



# Physics 2B Winter 2025 Electricity and Magnetism

By Julio Barreiro

## P1: Information and Announcements

Syllabus @ <https://barreirolab.com/ucsd-phys2b/>

## P2: Prerequisites

## P3: Electric charges and forces

Lecture notes are posted on Canvas before each class.  
All lectures are already available on canvas.



# Introduction

- Welcome to Physics 2B!
- Physics 2 is a four quarter course designed as an introduction into basic physics for students in the engineering and the physical sciences.
- Physics 2B focuses on Electricity and Magnetism, by having two 1hr 20min lectures per week (Tue/Th)
- Success in Physics 2B requires a LOT of hard work!



# Who is Julio Barreiro?



- First, your instructor
- Second: Experimental Atomic, Molecular and Optical (AMO) physicist

- <https://barreirolab.com>



- Raised in Acapulco

- PhD Physics @ University of Illinois at Urbana-Champaign (Fulbright scholar)
- Postdoc @ Institute of Quantum Optics and Quantum Information, Innsbruck, Austria
- Postdoc @ Max-Planck Institute of Quantum Optics, Munich, Germany



Assistant Professor @UCSD since 2014

Syllabus @ <https://barreirolab.com/ucsd-phys2b/>

# PHYS 2B • Winter 2025

## *Summary of resources*

Syllabus, Lecture Notes, and Grades

<http://canvas.ucsd.edu>

Announcements and online discussion

Piazza, access through Canvas

Homework & eText

Mastering Physics, access through Canvas.

- **Discussion** (strongly recommended, extra credit in the future)
  - Please bring iClickers to Discussion, though it doesn't affect your grade
  - Yes: Discussion tomorrow



- How to ask questions about HW

- “I tried doing the problem these ways, and got stuck at these points...”
- Not “How do I do this problem?”.  
• Please don’t: **“Can you go over ...?”**

A → 16 days ✓       $\boxed{16, 12} \rightarrow 48$   
 B → 12 days ✓  
 Starting with A, they work on alternative days?  
 So, How many days They will take to finish the work  
 total work = 48 units.    A, B, A, B.....

A →  $\frac{3}{4}$  u/d ✓  
 B →  $\frac{1}{4}$  u/d ✓  
 8 days → 7 u  
 $6 \times 2 \rightarrow 7 \times$   
 $\boxed{12} \rightarrow \boxed{42}$

# Physics 2B Winter 2025 Discussion sessions schedule

Phys 2B Instruc: Barreiro						
Wednesday	MYR-A 2702 2:00pm-2:50pm	MYR-A 2722 2:00pm-2:50pm	MYR-A 2702 3:00pm-3:50pm	MYR-A 2722 3:00pm-3:50pm	MYR-A 2702 4:00pm-4:50pm	MYR-A 2722 4:00pm-4:50pm
	A01 Nguyen 936182	A02 Altin 936183	A03 Nguyen 936184	A04 Altin 936185	A05 Nguyen 936187	A06 Tang 936217
	MYR-A 2702 5:00pm-5:50pm	MYR-A 2722 5:00pm-5:50pm	MYR-A 2702 6:00pm-6:50pm	MYR-A 2722 6:00pm-6:50pm	MYR-A 2702 7:00pm-7:50pm	MYR-A 2722 7:00pm-7:50pm
	A07 Altin 936219	A08 Tang 936220	A09 Canceled 936221	A10 Canceled 936224	A11 Altin 936229	A12 Nguyen 936231
Lecture TAs						
Last Name	First Name	Dept.	% Time	Hrs/Wk	Email	
Altin	Baha	Phys	50%	20	<a href="mailto:baltin@ucsd.edu">baltin@ucsd.edu</a>	
Nguyen	Luc Michael	Phys	50%	20	<a href="mailto:lmn006@ucsd.edu">lmn006@ucsd.edu</a>	
Tang	Paul	Phys	25%	10	<a href="mailto:jianrong.t@wustl.edu">jianrong.t@wustl.edu</a>	

A GOAL WITH NO  
PLAN IS JUST A WISH.

# Course goals



- We want to understand not just the **facts** of our topics, but the **methods** by which people came to understand them
  - And so empower ourselves to discover/build/invent and *do* new things
- We seek a ***conceptual*** and ***quantitative*** understanding of basic physics concepts, to allow:
  - Understanding a physical situation
  - Deducing the qualitative behavior of it
  - Assessing what information is available or needed to perform meaningful calculations
  - Performing such calculations
- Virtually *all* physical science occupations require such a basic understanding and skills
  - Email or talk with me about your course goals
- PHYS 2B is very abstract... so think of it as a game, where you're given the rules and you have to play with it.

# Required things

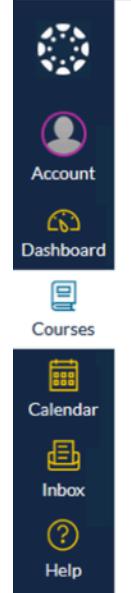
1. Canvas <http://canvas.ucsd.edu>
2. i>Clicker
  - May share your iClicker *with another class*
  - Can not share with another student *in this class*
  - If you need to recover its ID, I can help after class
  - Every class counts
  - Register your iClicker on Canvas, tab “iClicker Cloud Registration”
  - *Holding more than one iClicker in class is an Academic Integrity Violation.*
3. R Knight, Mastering Physics, *Physics For Scientists & Engineers*, UCSD Custom 2B
  - Custom version needed for homework: Mastering Physics
4. Homework/Reading Quizzes: Mastering Physics through TritonEd
5. Piazza, through Canvas



# Canvas

<http://canvas.ucsd.edu>

is for lecture notes and grades



☰ PHYS2B\_WI20\_A00 > Syllabus

Winter 2020

Home

MyLab and Mastering

Academic Integrity

Files

Syllabus

Announcements

iClicker Registration

Grades

PHYS 2B - Phys-Electricity and Magnetism - Barreiro Guerrero [WI20]

[Syllabus at http://barreirolab.com/ucsd-phys2b/](http://barreirolab.com/ucsd-phys2b/)

For prelecture assignments and homework, click on "MyLab and Mastering".

Announcement and Discussions on [piazza http://piazza.com/ucsd/phys2b/home](http://piazza.com/ucsd/phys2b/home)

Grades, lecture notes and discussion material will be posted here, on "Files"

- Waitlisted students have access to Canvas already
- Extension students, see <http://sdacs.ucsd.edu/~icc/ce.php> (confirm?)
- You must check your grades on Canvas
  - I have to update grades on Canvas manually, ~ once per week, including HW
  - You must notify me within 1 week of posting of any discrepancy
- You can configure Piazza to email you when announcements are posted.
  - Such as when I announce that a Reading Quiz or HW is assigned.
  - All announcements are posted on Piazza.

Syllabus @ Canvas

# iClickers

You must register on Canvas

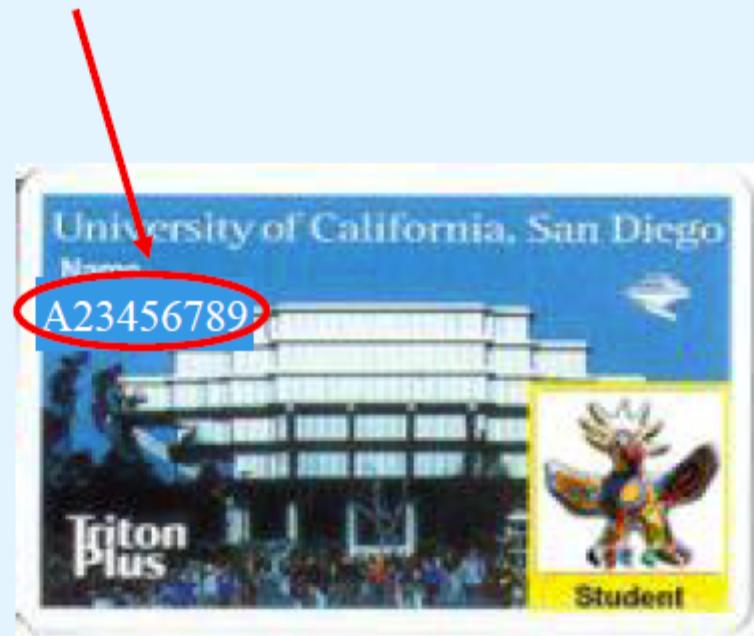


<https://www1.iclicker.com/>

Syllabus @ Canvas

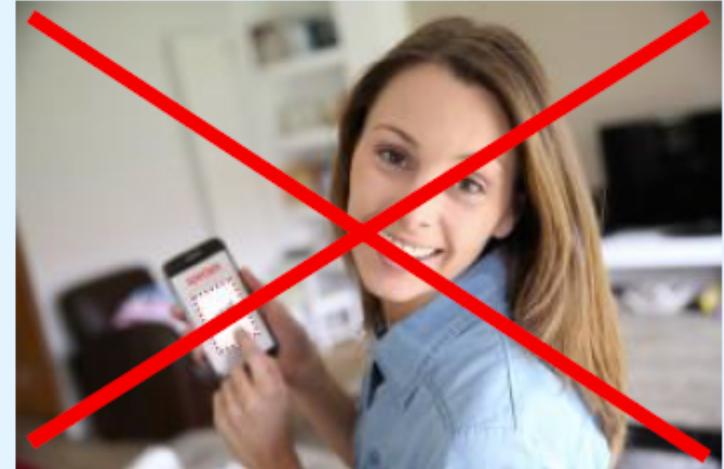
# You are unique

- But your name is not
- When you send me an email,  
always include your student ID



