PH 1110 Lab 4 CX17

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1 Propagation of Uncertainty

1) Python 3.6 code for propagation of uncertainty:

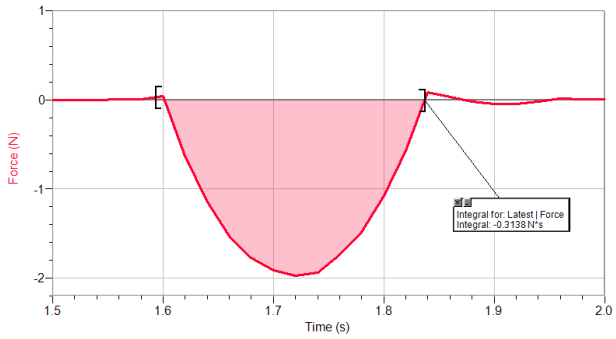
```
### 1: velocity
v_Ai =0.3283 #initial velocity
dv_Ai =0.0159 #uncertainty of velocity
v_Af =-0.2890 #final velocity
dv_Af =0.0028 #uncertainty of "
delta_vA =v_Af -v_Ai #change in velocity
dvA =dv_Ai +dv_Af #propogation of uncertainty for velocity
### 2: mass
m =0.4975 #measured mass of the cart in kg
dm =0.0001 #uncertainty in "
### 3: momentum
p_0 = (m *v_Ai) #initial momentum of the system
dp_0 =p_0 * ((dm/m)+((dv_Ai)/abs(v_Ai))) #uncertainty in "
#Some notes on the above equation
#Don't need to do absolute value of m
#because it's already positive
p_f = (m *v_Af) #final momentum of the system
#uncertainty in momentum
dp_f =p_f * ((dm/m)+((dv_Af)/abs(v_Af)))
delta_p =p_f -p_0 #change in momentum
dp =dp_f +dp_0 #uncertainty of "
print("change in momentum:",delta_p,"±",dp," kg * m/s")
#print the change in momentum and its uncertainty

#>> change in momentum: -0.30710675 ± 0.00652118  kg * m/s
```

2 Writing

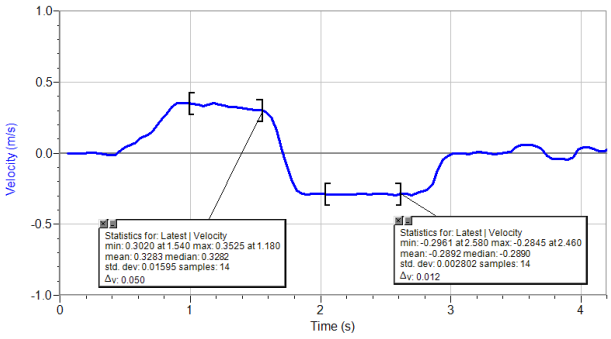
1) Firstly, you must set the force sensor to the 10 kN switch setting, and the motion sensor to the cart setting. Then, you start collection for 3 time trials, each of which has an increased velocity. Note, do not fully compress the force sensor spring. Next, after you have saved the force reading and velocity reading for each of the three time trials, you

will analysis them as follows. For the force sensor, preform an integral fit on the parabolic region to obtain the impulse over this area. For the velocity, preform a statics fit on the initial velocity, and on the final velocity.

2) This experiment validated the hypothesis that impulse is equal to the change in momentum, as shown by the data in Table 1.

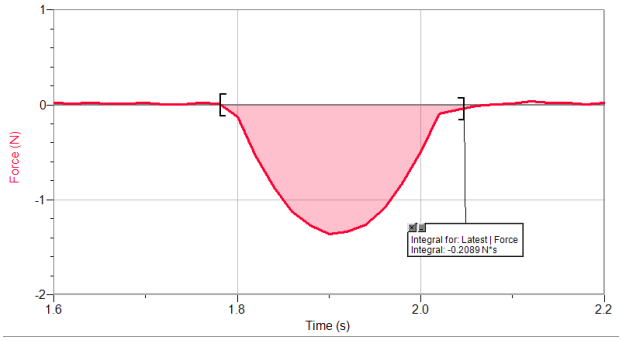


(a) Slow force. The impulse measured is $-0.3138\,\mathrm{N\,s}$.

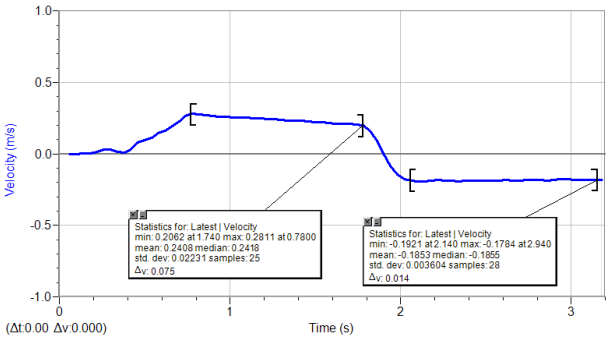


(b) Slow velocity. The initial velocity is $0.3283\,\mathrm{m\,s^{-1}}$ with $\sigma = 0.0159\,\mathrm{m\,s^{-1}}$, and the final velocity is $-0.2890\,\mathrm{m\,s^{-1}}$ with $\sigma = 0.0028\,\mathrm{m\,s^{-1}}$

Figure 1: Slow trial measurements.

