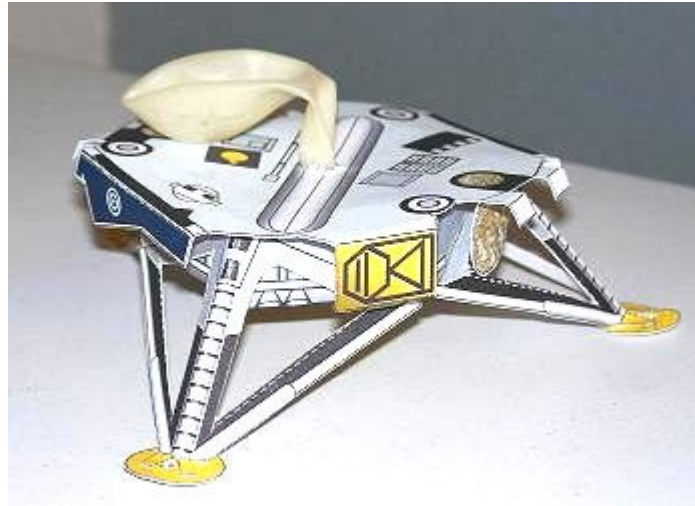


# *balloon powered* Phoenix Mars Lander Model

by Steve Widmark  
Mountain View High School, Mountain View, CA



## What is Phoenix?

Phoenix is NASA's latest mission to Mars. Launched on a Delta II rocket on August 4<sup>th</sup>, 2007, the Phoenix lander will touch down in the northern region of Mars on May 25, 2008. Once there, it will dig into the Martian permafrost using a robotic arm and analyze the composition of the soil and ice it removes with a sophisticated automated laboratory. In a nutshell, the goal of the mission is to determine if the Martian surface is (or was) capable of supporting life. Unlike the previous rover missions to Mars that made bounce landings using air bags, Phoenix will make a powered landing employing twelve thrusters positioned around the spacecraft. The model demonstrates this method of landing with a single balloon "thruster." For more information about the Phoenix mission go to <http://phoenix.lpl.arizona.edu>

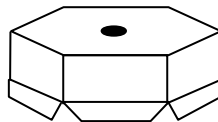
## Materials and tools:

1 parts sheet color printed on 110 lb (#110) card stock  
1 balloon (lander flies best with a 5" balloon)  
glue stick or Elmer's glue  
scissors  
pencil  
Optional items:  
X-Acto knife

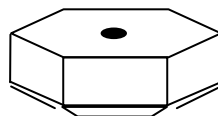
## Directions:

Note: If the directions tell you to bend a tab down, this means to bend the tab down with the printed portion of the part facing up. If the directions tell you to bend a tab up, this means to bend the tab up with the printed portion of the part facing up. The front side of a part is the side with the printing. The back side of a part is the side without any printing.

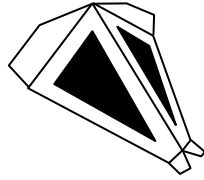
1. Cut out the **lander body** from the parts sheet. Cut out the large black circle in the center of the part.
2. Bend the six tabs labeled **A** on the **lander body** down. Now bend the six side panels on the **lander body** down. Put some glue on the **A** tabs and attach these to adjacent side panels to form the shape shown below.



3. Bend the tabs labeled **B** on the **lander body** inwards toward the center of the part to form the shape show below.

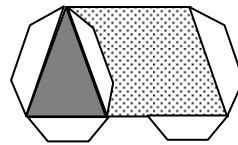


4. Cut out the three **landing gear legs**. Cut along the short dotted line at the tip of each part. Bend the four tabs on each **landing gear leg** up. Fold the **landing gear legs** in half length-wise. Optional: For a better looking model, cut out the middle of each part along the white dotted lines with an X-Acto knife. Each part should look like the diagram below.



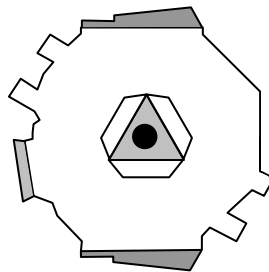
5. Notice the six, white stripes on the side panels of the **lander body**. For each **landing gear leg**, there is a corresponding pair of stripes that match the tabs on **the landing gear leg**. Put some glue on one pair of white stripes and attach a **landing gear leg** so that the tabs on the leg line up with the stripes. Repeat this procedure for the other two legs. Two of the panels and two of the legs have the pattern of a gold tank printed on them. Make sure these patterns line up as well.

