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/s^2, 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.

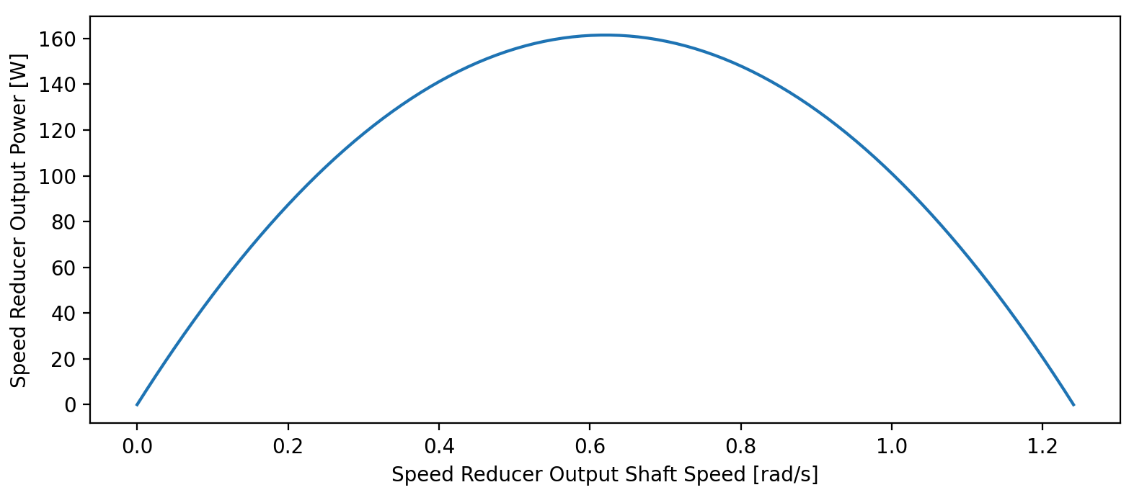
There is an advantage to defining the acceleration due to gravity as a field in a structure because it ensures the same number is used throughout the code rather than needing to retype it each time.

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.

If you tried to call F_gravity using a terrain slope of 110 degrees, it would output an exception error stating "Error: Invalid input value. All terrain_angle elements must be between -75 and 75 degrees.". This is desirable because the code is not fit to handle slopes greater than 90 degrees.

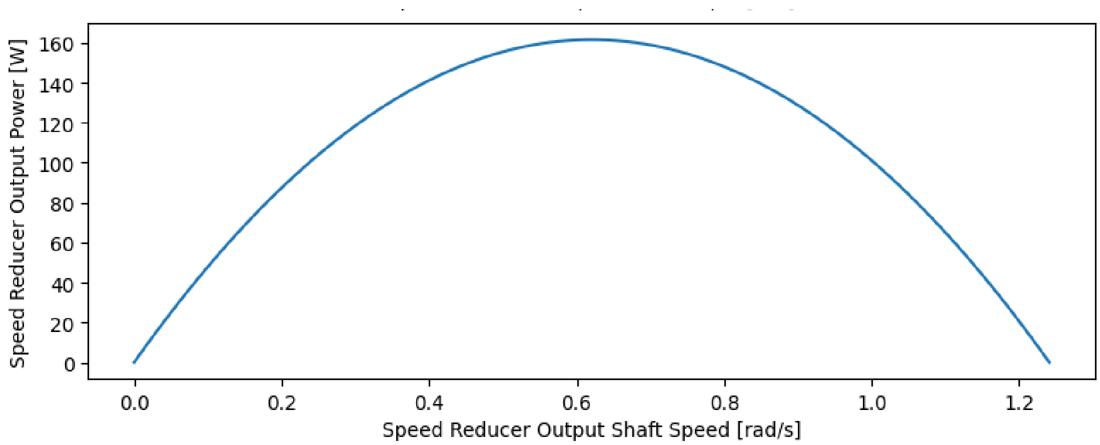
Question 3:
What is the maximum power output by a single rover motor? At what motor shaft speed does this occur? Provide graphs or other data to support your answer.

