Physics 1021
Lab Introduction & Graphing Workshop

Department of Physics and Physical Oceanography

MEMORIAL UNIVERSITY

Newfoundland & Labrador, Canada

MUN PHYSICS

Introductory Comments

Lab Documentation:

- Workbook copy is **required** and available in MUN bookstore
- Instructions and Workbook also available:
  - On Lab Computers
  - Online @ **www.mun.ca/physics/undergraduates/fylabs/index.php**

Prelabs:

- **Must be complete to enter the lab**
  - Print or copy from website.
  - Present completed copy at door of lab

Laboratory Guidelines - Highlights

- → Pass labs to pass the course.
- → **Cell phones off/silent**. **Keep it in your bag!**
- → Keep workplace tidy. Place bags under bench. No food or drink.
- → Absence: Let your Instructor KNOW.
  - ◆ Must contact by **email** within **48 hrs**. (MUN 6.7.5c2)
  - ◆ ehayden@mun.ca
- → Labs are **1 Hour and 50 minutes** long.
  - ◆ You may **not** start lab more than **15 min late**.
- → Handle equipment carefully, When done, tidy equipment.
- → You will work in pairs and share responsibilities but must write separate reports.

Laboratory Schedule

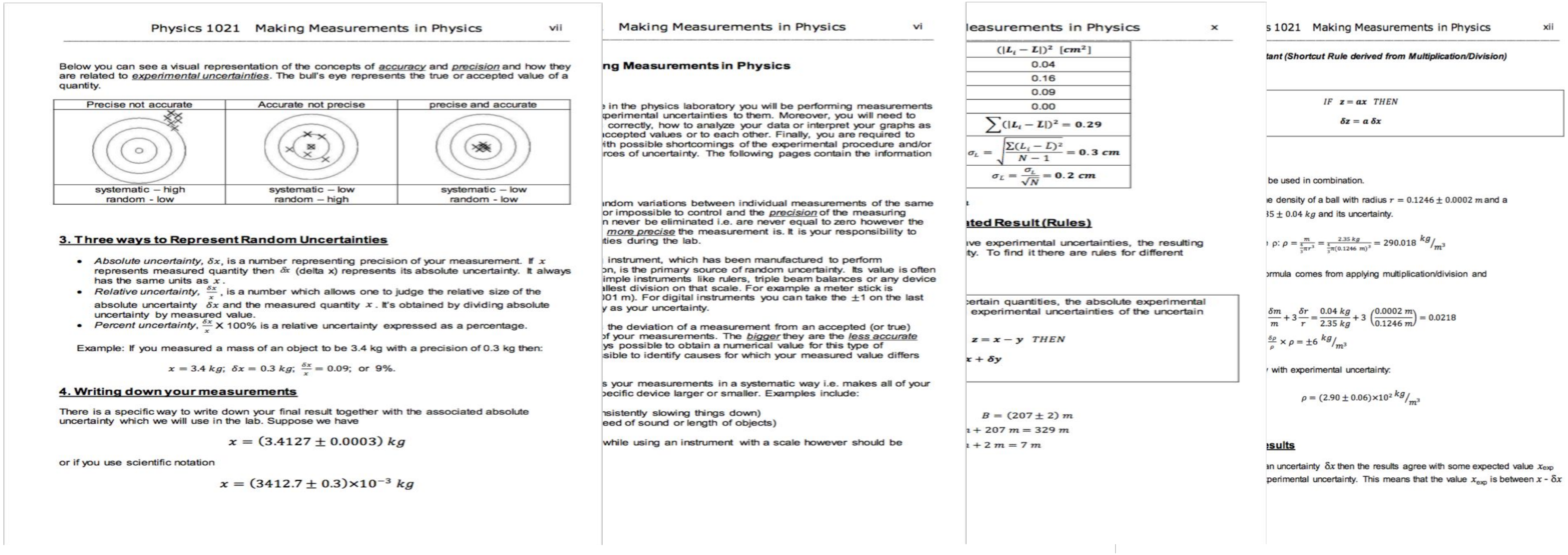
- ➔ Found on the MUN PHYSICS website @
  - ➔ https://www.mun.ca/physics/undergraduates/flylabs/p1021/schedule.pdf
- ➔ Have a copy somewhere!
  - ◆ Know what is coming up and what you are doing each week!
- ➔ Note the colours!