6. Cut out the **support column**. Bend the tab labeled **C** down and the tabs labeled **D** up. Bend the three panels of the part to form a triangular column with the printing on the outside. Put some glue on the front of tab **C** and glue the column together to form the shape shown in the figure below.

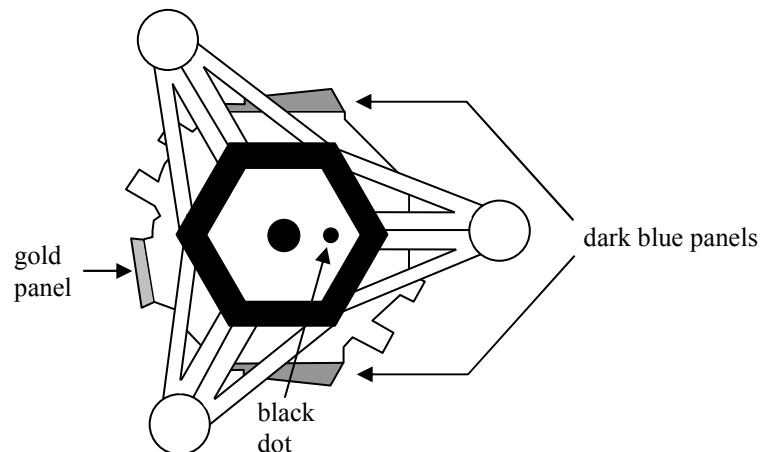


7. Cut out the **science deck** from the parts sheet. Cut out the black circle in the center of the part. Bend the dark blue tabs (solar panels) on either side of the part down. Bend the gold tab down. Bend the four small white tabs 45° down.

8. Place the **science deck** on your work table with the printed side facing down. Put some glue on the back of three of the tabs labeled **D** on one end of the **support column**. Attach the support column to the bottom of the **science deck** so that the **support column** is centered about the hole in the middle of the **science deck** as shown below.

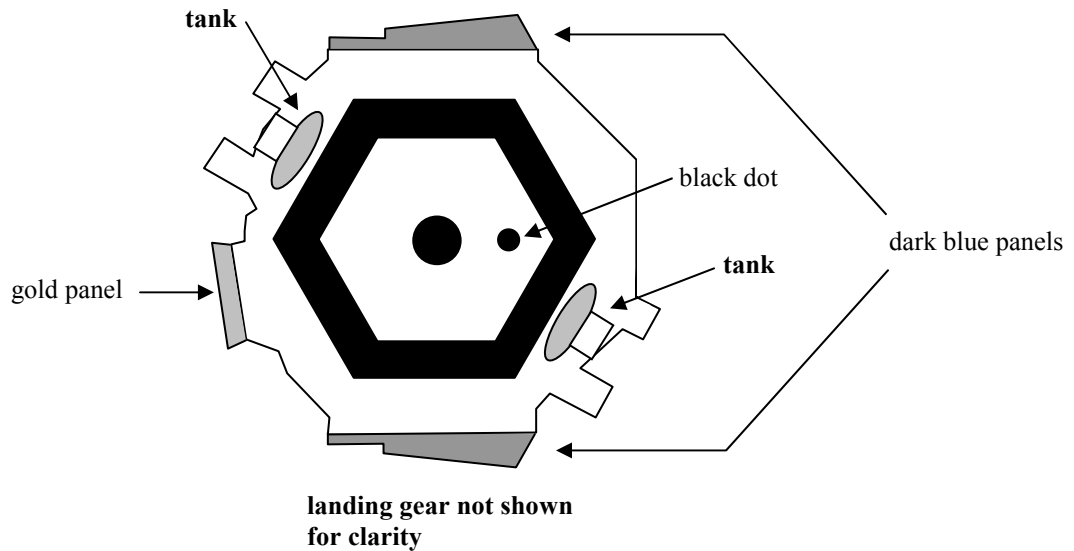


9. Put some glue on the front of the tabs labeled **B** on the **lander body**. Put some glue on the backs of the remaining tabs labeled **D** on the **support column**. Attach the **lander body** to the **science deck** so that the holes in each part are lined up **exactly** with one another and the black dot on the bottom of the **lander body** is oriented as shown in the figure below.