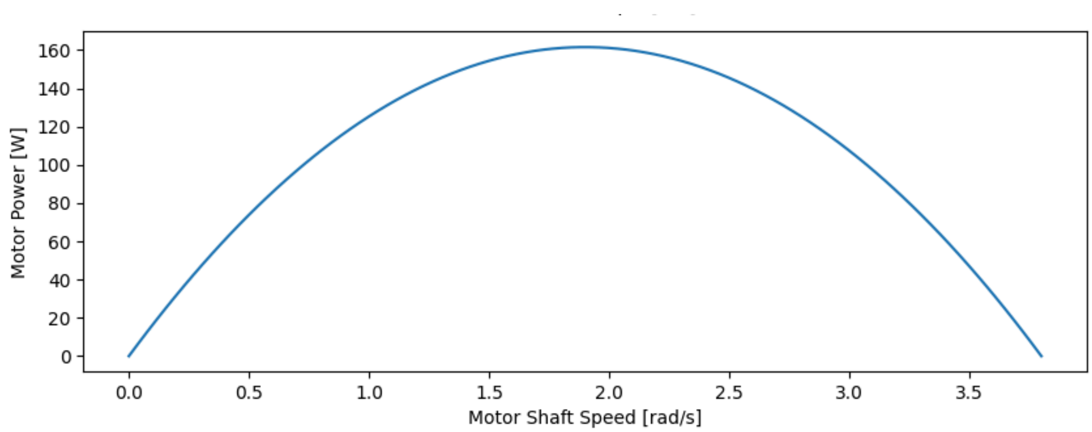
The maximum power output by a single rover motor is about 162 W, at an output shaft speed of around 0.6 rad/s.



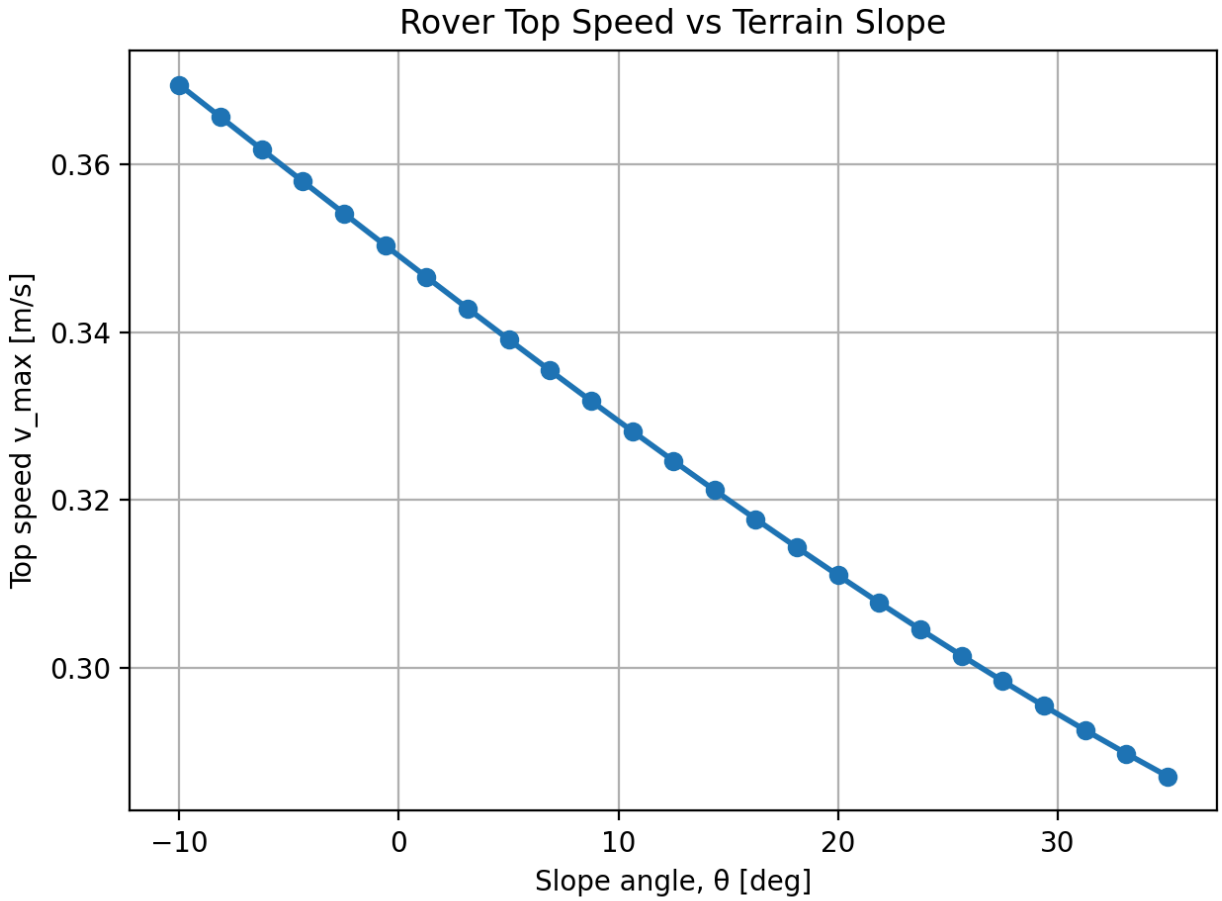
Question 4:
What impact does the speed reducer have on the power output of the drive system? Again, provide any graphs or supporting data.

