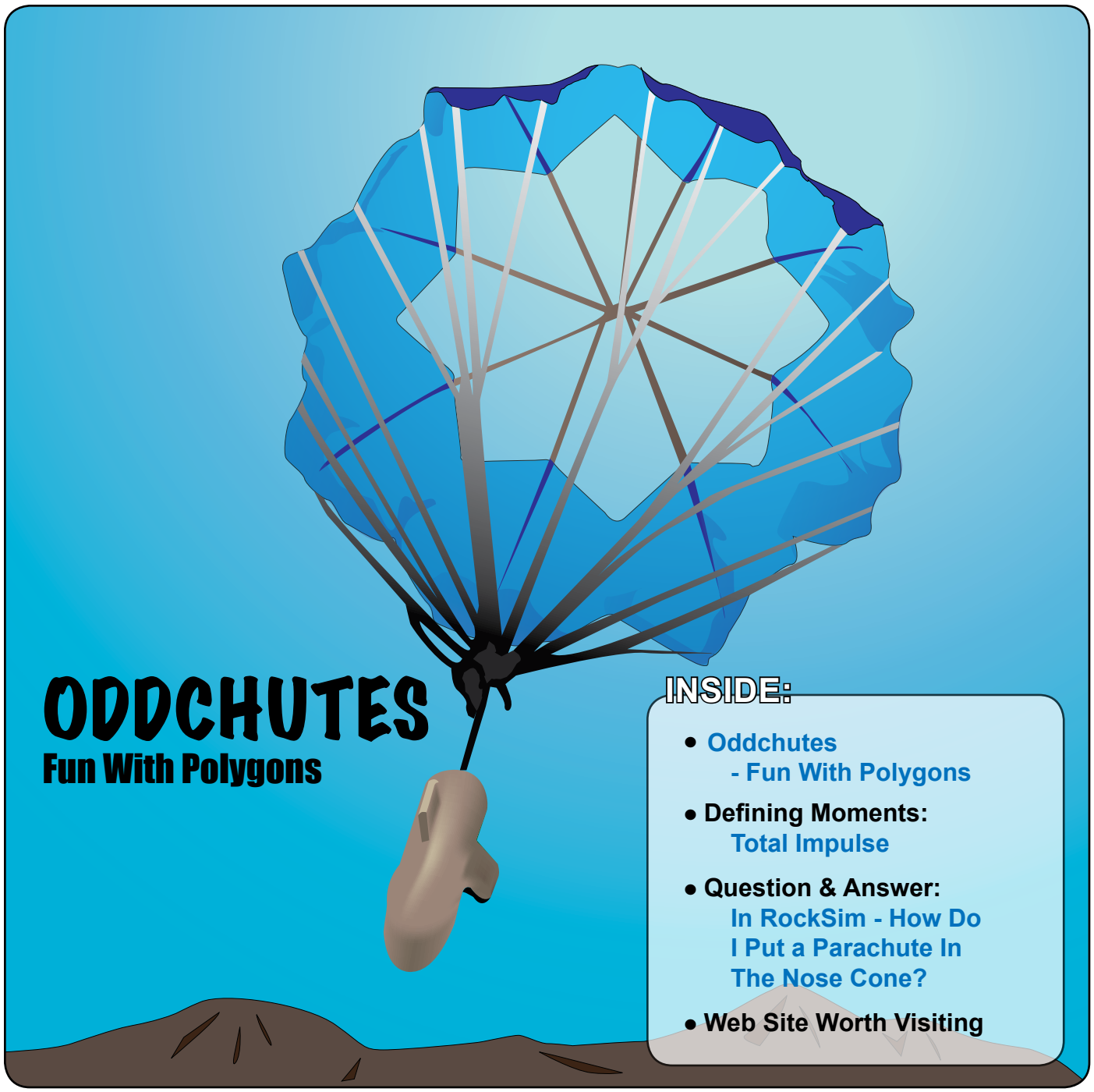
ISSUE 191 - AUGUST 28, 2007

APOGEE PEAK OF FLIGHT NEWSLETTER



ODDCHUTES
Fun With Polygons

INSIDE:

- Oddchutes - Fun With Polygons
- Defining Moments: Total Impulse
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- Web Site Worth Visiting

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Oddchutes
Fun With Polygons

By David T Flanagan

Introduction

Every amateur rocketeer has built or at least seen "Odd-Rocs." Models in the shape of soft drink bottles, baseballs, baseball bats, Santa Claus, G.I. Joe, and even in the shape of an outhouse have been launched and recovered.

You can build strange parachutes, too. This article describes two simple but unusual "odd-chutes" you can easily make that will add a little fun to the descent of your models.

