Calculation

1.Flat path

> $restart$:

> $Crr = 0.01,\ U \cdot I \cdot \eta = Fwheel \cdot Vab,\ \eta = 0.7$

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Assumtion η =70%

> $I = 0.91,\ U = 7$

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We can find on panel diagram

> $Twheel = 8.55 \cdot 0.7 \cdot 0.91 \cdot 10^{-3} \cdot i$

$$Twheel = 0.005446350000\ \ i$$

> $Fwheel = \frac{Twheel}{Rwheel}$

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We just think our Rwheel = 0.04

> $Fwheel = \frac{0.005446350000\ \ i}{0.04}$

$$Fwheel = 0.1361587500\ \ i$$

> $2 \cdot s = Vab \cdot tab$

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> $m = 1,\ Frolling = Crr \cdot N,\ N = 1 \cdot 9.81$

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> $Frolling = 0.01 \cdot 9.81$

$$Frolling = 0.0981$$

> $eq1 := \frac{(Fwheel - Frolling) \cdot 12}{Vab} = m \cdot Vab$

$$eq1 := \frac{12\ \ (Fwheel - Frolling)}{Vab} = m\ \ Vab$$

> $eq2 := 7 \cdot 0.91 \cdot 0.7 = Fwheel \cdot Vab$

$$eq2 := 4.459 = Fwheel\ \ Vab$$

> $Fwheel := 0.1361587500\ \ i;\ Frolling := 0.0981;\ m := 1$

$$Fwheel := 0.1361587500\ \ i$$

$$Frolling := 0.0981$$

$$m := 1$$

> $eq1 := \frac{(Fwheel - Frolling) \cdot 12}{Vab} = m \cdot Vab$

$$eq1 := \frac{12\ (0.1361587500\ \ i - 0.0981)}{Vab} = Vab$$

> $eq2 := 7 \cdot 0.91 \cdot 0.7 = Fwheel \cdot Vab$

$$eq2 := 4.459 = 0.1361587500\ \ i\ \ Vab$$

> $sol := solve([eq1,\ eq2],\ [i,\ Vab])$

$$sol := [[i = 8.937571391\ ,\ Vab = 3.664142817\ ],\ [i = -4.108544433 - 7.520683546\ \ \mathrm{I},\ Vab = -1.832071408 + 3.353603575\ \ \mathrm{I}],\ [i = -4.108544433 + 7.520683546\ \ \mathrm{I},\ Vab = -1.832071408 - 3.353603575\ \ \mathrm{I}]]$$

So our i=8.94, Vab=3.66m/s

> $tflat = \frac{12}{3.664142817}$

$$tflat = 3.274981517$$

> $i := 8.937571391$

$$i := 8.937571391$$

> $Fwheel$

$$1.216928549$$

>

On slope

> $Fr = 0.61$

$$Fr = 0.61$$

Fr=Frolling + mgsin(3)=0.61N,Fr= Fwheel

> $Fwheel := 0.61$

$$Fwheel := 0.61$$

> $Twheel := Fwheel \cdot 0.04$

$$Twheel := 0.0244$$

> $I = \frac{Twheel}{8.55 \cdot 0.7 \cdot 10^{-3} \cdot 8.937571391}$

$$\mathrm{I} = 0.4561483915$$

U=7.863V

> $V = \frac{7 \cdot 0.4561483915\ \cdot 0.7}{Fwheel}$

$$V = 3.664142816$$

V=4.115m/s

> $tslope = \frac{8}{3.664142817}$

$$tslope = 2.183321011$$

Tslop=1.944se

> $ttot = 2.18 + 3.27$

$$ttot = 5.45$$

Ttot=5.214se

Vfinal=3.66m/s(4.115m/s), ttotal=5.45s/5.214se
This is just the normal Assumption, we need caculate the bigger or smaller gear ratio

2.Assume that, i = 12

when I=0.91(reach the max current)

On the flat path(at point A)

> $Twheel := 8.55 \cdot 0.7 \cdot 0.91 \cdot 12 \cdot 10^{-3}$

$$Twheel := 0.06535620000$$

> $Rwheel := 0.04$

$$Rwheel := 0.04$$

> $Fwheel := \frac{Twheel}{Rwheel}$

$$Fwheel := 1.633905000$$

> $Frolling := 0.01 \cdot 9.81; m := 1$

$$Frolling := 0.0981$$

$$m := 1$$

> $a := \frac{(Fwheel - Frolling)}{m}$

$$a := 1.535805000$$

> $I = 0.91, \ U = 7, \ \eta = 0.7$

$$I = 0.91, \ U = 7, \ \eta = 0.7$$

> $U \cdot I \cdot \eta = Fwheel \cdot VA$

$$I \ U \ \eta = 1.633905000 \ VA$$

> $VA := \frac{0.91 \cdot 7 \cdot 0.7}{Fwheel}$

$$VA := 2.729044834$$

> $tA := \frac{VA}{a}$

$$tA := 1.776947486$$

> $SA := \frac{1}{2} \cdot a \cdot tA^2$

$$SA := 2.424684678$$

on the rest of flat path(A→B)

