3 parameter friction/loss model
- k3 = torque-dependent drivetrain friction torque losses (drivetrain efficiency fraction)
- k2 = speed-related rolling resistance force losses (carpet compression)
- k1 = misc constant force losses

Heun's integration
- 2nd order integration, superior speed and accuracy compared to Euler
- Heun's can use 0.01 time steps and be as accurate as Euler with 0.001 steps
- Heun's integration explained: http://calculuslab.deltacollege.edu/ODE/7-C-2/7-C-2-h.html

Full C source code
- the compiled executable writes to standard output
- redirect the output to "filename.CSV", which can be opened directly in Excel for graphing
- easy to edit the constants in the C code to reflect your drivetrain design
- easy to change the output format to target other graphing programs such as gnuplot[1]
- easy to write a "glue" script (BAT file) to automate the process of editing, compiling, running, and graphing

Engineering units
- SI units used internally for simplicity of computation
- English-to-SI conversions provided in source code so user can enter constants in English units
- SI-to-English conversions provided in source code for outputs

Model assumptions
- spec motor voltage is applied at t=0 (see footnote[2])
- all weight-bearing wheels are driven
- equal weight distribution on all wheels
- all wheels have the same “slipping” state
- transition from “slipping” to “not slipping” occurs instantaneously[3]

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[1] highly recommended: www.gnuplot.info
[2] voltages other than 12 can be accomodated by adjusting the values of Ts and Mfree accordingly
[3] with no energy transfer due to speed mismatch between vehicle and wheels

For the example I used:

- 4 CIM motors (n=4; Ts=343.4 in-oz; Mfree=5310 RPM);
- k1=10 lbf;
- k2=1 lbf/(ft/s);
- k3=0.9
- G=12.75
- r=3 inches
- M=150 lbs
- uk=0.7
- us=1.0
- dt=0.001 (1 ms time step for numerical integration)

For this example I picked k1, k2, and k3 out of the ether. For an accurate model you will want to determine these experimentally for your drivetrain. ***It would be enlightening to have a discussion about accurate and simple tests that could be used to determine these constants.***