up the Quest Astra rocket. They will then load a Quest C6-5 motor in the rocket. All simulations will use the C6-5 motor for consistency. They will record the flight details for all simulations that they perform. Next, each student will change the number of fins from 3 to 4 and finally to 5 fins. After each change, simulations will be run and data recorded. Also, graphs should be generated with altitude, time, and velocity.

Day 2 Activity:
The teacher will divide the class up into groups of 4 students each. Each student will open up the Quest Astra rocket. They will then load a Quest C6-5 motor in the rocket. All simulations will use the C6-5 motor for consistency. They will record the flight details for all simulations that they perform. Next, each student will change the shape of the fins from trapezoidal to elliptical. After each change, simulations will be run and data recorded. Also, graphs should be generated with altitude, time, and velocity.

Day 3 Activity: The teacher will divide the class up into groups of 4 students each. Each student will open up the Quest Astra rocket. They will then load a Quest C6-5 motor in the rocket. All simulations will use the C6-5 motor for consistency. They will record the flight details for all simulations that they perform. Next, each student will run a simulation with the C6-5. Then, they will change the size of the fins using the slider bar on "Semi Span" from 1.625 to 2.125. Each student should then change the semi span to 2.625. After each change, simulations will be run and data recorded. Also, graphs should be generated with altitude, time, and velocity.

Day 4 Activity:
Upon completion of the experiment, students will compile data and compare the results to their hypothesis. After participating in a classroom discussion, they will write a conclusion in their science journal answering the question, "Why are the shapes, sizes, and number of the fins important for the maximum performance of a rocket?"

Authentic Assessment (checking for understanding):

The team presentation will be used to evaluate their understanding of the activity. Each team member will also submit a team assessment survey indicating the performance and participation of all other team members. Each student will also be required to submit an assessment of his or her performance on the project. Students should read through http://www.apogeerockets.com/technical_publication_16.asp and compare their results against this report.

Evaluation:

Each student will turn in their science journal for it to be reviewed by the teacher.

Scaffolding Activities for At-Risk Students:

Teams will have individual students with a variety of different ability levels. The team will work together on all parts of the assignment. The teacher will assure that each team is actively working together and will assist when asked.

Extension Activities for Gifted and Talented Students:

Students will create a short power point presentation that discusses their findings from the experiment. Students may also create a graph that represents the specific data collected throughout the experimentation process.

Rocksim Lesson 4 Quiz

1. The nose cone shape:

A) Has no bearing on the altitude achieved by a rocket.
B) Plays a big part in the amount of drag on the rocket.
C) Should be flat in order to reach the highest altitude.
D) Should be pointed in order to achieve the highest altitudes.

2. Which of the following statements about fin geometry is true?

A) Fins with square edges allow the rocket to fly the highest.
B) Fins that have rounded edges create the most drag.
C) Streamlined fins have the lowest drag
D) Fin edge design has no effect on a rocket's altitude.

3. Increasing the number of fins:

A) Increases the maximum velocity of the rocket.
B) Slows the rocket down.
C) Makes the rocket's maximum altitude lower.
D) Both B and C.

4. In general, trapezoidal fins:

A) Will allow higher altitudes in rockets.
B) Are less effective at achieving high altitudes rather than elliptical fins.
C) Will usually not allow the rocket to leave the launch pad.
D) None of the above.

5. Shortening the Semi – span of the fins will:

A) Results in less fin surface area being attached to the rocket body.
B) Make them swept more toward the aft end of the rocket.
C) Make the fin tips shorter.
D) Make the distance of the fin shorter from the body tube to the fin tip.

Lesson 5
Optimal Launch Angle in Windy Conditions
Integrated Science and Math Unit

John Manfredo

Apogee Components, Inc.

2006

Integrated Unit Plan Summary

This 2-week unit is designed for seventh through twelfth grade students to teach students how to find the optimal launch angle of a rocket when launched in windy conditions. The lesson plans provided in this unit integrate science and technology. The technology and science standards used within the lesson plans are taken from the National Education Technology Standards (NETS) and National Science Teacher Association (NSTA). The purpose of this unit is to teach students about the effects of wind on a moving object, data collection, graphing, and presentation of results using computer media.