And since they are related to a class of "real" parachutes called "annulars," they might actually have some practical applications!

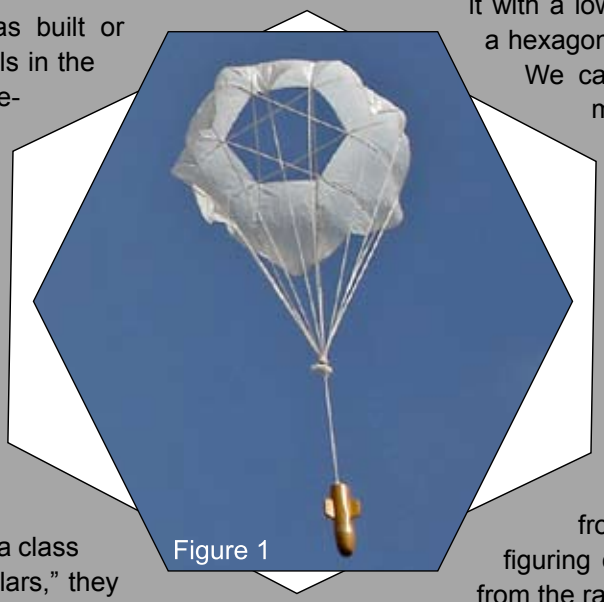

Figure 1

The "Hexannular" Odd-chute

Many of the plastic parachutes sold with kits have **six** sides. They are hexagons. What would happen if you made a parachute canopy with six hexagons connected in a circle? It can be done…

Figure 1. *A white "Hexannular" parachute based on six hexagons.*

The Math

There is a *little* bit of geometry here, but just enough so we can build parachutes.

If we look at any regular polygon with an even number of sides we see a diameter "across the flats." This is called the "inscribed diameter." One half of the inscribed diameter is called the "apothem" of the polygon. It is the radius of the inscribed circle. We use the apothem as our *reference dimension* and symbolize it with a lower case "a." Figure 2 shows a hexagon (left) and an octagon (right). We calculate all the parachute dimensions using a value of "a," and we use "n" to describe which kind of polygon we are talking about. The "n" stands for the number of sides in a polygon. In Figure 2 the hexagon has six sides (n=6) and the octagon has eight sides (n=8).

Figuring out everything about a hexagon or octagon from the apothem is just like figuring out everything about a circle from the radius. If we know the radius of a circle (*a reference dimension*) we know everything about it – its area, its circumference, etc. Right?

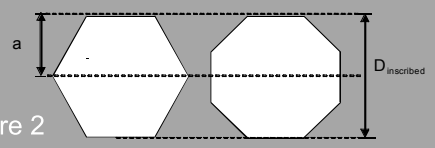

Figure 2

Figure 2. *The apothem "a" and inscribed diameter "D" of a hexagon (n=6, left) and octagon (n=8).*

Continued on page 3

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You can subscribe to receive this e-zine FREE at the Apogee Components web site (www.ApogeeRockets.com), or by sending an e-mail to: ezine@apogeerockets.com with "SUBSCRIBE" as the subject line of the message.

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Continued from page 2

Making the Hexannular

We start by figuring out what size parachute we want. For your first Hexannular a good size would be a=8 cm to a=10 cm. After you have made one chute you will be better able to judge how small or big you want to go given the material you have to work with and the rocket body tube diameter. The apothem of the Hexannular parachute pictured in this article is a=8.5 cm (Note: 1 inch is 2.54 centimeters).

The maximum dimension of the canopy is a little more than six times the apothem, or 6a. This is the size of the piece of canopy material you will need to use – a little bigger than a 6a x 6a square.

Once you have decided on your value for "a," make a single hexagon pattern out of cardboard. Using that pattern, trace out a ring of six hexagons with their sides touching. If you are really good you can trace the ring shape directly onto the canopy material. However, it is usually it is best to draw at least three of the hexagons of the pattern on to more cardboard, then use the resulting "half planform" to trace the full canopy pattern on to the canopy material.