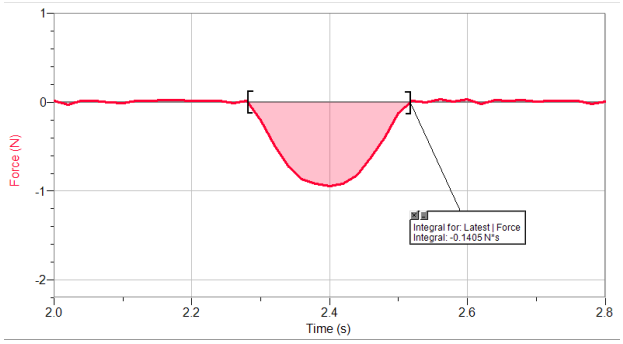


(a) Slower force. The impulse measured is $-0.2089\,\mathrm{N\,s}$.

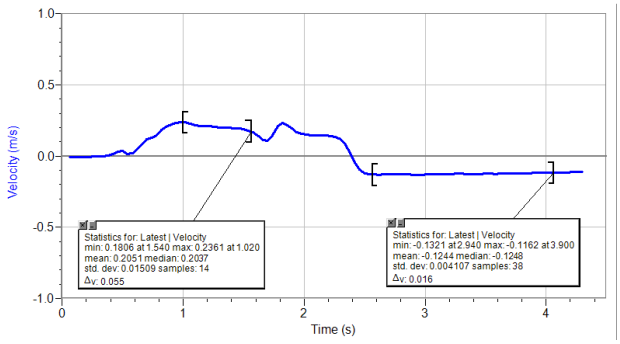


(b) Slower velocity. The initial velocity is $0.2408\,\mathrm{m\,s^{-1}}$ with $\sigma = 0.0223\,\mathrm{m\,s^{-1}}$, and the final velocity is $-0.1853\,\mathrm{m\,s^{-1}}$ with $\sigma = 0.0004\,\mathrm{m\,s^{-1}}$

Figure 2: Slower trial measurements.



(a) Slowest force. The impulse measured is $-0.1405\,\mathrm{N\,s}$.



(b) Slowest velocity. The initial velocity is $0.2051\,\mathrm{m\,s^{-1}}$ with $\sigma = 0.0151\,\mathrm{m\,s^{-1}}$, and the final velocity is $-0.1244\,\mathrm{m\,s^{-1}}$ with $\sigma = 0.0041\,\mathrm{m\,s^{-1}}$

Figure 3: Slowest trial measurements.

Table 1: Experiment Data

Measurement	Slow	Slower	Slowest
Impulse	$-0.3138\,\mathrm{N\,s}$	$-0.2089\,\mathrm{N\,s}$	$-0.1405\,\mathrm{N\,s}$
Initial Velocity	$0.3283\,\mathrm{m\,s^{-1}}$	$0.2408\,\mathrm{m\,s^{-1}}$	$0.2051\,\mathrm{m\,s^{-1}}$
Initial Velocity Uncertainty	$0.0159\,\mathrm{m\,s^{-1}}$	$0.0223\,\mathrm{m\,s^{-1}}$	$0.0151\,\mathrm{m\,s^{-1}}$
Final Velocity	$-0.2890\,\mathrm{m\,s^{-1}}$	$-0.1853\,\mathrm{m\,s^{-1}}$	$-0.1244\,\mathrm{m\,s^{-1}}$
Final Velocity Uncertainty	$0.0028\,\mathrm{m\,s^{-1}}$	$0.0004\,\mathrm{m\,s^{-1}}$	$0.0041\,\mathrm{m\,s^{-1}}$
Mass of Cart	$0.4975\,\mathrm{kg}$	$0.4975\,\mathrm{kg}$	$0.4975\,\mathrm{kg}$
Uncertainty of Mass of Cart	$0.0001\,\mathrm{kg}$	$0.0001\,\mathrm{kg}$	$0.0001\,\mathrm{kg}$
Change of Momentum	$-0.3071\,\mathrm{kg\,m\,s^{-1}}$	$-0.2119\,\mathrm{kg\,m\,s^{-1}}$	$-0.1639\,\mathrm{kg}$
Uncertainty on Momentum	$0.0065\,\mathrm{kg\,m\,s^{-1}}$	$0.0109\,\mathrm{kg\,m\,s^{-1}}$	$0.0054\,\mathrm{kg\,m\,s^{-1}}$

3) a) For the slow and slower tests, the results matched within the calculated uncertainty. The values were $-0.3138\,\mathrm{N\,s}$ and $-0.3071\,\mathrm{kg\,m\,s^{-1}}$, and $-0.2089\,\mathrm{N\,s}$ and $-0.2119\,\mathrm{kg\,m\,s^{-1}}$ respectively. For the slowest value, the impulse is $-0.1405\,\mathrm{N\,s}$, and the change in momentum is $-0.1639\,\mathrm{kg}$ with uncertainty of $0.0054\,\mathrm{kg\,m\,s^{-1}}$.

b) For the most part, the impulse equaled the change in momentum. I believe I should have redone the slowest trial, as the graph was inconsistent, and the data collected doesn't match up with what should be happening.

c) I believe an interesting addition would be to find the spring constant of the force meter.