

Problem Solving: Kinematics and One Dimensional Motion

Experiment One: Introduction to Data Studio

8.01t

Sept 10, 2004

Problem Solving Strategies

Four Stages of Attack

- Understand the Domain and Models
- Plan your Approach
- Execute your plan (does it work?)
- Look back - check answer/return to plan

Understand vs Get Answer?

If you expect exactly the same problem on a later test:
then get answer and memorize.

If you have to transfer the knowledge to a related problem:
learn the schema - the model and the overview

Understand: Domain & Models

What is the problem? Use pictures/graphs

What knowledge (chapter) is involved?

e.g. 1-d kinematics for two bodies

Find applicable models

e.g. uniform acceleration after t_0

Plan your Attack

Build on the models

Similarity to previous problems?

Pick coordinates, **define system**

Is all understanding embodied in Eqs.?

Check it Over

Does the solution seem reasonable?

Units, special cases, scaling, reasonable?

If it seems wrong, review whole process

If it seems right, **review the schema/pattern**

Experiment 01: Introduction to DataStudio



Goal

- Learn how to **use DataStudio** and the **750 interface** to measure position and velocity, with auto start & stop.
- Learn how to **plot your measurements** on a graph and to edit the data to make a subset of the original.
- **Fit a function to your data** and learn about regression analysis and how to interpret the result.
- Generally, this is to familiarize yourself with the tools we will use to make more sophisticated measurements and carry out a richer analysis of them than would be possible without the computer.

Two important links

The screenshot shows the MIT Physics 8.01T website in a Microsoft Internet Explorer browser window. The address bar shows the URL: <http://web.mit.edu/8.01t/www/coursedocs/current/experiments.htm?SEC=L01>. The page features a navigation menu with links for CURRENT, OVERVIEW, CALENDAR, TOPICS, INSTRUCTORS, and RESOURCES. Below this, a yellow bar indicates the current section is L01. The main content area is titled 'Experiments' and contains a list of modules. A red circle highlights the link 'Using DataStudio' in the 'Data Input Page (Students)' column. A red arrow points to the 'Module Name:' label in the 'Experiments:' column.

Module Name:	Experiments:
1. Physics: The Foundation of Science	Experiment 1: Introducing Data Studio (Report)
2. Kinematics: One Dimensional Motion	Experiment 1: Introducing Data Studio (Report)
3. Mathematics: The Language of Nature	Experiment 1: Introducing Data Studio (Report)
4. Kinematics: Two and Three Dimensional Motion	Experiment 2: Projectile Motion (Report) Experiment 3: Modeling Forces
5. Newton's Laws of Motion	