The speed reducer spreads out the output power curve across shaft speeds, but the maximum power output stays the same. This happens because the speed reducer reduces speed while increasing torque, so that the rover has a mechanical advantage and can traverse rough terrain.





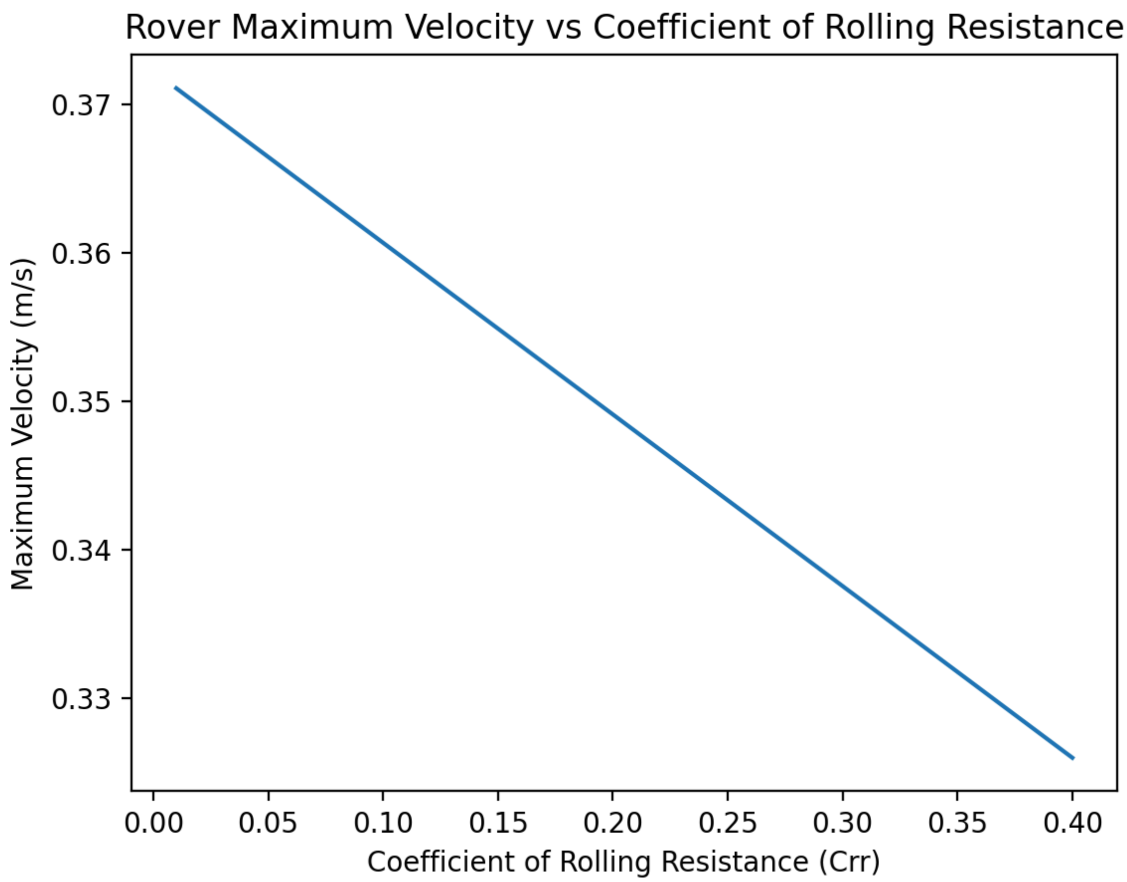
Question 5:
Examine the graph you generated using **analysis_terrain_slope.py**. (Provide the graph in your response for reference.) Explain the trend you observe. Does it make sense physically? Why or why not? Please be precise. For example, if the graph appears linear or non-linear, can you explain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



