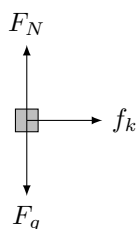# 2.1: Friction Lab

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Worked with Cole TerBush and Daniel Aronov

1 • Free Body Diagrams and Derivations

1.1 Section 1

1.1.1 Free body Diagram

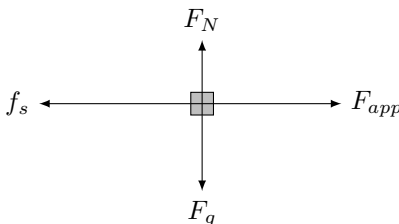### 1.1.2 Derivation

$$v_x{}^2 = v_{x0}{}^2 + 2a_x\Delta x$$

$$a_x = \frac{v_x{}^2 - v_{x0}{}^2}{2\Delta x} = \frac{f_k}{m} = \frac{\mu_k mg}{m}$$

$$\mu_k g = \frac{v_x{}^2 - v_{x0}{}^2}{2\Delta x}$$

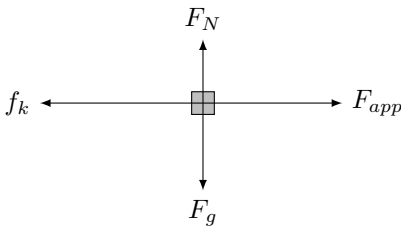$$\mu_k = \frac{v_x{}^2 - v_{x0}{}^2}{2g\Delta x}$$

Since the final velocity is zero, this can be simplified to:

$$\mu_k = \frac{-v_{x0}{}^2}{2g\Delta x}$$

1.2 Section 2

1.2.1 Free Body Diagram

1.2.2 Derivation

At peak static friction:

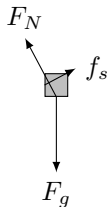$$f_s = \mu_s F_n = \mu_s mg$$

$$\mu_s = \frac{f_s}{mg}$$

At kinetic friction:

$$f_k = \mu_k F_n = \mu_k mg$$

$$\mu_k = \frac{f_k}{mg}$$

1.3 Section 3

1.3.1 Free Body Diagram

1.3.2 Derivation

At the point right before the box starts to fall:

$$f_s = \mu_s F_n = \mu_s mg\cos(\theta) = mg\sin(\theta)$$

$$\mu_s = \tan(\theta)$$

2 • Data

2.1 Section 1

Initial Velocity (m/s)	Distance (m)	Coefficient of kinetic friction	Acceleration (m/s^2)
0.82	0.13	0.33	-3.23
0.71	0.08	0.44	-4.30
1.09	0.12	0.45	-4.38
0.64	0.07	0.46	-4.47
0.63	0.07	0.44	-4.29

2.2 Section 2

Peak Static Friction (N)	Average Kinetic Friction (N)	Box Weights Mass (kg)	mu_k	mu_s
6.95	4.89	2.044	0.244	0.347
9.67	5.72	2.044	0.286	0.483
8.69	5.34	2.044	0.267	0.434

2.3 Section 3

Height (m)	Ramp Position (m)	Angle (deg)
0.385	0.800	28.767

3 • μ Values

3.1 Section 1

$$\mu_{k1} = 0.42$$

3.2 Section 2

$$\mu_{k2} = 0.265$$
$$\mu_{s2} = 0.421$$

3.3 Section 3

$$\mu_{s3} = 0.537$$

3.4 Comparison

Our values for both coefficients were very inconsistent, with μ_k having a difference of 0.155 and μ_s having a difference of 0.116. This should not happen, as we conducted the lab on the same surface

for all three sections. As such, these inconsistencies may have been a result of experimental error.

4 • Improvements

For Section 2, we had different people pull for each trial, which definitely skewed our results. Having one person pull would be better, as it results in more consistency. For Section 3, we only had enough time to perform one trial, but if we had more time, we definitely should have performed more trials. If we had more time, we would also redo some of the sections entirely, since the value for each coefficient of friction vary drastically between each section when they should not vary much.