Friction Lab

Part D

P_1 Data

m_n (g)	m_2 min (g)	m_2 max (g)	m_2 best (g)
411.4	149	150	149.5
511.4	184	185	184.5
611.4	225	226	225.5
711.4	257	258	257.5
811.4	297	298	297.5
911.4	332	333	332.5

P_2 data

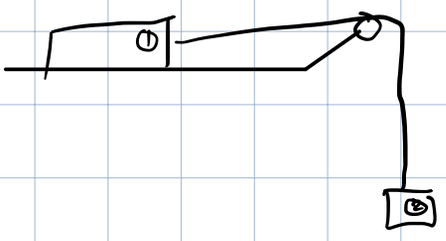
θ min	θ max	θ best
18.5	19	18.75

P_3 data

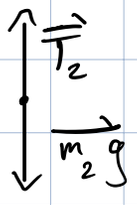
m_2 min	m_2 max	m_2 best
267	268	267.5

Part 1

(a)

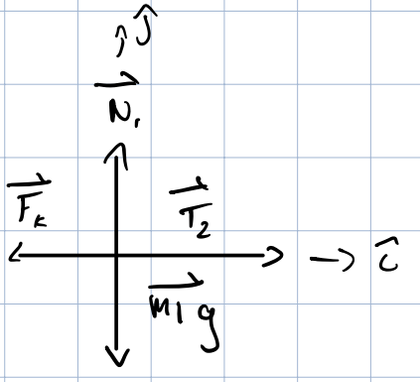


FBD - 2



$T_2 = m_2 g$

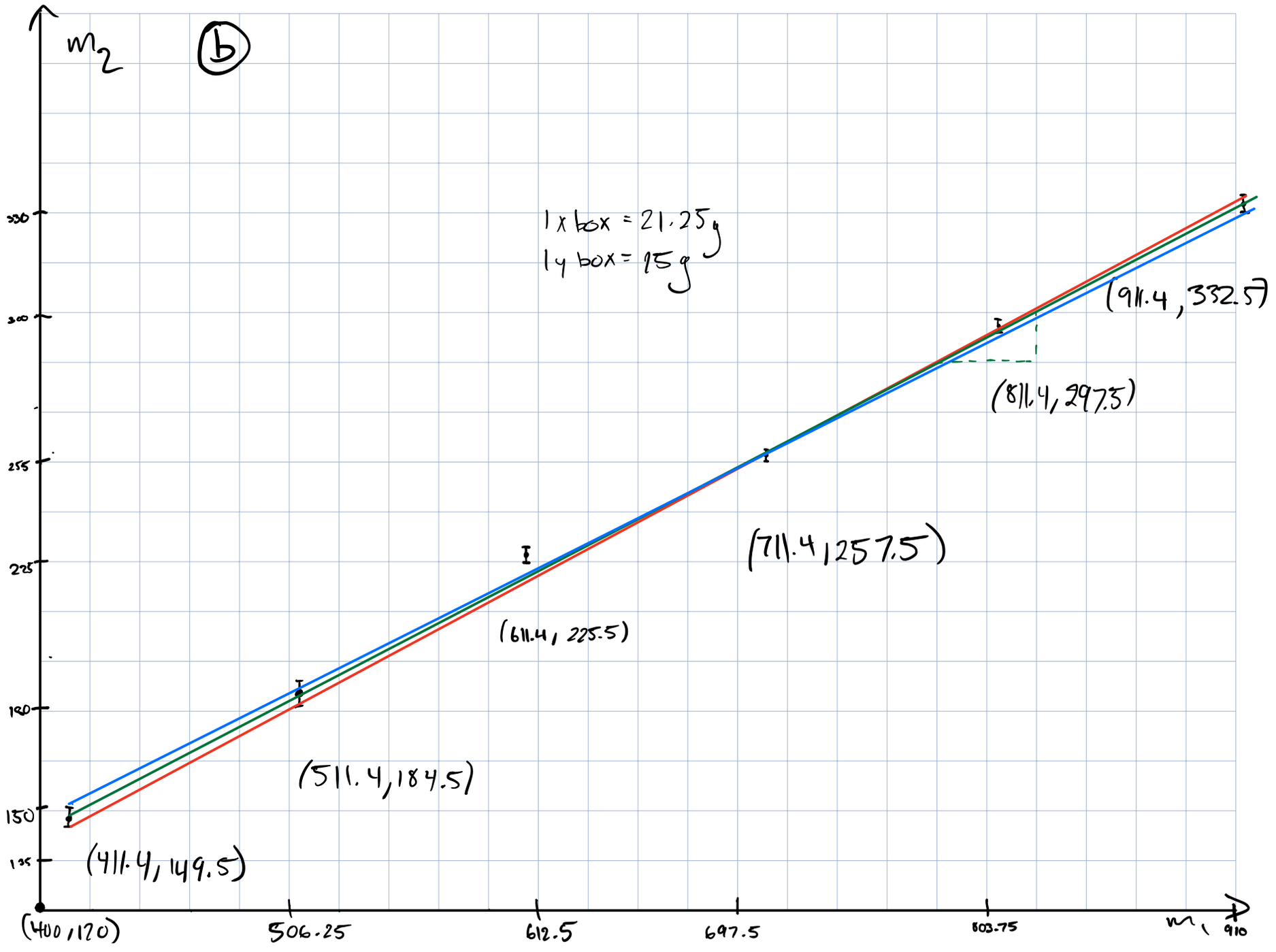
FBD - 1



	$\hat{i}$	$\hat{j}$
$\vec{w}_1$	0	$-m_1 g$
$\vec{N}_1$	0	$m_1 g$
$\vec{T}_2$	$m_2 g$	0
$\vec{F}_k$	$-\mu_k N_1$	0

$m_2 g = \mu_k m_1 g$

$$\boxed{\mu_k = \frac{m_2}{m_1}}$$


m_2
(b)
1 x box = 21.25 g
1 y box = 15 g
330
300
255
225
195
150
135
(911.4, 332.5)
(811.4, 297.5)
(711.4, 257.5)
(611.4, 225.5)
(511.4, 184.5)
(411.4, 149.5)
(400, 170)
506.25
612.5
697.5
803.75
910
m_1

