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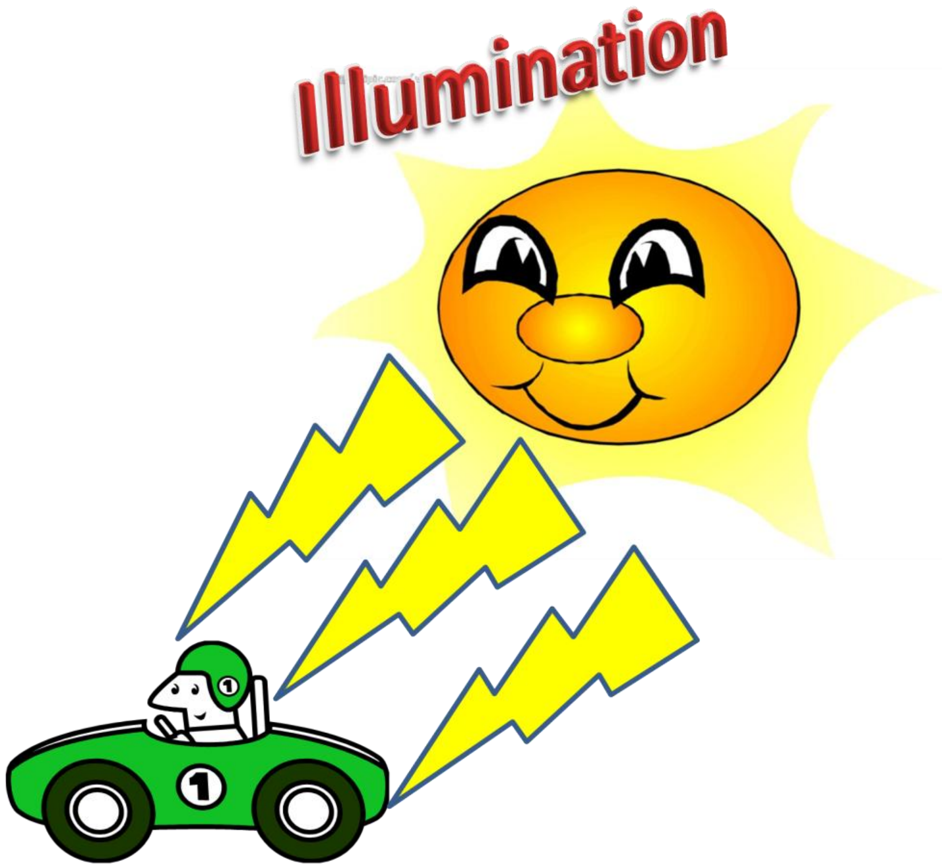
EE4 Project

