PHYS 391

F16
L1-1

1) Course organization

2) Some things about Error Analysis (will be "flipping" this)

3) intro to intro to scientific programming

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1)

Web page

- goals →
  - develop formal error analysis skills, using Taylor, through curve fitting, binomial + Poisson distr.
  - "scientific programming" in context of
    - getting data
      - in real life
      - from web
    - converting / alternate "processing" data
    - graphing / visualizing
    - interpreting
      - "fits"
      - simulation comparisons

aka "data wrestling"

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1) cont'd

- 5 HW from Taylor, 5 labs
  every 2 weeks each
  staggered
  not all labs ⇒ reports

- labs entail using + developing scientific programming for data wrestling, ~~#~~ simulations, tables ^ graphing (good graphs), fits ~~[illegible]~~ ← accounting for error

- looking @ astro-, bio ~~[illegible]~~, geo-physical data sets ← define

- we will explore practical role of (discrete) data acquisition + Fourier

2) Intro to Error

prolog: going to "Flip" this part of lectures. Expect students to come w/ questions about assigned Taylor readings each week henceforth + we'll spend time discussing / answering questions

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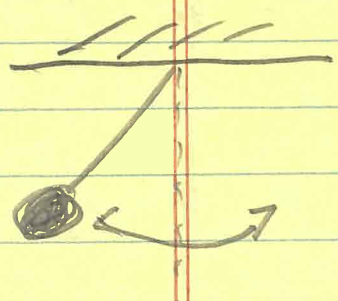
2) Error – continued

In science "error" has a special meaning – an estimate of the inevitable uncertainty in measurement. (Not a "mistake.")

No physical quantity can be measured w/ complete certainty, eg w/o "error"

But why should we care, after all, error is inevitable?

a) are 2 measurements consistent?



Simple pendulum

i) 1 person measures length of pendulum directly @ $l = 30.9$ cm

ii) 2nd person measures period of same pendulum to infer length via "theory", with period

$$T = 1.14\,s$$

are these 2 measurements of length consistent?

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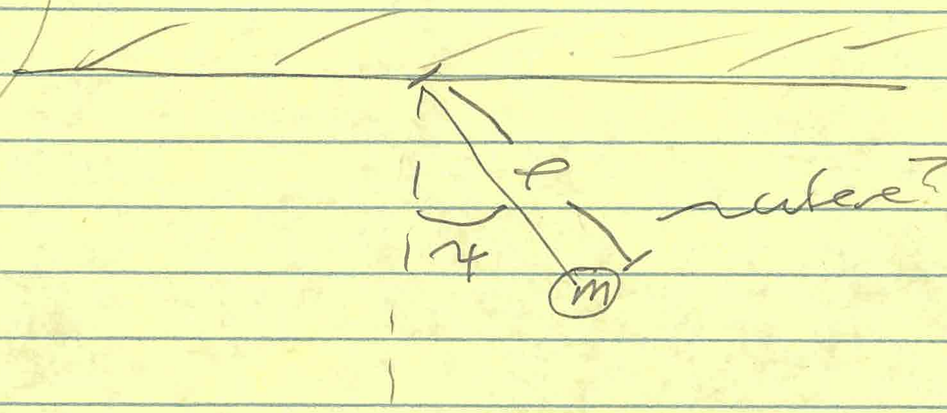
2) Error - continued

~~are measurements i) & ii) consistent?~~

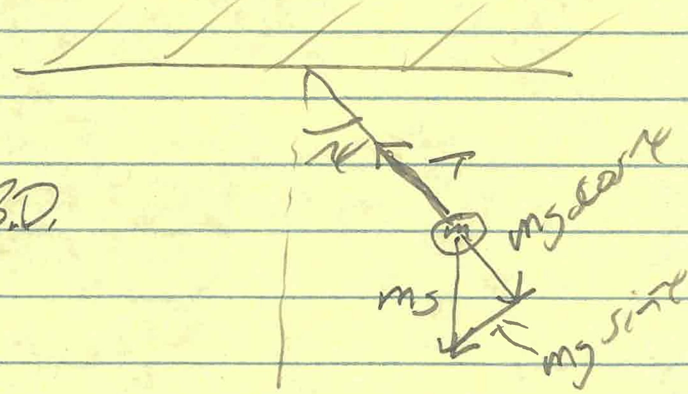
to check, turn ii)'s T measure into equivalent l_{ii} via "theory"

1st write down assumptions



could do forces

F.B.D.



Suggest we use torques

$$\tau = I\ddot{\varphi}$$

$$\Rightarrow \quad -mg\sin\varphi \cdot l = I\ddot{\varphi} = ml^2\ddot{\varphi}$$

$\Rightarrow$ m cancels, why?

