# COL Worksheet

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**Lab partner(s):** Katherine

**Course & Section:** PHYS121 Sec 18 **Station #** 14 **Date:** Mar 6 2024

## Section D. Procedure

1. What are the masses of your two carts, gratings, and mass bars?

$m_{cart1}$ = 490.3 ± 0.1 g (units)

$m_{cart2}$ = 495.3 ± 0.1 g (units)

$m_{grating1}$ = 12.7 ± 0.1 g (units)

$m_{grating2}$ = 13.1 ± 0.1 g (units)

$m_{bar1}$ = 497.7 ± 0.1 g (units)

$m_{bar2}$ = 494.9 ± 0.1 g (units)

2. What is the average velocity for each photogate? Remember that if the two don't agree, you will have to find their ratios and adjust the velocities of all subsequent velocity measurements.

$v_{photogate1}$ = 1.379 ± 0.006 m/s (units)

$v_{photogate2}$ = 1.330 ± 0.004 m/s (units)

## Section E Analysis

3. Record your data in the tables below. Do not forget to include the directions for the vector quantities.

**Collision 1**

| | Cart 1 before collision | Cart 1 after collision | Cart 2 before collision | Cart 2 after collision |
|---|---|---|---|---|
| Mass (kg) | 1.0007 ± 0.0002 | 1.0007 ± 0.0002 | 1.0033 ± 0.0002 | 1.0033 ± 0.0002 |
| Velocity (m/s) | 0.707 ± 0.004 | 0 ± 0 | 0 ± 0 | 0.572 ± 0.008 |
| Momentum (kg m/s) | 0.707 | 0 | 0 | 0.574 |
| Kinetic energy (J) | 0.250 | 0 | 0 | 0.164 |

$\varepsilon_p$ = -0.188

$\varepsilon_k$ = -0.344

**Collision 2**

| | Cart 1 before collision | Cart 1 after collision | Cart 2 before collision | Cart 2 after collision |
|---|---|---|---|---|
| Mass (kg) | 1.0007 ± 0.0002 | 1.0007 ± 0.0002 | 0.5084 ± 0.0001 | 0.5084 ± 0.0001 |
| Velocity (m/s) | 1.305 ± 0.002 | 0.38 ± 0.07 | 0 ± 0 | 1.54 ± 0.01 |
| Momentum (kg m/s) | 1.306 | 0.38 | 0 | 0.783 |
| Kinetic energy (J) | 0.852 | 0.073 | 0 | 0.603 |

$\varepsilon_p =$ -0.11

$\varepsilon_k =$ -0.21

**Collision 3***

| | Cart 1 before collision | Cart 1 after collision | Cart 2 before collision | Cart 2 after collision |
|---|---|---|---|---|
| Mass (kg) | 0.5030 ± 0.0001 | 0.5030 ± 0.0001 | 1.0033 ± 0.0002 | 1.0033 ± 0.0002 |
| Velocity (m/s) | 1.18 ± 0.02 | -0.278 ± 0.007 | 0 ± 0 | 0.720 ± 0.004 |
| Momentum (kg m/s) | 0.59 ± 0.01 | -0.139 ± 0.004 | 0 ± 0 | 0.722 ± 0.004 |
| Kinetic energy (J) | 0.35 ± 0.01 | 0.019 ± 0.001 | 0 ± 0 | 0260 ± 0.003 |

$\varepsilon_p =$ -0.01 ± 0.01

$\varepsilon_k =$ -0.20 ± 0.01

**Collision 4**

| | Cart 1 before collision | Cart 1 after collision | Cart 2 before collision | Cart 2 after collision |
|---|---|---|---|---|
| Mass (kg) | 1.0007 ± 0.0002 | 1.0007 ± 0.0002 | 1.0033 ± 0.0002 | 1.0033 ± 0.0002 |
| Velocity (m/s) | 1.50 ± 0.01 | 0.67 ± 0.02 | 0 ± 0 | 0.67 ± 0.02 |
| Momentum (kg m/s) | 1.50 | 0.67 | 0 | 0.67 |
| Kinetic energy (J) | 1.13 | 0.23 | 0 | 0.23 |

