2) Coding in for both for our resistance.

Note: we didn't account for our resistance in previous problems.

Can we fix this computationally? sunday

Need a \( F \) on seed ball, \( F = E + F_{air} \)

\[ y(t) = \frac{v_0 \cdot \sin(\theta)}{g} \]

\[ V(t) = V_0 + (F_{net}/m) \cdot \Delta t \]

\[ F_{net} = \frac{F - mg}{m} \]

\[ F = F_{air} = ge - \frac{g - Du \cdot v}{m} \]

\[ \frac{h_g - h_i}{\Delta t} = v_y + \Delta v \]

\[ \frac{F_{net}}{m} = \frac{g \cdot \text{air}}{m} + F_{air} \]

\[ V(t) = V_0 + (F_{net}/m) \cdot \Delta t \]

\[ V_{avg}(i) = (V_i + V(t))/2 \]

\[ V_i = V(t) \]

\[ y_{end}(i) = y((i-1)) + v_{avg}(i) \cdot \Delta t \]

\[ h_g = h_i - v_y + \Delta v \]
1) More about error

2) Python

(accuracy)

- Note students to suggest labels for plot. Good idea.

- Accuracy involves knowing what is good and what isn't.

1) Can reduce statistical error (increase precision) by taking more measurements.

2) Must address accuracy by removing and/or reducing "systematic errors".

Give example.

125.3 ± 0.6 
126.0 ± 0.6 (GeV/c)

took data until done.
Example of reducing δ

Higgs boson took 1/4 year to take data to use probability of getting at least as strong a result (for alt expl) was 1:3 million and significance of 5 sigma (δ)

result was $+ (120.3 \pm 0.6) \text{GeV/c}^2$ error

$- (120.4 \pm 0.6) \text{GeV/c}^2$ error

teams were blinded to each other since 2001

Example of systematic error:

Example would be mis-calibrated instrument

Actual quantity

Data fit experimt
First we'll look at 1) increasing precision.

1) Consider distribution of 10 measurements:

26, 27, 26, 28, 27, 29, 25, 24, 26, 25

We'll look at the distribution, so we

i) Sort

23, 27, 29, 24, 25, 27, 26, 26, 22, 23

ii) Count

23 27 25 26 27 26
1 3 2 3 0 1

iii) Plot frequency of occurrence.
\[ x = \frac{\sum_{i} x_{i}}{N} = \frac{\sum_{j} N_{j} x_{j}}{\sum_{j} N_{j}} \]  

- \( j \) ranges over bins  
- \( x = \) value of \( x_{i} \)  
- \( N_{j} \) th in bin

1) could write \( f_{j} = \frac{x_{j}}{N} \) 

\[ \bar{x} = \sum_{j} f_{j} x_{j} \]

b1) aside about real could be bin widths

"Normally occurs real number with some accuracy say 0.1 or 0.01..."  

distribution of so measure looks in "real like this" [already ordered]

23.7, 23.8, 23.9, 23.1, 23.16, etc

- 0.1
- 0.1
- 0.0
- 0.7

With at spacers in list, pick some reasonable average of gaps or "bin widths"
(1) were working towards a statistical description of data distribution

So a probability distribution function (it is data dependent)

So will have from

\[ \int f(x) \, dx \]

limit as \( \Delta x \to 0, N \to \infty \) is \( f(x) \)

Then \( \int f(x) \, dx \) is the fraction of

simpler between \( x \) and \( x + \Delta x \)

or more properly formally,

\[ \int_{a}^{b} f(x) \, dx = \text{fraction of simpler between } a \text{ and } b \]

and need to normalize \( \int_{a}^{b} f(x) \, dx = 1 \)
e) Now, with our fixed properly normalized we can state that:

\[ \bar{X} = \int x f(x) \, dx \quad \text{expectation value} \]

\[ \sigma^2 = \int (x - \bar{X})^2 f(x) \, dx \quad \text{variance} \]

5) Central Limit Theorem

Start with any distribution with well-defined mean and variance.

Can set a sample size \( N \)
and take \( N \) samples (example) of above.

\[ \bar{X}_N = \frac{\sum_{i=1}^{N} x_i}{N} \]

\[ \text{e.g., } N = 4 = \left\{ 10, 10, 14, 16 \right\} = 12.5 \]
get something that looks like a "normal distribution" further, if we increase example size \( N \) and look at test data, data more normal CLT says that as \( N \to \infty \) so for \( d \to \) "normal" with well-defined mean and variance.

Note, we started with any distribution and only arrived if had a well defined mean and variance.

It might not, itself, be "normal."

But what does it mean to be "normal?"

Implies that \( f(x) = \frac{1}{\sqrt{2\pi}} e^{-x^2/2} \) or \( e^{-x^2/2} \)
For now we will call \( z \) the "indih Felpa" and \( x \) the "maximally probable value."

I would typically need to normalize this

\[
\int f(x) \, dx = 1
\]

h.) ERF

So the probability of finding \( z \) in a sample between \( u-\sigma \) and \( u+\sigma \),

\[
\text{Prob} (u-\sigma, u+\sigma) = \int_{-\sigma}^{\sigma} \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{x^2}{2\sigma^2}} \, dx
\]

can be done as

\[
\text{Prob} = \int_{-\infty}^{\infty} \frac{1}{2\pi} e^{-\frac{z^2}{2}} \, dz
\]

called the "error Felpa" or ERF.

Look up values in book.