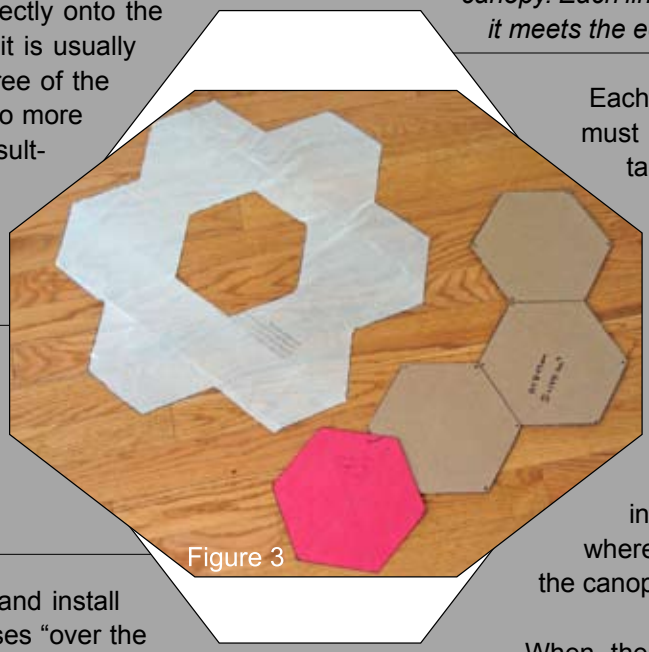

Figure 3. *A Hexannular canopy, the "half-planform" used to trace it out, and the single hexagon used to make the half planform.*

Lay the canopy out flat and install the lines. The Hexannular uses "over the top" suspensions lines (called "continuous" suspension lines). Each suspension line starts at the payload, goes up over the top of the canopy and down the other side to the payload again. There are actually only six continuous lines on the Hexannular, but when the parachute flies it will look like it has twelve lines. Figure 4 shows the first two of the six continuous lines installed.

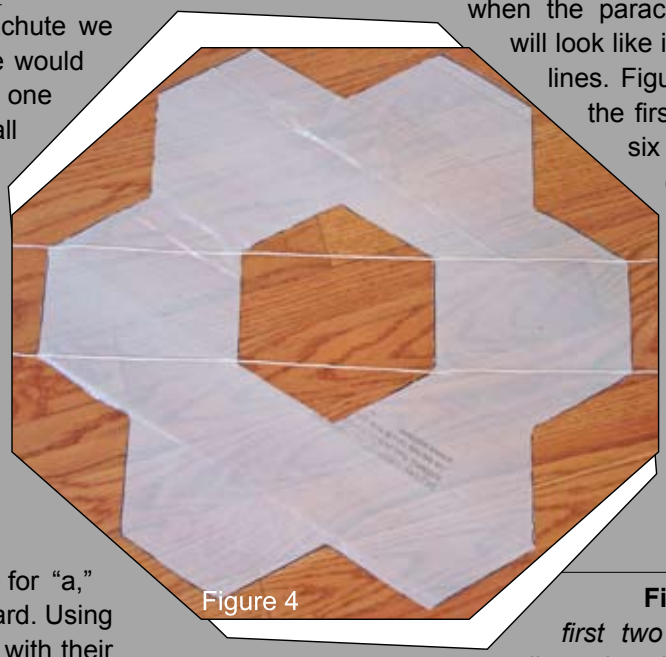

Figure 4. *The first two continuous lines installed on the canopy. Each line is taped in four places where it meets the edges of the canopy material.*

Each of the six continuous lines must be taped or otherwise attached to the canopy in at *least* four places. Larger canopies might need to have the lines taped in more than four places to keep them from flopping around and perhaps tangling the chute during deployment. The chute shown here has each continuous line taped in four places – at each point where the line crosses the edge of the canopy.

When the lines are correctly installed they will form a six-pointed star pattern in the

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apex vent area. See Figure 5. Note the lines across the vent are *required* – the parachute will not open without the apex vent lines.

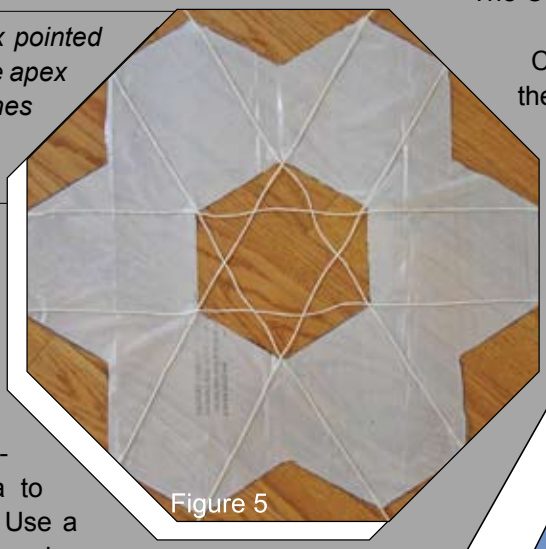

Figure 5. *A six pointed star is formed in the apex area when the lines are installed correctly.*

After all the lines are installed, even up the skirt of the parachute and gather the lines all together. Knot them at a distance of about 6a to 7a from the skirt. Use a method of your own choosing to connect the parachute to the payload.