# Electronics in class

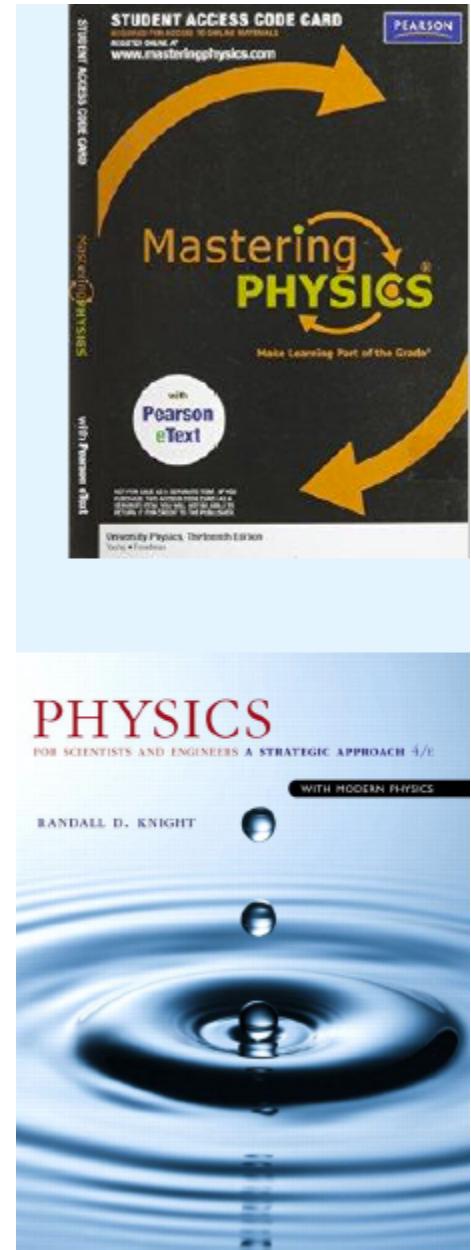
- Be fair to those around you: don't distract them
- During class, open computers for *this class only*
  - If you don't want to be in class, don't come
- No cell phones
- If you *must* take a call, sit on the aisles, and feel free to step outside



# Homework is for credit!

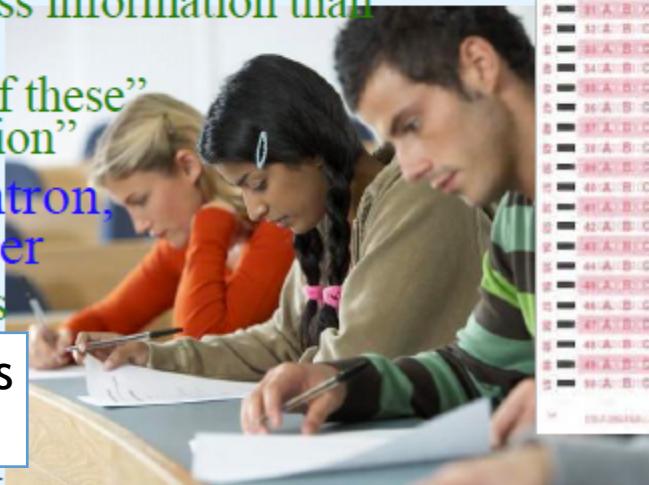
## Mastering Physics (Pearson)

- HW is essential for conceptual and numerical practice
- Class discussion ...
  - provides a conceptual understanding for numerical calculations
  - alone is insufficient for doing well on the exams
- Homework will be assigned once or more per week
- Prelecture assignments, once/twice per week
- Solutions to some problems will be posted online
- Tutorials available are very useful
- **Registration through Canvas, see the**



# Quizzes

- ~10 questions except, Quiz 1: ~30 questions
  - Some simple definitions or formulas
  - Some advanced (Separates the ‘A’s from the ‘B’s)
  - Most in the middle
- All exams come in 4 forms:  
A, B, C, and D
  - You must bubble in your form letter
- The question order is randomized by computer
  - Show me what you know
    - Don’t get hung up on what you don’t know
- Question are like HW and iClickers, except ...
  - I may give you more or less information than needed
  - Some choices are “none of these” and “not enough information”
- Bring only a pencil, Scantron, calculator, and *blank* paper
  - We will give you formulas



Seats are pre-assigned on canvas  
**Simple calculators only**

11/28/2010

PHYSICS 2D.

ParScore®  
TEST FORM

NAME \_\_\_\_\_ LAST \_\_\_\_\_ FIRST \_\_\_\_\_ MIDDLE \_\_\_\_\_  
SUBJECT \_\_\_\_\_  
DATE \_\_\_\_\_ HOUR DAY \_\_\_\_\_

DIRECTIONS

- USE DARK MARKERS
- ERASE COMPLETELY ORANGE
- A B C D

ID NUMBER

1	2	3	4	5	6	7	8	9	0
---	---	---	---	---	---	---	---	---	---

TEST FORM

A	B	C	D
---	---	---	---

EXAM NUMBER

1	2	3	4	5	6	7	8	9	0
---	---	---	---	---	---	---	---	---	---

SIDE

F-289-PAR-L

Reorder Form # F-289-PAR-L  
www.Scantron.com  
800-722-4670

# Final Exam

- Just like a big quiz
  - Same Scantron and everything
  - It might be in a different room
  - ~30 questions
  - Covers entire course uniformly



# OSD Students



- Per the contract you signed:
  - You must meet with me before the course starts to determine if this class is right for you
    - I have extended the time to this Monday 9/26
  - Establish the accommodations for this class
    - Physics cannot, and does not, accept all requested accommodations
  - Extended exam hours are available
  - The homework system is automated, so there is no late homework
    - As in much of the Math Department

# Waitlisted students

- Historically, waitlists are highly variable
  - There are no guarantees
- To be eligible to enroll if space opens up:
  - Pretend you are in the class:
    - Do the iClickers
    - Do the homework
    - Take the quizzes
    - etc.



# I Can't Teach You Anything

- I guess they picked the wrong guy for this job
- You must learn
  - I can help you
- What is the best way to get a good grade?
  - Understand the concepts!
  - Do homework alone at first, to force thinking on your own
    - Then get together and explain concepts to each other
- It's about *concepts* and *practice*
  - No one ever learned to play the piano by *watching* someone else play
    - Therefore, I don't do problems in class
    - *You* work problems, with help from Discussion, Problem Solving, Office Hours, and Tutorial Center



# Smart People Ask Questions

- That's how they got that way
  - We *never* look down at questions or incorrect answers
  - Better to think, risk, and learn, than to do nothing and learn nothing



- My job is to provide a safe environment conducive to learning and questions
  - I take that very seriously

# Take chances

- Make mistakes
  - In class
  - On exams, not so much



# Course Administration

- You must check the web page every day for updates
  - Schedules, contact info, etc. are there
- I will post the class slides there
  - With updates and corrections
  - Podcasts are online: audio and video
- Respect your classmates
  - No cell phones in class
  - If you expect an *important* call or text, sit on the aisle, and excuse yourself quietly *before* taking it
- I will allow computers for now
  - But only for class-related work
  - Be fair to your fellow students
- **Check your Inbox on Canvas**
  - I am *required* to use it for any private matters, e.g. grades



# Grading

Classroom response	5%
Homework	10%
Four of five Quizzes	50%
Final Exam	35%

- The following grades are a minimum:
  - 85% A-
  - 75% B-
  - 65% C-
  - 55% D
- Plusses and minuses at instructor discretion
- Actual grades *may* be higher if warranted by overall class performance ...
  - But don't count on it*
  - Curves in my previous similar classes were small (avg ~72%)



