MODEL SOLAR VEHICLE MATHEMATICAL SIMULATOR QUICK START

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This document has been produced to make it quicker and easier to learn to use the Mathematical Simulator.

The information and data in this document is a brief overview of that available in the full instructions. PLEASE REFER TO THEM. They are included in the Design Hints.

The Simulator is a mathematical approximation of a car on the figure of 8 track, it is not 100% accurate. However with accurate input data the simulator predictions are Typically within 5% of results obtained from track testing.

Listed below are some of the factors which influence the Simulators accuracy.

ACCURACY OF INPUT DATA;

For best results the input data in the PARAMETERS section must be accurate. Remember GIGO garbage in garbage out.
Careful testing of your car is required to obtain these parameters.

CAR AND OPERATIONAL ADJUSTMENTS:

Car build standard. (square straight and clearances good)
Adjustment of electronics
Panel Temperature (power falls as panel heats)
Correct gear ratio fitted.

SIMPLIFYING ASSUMPTIONS: A number of simplifying assumptions are made in the simulation, some are listed here.

The track is laid out on flat ground.
The sections of track between the corners are straight.
Joints in the track are in perfect alignment.
The surface of the track is flat (not undulating & no hollows)
No wind.
Sun level constant
Motor Torque vs RPM graph is treated as a graph with 3 straight line sections. As it is in fact a curve, errors are introduced in representing it as straight line sections.

To use the Simulator, just enter your cars characteristics into the parameters section, the predicted results of a race will then be displayed in the results area.

Below is a copy of the input/output section of the Simulator showing the layout. The data loaded is for PHOTON CRUNCHER MK IV this is the data loaded in the excel spreadsheet when you received it. Use this data to practice with the simulator as described later.

Model Solar Car Simulator

Parameters					Results	
Car Name:	PC IV MODIFIED FOR WHEEL SLIP				**1 LAP RACE**	
Sun Power:	88% Sun Solarex SX 10				**Time:**	19.5
Motor Type:	Faulhaber 2232 6Volt Engelec Electronics				**Velocity:**	6.897
Guide Roll CoEf:	0.015	**Wheel Slip Coeff**	0.9		**Mtr RPM:**	14694
Mass(kg):	2.1				**Air Drag**	0.333
Wheel Roll RS:	0	**Roll CoEf:**	0.097		**Rolling R:**	0.2037
Air Drag Coefficient:	0.007	**Steering(Yes/No):**	NO		**Mtr Torque:**	4.008
Wheel Diameter(mm):	64	**Steering Drag(N):**	0.13			
Acceleration Gear Ratio:	7.14	**Change RPM:**	0		**2 LAP RACE**	
Final Gear Ratio:	7.14				**Time:**	31.9
Transmission Effy:	92				**Velocity:**	7.373
Motor Tourque:	**Finish RPM:**	**Start T(mNm):**		**Formula**	**Mtr RPM:**	15710
Section 1:	5600	17.8		0.001429	**Air Drag**	0.381
Section 2:	10300	9.8		0.00083	**Rolling R:**	0.2037
Section 3:	24000	5.9		0.000431	**Mtr Torque:**	3.570

ABOVE IS SIMULATOR INPUT OUTPUT PANEL FOR PHOTON CRUNCHER MK IV USING AN ALUMINIUM DRIVE WHEEL, NO TYRE.

Model Solar Car Simulator

Parameters					Results	
Car Name:	PC IV MODIFIED FOR WHEEL SLIP				**1 LAP RACE**	
Sun Power:	88% Sun Solarex SX 10				**Time:**	19.1
Motor Type:	Faulhaber 2232 6Volt Engelec Electronics				**Velocity:**	6.851
Guide Roll CoEf:	0.015	**Wheel Slip Coeff**	1.67		**Mtr RPM:**	14597
Mass(kg):	2.1				**Air Drag**	0.329
Wheel Roll RS:	0	**Roll CoEf:**	0.11		**Rolling R:**	0.231
Air Drag Coefficient:	0.007	**Steering(Yes/No):**	NO		**Mtr Torque:**	4.049
Wheel Diameter(mm):	64	**Steering Drag(N):**	0.13			
Acceleration Gear Ratio:	7.14	**Change RPM:**	0		**2 LAP RACE**	
Final Gear Ratio:	7.14				**Time:**	31.55
Transmission Effy:	92				**Velocity:**	7.319
Motor Tourque:	**Finish RPM:**	**Start T(mNm):**		**Formula**	**Mtr RPM:**	15594
Section 1:	5600	17.8		0.001429	**Air Drag**	0.375
Section 2:	10300	9.8		0.00083	**Rolling R:**	0.231
Section 3:	24000	5.9		0.000431	**Mtr Torque:**	3.620

ABOVE IS SIMULATOR INPUT OUTPUT PANEL FOR PHOTON CRUNCHER MK IV USING AN ALUMINIUM DRIVE WHEEL WITH A TYRE. (Tyre used is "O" ring BS032 fitted in a groove 0.050 inch deep)

PARAMETERS ENTERED

Car Name, Sun Power, and Motor Type, identify the test conditions for future reference.