$\varepsilon_p =$ -0.11

$\varepsilon_k =$ -0.60

**Collision 5**

| | Cart 1 before collision | Cart 1 after collision | Cart 2 before collision | Cart 2 after collision |
|---|---|---|---|---|
| Mass (kg) | 1.0007 ± 0.0002 | 1.0007 ± 0.0002 | 0.5084 ± 0.0001 | 0.5084 ± 0.0001 |
| Velocity (m/s) | 0 ± 0 | -0.409 ± 0.004 | 0 ± 0 | 0.829 ± 0.005 |
| Momentum (kg m/s) | 0 | -0.409 | 0 | 0.421 |
| Kinetic energy (J) | 0 | 0.084 | 0 | 0.175 |

$\Delta p =$ 0.012 Kg.m/s

$\Delta K =$ 0.512 J

**Collision 6**

| | Cart 1 before collision | Cart 1 after collision | Cart 2 before collision | Cart 2 after collision |
|---|---|---|---|---|
| Mass (kg) | 0.5030 ± 0.0001 | 0.5080 ± 0.0001 | 0.5084 ± 0.0001 | 0.5084 ± 0.0001 |
| Velocity (m/s) | 0 ± 0 | -0.926 ± 0.003 | 0 ± 0 | 0.891 ± 0.005 |
| Momentum (kg m/s) | 0 | -0.466 | 0 | 0.453 |
| Kinetic energy (J) | 0 | 0.216 | 0 | 0.202 |

$\Delta p =$ 0.013 Kg.m/s.

$\Delta K =$ 0.835 J.

4*. Write out the error analysis for collision 3 to find the uncertainties in momentum and kinetic energy, and the uncertainties in $\varepsilon_p$ and $\varepsilon_k$.

$$\vec{\varepsilon}_p = \frac{\vec{p}_1' + \vec{p}_2' - \vec{p}_1}{\vec{p}_1} \qquad \delta_{\vec{\varepsilon}_p} = \sqrt{\delta^2_{\varepsilon_p p_1'} + \delta^2_{\varepsilon_p p_2'} + \delta^2_{\varepsilon_p p_1}} = \sqrt{\frac{\delta^2_{p_1'}}{\vec{p}_1^{\,2}} + \frac{\delta^2_{p_2'}}{\vec{p}_1^{\,2}} + \frac{\delta^2_{p_1}(\vec{p}_1' + \vec{p}_2')^2}{\vec{p}_1^{\,4}}}$$

$$\varepsilon_k = \frac{K_1' + K_2' - K_1}{K_1} \qquad \delta_{\varepsilon_k} = \sqrt{\frac{\delta^2_{K_1'}}{K_1^2} + \frac{\delta^2_{K_2'}}{K_1^2} + \frac{\delta^2_{K_1}(K_1' + K_2')^2}{K_1^4}}$$

5. For the elastic collisions, did your data fit the conservation of energy and momentum model? Explain.

Yes, all of our $\Delta E_p$ were very low, meaning it did not change much during the collision, which means it follows the model

And not as much of conservation of energy, as our collisions were not perfectly elastic, more energy was lost, as seen by our higher (but still low) $E_k$ value.

6. For the inelastic collisions, did your data fit the conservation of momentum model? Explain. What was the relative energy loss? Where did the energy go?

Yes, just like our elastic collisions, our $E_p$ were low.

Our $E_k$ was $-0.20 \pm 0.01$, which is expected as the energy was absorbed by the velcro holding the carts together.

7. For the "explosion," did your data fit the conservation of momentum model? Explain. What was the energy gained?

Yes, just like the others, our $\Delta p$ was low.

We gain energy from the stored spring energy, that is why our $\Delta k$ was positive.

**GRADE:**_____ (out of 30 points)

**GRADED BY** _____ (TA's initials)