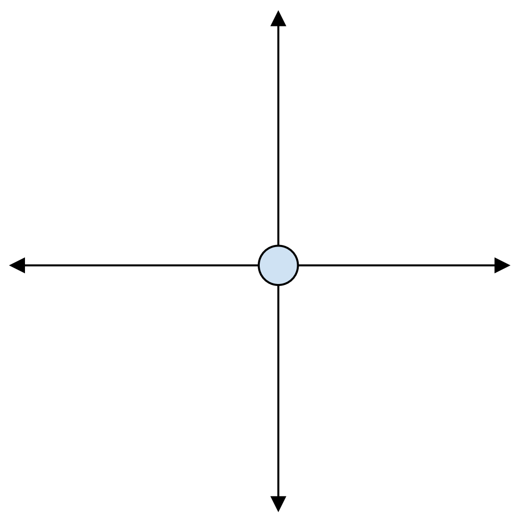
FTC 2020 - February 1
Grabber Physics Analysis

For the grabber, we wanted to find out how much force was being applied on the stone by the grabber. In the grabber-stone system, there are 4 forces exerted on the stone: the force of gravity, the force of friction, the applied force by the grabber, and the normal force perpendicular to the contact force. The force of gravity always pulls straight down, so we knew that the force of friction would be acting directly upwards on the stone (Fig 1).

Free-body Diagram of Stone:



Finding the force applied:

Because we want the stone not to fall out of the grabber, and therefore not be moving, the stone in our case has no acceleration. This means that the sum of the external forces ($\Sigma Fext$) in both the x and y directions is equal to 0.

Solving for Fp:

$\Sigma F_x = 0$
$Fp - Fn = 0$
$Fp = Fn$

$\Sigma F = 0$

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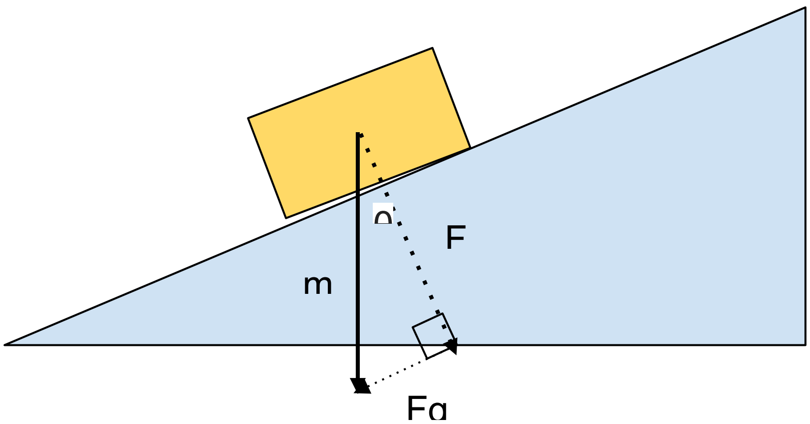
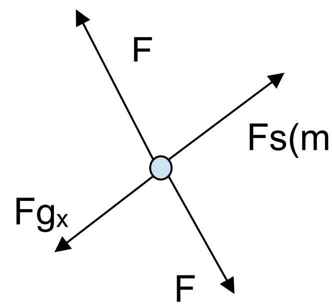
$\mu Fn = Fg$
$\mu Fp = Fg$
$Fp = Fg/\mu$
$Fp = (mg)/\mu$

Calculating the Static Coefficient of Friction:

We had every value to calculate the force applied by the grabber except μ, the coefficient of friction. Because we were doing everything through trial and error and without experimental data, we did not know the coefficient of friction between the rubber window sealant that we used on the grabber, and the plastic skystone. We were unsuccessful in finding this value online, so we decided to calculate it ourselves (Fig. 2). We taped some of the window sealant to a wooden board, set the stone on the sealant, and tilted the board until the stone slipped. The angle at which that occured was 25°





Fg_x = Fs(max)

Fg_y = mgcosθ

$mg\sin\theta = \mu F_n$

$mg\sin\theta = \mu mg\cos\theta$

$\sin\theta = \mu\cos\theta$

$\mu = \tan\theta$

Finally, calculating the force applied:

We now have an equation to find the applied force, Fp, and the value of the coefficient of friction, μ. We just need to put them together.

$Fp = (mg)/\mu$
$Fp = ((1.92kg)(9.8m/s^2))/0.466$
$Fp = 4.03\ N$

This value of the applied force is means that the stone will stay in the grabber. The stone weighs (1.92)(9.8) = 1.88 N (0.422 lb), which is much less than the force applied on the stone by the gripper, 4.03 N (0.905 lb

Fig. 1:

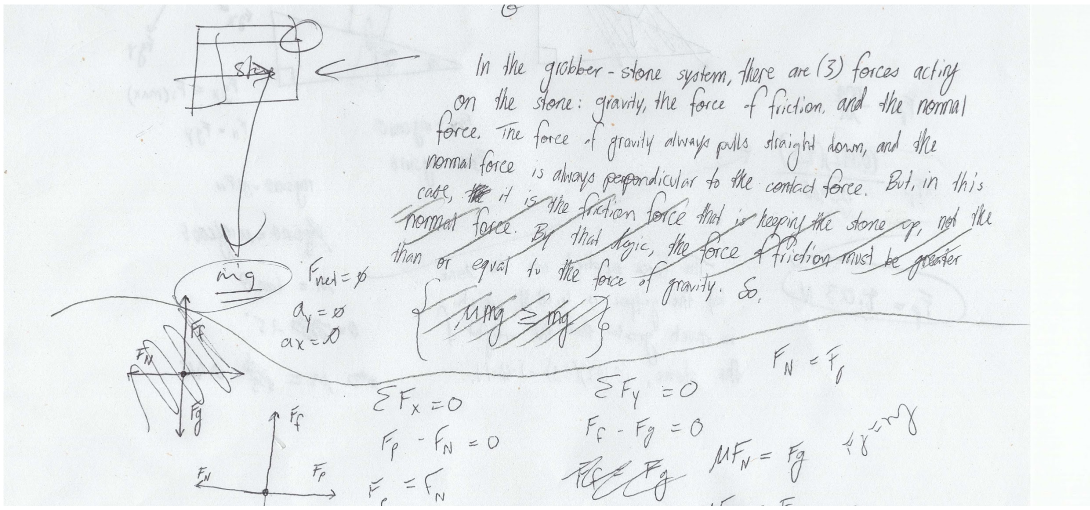


Fig. 2