This template shows how to present analyses and calculations in the submitted design reports. The idea is to explain what you are doing for each calculation while showing all units and unit conversions in a sample calculation, and then summarize similar calculations for other concepts under comparison in a summary table. For convenience, the explanations in this example were copied from the related [EML2322L Drive Wheel Motor Torque Calculations document](http://www2.mae.ufl.edu/designlab/motors/EML2322L%20Drive%20Wheel%20Motor%20Torque%20Calculations.pdf).

**Drive Wheel Motor Torque Calculations**

The following calculation is taken from the *EML2322L Drive Wheel Motor Torque Calculations* document.

**Concept 1 Mobile Platform Drive Wheel Parameters:**

|  |  |
| --- | --- |
| Gross vehicle weight (WGV, lb) | 35 |
| Weight on each drive wheel (WW, lb) | 10 |
| Radius of wheel/tire (Rw, in) | 4 |
| Desired top speed (Vmax, ft/sec) | 1.5 |
| Desired acceleration time (ta, sec) | 1 |
| Maximum incline angle (α, deg) | 2 |
| Worst surface friction coeff. (Csf, -) | 0.01 |
| Static friction coeff. (μs, -) | 0.4 |

To choose motors capable of producing enough torque to propel the example vehicle, it is necessary to determine the total tractive effort (TTE) requirement for the vehicle:

TTE [lb] = RR [lb] + GR [lb] + Fa [lb]

where:

 TTE = total tractive effort [lb]

 RR = force necessary to overcome rolling resistance [lb]

 GR = force required to climb a grade [lb]

 Fa = force required to accelerate to final velocity [lb]

The components of this equation will be determined in the following steps.

**Step One: Determine Rolling Resistance**

Rolling Resistance (RR) is the force necessary to propel a vehicle over a particular surface. The worst possible surface type to be encountered by the vehicle should be factored into the equation.

RR [lb] = WGV [lb] × Csf [-] = 35 lb × 0.01 = ***0.35 lb***

where:

 RR = rolling resistance [lb]

 WGV = gross vehicle weight [lb]

 Csf = surface friction coefficient [-] (value obtained from Table 1 in *EML2322L Drive Wheel Motor Torque*

*Calculations* document)

**Step Two: Determine Grade Resistance**

Grade Resistance (GR) is the amount of force necessary to move a vehicle up a slope or grade. This calculation must be made using the maximum grade the vehicle must climb in normal operation.

To convert incline angle, α, to grade resistance:

GR [lb] = WGV [lb] × sin(α) = 35 lb × sin(2°) = ***1.2 lb***

where:

 GR = grade resistance [lb]

 WGV = gross vehicle weight [lb]

 α = maximum incline angle [degrees]

**Step Three: Determine Acceleration Force**

Acceleration Force (Fa) is the force necessary to accelerate from a stop to maximum speed in a desired time.

Fa [lb] = WGV [lb] × Vmax [ft/s] / (32.2 [ft/s2] × ta [s]) = 35 lb × 1.5 ft/s / (32.2 ft/s2 x 1 s) = ***1.6 lb***

where:

 Fa = acceleration force [lb]

 WGV = gross vehicle weight [lb]

 Vmax = maximum speed [ft/s]

 ta = time required to achieve maximum speed [s]

**Step Four: Determine Total Tractive Effort**

The Total Tractive Effort (TTE) is the sum of the forces calculated in steps 1, 2, and 3. (On higher speed vehicles friction in drive components may warrant the addition of 10%-15% to the total tractive effort to ensure acceptable vehicle performance.)

TTE [lb] = RR [lb] + GR [lb] + Fa [lb] = 0.35 lb + 1.2 lb + 1.6 lb = ***3.2 lb***

**Step Five: Determine Wheel Motor Torque**

To verify the vehicle will perform as designed in regards to tractive effort and acceleration, it is necessary to calculate the required wheel torque (Tw) based on the tractive effort.

Tw [lb-in] = TTE [lb] × Rw [in] × RF [-] = 3.2 lb × 4 in × 1.1 = ***14 lb-in***

where:

 Tw = wheel torque [lb-in]

 TTE = total tractive effort [lb]

 Rw = radius of the wheel/tire [in]

 RF = resistance factor [-]

The resistance factor accounts for the frictional losses between the caster wheels and their axles and the drag on the motor bearings. Typical values range between 1.1 and 1.15 (or 10 to 15%).

**Step Six: Reality Check**

The final step is to verify the vehicle can transmit the required torque from the drive wheel(s) to the ground. The maximum tractive torque (MTT) a wheel can transmit is equal to the normal load times the friction coefficient between the wheel and the ground times the radius of the drive wheel.

MTT = Ww [lb] × μs [-]× Rw [in] = 10 lb × 0.4 × 4 in = ***16 lb-in***

where:

 Ww = weight (normal load) on drive wheel [lb]

 μs = friction coefficient between the wheel and the ground (~0.4 for plastic on dry wood) [-]

 Rw = radius of drive wheel/tire [in]

**Interpreting Results**

Total Tractive Effort is the net horizontal force applied by the drive wheels to the ground. If the design has two drive wheels, the force applied per drive wheel (for straight travel) is half of the calculated TTE.

The Wheel Torque calculated in Step Five is the total wheel torque. This quantity does not change with the number of drive wheels. The sum of the individual drive motor torques (see [Motor Specifications](http://www2.mae.ufl.edu/designlab/motors/Motor%20Specifications.pdf)) must be greater than or equal to the computed required Wheel Torque.

The Maximum Tractive Torque represents the maximum amount of torque that can be applied before slipping occurs for each drive wheel. ***The total wheel torque calculated in Step Five must be less than the sum of the Maximum Tractive Torques for all drive wheels or slipping will occur.***

**Summary Table** (Insert → Object → MS Excel Worksheet, or copy and paste from an Excel document)



**NOTE: it is not necessary to include detailed calculations for Concepts 2 thru 5 in the above example, since the DRT only requires drive wheel motor torque calcs for the final selected design; the results are simply presented to show how you summarize similar calculation results for different concepts.**