

## **Directions**

You will be participating in an *Orientation Lab* that is designed to:

- Introduce you to the physics laboratory
- Cover basic observation and data collection techniques
- Explore interesting physics phenomena not covered in our regular lab schedule.

The Orientation Lab consists of 3 experiments, each using different equipment. Your lab group will rotate through 3 stations. Your lab instructor will notify your group when it's time to move to the next station.

Students will work in groups, but each student will individually complete and submit the provided laboratory report. All data tables and questions you need to answer may be found in the report. Before leaving, be sure your instructor has signed all the required pages of your report.

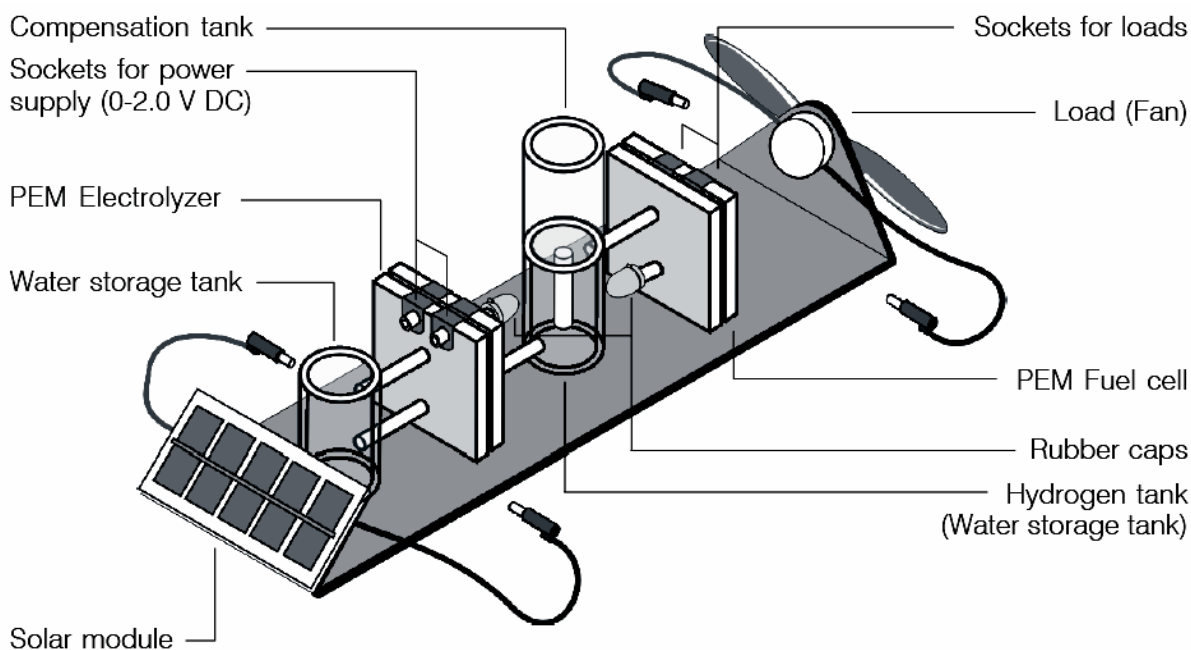
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## **Experiment 1: THE FUEL CELL**

This experiment explores the operation of a hydrogen fuel cell which works via a proton exchange membrane (PEM). Fuel cells have the potential to deliver compact energy to mobile devices such as cars, laptop computers and cell phones in a much more efficient way than offered by other current technology. To the right is an image of a PEM fuel cell in a Toyota car. Many research initiatives are underway to greatly improve fuel cell technology and its use.



The PEM fuel cell featured in this experiment uses a solar cell to generate electricity which in turn is used to break down distilled water in an electrolyzer to form oxygen and hydrogen. In any fuel cell an initial power source is used to produce the fuel, which in this case is hydrogen. The hydrogen is collected in a gas storage tank. Inside the actual fuel cell, the stored hydrogen can then react with oxygen in the air to form water energy. The PEM converts this energy into electricity which can then be used to power a motor, or in this case, a fan. The following diagram illustrates this process.