# Dropping a Quiz is not to Improve your Grade



- The purpose of dropping one quiz is to accommodate one unavoidable conflict for medical, academic, athletic, or other reason
  - The purpose is not to improve your grade
- Quizzes are on Wednesdays at 6 PM @ York 2722
- If you have to miss one quiz, that's the one you drop
  - Consider yourself normal
  - If you can take all 5 quizzes, consider yourself lucky
- If you have to miss 2 quizzes, you will likely need to drop the class
- To be fair to everyone:

No early exams, no late exams, no makeup exams

# No trick questions

- Life is tricky enough
- Every quiz question is a description of a situation ...
  - As plainly and simply as I can
  - But often, there is extraneous information
- Followed by a question about it
  - Sometimes, one of the choices is “not enough information”
  - Sometimes there is insufficient information to answer the question
- It’s like real life
  - When real-life is crammed into a 50 minute, multiple-choice quiz



# Academic Integrity: Don't Cheat

- Every honest student benefits from maintaining high academic integrity
- Please read “UCSD Policy on Integrity of Scholarship” in the UCSD General Catalog,  
<http://www.ucsd.edu/catalog/front/AcadRegu.html>
  - These rules will be rigorously enforced
- Cheating includes
  - Submitting another person’s work as your own
  - Copying from another student on homework, quizzes, or exams
  - Knowingly allowing another student to copy from you
  - Use of unauthorized materials during a quiz or exam
  - Misusing iClickers
  - Attempts to manipulate grades unfairly
  - Any attempt to obtain a higher grade by means other than honest effort



#excelwithintegrity

<https://academicintegrity.ucsd.edu>

# Academic Integrity (2)



- The Scarlet Letter: F
  - Any case of suspected cheating will be referred to the Office of Academic Integrity for disciplinary action
    - And may result in an F grade for the course
      - I have given F's for cheating in the past
      - Don't make me do it again
    - When caught, more cooperation => more leniency
  - Unlike an “F” earned by honest effort ...
    - An “F” earned by cheating cannot be excluded
    - There is no forgiveness for a dishonest F

#excelwithintegrity

# Common screwups

- Not following directions on Mastering Physics
  - Another quarter, some students did all the homework, and got no credit because they entered the wrong ID
- Not checking your grades on TED
  - You are responsible for verifying your grades
  - You must notify me within 1 week of posting of any grade discrepancy
    - Don't tell me in week 10 that you missed iClicker credit in week 2
  - Students have lost iClicker credit because they didn't catch a problem early, and fix it
- "Planning" to miss a quiz. Real reasons I've seen:
  - Broken leg, sprained ankle
  - Flu
  - Power failure defeated alarm clock
  - Car accident on way to school
- Entering your ID incorrectly on exams (-10%)
  - Follow my instructions, and no one else's
  - If you realize your mistake afterward, email me right away
- Telling me, "I'm *sure* I filled out my Scantron correctly"
  - No, you didn't. That's why you got a penalty
    - Instead, ask, "Why did I get a penalty?"
- Not including your student ID on email to me
  - You may be unique, but your name is not



Set subfrequency code  $1/2 = \text{C/A}$   
for York 2722.

Have you used iClickers before?

- A Yes, and I have mine with me.
- B Yes, but I don't have mine with me now. I promise to bring it every day from now on.
- C I don't know what iClickers are.
- D I don't know how to spell iClicker.
- E I don't know what class I'm in.

# Do you know how to register your iClicker online?

- A Yes, and I will do it tonight on Canvas
  - I will use my 9-character Student ID to register
  - I will use full 8-digit clicker ID, including leading zeros
- B Yes, but I don't have mine with me now
  - I promise to bring it every day from now on.
- C I don't know what iClickers are
- D I don't know how to spell iClicker
- E I don't know what class I'm in

See next slide for location of registration link.



## ≡ PHYS2B\_WI20\_A00 > PHYS 2B - Phys-Electricity and Magnetism - Barreiro Guerrero [WI20]

### Register Your iClicker

Winter 2020

Home

MyLab and Master-ing

Enter your 8-character remote ID and other information below...

Academic Integrity

Files

Syllabus

Announcements

iClicker Registration

Grades

Please use Chrome browser for the best registration experience.

Enter your 8-character remote ID and other information below...

Remote ID:

E-Mail:

Country:

#### iClicker Student Registration FAQ

##### Where do I find my remote ID?

Your iClicker remote ID is printed on a sticker located on the back of your remote. The ID is the 8-character code below the barcode. Newer original iClicker remotes have a secondary ID location behind the battery compartment and iClicker 2 remotes display the ID upon power up. The remote ID will only contain letters A-F and numbers 0-9.



**STUDENT INFORMATION ON THE WEB****PRIVACY IN THE CLASSROOM**

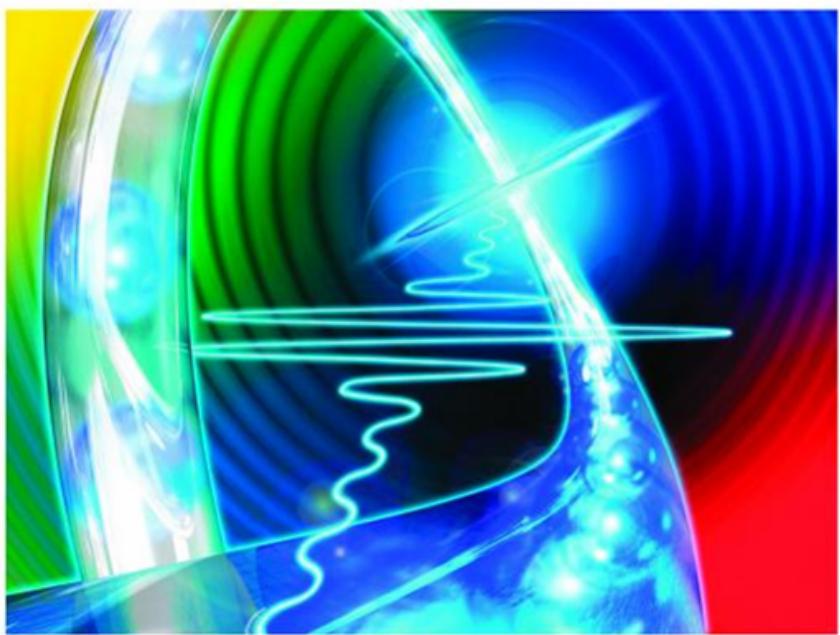
- Student disclosure restrictions – such as designating themselves Directory Confidential or All Records Confidential – do not apply to certain class-related disclosures
- Students cannot refuse to identify themselves or prohibit the faculty or school from disclosing their identity in class or as part of a class roster or email list
- Students cannot be anonymous in class, whether in-person, online, or in other forms of instruction
- Students may be required to disclose their name, student ID, and email address to their instructor or TA

The logo for PIAZZA! features the word "PIAZZA!" in a bold, orange, sans-serif font. The letter "I" has a horizontal orange bar extending from its top to its bottom, and the letter "Z" has a similar bar extending from its bottom to its top, creating a stylized, interconnected look.

## PROTECTING STUDENT INFORMATION

The answer is No!

Students are not permitted to be anonymous in class, whether in person or online. They cannot prohibit an instructor from identifying them to other students in the class or from including them in class.



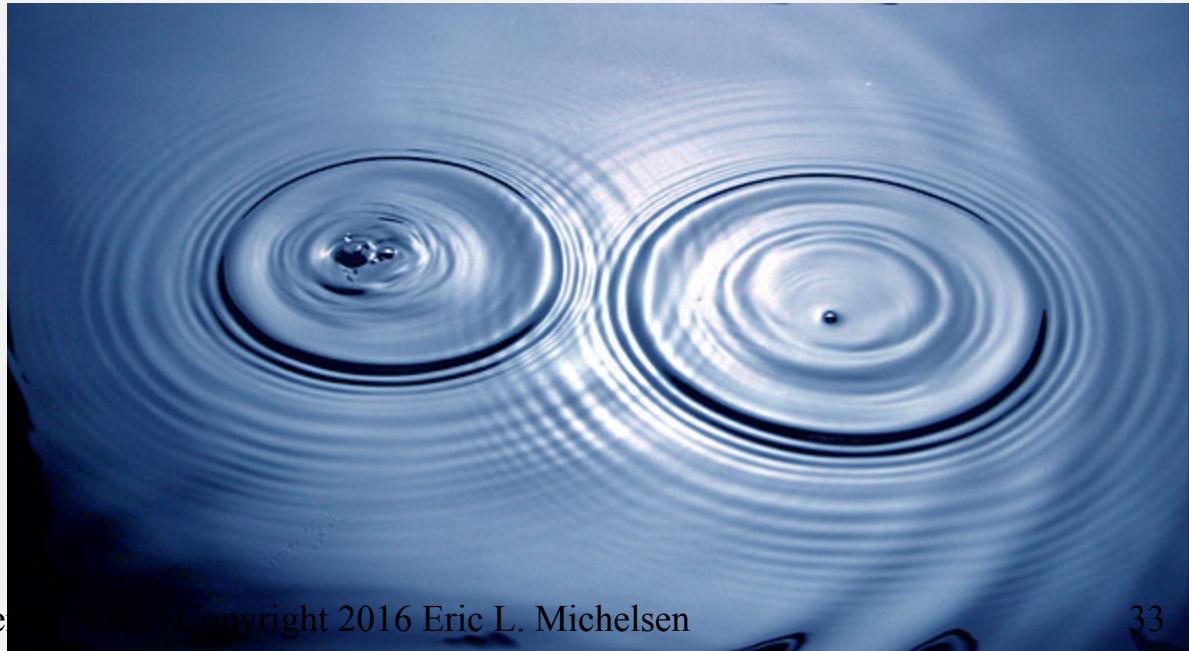
# Physics 2B

## Part 2: Prerequisites

Math 20A-B PHYS 2A or 4A  
**Quiz on Friday, 30 questions**

Never underestimate the pleasure of seeing again something you already know

Julio Barreiro  
[barreiro@ucsd.edu](mailto:barreiro@ucsd.edu)  
Material from  
Eric Michelsen