Throughout this unit, students will use the scientific method to complete a variety of experiments. The experiments will provide students with the knowledge they need to explain what effect wind and launch angle have on an object and how this relates to rocketry. The students will be required to complete observations, journal their findings, and graph their data. In addition, they will be required to work in teams, assess themselves and others, and submit their science journals for teacher review.

Integrated Lesson Plan

Name	John Manfredo	**National Model Content Standards**	*SCIENCE* STANDARD 1: Students understand the processes of scientific investigation and design, conduct, communicate about, and evaluate such investigations. **National Educational Technology Standard 4** *Technology Communications Tools:* Students use a variety of media and formats to communicate information and ideas effectively to multiple audiences. STANDARD 6: Students understand that science involves a particular way of knowing and understand the common connections among scientific disciplines.
Activity Title	Finding the optimal launch angle in windy conditions		
Lesson Completion Time	*Weeks: 2* *Days:* 2 days a week and 40 minutes a day.		
Intended Grade Level	7th-12th Grade		

Specific Objective:

Instructional (teacher) Objective	Behavioral (learner) Objective
1. The teacher will introduce the scientific method. 2. The teacher will prepare and facilitate an integrated technology and science experiment. 3. The teacher will explain the forces acting on a rocket during its flight.	1. The students will complete a review of the scientific method. 2. The students will discuss the weekly theme to gain an understanding of the unit. 3. The students will complete an integrated technology and science experiment.

Materials Required:

- Computers for each student
- Rocksim 8.0 software on computers
- Science journals
- Pencils
- Rulers

Sequence of Lesson:

Introduction:

The teacher will conduct a short review and discussion of the scientific method. The scientific method consists of five steps: identifying a problem, making a hypothesis, deciding on a procedure, collecting and analyzing data, and deriving a conclusion. See Appendix A for scientific method worksheet. The teacher will then pose the question, "What is the optimal launch angle for a rocket in order to achieve the highest altitude?" and a short classroom discussion will be held. Students should establish a hypothesis as to what determines the optimal launch angle for a rocket. The students should already have been shown the basics on how to use the different Rocksim screens.

Days 1 and 2 Activity:

Each student will open up the Quest Payloader One rocket in Rocksim. Students will then load a C6-5 motor into the rocket and then set the "launch conditions" to an altitude of "0", temperature of 60°, humidity of 30%, and a "very windy" wind speed. Launch the rocket and note the results. Next, change the launch angle to 3°, launch, and record the results. Keep changing the launch angle to 5°, 7°, 9°, and 11° while recording the results after each flight. Student may also want to view the "2D flight profile" in order to gain a better understanding of their rocket's performance for a given launch angle. Students should take note of the direction that the smoke from the rocket is going to indicate the wind direction. They may also double-click on any given simulation to see those particular flight details.

Days 3 and 4 Activity:

Upon completion of the experiment, students will compile data and compare the results to their hypothesis. They may print out a graph of 'Time/Velocity/Altitude' from Rocksim to aid their results. After participating in a classroom discussion, they will write a conclusion in their science journal answering addressing their hypothesis and answering the question, "What is the optimal launch angle for a rocket in order to achieve the highest altitude?"

Authentic Assessment (checking for understanding):

Through class discussions and observation the teacher will check students for understanding of the material. The students will complete a self-assessment of their own understanding and ability levels at the mid-point of the unit.

Evaluation:

Each student will be required to submit his or her science journal and Venn Diagram. An automated Venn diagram site may be found at: http://teachers.teachnology.com/web_tools/graphic_org/venn_diagrams/. The teacher for understanding and accuracy of the material will review them. The teacher will collect the students' science journals, specifically evaluating the data collection process and how the scientific method was used. Suggested resources are: http://teach-nology.com/web_tools/rubrics/lab_report/ and http://teach-nology.com/web_tools/rubrics/research/.