To pack the chute, first hold it by the payload. Work the lines downward so the skirt of the parachute is even. Pull all the apex lines out of the canopy so none are inside the chute or tangled up. Form the canopy into a cylinder or fold it flat, still keeping the suspension lines straight, then lay the apex lines on top of the canopy material. Fold the canopy in half once to cover the apex lines. Wrap a little of the suspension lines around the canopy and install it in the rocket.

It is really useful to toss test any new parachute a few times to get the hang of folding it and also to see how it opens.

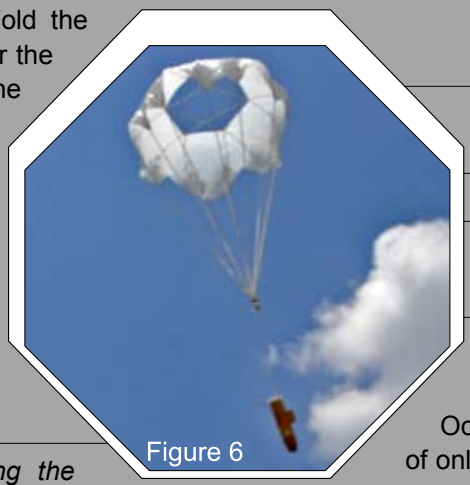

Figure 6. *Toss testing the Hexannular.*

The "Octannular" Odd-chute

What you can do with hexagons you can also do with octagons to make a different kind of "odd-chute". The Octannular has eight octagons arranged in a ring.

Construction of the Octannular is very similar to the Hexannular, but the suspension lines are a bit more complicated.

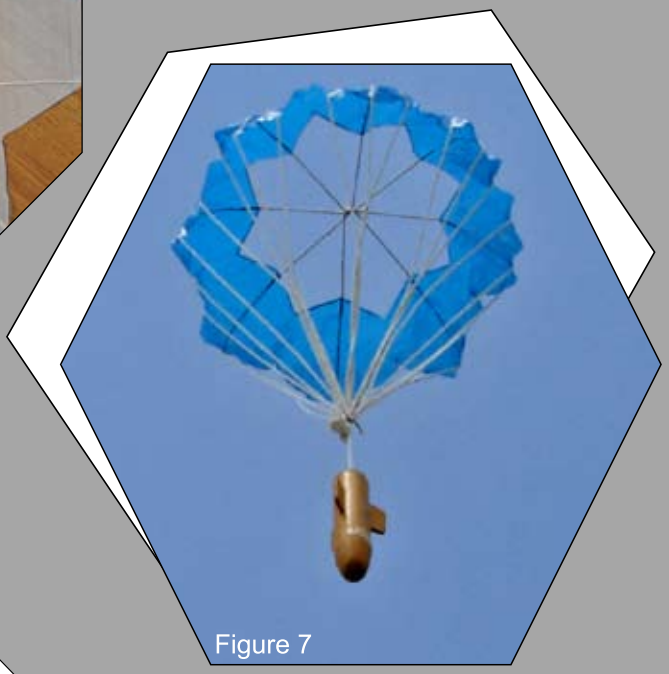

Figure 7. *Eight octagons are joined in a ring to create an Octannular Oddchute.*

Figure 8. *A blue Octannular canopy and the patterns used to make it. (page 5)*

As with the Hexannular, a good size for a first Octannular is a=8 cm to a=10 cm. The Octannular shown in this article had an apothem of only a=5 cm and was made from unusually thick

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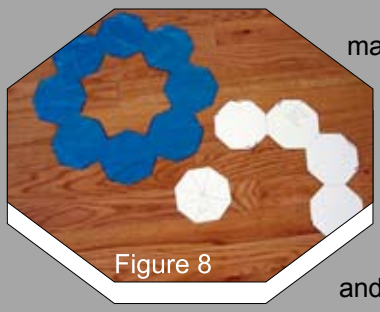
Figure 8

material (about 2 mil), and was difficult to work with. So pick a larger size to try first. It is best to make an octagon of the selected sized and use the octagon to make a half-planform, which is in turn used to trace the canopy on to the stock canopy material. Note for the Octannular parachute you will need a piece of stock canopy material with dimensions of about 7a x 7a to make the canopy.

The Octannular has two types of suspension lines – there are four "continuous lines" that cross the apex vent area, and sixteen "regular" suspension lines that are attached to the skirt of the canopy in the normal fashion. Lines are taped to the canopy where they cross the edge of the canopy. Figure 9 shows all lines installed. If done correctly you will have 24 lines tied together at the payload attachment point. As with the Hexannular, do not skip the apex vent lines – the parachute will not open.

