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Fig 2.1

1) Error & Taylor 2-3

- rules for sig. figures? [2.2]

flipped style note [uncertainty to 1 sig fig (2 if ~1), this determines best value sig figs]

- discrepancy (Fig 2.1) [2.3]

~~accept~~ accepted or expected when precision is high (error small)

- "interesting conclusions" compare 2 or more numbers

9.823

- though probable that "true value" [2.4] lies between $x_{best} - \delta x < \text{value} < x_{best} + \delta x$ is possible it lies outside this range

error det by

compare |discrepancy| to $|\delta x|$

0.2

- provisional rules developed [2.5]

So

for $q = x + y$

9.8 ± 0.2 m/s²

$\delta_q = \delta_x + \delta_y$

- graphic representation + fit

include eg. when $y = Ax^2$

plot y vs. x^2 ⇒ straight line slope A

- fractional uncertainties [2.7]

if $x = x_b \pm \delta x$, frac. uncertainty = $\frac{\delta x}{|x_b|}$

(b = best)

Fig
2.2

1). continued) [2.7]

frac uncertainty (or relative uncert
or precision)
can be stated as %. (no units!)

— (not much here...) [2.8]

— mult 2 number [2.9]

state in terms of frac unc

$q = x \cdot y \Rightarrow$

δx_f

$x = x_0\left(1 \pm \frac{\delta x}{|x_0|}\right)$, $y =$ etc

$q_{max} = x_0 \cdot y_0 (1 + \delta x_f + \delta y_f + \delta x_f \delta y_f)$

ignore this

$q_{min} \doteq x_0 \cdot y_0 (1 - \delta x_f - \delta y_f)$

$\Rightarrow q = q_0 [1 \pm (\delta x_f + \delta y_f)]$

provisional

Chapter 3

— "problems of definition" $\Rightarrow$ [3.1]
challenges in est. error

— reporting measurements many
times generally good

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F17
L2.3

1.) continued Chapt 3

- $\sqrt{\ }$ rule for counting (rules) [3.2] {stable time interval}

usual rule is $q = q_{obs} \pm \sqrt{q_{obs}}$

- provisional rules (not very compelling) [3.3]

$q = x + y \Rightarrow$

$\delta q = \delta x + \delta y$ (same for $-$)

$q = x \cdot y \Rightarrow$

$\frac{\delta q}{q} = \frac{\delta x}{x} + \frac{\delta y}{y}$ (same for $\div$)

- Two special cases [3.4]

1) $q = Bx$ no uncertainty in B

$\Rightarrow \delta q = |B| \delta x$

2.) $q = x^n \Rightarrow$ (n power)

$\frac{\delta q}{|q|} = n \frac{\delta x}{|x|}$

- here it gets interesting ?? [3.5]

if $q = x + y$, and measurement of $x \pm \delta x$ made randomly, so uncorrelated w/ measure of $y \pm \delta y$, then better est of error is

$q \pm \delta q = (x + y) \pm \sqrt{(\delta x)^2 + (\delta y)^2}$

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F17

L 2.4

1.) Cont'd Chapt 3.

- continuing w [3.5]