Physics 1021 - Winter 2020

Monday	Tuesday	Wednesday	Thursday	Friday
Jan/6 Lectures Begin Lab Introduction	Jan/7	Jan/8 Lab Introduction	Jan/9 Lab Introduction	Jan/10 Lab Introduction
Jan/13 Experiment 1 Intro. to SHM	Jan/14	Jan/15 Experiment 1 Intro. to SHM	Jan/16 Experiment 1 Intro. to SHM	Jan/17 Experiment 1 Intro. to SHM
Jan/20 Experiment 2 Standing Waves	Jan/21	Jan/22 Experiment 2 Standing Waves	Jan/23 Experiment 2 Standing Waves Quiz 1	Jan/24 Experiment 2 Standing Waves
Jan/27 Problem Set 1	Jan/28	Jan/29 Problem Set 1	Jan/30 Problem Set 1	Jan/31 Problem Set 1
Feb/3 Experiment 3 Sound and Resonance	Feb/4	Feb/5 Experiment 3 Sound and Resonance	Feb/6 Experiment 3 Sound and Resonance Term Test 1	Feb/7 Experiment 3 Sound and Resonance
Feb/10 To Be Announced	Feb/11	Feb/12 To Be Announced	Feb/13 To Be Announced	Feb/14 To Be Announced
Feb/17 Break	Feb/18 Break	Feb/19 Break	Feb/20 Break	Feb/21 Break
Feb/24 Experiment 4 Buoyancy	Feb/25	Feb/26 Experiment 4 Buoyancy	Feb/27 Experiment 4 Buoyancy	Feb/28 Experiment 4 Buoyancy
Mar/2 Experiment 5 Electric Field and Potential	Mar/3	Mar/4 Experiment 5 Electric Field and Potential	Mar/5 Experiment 5 EF and EP Quiz 2	Mar/6 Experiment 5 Electric Field and Potential
Mar/9 Problem Set 2	Mar/10	Mar/11 Problem Set 2	Mar/12 Problem Set 2	Mar/13 Problem Set 2
Mar/16 Experiment 6 Magnetic Fields	Mar/17	Mar/18 Experiment 6 Magnetic Fields	Mar/19 Experiment 6 Magnetic Fields Term Test 2	Mar/20 Experiment 6 Magnetic Fields
Mar/23 Lab Skills Test	Mar/24	Mar/25 Lab Skills Test	Mar/26 Lab Skills Test	Mar/27 Lab Skills Test
Mar/30 To Be Announced	Mar/31	Apr/1 To Be Announced	Apr/2 To Be Announced	Apr/3 To Be Announced Lectures End
Apr/6	Apr/7	Apr/8 Exams Begin	Apr/9	Apr/10

Uncertainty

From 1021 Lab manual… Same as 1020… Read through **Preliminary Pages** before next week…



Physics 1021 Making Measurements in Physics vii

Below you can see a visual representation of the concepts of *accuracy* and *precision* and how they are related to *experimental uncertainties*. The bull's eye represents the true or accepted value of a quantity.

Precise not accurate	Accurate not precise	precise and accurate
systematic – high random - low	systematic – low random – high	systematic – low random - low

3. Three ways to Represent Random Uncertainties

- *Absolute uncertainty*, δx, is a number representing precision of your measurement. If x represents measured quantity then δx (delta x) represents its absolute uncertainty. It always has the same units as x.
- *Relative uncertainty*, $\frac{\delta x}{x}$, is a number which allows one to judge the relative size of the absolute uncertainty δx and the measured quantity x. It's obtained by dividing absolute uncertainty by measured value.
- *Percent uncertainty*, $\frac{\delta x}{x}$ X 100% is a relative uncertainty expressed as a percentage.

Example: If you measured a mass of an object to be 3.4 kg with a precision of 0.3 kg then:

$$x = 3.4\ kg;\ \delta x = 0.3\ kg;\ \frac{\delta x}{x} = 0.09;\ \text{or}\ 9\%.$$