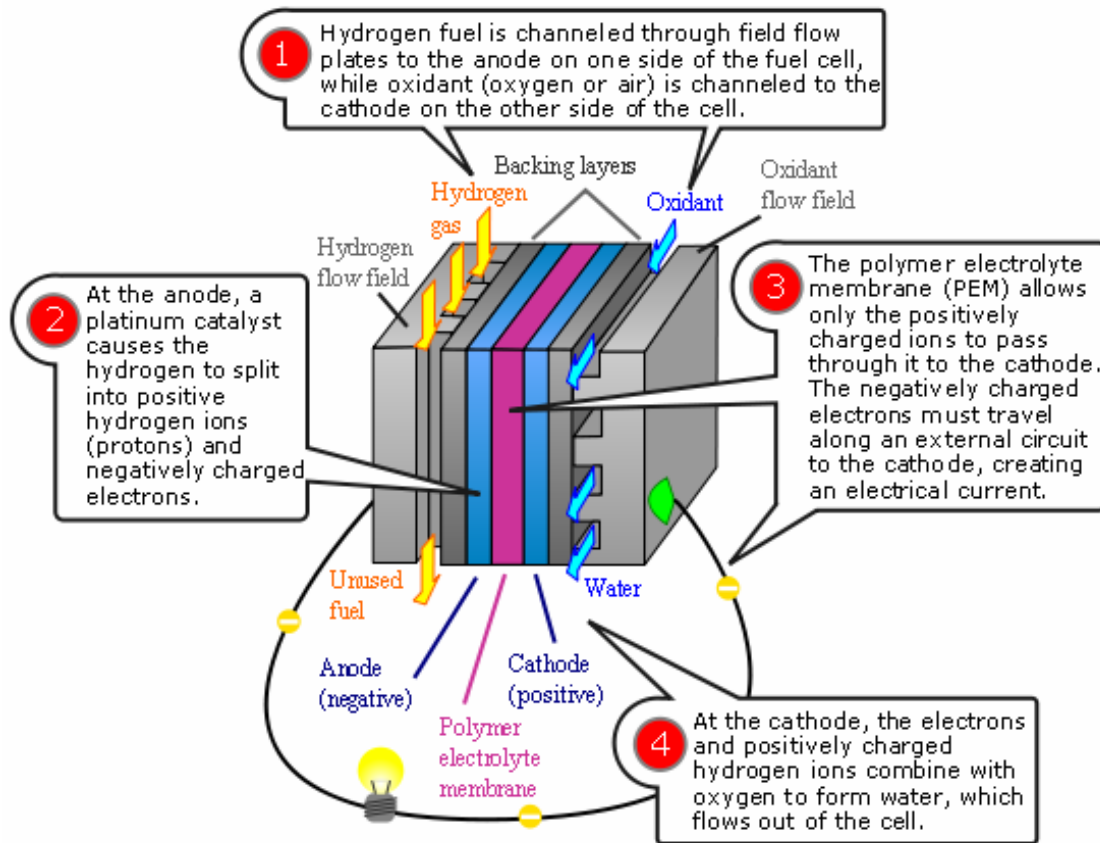
### **Observing the PEM Fuel Cell in Operation**

This is an observational experiment in which you will observe the operation of the fuel cell and answer a few questions based on your understanding of its operation.

**Procedure:**

1. The fuel cell should already be operating at your table. Verify that there is a reservoir of hydrogen gas in the storage tank (if not, contact your instructor).
2. Connect the fan leads to the fuel cell terminals. This will allow the electrical current produced in the fuel cell to flow into the fan motor.
3. While observing the operation of the fuel cell, answer your report questions.
4. Do not empty the hydrogen tank so that the next group will have fuel for the fuel cell.

## Proton exchange membrane fuel cell



## **Experiment 2: WAVE PROPERTIES**

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This experiment uses a Ripple Tank to explore wave properties. In particular, you will be measuring wave speed and observing the Doppler effect. Although the Ripple Tank uses water, these wave properties are shared by all waves, including light, radio, sound and microwaves.

### **Measuring Wave Speed**

The purpose of this activity is to demonstrate the relationship of wave speed to frequency

Wavelength ( $\lambda$ ) is the distance from one point on a wave to an identical point on the next wave, such as the distance from one crest to the next crest. Frequency ( $f$ ) is the number of waves per unit of time. Wave speed ( $v$ ) is wavelength multiplied by frequency



### **Procedure:**

1. Turn on the ripple generator and the light source. Set the light source to 'STROBE'. Set the frequency to 15 Hz and the amplitude slightly less than half of maximum. Adjust the amplitude if needed to make a clear wave pattern.
2. The waves fronts appear as light and dark stripes that are formed as light travels through wave crests and troughs. Measure and record the distance of five wavelengths in the table provided.
3. Choose a new frequency and repeat the measurement of the distance for five wavelengths. Do this for five different frequencies.
4. Calculate the wavelength that corresponds to each different frequency.
5. Based on the wavelength and frequency, calculate the wave speeds using the wave equation  $v = \lambda f$ .
6. Calculate the average wave speed.