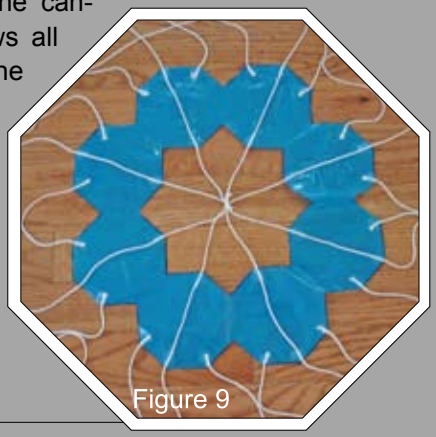
Figure 9

Figure 9. *All four continuous lines and all sixteen regular lines are installed on the blue Octannular. Note that in the apex area where the continuous lines cross they are tied together with a short length of line. This makes packing the parachute easier and reduces tangling.*

Once all the lines are installed gather them together. Even up the skirt of the parachute and tie off the lines about 7a or 8a from the edge of the skirt. Trim the excess and use your preferred method of attaching the parachute to the payload.

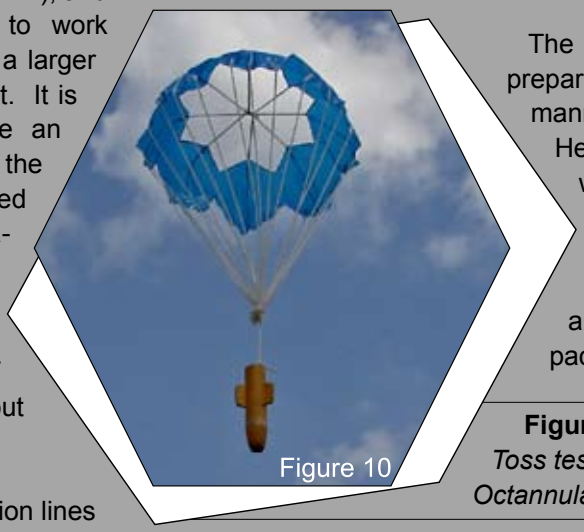
Figure 10

The Octannular is prepared for flight in a manner similar to the Hexannular. Also, as with the Hexannular, it is useful to toss test the Octannular to get an idea of how it will pack up and deploy.

Figure 10. *Toss testing the Octannular*

Extra For Experts

Annular Parachutes

Annular parachutes are a loose class of parachutes characterized by large vent areas. Examples include the so-called "airfoil parachute", the annular parachute used in mid-air retrieval exercises, and various other ring shaped chutes. Generally they enjoy slower and softer (but less organized) openings and are more stable than "regular" parachutes. On the other hand the large vent area generally means a higher rate of descent.

Hexannular Formulas

The canopy area "S" of the Hexannular is

$$S = 20.784\,a^2$$

where "a" is the apothem. Or to work it backwards

$$a = \sqrt{\frac{S}{20.784}}$$

Continued on page 5

Continued from page 5

which will give us the apothem for area "S."

Octannular Formulas

The canopy area "S" of the Octannular is

$$S = 26.511a^2$$

where "a' is the apothem. Or to work it backwards

$$a = \sqrt{\frac{S}{26.511}}$$

which will give us the apothem for area "S."

Future Work

The Oddchutes presented here are based on simple hexagons and octagons. The geometry of polygons suggests that it is also possible to arrange ten pentagons (n=5) in a flat ring, or even fourteen heptagons (n=7). It is not clear how the suspension lines could be installed (there may even be alternate ways to install suspension lines on the Hexannular and the Octannular.) It is quite possible a parachute made of pentagons or heptagons would not even open. The problem would be the excessive vent area. The negative effect of a large vent area might be reduced by an apex line. This line would be attached at one end to where the suspension lines cross each other in the center of the vent area and at the other end to the payload. If it is of the correct length it will "pull down" on the inside of the ring, helping the parachute inflate. *Maybe!*

A mix of polygons might also work. Possibly alternating hexagons and octagons would work. To do this the edges of the polygons "e" must be the same length.

General Formulas

For any regular polygon of "n" sides and apothem "a", where "a" is the radius of the inscribed circle

$$S = a^2 n \tan(180/n)$$

The mathematically inclined will notice that in the limit as "n" approaches infinity the coefficient of the square of the apothem becomes pi.

$$\lim_{n \to \infty} n \tan(180/n) = \pi$$

And this makes sense. A circle can be considered a polygon with an infinite number of sides, and then the apothem "a" becomes the radius.

