2023Q3 INCLINED PLANES

Greetings everyone! This week's Wind Study is going to focus on the topic of inclined planes. In physics, inclined planes are surfaces which extend from the horizontal at an angle greater than zero degrees. Every inclined plane can be thought of as a right triangle; each one has a base and height which meet at a 90° angle, as well as a hypotenuse that connects the two. Inclined planes are unique because the forces on an object on an inclined plane act at an angle, whereas the forces on an object sitting on a flat surface, like the book on the table from the last Wind Study, operate along an imaginary x and y axis. This means we have to split force vectors acting at an angle not perpendicular or parallel to the inclined plane (such as gravity) into their x and y components.

A handy trick for dealing with inclined planes is to rotate our coordinate axes so they align with the angle of the inclined plane. Let's take a look at how this would affect our perspective on the force of gravity.

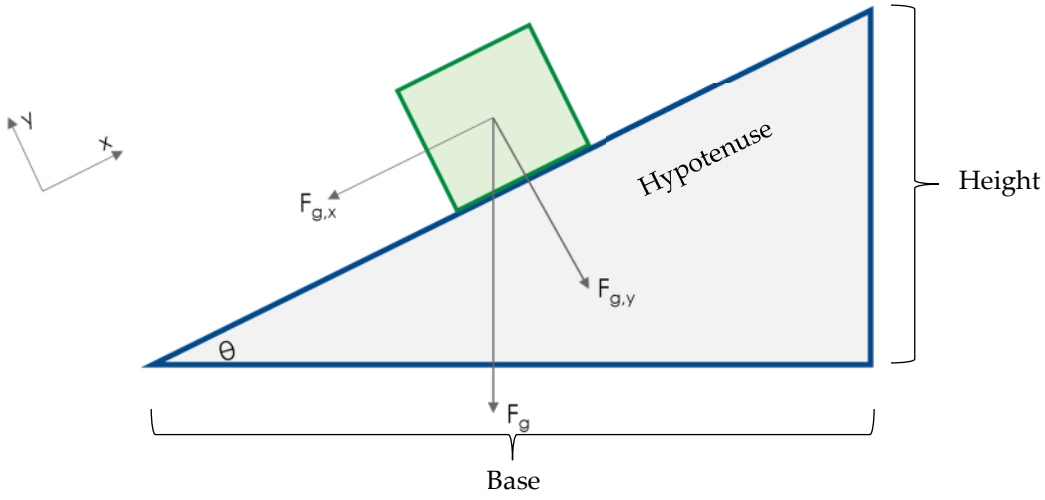

Figure 1: Partial free body diagram showing the force of gravity on an inclined plane

As we can see from our partial free body diagram above, the force of gravity can be split into its x and y components, where $F_{g,x} = F_g \sin\theta$ and $F_{g,y} = F_g \cos\theta$. This allows us to operate in the same coordinate plane as the inclined plane. Think about how other forces act on an inclined plane. If an object is sitting still, what force opposes $F_{g,x}$ and what force opposes $F_{g,y}$? (Hint: we talked about one of these in our last Wind Study.) Now, let's take a quick look at how inclined planes tie into the wind turbine construction process.

An initial phase of wind turbine construction consists of civil work in the project area. This involves creating flat compact areas for wind turbine construction by moving around dirt and rock. Sometimes if there are elevation changes at the project site, ramps are built from gravel or dirt to facilitate transit from one area of the project site to another.

Figure 2: Dirt ramp at a wind turbine construction site

While these ramps may be curved to accommodate terrain and vehicle travel, they more or less adhere to the same basic physics principals as an inclined plane. So, without further ado, let's hop into this week's questions!

Level 1: A truck is sitting still on a ramp leading to the construction site. Draw this scenario, include a free body diagram of the forces acting on the truck. We already know how the force of gravity would affect the truck, but there are two more forces for which we need to account. Make sure to include any necessary x and y components for each force.

Level 2: Solve for each force from your free body diagram above, assume the truck is still not moving. The mass of the truck is 1,008 kilograms (kg), the length of the ramp is 50 meters (m), and the height change of the ramp is 10 m. Assume g is 9.8 m/s.