© $P_2 = (825, 300)$; $P_1 = (782.5, 285)$

$$\mu_{k\,best} = \frac{300-285}{825-782.5} = \frac{15}{42.5} = 0.353$$

~~$P_2 = ($ doesn't intersect~~

~~$P_2 = (782.5, 285)$~~ ~~$P_1 = ($ don't intersect again~~

★ Because blue & red don't intersect grid @ 2 points I will be using the actual measuremets

$P_2 = (911.4, 332)$; $P_1 = (411.4, 150)$

$$\mu_{k\,min} = \frac{332-150}{911.4-411.4} = \frac{182}{500} = 0.364$$

$P_2 = (782.5, 285)$; $P_1 = (411.4, 149)$

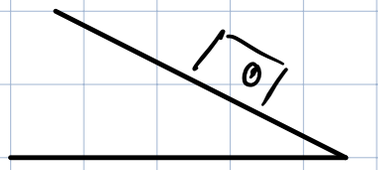
$$\mu_{k\,max} = \frac{285-149}{782.5-411.4} = \frac{136}{371.1} = 0.366$$

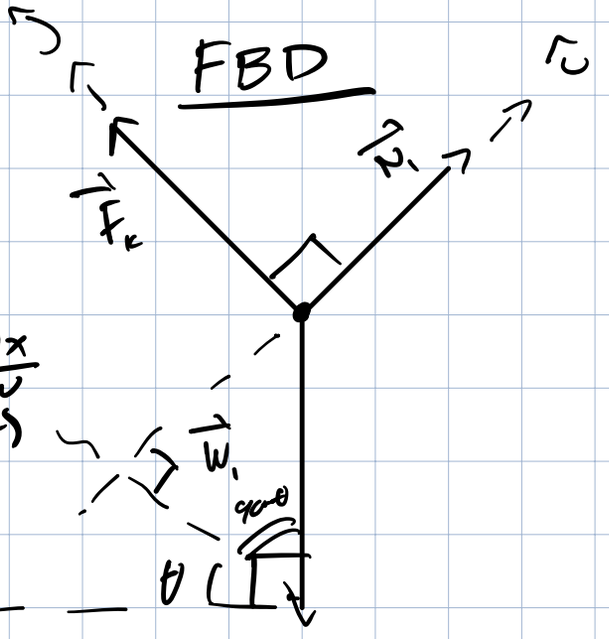
(d) Not sure what went wrong.
μ_k from the data is $.367 \pm .02$ but from my graph, is $.354 \pm$? μ_k from the graph isn't even within its bounds. With a larger graph paper maybe I could have used only values from the graph.

$$\mu_k = .367 \pm .02$$

Part 2

(a)





