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Solar Thermal Lab

Fall 2007

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Name_____

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Introduction/Purpose:

In this experiment, you will explore the relationship between flow rate and energy generation in solar thermal panels.

Apparatus:

Solar Thermal Panel, Bucket (insulated), Fountain Pump, two hoses (one to attach pump to solar thermal and one from solar thermal panel back to bucket), 1 L Beaker, Timer, Two Thermometers (waterproof if possible), Ruler.

Theory:

Solar thermal panels capture energy from the sun to heat water. There are two thermometers, one in the storage tank and the other on the solar collectors. When the controller senses the temperature difference between the solar collectors and the storage tank is more than a few degrees, it will turn on the system-pumping water from the storage tank, through the solar panel, and back into the tank.

 The flow rate of the water in the system is an important part of the efficiency of the system; if the flow rate is too fast, the water will not be in the panel long enough to heat up. The flow rate is defined mathematically as:

$$\text{Flow rate} = \text{Volume/Time} \qquad\qquad (1)$$

In this lab, volume will be measured in units of m^3 and time in seconds.

In the second part of the lab, you will be measuring the speed of the water as it runs through a system using the flow rate and kinematics. An object in motion can be described:

$$\Delta y = y_o + v_o t + \tfrac{1}{2}gt^2 \ \text{ OR}$$

$$\Delta x = x_o + v_o t + \tfrac{1}{2}at^2 \qquad\qquad (2)$$

In this experiment, there is no initial velocity in the y direction and no acceleration in the x so

$$\Delta y = \tfrac{1}{2}\,gt^2 \text{ and } \Delta x = v_o t \qquad\qquad (3)$$

When Δx, Δy, and t are measured, v_o can be calculated. To calculate the actual velocity, use the flow rate and area:

$$v = \text{Flow rate} / \text{area} \qquad\qquad (4)$$

Procedure:

Solar Thermal Water Projection

1. Place fountain pump into bucket.
2. Fill the bucket with enough water to cover the fountain pump.
3. Slide the hose from the pump into the input nozzle on the solar thermal.
4. Attach a hose to the output nozzle of the solar thermal panel and place it above the water level in the bucket.
5. Place the temperature probe into the bucket of water and place the other temperature probe in the opening on the top of the solar panel (next to the output nozzle).
6. Plug in the pump so the water will start flowing.
7.   Record the temperatures every minute for 15 minutes or until the water is heated by 20˚C. Adjust the flow rate, by turning the dial on the side, to achieve the greatest difference between the input and output temperatures.
8. Determine the flow rate by timing how long it takes to fill a 1L beaker.

Projectile Motion

1. Disconnect the pump hose from the solar thermal panel input.
2. Set the flow rate of the pump to be investigated (using the dial on the side).
3. Determine the new flow rate as you did earlier (time how long it takes for the water to fill a 1 L beaker). Repeat three or more times and determine the average flow rate.
4. Place the hose at the top edge of the bucket so that the water is shooting out in a projectile fashion into the bucket.
5. Record the distance from the water level in the bucket to the middle of the hose (vertical distance) and the distance from bucket wall to the spot where the stream hits the water (horizontal distance).
6. After this, turn off the pump and measure the diameter of the inner portion of the hose using the calipers.
7. Calculate the theoretical velocity and the actual velocity.
8. To determine the theoretical value, use equations (3).
9. To determine the actual value, divide the flow rate by the area of the tube.
10. Compare these values.

Repeat this experiment with the solar thermal panel attached to the hose off the pump. The tube coming out of the solar thermal panel will be placed on the top edge of the bucket as before, but this time the distance traveled by the water should be different (depending on the tubes the diameter of these may be different as well). Use the above formulas to decide on the actual and theoretical values of the velocity (you will also have to find the new flow rate).

Analysis:

Did running the water through the solar panel change the flow rate? If so, why do you think that happened? If you were to use a solar thermal panel to heat a swimming pool, how would you determine the most efficient flow rate?

NOTE: Another experiment to conduct would be to repeat this process using ethylene glycol instead of water.