# The purpose of physics is to relate mathematics to reality

Single Stage Fehskens-Malewicki Equations:

burnout velocity:

$$v_b = \sqrt{\frac{F-mg}{k}} \tanh\left[\frac{t_b}{m} \sqrt{k(F-mg)}\right]$$

burnout altitude:

$$y_b = \frac{m}{k} \ln \left\{ \cosh \left[ \frac{t_b}{m} \sqrt{k(F-mg)} \right] \right\}$$

coast altitude:

$$y_c = \frac{m_b}{2k} \ln \left[ \frac{k v_b^2}{m_b g} + 1 \right]$$

coast time:

$$t_c = \sqrt{\frac{m_b}{g k}} \tan^{-1} \left[ v_b \sqrt{\frac{k}{g m_b}} \right]$$

Where:

$$k = \frac{1}{2} \rho C_D A$$

$\rho$  = atmospheric density

$C_D$  = drag coefficient

$A$  = frontal area

$t_b$  = burn time

$F$  = average thrust

$m$  = average thrusting mass

$m_b$  = burnout mass

$g$  = acceleration due to gravity



[Return](#)



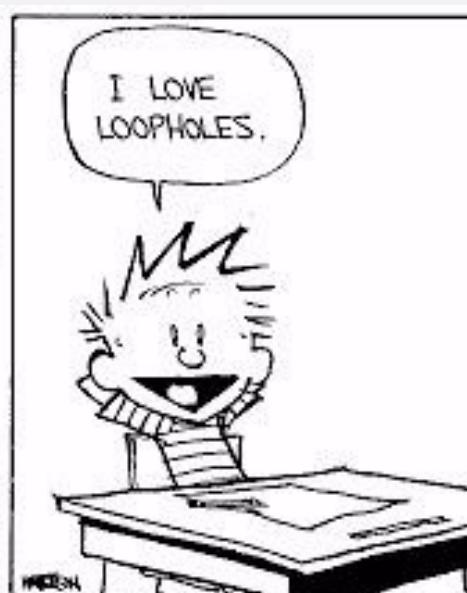
$$-c^2 \frac{dv}{(c^2 - v^2) ((1 - \gamma_e x)v + \gamma_e x e)} = \frac{dm}{m}$$

where  $dm < 0$

# Physics includes math

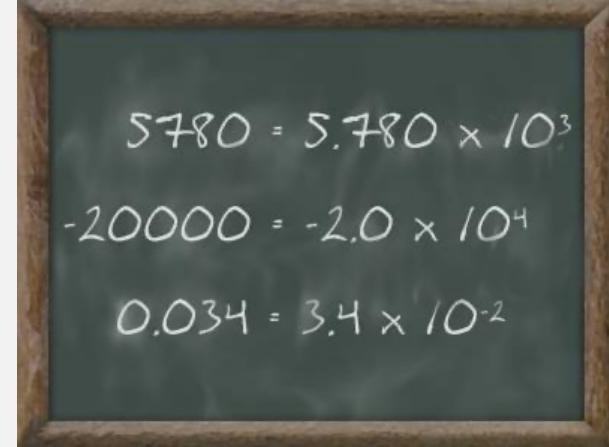
- And we're not shy about it.
- But we don't hide behind it
  - Without a conceptual understanding, math is gibberish

1. Explain Newton's First Law of Motion in your own words.



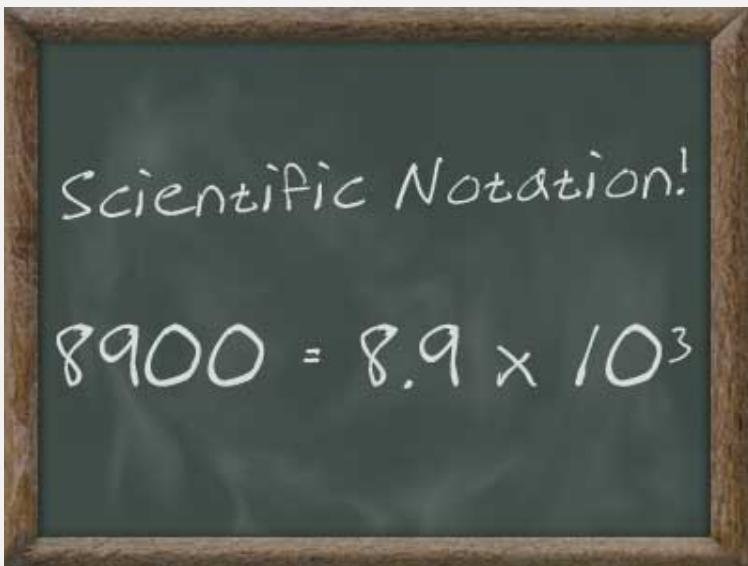
# Superfast review of these topics

- Scientific notation, significant digits
- Metric prefixes
- Radians
- Trigonometry
- Rectangular, cylindrical, and spherical polar coordinates
- Fundamental measurable quantities
  - SI units: MKSA
  - Metric prefixes: difference 'tween mJ and MJ
- Vectors
- Calculus: there will be some
- The Greek alphabet: learn it (there's a song)



# Scientific Notation

- Computer scientific notation:
  - $3.14\text{e}7$  (or  $3.14\text{E}7$ , or  $3.14\text{e}+7$ , etc.)
    - Equivalent to  $3.14 \times 10^7$
  - $1.745\text{e}-2 = 1.745 \times 10^{-2} = 0.01745$
- Significant digits: use them
  - 10. has 2 significant digits
  - 10.0 has 3
  - 100 has 1
  - If in doubt, use scientific notation
    - It's unambiguous: in scientific notation, every digit you write is significant
- When comparing numbers:
  - A difference of 1 in the least digit is *never* significant



# What is 10e6?

- A 10,000,000
- B 1,000,000
- C  $1 \times 10^6$
- D  $1.0 \times 10^6$
- E  $1 \times 10^5$

A confusing notation due to the limited technology of the time!  
albeit handy...

# Unit Conversions

- Sometimes you will need to switch between units.
- Conversion factors with unit value allow you to change the units of a quantity without changing its physical value.
- For example, changing 4.50 g/cm<sup>3</sup> to ?? kg/m<sup>3</sup>

$$4.50 \text{ g/cm}^3 \left( \frac{1 \text{ kg}}{1,000 \text{ g}} \right) \left( \frac{100 \text{ cm}}{1 \text{ m}} \right)^3 = 4,500 \text{ kg/m}^3$$

