flip.tanedo@ucr.edu (PHYS 3054)

sites.google.com/ucr.edu/p231

IMPORTANT: this course is not mandatory.
IF YOU ALREADY HAVE A STRONG BACKGROUND, YOU MAY CHOOSE TO DROP IT.

Go over syllabus. (slide?)

→ index card:

NAME (pronoun)

POTENTIAL ADVISORS / GROUPS

FLIP SHOULD KNOW THIS ABOUT ME:

BACK: any topics you want covered?

LPT:

1. you can always ask:

   Why are we doing this?

2. afraid to ask a question?

   Is it obvious that ... ?

THIS COURSE: how to use Green's functions to solve differential eq.

... ALSO: WTF IS A GREEN'S FUNC.
... & WHY USE THEM?

b/c they're the "EASY" thing to do

context → ... MOST OF OUR CHALLENGES HAVE TO DO w/ nonlinear systems where GREEN'S FUNC. FAIL.

$$\underbrace{\left[\frac{1}{c^2}\left(\frac{\partial}{\partial t}\right)^2 - \left(\frac{\partial}{\partial x}\right)^2\right]}_{\text{DYNAMICS}} f\underbrace{(x,t)}_{\text{SPACE, TIME}} = \underbrace{S(x,t)}_{\text{SOURCE}}$$

RESPONSE

Q: given the source & dynamics ← PHYSICAL MODEL

BTW: why this OPERATOR?

Q: how is physics different from mathematics?

Physics $\neq$ Math ← not even "sketchy math" ("TAYLOR EXPAND IT ALL!")

has units

~100 kcal

3 $\underbrace{\text{apples}}_{\text{unit}}$ → WHAT DOES THIS MEAN?

converting units: MULTIPLY BY 1

eg $(3 \text{ apples}) \times \left(\underbrace{\$1/\text{apple}}\right) = \$3$

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

exchange rate ⇔ "mult. by 1"

eg NATURAL UNITS: $\underbrace{\hbar = c}_{\text{constants of nature}} = 1$

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

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

"one light-second" is a distance

$$1\text{s} = 3 \cdot 10^{-8} \text{ yr} \longrightarrow 1 \text{ yr} = \underbrace{10^{18} \text{ cm}}_{\text{light-year}}$$

DIMENSIONAL ANALYSIS

$$[\, q \,] = L^a M^b T^c$$

anything missing? (I ALWAYS miss CHARGE)

physical quantity

LENGTH

MASS

TIME

DIMENSIONS "measure the units"

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

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

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. CHECK YOUR WORK (or other people's work)

$f = \cdots [1 + l] \cdots$

WRITING RESULTS

if $[l] \neq 1$, then this makes no sense!

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.

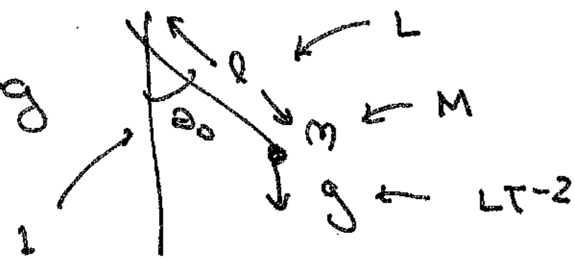
eg. $\sin(3\ \mathrm{cm})$ $\qquad e^{5\ \mathrm{sec}}$

makes no sense?! $\qquad$ WHY NOT?

$$e^x = \underbrace{1 + x + \tfrac{1}{2!}x^2 + \cdots}_{\text{must all have same units.}}$$

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

eg



what is period of pendulum?

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

$\boxed{\text{most important symbol in physics.}}$

DON'T KNOW FROM D.A.

RATIO l/g is IMPORTANT

l goes ↑, τ goes ↑
g goes ↑, τ goes ↓

like sq. root!

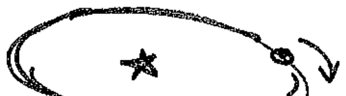
BTW: why not G, $R_\oplus$, $M_\oplus$, $T_{\mathrm{UNIV.}}$, ... ?

3. <u>SCALING</u> ← so much of physics.

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

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

suppose:



$\underline{r}_0(t)$ ← <u>one</u> solution to this DIFF. EQ. ("EXPTLY. VERIFIED")

DIM ANALYSIS GIVES <u>OTHER</u> SOLUTIONS:

<u>scale</u> time: $\boxed{t = \alpha t'}$

new var. (LIKE NEW UNIT)

IF POTENTIAL IS <u>STATIC</u>, only LHS changes.

eh? RHS has DIM $\sim T^{-2}$!
BUT THAT COMES FROM G_N, NOT $(d/dt)^2$.
<u>constant</u>

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

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

new mass — SCALING — same

so, eg: $\boxed{\alpha = 2}$, $\underline{r}_0(\alpha t')$ IS A SOLUTION

w/ same trajectory

$m' = m/4$ (1/4th MASS)

+ <u>double</u> the velocity.

4. ERROR ESTIMATE

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

HIGH SCHOOL PROBLEM :

$\boxed{?\ t_0}$

time to hit ground

HS ANSWER : integrate

leading order (in what?)

$$\ddot{x} = g$$

$$x = \tfrac{1}{2} g t^2 + \cancel{c}t + \cancel{d}$$

$0 = v_0$ 0

PICK COORD

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

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

Q. HOW GOOD??

next-to-leading order

DIRECT, HARD, STUPID: DO NLO & compare.

why do a hard calc to justify an easy one?

WANT: ERROR ESTIMATE $\boxed{\dfrac{t_{realistic} - t_0}{t_0}}$

DIM'LESS

IDEALLY NOT A FULL CALC.

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

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

SOME DIMLESS PARAM
... BUT WHAT?

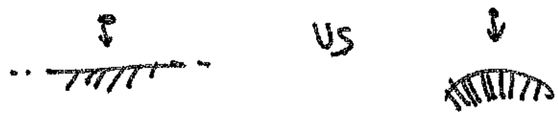
WANT: $\xi \to 0 \Rightarrow f(\xi) \to 0$

$$f(\xi) \approx \underset{0}{f(0)} + \underbrace{f'(0)}_{\text{DIMLESS, PRESUMABLY } O(1)} \xi + O(\xi^2)$$

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

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