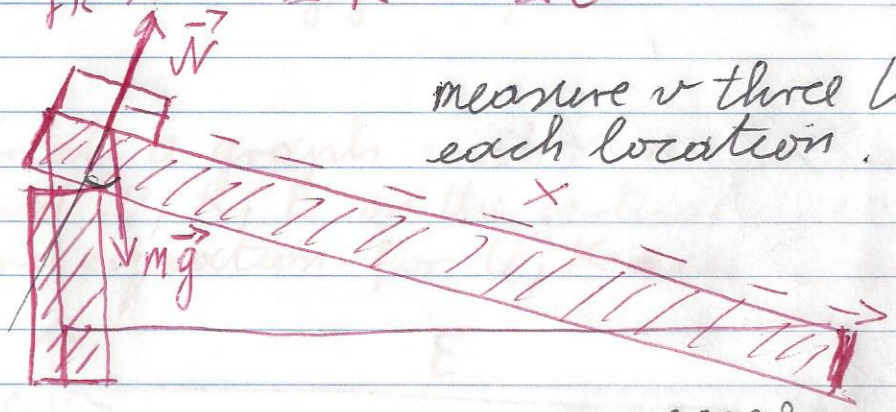
# Lab 4: Energy Conservation Lab

## 1) Description of Experiment

$$-f_k \cdot x = \Delta K + \Delta U$$




measure v three times at each location.

$m_1 = 0.200$ kg

We allow a cart of mass m to slide down an inclined plane with angle $\theta$.
There is kinetic friction.

$$-f_k \Delta x = \Delta K + \Delta U = \frac{1}{2} m \Delta v^2 - mg(y_f - y_i)$$

We choose the positive x-axis along the inclined plane. We choose x=0 ~~at~~ the center of the cart at the 10 cm mark on the tape measure of the inclined plane, and measure $y_i$ from the table to the cart. (center contact point with plane, or anywhere else. You must be consistent.) every 20 cm down to 180 cm.

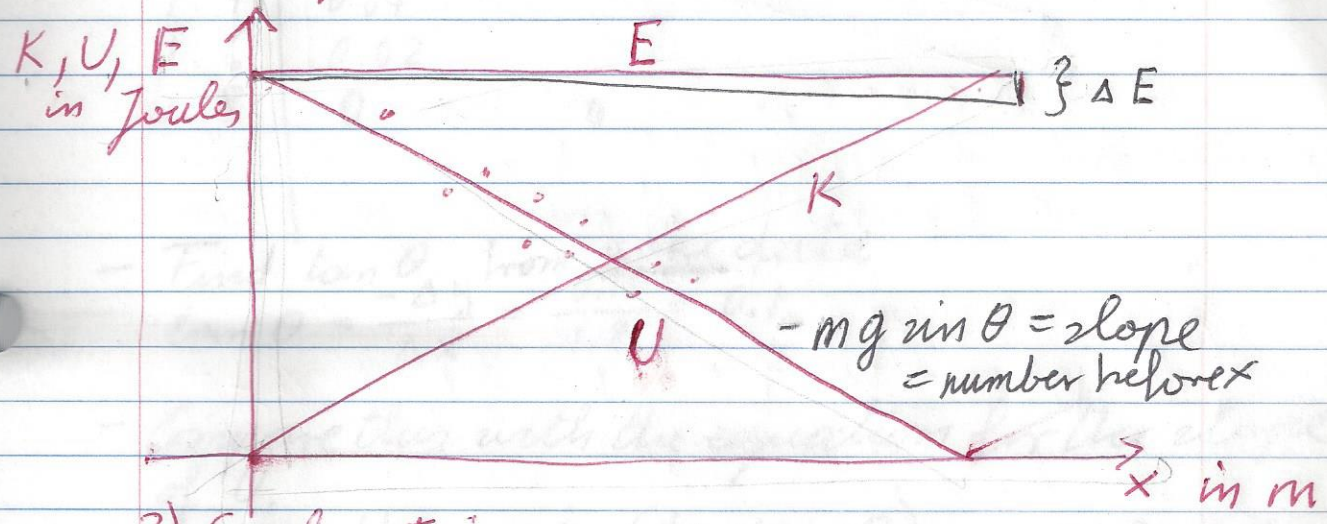
- Then we measure v at the same points by using a photo gate and a smart-timer set to speed and one gate.