use adding error in quadrature

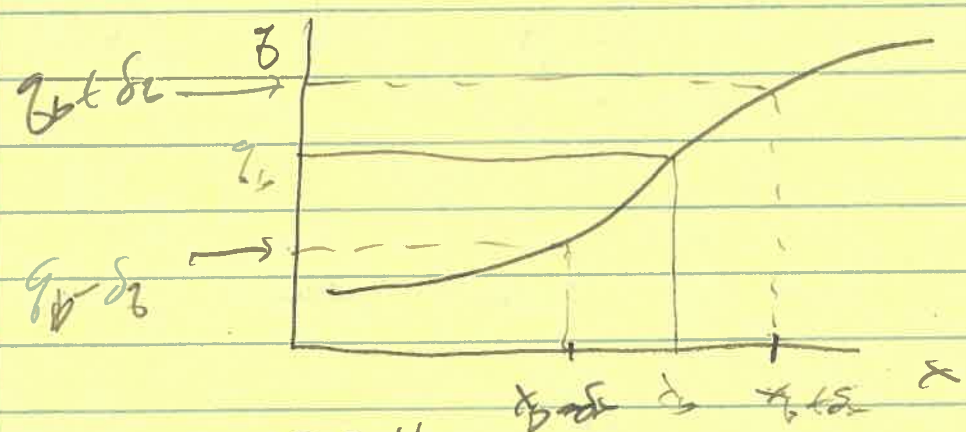
$\delta_q = \sqrt{(\delta_x)^2 + (\delta_y)^2}$ when measurements are uncorrelated: independent of one another.

one deviation/fluct. perhaps a larger measure of when obs larger measure in x.

- $q = x \cdot y \cdot z \Rightarrow$ [3.6]

$$\frac{\delta q}{|q|} = \sqrt{\left(\frac{\delta x}{x}\right)^2 + \left(\frac{\delta y}{y}\right)^2 + \left(\frac{\delta z}{z}\right)^2}$$

- fctn one variable [3.7]



Can use calculus to est δ_q?

$$\delta_q = q(x_b + \delta x) - q(x_b)$$

FAC

$q(x + u) - q(x) = \frac{dq}{dx}$ i.e.

(3a1)

F17
L25

(1.) cont'd

$\therefore \quad \delta q = \frac{dq}{dx}\, \delta x$

$\rightarrow \quad \delta q = \left|\frac{dq}{dx}\right| \delta x$

- some examples [3.8]

good ex

$q = x(y - z\sin\phi)$

mult. form

do $\sin\phi_0$, then $z_0\sin\phi_0$ for error
then $y - z\sin\phi \Rightarrow$ error (a difference)
then $\cdot\, x$ (above) $\leftarrow$ mult. form

- examples [3.9 + 3.10]

- general formula (not provisional)
uncertainty in fctn of sev. variables
$q(x, y, \ldots)$

$$\delta q = \sqrt{\left(\frac{\partial q}{\partial x}\delta x\right)^2 + \left(\frac{\partial q}{\partial y}\delta y\right)^2 + \ldots}$$

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reference Lect

L2.6

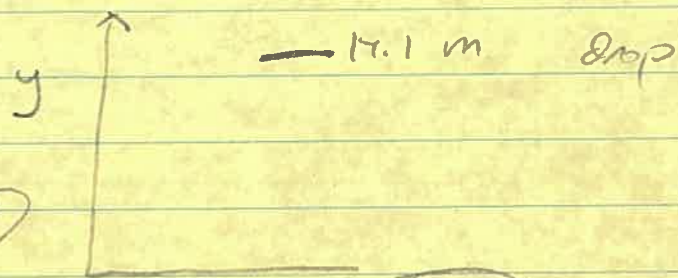
2) Coding, in for loops for air resistance

Sp 16 (2.0)

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

$\Rightarrow$ could we fix this computationally? signs?

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



$D = 2e-4$

.0002

$V = V_f$

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

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

v_{avg} dx

ge = -9.8 (final)
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

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's the #

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

$= ge - Dv^2$

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

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

```
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;
```

