Phys 371 Fri

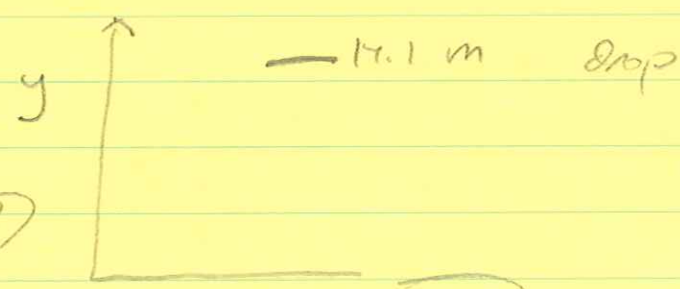
L2.6

2) Coding in for loops for air resistance

note, we didn't account for air resistance in previous problem.?

⇒ could we fix this computationally ? signs?

need new F on steel ball, $= F_g + F_{drag}$



$D = 2e^{-4}$

.00002

ge = -9.8 (trial)

$V = V_f$

$v_y = \frac{V_{avg}}{dt}$

$V_{avg} = \frac{y(i+1)-y_i}{dt}$

$V_{avg} \cdot dt$

eqn $\frac{F_{tot}}{m} = a = \frac{V_f - V_i}{dt}$

$V_f - V_i = \left(\frac{F_{tot}}{m}\right) dt$

$V_f = V_i + \left(\frac{F_{tot}}{m}\right) dt$

what sets this #

$F_a = \frac{F_{tot}}{m} = ge - \frac{F_d}{m}$

$= ge - Dv^2$?

$= ge - D(v_{avg})^2$?

$\frac{h_f - h_i}{dt} = v_{avg} \cdot dt$

```
y(1) = 14.1
t(1) = 0
Vi = 0
dt = 0.1 (s)
Fam = ge
V(1) = Vi + Fam*dt
Vavg = 0.5*V(1)
y(2) = y(1) + Vavg*dt
for i = 2:1000
    Fd = + D*Vavg(i-1)^2;
    Fam = ge*m + Fd;
    V(i) = Vi + (Fam/m)*dt;
    Vavg(i) = (Vi + V(i))/2;
    Vi = V(i);
    y(i) = y(i-1) + Vavg(i)*dt;
end
```

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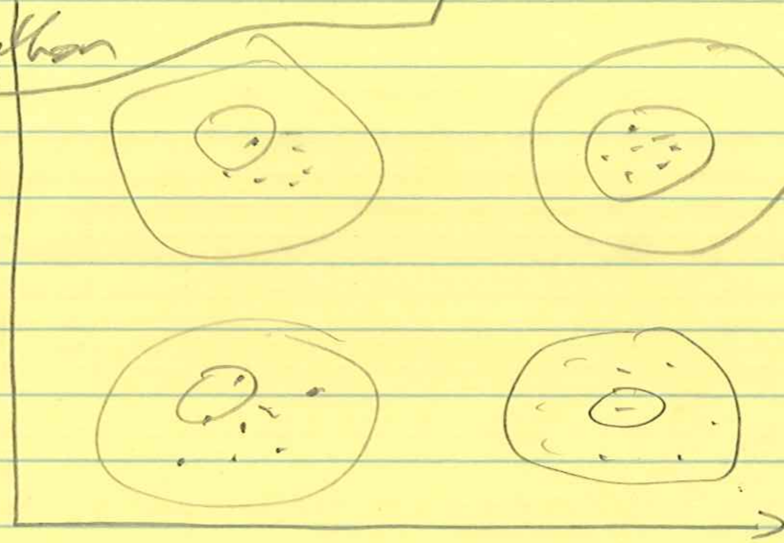
1) more about Error
2) python

(precision)



(accuracy)

(ask students to suggest labels for plot above)

→ "accuracy" involves knowing what is a good value ⟸

1) Can reduce statistical error (increase precision) by taking more measurements NT. Note example for LHC Higgs Boson experiment [look up]

$\boxed{125-127\ \frac{GeV}{c^2}}$ actually

2) must address accuracy by removing and/or reducing "systematic error"

⟹ give example → 125.3 ± 0.6 CMS
and 126.0 ± 0.6 ATLAS
(GeV/c)

took data until chance

(example of reducing σ)