Scaffolding Activities for At-Risk Students:

The teacher will help children who are having difficulty with the science experiment. Students will be paired with other students so that they may use each other's knowledge to complete their individual science journals.

Extension Activities for Gifted and Talented Students:

Students may also create a graph that represents the specific data collected throughout the experimentation process.

Rocksim Lesson 5 Quiz

1. For a rocket to fly the highest in windy conditions, which of the following statements is true?

A) The launch rod must always be pointed straight up.
B) The greater the launch rod is angled, the higher the rocket will go.
C) There is an optimal launch angle that will allow the rocket to achieve the greatest altitude possible.
D) Angling the launch rod into the wind is always the most effective.

2. The angle of the launch rod:

A) has no bearing on the maximum altitude achieved by the rocket.
B) is very important because the rocket will gain more altitude at one angle over others.
C) is best for a rocket's maximum altitude the more you angle it.
D) None of the above.

3. Rocksim can be a great help to find the maximum launch angle:

A) due to the fact that the program is highly sophisticated and will help predict and simulate the optimal launch angle for a rocket launching in the wind.
B) because it takes random guesses at the maximum altitude for a rocket launching in the wind.
C) Rocksim is actually no better than taking a guess on your own.
D) Rocksim cannot simulate windy conditions.

4. The graphs that Rocksim can generate:

A) are very limited.
B) have no practical application.
C) provide you with temperature information at any given altitude.
D) will provide you with the altitude and velocity at any point during the rocket's flight.

5. Which of the following statements is false?

A) Rocksim's 2D flight profile is visually helpful to see what the flight track of a rocket looks like.
B) Rocksim's 2D flight profile will show you the direction of the wind.
C) Rocksim's 2D flight profile shows when the burnout of the motor occurs.
D) Rocksim's 2D flight profile does not help as far as showing you what occurs in the rocket's flight during windy conditions.

Lesson 6

Effects of Fin Cross Section on a Rocket's Flight
Integrated Science and Technology Unit

John Manfredo

Apogee Components, Inc.

2006

Integrated Unit Plan Summary

This 2-week unit is designed for seventh through twelfth grade students to teach rocketry aerodynamics of fin design. The lesson plans provided in this unit integrate science and technology. The technology and science standards used within the lesson plans are taken from the National Education Technology Standards (NETS) and National Science Teacher Association (NSTA). The purpose of this unit is to teach students about rocket aerodynamics and design, data collection, graphing, and presentation of results using computer media.

Throughout this unit, students will use the scientific method to complete a variety of experiments. The experiments will provide students with the knowledge they need to explain how the structural aspects of a rocket's fins affect the speed and maximum altitude of a rocket and how one can optimize the design for maximum performance. The students will be required to complete observations, journal their findings, and graph their data. In addition, they will be required to work in teams, assess themselves and others, and submit their science journals for teacher review.

Integrated Lesson Plan

Name	John Manfredo	**National Model Content Standards**	*SCIENCE* STANDARD 1: Students understand the processes of scientific investigation and design, conduct, communicate about, and evaluate such investigations. **National Educational Technology Standard 4** *Technology Communications Tools:* Students use a variety of media and formats to communicate information and ideas effectively to multiple audiences. STANDARD 6: Students understand that science involves a particular way of knowing and understand the common connections among scientific disciplines.
Activity Title	Effects of fin cross section on a rocket's altitude		
Lesson Completion Time	*Weeks: 2* *Days:* 2 days a week and 40 minutes a day.		
Intended Grade Level	7th-12th Grade		

Specific Objective:

Instructional (teacher) Objective	Behavioral (learner) Objective
1. The teacher will introduce the scientific method. 2. Each week the teacher will introduce the theme for the week. 3. The teacher will prepare and facilitate an integrated technology and science experiment.	1. The students will complete a review of the scientific method. 2. The students will discuss the weekly theme to gain an understanding of the unit. 3. The students will complete an integrated technology and science experiment.

