C_τ = Clutch output torque $\left(^{Nm}/_{rpm}\right)$

$C_{\tau Min} = 0\ ^{Nm}/_{rpm}$

W_{eng} = Engine Speed (rpm)

$C_{\tau R}$ = Clutch output torque rate $\left(^{Nm}/_{rpm}\right)$

$C_{\tau int} = -20.7$

$m_{kart} = 120\,Kg$ = mass of kart

Sp_{front} = # teeth front sprocket = 12

Sp_{rear} = # teeth rear sprocket = 85

$Sp_{ratio} = \frac{Sp_{rear}}{Sp_{front}}$

W_{dia} = diameter of rear wheel = 22 in = 0.5588 m

W_{cir} = circumference of rear wheel = $W_{dia} \cdot \pi$

C_ω = clutch output speed (rpm)

$C_{\omega int}$ = initial clutch output speed = 0 (rpm)

$C_{slip} = \left(\frac{W_{eng} - C_\omega}{W_{eng}}\right)\%$

Eng_τ = Engine Torque (Nm)

$C_\tau \neq Eng_\tau$

V_{sp} = Vehicle speed (m/s)

W_{sp} = Wheel speed (rpm)

F_D = Force air drag = $\frac{1}{2} \rho V_{sp} C_D A$

ρ = air density = $1.225\ ^{kg}/_{m^3}$

C_D = coefficient of drag = 0.3 (ratio)

A = cart frontal Area = $0.560\ m^2$

$rpm_{Con} = \frac{rev}{min} \cdot \frac{2\pi\ rad}{rev} \cdot \frac{1\ min}{60\ sec} = 0.104\ \frac{(rad/s)}{rpm}$

Th = throttle position (%)

F_{rr} = Force rolling resistance = 10_N

T_{step} = Time step

initial condition

$V_{sp} = 0$

$Th = 100\%$

$m_{kart} = 120\ kg$

$T_{step} = 0.5\ sec$

$C_{wint} = 0\ rpm$

$A = 0.56\ m^2$

$C_D = 0.3$ (ratio)

$C_{tint} = -20.7\ Nm$

$C_{tmin} = 0\ Nm$

$F_{rr} = 10N$

$Sp_{front} = 12$ teeth

$Sp_{rear} = 85$ teeth

$W_{Dia} = 0.5588\ m$

$\rho = 1.225\ kg/m^3$

$rpm_{ratio} = 0.104172\ rpm/rad/s$

Boundry condition

10 m/s

(22 mph)

$Sp_{ratio} = \frac{Sp_{rear}}{Sp_{front}} = 7.0833$

determine sprocket ratio

$W_{eng} = 2000 rpm$

$C_t = C_{tr} W_{eng} + C_{tint}$

find intersection of clutch torque and engine torque curves to determine engine speed

determine engine speed

t = 0.5

$C_t = 6.9 Nm$

$C_t = Eng_T$ @ 100% throttle 2000 rpm

determine clutch output torque

$C_{slip} = \frac{W_{eng} - C_w}{W_{eng}} = 100\%$

determine clutch slip

$F_D = \frac{1}{2} \rho V_{sp}^2 C_D A = 0$

determine wind resistance

$F_{rtotal} = F_D + F_{rr} = 10N$

determine total vehicle rolling resistance

$K_{accel} = \left(\frac{C_t \cdot Sp_{ratio} \cdot 2}{W_{Dia}} - F_{rr} - F_D \right) \div M_{kart} = 1.374\ m/s^2$

determine Kart accel due to clutch

$V_{sp} = K_{accel} \cdot T_{step} = 0.687\ m/s$

Vehicle Speed final

$F_{con} = BSFC \cdot T_{step} \cdot {}^{EngPW} = 0.1437 \frac{g}{kw \cdot s} \cdot 0.5\,sec \cdot 1.45\,kw = 0.1042g$ Fuel consumed during time step

$W_{sp} = \frac{V_{sp} \cdot \frac{60sec}{min}}{W_{cir}} = 23.4\,rpm$ Final clutch output speed

$C_w = W_{sp} \cdot S_{pratio} = 23.4(7.0833) = 165.89\,rpm$ 1.0

$C_{slip} = \frac{W_{eng} - C_w}{W_{eng}} = \frac{2000 - 165.89}{2000} = 91.7\%$

$C_T = 6.9\,Nm$

$F_D = \frac{1}{2}\rho (0.687\,m/s)^2 0.3(0.56) = 0.0486\,N$

$F_{rr} = 10\,N$

$F_{r\,total} = 10.0486\,N$

$K_{accel} = \left(\frac{C_t \cdot Sp\,ratio \cdot 2}{W\,Dia} - F_{r\,total} \right) \div M_{kart} = 1.374\,m/s^2$

