WIND STUDY

Wind Study is intended for grades 5-8 and 8-11
Questions posted on: Monday Answers posted on: Friday
Find downloadable one pagers at www.oneenergy.com/one-energy-feed

2024 Q3

FREE-BODY DIAGRAMS WITH FRICTION & SLOPES

Here at One Energy, we move a lot of heavy equipment, tools, and materials. One major factor that can make moving things harder, as well as require more effort and force, is friction. Friction is a counteracting force generated because of a downward force (like gravity) and the sideways force attempting to move the object. Solving systems of friction means breaking down questions into free body diagrams. **<u>Friction will always be in the opposite direction of motion</u>**. The necessary equations for forces and acceleration are as follows:

F_{net} = Net Force
F_a = Force Applied
m = mass
a = acceleration
N = Normal Force
μ = Coefficient of friction
F_f = frictional Force

$$F_{net} = ma$$

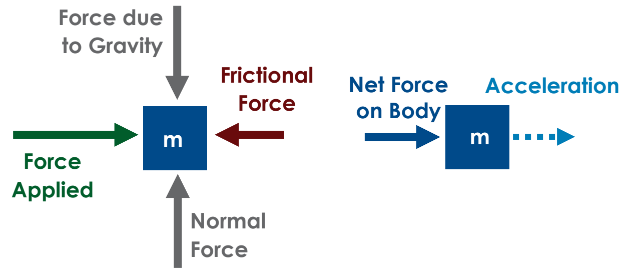
$$F_f \leq \mu N$$

$$N = mg * cos(\theta)$$

$$F_{gravity} = mg$$

$$g = 9.81\ m/s^2$$

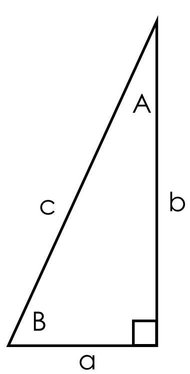
$$Newton = \frac{kg * m}{s^2}$$



Newton's second law of motion states, "The force action on an object is equal to the mass of that object times its acceleration, F=ma." This law applies directly to free-body diagrams. Adding together forces applied will cancel out equal and opposite forces, revealing the net force applied. Using the net force with the equation *F=ma* will allow you to calculate an object's acceleration in that direction. An illustration of cancelling terms in a free-body diagram is shown above.

When solving free-body diagrams on slopes and ramps specifically, it is important to find the correct perpendicular components of forces, so that they can be cancelled out with others. This means using basic trigonometric right triangle equations that are shown below:

Frictional force cannot be greater than the opposing motion, if frictional force equals the opposing motion, the forces cancel, and the object does not accelerate.



$\sin(A) = \frac{a}{c}$	$\tan(A) = \frac{a}{b}$	$\cos(A) = \frac{b}{c}$
$\sin\left(\frac{a}{c}\right)^{-1} = A$	$\cos\left(\frac{b}{c}\right)^{-1} = A$	$a^2 + b^2 = c^2$

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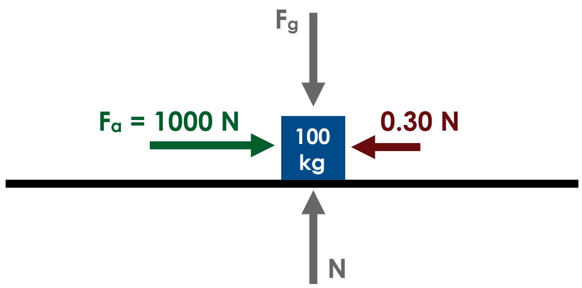
Level 1: A steel cube counterweight with a mass of 100kg is sitting on an asphalt road. The coefficient of friction between the weight and the road is given as 0.30. If the block is pushed horizontally with a force of 1000 newtons, how fast is the block accelerating in m/s²? *Hint: The gravitational and normal forces will cancel out on flat surface, but the normal force will still affect the frictional force.*



$$F_{net} = F_a - F_f$$

$$F_{net} = ma$$

$$a = F_{net}/m$$

Level 2: A steel cube counterweight with a mass of 100kg is sitting on an asphalt road. The coefficient of friction between the weight and the road is given as 0.30. The road is at a 25° slope as shown below. If the counterweight is pushed on its side as shown with 1000 newtons, how fast would the counterweight accelerate in m/s²?