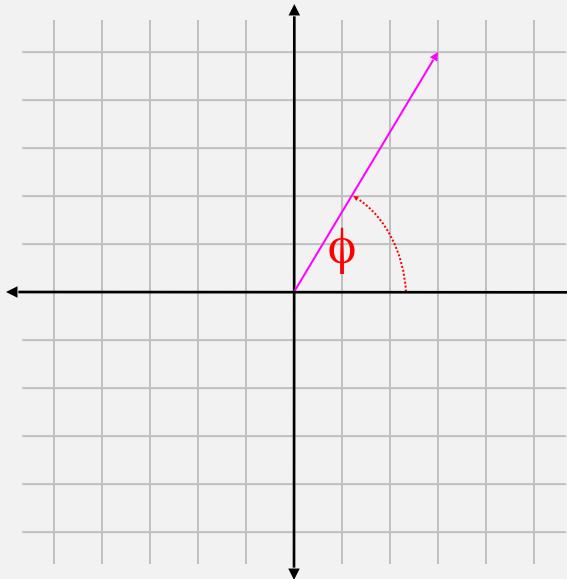
# Unit Conversions

## How important are unit conversions?

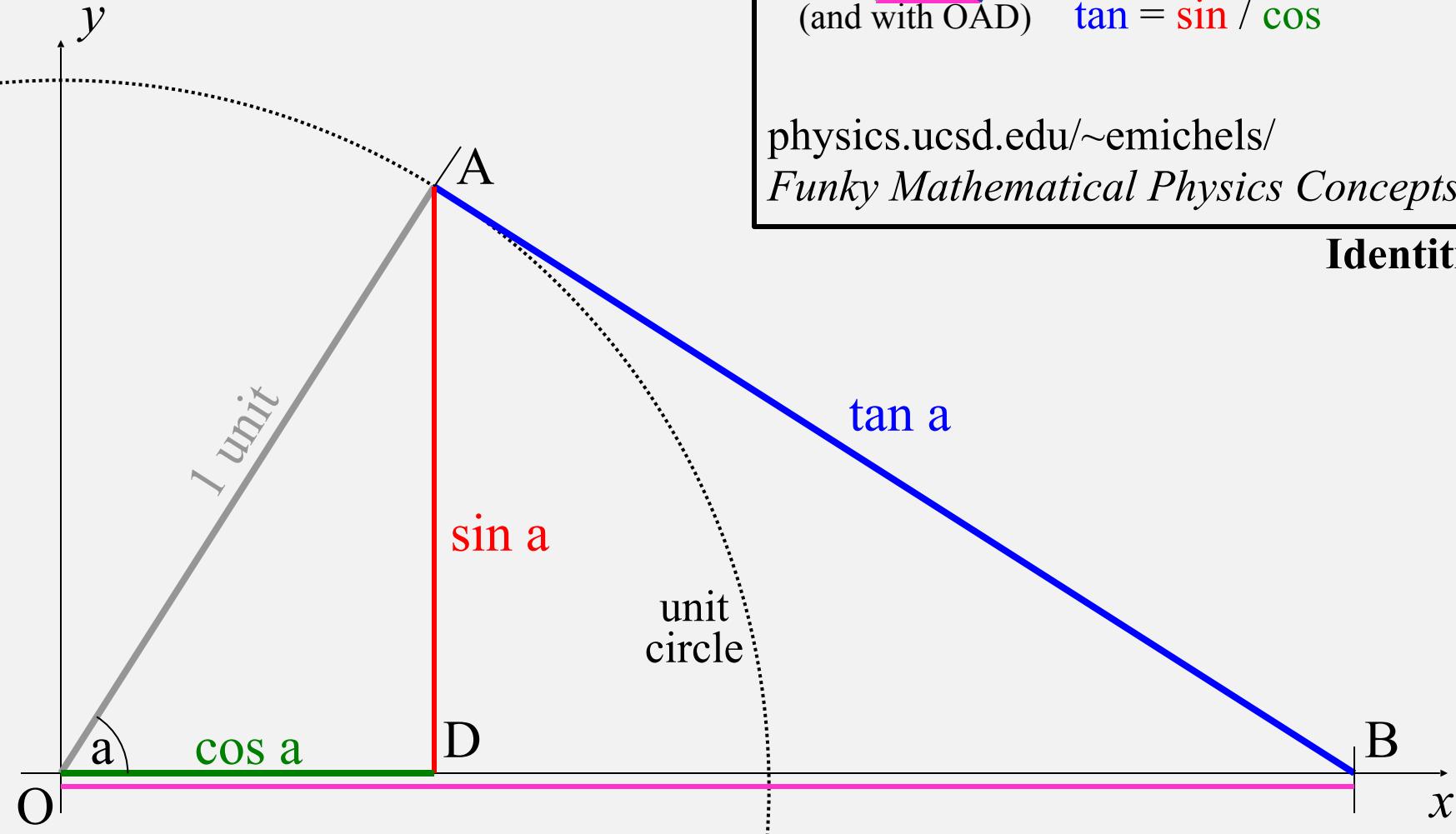
- In 1999, \$125-million Mars Climate Orbiter was approaching Mars. Contact was lost as it reached Mars.
- The Orbiter passed 57 km above the Mars surface, instead of the intended 147 km.
- Lockheed-Martin Astronautics (spacecraft builders) programmed in conversion information for telemetry data with English units.
- NASA's JPL (navigation) used SI units. Mix up caused crash.

This angle is about how many radians?

- A 0.5
- B 1
- C 2
- D  $\pi$
- E  $2\pi$



# Simplified Trigonometry



From OAD:



$$\sin = \text{opp} / \text{hyp}$$

$$\cos = \text{adj} / \text{hyp}$$

$$\sin^2 + \cos^2 = 1$$

From OAB:



(and with OAD)

