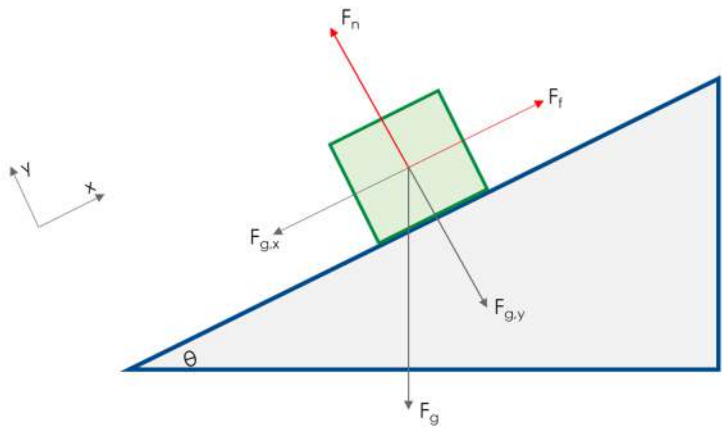
2023A3

INCLINED PLANES

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.

Generally when drawing free body diagrams, it is best to keep them as simple as possible, especially when there are multiple forces acting at multiple angles on an object. For this scenario, we used a right triangle to represent the inclined plane that makes up the ramp and a box to represent the truck.



We already know how the force of gravity (F_g) affects the truck, but there are two other forces acting on the truck which keep it sitting in place. These forces respectively oppose the x and y components of gravity. In the y-direction, we have the normal force opposing the force of gravity, just like we did with the book on the table and wooden platform on the ground in the last Wind Study.

In the x-direction, we have the force of friction (F_f) opposing the force of gravity. Remember, friction is the force that occurs between an object and the surface it rests on. Every surface has a coefficient of friction which governs how much resistance it gives to an object's motion on it. We do not need to worry about the magnitude of the coefficient of friction for this Wind Study, just know that it is enough to oppose the x-component of the force of gravity in this scenario.

As we can see from our free body diagram, we have equal forces acting on the truck in both the x and y directions. This makes sense because we stated the truck was sitting still in the problem statement!

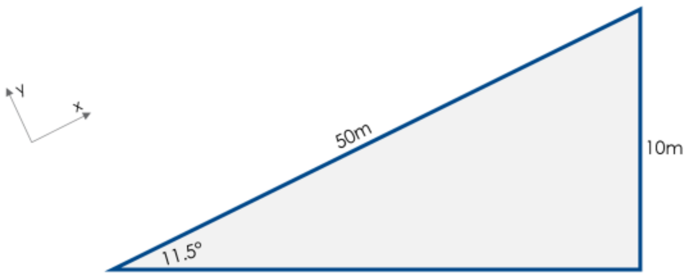
Level 2: Solve for each force from your free body diagram above, assume the truck is still not moving. The mass of the truck is 1,008 kilograms (kg), the length of the ramp is 50 meters (m), and the height change of the ramp is 10m. Assume g is 9.8 m/s.

The first step in this problem is to define what we know about the ramp. We know the length of the ramp is 50m and the height change is 10m. We need to solve for the angle of the ramp because we need θ to solve for the x and y components of gravity. To do this we can use:

$$\sin\theta = \frac{opposite}{hypotenuse}$$

$$\theta = \sin^{-1}\frac{10m}{50m}$$

$$\theta = 11.5°$$



Now that we have the dimensions of our inclined plane defined, we can solve for each of the forces on the truck.

For the force of gravity, we can solve using the equation $F_g = mg$.

$$F_g = 1{,}008kg \times -9.8m/s$$

$$F_g = -9{,}878.4\ N$$

The acceleration due to gravity is negative because we have our coordinate axes set so that up is positive and right is positive. For the x and y components, we can use the equations we defined earlier.

$$F_{g,x} = F_g \sin\theta$$

$$F_{g,x} = -9{,}878.4N \times \sin 11.5°$$

$$F_{g,x} = -1{,}969.4N$$

$$F_{g,y} = F_g \cos\theta$$

$$F_{g,y} = -9{,}878.4N \times \cos 11.5°$$

$$F_{g,y} = -9{,}680.1N$$

For the normal force, we know that is opposes $F_{g,y}$. F_n = 9,680.1N because it acts in the positive y-direction.

For the force of friction, we know that is opposes $F_{g,x}$. F_f = 1,969.4N because it acts in the positive x-direction.