SSV-2



Question 1

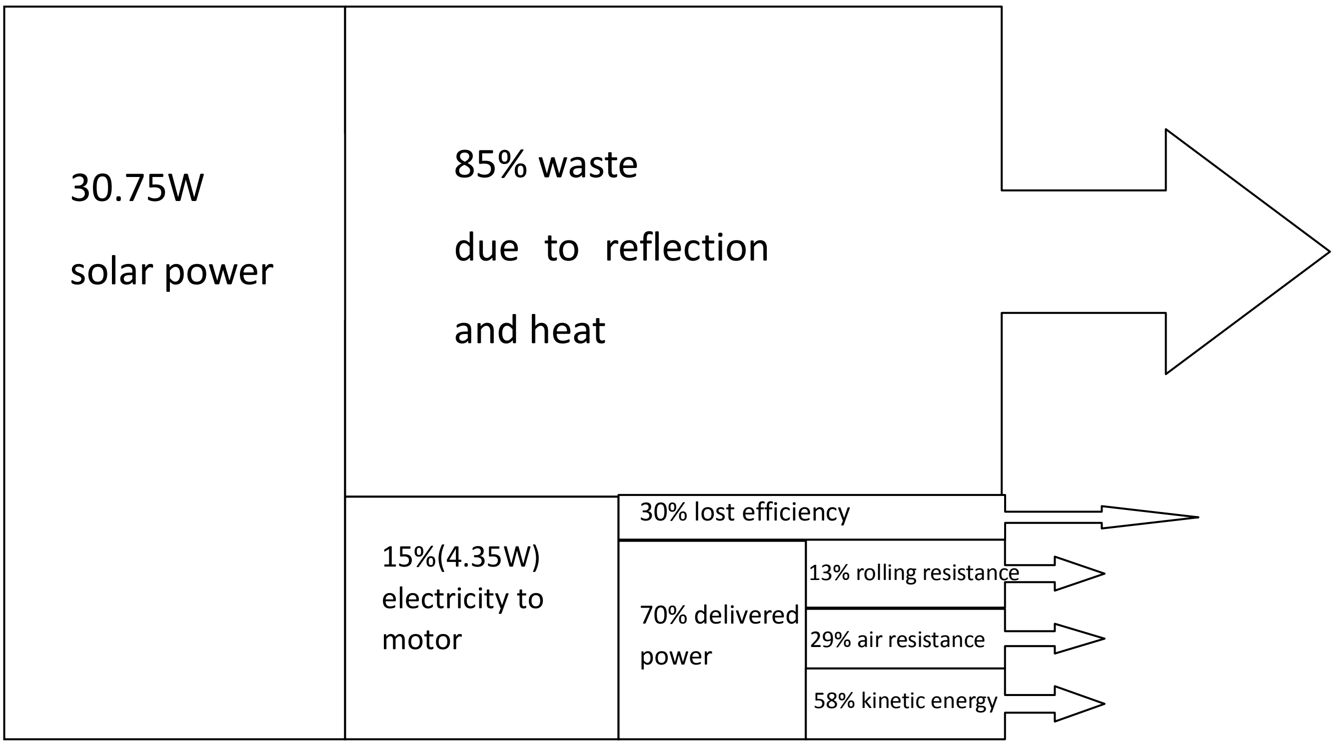
The result of the simulation we did before is 5.2m (including the part of the slope). But when we let the solar car roll down from the 1m slope, it reached 2.9m. So they are not same.
One of the factors is that we assumed the mass is 1kg. But our solar car is 756g. It has effects on the potential energy and the friction between wheels and the ground.
Also we assumed Crr(frictional factor) is 0.01. it is not the same with real value.

m*g*h=Crr*m*g*cos3*d(slope)+Crr*m*g*d(flat)
h=1*sin3
So
0.756*9.81*1*sin3=Crr*0.756*9.81*cos3*1+Crr*0.756*9.81*(2.9-1)
So Crr=0.018
It is larger than 0.01 which we assumed.

Another factor is that we used tapes and added wooden part made in fablab to fix the shaft. There are more friction on them. And also there are frictions with gears.

New sankey diagram

The top speed of our car is 4.115m/s. So the loss on rolling resistance is 0.549W. Also we changed the calculation about the air resistance. Now the air resistance is Fr=0.5*0.47*0.2128*0.281*1.29*4.115^2=0.307N. So the loss on air resistance is 1.26W.