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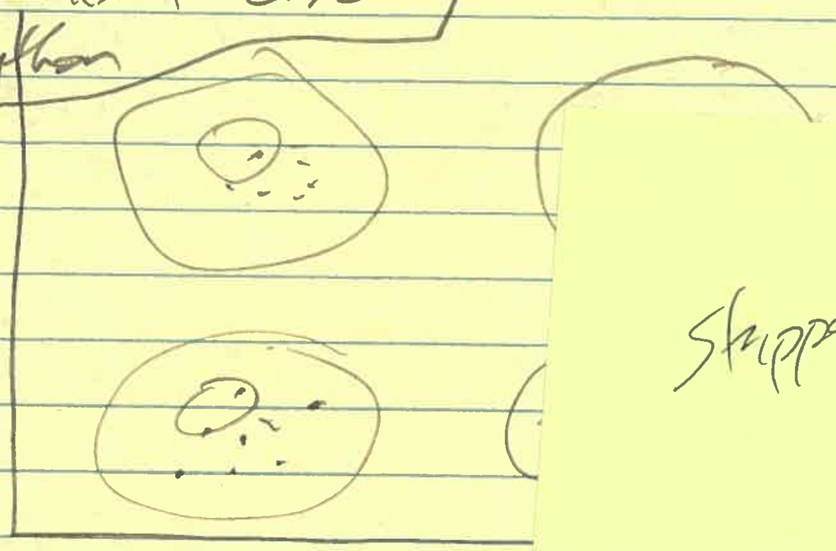
FC7
L3.2

1) more about Error
2) python

(precision)



Skipped

(accuracy)

Info for "Flipped Taught Chapter"

(ask students to suggest labels for plot above)

→ "accuracy" involves knowing what is the goal or value ←

1) Can reduce statistical error (increase precision) by taking more measurements N↑. 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 → CMS 125.3 ± 0.6 and ATLAS 126.0 ± 0.6 (GeV/c)

took data

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~~4/7~~
L2.1b

(~~example of reducing σ~~)

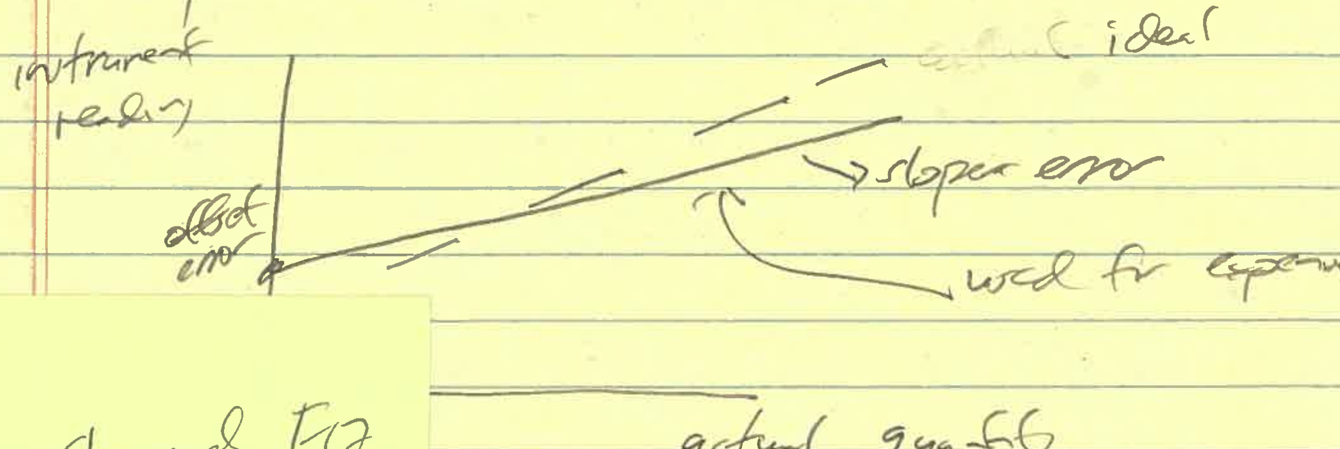
Higgs Boson, took ~~4~~ 40 years
took enough data to where probability of "getting at least as strong a result" (for alt expl) was 1:3 million
and significance of 5 sigma (σ)

results were ~~(125.3 ± 0.6) GeV/c² CMS~~
(126.0 ± 0.6) GeV/c² ATLAS

teams were blinded from each other since 2011

example of systematic error:

example would be mis-calibrated instrument



Skipped F17