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

Team 3

Wheel radius = 15 mm
Mass lifted = 523.2 g
Height achieved = 5 ft.
Time used = 3:31 (m:sec)

Weights are fishing supplies gathered in plastic bag:



Team member working together to attach their motor before the run (note competitor in background with grimace!):



Design is central wheel with recycled CD's as rims:



Oren Gall & Marisa Jenkins December 9, 2004

Solar Cell Design Project

First we needed to determine the optimal interconnection for the solar cells. From the IV characteristic plots of the known cells, we found an internal resistance (V/I – R) of roughly .05 ohms. A source resistance this small yields a negligible voltage drop from each cell. Therefore, a series connection effectively sums the V_{oc}'s from the three cells while only producing a negligible voltage drop. We also compared a parallel interconnection to a series connection of the cells and found that the motor ran at a much lower rpm when the cells were placed in parallel.

It was then necessary to find the K and R value for the motor. We used the data provided on the motor spec. sheet. It stated that T_{stall} was 43 in-oz (.3037 Nm). At that point, it also said that the current I = 0.67 A. Using the relationship T=KI, we found K=.453. Then, using the equation $T_{stall} = KV/R$, R=7.46 Ω. We tested the resistance of the actual motor and found it to be approximately 7.3 Ω, so this supports our calculation.

Taking the derivative of $\omega = \omega_0 - (R/K^2)T$, the max power becomes $P_{max} = (1/4)(V^2/R)$. Since we are using the three solar cells in series, the voltages will add. We assume, (which we also tested) that a reasonable value for voltage was 0.5 V. Therefore, the V for this equation became 1.5 V. When we actually tried this in the lab, we got something very similar to this. Therefore, P_{max} = 0.0754 W.

Under peak power conditions, the motor will drop as much voltage per current drawn as its internal resistance, effectively behaving as another resistor of equal value. Therefore, it's voltage is half that applied to the entire system. So P=IV/2. Solving for I, we get .1005 A. Using the equation T = KI, we get the torque to be 0.0456 N-m.

We chose the smallest practical radius available, which was .0127 m (the white disk). From this, we were able to find what optimum ω would allow a mass to travel 5 feet in 5 minutes. This turned out to be 0.4 rad/s. After doing some trial runs, we found that using fishing line was much more effective because the rope increases the radius too much as it spools up. This caused stall at much less weight than with the fishing line.

Using the equation $\omega = V/R - (R/K^2)T$, we found the torque to be .08 N-m. This is larger than the torque at the peak power point. Therefore, for the constraints of this project, it would be best to use this torque value. Using this higher torque will allow us to lift a higher mass. In order to find that mass, we used the equation T=mgr. Here, T= 0.08 N-m and r = 0.0127m. This gives the mass that we can lift to be 0.642 kg.

We ran a few tests in the lab trying different masses. The graph below relates the amount of time that was needed to lift a particular weight 5 feet. A curve fit is seen on the graph with its equation. Using this equation, in five minutes, it should lift 0.559 kg the equivalent 5 feet. We tested this and it was correct. It is obvious that this is a bit lower than our theoretical calculation of 0.642 kg. It is important to remember that in the actual system, there are different energy losses that are not accounted for in the theoretical calculation. After investigating the average efficiencies of motors and such systems, this appears to be reasonable. Some energy losses can be explained by heat loss, friction, vibrations in the system (we saw some vibrations in the string). Even if these

losses may individually be small, cumulatively, they are significant especially when summed up over five minutes.