Question 2

1. For the gear

The torque made by motor $T = 8.55 * 84\% * I * 10^{-3} * i\ Nm$

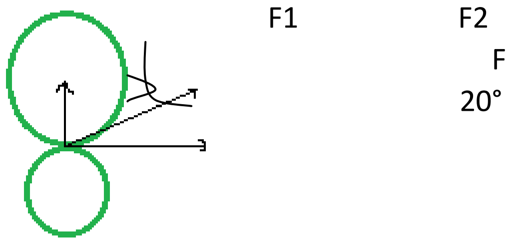
With I = 0.91 A

Torque constant= 8.55 mNm/A

Max efficiency= 84%

Gear ratio i=10

⇒ T=0.0653562 Nm



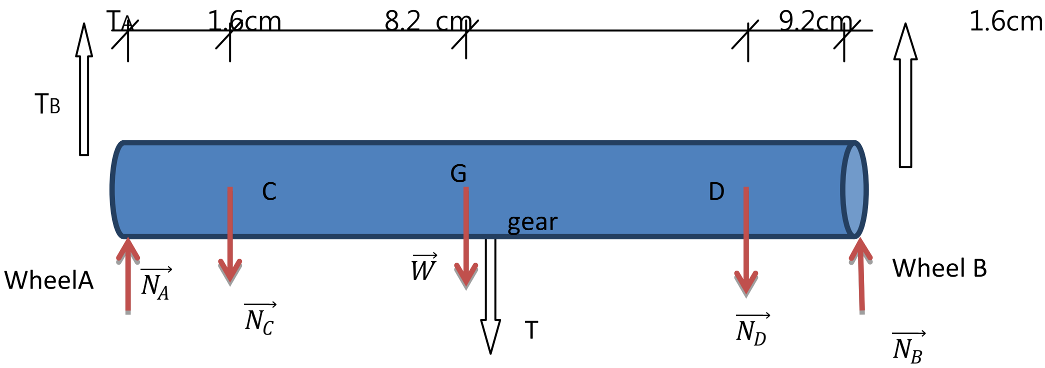
According to the radius of gear, 0.0105m, we can get the force translated from motor.

F=T/r=0.0653562 Nm/0.0105m=6.2244 N

F1=F*tan20°=2.265 N

F2=F/cos20°=2.410 N

2. The mechanical load on the shaft



We assume $\overrightarrow{N_A}$=$\overrightarrow{N_B}$. So N_A =N_B =3/5 W=4.4498 N (ANALYSISED FROM OUR CAR)