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2) Error - continued

$$\Rightarrow -g\sin\psi \approx g\psi = l\ddot{\psi}$$

operation bit is we need a function whose double derivative is $\propto$ to itself

Suggest $\psi = \psi_0 \cos(\omega_0 t + \phi)$

solves w with $\omega_0 = \frac{2\pi}{T} = \sqrt{\frac{g}{l}}$

[could plug in soln and check]

$\Rightarrow$ (use matlab for this)

ML

$l_i = 30.9$ cm $= .309$ m

compared to $\frac{(2\pi)^2}{T^2} = \frac{g}{l} \Rightarrow$

$$l = \frac{gT^2}{(2\pi)^2}$$

direct length measure

plug in $T_{ii} \Rightarrow .3226$

or $l_{ii} = .323$ m

$(l_i = .309$ m$)$

~~don't~~ doesn't look prima facie consistent, but we need errors to know?

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2) Error continued

i) error estimation: measured w/ meter stick 30.9 cm means measuring to ± 0.1 mm hard to do. Likely could measure to ± 0.5 cm

⇒ measurement stated as $l_1 = (30.9 \pm 0.5)$ cm

ii) measures ("stacks") 10 complete oscillations each time, does error prop →

(32. ± 2) cm

from Taylor Chpt. 3

⇒ OK measurements consistent? yes

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b.) why study error part 2

1904-05 15, Einstein postulates special/general theory of relativity.

predicts light passing our sun bent by $\alpha_R = 1.8''$ (seconds of arc), double the $\alpha_c = 0.9''$ predicted by "classical" arguments

1920 Dyson, Eddington, Davidson do "small experiment" & got $\alpha = (2.0 \pm 0.3)''$

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Eddington → Principe (island w of Africa)
Dyson → Sobral, Brazil

why 2 measures?

observed stars "near" Sun during eclipse to compare angular separation bent by sun, and unbent by sun (at night other than eclipse) at 2 places on Earth

(writing) sci. fic. books turn into blockbuster movies
Capt Jack Sparrow
Grandson kidnaps Dyson, etc.

→ result consistent with G.R. but not classical ←

3) Intro to scientific programming (to L1-7b)

- suppose we want to "simulate" a ball dropped from 14.1 m heigth above the floor?

(do this with ball drop video)

- first, "simulate" means to write a computer program that gives details about the balls position during the drop, etc.

- second, let's make some assumptions. we will initially ignore air resistance (drag), but want to add this in later.

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3) Intro to Intro to Scientific Programming

? Suppose we want to simulate a ball drop?

- 1st, simulate means to develop a computer code that gives fine-grained details about the ball's position, velocity, acceleration vs. time, as it drops.

step 1

- 2nd we have assumptions and initial conditions. Assumption: for now we ignore air resistance but will add in later

could solve for, say, drop time analytically, but much much harder to do with air resistance

step 2

- Draw experiment to help visualize. (our later graphs also should help visualize). For simulation, think of creating high speed video of drop, get info frame by frame

need initial conditions:

mass = m = ??

initial height = y_i = ??

step 3

ball shape = ? = ??

initial velocity = v_i = ??

accel. grav. constant = g = ?? on Earth? elsewhere?

are we near planet's surface?

color of ball?

dropping through normal air?

initial accel of ball = a_i = ??

T of air through which dropped? density?

3) cont'd Sci. Proj.

step 3b) assign symbols to characteristics
e.g. y = height
v = velocity, etc.
(will need to do this, also, in code)

step 4) consider physics to get "governing equations" ("theory")

$$F_{tot} = ma \Rightarrow \frac{F_{tot}}{m} = a = \frac{v_f - v_i}{\Delta t}$$

Δt = time step, you choose!

further: $v_f = v_i + \frac{F_{tot}}{m} \Delta t$ ⟸ (looks useful)

and $\vec{v} = \frac{y_f - y_i}{\Delta t} \Rightarrow y_f = y_i + \frac{\vec{v}}{\Delta t}$

gives new ball position (y_f) after time step Δt + ball velocity (v_f) then

also $t_f = t_i + \Delta t$ helps develop "time array"

(a few words about "arrays")

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3) cont'd Sci. Prog.

Step 5

construct "function*" (bit of computer code) to simulate ball drop. We give this function initial conditions, it gives us arrays t, y, v, a, etc

[call part]

you choose which

[set some? constants, initial conditions]

["for" or "while" loop, step through ball drop in steps Δt]

if time note that we:

a) described the scene, both pictorally + with symbols, before changing above

b) we made assumptions (ignore air resistance) + used physics to develop specific "theory" in form an governing eqns

c) built "function" using a standard form

* function here is a bit of code, not something like F=ma.