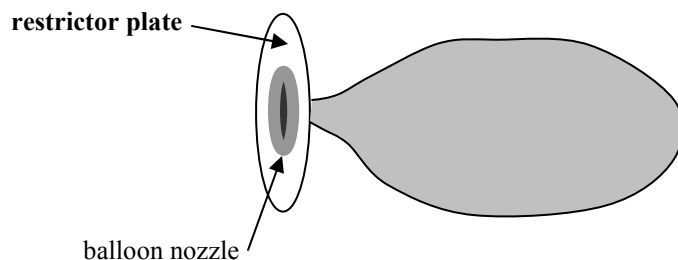


10. Cut out the three **landing gear pads**. Put some glue on the back of the small yellow tabs at the tip of each **landing gear leg**. Attach each pad to each leg so that the shaded region on each pad is covered by the yellow tabs on each leg. .

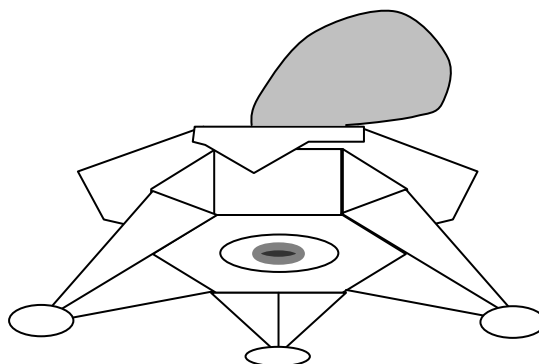
11. Cut out the two **fuel tanks**. Bend the white tabs on each fuel tank up. Put some glue on the back of each tab and attach the tanks to the bottom of the science desk as shown in the figure below. Make sure the ends of the tabs are flush with the edges of the **science deck**.



12. Cut out the **restrictor plates**. The model needs only one plate – the other two are spares. Poke a hole in the middle of the plate with a sharp pencil. Start with a small hole (3-4 mm), it can be enlarged later if necessary. Inflate and deflate the balloon to maximum size at least five times to stretch it out. Poke the nozzle of the balloon through the hole in the **restrictor plate** with the pencil (carefully so you do not puncture the balloon) so it looks like the diagram below.



13. Poke the balloon through the hole in the bottom of the **lander body** and then through the hole in the **science deck** with the pencil (carefully so you do not puncture the balloon) and pull it all the way through so it looks like the diagram below. The **restrictor plate** should lie flat against the bottom of the **lander body**. Do not glue the **restrictor plate** to the **lander body**.



### Flying the lander:

Inflate the balloon. Trial and error will determine how much air to put into the balloon. A well-stretched balloon inflated to maximum size seems to work the best. After inflating, put your thumb over the end of the balloon to keep the air in. Hold the lander up over your head (or stand on a chair). Release the lander in a level attitude. Ideally, it should make a powered descent all the way to the ground and land upright on its landing gear. If it does not, try the following:

1. Put a different amount of air in the balloon
2. Release it from a different height
3. Add a small amount of weight (such as clay) to each landing gear pad.
4. Try a different sized balloon.
5. Make the hole in the **restrictor plate** a little bigger by working the tip of the pencil into the nozzle of the balloon with a twisting motion.

Enjoy!

### Instruments on the Phoenix science deck

#### a. Meteorological Station (MET) boom

Measures surface temperatures, wind speeds and pressures.

#### b. Robotic Arm (RA) in protective cover

Delivers soil and ice samples from the surface to the TEGA and MECA instruments

#### c. Microscopy, Electrochemistry and Conductivity

**Analyzer (MECA)** Wet chemistry lab with optical and electron-force microscopes.

#### d. Thermal Evolved Gas Analyzer (TEGA)

Determines the composition of soil and ice samples from the surface  
By measuring the power needed to vaporize the samples.