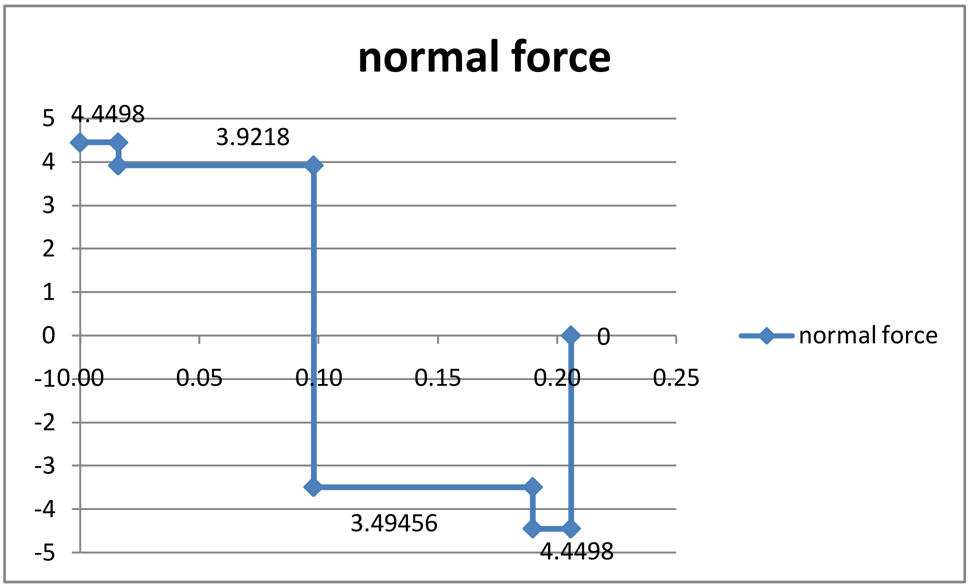
W =mcar*g=0.756*9.81=7.41636 N

∑Fy=0 → $N_A + N_B - N_C - N_D - W = 0$

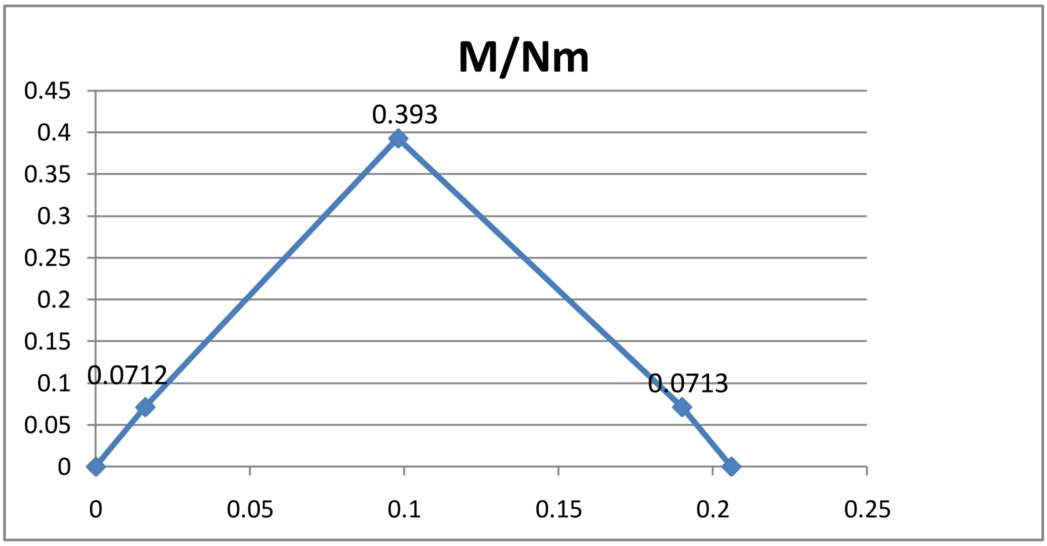
∑MC=0→ $-0.016 \cdot N_A - 0.082 \cdot W - 0.174 \cdot N_D + 0.190 \cdot N_B = 0$

→$N_D = 0.955N$ $N_C = 0.528N$

The force distribution on the shaft:



The bending moment:



The maximum bending moment:

$\sigma_{MAX} = \frac{M_{max} \cdot R}{I}$, where $I = \frac{1}{4} \cdot \pi \cdot R^4$

M_{max} = 0.393 N/m

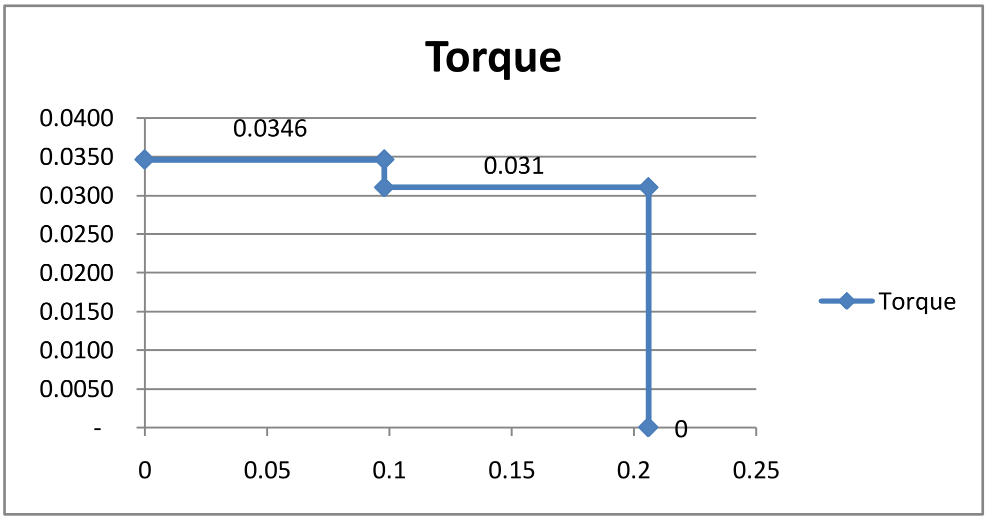
$\rightarrow \sigma_{MAX} = \frac{4 \cdot M_{max}}{\pi \cdot R^3} = \frac{4 \cdot (0.393)}{\pi \cdot 0.0015^3} = 0.22\ MPa$

The torque:

T= TA+ TB
We know $\phi_{G/A} + \phi_{G/B} = 0$

$\rightarrow \; -T_A \cdot \frac{0.098}{G \cdot I_p} + T_B \cdot \frac{0.108}{G \cdot I_p} = 0$