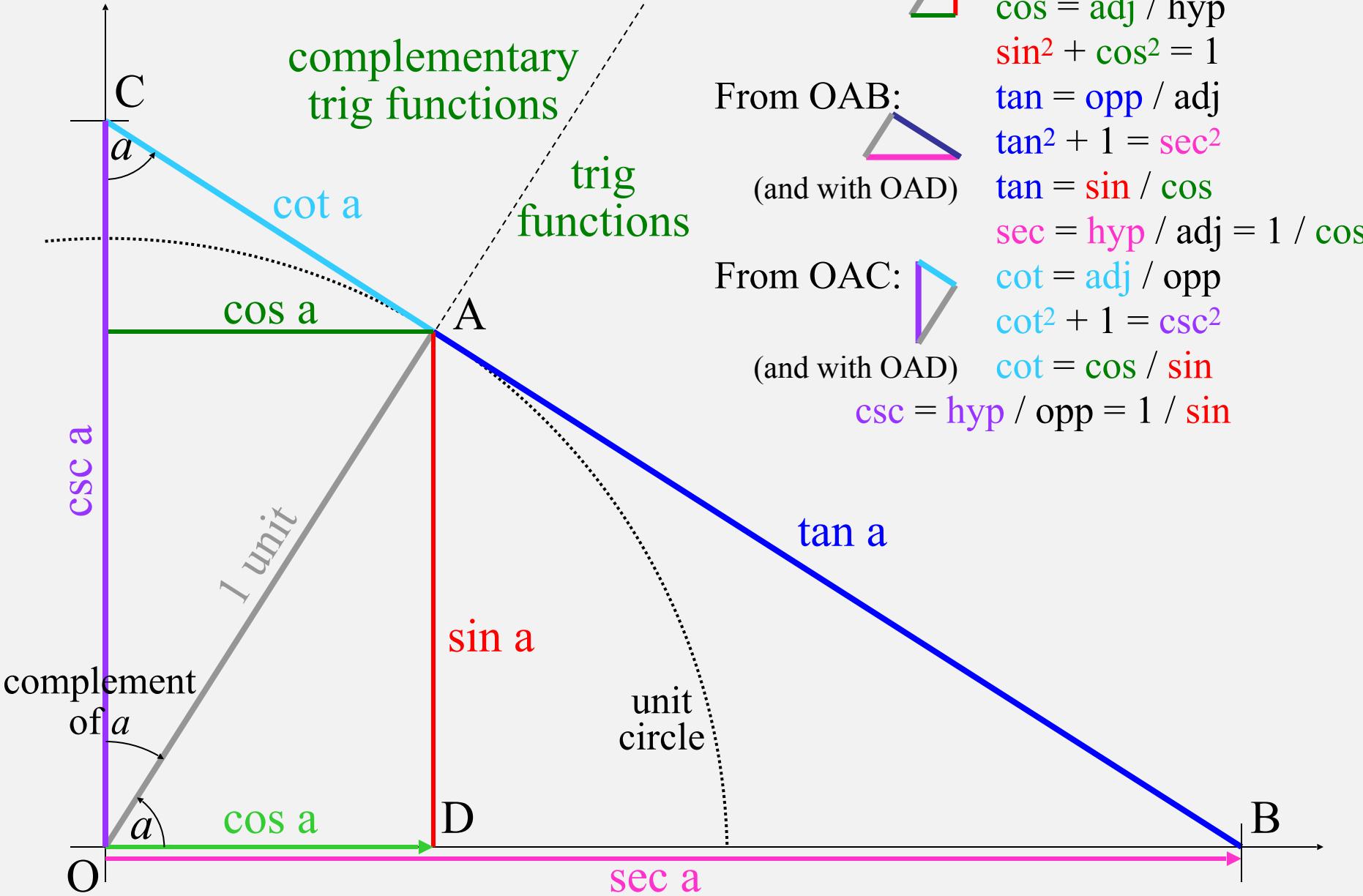
$$\tan = \text{opp} / \text{adj}$$

$$\tan^2 + 1 = \sec^2$$

$$\tan = \sin / \cos$$

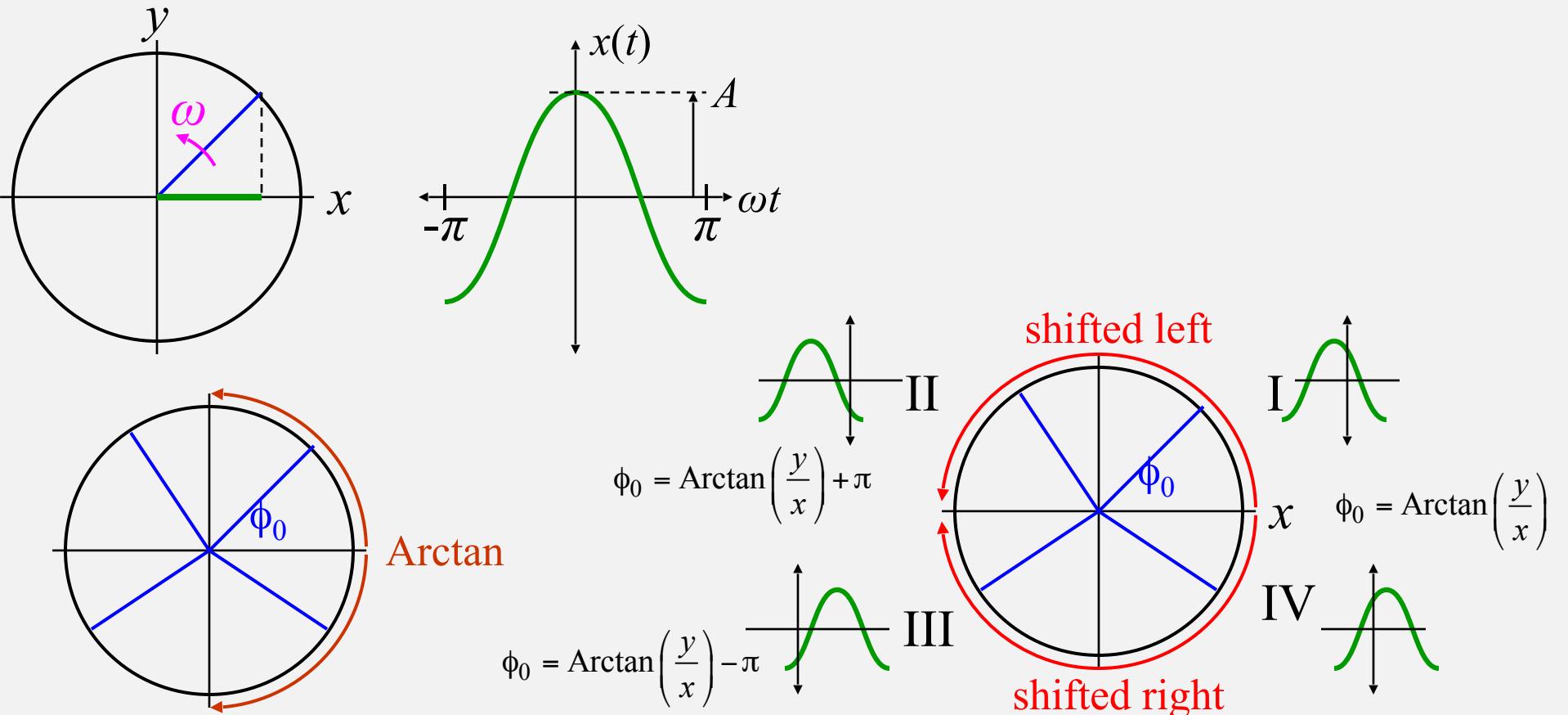
[physics.ucsd.edu/~emichels/  
Funky Mathematical Physics Concepts](http://physics.ucsd.edu/~emichels/Funky Mathematical Physics Concepts)

Identities



# Harmonic oscillations and phase [Kni 3rd p382-3]

- Harmonic  $\equiv$  sinusoidal:  $x(t) = A \cos(\omega t + \phi_0)$ 
  - Instantaneous phase  $\phi(t) \equiv \omega t + \phi_0$



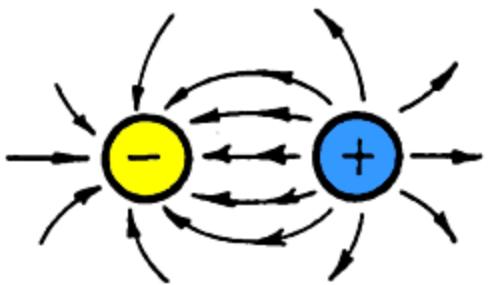
# Fundamental (macroscopic) measurable quantities

- How many fundamental (macroscopic) measurable quantities are there?
  - What are they?



# Review: Four fundamental (macroscopic) quantities

- MKSA
- distance: meter, m
- mass: kilogram, kg
- time: second, s
- charge: ampere => coulomb, C



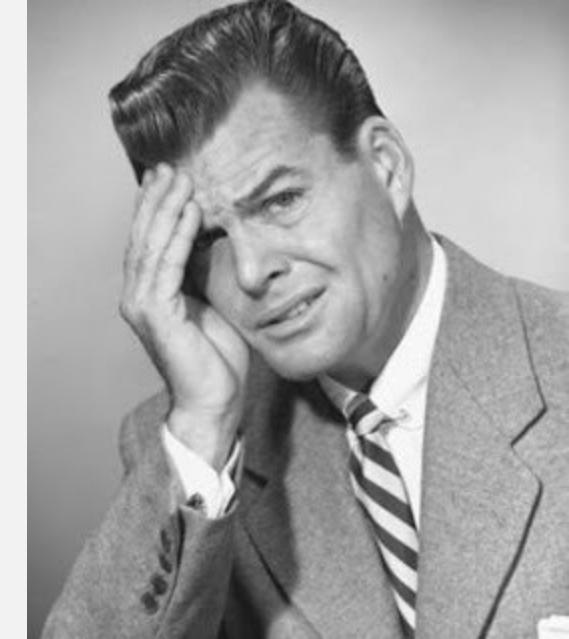
# What are the units of energy, in fundamental units?

- A  $\text{kg}\cdot\text{m}/\text{s}$
- B  $\text{kg}\cdot\text{m}^2/\text{s}$
- C  $\text{kg}\cdot\text{m}/\text{s}^2$
- D  $\text{kg}\cdot\text{m}^2/\text{s}^2$
- E  $\text{N}\cdot\text{m}$



# Metric prefixes

- pico      p       $10^{-12}$
- nano      n       $10^{-9}$
- micro       $\mu$        $10^{-6}$
- milli      m       $10^{-3}$
- kilo      k       $10^3$
- mega      M       $10^6$
- giga      G       $10^9$

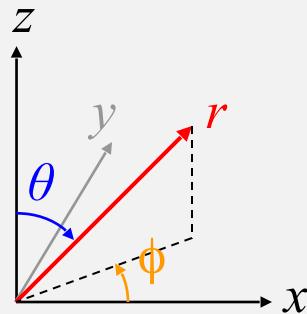
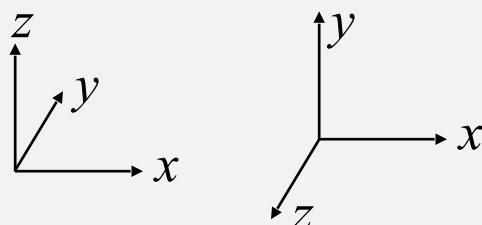


The difference between 'm' and 'M' is a factor of a billion

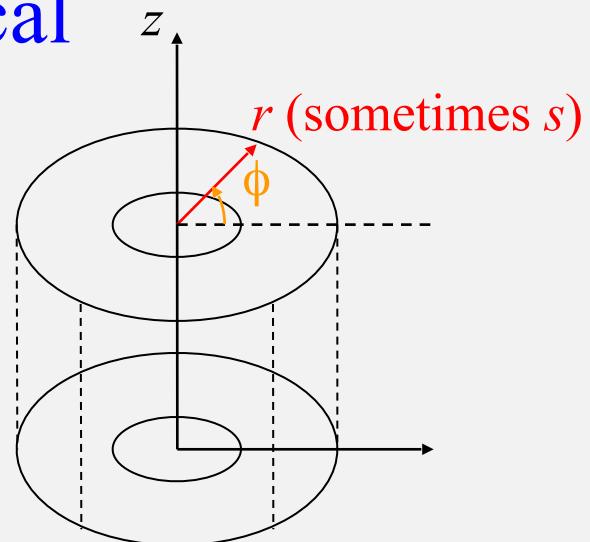
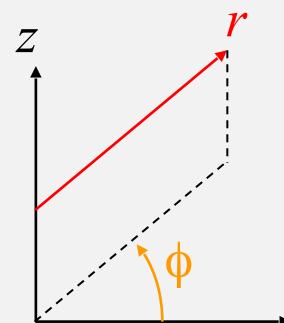
Science and technology nowadays talk about  
femto (f,  $10^{-15}$ ) & tera (T,  $10^{12}$ )