#### e. Mass Spectrometer

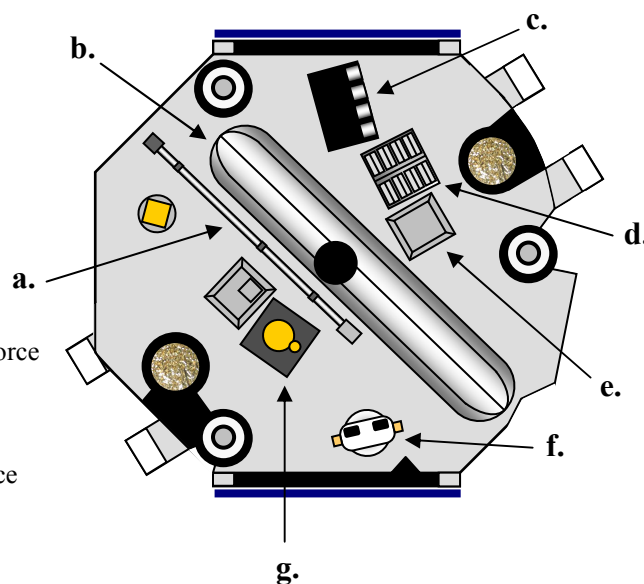
Determines the composition of soil and gas samples vaporized in the TEGA.

#### f. Surface Stereo Imager (SSI)

Provides stereoscopic, high resolution images of the surface,

#### g. MET Light Detection and Ranging (LIDAR)

Uses a laser to measure the size and distribution of particles in the atmosphere.



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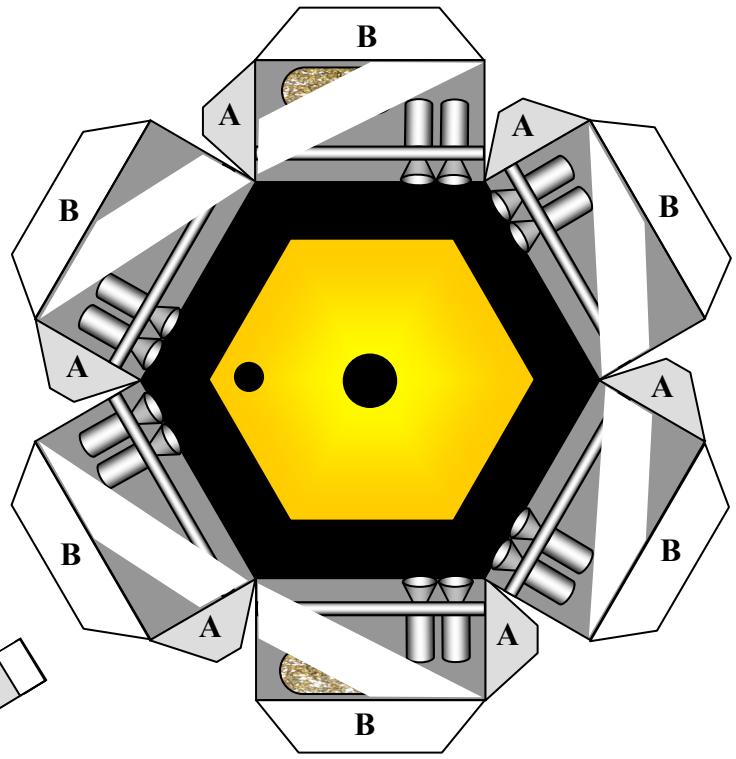
Additional copies of this model are available at [www.paleoneon.com](http://www.paleoneon.com)  
My e-mail: [steve@paleoneon.com](mailto:steve@paleoneon.com)

