MEEN 357 Project Phase 1

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Question 1:

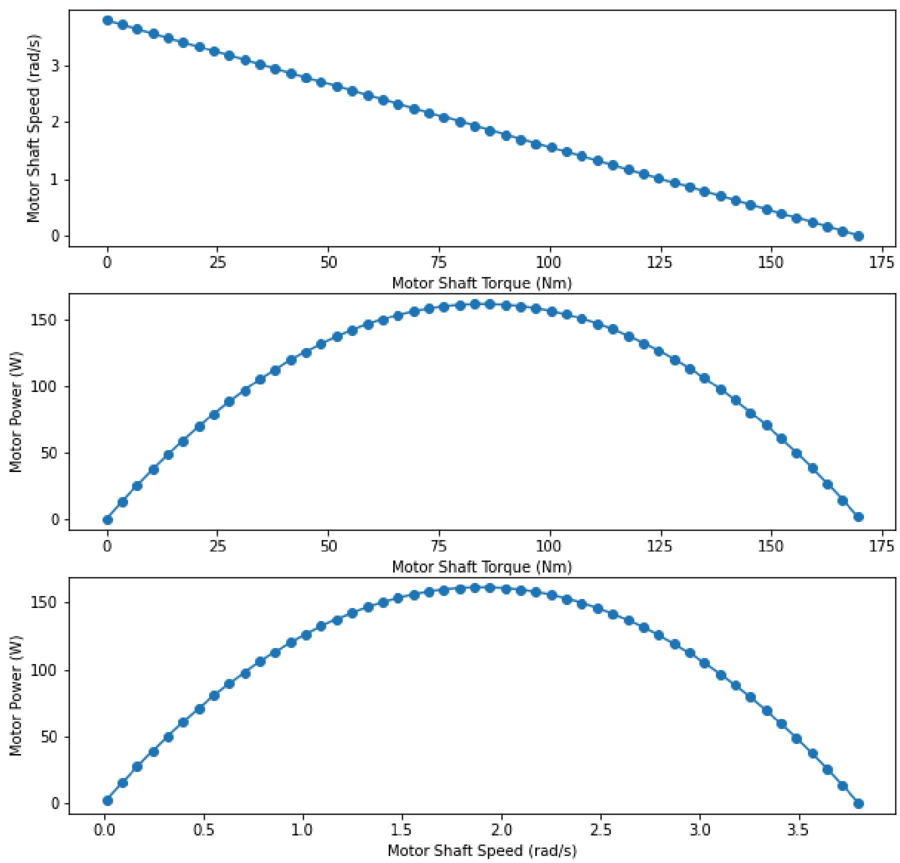
Making gravity as a field allows for more flexibility and reusability. The code can operate on different planets. We can also change it once and it affects all functions. We could also have made a static variable for each of the functions which would have accomplished a similar result.

Question 2:

One of the tasks to be performed by the **F_gravity** function is to check if the terrain angle is between -75 degrees and 75 degrees. It must be designed to raise an exception if the input angle is outside this range. Thus, if **F_gravity** is called for a terrain angle of 110 degrees, an exception will be raised and there will eb no numerical output. The raising of this exception is desirable as at a particular point, there would be a very steep slope, causing the rover to lose contact with the surface and move in, which scenario is not designed to be handled by the code.

Question 3:

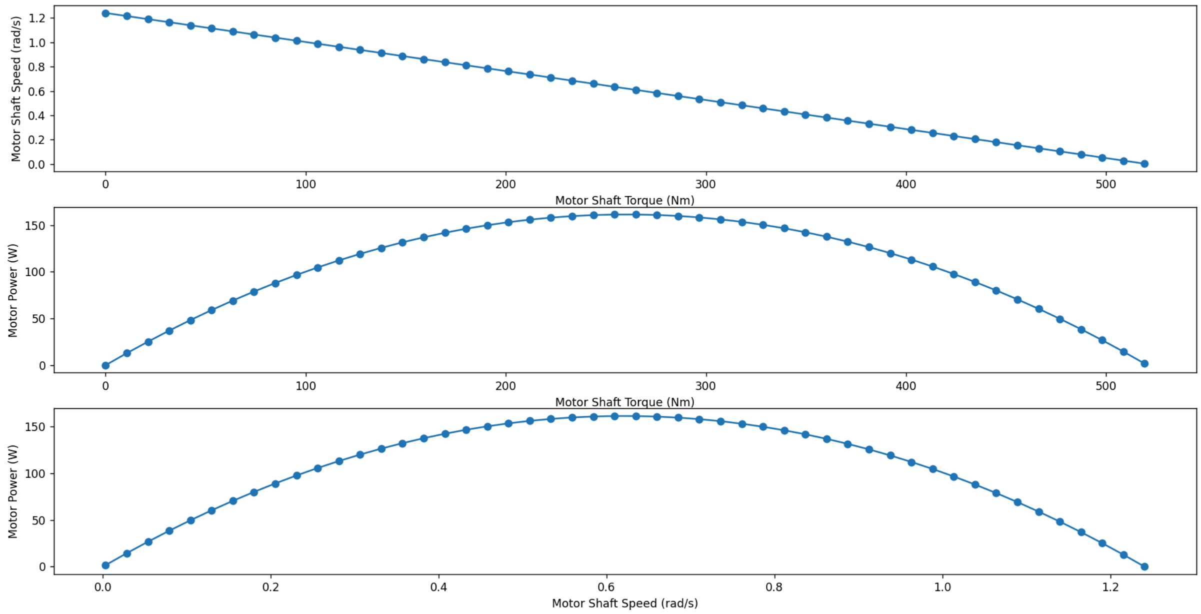
From the third subplot Motor Power (W) vs Motor Shaft Speed (m/s) in *Graph 1* from *graphs_motor.py* given below, the max power output can be estimated to be approximately 161.5 W all 6 motors combined. Since power is distributed equally across all 6 motors, the max power output from a single shaft motor can be estimated to be approximately 26.92 W. Again, on further inspection of the same subplot carefully, this max value can be estimated to occur around a motor shaft speed of 1.8 rad/s. Therefore, Max Power output of a motor shaft is 26.92 W at a motor shaft speed of 1.8 rad/s.