For any regular polygon the edge length is

$$e = 2a \tan(180/n)$$

or solving for the apothem

$$a = \frac{e}{2\tan(180/n)}$$

Note the above formulas assume the calculator is set for "degrees." If the calculator is set to "radians" replace 180 with π (pi) in all the formulas

There are many possibilities for combining polygons and making odd parachutes. Might be a good science project!

About The Author

Mr. Flanagan holds degrees in life sciences and mechanical engineering and is a registered professional engineer in several states. He has held both research and engineering positions with contractors at NASA -JSC, and is currently with Jacobs Engineering at NASA - MSFC supporting the Experimental Fluids and Environmental Test Branch. He is a licensed airplane pilot, ultralight pilot, an expert scuba diver and a former Army paratrooper. He has had a life long interest in parachutes and made his first sky dive at the age of 17. He has made several hundred parachute jumps, holds a master parachute rigger certificate from the FAA, and has completed the University of Minnesota Parachute Technology Short Course. He continues to monitor developments in the field of "aerodynamic decelerators", has made models of most types of parachutes, and has flown most of them in model rockets. He lives in Madison, Alabama, with his wife and two cats.

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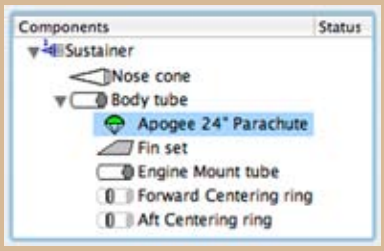
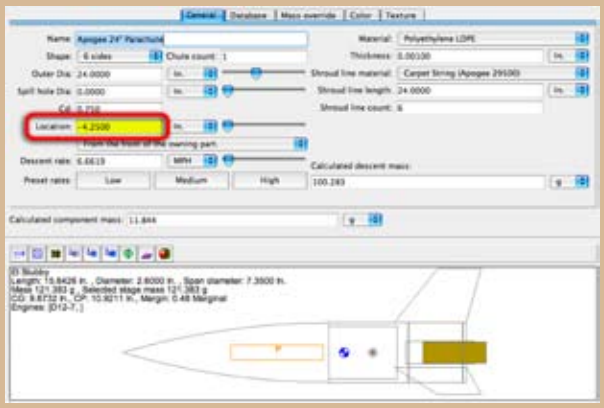
Question & Answer

Q: Say I have a very short rocket, and there isn't room in the body tube to install a parachute, but the nose cone has a huge internal volume where I can place the chute. In RockSim, how do I put a parachute into the nose cone?

A: As you know from Rocksim, the software will not allow you to attach a parachute to a nose cone. The parachute button is greyed out when you select the nose cone in the parts tree. To get around this, you must start by attaching it to the body tube.



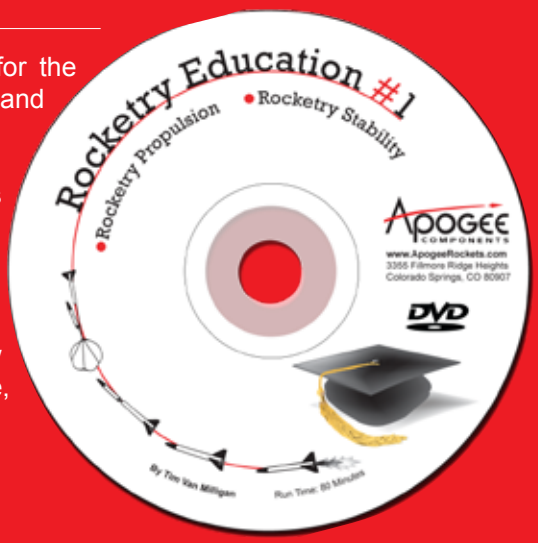
Open up the parachute editor, and create the chute as normal. The key trick is to TYPE in a negative value for the location of the parachute. In this case, I've typed a "-4.25 " into the location field.



New Rocketry Education DVD

This DVD was videotaped at a graduate course I presented for the Space Foundation as part of their summer institute course "Rocketry and the Biology of Living in Space, Space History, and Space Law."

The purpose of my particular presentation was to give teachers a strong foundation in rocketry, so that they could be ready to take it back to their classrooms. There was particular emphasis on rocket propulsion and rocketry stability. In the rocket propulsion discussion, we talked about the physics - how rockets produce thrust, the types of propellants used in model rocketry, characteristics of high and low thrust motors, the nomenclature for rocket motors, the thrust curve, and how to select the best motor for a model rocket.