4. Writing down your measurements

There is a specific way to write down your final result together with the associated absolute uncertainty which we will use in the lab. Suppose we have

$$x = (3.4127 \pm 0.0003)\ kg$$

or if you use scientific notation

$$x = (3412.7 \pm 0.3)\times 10^{-3}\ kg$$

Making Measurements in Physics vi

ng Measurements in Physics

e in the physics laboratory you will be performing measurements xperimental uncertainties to them. Moreover, you will need to correctly, how to analyze your data or interpret your graphs as ccepted values or to each other. Finally, you are required to ith possible shortcomings of the experimental procedure and/or rces of uncertainty. The following pages contain the information

ndom variations between individual measurements of the same or impossible to control and the *precision* of the measuring n never be eliminated i.e. are never equal to zero however the *more precise* the measurement is. It is your responsibility to ties during the lab.

instrument, which has been manufactured to perform on, is the primary source of random uncertainty. Its value is often imple instruments like rulers, triple beam balances or any device allest division on that scale. For example a meter stick is 01 m). For digital instruments you can take the ±1 on the last y as your uncertainty.

the deviation of a measurement from an accepted (or true) of your measurements. The *bigger* they are the *less accurate* ys possible to obtain a numerical value for this type of sible to identify causes for which your measured value differs

s your measurements in a systematic way i.e. makes all of your pecific device larger or smaller. Examples include:

nsistently slowing things down)
eed of sound or length of objects)

while using an instrument with a scale however should be

leasurements in Physics x

$(\lvert L_i - \bar{L}\rvert)^2$ $[cm^2]$
0.04
0.16
0.09
0.00
$\sum(\lvert L_i - \bar{L}\rvert)^2 = 0.29$
$\sigma_L = \sqrt{\frac{\sum(L_i - \bar{L})^2}{N-1}} = 0.3\ cm$
$\sigma_{\bar{L}} = \frac{\sigma_L}{\sqrt{N}} = 0.2\ cm$

ated Result (Rules)

ve experimental uncertainties, the resulting ty. To find it there are rules for different

ertain quantities, the absolute experimental experimental uncertainties of the uncertain

$z = x - y$ THEN

$x + \delta y$

$B = (207 \pm 2)\ m$

$+ 207\ m = 329\ m$

$+ 2\ m = 7\ m$

s 1021 Making Measurements in Physics xii

tant (Shortcut Rule derived from Multiplication/Division)

IF $z = ax$ THEN

$\delta z = a\,\delta x$

be used in combination.

e density of a ball with radius $r = 0.1246 \pm 0.0002\ m$ and a 35 ± 0.04 kg and its uncertainty.

ρ: $\rho = \frac{m}{\frac{4}{3}\pi r^3} = \frac{2.35\ kg}{\frac{4}{3}\pi(0.1246\ m)^3} = 290.018\ {}^{kg}/_{m^3}$

rmula comes from applying multiplication/division and

$\frac{\delta m}{m} + 3\frac{\delta r}{r} = \frac{0.04\ kg}{2.35\ kg} + 3\left(\frac{0.0002\ m}{0.1246\ m}\right) = 0.0218$

$\frac{\delta\rho}{\rho} \times \rho = \pm 6\ {}^{kg}/_{m^3}$

with experimental uncertainty:

$\rho = (2.90 \pm 0.06)\times 10^2\ {}^{kg}/_{m^3}$

esults

n uncertainty δx then the results agree with some expected value x_{exp} perimental uncertainty. This means that the value x_{exp} is between $x - \delta x$

Resources: Physics Help Center!

- ✓ Room C-3071

- ✓ Fall and Winter Semesters
- ✓ **Monday to Friday**, **10:00 am to 4:00 pm**

- ✓ The Help Centre is staffed during working hours by Faculty and Laboratory Staff.

To begin, Login to Computers...

Username: maclab##

(see number on top of your screen)

Password: raptors

Fill out attendance:

- **Everyone** enter attendance data

Graphing Workshop

Graphing Workshop

- In experiments, we collect sets of data.
- To most effectively use the data:
  - We plot a graph of the data
  - Then draw meaning from that graph.
- We determine the meaning by comparing known physics equations to the equations that describe the graph.

General Approach to Graphing Data

1. What **data** have we **collected** and what do we want to **find**?
2. What equation relates these?
    i. **Write the physics equation containing those variables.**
3. **Plot the data.**
4. Compare the physics equation to the equation for the graph.
5. Use the comparison to draw your conclusions.

Graphing Workshop: Example 1

- In a OLD experiment of Physics 1020, we examined *mass vs volume* of aluminium cylinders.

- Let's say we have 4 objects dimensions and masses.
- And we want to find Density, ρ.