Materials Required:

- Computers for teams of 4 students each
- Rocksim 8.0 software on computers
- Handouts from Appendix A
- Science journals
- Pencils
- Rulers

Sequence of Lesson:

Introduction:

The teacher will conduct a short review and discussion of the scientific method. The scientific method consists of five steps: identifying a problem, making a hypothesis, deciding on a procedure, collecting and analyzing data, and deriving a conclusion. See Appendix A for scientific method worksheet. The teacher will explain to the students what the center of gravity on an object is. The students should already have been shown the basics on how to use the different Rocksim screens. The teacher will then pose the question "How does the fin cross section on a rocket affect the speed and maximum altitude of the rocket?" and a short classroom discussion will be held. The students will come up with a hypothesis as to how they think the rocket will perform under different fin cross sections and the reason for this.

Day 1 Activity:

The teacher will divide the class up into groups of 4 students each. Each student will open up the Quest Payloader One rocket. They will then load a Quest C6-5 motor in and launch the rocket. All simulations will use the C6-5 motor for consistency. They will record the flight details for all simulations that they perform. Next, each student will check the shape of the fin cross section on all 3 fins. It needs to be "square" on all the fins for the first flight. The students will make sure that the launch conditions are set with an altitude of 0 feet, humidity of 30%, temperature of 60°, and wind speed of 0-2 mph. Students will then launch the rocket on the C6-5 motor. Students should record their findings and graphs should be generated with altitude, time, and velocity.

Day 2 Activity:

The teacher will divide the class up into groups of 4 students each. Each student will open up the Quest Payloader One rocket. They will then load a Quest C6-5 motor in and launch the rocket. All simulations will use the C6-5 motor for consistency. They will record the flight details for all simulations that they perform. Next, each student will check the shape of the fin cross section on all 3 fins. It needs to be "rounded" on all the fins for the second flight. The students will make sure that the launch conditions are set with an altitude of 0 feet, humidity of 30%, temperature of 60°, and wind speed of 0-2 mph. Students will then launch the rocket on the C6-5 motor. Students should record their findings and graphs should be generated with altitude, time, and velocity.

Day 3 Activity:

The teacher will divide the class up into groups of 4 students each. Each student will open up the Quest Payloader One rocket. They will then load a Quest C6-5 motor in and launch the rocket. All simulations will use the C6-5 motor for consistency. They will record the flight details for all simulations that they perform. Next, each student will check the shape of the fin cross section on all 3 fins. It needs to be "airfoil" on all the fins for the third flight. The students will make sure that the launch conditions are set with an altitude of 0 feet, humidity of 30%, temperature of 60°, and wind speed of 0-2 mph. Students will then launch the rocket on the C6-5 motor. Students should record their findings and graphs should be generated with altitude, time, and velocity.

Day 4 Activity

Upon completion of the experiment, students will compile data and compare the results to their hypothesis. After participating in a classroom discussion, they will write a conclusion in their science journal answering the question, "How does the fin cross section on a rocket affect the speed and maximum altitude of the rocket?"

Authentic Assessment (checking for understanding):

Through class discussions and observation the teacher will check students for understanding of the material. The students will complete a self-assessment of their own understanding and ability levels at the mid-point of the unit.

Evaluation:

The teacher will collect the students' science journals, specifically evaluating the data collection process and how the scientific method was used.

Scaffolding Activities for At-Risk Students:

The teacher will help children who are having difficulty with the science experiment. Students will be paired with other students so that they may use each other's knowledge to complete their individual science journals.

Extension Activities for Gifted and Talented Students:

Students will create a short power point presentation that discusses their findings from the experiment. Students may also create a graph that represents the specific data collected throughout the experimentation process.