$\rightarrow T_A = 0.0346\text{Nm}, \; T_B = 0.031Nm$



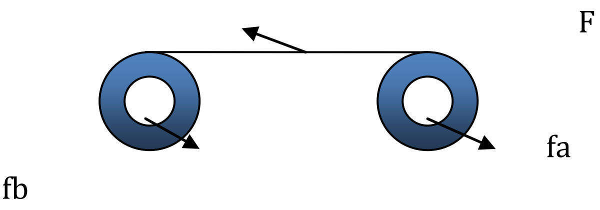
<u>The maximum torsion stress</u>

$$\tau_{max} = \frac{(T_{max} \cdot R)}{I_P}$$

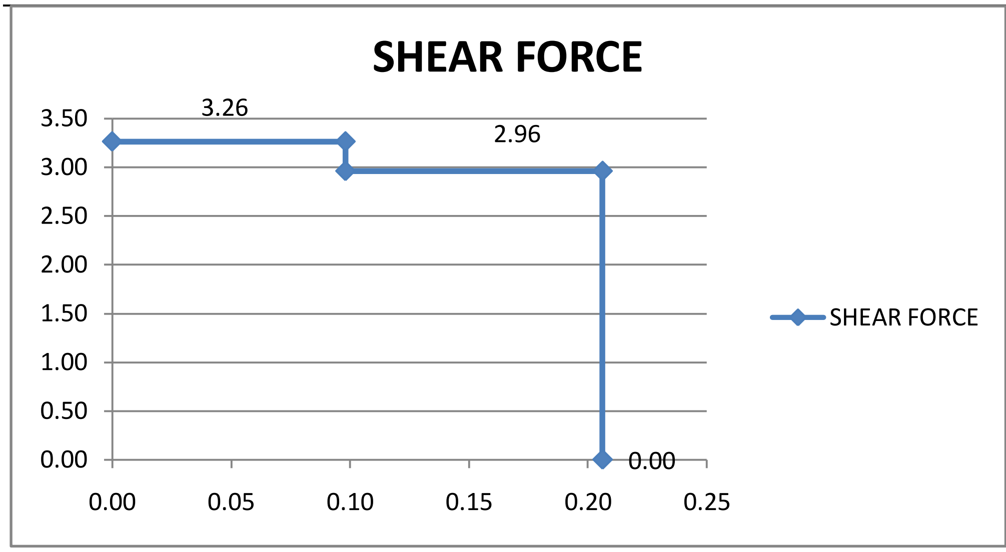
Where $I_P = \frac{1}{2} \cdot \pi \cdot R^4$, R=0.15cm, T=0.0346N

$\rightarrow \tau_{max} = 6.527\text{MPa}$

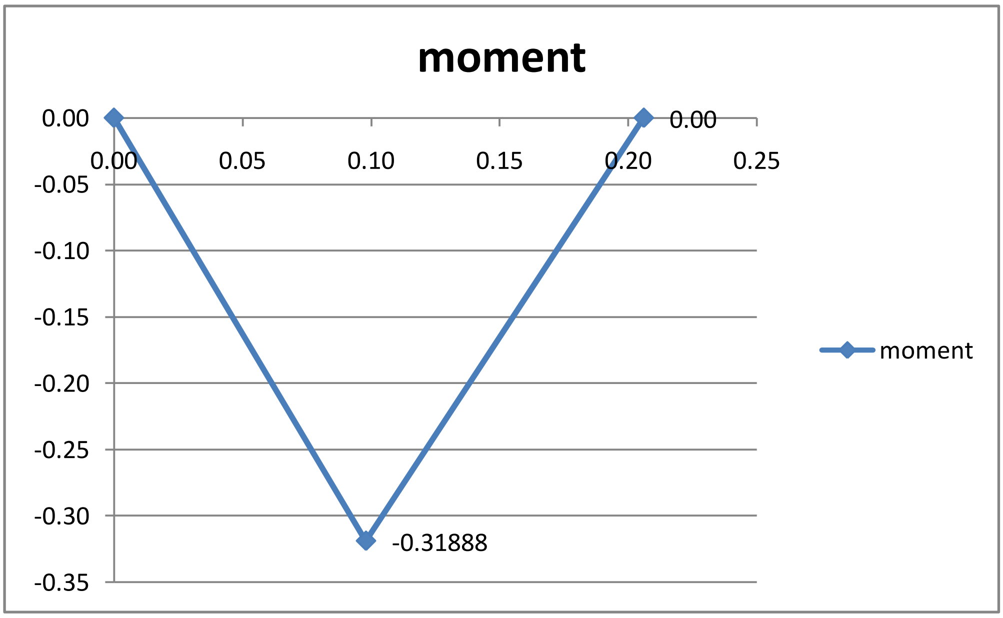
Shear force:



