PHYS 391

Sp16 | Wk6 L1-1

1) course organization

2) a bit about Error Analysis

3) scientific programming

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1) (show web page)

- goals →
  - formal error analysis Taylor through curve fitting, binomial & Poisson
  - scientific programming
  - "data wrestling"

- 5 HW + 5 labs (every 2 weeks)

- labs involve using/developing scientific programming for simulations & to ascertain data; "reduce" it to a useable & preferred form; make tables & graphs; and interpret it/fit it with mathematical relationships

1) continued

- we'll be looking at data from biophysics, astrophysics, geophysics + climate science realms

- we will explore the practical sides of data ~~sampling~~ acquisition + Fourier

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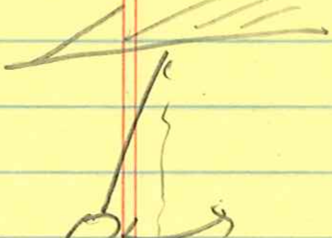
2) Intro to Error

In science the term "error" is an estimate of the <u>inevitable</u> <u>uncertainty</u> in <u>measurement</u>, not a mistake

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

But why should we care about "error" which is, after all, <u>inevitable</u>?

a) are 2 measurements consistent?



i) one person measures length of pendulum as $l = 30.9$ cm

ii) another person measures period of same pendulum to be

$T = 1.14$ s

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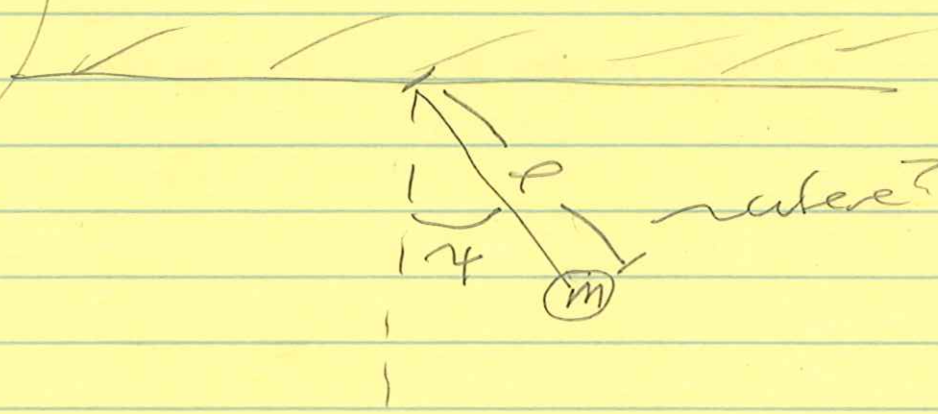
2) Error - continued

are measurements i) & ii) consistent?

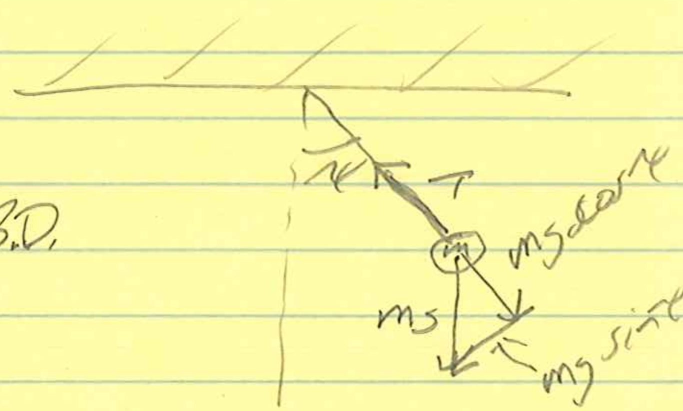
to check, turn ii)'s T measure into equivalent l_{ii}

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 ∝ to itself

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

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

[could plug in soln and check]

(use matlab for this)

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

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

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

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

or $l_{ii} = .323$ m

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

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 $l_i = (30.9 \pm 0.5)$ cm

ii) measures ("stacks") 10 complete oscillations each time, does error prop. → (from Taylor Chpt. 3)

$(32. \pm 2)$ cm

⇒ OK measurements consistent?

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" & get $\alpha = (2.0 \pm 0.3)''$

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

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

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

Why 2 measures?

(writing) side: adv. books turn into blockbuster movie Capt. Jack Sparrow Snowdon kidnaps Dyson, etc.?

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3) Intro to scientific programming

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

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

(do this with ball drop video)

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

S.P. 1)

step 2) draw experiment to help visualize. For simulation think of recreating high-speed movie of ball drop

?? what characteristics of the experiment should we consider ??

step 3)

- mass of ball?
- shape of ball? (radius?)
- is it dropping through normal air or something else?
- ~~T~~ T_{air}?
- g of planet?
- are we near planet's surface?
- color of ball?
- speed, position, accel of ball

cull useless characteristics from list

step 4) assign symbolic variables to characteristics

m (mass), g (accel of gravity), etc.

step 5) need to consider physics and get governing eqns

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

(dt = time step)

3) sci. prog. continued
furthermore

$$v_f = v_i + \frac{F_{tot}}{m} dt$$

- this looks useful ↑

- also, $V_{avg} = \frac{y_f - y_i}{dt} \Rightarrow y_f = y_i + \frac{V_{avg}}{dt}$

gives us new ball position from initial (last) position & avg velocity after time step dt

also $t_f = t_i + dt$ (helps us build a "time array")

(to step 6, code) build "function*" to simulate ball drop

[call part]

[set constants and initial variables]

[for loop to step through ball drop
step = dt

(do this in ML + python?)

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* in sci. programming sense

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3) ski proj. continued

(If time)

note that we:

a) described the scene (both pictorally + with characteristics (config) before

b) mapping to physics to get eqns

c) built fctn using standard form

at meta level, we started simple + neglected drag. But we formulate s.t. we can easily add it in later.