### **Doppler Effect Demonstration**

The Doppler effect is the change in frequency and wavelength of a wave for an observer moving relative to the source of the waves. It is commonly heard when a vehicle sounding a siren (such as a police vehicle) approaches or recedes from an observer. The received frequency is increased (compared to the emitted frequency) during the approach, it is identical at the instant of passing by, and it is decreased when moving away.



**Procedure:**

The Doppler effect can be demonstrated using the Ripple Tank System. Arrange the ripple generator and ripple tank as for the previous experiment, but replace the wave bar with the peg accessory. Start with the ripple generator's default frequency of 15 Hz, and put the strobe light in a constant on position. By moving the ripple generator at a constant speed, the Doppler phenomenon can be observed. Be sure to slide the generator in a way so that the light shines in front of and behind the vibrating peg so that you can easily see the waves produced.

It will require some experimenting to determine the right speed to use for a given frequency. One way to move the ripple generator is to simply pivot the generator on its support rod. To do this, grip the rod with one hand just below the generator's rod clamp. Slightly loosen the rod clamp and use your thumb to support the clamp so that the generator stays at the same vertical position on the rod. Use the other hand to rotate the generator one way and then the other. Wavelengths in front of the moving dipper will decrease, and wavelengths behind the moving dipper will increase.

## **Experiment 3: HANG TIME**

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This experiment utilizes a force platform to explore the physics of hang time, the time spent in the air while jumping. Your lab table computer will be used to graph the force versus time during jumping activities.

**Procedure:**

1. Check to make sure the force platform is connected to the computer and that the Data Studio program is open. Data collection will begin when you click the START button. You will need to open a graph (under Displays) to see a plot of force versus time for each data run. The Data Studio program is fairly intuitive to use, and all functions are menu driven. You may need to spend a few minutes initially exploring the software. Check with your instructor if you have any questions.
2. Each person in your group will jump vertically off the force platform and land back on the platform. Try to do this smoothly without "jarring" the platform. For each person's jump, record the maximum force generated for jumping up, for landing, and record the hang time. Record this data in your report data table. Note that force is measured in Newtons (N). Also make note of who appears to jump the highest.
3. Be sure to leave the Data Studio program open after you have collected your data. Clear out any data you have taken. Answer all the questions following the report data table.



Name: \_\_\_\_\_

Section: \_\_\_\_\_



# REPORT

Complete all tables and answer all questions for each experiment you participated in. To receive a grade for the Orientation Lab, be sure your instructor signs your report before leaving the lab.

## **Experiment 1: THE FUEL CELL**

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### Questions

1. What is the purpose of the solar cell in the fuel cell system you observed?
2. What fuel is used by the fuel cell?
3. During operation the solar cell produces a power of 500 mW and the fuel cell produces a power of 300 mW. Does this mean that more power is coming into the system than is being used? Where does the energy produced by the solar cell ultimately go?
4. What by-product is produced in the fuel cell?
5. When a fuel cell is used in a car, some of the components used in the display model are not necessary or are replaced by something else. For each of the components of the fuel cell system you observed, identify how they would be adapted to a car. Which would be used differently? Which would be unnecessary? What part of the fuel cell system do you think would present the greatest safety risk in a car? Draw a diagram to help illustrate your answers.

## ***Experiment 2: WAVE PROPERTIES***

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### **Measuring Wave Speed**

Frequency (Hz)	15 Hz				
Five $\lambda$ (m)					
$\lambda$ (m)					
$v$ (m/s)					

### **Questions**

1. Is the wave speed roughly constant for the frequencies you chose?
2. Why does the wave speed not change when you change the frequency?

### **Doppler Effect Demonstration**

Draw a sketch below of the waves produced in the ripple tank illustrating the Doppler effect. Be sure to label which direction the dipper is moving, and comment on the observed wavelengths.

### **Questions**

3. In which direction relative to the dipper's motion is the frequency of the waves the greatest? The least?
4. How does the speed of the water waves in front of the dipper's motion compare to the speed of those behind it? Explain your answer using the wave equation  $v = \lambda f$ .

## ***Experiment 3: HANG TIME***

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### **Measuring Hang Time**

Student Name	Max Force (N)	Hang Time (seconds)

### **Questions**

1. Based upon your observations, what factors affect hang time?
2. Is hang time related to how high you jump?
3. Does the person who exerts the greatest max force always have the greatest hang time? Why or why not?
4. Based upon your observations, what factors affect the max force a person generates? How does a person's weight affect the max force?
5. How does the max force generated while jumping compare to the max force produced when landing? Explain any differences.
6. At what point in a person's jump is the max force produced? In other words, explain physically what motion the person is going through at this moment.

**INSTRUCTOR SIGNATURE:** \_\_\_\_\_  
*Your instructor must sign your report for you to receive a grade for this Orientation Lab.*