> $Fwheel := 0.0981$

$$Fwheel := 0.0981$$

> $eq1 := Fwheel \cdot Rwheel = 8.55 \cdot 0.7 \cdot I \cdot 10^{-3} \cdot 12$

$$eq1 := 0.003924 = 0.07182000000\ I$$

> $Iab := \frac{0.003924}{0.07182}$

$$Iab := 0.05463659148$$

> $U - I\ diagram;\ U1 := 8.25$

$$U - I\ diagram$$

$$U1 := 8.25$$

> $Vab := \frac{U1 \cdot Iab \cdot 0.7}{Fwheel}$

$$Vab := 3.216374269$$

>

on the slope

$Fr := 0.0981 + 1 \cdot 9.8 \cdot \sin(3)$

> $Fr := 0.6109923712$

$$Fr := 0.6109923712$$

> $Fwheel := Fr$

$$Fwheel := 0.6109923712$$

> $Islope := \frac{Fwheel \cdot 0.04}{8.55 \cdot 0.7 \cdot 10^{-3} \cdot 12}$

$$Islope := 0.3402909336$$

> $U - I\ diagram;\ U := 7.98$

$$U - I\ diagram$$

$$U := 7.98$$

> $Vslope := \frac{U \cdot Islope \cdot 0.7}{Fwheel}$

$$Vslope := 3.111111112$$

> $ttot := tA + \frac{(6 - SA)}{Vab} + \frac{8}{Vslope}$

$$ttot := 5.459974092$$

>

3.Assume that, i = 7

Flat path:-

Twheel = 8.55 * 0.7 *0.91 * 10^{-3} *7 = 0.0381

Fwheel = Twheel / Rwheel = 0.953

a = (Fwheel – Frolling)/m = 0.855

U * I * n = Fwheel * Va

Va =(7 * 0.91 * 0.7) / 0.953 = 4.679m/s

ta = Va / a = 5.4724s

Sa = 0.5 * a * ta^2 = 12.8m

But the total length of the flat path is 6m, so we have to calculate the time for the flat path only.

6m = 0.5 * a * tflat

tflat = 3.746s

For the slope part:-

Assume that, it has constant acceleration

Means it reaches at equilibrium

Fr = Frolling + mg sin(3) = 0.61N

Assume that

Fwheel = Fr = 0.61N

Twheel = Fwheel * Rwheel = 0.0244

I = Twheel/(8.55 * 0.7 * 7 * 10^{-3}) = 0.58

From the U-I graph we get:-

U = 7.78V

Vslope = (7.78 * 0.58 * 0.7) / 0.61 = 5.177 m/s

tslope = 8 / Vslope = 1.545s

Ttotal = tflat + tslope = 3.746 + 1.545 = 5.29s

4.Another calculation

Air resistance (no wind):

1. $F_w = \frac{1}{2} \cdot C_w \cdot A \cdot \rho \cdot v^2$

Cw=0.47, A=π*r^2,ρ=1.29kg/m^3,

$$F_{wpath} = \frac{1}{2} \times 0.47 \times \pi \times 0.04^2 \times 1.29 \times 3.66^2 = 0.0204\text{N}$$

$$F_{wslope} = \frac{1}{2} \times 0.47 \times \pi \times 0.04^2 \times 1.29 \times 4.115^2 = 0.0258\text{N}$$

It is too small, I think we can ignore it but we should simulate it first.

2. Another one

Check the table

We know Terminal resistance = 3.20Ω; Torque constant = 8.55;

Our U = 7V, I =0.91A

T = 8.55*0.7*0.91*10^-3=5.446$\times 10^{-3}$

n = 1120 * E

E = U-I*R=7-0.91*3.2=4.088J

n = 4578.56

3.Static Friction

$$F_{rs} = \eta * N$$

We can find on Toledo the static friction coefficient = 0.9 =η

N = 1/3 * 9.81 = 3.27 N

$$F_{rs} = 0.9 * 3.27 = 2.943\text{N}$$