6.1 Coding

Question 1: We had you define the acceleration due to gravity as a field in a structure that you had to pass as an input argument to several functions. Instead, we could have had you type the value for the constant, 3.72 m/s2, directly in those functions. Do you believe there is an advantage to how we had you do it? Explain. Would you have done it differently? Explain why or why not.

The advantage to using gravity as a dictionary was the consistency when defining and calling functions. This also ensured that the correct conversion of gravity was used for every function. We would have done it the same way to keep consistency with all known values being in a dictionary format.

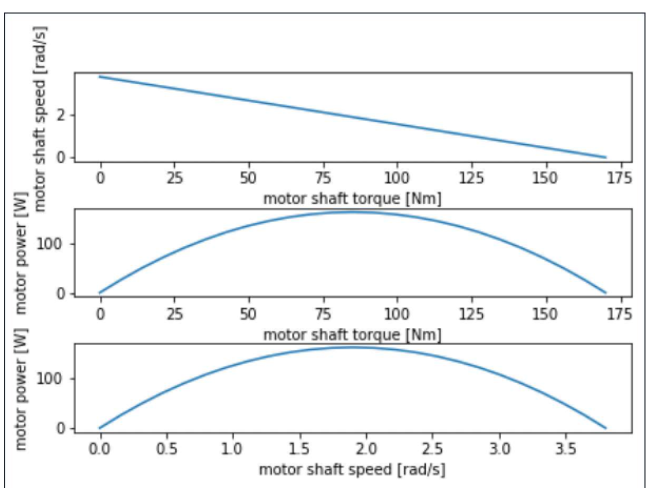
Question 2: What happens if you try to call F_gravity using a terrain slope of 110 degrees? Is this desirable behavior? Explain why you think this.

When using a terrain angle of 110 degrees, there is a raised Exception output since it is not in the terrain angle constraint of -75 to 75 degrees. This is desirable behavior because of the diagram and coordinate system the code was based off of. Between 0 and 75 degrees, the gravitational force will be negative, as it is opposing the positive x direction to the right. Between 0 and -75 degrees, the slope will be negative, and the gravitational force will be positive. If our degree reached 110 it would not fit with the sign conviction we used then creating our force functions resulting in negativity.

6.2 Motor and Speed Reducer Behavior

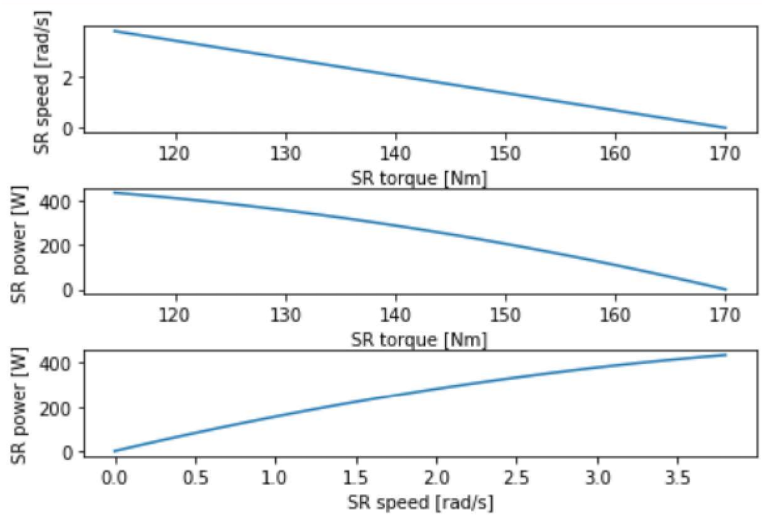
Question 3: What is the maximum power output by a single rover motor? At what motor shaft speed does this occur? Provide graphs or other data to support your answer.

The maximum power output by a single rover, shaft speed times shaft torque, is 161.5 W with a shaft speed of 1.7417 rad/s. This can be seen on the graph directly below.