$V_{sp} = V_{sp_1} + (K_{accel} \cdot T_{step}) = 0.687 + (1.374 \cdot 0.5) = 1.374\,m/s$

$F_{con} = F_{con_1} + F_{con} = 0.10429 + 0.1042g = 0.2084g$

$W_{sp} = \frac{V_{sp} \cdot 60}{W_{cir}} = \frac{1.374 \cdot 60}{1.76} = 47.379\,rpm$

$C_w = W_{sp} \cdot S_{pratio} = 335.6\,rpm$

1.5

$$C_{slip} = \frac{W_{eng} - C_w}{W_{eng}} = \frac{2000 - 335.6}{2000} = 83.2\%$$

$C_t = 6.9 Nm$

$F_D = \frac{1}{2} \rho (1.374)^2 0.3(0.56) = 0.19\ N$

$F_{rr} = 10N$

$F_{r\,total} = 10.19\ N$

$$K_{accel} = \left(\frac{C_t \cdot S_{pratio} \cdot 2}{W_{dia}} - F_{r\,total} \right) \div M_{kart} = \left(\frac{6.9(7.0833)2}{0.5588} - 10.19 \right) \div 120$$

$K_{accel} = 1.373\ m/s^2$

$= (175.178 - 10.19) \div 120$

$V_{sp} = V_{sp_2} + (K_{accel} \cdot T_{step}) = 1.374 + (1.373 \cdot 0.5) = 2.060\ m/s$

$F_{con} = F_{con_2} + F_{con} = 0.2084_g + 0.1042_g = 0.3126g$

$$W_{sp} = \frac{V_{sp}\,60}{W_{cir}} = \frac{2.060(60)}{1.76} = 70.227\ rpm$$

$C_w = W_{sp} \cdot S_{pratio} = 497.44 rpm$

$C_{slip} = 75\%$ $C_T = 6.9Nm$ $F_D = 0.437$ $F_{r\,total} = 10.437$

$K_{accel} = 1.371$ $V_{sp} = 2.745$ $F_{con} = 0.4168$ $W_{sp} = 94.655$ $C_w = 670_{rpm}$ $t = 1.0$

$C_{slip} = 66.4\%$ $F_D = 0.775$ $F_{r_t} = 10.775$ $K_{accel} = 1.378$ $V_{sp} = 3.429$

$F_{con} = 0.521$ $W_{sp} = 116.898$ $C_w = 828.021$ $t = 2.0$

$C_{slip} = 58.6\%$ $F_D = 1.210$ $F_{r_t} = 11.210$ $K_{accel} = 1.366$ $V_{sp} = 4.112$

$F_{con} = 0.625$ $W_{sp} = 140.189$ $C_w = 992.999$ $t = 3.0$

$C_{slip} = -6.5\%$ New operating mode

$C_{slip} = 0$

$\epsilon = 7.0$

$C_\tau = Eng_\tau$ $\omega_{eng} = 2131.4$

Eng_τ = lookup speed torque chart
linear interpolate

table

EngSp	Eng_τ
2100	7.0
2200	7.08

~~$\frac{7.08-7.0}{2200} \cdot 2131.4 + 7.0$~~

$$Eng_\tau = 7.025 = \left(\frac{2131.4-2100}{2200-2100}\right) \cdot (7.08-7.0) + 7.0$$

Fuel cons

lookup BSFC chart
linear interpolate

EngSp	Eng P	BSFC
2100	1.54	.1197
2200	1.63	.1197

$$Eng\,P = \frac{Eng_\tau \cdot \omega_{eng}}{9548.8} = \frac{7.025 \cdot 2131.4}{9548.8} = 1.57$$

EngSp ↑

~~$BSFC = \frac{|1.57 - 1.54|}{|1.63 - 1.54|} \cdot (.1197 - .1197) + .1197$~~

$BSFC = 0.1197$

$$F_{con} = F_{con_{n-1}} + F_{con} = 1.3546 + 0.187929 = 1.54g$$

$BSFC = \frac{2131.4-2100}{2200-2100} \cdot (.1197 - .1197) + .1197$

$Eng_\tau = \frac{2292.9 - 2200}{2300 - 2200} \cdot (7.16 - 7.08) + 7.08 = 7.154$

7.5

$Eng\,P = 1.72$

~~$BSFC = \frac{|1.72 - 1.63|}{|1.72 - 1.63|}$~~

$BSFC = \frac{2292.9-2200}{2300-2200}(0.1078 - 0.1197) + 0.1197$

Until max vehicle speed