∑Fx=0 → fa+fb-F=0
∑Ma=0 → -0.098*F+fb*0.206=0
→fb=2.96 N, fa=3.263N



The moment



The max shear stress:

$\tau_{MAX} = \frac{V_{max} \cdot Q}{I \cdot t}$.

Where $Q = \frac{2}{3} R^3$, $I = \frac{1}{4} \cdot \pi \cdot R^4$,t=2R

$\rightarrow \tau_{MAX} = \frac{V_{max} \cdot \frac{2}{3} \cdot R^3}{\frac{1}{4} \cdot \pi R^4 \cdot 2R} = \frac{4 \cdot V_{max}}{3 \cdot \pi \cdot R^2} = \frac{4 \cdot 3.26}{3 \cdot \pi \cdot 0.0015^2} = 0.614\ MPa$

Question 3

Calculations Sankeydiagram

Solarpanel

Total surface RWE solarcells

= number of cells*surface cell = 280*0.003018 m^2 = 0.84504m^2

Total surface Emcore solarcells

= 2578*0.002756 = 7.104986m^2

The maximum of power delivered by the solarcells is calculated by:

$\mu = P_{MPP}/(Ac*E)$

μ = effiency

P_{MPP} = maximum power(W)

Ac = surface solarcells (m^2)

E = irradtiation (W/m^2)

Transformed to get P

$P_{MPP,RWE}$ = 0.30*0.84504*1000 = 253.51W

$P_{MPP,Emcore}$ = 0.245*7.104968*1000 = 1740.72W

P_{Totaal} = 253.51 + 1740.72 = **1994.23W**

Motor – Controller – transmission

Average motor efficiency = 0.95

Average controller efficiency = 0.99

$P_{motor,useful}$ = **1994.23***0.95*0.99 = 1875.57

$P_{motor, used}$ = 1994.23 – 1875.57 = 118.66W

Rolling resistance

$F_{roll} = m*g*C_{rr}$

F_{roll} = rolling resistance

m = mass of Umicar

g = coefficient of gravity

C_{rr}= coefficient of rolling resistance (experimental)

F_{roll} = (225 + 80)*9.81*0.0056 = 16.76N

$P_{roll,used,topspeed} = 16.76*v_{topspeed}$

$P_{roll,used,half\ topspeed} = 16.76*V_{half\ topspeed}$

Air resistance

$F_{lucht} = A*C_w*\rho*v^2/2$

F_{lucht} = air resistance

A = surface perpendicular to driving direction

C_w = coefficient of air resistance(We can calculate C_w from the date of the windtunnel (schaled model).

We try to get an kwadratic association between the formula above)

$a = A*C_w*\rho/2$
$F = a*v^2$

We know A, ρ and a, so we calculate C_w. The windtunnel data are obtained of a schalemodel of the Umicar(1:3). So we divide the surface by 9.

$C_w = 0.136$

$P_{air,used;topspeed} = F_{air,top}*v_{top}=(0.81*0.136*1.2/2)*v^3_{top}$

$P_{air,used,half\ topspeed} = 0.066v^3_{half\ topspeed}$

Calculating v

$P_{motor,\ useful} = P_{roll,used,topspeed} + P_{air,used,topspeed}$

$1875.57 = 16.76*v_{topspeed}+0.066v^3_{topspeed}$

Solving for v:

$V_{topspeed} = 27.73$ m/s *(3600s/h)*1km/1000m = 99.84 km/h

$V_{half\ topspeed} = 13.87$ m/s *(3600s/h)*1km/1000m = 49.92 km/h

Solving roll resistance and air resistance with V

$P_{roll,used,topspeed} = 464.7$ W

$P_{roll,used,half\ topspeed} = 232.35$ W

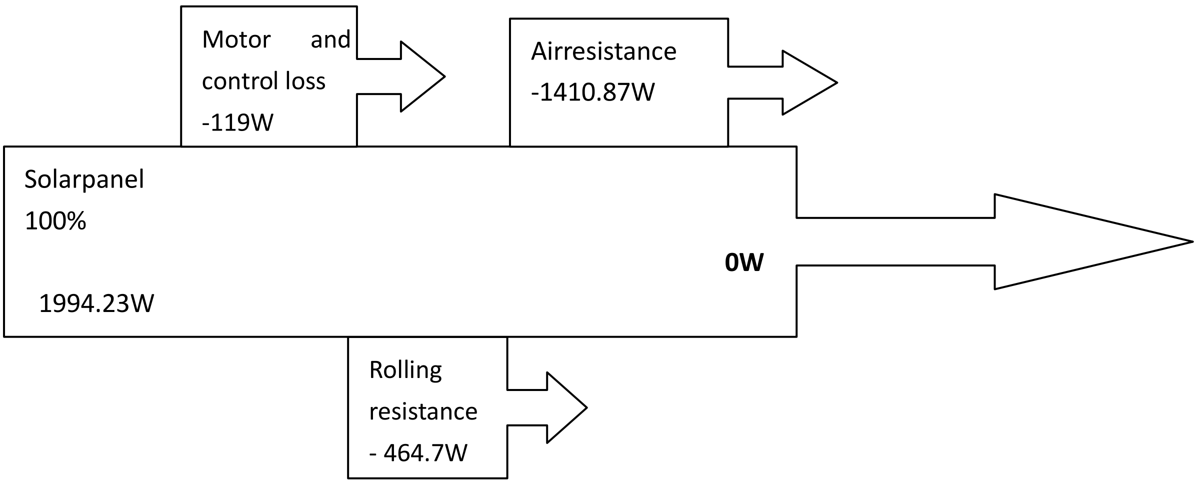
$P_{air,used;topspeed} = 1410.87$ W

$P_{air,used,half\ topspeed} = 176.36$ W

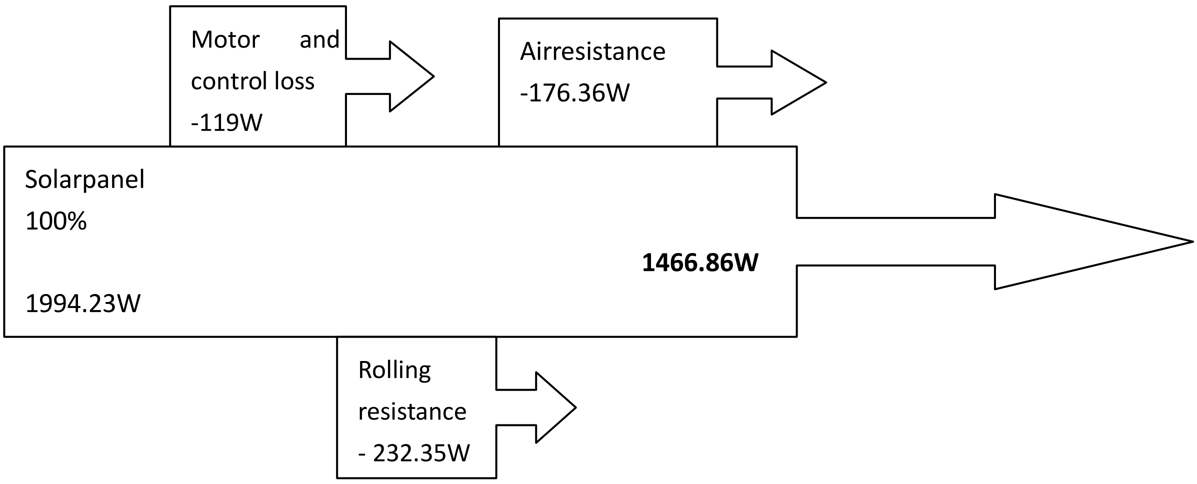
$P_{useful,\ half\ topspeed} = 1466.86$ W

Sankeydiagrams

Topspeed



Half topspeed



Question 3