

EXCEL and Uncertainty Assignment

- To be handed in no later than 14:00 pm on Monday Oct. 17, 2011.

Drop it in the wooden box outside room DV 2053

- Read very carefully what is written on the code of behavior on academic matters, plagiarism, and undue collaboration in the PHY136 class policy

Part 1: EXCEL TEST

- You may use EXCEL or any other spreadsheet program that you are familiar with.
- **N.B.:** We are interested in the equation of a straight line in its form $y = mx \pm b$:
vertical variable = slope \times horizontal variable \pm intercept

(1.1) Create a table of y vs. x for the function:

$$y = 1.234x^{-0.567} \quad \text{for } x = 0.01, 0.1, 1, 10, 20, \dots, 100, 1000, 10000, 100000.$$

- Plot y (on the Y axis) vs. x (on the X axis) for $x = 1, 10, 20, \dots, 100$.
Do the points take on the form of a straight line?
- Plot $Y = y$ (on the Y axis) vs. $X = x^{-0.567}$ (on the X axis) for $x = 0.01, 0.1, 1, 10, 20, \dots, 100, 1000, 10000, 100000$. Do the points take on the form of a straight line? Is it what you expected? Why?
- Extend your table to include columns for $\ln y$ and $\ln x$, for the same function i.e. $y = 1.234x^{-0.567}$ for $x = 0.01, 0.1, 1, 10, 20, \dots, 100, 1000, 10000, 100000$ and plot $\ln y$ (on the Y axis) vs. $\ln x$ (on the X axis). Do the points take on the form of a straight line? Is the resulting graph what you expected? What is the magnitude of the slope and intercept of this straight line?

[N.B. This problem shows two main methods that are widely used to manipulate a mathematical formula (model) to convert and then analyze it in the standard form of a straight line: $y = mx \pm b$.] [12]

(1.2) In an experiment on free fall under gravity the following table is established:

Experimentally measured time of fall
vs. distance for a freely falling object

Distance, x , m	Time, t , s
0.2	0.201
0.4	0.284
0.6	0.349
0.8	0.403
1.0	0.451
1.2	0.493
1.4	0.533
1.6	0.570
1.8	0.604
2.0	0.637

Let the mathematical model be: $x = 0.5gt^2$ and assume that $x = 0$ at $t = 0$:

- In the light of what you learnt in problem 1.1 (parts b and c) and the form of the equation $x = 0.5gt^2$, discuss (without doing the detailed calculations) the two different methods (algebraic and logarithmic) that can be used to find g , the acceleration due to gravity, from a straight line graph representation. In each method, indicate explicitly the vertical variable, horizontal variable, slope, and intercept. Draw sketches.
- Find a numerical estimate for g by only one method, based on the above table, using the EXCEL program? [12]

(1.3) Using the data that you collected from your mass-spring and/or elastic band experiment, in the Introductory Lab L1, plot a graph for the load (hanged weight) F in Newtons vs. the extension x in *meters*. Use EXCEL program to find the slope in the linear region of Hooke's Law $|F| = kx$. How would you use your data to calculate the spring constant k for the selected spring? What are the “units” of k ? What are the units of the number π ? Suppose your lab partner tells you to calculate the volume of a cone of radius r and height h using the formula $V = \pi r^3 h$. Why this formula “must” be incorrect? (*Hint*: Review the meaning of “dimensional consistency” in your lecture notes of chapter 1.) [12]

In all the following problems state the variables or combination of variables which should be plotted to check the suggested variation and state how the unknown may be found (through the slope and/or intercept of the best fitting straight line $y = mx + b$). Because you are not given any numerical data it is just required to qualitatively describe your method of solution in few lines with schematic graphs.

(1.4) The gas law for an ideal gas is $PV = RT$, P and T are measured variables, V is fixed and known. Determine R . [4]

(1.5) The fundamental frequency of vibration of a string is given by $f = \frac{1}{2\ell} \sqrt{\frac{T}{m}}$ where f , ℓ , and T are measured variables. Determine m . [4]

(1.6) The linear expansion of a solid is described by $\ell = \ell_o (1 + \alpha \Delta t)$ where ℓ and Δt are measured variables, ℓ_o is constant but unknown. Determine α . [4]

(1.7) The velocity of outflow of an ideal fluid from a hole in the side of a tank is given by $v = \sqrt{\frac{2P}{d}}$ where v and P are measured variables. Determine d . [4]

(1.8) A conical pendulum has a period given by $T = 2\pi \sqrt{\frac{\ell \cos \alpha}{g}}$ where T and α are measured variables, ℓ is fixed and known. Determine g . [4]

(1.9) The discharge of a capacitor is described by $Q = Q_0 e^{-t/RC}$ where Q and t are measured variables. R is fixed and known. Determine C . [4]

(1.10) The wavelength of the lines in the Balmer series of the hydrogen spectrum are given by $\frac{1}{\lambda} = R \left(\frac{1}{4} - \frac{1}{n^2} \right)$ where λ and n are measured variables. Determine R . [4]

(1.11) The force between electrostatic charges is described by $F = \frac{q_1 q_2}{4\pi \epsilon_o r^2}$, F and r are measured variables for fixed and known q_1 , q_2 , and ϵ_o . How do you check the inverse-square law? [Hint: use the method used in problem 1.1c] [4]

Part 2: UNCERTAINTY TEST

Note: Thoroughly review your lab manual “Introduction to Experimental Physics” before answering the following questions.

(2.1) Rearrange the steps of the scientific method (i.e. put them in order):

Hypothesis – Experimental procedure – Conclusion – Recognize a phenomenon – Apparatus
– Observations.

[4]

(2.2) To convert from g/cm^3 to kg/m^3 , which factor a you must multiply by? (e.g. $1 \text{ g/cm}^3 = a \text{ kg/m}^3$.)

[4]

(2.3) What is the difference between “accuracy” and “precision”? (Hint: Review your lab manual “Introduction to Experimental Physics”).

[4]

(2.4) Encircle the correct answer :

Repeated, independent measurements of a quantity will vary about....

- | | |
|-------------------------------|-------------------------------|
| a. the maximum value | b. the average measured value |
| c. the minimum measured value | d. the “accurate” value |

[4]

(2.5) You are performing an air track experiment. You determine that the track cart travels a distance of $x = 60.0 \pm 0.2 \text{ cm}$ in a time $t = 82.4 \pm 0.3 \text{ s}$. What is its average velocity v ? (Hint: Please review your lab manual “Introduction to Experimental Physics”)

[4]

(2.6) You use the meter stick to measure the length of a table. You are sure that the length is not less than 152.5 cm and not more than 152.8 cm.

- State this measurement as a central value \pm uncertainty. Use the appropriate number of significant figures.
- What is the absolute uncertainty?
- What is the relative uncertainty?

[4]

(2.7) Your digital watch (or Stop Watch) gives a time reading in hours, minutes, and seconds as 08:36:00. What is the absolute uncertainty of the measurement in minutes (or seconds)?

[4]

(2.8) Compute the percent error of the approximate value $\sqrt{10}$ for $\pi = 3.142$ (consider this numerical value of π as exact).

[4]