$\cos(90-\theta) = \frac{w_y}{w}$ $\quad$ $\sin(90-\theta) = \frac{w_x}{w}$

$w_y = w\cos(90-\theta)$ $\quad$ $w_x = w\sin(90-\theta)$

	$\hat{\imath}$	$\hat{\jmath}$
$\vec{N}_1$	N_1	0
$\vec{F}_k$	0	$\mu_k N_1$
$\vec{w}_1$	$-w\sin(90-\theta)$	$-w\cos\theta$

soln

$\sin(\theta) = \frac{w}{w_1}$

$N_1 = w\sin(90-\theta)$

$\mu_k [w\sin(90-\theta)] = w\cos(90-\theta)$

$\mu_k = \frac{\cos(90-\theta)}{\sin(90-\theta)} = \cot(90-\theta) = \boxed{\tan(\theta) = \mu_k}$

$\mu_k = \tan(18.75) = \boxed{1.339 = \mu_k}$

(b) $\delta\mu_k = \frac{d\mu_k}{d\theta}\delta\theta$ $\qquad \mu_k = \tan\theta$

$\frac{d\mu_k}{d\theta} = \frac{d}{d\theta}\tan\theta = \sec^2\theta$

θ_{min}	θ_{max}	θ_{best}
18.5	19	18.75

$\Rightarrow$ in radians

.3229 | .3316 | .3272

$$\delta\theta = \frac{.3316 - .3229}{2} = .00435 \text{ rad}$$

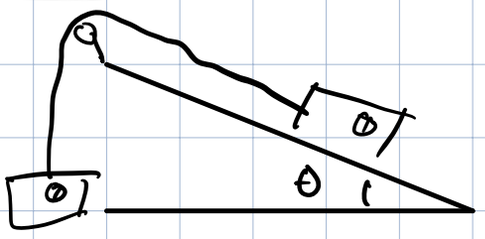
$$\delta\mu_k = \sec^2(.3272)(.00435) = .00485 \text{ radians}$$

$$\boxed{\delta\mu_k \approx 4.85 \times 10^{-3}}$$

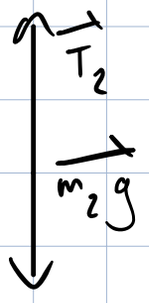
© In part 1, μ_k was $.367 \pm .02$.
In part 2, μ_k is $.339 \pm 4.85 \times 10^{-3}$.
One reason for the difference in μ_ks is that my measurement of the angle in part 2 is less precise. As you can see I said θ_{min} is 18.5°, this was an eyeball estimate. the device only measure in 1° increments. At 18° the block wouldn't move & at 19° the block moved at constant velocity so I estimated the min to be 18.5°.

Part 3

(a)

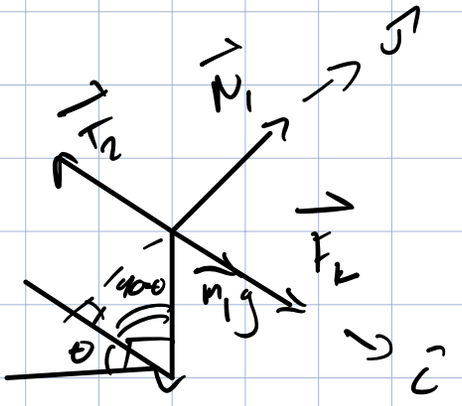


FBD-2



$T_2 = m_2 g$

FBD-1



$\sin(90-\theta) = \frac{w_y}{m_1 g}$

$w_y = m_1 g \sin(90-\theta)$

$w_x = m_1 g \cos(90-\theta)$

	$\hat{i}$	$\hat{j}$
$\vec{N}_1$	0	N_1
$\vec{T}_2$	$-m_2 g$	0
$\vec{F}_k$	$\mu_k N_1$	0
$\vec{W}_1$	$m_1 g \cos(90-\theta)$	$-m_1 g \sin(90-\theta)$

$$N_1 = m_1 g \sin(90-\theta)$$

$$m_2 g = \mu_k m_1 g \sin(90-\theta) + m_1 g \cos(90-\theta)$$

$$m_2 = m_1 (\mu_k \sin(90-\theta) + \cos(90-\theta)$$

$\mu_k = .367$

$\theta = 18.75°$

$m_1 =$

$$m_2 = 411.4\,g\,(.367 \sin(90-18.75) + \cos(90-18.75))$$

$$\boxed{m_{2c} = 275.2\,g}$$

(b) $$\left(1 - \frac{268\,g}{275.2\,g}\right) 100 \approx \boxed{2.62\%}$$