Graph 1: Graphs of Motor Characteristics

<u>Question 4:</u>

The impact that the speed reducer has on the system thus increasing the torque energy. We can see that compared to the previous graph it takes less speed in rad/s to get the maximum amount of power. The maximum power seems to be the same around 160W the main difference is seen by the horizontal axis being more narrow when talking about rad/s and wider when talking about the torque. This show evidence that the change of torque leads to more power with less speed.



Graph 2: Graphs of Motor srCharacteristics

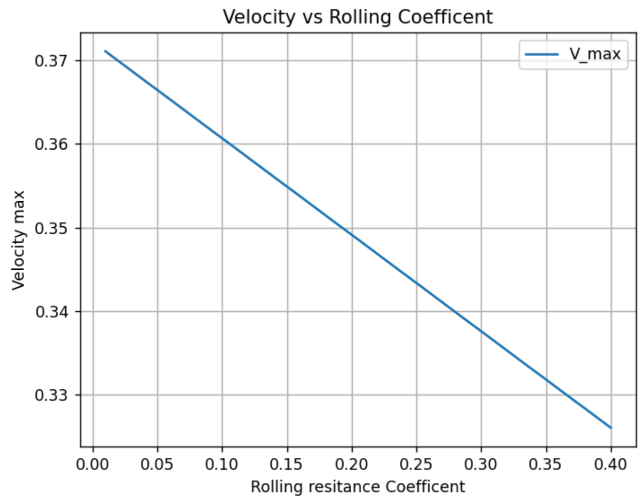
<u>Question 5:</u>

From *Graph 3* below, it can be observed that it is fairly linear with a negative slope. This linearly proportionality shows that when the terrain angle increases, the Max Rover Speed decreases. Physically speaking this makes sense as it takes the rover more effort to move uphill with a steeper slope (higher terrain angle) than it does to move at a relatively flatter slape (lower terrain angle) or just flat ground (zero terrain angle). This is mainly due to the fact that speed is divided into horizontal and vertical components. Thus, when the rover moves horizontally, all the power input to the rover is attributed to that horizontal movement. While in a vertical movement against gravity upwards, the power is dissipated in opposing gravity in moving upwards and only the remaining is attributed to the horizontal motion. The speed increases further in a negative angle scenario as gravity is now aiding in the motion of the rover, helping it to pick up momentum, in addition to being powered in the horizontal direction.

Graph 3: Graph of the Analysis Terrain Slope

Question 6:

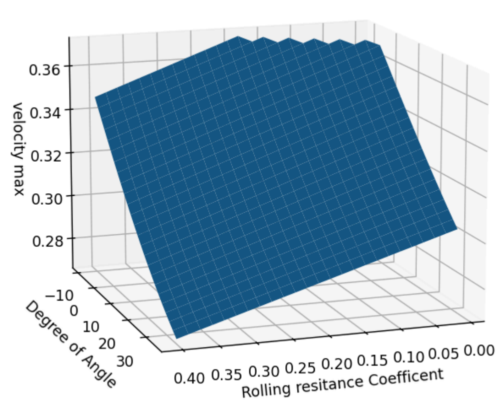
From *Graph 4* below, again it can be observed that it is linear with a negative slope. Yet again, there is a linear decreasing relationship between the Maximum velocity and Rolling resistance coefficient (CRR). As the Coefficient of Rolling resistance (CRR) increases, the maximum velocity decreases. Physically speaking, this makes sense as higher CRR values will ensure more energy dissipation due to friction. Since, the mechanical energy is conserved, the kinetic energy decreases. Thus, lower max velocity is a by-product of decreased kinetic energy. Therefore, the linear decreasing proportionality in the graph is justified.



Graph 4: Graphs of different rolling coefficients

Question 7:

The surface plot shown in *Graph 5* below shows that the Coefficient of Rolling Resistance (CRR) has a lesser impact on the max velocity of the rover compared to the Terrain Angle. This is implied as the velocity max vs terrain angle slope is steeper than the velocity max vs CRR slope. To summarize, this graph shows that for maximum velocity, the rover must travel with the highest downslope possible (most negative angle) and in least CRR conditions.



Graph 5: Graphs of changes of Degree of angle and resistance coefficient.