This graph makes sense physically because as the slope (degrees) increases, the rover's top speed (m/s) decreases. The graph appears slightly non-linear because the effect of gravity increases with slope angle, and the rover's motor has non-linear performance limits. The terrain angle is a function of force of gravity and rolling resistance. We see in the functions and formulas that as terrain angle is increased, the gravity and rolling resistance imposes the driving force and affects the velocity. In addition, the force of gravity is non-linear but can be considered linear from our [10, 35] degree ranges. Thus, the trend is linear.

<u>Question 6:</u>

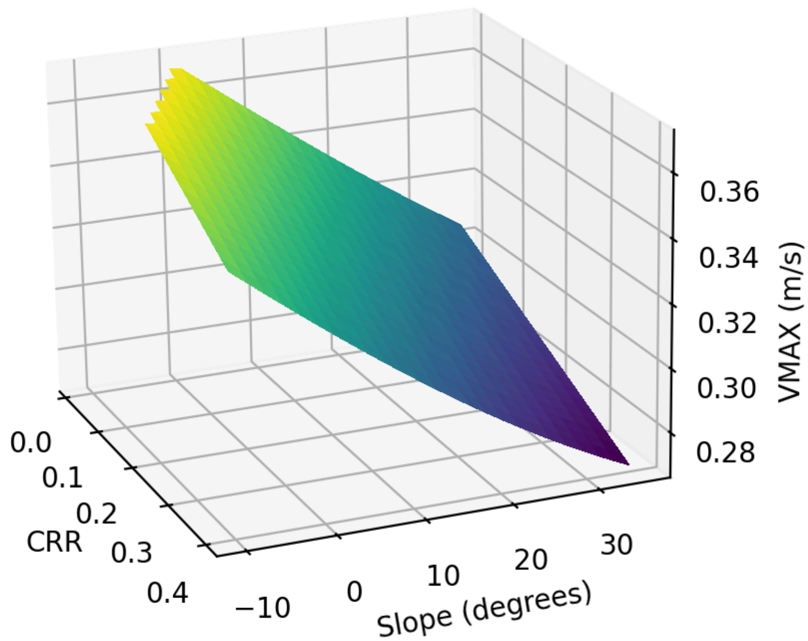
Examine the graph you generated using **analysis_rolling_resistance.py**. (Provide the graph in your response for reference.) Explain the trend you observe. Does it make sense physically? Why or why not? Please be precise. For example, if the graph appears linear or non-linear, can you explain why it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



The graph appears to show a negative linear relationship, which makes sense because there is a direct proportionality between Crr and the reduction in velocity.

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.



This graph tells us that as the slope (degrees) and Crr increase, the maximum velocity (m/s) decreases. This shows that it is more appropriate to operate the rover when the slope and Crr are slow. According to the graph, between -10 and 10 degrees of slope and a Crr below around 0.2 would be considered ideal conditions. Furthermore, it appears that the slope is the more dominating factor when considering how fast the rover can travel since it has a steep negative slope, while the Crr has a less steep slope.