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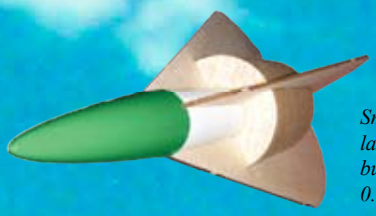
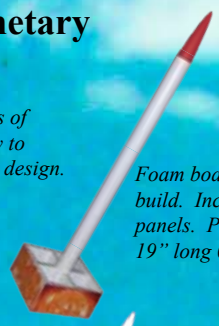


Interplanetary Shuttle

Small rocket with lots of laser cut balsa. Easy to build with distinctive design. 0.976" dia 11"long



Box Racer

Foam board fins for a different build. Includes pre-printed side panels. Plastic nose cone. 19" long 0.976 dia.

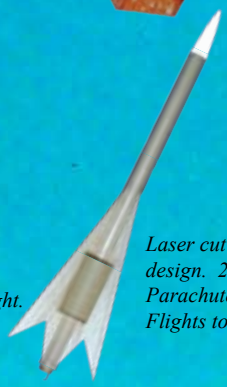
Space Speedster

Printed body with foam board fins. Preprinted fins. Laser cut foam mounting rings.

Flechette

3 fins 6 piece laser cut balsa. Flights to 1000'/ 300m. Parachute recovery.

Flechette: *The word flechette is French for "dart." In military use, it is a projectile having the form of a small metal dart: a sharp-pointed tip and a tail with several vanes to stabilize it during flight.*



Explorer

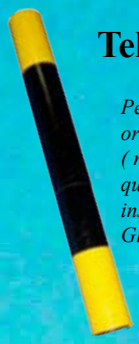
Laser cut 4 fin with distinctive design. 21" long 0.976" dia Parachute recovery. Flights to 750'/ 250m

Bug Me Not!

Great beginner's rocket. Laser cut fins. Streamer recovery. 0.976" dia 11" long.

Lightning Fury

Simple to build. Laser cut fins. Streamer recovery. 0.796" dia, 21" long



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Web Site Worth Visiting

http://www.jamesyawn.com/aiptek/index.html

As the price of solid state video cameras continues to come down (less than $30 these days), many modelers are taking the plunge and putting these devices into model rockets. This issue's web site worth visiting is one such story. It comes from the web site of James Yawn.

What I really like about Jimmy's web site is that he takes great pains to detail the process of how he does things. You'll find very detailed step-by-step photographs of his assembling the carrier for the Aiptek video camera that he used.

The finished rocket is very nice. You can tell that Jimmy is a expert craftsman. I could probably learn a thing or two from him myself. And the video from the camera is worth seeing too. Be sure to download them.

One of the other things that I like about the web site is that you can tell Jimmy has a great sense of humor. This makes it a fun web site to read too. Here is an example of his writing style:

"My wild spending spree was short-lived. During my morning in the hospital, many strangely-dressed people stopped by my bed to express their concern, and offer their services. One after the other they poked, prodded, examined, questioned, informed, pierced, injected, and poked some more. Every word, every gesture had a price tag hanging from it. Every one of them wanted a tip. Not right away, mind you. Didn't have to. They have a talented and enthusiastic billing department to back them up.

So I endured a period of forced frugality while the tide of bills rose, fell, and rose again, washing my accounts clean and leaving them to bleach in the sun."

If you want to put up a video camera, and would like to see how someone else has done it, check out Jimmy's web site. You'll definitely get a chuckle while reading it, and it is well worth visiting.

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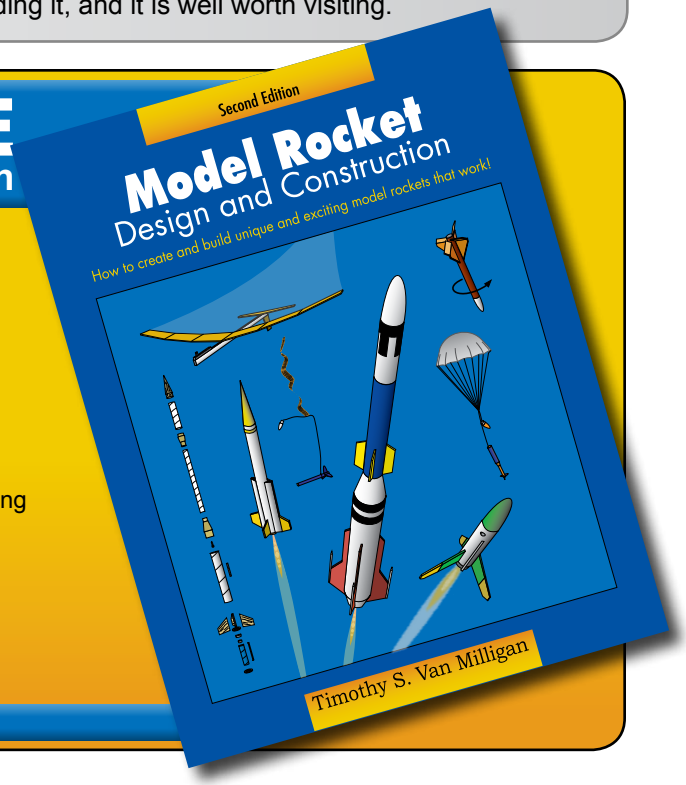


