THE STATE UNIVERSITY OF NEW JERSEY
RUTGERS

Design Competition Results
Includes photos shot during the competition and Team Report Submitted by the Team.

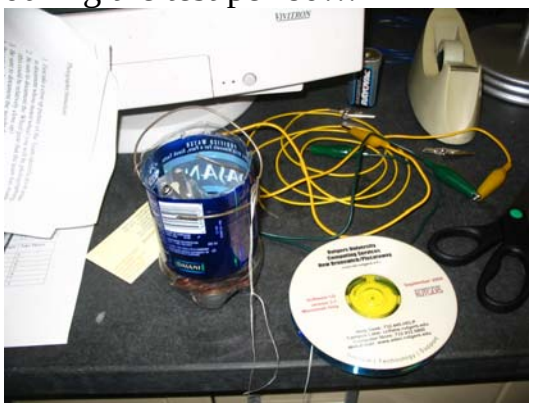
Team 4

Wheel radius = 15 mm??
Mass lifted = 305.9
Height achieved = 4.25 ft.
Time used = 4:11 (m:sec)

Team worked carefully to attach their motor to the supporting beam for their test:

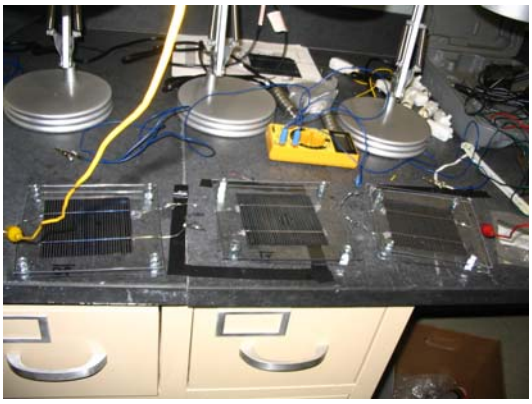


Their weight included a custom crafted bucket with loose change and a cell phone – which rang/sang during the test period!!:

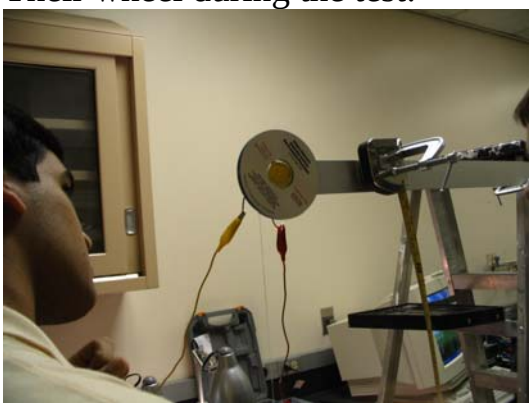


This pic shows their wheel too.

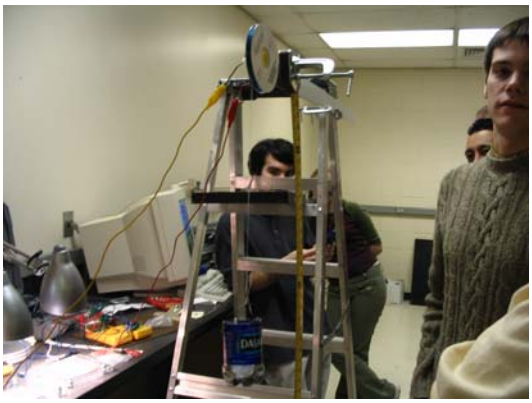
The team used series connection of their solar cells:



Their wheel during the test:



Near the end:



TEAM 4

This solar cell design project centered around the use of three six-by-six inch solar panels to power a motor in order to lift a load. The objective, thus, was to do the most work (lift the most weight, the most height), with a maximum height of five feet and a time constraint of five minutes.

In order to utilize the energy available most efficiently, it is necessary to find the matching point where the solar cell will maximize its output to our specific electric motor. The product of the solar cell's voltage, V, and current, I, determines its power. The power of the motor, on the other hand, is determined by the product of its rotation rate, w, and torque, t.