Experiment One: Steps

Connect motion sensor

- set sensor properties
- set trigger rate
- set sampling options

Create Graphs

Take Data

Fit Sine Curve

Report Results

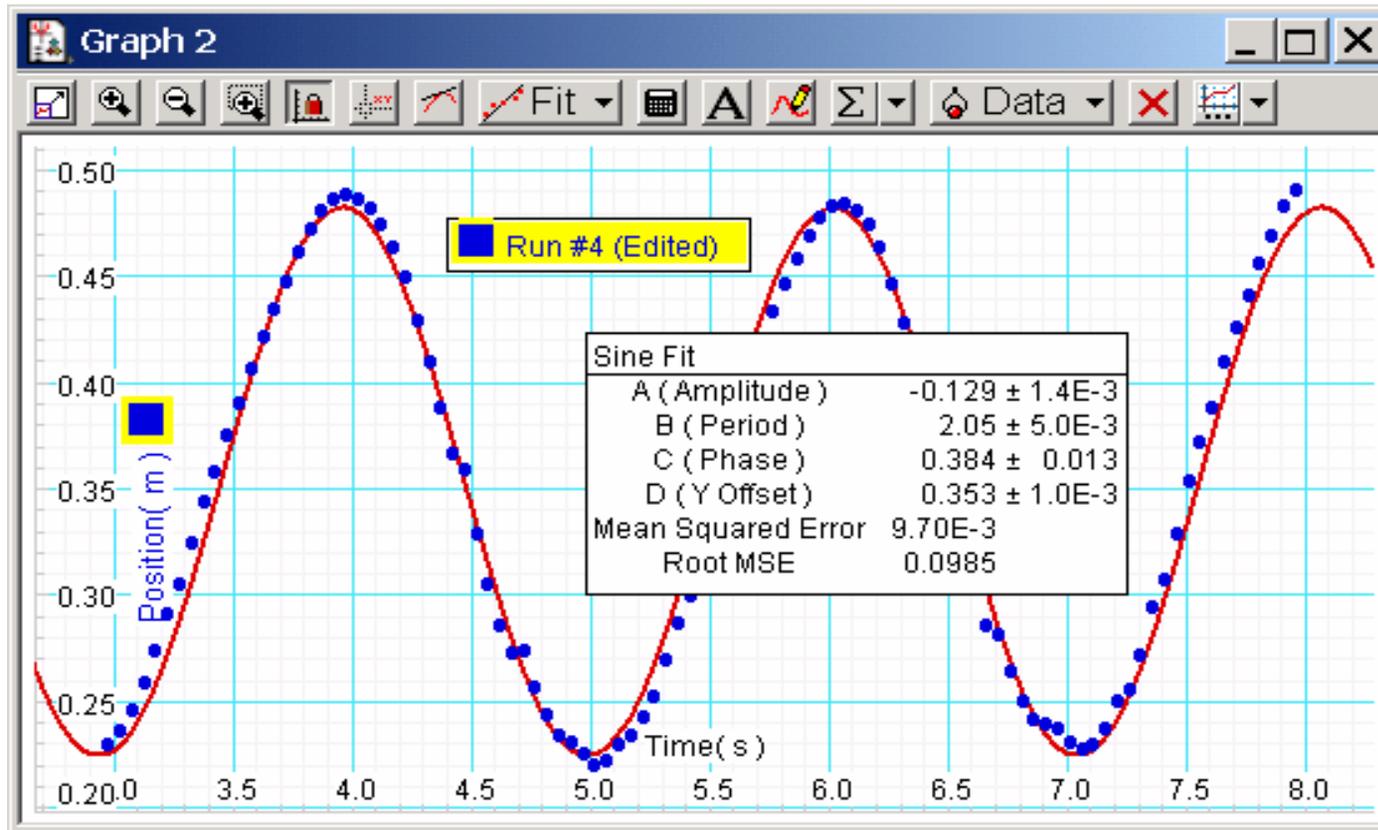
Fitting data

- Finding the best possible parameters of a theoretical model (here: sine-function to account for hand movement):
 - Least-square method: Minimize by varying parameters in y_{fit}

$$y_{fit}(x_i) = A \sin \left(\frac{2\pi(x_i - C)}{B} \right) + D$$

$$\Phi = \sum_i [y_{fit}(x_i) - y_i]^2$$

Dave Litster's best fit



The normalized RMS error ($\text{Root MSE} / 10A$) is 8% of the amplitude, or 10 mm. Can you do better?