Rocksim Lesson 6 Quiz

1. Which of the type of fin cross-section will help a rocket to gain the highest altitude?

A) Square
B) Streamlined
C) Rounded
D) B and C

2. A streamlined fin:

A) Has no effect upon the aerodynamics of the rocket.
B) Decreases the efficiency of air flowing over the fins.
C) Increases the efficiency of air flowing over the fins
D) None of the above

3. Keeping the "launch conditions" the same for each flight:

A) Can be changed from flight to flight without compromising results.
B) Has no bearing on the results.
C) Is crucial for comparing results accurately.
D) A and B.

4. A fin that has a square cross-section:

A) Is more effective on reaching higher altitudes than any other type.
B) Has less drag than either of the other 2 types of fins.
C) Has more of a chance of coming loose as the rocket ascends.
D) Has more drag than either of the other 2 types of fins.

5. If you are trying to design a rocket for an altitude project:

A) Using streamlined fins will gain the greatest altitude.
B) Using square cross-section fins keeps the rocket from reaching its highest potential altitude.
C) None of the above
D) A and B

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Appendix A

Scientific Method

What is the scientific method? It is a _____ that is used to find_____ to questions about the world around us.

Is there only one "scientific method"? No, there are several versions of the scientific method. Some versions have more _____, while others may have only a few. However, they all begin with the identification of a _____ or a _____ to be answered based on observations of the world around us and provide an _____ method for conducting and analyzing an experiment.

What is a hypothesis? It is an _____ _____ based on observations and your knowledge of the topic.

What is data? It is _____ gathered during an experiment.

_____

What do you want to know or explain? Use observations you have made to write a question that addresses the problem or topic you want to investigate.

↓

_____

What do you think will happen? Predict the answer to your question or the outcome of the experiment.

↓

_____

How will you test your hypothesis? A reliable experiment with safety rules is a good place to start.

↓

_____

Record data and observations. Do your data and observations from the experiment support your hypothesis?

↓

_____

Write a summary of the important parts of your experiment and the results.

T. Trimpe 2003 http://sciencespot.net/

Appendix B

CG/CP Relationship

The CG (Center of Gravity) and CP (Center of Pressure) are very important fundamental design and flight parameters of any rocket, and have an important relationship to each other. The general relationship between the CG and CP is as follows: the center of pressure must be a minimum of 1 body diameter BEHIND the center of gravity on a rocket fully prepped for launch to ensure stability. Now we'll explain why it must be this way, and what you can do to make sure your rocket meets this requirement, whether it's a kit or a scratch built design.

You're probably aware of the center of gravity (CG); this is the point on a rocket (or any object) where all the weight seems to be "centered". The center of pressure (CP) is similar; it is the point on the rocket where the corrective force of the fins is "centered". OK, now imagine just a simple stick, a piece of dowel 12" long. This is your "rocket", with one end the nose end and the other the motor end. It weighs the same on the first 6" as it does on the rear 6"; that's why the CG is exactly in the middle at 6". That's what the CG means, where the weight (or, more correctly, mass) of the item is centered. Now, drive an imaginary nail into your stick "rocket" into the table it's sitting on right at that CG point of 6". OK, now push on the front of the rocket, and it spins right at the nail, the CG. Push on the rear of the rocket, and it spins right at the nail, the CG. That's a good way to think of the CG…it's the "nail" that your real rocket will turn around in flight.

Now, think about if you put fins on the back end of your stick (rocket). Though it's not completely true, say that the CP is exactly where you stuck the fins on your rocket (it's true enough for this example). If that stick was flying through the air front end first, and wind pushes on the rocket, the fins will push on the stick. The stick will rotate around the "nail"/CG. Since the fins are on the back, the rocket straightens back out and continues nose forward. Now remove your imaginary fins from the back of the rocket and put them only on the front near the "nose cone" end of your rocket. OK, now it's flying again, and wind pushes on the fins; push on the fins of your imaginary rocket. What happens? The nose of the rocket turns around the "nail"/CG, and the front end flips over and turns into the rear end. This is bad! Of course, you want the front end of the rocket to stay the front! That's the general reason why the CG must be ahead of the CP… keeping the CP behind the CG makes sure the front of the rocket stays the front!