Therefore, for maximum efficiency,

$$V * I = t * w$$

The power of a motor is described by

$$P = (1/4)\, V^2 / R,$$

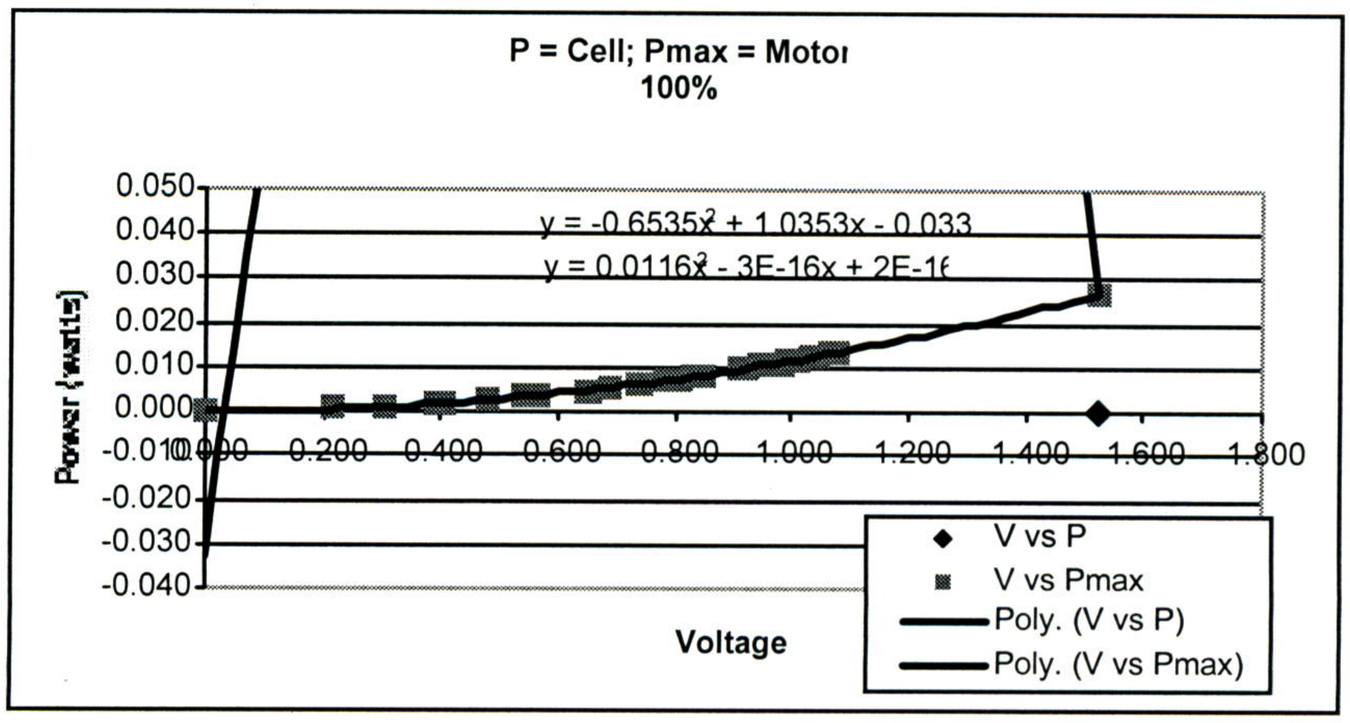
where V is the voltage supplied and R is the internal resistance of the motor.

Due to the fact that the power of the motor is a direct function of the voltage supplied, in order to maximize the power of the motor, it is beneficial to maximize the voltage of the solar cell system. This was easily achieved by connecting the three solar panels in series (where voltages sum) instead of in parallel (where currents add).

The next pertinent question regarded the actual choice of mass for the motor to lift. It was determined that the most efficient use of the motor's power, the height constraint, and the time constraint would be to fully utilize all the height in all the time. It would serve no purpose to lift a mass, m, five feet in less than five minutes; the additional time could have been used for slower rotation rate and a higher torque- i.e. a higher mass.

Thus, given a wheel apparatus on the motor which had a radius around the axle of 3.33 cm, or .0333 m, based on the circumference of the motor and the height of five feet (or 1.542 m), it would require the motor-wheel apparatus to operate at a rotation rate 1.458 revolutions per minute, or 0.1525 radians per minute.

The matching peak power point was found by the intersection of the Power vs. Voltage curves of the solar cell and motor, respectively, shown below. The intersection yields a peak power point of 0.025 W.