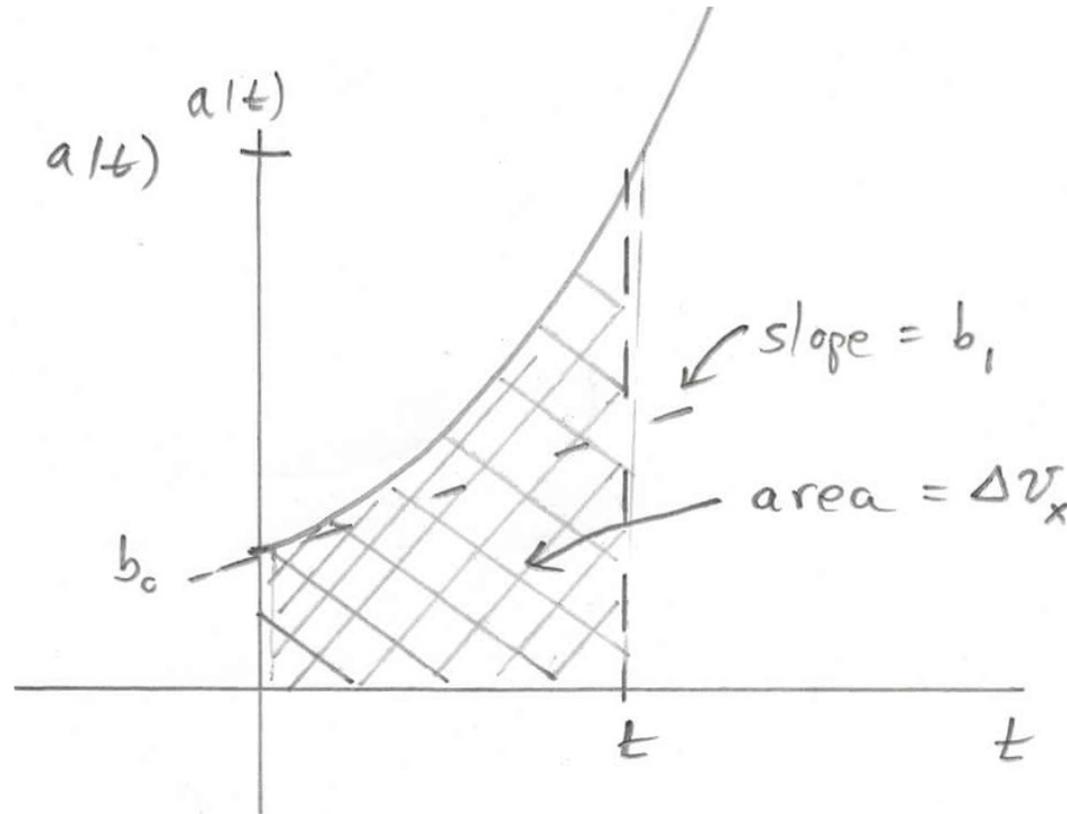
Steps to take today

- Follow the instructions in the notes to set up the motion sensor to measure the position and velocity of your hand as you move it back and forth between two marks 30 cm (1 foot) apart.
- Everyone in the group tries to move their hand so its position vs. time is a square, triangle and sine wave.
- Look at the graphs of position and velocity and examine them to decide how well you did.

Steps to take today (cont.)

- Choose the best 5 sec (100 points) of sine wave data and use DataStudio's Sine Fit function to get a quantitative measure of how close it is to a sine wave.
- Report the properly normalized (see notes) Root MSE:
(**Root MSE / 10A**)
- If you have time, experiment and have fun. Left hand vs. right hand, other motions, and so on. Use your imagination.

Velocity as the integral of the acceleration



Velocity as the integral of the acceleration

- *the area under the graph of the acceleration vs. time is the change in velocity*

$$\int_{t'=0}^{t'=t} a_x(t') dt' \equiv \lim_{\Delta t_i \rightarrow 0} \sum_{i=1}^{i=N} a_x(t_i) \Delta t_i = \text{Area}(a_x, t)$$

$$\int_{t'=0}^{t'=t} a_x(t') dt' = \int_{t'=0}^{t'=t} \frac{dv_x}{dt} dt' = \int_{v'_x=v_x(t=0)}^{v'_x=v_x(t)} dv'_x = v_x(t) - v_{x,0}$$

Position as the integral of velocity

- area under the graph of velocity vs. time is the displacement

$$v_x(t) \equiv \frac{dx}{dt}$$

$$\int_{t'=0}^{t'=t} v_x(t') dt' = x(t) - x_0$$

In-Class Problem #1: Motorcycle and Car

A car is driving at a constant but unknown velocity, v_0 , on a straightaway. A motorcycle is a distance d behind the car. Initially, they are both traveling at the same velocity. The motorcycle starts to pass the car by speeding up at a constant acceleration a_m . When the motorcyclist is side by side with the car, the motorcycle stops accelerating and is traveling at twice the velocity of the car.

- How long does the motorcycle accelerate?
- What was the initial velocity of the car and motorcycle?
- How far did the motorcycle travel while accelerating?

Express all your answers in terms of the given quantities in the problem.

Extra Class Problem: Keys falling in elevator

You and a friend are in an elevator that is rising at constant but unknown velocity. You are curious to know what speed the elevator is moving. You each happen to be carrying altimeters (you are avid bicyclists). You get an idea and drop your keys from a height above the floor of the elevator. You place one altimeter where you dropped the keys and the your friend places the other one on the floor. You check your altimeter when you release the keys and find the keys are a height above the ground. Your friend checks the other altimeter when the keys hit the floor and finds the keys are the same height above the ground. Assume that the gravitational constant is g . You will analyze this problem from two different reference frames. The first reference frame moves with the elevator. The second reference frame is fixed to the ground.

- As seen from a reference frame moving with elevator, how long does it take for the keys to hit the floor?
- As seen from a reference frame is fixed to the ground, using your result from part a), find an expression for the speed of the elevator in terms of the height h and the gravitational constant g .
- As seen from a reference frame is fixed to the ground, what maximum height above the ground did the keys reach?