# Parts Sheet

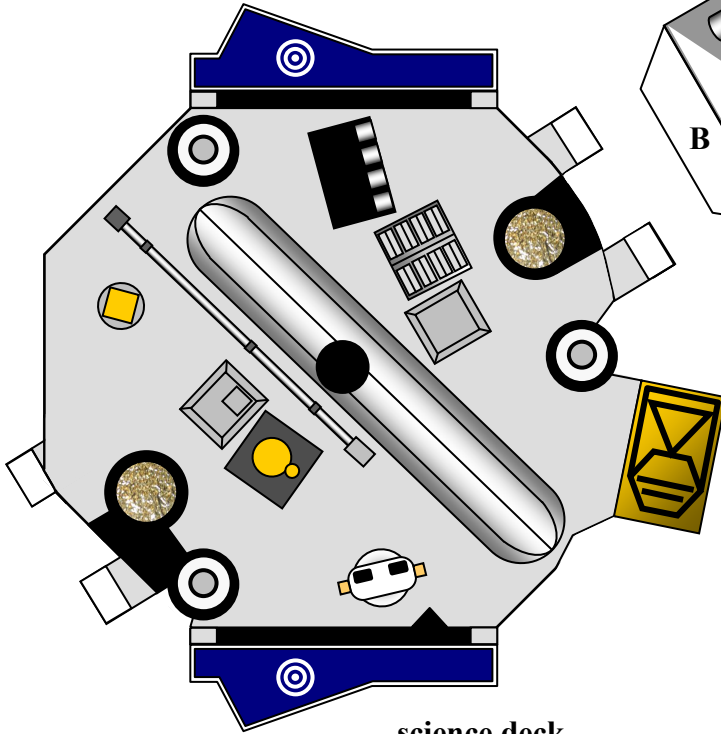
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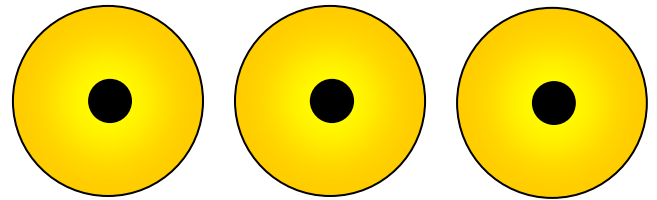
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lander body



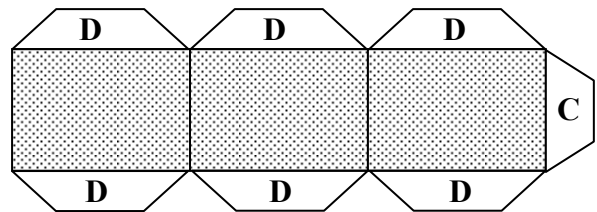
science deck



restrictor plates



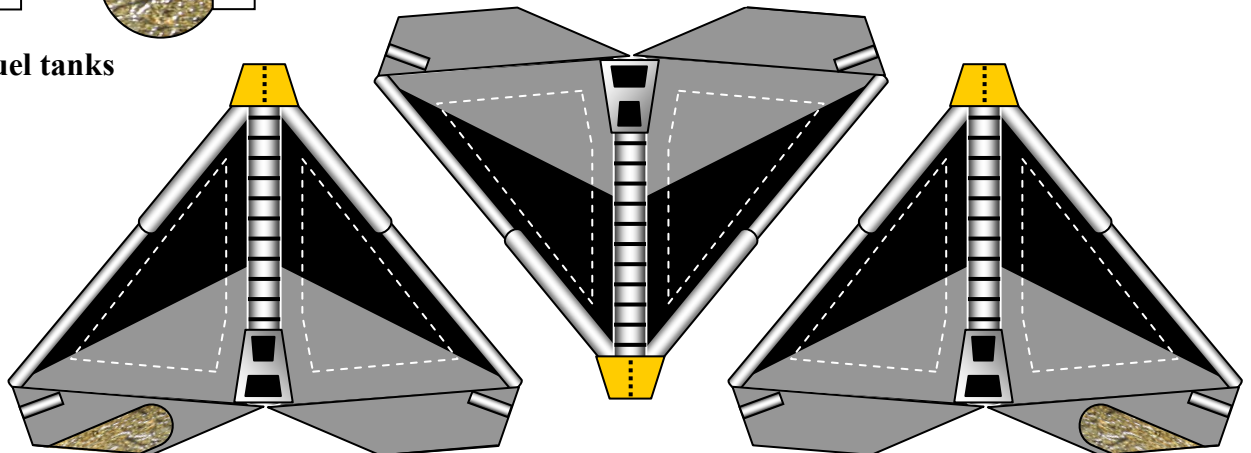
landing gear pads



support column



fuel tanks



landing gear legs