# Coordinates (different than math)

- Rectangular
  - Right-handed
- Spherical polar



- Cylindrical





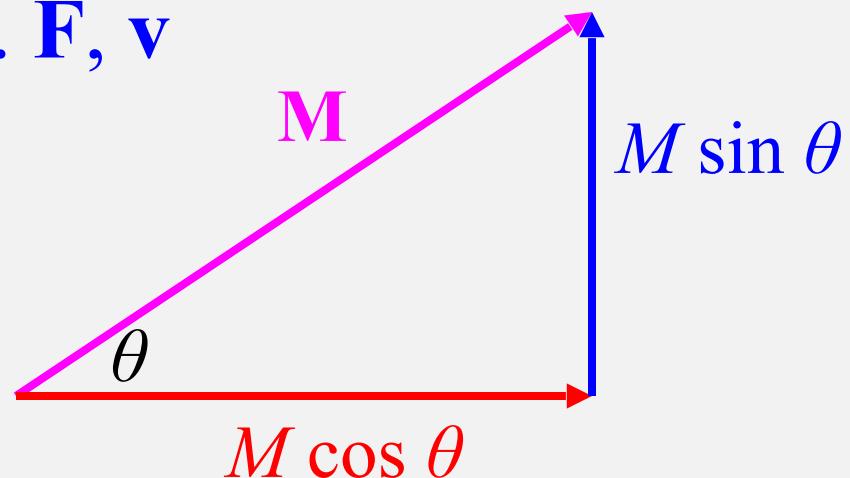
# Greek alphabet

How many  
letters?

A	$\alpha$	alpha	N	$\nu$	nu	(like “moo”)
B	$\beta$	beta (“baytu”)	$\Xi$	$\xi$	xi	(“zie”)
$\Gamma$	$\gamma$	gamma	O	$\circ$	omicron	
$\Delta$	$\delta$	delta	$\Pi$	$\pi$	pi	(“pie”)
E	$\epsilon$	epsilon	P	$\rho$	rho	(“roe”)
Z	$\zeta$	<b>zeta</b> (“zaytu”)	$\Sigma$	$\sigma$	sigma	
H	$\eta$	eta (“aytu”)	T	$\tau$	tau	(like “cow”)
$\Theta$	$\theta$	theta (“thaytu”)	Y	$\upsilon$	upsilon	(“oopsilon”)
I	$\iota$	iota	$\Phi$	$\phi$	phi	(“fie” or “fee”)
K	$\kappa$	kappa	X	$\chi$	chi	(“kie”)
$\Lambda$	$\lambda$	lambda	$\Psi$	$\psi$	psi	(“sigh”)
M	$\mu$	mu (like a cat)	$\Omega$	$\omega$	omega	(“omaygu”)

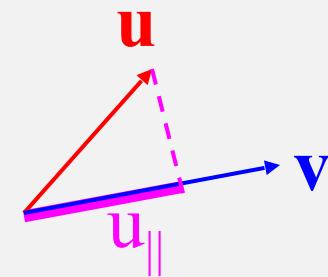
# Vectors: Decomposition

- We eat vectors for breakfast
- What is a vector?
  - A quantity with magnitude and direction
- Vectors add:  $\mathbf{w} = \mathbf{u} + \mathbf{v}$  ← **bold** or arrow
- Scalar multiply:  $\mathbf{w} = a\mathbf{u}$
- Vectors have units: e.g.  $\mathbf{F}$ ,  $\mathbf{v}$



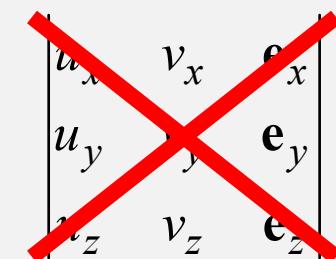
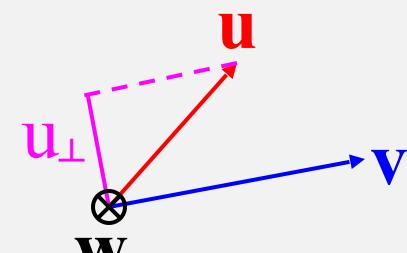
# Vectors: dot product

- Dot product:  $a = \mathbf{u} \cdot \mathbf{v}$ 
  - Product of parallel components
  - Coordinate-free definition
- Bi-linear



# Vectors: Cross product

- Cross product:  $\mathbf{w} = \mathbf{u} \times \mathbf{v}$ 
  - Product of perpendicular components
  - In direction perpendicular to both
  - **Right Hand Rule (RHR) (review for next quiz!)**
  - *Not* commutative
  - Bilinear



# Math for 2B

- Quadratic formula:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

- Basic derivatives and integrals

- *Setup* and evaluate:

$$E(x) = -\frac{dV(x)}{dx} \quad V(x) = -\int_A^B E(x) dx$$

- Gradients:

$$\mathbf{E}(\mathbf{r}) = -\nabla V(\mathbf{r})$$

representative  
element

- Line integrals:

$$V(\mathbf{r}) = -\int_A^B \mathbf{E}(\mathbf{r}) \cdot d\mathbf{r}$$

- Solving simple ordinary differential equations:

$$v = v(t)$$

$$\frac{dv}{dt} + \frac{1}{RC}v = \frac{V}{RC}$$

# Calculus

- You are expected to be able to perform simple calculus in homework and on exams.
- Be prepared to use the following:

- Simple derivatives:  $\frac{d}{dx}(ax^2 + bx + c) = 2ax + b$

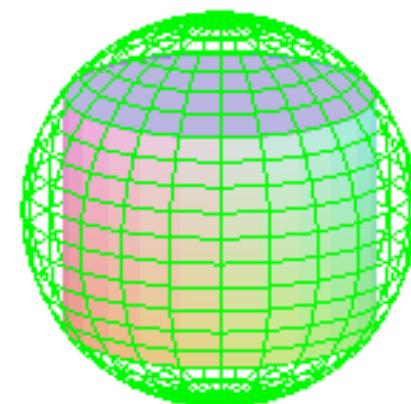
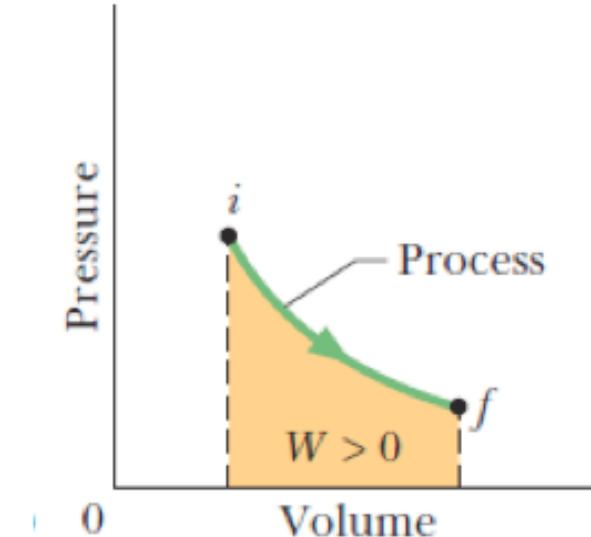
$$\frac{d}{dx}\cos(ax) = -a\sin(ax)$$

- Simple integrals:  $\int \frac{r}{(a^2 + r^2)^{3/2}} dr = \frac{-1}{\sqrt{a^2 + r^2}} + C$

