# ENGINEERING EXPERIENCE 4

## MEASUREMENTS AND CALCULATIONS REPORT

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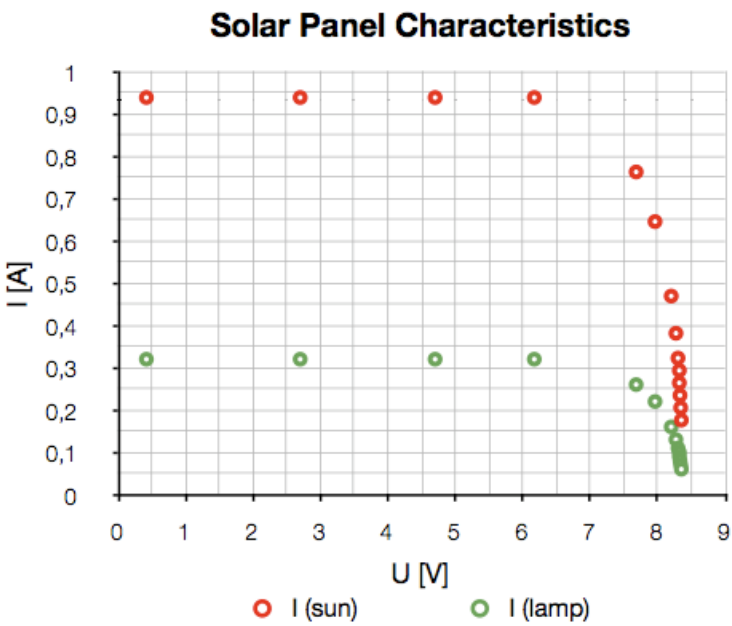
# Solar panel

The solar panel is the energy source of the solar car.Having a basic knowledge of the solar panel help us make a better solar car.We can not measure the behavior of the solar panel under racing condition,so we just calculate the m value of it to predict how it will perform.

We connected a voltmeter ,an ammeter and a variable resistance to the solar panel.We placed the solar against a fixed lamp and adjusted the resistance.

Measurements we kept

| | Measurements | | Transformed to the expected sun rays |
|---|---|---|---|
| | U [V] | I [A] | 0,88/I [A] |
| 1 | 0,42 | 0,32 | 0,9387 |
| 2 | 2,7 | 0,32 | 0,9387 |
| 3 | 4,7 | 0,32 | 0,9387 |
| 4 | 6,17 | 0,32 | 0,9387 |
| 5 | 7,68 | 0,26 | 0,7627 |
| 6 | 7,96 | 0,22 | 0,6453 |
| 7 | 8,20 | 0,16 | 0,4693 |
| 8 | 8,27 | 0,13 | 0,3813 |
| 9 | 8,30 | 0,11 | 0,3227 |
| 10 | 8,32 | 0,10 | 0,2933 |
| 11 | 8,32 | 0,09 | 0,2640 |
| 12 | 8,33 | 0,08 | 0,2347 |
| 13 | 8,34 | 0,07 | 0,2053 |
| 14 | 8,35 | 0,06 | 0,1760 |




We calculated the m value with given formula and known data.

$$m = \frac{1}{\frac{N * U_r * \ln\left(\frac{I_{sc} - I}{I_s} + 1\right)}{U}}$$

So,we got a list of the m value.

**Constants**

| What | Value | S.I. |
|---|---|---|
| Is | 0,0000001 | A/m^2 |
| Ur | 0,0257 | V |
| N | 15 | Cells in series |
| Isc = Iph | 0,94 | A |

The average m value we get is 1.256

**Calculation "m" value**

| | m | control |
|---|---|---|
| 1 | 0,115 | 0,9399994 |
| 2 | 0,737 | 0,9399994 |
| 3 | 1,284 | 0,9399994 |
| 4 | 1,685 | 0,9399994 |
| 5 | 1,385 | 0,9399996 |
| 6 | 1,386 | 0,9399997 |
| 7 | 1,384 | 0,9399998 |
| 8 | 1,381 | 0,9399999 |
| 9 | 1,377 | 0,9399999 |
| 10 | 1,376 | 0,9399999 |
| 11 | 1,372 | 0,9399999 |
| 12 | 1,370 | 0,9399999 |
| 13 | 1,368 | 0,9399999 |
| 14 | 1,367 | 0,9400000 |
| **Average** | **1,256** | **0,9399997** |

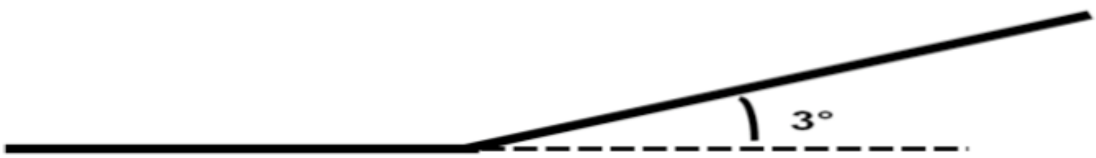
# Gear Ratio

The solar cell supplies current and voltage

$$I = Isc - Is\left(e^{\frac{U}{m.N.Ur}} - 1\right)$$

So if we want the max power:
P=U*I
When U=7.55V
I=0.93A
Pmax=7w
(calculated by maple 14)

Therefore:




$$U \cdot I \cdot \eta = F_{wheel} \cdot V_{A/B}$$

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$T_{wheel} = 8.55 \cdot 70\% \cdot I \cdot 10^{-3} \cdot n$ (n is the gear ratio)

$T_{wheel} = F_{wheel} \cdot R_{wheel}$

$S = ½ a \cdot t^2 = ½ V_{A/B} \cdot t_{A/B}$ (S = 6 m, at point A/B)

$F \cdot t = m \cdot \Delta V \rightarrow (F_{wheel} - F_{rolling}) \cdot t_{A/B} = m \cdot V_{A/B}$

Estimate the weight of the car (m) and the radius of the wheel ($R_{wheel}$).

