Name 1: _____

Name 2: _____

Date: _____

Challenge #6: Welcome to Seattle

Overview

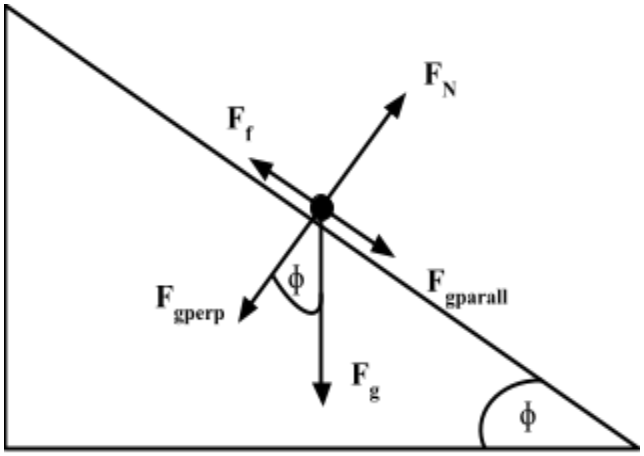
Up to **two** students can work on this challenge. Remember each team member must contribute to at least one the completion of one of the physics components for one challenge and the completion of one of the engineering components for another challenge. This challenge is about **forces**. You will be asked to do the following:

1. Determine the maximum angle at which your rover can stay still on an incline
2. Determine the values of all forces on your rover on an incline plane

Force Diagram on an Incline

Force diagrams, or free body diagrams, are a little bit different when on an incline plane. This is because the normal force is perpendicular to the surface while the gravitational force remains down; this means that a portion of the gravitational force will be equal to the normal force and a portion of the gravitational force works alongside the axis of motion (parallel to the incline).

For this specific challenge, the force diagram looks like this:



Determining Maximum Angle

One important thing that you need to measure is the angle at which your rover is just about to start slipping. Grab an available ramp, with the same surface material as that for this challenge. Place your rover in the middle of the ramp, as illustrated in the force diagram above, and increase the height on one end (either through textbooks or something else) until your rover is just about to start slipping, but can hold steady.

Measure the angle, either using your smartphone's Measure app or a protractor, and write it below:

Angle (ϕ): _____

Gravitational Force

To determine the gravitational force, remember that:

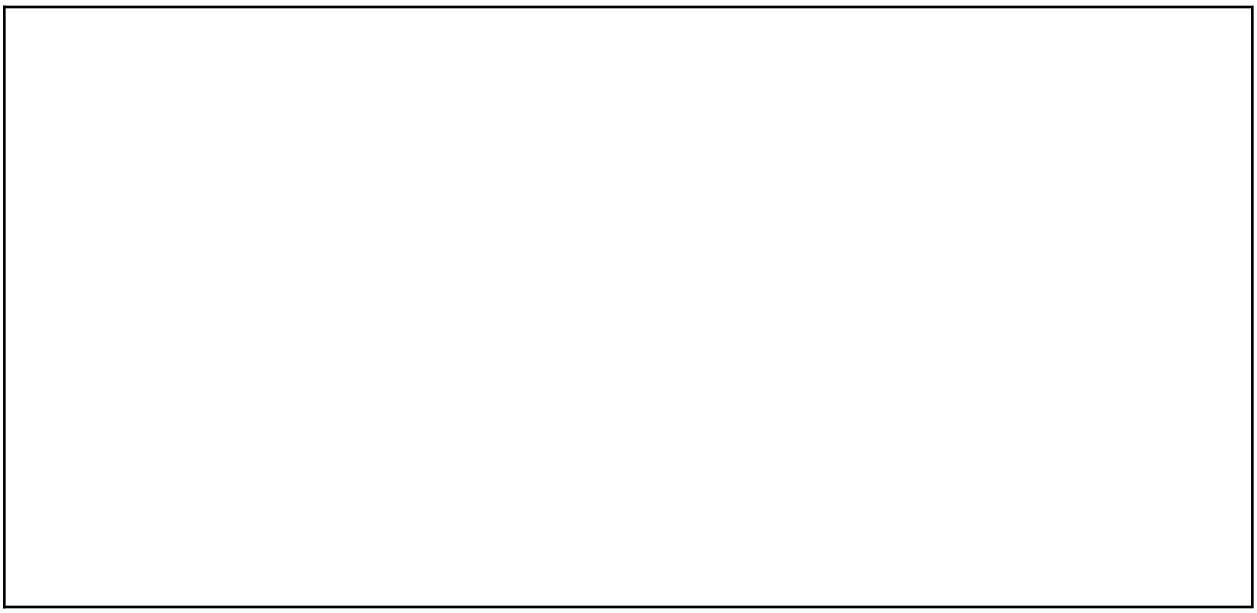
$$F_g = mg$$

Once you have determined your gravitational force, please write it below.

Gravitational Force (F_g): _____

One important note is that it is more useful knowing the components of the gravitational force; that is, the components that are parallel to it and the components that are perpendicular to it. Using trigonometry (remember SOH CAH TOA), calculate the perpendicular and parallel

components to gravitational force and write them below. Feel free to use the space below for your calculations.



Perpendicular Gravitational Force (F_{gperp}): _____

Parallel Gravitational Force ($F_{gparall}$): _____

Normal Force

Normal force is easy to determine once you have calculated the components of the gravitational force; please write down what your normal force should be below.

Normal Force (F_N): _____

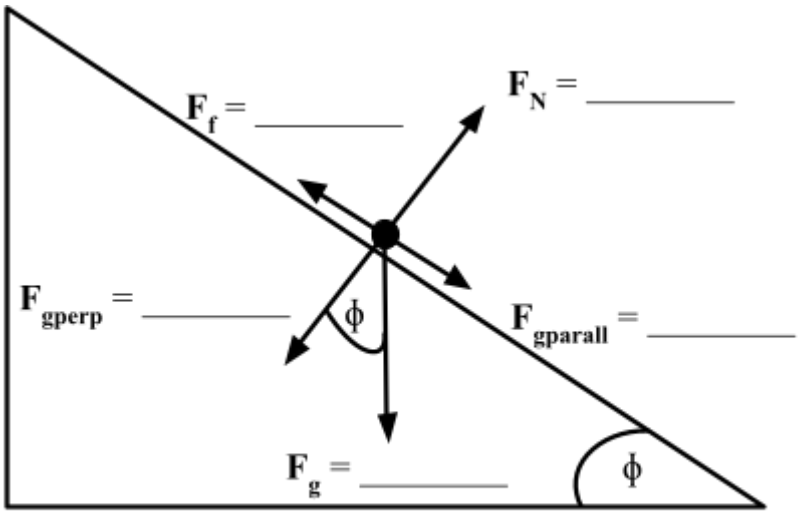
Friction Force

Similar to the normal force, since your object is just about the slide, your friction force should be equal to a different component of your gravitational force. Please identify it and write it below.

Friction Force (F_f): _____

Revisiting the Force Diagram

Please take a moment to complete the force diagram below with your previously calculated values.



ϕ = _____

***Exceeding Proficiency**: If you determine the coefficient of friction for the following part on your own, and it is correct or reasonable, you will receive exceeding proficiency.*

Please determine the coefficient of friction below, using what you know from the diagram and the equation for the friction force.

Coefficient of Friction (μ): _____

Point System (TEACHER ONLY - CIRCLE ONE)

Not Yet (0pts) (50%)	**Approaching Proficiency (10pts) (60%)**	**Somewhat Proficient (20pts) (70%)**	**Proficient (30pts) (85%)**	**Exceeding Proficiency (40pts) (100%)**
You have not correctly completed any of the elements of this challenge component.	You have correctly completed at least one element of this challenge component.	You have correctly completed half of the elements of this challenge component.	You have correctly completed all of the elements of this challenge component.	You have additionally and correctly completed the independent element of this challenge component.
Comments:				