With 0.025 W of operational power for the motor, and with a target rotation rate of 0.1525 radians per minute (1.458 rpm), using power divided by rotation rate equals torque, we find that the optimal torque is 0.16390 N*m, or in other words- capable of bringing up a mass 502 grams.

Prior characterization of the solar cell, however, yielded a stall torque at 0.10025 N*m; hence the motor is only capable of lifting 310 grams. Thus, the motor is not capable of rotating at a rate sufficiently slow to allow for the full usage of the five minutes without compromising the amount of weight being lifted. It was therefore determined that the best way to maximize the work done by the motor is simply to use a mass as close to the stall mass, 310 g(i.e. increase the torque as close to the stall torque), as possible.

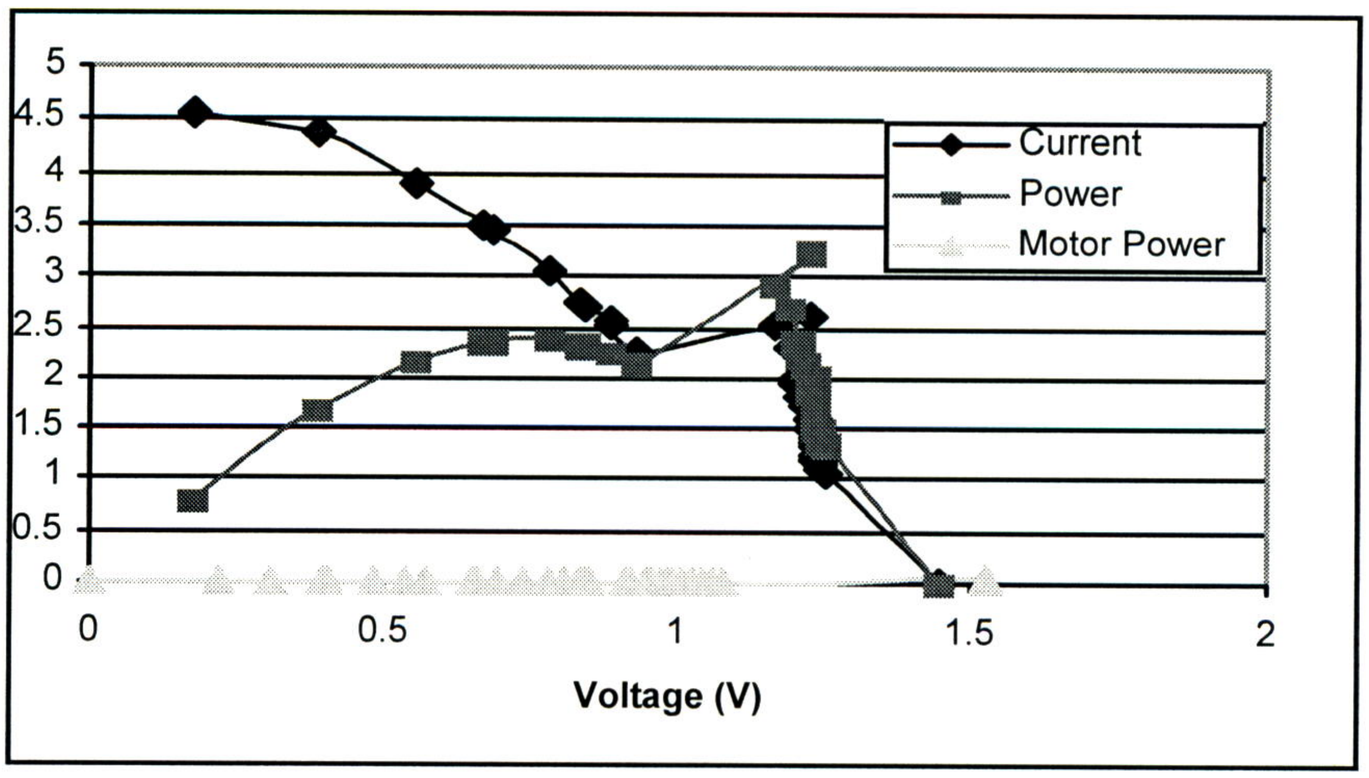


Figure 2. Solar cell current, power, and motor power plotted against voltage scale. The "kink" in the solar cell current and power graphs arose from a voltage drop (and associated decrease in current and power) due to heating of the solar panels.