Make sure that the upper 3 bars are at the level of the photo beam holes.

2) Create columns in Excel:

| x | y | $v$ | $U = mgy$ | $K = \frac{1}{2}mv^2$ | $U + K = E$ | $v$ ideal $\sqrt{2gh}$ |
|---|---|---|---|---|---|---|

Create a graph with x as the horizontal axis and U, K, E on the vertical axis. Get an equation for U, K and E from Excel.




3) Evaluation

If E is not horizontal you have energy lost due to friction. $v = \sqrt{2gh}$ if no friction

$$\Delta E = -f_K \cdot x = \Delta K + \Delta U$$

$$f_K = \mu_K \cdot N = \mu_K \cdot mg\cos\theta$$

$$\Delta K = \frac{1}{2}m(v_f^2 - v_i^2)$$

$$\Delta U = -mg\Delta y = -mgx\sin\theta$$

My example:

| | x | y | v | U | K | E | v ideal |
|---|---|---|---|---|---|---|---|
| m=0.2 | 0.0 | 0.18 | 0 | =mgy | 0 | 0 | 0 |
| | 0.2 | 0.16 | | | | | $\sqrt{2gh}$ |
| | 0.4 | 0.14 | | | | | |
| | 0.6 | 0.12 | | | | | |
| | 0.8 | 0.10 | | | | | |
| | 1.0 | 0.08 | | | | | |
| | 1.2 | 0.06 | | | | | |
| | 1.4 | 0.04 | | | | | |
| | 1.6 | 0.02 | | | | | |
| | 1.8 | 0 | | 0 | | | |

These are idealized numbers (no friction).

- Find $\tan\theta$ from ~~your~~ data

$$\tan\theta = \frac{-\Delta y}{\Delta x} = \frac{0.18}{1.8} = 0.1$$

- Compare this with the equation for the slope of U.

$$\Delta U = mg(y_f - x_f \sin\theta); \quad y_i = 1.8 \cdot \sin\theta \text{ m}, \quad x_f = 1.8 \text{ m}$$

force equation: $\sum \vec{f}_K + \vec{N} + m\vec{g} = m\vec{a}$

$$x: \; -f_K + mg\sin\theta = ma$$

$$-\mu_K mg\cos\theta + mg\sin\theta = ma$$

$$W = -\mu_K mg\cos\theta\Delta x + mg\sin\theta\Delta x = ma\Delta x = m\cdot\frac{1}{2}\Delta v^2$$

$$-\mu_K mg\cos\theta\cdot\Delta x = \frac{1}{2}m\Delta v^2 - mg\sin\theta\,(x_f - x_i)$$

$$= \frac{1}{2}m\Delta v^2 + mg\sin\theta\,(x_i - x_f)$$

$\Delta x = x_f - x_i$

from graph

from $\Delta E = -\mu_K m g \cos\theta (x_f - x_i) = -f_K \cdot \Delta x$

① Find $\Delta E$ from your graph:

Use the slope of E and multiply by 1.8 m

You have $\theta$ from both

$\theta_1$ : ~~tan~~ sin $\theta_1 = \frac{-\Delta y}{\Delta x} = ?$

and from the slope of U which is

$-mg \sin\theta_2$ ②

Divide by mg and get $\sin\theta = ?$

Compare both $\theta$ values for $\theta$.

Find $\mu_K$:

$$\mu_K = \left| \frac{\Delta E}{mg\cos\theta x} \right|$$

$m = 0.2$ kg
$g = 9.8\ m/s^2$
$x = 1.80$ m

$\frac{\theta_1 + \theta_2}{2}$

- Excel table: numbers + formulas
- Graph with E, U, K versus x

Get up to 14 points !!