DEFINING MOMENTS

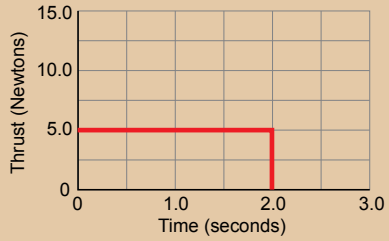
Total Impulse

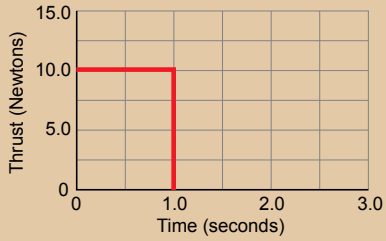
Total Impulse is the measure of how much power a rocket engine has. I like to tell people that are just getting started in rocketry to think of "power" as "how big is your gas tank." The more Total Impulse a motor has, the faster it can push a rocket, or it can make it travel higher into the air.

Total Impulse is determined by measuring the thrust of the rocket motor (measured in Newtons) and multiplying it by the duration of the burn time in seconds. The units are then Newton-seconds (N-s).

For example, in the chart below, the rocket engine creates 5 Newtons of thrust, and burns for two seconds. The Total Impulse is then 10 N-s.

Motor Designation	Minimum Total Impulse	Maximum Total Impulse
A	1.25 N-s	2.50
B	2.51	5.00
C	5.01	10.00
D	10.01	20.00
E	20.01	40.00
F	40.01	80.00



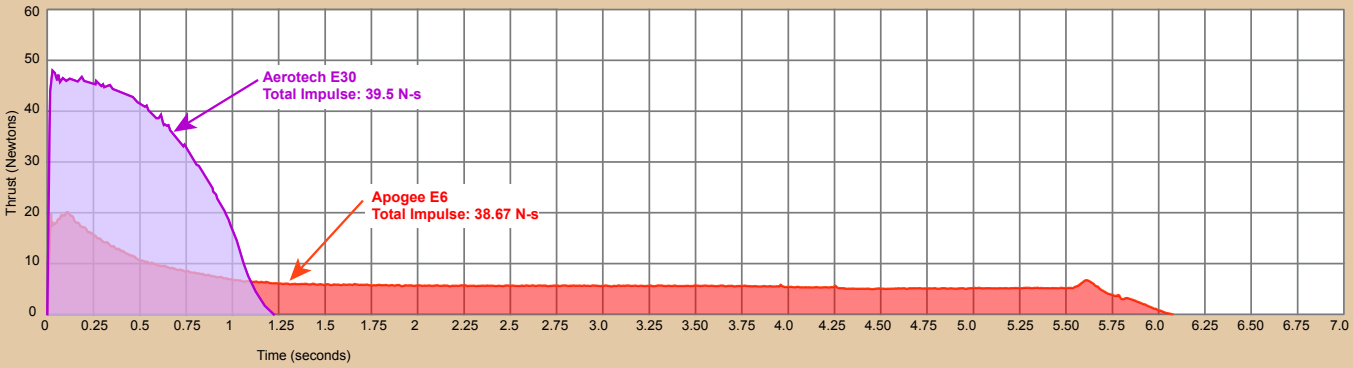


If the rocket motor produces 10 Newtons of thrust, and burns for 1 second, it also has 10 N-s of Total Impulse.

In these two cases, the amount of energy available to the rocket is identical. That is why I say to youngsters to think of it like "how big is your gas tank."

The NAR classifies rocket engines according to the Total Impulse the motor produces. The chart below shows the designation that is given.

Total Impulse gets a little harder to determine if the thrust of the rocket motor changes while it is burning. So what you have to do is to make a chart showing the thrust at every instant during the burn, and then calculate the area under the curve of the chart. This chart has a special name: The Thrust Curve (see http://www.ApogeeRockets.com/education/dowloads/Newsletter189.pdf).

As we saw in Newsletter 189 the E6 motor and the E30 both have similar amount of area under the curve, so they have similar amount of power available.

Related Information: Thrust Curve (http://www.ApogeeRockets.com/education/dpwnloads/Newsletter189.pdf), Specific Impulse (http://www.ApogeeRockets.com/education/downloads/Newsletter188.pdf)