DEMONSTRATIONS
CHAPTER 8

1. Spontaneous symmetry breaking, oil and water:

Pour four parts water and one part vegetable oil in a jar. Seal the lid tightly, and shake the mixture vigorously. How would the mixture appear to a water bug swimming in the solution immediately after shaking?

Let the jar sit for several minutes. What happens to the mixture if it is undisturbed? How would it appear to a water bug now?

2. Spontaneous symmetry breaking, magnets:

Place a bar magnet on a flat surface, cover it with a sheet of paper, and sprinkle iron filings on the paper to outline the magnetic field. Then heat the magnet in an oven or hot water bath (100 degrees Centigrade -- the temperature of boiling water -- should be sufficient), and try to outline the magnetic field with iron filings while the magnet is still hot. (Use hot pads or insulated gloves when handling the magnet, to protect your fingers.) What has happened to the field?

Let the magnet cool slowly back to room temperature, and repeat the application of iron filings. Is the magnetic field evident? Why (or why not)?

3. Mobius strip topology, and an operation that reverses handedness:

Make a Mobius strip by twisting one end of a strip of paper 180 degrees then taping the ends together. (A strip of paper an inch wide and ten inches long works well.)

Explore the properties of the Mobius strip: how many surfaces does it have? (Trace the surface with a pencil or with your finger. If the strip had two surfaces, you would have to lift your finger off one surface, over an edge, to transfer to the second surface.) How many edges does the Mobius strip have?

Cut out a diagram of a right hand small enough to fit on the surface of the Mobius strip, and transport it around the strip one revolution being careful to maintain the orientation of the hand relative to the surface of the Mobius. What is the handedness of your cutout after one revolution? After two revolutions?

4. Operations on mirror images:

Rotate the reflecting plane of a hand-held mirror around the line of sight to a distant object, as diagrammed below.

How many times does the image rotate in one revolution of the mirror?

5. <u>Model of a gauge change</u> that <u>mimics force:</u>

Imagine a car on a race track with the following unusual properties: the car travel at a constant speed of 50 meters per second, but space along the racetrack is warped such that meter sticks have different lengths at different locations on the track. In the diagram below, the space between each successive stripe across the track is 50 meters as measured by the local meter sticks.

How would the car's motion appear to an observer looking down from the Goodyear blimp, floating above the track? How would the car's progress appear to the driver, assuming the 50 meter marks were his only available references?

6. <u>Force as a change in gauge:</u>

Draw a uniform grid on a stretchy rubber sheet, then distort the sheet with a heavy marble or bearing.

Explain how the grid might serve as a geometric measure of the local force of gravity.

Roll a lighter sphere across the distorted surface, and time the interval between grid lines as the sphere progresses along its trajectory. (You might need a larger grid and distortion, as provided by a bowling ball on a trampoline.) How does the velocity of this test sphere, as measured by the local grid, compare to the sphere's velocity rolling across an undistorted, flat grid?

7. <u>Hidden dimensions:</u>

Draw uniform grid lines on a strechy rubber sheet and suspend the sheet loosely in a frame (such as a needlepoint frame). Apply suction at some point on the back of the sheet with the hose on a vacuum cleaner or the vacuum pump for a bell jar attached to a large syringe tube.

How does the hidden surface of the invagination affect the grid? Suppose there was a constant total surface area available to the visible sheet and the hidden invagination. What would happen to the grid on the visible surface if the hidden surface increased?