



PROBLEM-SOLVING TUTORIAL

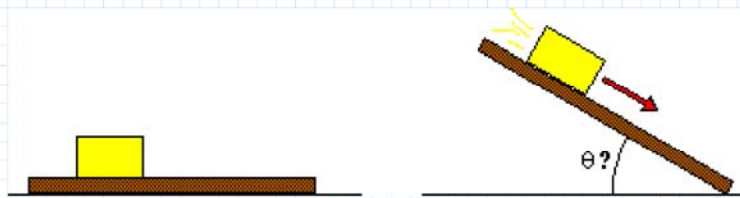
4.5 Solving Equations: Supplemental Problems

Introduction

In this supplemental section there is another problem that uses the symbolic equal sign and commands that you learned about in the Tutorial and the Exercises.

Question

A block with some mass M sits on a board. If the coefficient of static friction μ_s is 0.36, then at what angle θ does the block just begin to slide?



Hints

This problem is not easy. Remember, you should not expect to write down $\tau = ?$ on the first step. Mathcad can solve for that variable when needed. In fact, forget about getting the equations at first and describe for yourself what will happen in everyday terms, **then** try to explain that in physical terms. Ask yourself, “why does the block stay still and why does it begin to move?”

As you start to identify the various forces involved in the problem, you can jot them down with the symbolic equals sign $=$. Then you can use the **Symbolics** \Rightarrow **Solve** command to find the solution.

Problem Space

Question

A block with some mass M sits on a board. If the coefficient of static friction μ_s is 0.36, then at what angle θ does the block just begin to slide?

Solution

We are given in the problem that

Coefficient of static friction: $\mu_s := 0.36$

The two forces acting on the block and the normal force are:

$$\text{Component of weight along board: } F_g = M \cdot g \cdot \sin(\theta)$$

$$\text{Friction force: } F_f = \mu_s \cdot F_N$$

$$\text{Normal force: } F_N = M \cdot g \cdot \cos(\theta)$$

Just at the point where the block begins to move on the board, we have:

$$F_g = F_f$$

Using cut and paste we find

$$M \cdot g \cdot \sin(\theta) = \mu_s \cdot F_N$$

$$M \cdot g \cdot \sin(\theta) = \mu_s \cdot M \cdot g \cdot \cos(\theta)$$

Now using the symbolic **Variable E Solve** command for the angle θ , we find the angle just at the point the block begins to move is:

$$M \cdot g \cdot \sin(\theta) = \mu_s \cdot M \cdot g \cdot \cos(\theta)$$

has solution(s)

$$\text{atan}(\mu_s)$$



Therefore

$$\theta := \text{atan}(\mu_s)$$

$$\theta = 19.8 \text{ deg}$$

**State
Conclusions**

So at 19.8 degrees the block will start to slide.

Now you are ready to move on to **Chapter 5: Graphs**, where you will learn how graphs can help you understand more about each problem you encounter.