Cylinder	Volume(cm^3)	Mass (g)
1	8.314	22.50
2	34.110	91.95
3	22.700	61.30
4	13.300	36.10

Graphing Workshop: Example 1

- What **data** have we **collected**?
  - Volume and Mass.
- what do we want to **find**?
  - Density, *ρ*.
- What equation relates these?
  - $\rho = m/V$
- How do we plot the data? Volume on x or y? Mass on y or x? Does it matter?

Volume(cm^3)	Mass (g)
8.314	22.50
34.110	91.95
22.700	61.30
13.300	36.10

Graphing Workshop: Example 1

$\rho = m/V$, density = mass/volume

This is a **Linear Relationship**, and thus can we rewrote as:

$$m = \rho V + 0$$

$$y = \{slope\}\, x + b$$

What happens if V on y-axis?

Graphing Workshop: Example 1

This is also a Linear Relationship:

$$y = \{slope\}\, x + b$$

$$V = (1/\rho)\, m + 0$$

What happens to the uncertainty?

Graphing Workshop: Example 2

- Have velocity and time of a falling object.
- We want to find acceleration and initial velocity.

➢ What do we do?

➢ Where do we start?

Velocity (m/s)	Time (s)
0.699	0.00
1.202	0.0523
1.574	0.0883
1.866	0.1180
2.091	0.1430
2.336	0.1660
2.512	0.1860
2.718	0.2050

Remember the General Approach…

1. What **data** have we **collected** and what do we want to **find**?
2. What equation relates these?
   i. **Write the physics equation containing those variables**.
3. **Plot the data**.
4. Compare the physics equation to the equation for the graph.
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Graphing Workshop: Example 2

1. What data was collected?
   a. Velocity and Time
2. What data are we trying to find?
   a. Acceleration and Initial Velocity
3. What equation relate these??
   a. Kinematics Equations

$$v_x = v_{x0} + a_x t$$

$$v_x^2 = v_{x0}^2 + 2a_x(x - x_0)$$

$$x = x_0 + v_{0x}t + \frac{1}{2}a_x t^2$$

Velocity (m/s)	Time (s)
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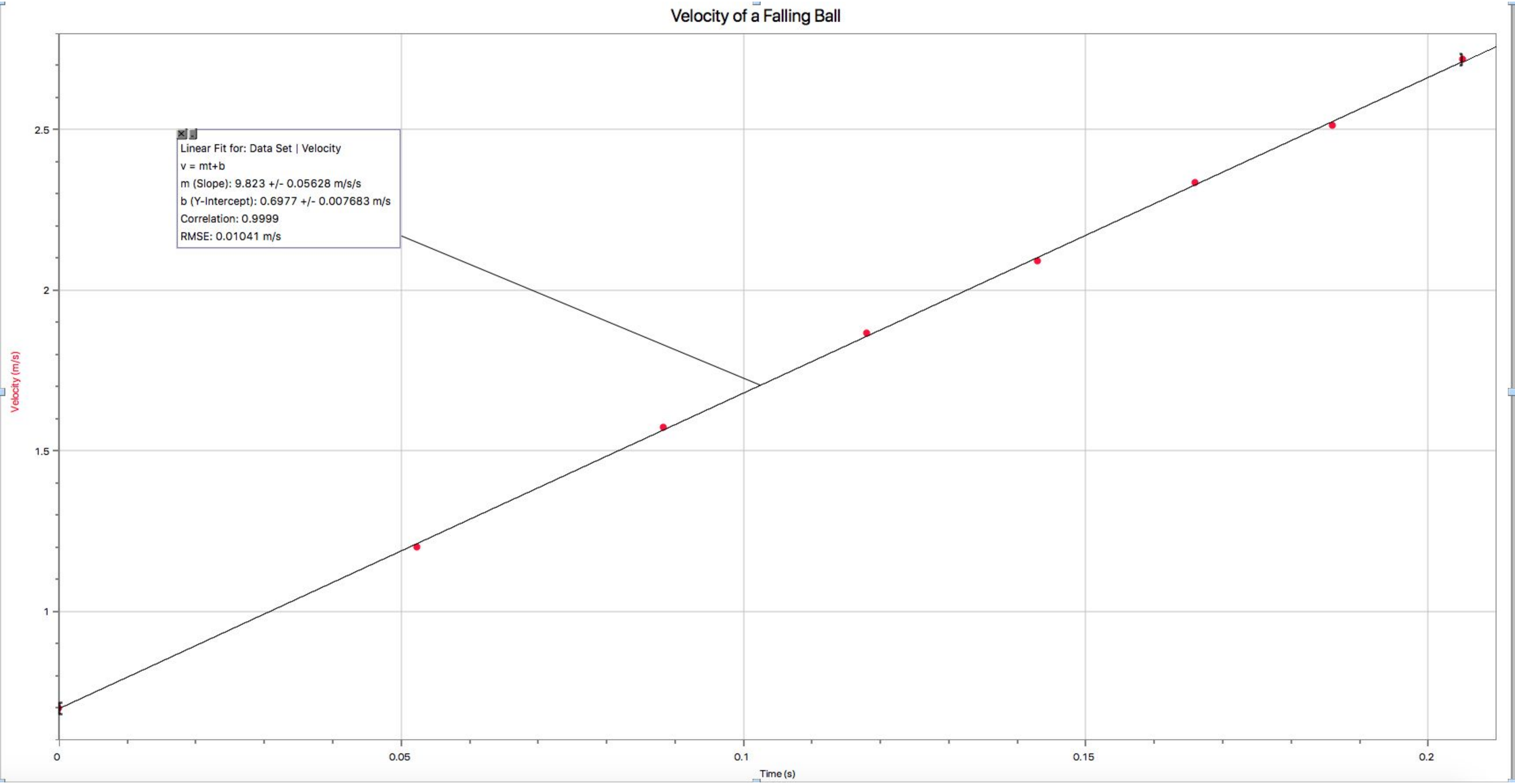
TIME TO PLOT DATA!!!