Higgs Boson, took 40 yrs years
took enough data to where probability of getting "at least as strong a result" (for alt expl.) was 1:3 million and significance of 5 sigma (σ)

results were *
(125.3 ± 0.6) GeV/c^2 CMS
(126.0 ± 0.6) GeV/c^2 ATLAS

teams were blinded from each other since 2011

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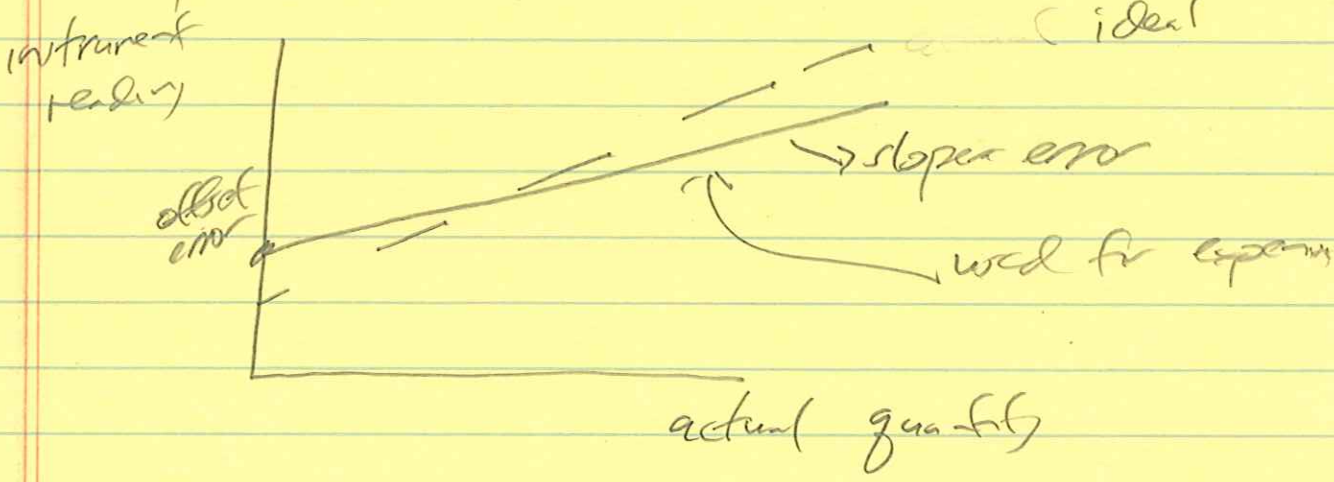
example of systematic error:

example would be mis-calibrated instrument



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L2.2

first we'll look at 1) increasing
precision

a) consider distribution of 10 judge measurements

26, 24, 26, 28, 23, 24, 25, 24, 26, 25

want to look at the distribution, so we

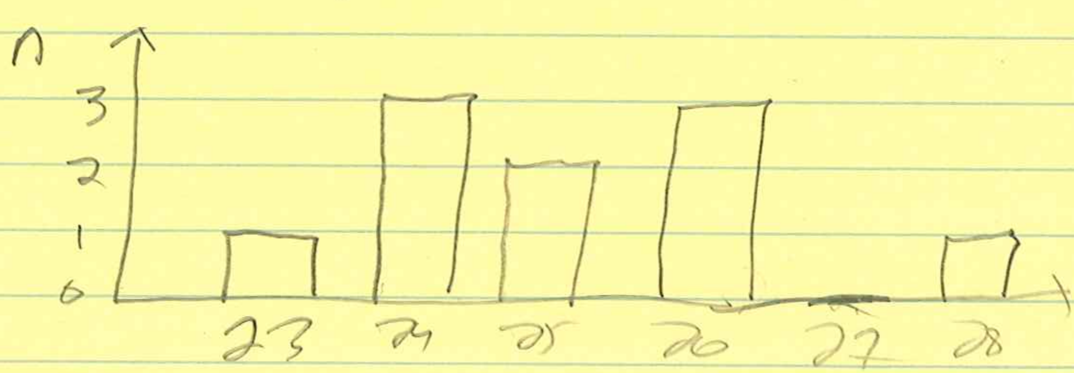
i) sort

23, 24, 24, 24, 25, 25, 26, 26, 26, (27), 28

ii count

23	24	25	26	27	28
1	3	2	3	0	1

iii plot frequency of occurrence



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iv) represent as mean

$$\bar{x} = \frac{\sum x_i}{N} = \frac{\sum_{j=1}^{m} n_j x_j}{\sum n_j \quad (=N)}$$

- j ranges over bins
- x_j value of bin
- n_j # in bin

v) could write $f_j = \frac{n_j}{N}$

$$\Rightarrow \quad \bar{x} = \sum_j f_j x_j$$

b) aside about real world "bin widths"

normally measure real number with some accuracy say 0.1 and

so measure distribution of looks instead like this
[already ordered]

$$\underbrace{23.7, 23.8}_{0.1}, \underbrace{23.8, 23.9}_{0.1}, \underbrace{23.9, 23.9}_{0.0}, \underbrace{23.9, 24.6}_{0.7}, \text{etc}$$

look at spacer in data

pick some reasonable average of gaps as "bin widths"

