Slip-n-Tip/Breaking Bats

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* Coefficient of Friction μ_s
* Incline Method
* Slipping and Tipping Method
* The Experiment
* The Results

Coefficient of Friction

What is the coefficient of friction? Where does it come from?

Experimental expression for friction:

$$F_f \leqslant \mu_s F_N$$

Express the Coefficient of friction as a ratio between the frictional force (F_f) and the normal force (F_N).

$$\mu_s \geqslant \frac{F_f}{F_N}$$

If μ_s is less than 1(which is normally the case), what can be said about F_f and F_N?

How can we calculate this value in the lab?

Coefficient of Static Friction Incline Method

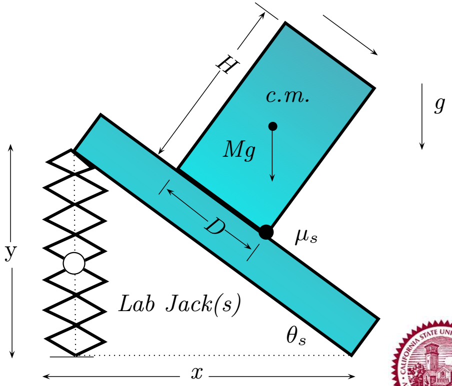
An incline plane is one way to calculate the coefficient.

How it works:

* Two surfaces
* Start flat and lift
* Watch for the object to slide

How does this give us the coefficient of friction?

Figure: Incline Plane Method for calculating μ_s



Coefficient of Friction Incline Method cont...

After seconds of thinking, and hours of distraction...

We finally use Newton's 2nd law and our equation for friction to derive and expression for the coefficient of friction:

$$\sum F_x : Mg\sin\theta - F_f = 0$$

$$\sum F_y : F_N - Mg\cos\theta = 0$$

$$F_f \leqslant \mu_s F_N$$

$$\mu_s = \tan\theta$$

$$\mu_s = \frac{y}{x}$$

Notice anything interesting about the μ_s?

The *Slipping and Tipping* method uses torque arguments to find the coefficient of friction between two objects.

How the method works:

* Set object on flat surface
* At the bottom of the object apply a gentle force
* Gradually increase the applied force until:
  1) the object slips
     - apply the force higher on the object
  2) the object tips
     - then you've reached the critical height and you may now calculate μ_s

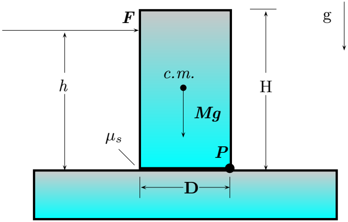


Figure: Slipping and Tipping Method μ_s

How do we calculate the coefficient of friction?

We calculate μ_s by summing up the torques

$$\sum \tau : Fh - Mg\frac{D}{2} = 0$$

Solve for Applied force

$$F = \frac{MgD}{2h}$$

Height at which tipping occurs

$$h_c = \frac{MgD}{2F}$$

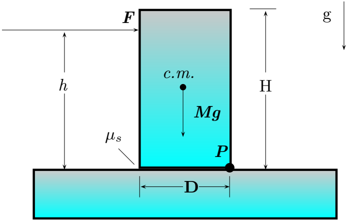


Figure: Slipping and Tipping Method μ_s

The object tips when $F = F_f$

$$h_c = \frac{MgD}{2\mu_s Mg}$$

Relationship between the critical height and μ_s

$$\mu_s = \frac{D}{2h_c}$$

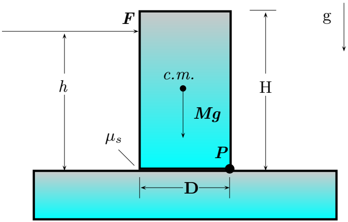


Figure: Slipping and Tipping Method μ_s

Incline Method vs. Slipping and Tipping

Incline Plane:

Problems and limitations

* Block cannot tip before sliding $\tan\theta_s < \frac{D}{H}$
* Homogeneous surfaces
* Careful lifting
* Slide and Stop!!!!

Slipping and Tipping:

Problems and limitations

* Find objects where $H > h_c$
* Homogeneous surfaces

Results

Turns out that we couldn't get a complete agreement between the two methods.

Surfaces	Slip-n-Tip	Incline
Wood/Glass	0.35 ± 0.01	0.35 ± 0.01
Al/Glass	0.33 ± 0.01	0.38 ± 0.01
Styrofoam/Glass	0.49 ± 0.01	0.49 ± 0.02

This disagreement between the Aluminum block and glass may reflect the limitation of this method.

Breaking Bats

Overview

- The Problem
- The Experiment
- The Results
- Future Work (if I feel like it)

The Problem

How do bats break?

Figure: Screen Shot from Baseball Bugs - 1946

The Problem cont...

* Why is a Breaking Bat a problem?
* How has it gotten worse?
* How does this transition make it worse?

The Problem cont...

So why the transition from ash to maple?

The transition is due to a belief among players that maple bats can exert more force on a baseball than ash without failing.

So we tested this idea. We also looked at two other properties that are exhibited by baseball bats on the field:

1. The force required to break the dowels
2. The flexibility of each type of wood
3. The consistency of each type of wood's failure mode

The Set Up

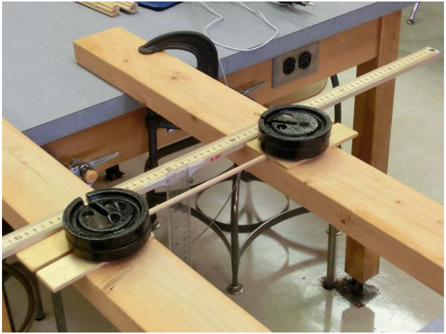
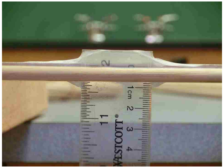
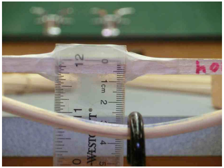


Figure: The set up we designed to break our lovely dowels.

* Used two 2x4's to support the 9" dowels.
* Used a ruler and camera to measure the deflection
* Used wedges and weights to hold the orientation of the dowels

Data Collection





The figures at the left is how we collected the data.

* Set weight on dowel for 20 seconds
* Took picture at 20 second mark
* Took mass off of dowel added $\frac{1}{2}$ kg
* Repeat steps until dowel breaks

From the 16 trials we ran we discovered that:

1. The average force required to break the dowels was the same within uncertainty

   Ash: $F_{break} = 78.5 \pm 1.1$ N
   Maple: $F_{break} = 76.6 \pm 0.8$ N

2. The average deflection of the dowels

   Ash: 2.31 ± 0.36 cm
   Maple: 1.69 ± 0.18 cm

3. Failure Mode

   Ash: 3 : 8 broke with sharp edges
   Maple: 7 : 8 broke with shape edges

Results cont...

Even though we didn't use bats, we were able to demonstrate these three key features with the dowels:

1. Ash is more flexible then maple
2. The force to break them is about equal
3. maple consistently breaks with sharp edges

If you feel like reading...

If you are interested in reading the papers this talk is based on you can check them out here

Isaac Aguilar, David Kagan. *"Breaking Bat"*. The Physics Teacher 51: 80, Feb 2013

Dietz, Eric, Isaac Aguilar. *"Slipping and Tipping: Measuring Static Friction with a straight-edge"*. The Physics Teacher 50: 475, Nov 2012