Many manufacturers specify the CP location on their kits. CP doesn't vary in kit rockets; it's controlled by the design of the kit. Such things as the rocket's body diameter, length of body, fin size, number of fins, and fin placement on the body tube, affect CP. CP can't be changed in kits. However, you CAN vary CG, by adding more nose weight. That's why the kit manufacturers specify CP, so the owner of the rocket can find their CG and compare it against the CP to see if they

need to add some nose weight (to move the CG ahead of the CP) for stability.

The CG will be dependent upon how you build and use the rocket, which is why manufacturers usually don't specify CG. Some people really use a bunch of epoxy, others don't. It's variable enough on how the person builds the rocket, but even more so as what type of payload you have (if any). You can imagine that given the same kit design, if someone were carrying some complex and heavy video electronics that the CG would be dramatically different from someone who flies no payload at all.

Once a kit is built and ready to fly (with payload), CG location is most dependent on the motors used. Of course a G motor is much lighter than an I motor, but a certain kit may be able to use G's, H's, and I's. The motor is obviously in the back of the rocket, and weight in the back of the rocket shifts the CG rearward, so the bigger (heavier) the motor, the worse the CG/CP relationship will be. Remember, CP doesn't change…any weight added to the rear of the rocket will move the CG back (bad), and weight added to the front of the rocket will move the CG forward (good).

Mark the CP on the rocket, then mark a point at least one body diameter ahead of the CP. Make sure you prep the rocket as it'll be in flight (with the motor you intend to use installed, chute(s) installed, payload installed, etc.) before you do the CG/CP check. No need to add black powder to an altimeter or the delay area of a reload casing, or to put in igniters; they're not heavy enough to matter. Now balance the rocket "teeter-totter style" on a piece of dowel, back of a chair, something like that. If the rocket balances level with the pivot point of the teeter-totter arrangement at or forward of the CG point you marked, you're good to go! If not, you'll have to add nose weight until it does.

Up to two body diameters is usually even better, but don't go much over two diameters or the rocket will be overstable. By the way, this is what's meant by "one-caliber" or "two-caliber" stability. It comes from wartime artillery terminology, where the diameter of a gun is called the "caliber", so "one-caliber" = one diameter, and so on. Don't forget that if you use, say, a small H motor and set the CG, that if you then decide to use a big J motor, the J weighs more and you may have to add nose weight again to compensate. That's why it's usually recommended to set the CG/CP relationship with the largest motor you intend to use in the rocket.

If you don't have the biggest motor you intend to fly on hand, or if you haven't reached a certification level where you can buy one, check out the weight of the propellant you intend to use and the reload casing from the manufacturer. Many times that information is available on the manufacturer's web site. Simulate the weight of the casing and propellant in the motor mount tube. Use one or more rolls of coins, a baggie with dirt in it, whatever you can come up with that's similar to the weight of the motor and casing.

Rocksim Quiz Answers

Lesson 1

1. The answer is "C". Left clicking on the "Open" button will bring up a list of all the designs that are in the system. Two other ways are to go under the "File" menu and also "Command-O".
2. The answer is "B".
3. The answer is "D".
4. The answer is "A".
5. The answer is "D".

Lesson 2

1. The answer is "A". Refer to the" Handbook of Model Rocketry" by G. Harry Stine, 6th edition, Chapter 9 on "Stability". Note references on pages 137 and 138.
2. The answer is "A". To make the rocket stable the center of gravity (C.G.) must be moved forward of the center of pressure (C.P.). Adding weight to the nosecone moves the C.G. forward. Removing weight from the nosecone moves the C.G. aft, which is incorrect. Moving the fins forward towards the nosecone moves the C.P. forward, which is also incorrect. Finally, making the rocket shorter reduces the correcting moments produced by the aerodynamic forces at the C.P.; the reduced moment makes the rocket less stable.
3. The answer is "C". Refer to the" Handbook of Model Rocketry" by G. Harry Stine, 6th edition, Chapter 9 on "Stability". Note Figure 9-6 on page 138. Center of pressure equations and the cardboard cutout method only allow you to determine the center of pressure of the model; the center of gravity location must also be known to determine stability.
4. The answer is "B". To make the rocket stable the center of pressure (C.P.) must be moved aft of the center of gravity (C.G.). Adding larger fins on the aft portion of the model moves the center of pressure aft. A shorter nosecone removes weight from the nose moving the C.G. aft, which is incorrect. A larger, heavier rocket motor has the same affect of moving the C.G. aft. Finally, increasing the rocket diameter has essentially no effect on its stability.
5. The answer is "B". Refer to the" Handbook of Model Rocketry" by G. Harry Stine, 6th edition, Chapter 9 on "Stability". Note references on pages 137 and 138.

