flip.tanedo @ ucr Physics 3054

COURSE: tanedo.github.io/Physics231-2018

IMPORTANT STUFF

- 32 meetings → not "lecture" or "dis"
  all are equally mandatory / optional

→ PLEASE SEE CALENDAR
  - we will not meet on 3 mondays
    3 fridays
  - the "DIS" hour will be used on equal footing as "LEC" hour.
  - MONDAY 3:10pm will be in Reading Room not in SURGE / SKYE HALL.

- TA: IAN CHAFFEY (also TA of E&M)
  ↑ HW questions / by APPT.
  BUT: 1st option: DISCUSS w/ COLLEAGUES!

EVALUATION:
- 5 × { SHORT HW [5 pt] / LONG HW [20 pt] }
- 1 × 5 min presentation (POP TALK) [25]
- Many in-class index cards [1 pt ea]

GRAD grades: will be normalized generously
UNDERGRADS get 'real' grades.

Structure: PROBLEM BASED

Meetings exist to help solve the problems in the HW.

YOUR INPUT (questions, curiosity, demands) will shape where we go & how we get there.

YOU CAN ALWAYS ASK "WHY ARE WE DOING THIS?"

TOPIC → HOW TO USE GREEN'S FUNCTIONS TO SOLVE DIFF. EQS ?

... Why?

$$\text{eg. } \left[\frac{1}{c^2}\left(\frac{\partial}{\partial t}\right)^2 - \left(\frac{\partial}{\partial x}\right)^2\right] f(x,t) = s(x,t)$$

given $s(x,t)$, what is $f(x,t)$?
SOURCE RESPONSE

WRT $[\cdots]$, DIFF. OPERATOR.

along the way: WHY this eq? !!

SciComm : how do we communicate as scientists?

IMO: this is the most underappreciated skill in grad school & THE MOST IMPORTANT for your success early & late in your PhD.

LESSON 1: how to ask questions without sounding like you don't belong in grad school.

my strategy: "Is it obvious that ...?"

IN THIS CLASS: WED POP TALKS & WRITING EXERCISES

Physics ≠ Math ← not even "sketchy math" ("TAYLOR EXPAND IT ALL!")

↑ has units

3 apples → WHAT DOES THIS MEAN?

apples: unit

converting units : MULTIPLY BY 1

eg (3 apples) × ($1/apple) = $3

$1 = apple ⇔ $\frac{\$1}{\text{apple}} = 1$

exchange rate ↔ "mult. by 1"

eg NATURAL UNITS : $\hbar = c = 1$

constants of nature

$c = 3 \times 10^{10}$ cm/s $= 1$

$1\text{ s} = 3 \times 10^{10}$ cm

3×10^{10} cm → DISTANCE

"one light-second" is a distance

$1\text{s} = 3 \cdot 10^{-8}$ yr → $1\text{ yr} = 10^{18}$ cm

10^{18} cm: light-year.

DIMENSIONAL ANALYSIS

$$[\![g]\!] = L^a M^b T^c$$

anything missing? (I ALWAYS miss CHARGE)

- $[\![g]\!]$: physical quantity
- L^a: LENGTH
- M^b: MASS
- T^c: TIME

$L^a M^b T^c$ → DIMENSIONS "measure the units"

eg $[F]$? well, $\underline{F} = m\underline{a} = m\ddot{\underline{x}}$

$[F] = L^1 M^1 T^{-2}$

eg $[E]$ = ? $E = \frac{1}{2}mv^2$ (or mc^2)

$[E] = M^1 L^2 T^{-2}$

pretty simple. what's it good for?

1. <u>CHECK YOUR WORK</u> (or other people's work)

$f = \cdots [1 + \underbrace{l}] \cdots$

if $[l] \neq 1$, then this makes <u>no sense</u>!

compare to $(1 + x)$ w/ $[x] = 1$ (dim'less)

if x changes from 0.1 to 0.2, no big deal.

BUT IN $(1 + l/l_0)$, if I CHANGE l from 1 cm to 2 cm, I HAVE NO IDEA WHAT HAPPENS UNLESS I KNOW l_0.

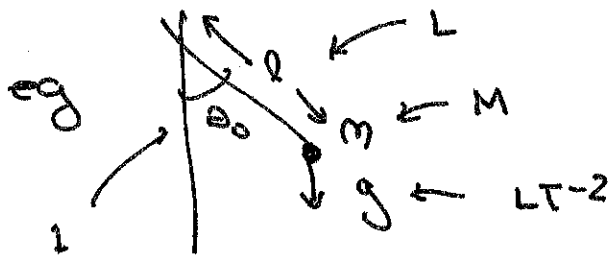
eg. $\sin(3\text{ cm})$ $\quad e^{5\text{ sec}}$

makes no sense?! WHY NOT?