Velocity of a Falling Ball
Linear Fit for: Data Set | Velocity
v = mt+b
m (Slope): 9.823 +/- 0.05628 m/s/s
b (Y-Intercept): 0.6977 +/- 0.007683 m/s
Correlation: 0.9999
RMSE: 0.01041 m/s
Velocity (m/s)
2.5
2
1.5
1
0
0.05
0.1
0.15
0.2
Time (s)

Graphing Workshop: Example 2

- Physics Equation:

$$v_{xf} = a_x \, t + v_{x0}$$

- Linear Relationship:

$$Y = \{slope\} \, x + b$$

- Thus from graph:
  - Acceleration = 9.82 ± 0.06 m/s^2
  - Initial Velocity = 0.698 ± 0.008 m/s

Graphing Workshop: Example 3

- And Now for Something Completely Different…
- Given:
  - Energy (J)
  - Speed (m/s)
- Want to find:
  - mass of the object (kilograms)
- How do we proceed?

Energy (J)	Speed (m/s)
4.56	1.91
8.29	2.58
11.36	3.02
14.32	3.38
16.32	3.61
19.36	3.94
21.38	4.14
24.13	4.39

General Approach For Example 3

- What **data** have we **collected** and what do we want to **find**?
  - We Have **Energy** and **Velocity**
  - And we want to find **mass.**
- What equation relates these?
  - $\mathbf{E=\frac{1}{2} m v^2}$
- **Plot the data**.

Graphing Workshop: Example 3

- And Now for Something Completely Different…

- Given:
  - Energy (J)
  - Speed (m/s)

- Want to find:
  - mass of the object (kilograms)

- How do we proceed?