3?
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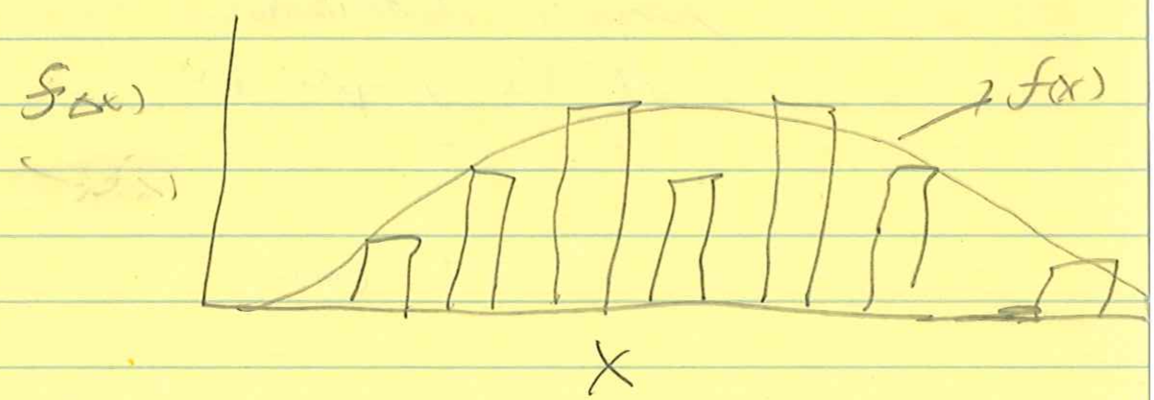
L2.4

(i) we're working towards a statistical description of data distributions

$f(x)$ a probability distribution fctn
(it is data dependent)

so will move from



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

→ then $f(x)\,dx$ is the fraction of samples between x and $x+dx$

or more ~~properly~~ formally

$\int_a^b f(x)\,dx$ = fraction of samples between a + b

d) need to normalize s.t.

$$\int_{-\infty}^{\infty} f(x)\,dx = 1$$

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e) now, with our $f(x)$ properly normalized we can state that:

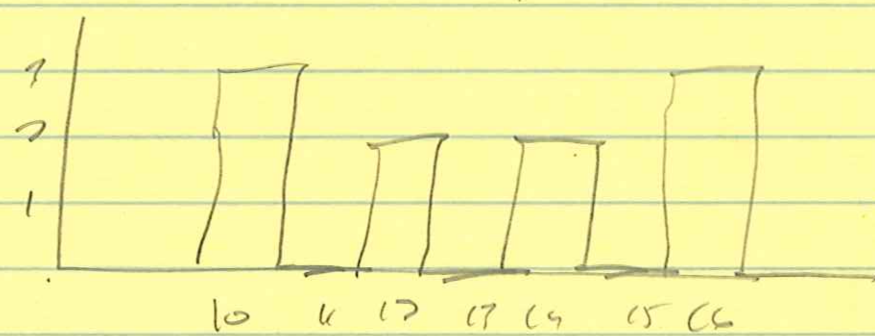
these two things define our data distribution somewhat well

i) $\bar{x} = \int_{-\infty}^{\infty} x\, f(x)\, dx$ "expectation value"

ii) $\sigma_x^2 = \int_{-\infty}^{\infty} (x-\bar{x})^2 f(x)\, dx$ "variance"

f) Central Limit Thrm

start with any distribution with well-defined mean and variance



can set a sample size N

and take samples (examples) of above

say $N=4 \Rightarrow [10, 10, 14, 16] \Rightarrow \bar{x}_1 = 12.5$

keep doing this, then plot freq. dist of example means get something that looks like a "normal distribution"

further, if we increase example size N and look at freq. distr. looks more normal

CLT says that as $N \to \infty$
freq distr. $\to$ "normal"
with well-defined mean
& variance.

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note, we started with any distribution and only assumed it had a well defined mean and variance

it might not, itself, be "normal"

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g) but what does it mean to be "normal?"

implies that $f(x) = \text{Gaussian} = e^{\frac{-x^2}{2\sigma^2}}$

or $e^{\frac{(x-\bar{x})^2}{2\sigma^2}}$

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for now we'll call σ the "width fctn"
and $\bar{X}$ the "maximally probable value"

→ would typically need to normalize this $f(x)$ s.t

$$\int_{-\infty}^{\infty} f(x)\,dx = 1$$

h.) ERF

so the probability of finding a sample between $\mu-\sigma$ & $\mu+\sigma$ is

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

can let $z \equiv \frac{x-\mu}{\sigma} \Rightarrow$

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

called the "error fctn" or ERF

look up values in book