$e^x = 1 + x + \frac{1}{2!}x^2 + \cdots$

must all have same units.

2. SOLVING PROBLEMS, understanding relevant **RATIOS** ← eg l/l_0



What is period of pendulum?

$[\tau] = T \quad \Leftarrow \quad \tau \sim \underbrace{g^{-1/2}}_{T L^{-1/2}} \times \underbrace{l^{1/2}}_{L^{1/2}} = \sqrt{l/g} \cdot \underbrace{f(\theta_0)}_{1}$

most important symbol in physics.

DON'T KNOW FROM D.A.

RATIO l/g is IMPORTANT

l goes ↑, g goes ↑ ; τ goes ↑ / ↓

like sq. root!

BTW: Why not G, $R_\oplus$, $M_\oplus$, $T_{UNIV.}$, ... ?

3. SCALING ← so much of physics.

eg. $\boxed{m\ddot{\underline{r}} = -\frac{\partial U}{\partial \underline{r}}}$ → $[\ldots] = MLT^{-2}$

recall $[U] = L \times [F]$

suppose:

$\underline{r}_0(t)$ ← one solution to this diff. eq. ("EXPTLY. VERIFIED")

DIM ANALYSIS GIVES OTHER SOLUTIONS:

scale time: $t = \alpha t'$

↑ new var. (like new unit)

IF POTENTIAL IS STATIC, only LHS changes.

↳ eh? RHS has dim $\sim T^{-2}$! BUT THAT COMES FROM GN, NOT $(d/dt)^2$.

$$m\left(\frac{d}{dt}\right)^2 \underline{r}_0(t) = \underbrace{m\alpha^{-2}}\left(\frac{d}{dt'}\right)^2 \underline{r}_0(\alpha t')$$

$$\equiv m'\left(\frac{d}{dt'}\right)^2 \underline{r}_0(\alpha t') = \frac{-\partial U}{\partial \underline{r}}$$

m': new mass; $\underline{r}_0(\alpha t')$: scaling

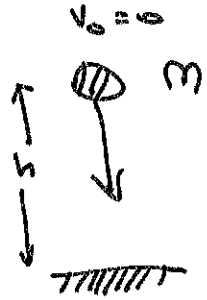
so, eg: $\boxed{\alpha = 2}$, $\underline{r}_0(\alpha t')$ is a solution w/ same trajectory

$m' = m/4$ ($1/4^{th}$ mass)

+ double the velocity.

4. ERROR ESTIMATE Bohren, Am J. Phys. 72 534 (+ 1102.1120)

HIGH SCHOOL PROBLEM :



? t_0

time to hit ground

HS ANSWER : integrate $\ddot{x} = g$ (leading order (in what?))

$x = \frac{1}{2}gt^2 + \cancel{vt} + \cancel{\delta}$ ($0 = v_0$, 0 = pick coord)

$$\rightarrow \boxed{t_0 = \sqrt{\frac{2h}{g}}}$$

good approx. (@ surf. of earth ...)

Q. HOW GOOD??

DIRECT, HARD, STUPID: DO NLO & compare. (next-to-leading order)

Why do a hard calc to justify an easy one?

WANT: ERROR ESTIMATE

$$\frac{t_{\text{realistic}} - t_0}{t_0}$$

dim'less

IDEALLY NOT A FULL CALC.

ASSUME WE'RE IN REGIME WHERE ERROR IS SMALL.
(otherwise LO estimate no good.

error is $f(\xi) = \frac{t_{realistic} - t_0}{t_0}$

↑ some DIMLESS PARAM ... BUT WHAT?

WANT: $\xi \to 0 \Rightarrow f(\xi) \to 0$

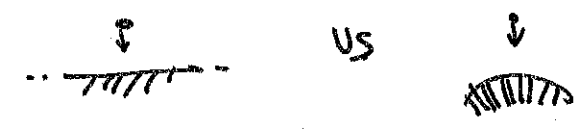
$f(\xi) \approx f(0) + f'(0)\,\xi + \mathcal{O}(\xi^2)$

↑ 0 ; $f'(0)$: DIMLESS, PRESUMABLY $\mathcal{O}(1)$

so: $\boxed{\text{ERROR} \sim \xi}$ — DIMless combo that sends $f \to 0$ when $\xi \to 0$.

WHAT KIND OF CORRECTION?

eg: EARTH IS ROUND w/ RADIUS R.



Why not G_N? already encoded in g (for given potential and R)

obvious choice: $\xi = \boxed{h/R}$ or R/h

from $R \to \infty$ limit

so: $\boxed{\frac{t_{realistic} - t_0}{t} \sim \frac{h}{R}}$

EXERCISE: CHECK THIS BY EXPLICIT CALC. (see 2017 Lec 1)