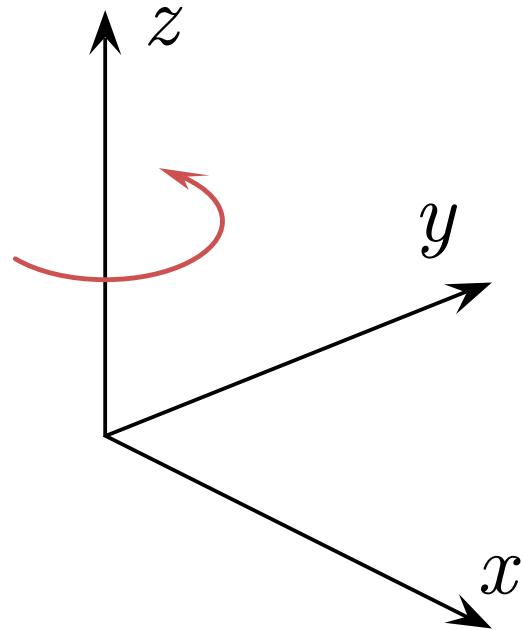
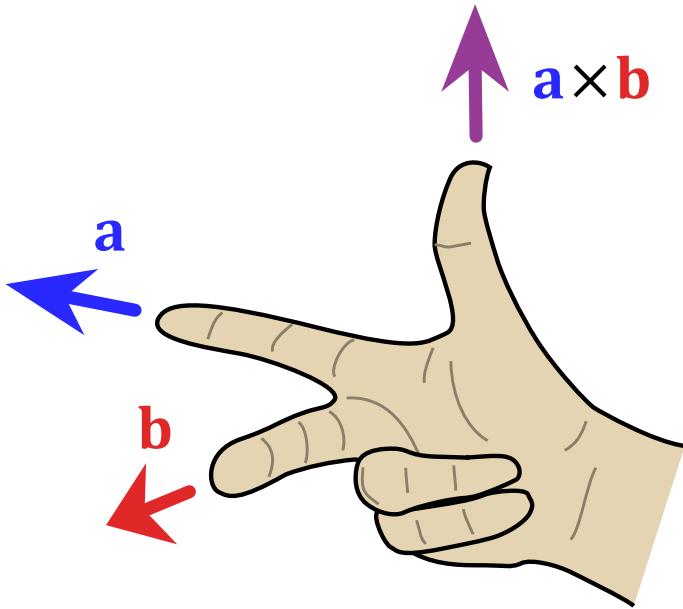
- Multi-variable calculus:  $\frac{\partial}{\partial y}\cos(xy) = -x\sin(xy)$

# Calculus

- Be prepared to use calculus with plots.
- Such as calculating the area under a curve.
- Also be prepared to use calculus with word problems.
- Such as maximization problems (for example, finding the largest cylinder inscribed in a sphere).
- Your first homework assignment is to review this math.



# Right-hand rule



# The 4 sizes of “numbers”

- Really, the 4 kinds of “bigness”
- Zero
- Infinitesimal (aka “differential”):  $dx$ ,  $dy$ , etc.
- Finite
- Infinite



# 2B Prerequisites: All of Physics 2A

- Kinematics

- $s = \frac{1}{2} at^2 + v_0 t$
- $a = v^2/R$
- ...
- $v = ds/dt$
- $a = dv/dt$
- etc...

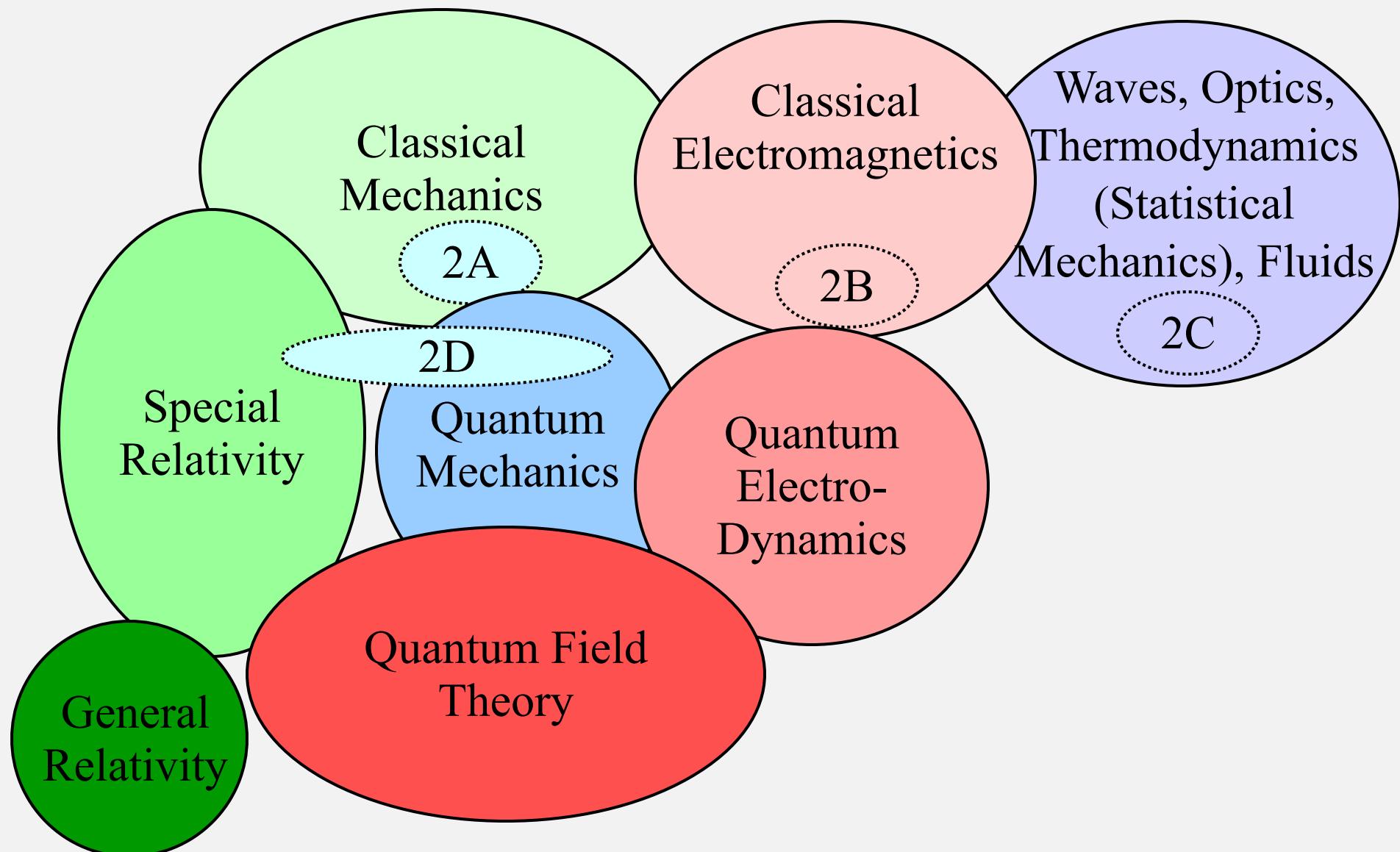
- Dynamics

- $F = ma$
- $\Gamma = I\alpha$
- $p = mv$
- $dW = F dx$
- $KE = \frac{1}{2} mv^2$
- $PE = mgh$
- etc...



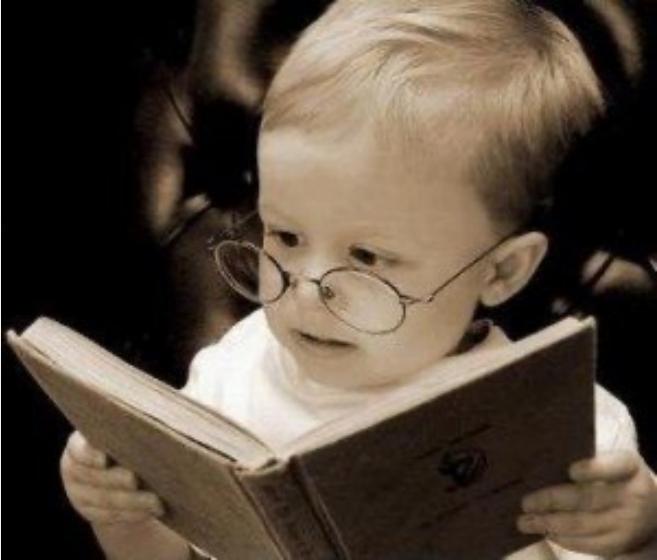
Oh what to do, what to dooo?

# The pedagogical structure of physics



# Study tips

- The antidote to “freezing” is familiarity through repetition
- Do *all* the homework
  - Try them all on your own first
  - Forge a path, do the math
  - Then study in a small group (3-4)
    - Verbalize your understanding
    - Explain it to others
- Don’t memorize any formulas (Do)
  - Instead, *understand* them (also)
    - Then they will be obvious, useful, and you’ll have memorized them ;)
- Review every slide:
  - Say **out loud** the main point of each slide
  - Speaking **aloud** engages important cognitive functions for both understanding and retention
- Draw a diagram illustrating each equation
  - Say **out loud** the meaning and units of symbols in equations
- Redo the HW questions you had



# Announcements

## Thursday, 9/25/2025



- Homework assignment due Sunday 10/05/2025 @ 11:59 PM
  - Use instructions on Canvas/“MyLab and Mastering” to register
- **iClicker credit starts next Tuesday 9/30/2025**
- My office hours **Monday 12PM by Mayer Hall Addition 4531**
- **Quiz every other Wednesday, starting Oct. 8 @ 6:00 PM**