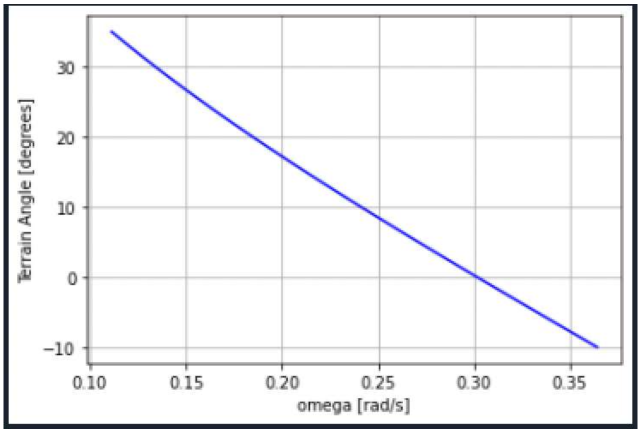
Question 4: What impact does the speed reducer have on the power output of the drive system? Again, provide any graphs or supporting data.

The speed reducer increases the power output of the drive system. The maximum power output is 435.1 W at a speed of 3.6417 rad/s. This can be seen on the graph directly below. In conclusion, the speed reducer increases the power output by about 269% and increases the speed by about 209%.



6.3 Rover Behavior

Question 5: Examine the graph you generated using analysis_terrain_slope.py. (Provide the graph in your response for reference.) Explain the trend you observe. Does it make sense physically? Why or why not? Please be precise. For example, if the graph appears linear or non-linear, can you explain why it should be the way you observed? Refer back to the rover model and how slope impacts rover behavior.



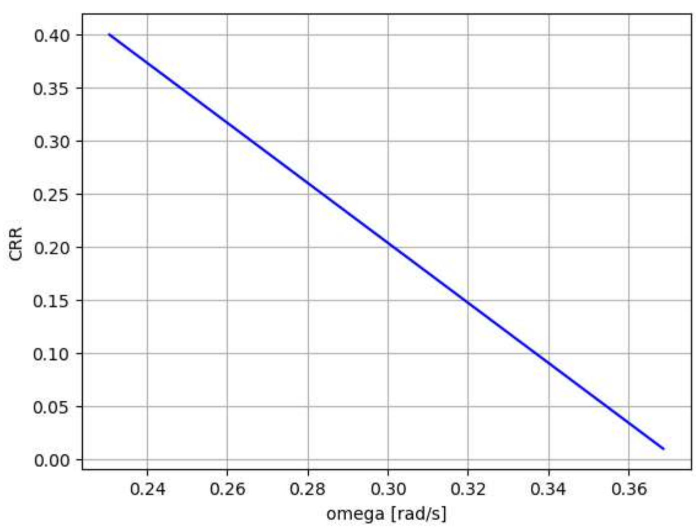
The angle of the slope impacts the magnitude of the gravitational force. As the terrain angle increases, the sin of the gravitational force increases, which slows the rover down. This explains why the graph has a negative linear output. When the terrain angle is at its smallest value, the speed of the rover is at it's highest.

Question 6: Examine the graph you generated using analysis_rolling_resistance.py. (Provide the graph in your response for reference.) Explain the trend you observe. Does it make sense physically? Why or why not? Please be precise. For example, if the graph appears linear or non-linear, can you explain why it should be the way you observed? Refer back to the rover model and how the coefficient of rolling resistance impacts rover behavior.

The trend observed is a negative linear relationship. As omega (angular speed) increases ,the value of CRR decreases. This is because as the angular velocity increases the value of torque decreases as seen in **Equation 1** below. The term omega is multiplied by a negative number resultign in the overall torque value to decrease as omega increases. Crr is related to the force of friction and the interaction between the wheels and the ground. Because the wheels exert less torque, there is less force exerted by the wheel. Additionally the change in of the gear does not affect the linearity of the function because it is a scalar value applied to each angular velocity.

$$\tau = \tau_S - \left(\frac{\tau_S - \tau_{NL}}{\omega_{NL}}\right)\omega$$

Equation 1



Question 7: Examine the surface plot you generated using analysis_combined_terrain.py. (Provide the graph in your response for reference.) What does this graph tell you about the physical conditions under which it is appropriate to operate the rover? Based on what you observe, which factor, terrain slope or coefficient of rolling resistance, is the dominant consideration in how fast the rover can travel? Please explain your reasoning.

To operate the rover, there needs to be a slope terrain angle smaller than 35 degrees and a Crr coefficient smaller than 0.40. If either of those numbers are surpassed, the rover will exceed the set safety limits set in the problem. After analyzing the graph, the terrain slope was determined to have the dominant impact on how fast the rover can travel. The V max differences from the slope range compared to the differences when the range of coefficients is challenged is larger. The differences in the velocity when Crr is constant is greater than the differences when the degree angle is kept constant.