Guide Roll CoEf : Used to calculate the rolling resistance of the guide rollers.

Mass: The Mass of the car in kg.

Wheel Roll RS: Used to calculate the wheel rolling resistance on the track.

Roll CoEf : Used to calculate the wheel rolling resistance on the track. (in conjunction with Wheel Roll RS above)

Air Drag Coefficient: Used to calculate the air drag on the car.

Wheel Diameter : The drive wheel diameter in mm.

Acceleration Gear Ratio: This gear ratio will be used in the calculations until the nominated motor RPM (Change RPM) is reached . The Final Gear Ratio is used thereafter.

Change RPM: The motor RPM at which you nominate the gear change from the acceleration ratio to the Final Gear Ratio to take place.

Final Gear Ratio: This is the gear ratio used for the remainder of the race after the change RPM has been reached.

Transmission Effy.: The efficiency of your transmission system between the motor and the drive wheel , an efficiency of 95% would be entered as 95.

Motor Torque: Motor Torque vs RPM graph is treated as a graph with 3 straight line sections. The 3 Sections listed under this heading correspond to these 3 straight line sections.

Wheel Slip Coefficient: Used in calculating the maximum drive force the wheel can exert before wheel slip occurs.

Steering (Yes/No): This sets the additional drag force which occurs during cornering when there is no steering, either on or off.

Steering Drag (N): The amount of additional drag force in Newtons which occurs during cornering when the car has no steering.

RESULTS DISPLAYED

Results are displayed for both a single and two lap race.

Time: The total time in seconds taken for the car to complete the course.
(Note: A 90 second return for race time indicates the car has stopped. This occurs because simulator configuration will not allow a greater race time)

Velocity: The velocity of the car in Meters per Second as it crosses the finish line.

Mtr. RPM: The motor RPM as the car crosses the finish line.

Air Drag: The air drag force in Newtons acting on the car as it crosses the finish line.

Rolling R: The rolling resistance in Newtons acting on the car as it crosses the finish line.

Mtr. Torque: The torque in mNm being produced by the motor as the car crosses the finish line.

LEARNING TO USE THE SIMULATOR

Using the data as loaded in the simulator for PHOTON CRUNCHER MK IV at 88% Sun.
Run the simulator and make the changes suggested below.

1 EFFECT OF CAR MASS:

Run the simulator as supplied and note the race time.
Run the simulator with car mass increased and decreased by say 500gm.
Note the race time.

2 EFFECT OF AERODYNAMICS:

Run the simulator as supplied and note race time and air drag at end of race.
Run the simulator with the Air Drag Coefficient doubled.
Note the race time and Air Drag at end of race.
COMPARE THESE TWO SETS OF RESULTS.
THIS SHOWS THE EFFECT OF DOUBLING FRONTAL AREA
(Improving the cars shape can also significantly lower the air drag)

3 EFFECT OF STEERING:

Run the simulator as supplied and note the race time.
Run the simulator with steering turned on, note the race time.
Consider the differences in race time.
(remember changing car Mass will change steering drag)

4 EFFECT OF WHEEL DIAMETER & GEAR RATIO:

Run the simulator as supplied and note race time.
Change wheel diameter by say 20mm up and down, note race time changes.
At each wheel diameter you run in the simulator change the gear ratio up and down to obtain the best time.
Note the best race time and compare results.

5 EFFECT OF SUN LEVEL:

Run the simulator as supplied and note race time.
Change the motor data to that for a different sun level.
Note race time, change gear ratios to obtain best race time.

6 EFFECT OF ELECTRONICS:

Run the simulator with motor data at a selected Sun level with and without electronics, changing gear ratios to obtain best race time. Motor data without electronics is provided for the Solar Panel of 10 Dick Smith segments in attachment 1.
Particularly conduct this test at low Sun levels.

7 EFFECT OF TYRE:

Run the simulator with parameters for a car with a tyre and without.
NOTE: at high sun levels the additional drag caused by a tyre is compensated for by better wheel grip and reduced wheel spin on initial take off.

NOW YOU HAVE GAINED AN INSIGHT INTO THE SIMULATORS OPERATION
START USING IT TO DESIGN YOUR CAR.