Taking m = 0.75kg, $R_{wheel}$ = 0.04m, $F_{rolling}$ can be calculated by

Fr = $C_{rr}$ x N

N is the normal force

$C_{rr}$ = 0.015

U = 7.56V; I = 0.93A; η = 70%; S = 6m

So we calculate it by maple14:

$eq1 := 7 \cdot 0.7 = Fwheel \cdot Vab$

$$4.9 = Fwheel\ Vab$$

$eq2 := Twheel = 5.985 \cdot 0.001 \cdot n \cdot 0.9272$

$$Twheel = 0.0055492920\ n$$

$eq5 := Twheel = Fwheel \cdot 0.04$

$$Twheel = 0.04\ Fwheel$$

$eq3 := 6 = \frac{1}{2} \cdot Vab \cdot t$

$$6 = \frac{1}{2}\ Vab\ t$$

$eq4 := (Fwheel - 0.1104) \cdot t = 0.75 \cdot Vab$

$$(Fwheel - 0.1104)\ t = 0.75\ Vab$$

$simplify(solve(\{eq1, eq2, eq3, eq4, eq5\}, [Vab, n, t, Fwheel, Twheel]))$

$$[[Vab = 4.142427119, n = 8.526359055, t = 2.896852414, Fwheel = 1.182881402, Twheel = 0.04731525609], [Vab = -2.071213560 - 3.825725660\,I, n = -3.865290932 + 7.139554796\,I, t = -1.313242534 + 2.425682101\,I, Fwheel = -0.5362407012 + 0.9904868579\,I, Twheel = -0.02144962805 + 0.03961947432\,I], [Vab = -2.071213560 + 3.825725660\,I, n = -3.865290932 - 7.139554796\,I, t = -1.313242534 - 2.425682101\,I, Fwheel = -0.5362407012 - 0.9904868579\,I, Twheel = -0.02144962805 - 0.03961947432\,I]]$$

Now we get :

Vmax=4.142m/s

N=8.53

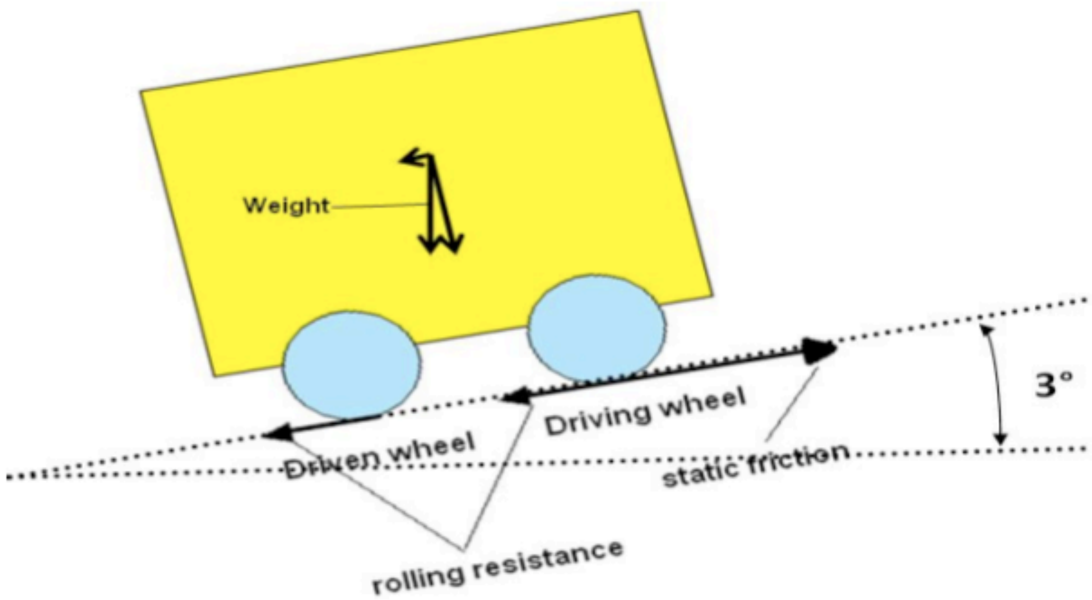
Fwheel=1.183N

Twheel=0.0473.m

When the car gets max velocity,it will take t.

t=2.897s

When our car arrives at the slope:




On the slope

Total resistant force:

Rolling resistance;part of the weight;

Air resistance(neglected)

**$F_r = F_{rolling} + mg \cdot \sin(3°) \approx 0.4953N$**

**Thus, On the slope $F_{wheel} > F_r$**

**$F_{wheel} = F_r = 0.4953N \rightarrow T_{wheel}$, gear ratio i is known**

**$\rightarrow$ I (current) $\rightarrow$ solar panel U-I graph $\rightarrow$ U**

**$\rightarrow U \cdot I \cdot \eta = F_{wheel} \cdot V \rightarrow V_{slope} = 4.77$ m/s**

**$V_{final} \approx 3.66$ m/s**

In this case, $V_{A/B}$ and $V_{final}$ are almost equal

So $t_{slope} < 8m/ V_{A/B} \approx 1.813s$

**$t_{total} \approx t_{A/B} + t_{slope} = 2.897 + 1.813 = 4.71s$**