

# The Strange Effects of a Vacuum

## Equipment List

- Mechanical vacuum pump (1 to 16 cfm) with oil mist filter on outlet.
- Vacuum connection: Tygon tubing (~5/8 inch O.D.), in-line vacuum shut off valve, vent valve on Tee fitting, hose clamps, adapter KF connection to mate with vacuum pump inlet.



Vacuum connection assembly: Vacuum gauge, vent valve, vacuum shutoff valve.



Vacuum pump and oil mist filter.

- Nalgene® plastic vacuum bell jar, ~6½ inch diameter, ~7½ inch high with baseplate.
- Custom-built hose adapter to connect to soft drink can.
- Hose clamps
- Screw driver
- Small balloons
- Latex gloves
- Marshmallows (A bunny if available)
- Shaving cream and shaving gel in aerosol cans
- Transparent plastic stemware (for shaving cream demo).
- Q-Tip cotton swabs
- Bubble wrap
- Empty, opened, soft drink cans



# Strange Effects of a Vacuum

## Preparation

1. Check oil level in vacuum pump. Attach oil mist filter if not already on pump outlet. Connect Tygon hose assembly to the vacuum pump inlet. Tighten all hose clamps for good seal.
2. Close vent valve (full clockwise) and vacuum shut off valve (handle at right angle to valve body). Plug in pump. Turn on pump. Pump should pump quietly after less than a minute. If not check fittings for tightness.
3. Connect pump tubing to bell jar baseplate. See Figure. 
4. Put bell jar in place and open vacuum shut off valve. Pump should pump quietly after less than a minute and gauge should indicate a vacuum within a couple of minutes. If not check fittings for tightness.



Vacuum gauge at atmospheric pressure



Vacuum gauge at vacuum pressure

## Demonstration Experiments

You can test what happens when some common items are exposed to a vacuum, that is, when the surrounding air pressure is reduced to near-zero. Actually the pressure is reduced to well below one-thousandth of an atmosphere. The mechanical pump used can easily pump down to below 10 millitorr (mTorr) or 0.075 millibar (1 bar=750 Torr= approximately atmospheric pressure).

### Self-Inflating Balloon and the Expanding Hand

Partially inflate a small balloon, and tie it off. Place it and an empty, untied balloon in the bell jar and pump it down.

What happens? Why?

Tied and untied latex gloves can be used with or instead of a balloon (the expanding hand).



## *Strange Effects of a Vacuum*

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### **Marshmallow in Space**



**Before**



**Under vacuum.**

Place a few marshmallows (untoasted) on the baseplate. Pump down. Try this with a bunny-shaped Easter marshmallow if available and create a bunny monster. Explain what would happen to a marshmallow in space. After venting to air the marshmallows collapse. If you touch them they will feel cold. Why?

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# Strange Effects of a Vacuum

## Shaving Cream Explosion

You can try this with shaving cream or gel from an aerosol can. Place small amount in transparent plastic stemware. Use only about an inch-long portion of cream and only about ½-inch of gel *ONLY!* Otherwise you will need the cotton swabs to clean out the vacuum pumping port.

### Shaving Cream Explosion



During



Before



After venting to air.

### Shaving Gel Explosion



During



Before. Note very small amount of gel.



After. Cleanup still required.

# Strange Effects of a Vacuum

## Bubble Wrap Rap

Pump down a small section of bubble wrap. Can you hear when it pops? The quality of bubble wrap often is tested by subjecting it to a vacuum.

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## Crushed Bottle



**Plastic water bottle; empty and dry**

 **Black rubber bung adapter**



With vacuum manifold valve closed, insert bung/bottle as shown.



Switch on vacuum pump, open manifold valve and observe bottle.

What has caused the bottle to be crushed?

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## Feather Drop Experiment

### Equipment

1. Strong magnet
2. Metal washer (mild steel)
3. Feathers
4. Vacuum system



Figure 1

### Procedure

1. Tip vacuum chamber upside down.
2. Place feather and washer at bottom of chamber with washer on top of feather – see Figure 2.
3. Lift chamber up with one hand and with the other hand hold the washer and feather against the chamber wall.
4. Carefully rotate chamber to upright position and place magnet on the outside of chamber over the feather and washer. The magnet should hold the feather and washer together.
5. Carefully move chamber on to vacuum baseplate (Figure 3).
6. Pull magnet away and observe the fall of the washer and feather.
7. Repeat steps 1 to 5.
8. Switch on vacuum pump and open isolation valve to evacuate the chamber.
9. After several minutes of pumping, repeat step number 6.

Compare the two feather/washer drops. Was there any change in the speed of washer? Was there any change in the speed of the feather? What conclusions can be made from the observations?



Figure 2



Figure 3

*This is an adaptation of the famous Guinea (a British coin) & Feather demonstration probably first described by the Dutch scientist Christiaan Huygens (1629-1695) around 1662.*

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## Additional Information

### Questions to ponder:

What household items would be interesting to expose to a vacuum? Why?

What do you think the effect would be?

If air (at sea level) weighs about  $0.00013 \text{ g/cm}^3$  and the volume of a soda can is  $1500 \text{ cm}^3$ , how much more would the can weigh in a vacuum compared to its weight in air?

**Website.** Visit *The Bell Jar*– A website for amateur vacuum experimenters:

[www.belljar.net](http://www.belljar.net)



*The Bell Jar Welcomes You to the World of Amateur Vacuum*

A famous painting in the National Gallery, London:

"An Experiment on a Bird in the Air Pump"

Joseph Wright of Derby 1734-1797

Oil on Canvas



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