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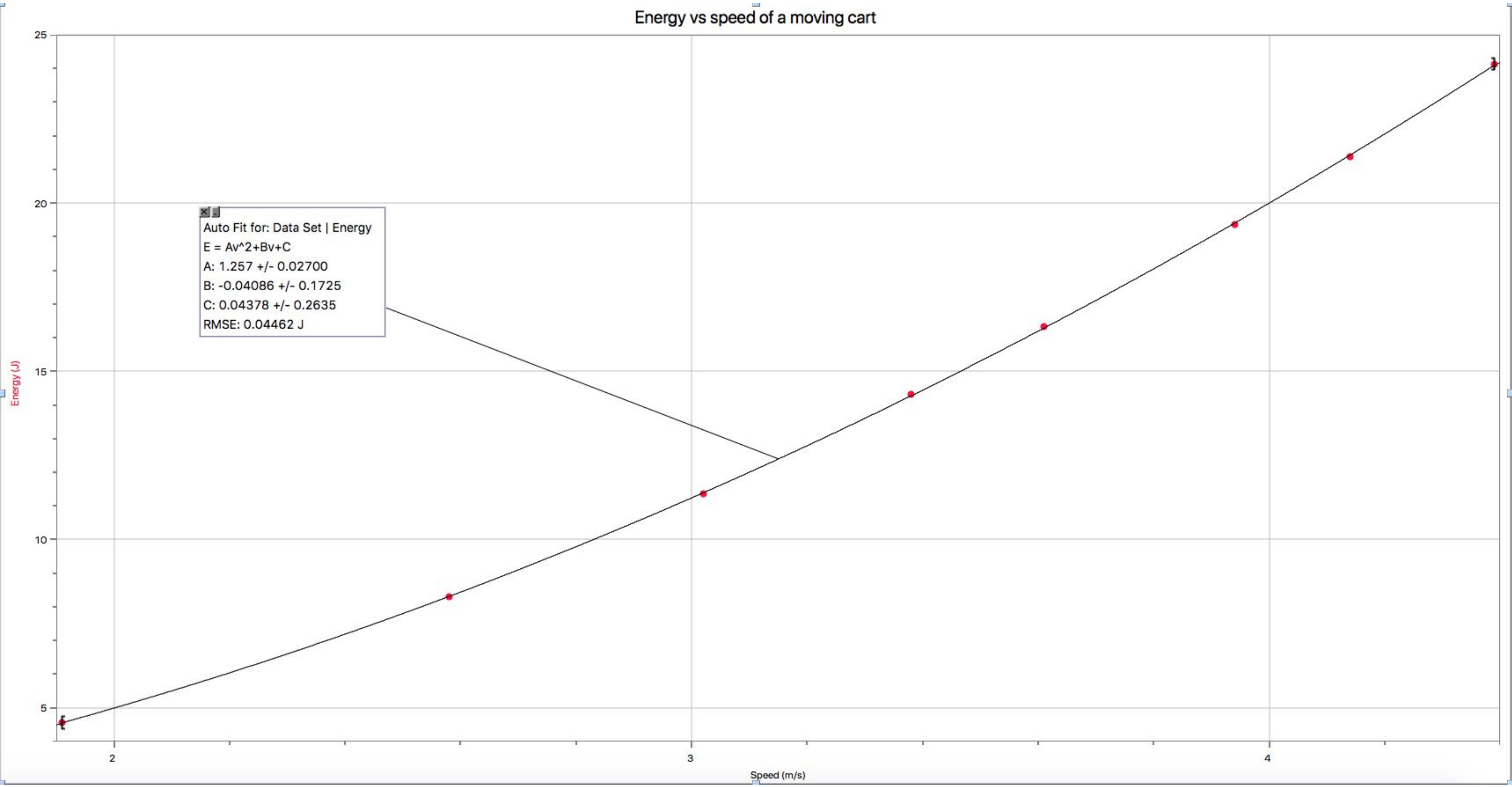
Energy vs speed of a moving cart
Auto Fit for: Data Set | Energy
E = Av^2+Bv+C
A: 1.257 +/- 0.02700
B: -0.04086 +/- 0.1725
C: 0.04378 +/- 0.2635
RMSE: 0.04462 J
Energy (J)
Speed (m/s)
25
20
15
10
5
2
3
4

Graphing Workshop: Example 3

- Relationship:

$$y = A\,x^2 + B\,x + C$$

- Physics Equation:

$$E = (\tfrac{1}{2}\,m)\,v^2 + 0 + 0$$

- Thus from graph:
  - ½ Mass = 1.26 ± 0.03 kg
  - Mass = 2.52 ± 0.06 kg

Your turn… Assignment!

- You have collected position and time data for an object starting from rest.
- Use kinematics to determine the **acceleration (m/s²)** and the **initial position (m)**.
- Create a plot in Graphical Analysis, and
- **write the reasoning** and the **answers** directly on the printout.

$$v_x^2 = v_{x0}^2 + 2a_x(x - x_0)$$

$$v_x = v_{x0} + a_x t$$

$$x = x_0 + v_{0x} t + \frac{1}{2} a_x t^2$$

Position (m)	Time (s)
16.24	0.81
14.01	1.10
12.14	1.27
10.17	1.39
8.42	1.55
6.30	1.67
4.92	1.76
2.72	1.89

Before You Go....

- Sign the sign-out sheet
-
- Logout of computers