Lesson 3

1. The answer is "B". Newton's first law of motion is often stated as "An object at rest tends to stay at rest and an object in motion tends to stay in motion with the same speed and in the same direction unless acted upon by an unbalanced force.
2. The answer is "C". The second law states that the acceleration of an object is dependent upon two variables - the net force acting upon the object and the mass of the object.
3. The answer is "B". In every interaction, there is a pair of forces acting on the two interacting objects. The size of the forces on the first object equals the size of the force on the second object. The direction of the force on the first object is opposite to the direction of the force on the second object. Forces always come in pairs - equal and opposite action-reaction force pairs.
4. The answer is "B". The second law states that the acceleration of an object is dependent upon two variables - the net force acting upon the object and the mass of the object.
5. The answer is "D". An object at rest tends to stay at rest and an object in motion tends to stay in motion with the same speed and in the same direction unless acted upon by an unbalanced force.

Lesson 4

1. The answer is "B". Form drag is related to the shape of the rocket. For example, a rounded shape has less drag than a blunt shape or a pointed shape.
2. The answer is "C". Streamlining the fins into a teardrop shape-that is, making them round at the leading edge and tapering them to a sharp edge at the trailing edge—will also lead to a lower value of form drag.
3. The answer is "D". Adding more fins will increase the total mass of the rocket and will therefore slow the rocket down as well as keep it from flying as high.
4. The answer is "A". Many people have been told that the elliptical fin shape has the lowest induced drag. While that may be true for full size airplanes, it may not be necessarily true for small model rockets.
5. The answer is "D". The span is the maximum distance, measured parallel to the lateral axis, from tip to tip of the fins. The semi – span is half of that.

Lesson 5

1. The answer is "C". There is an optimum angle that the rocket should be launched at in order to achieve the greatest altitude. Neither straight up or too great of an angle will allow the rocket to gain the most altitude for a given motor.
2. The answer is "B". There is an angle that is the most beneficial in order to assure that the rocket will gain the most altitude.
3. The answer is "A". Rocksim is a highly sophisticated program and will help predict and simulate the optimal launch angle for a rocket launching in the wind.
4. The answer is "D". The graphs will provide you with the altitude and velocity at any point during the rocket's flight, which can be very helpful in finding the correlation between the velocity and altitude achieved.
5. The answer is "D". Rocksim's 2D flight profile does indeed show in an animated form what will occur during a rocket's flight in windy conditions.

Lesson 6

1. The answer is "B". Streamlined fins will cut through the air easier and allow the rocket to have less drag.
2. The answer is "C". An airfoiled fin is aerodynamically better than a square or rounded fin because the air molecules move over the surface easier.
3. The answer is "C". It is important to keep the launch conditions the same for all launches so that the only variable is the fin cross section. Otherwise, you can't determine which variable changed the altitude.
4. The answer is "D". A fin that has a square cross-section has more drag due to the fact that there is more surface area on the edge for air molecules to go against and try to move over.
5. The answer is "A and B". Just as a streamlined fin helps the rocket cut through the air more efficiently, a square cross-section creates more drag and slows the rocket down.

Meeting the National Science Education Standards

The science standards in these lessons are designed to meet the National Science Standards. For more detailed information, please see http://www.nap.edu/readingroom/books/nses/html/6a.html .