Welcome to Physics 2A !

Please switch your phone to silent mode

Physics 2A
Lecture 1: Sept 27, 2010

Ken Intriligator
Course and slides by Vivek Sharma
(He's Higgs Hunting at the LHC!)

Welcome to Physics 2A

- This is the first quarter of a four quarter calculus based introductory physics sequence
- **Why study physics?**
  - It's the foundation of all Science & Engineering!
    - physics concepts & methods needed for everything from GPS system to iphone's accelerometer to interplanetary spacecrafts….
    - EVEN video-game developers
      - who want realistic animation…

  - Physics teaches **practical and analytical t[illegible]g** like none else
    - You are trained to solve all kinds of problems
  - …and …yes…your major requires it !

This Course: PHYS 2A

- We will explore Classical mechanics which is the study of motion of macroscopic objects such as baseball, cars, rockets, planets etc.
  - Different from Quantum Mechanics which operates at subatomic scale
  - Different from the mechanics when things go at speed of light
    - You will study Relativity & Quantum Physics in PHYS2D
- **Newton's laws and Conservation laws form the basis of classical mechanics.**
- **But first we will learn the basic language describing motion in one and more dimensions**.
  - Hopefully you are taking the prerequisite Calculus course !

Classical Mechanics (PHYS 2A)

- We will start by looking at motion in terms of particles and forces
  - Use these concepts to study motion of everything from accelerating snowboarder to the orbits of satellites
- Next we will introduce the ideas of momentum and energy .
  - The concept of energy will allow us a new perspective and extend our ability to analyze motion
- Remainder of the course will be on applications of classical mechanics:
  - Theory of gravity
  - Rotational motion
  - Oscillatory motion

Why You Should Plan to Excel in 2A

- It's the FOUNDATION course. If you do well here, you will be well prepared to excel in the your upcoming courses
  - in Physics 2B, 2C or 2D
  - in your own major in science or engineering
- Excellent performance in Physics courses will improve your prospects and financial worth in the job market since **industries love problem solvers!**
- I will write letters for you if you get an A+

http://physics.ucsd.edu/students/courses/fall2010/physics2a/

- **Pl. pay attention to the class web site. It will have a lot of information critical to your success in this course.**
- Note particularly the **Front page**. This will be the way by which we will communicate all important information regarding this class to you.
- It is your responsibility to check it often (starting today!) and follow the instructions posted. We will not send mass-emails of breaking news (they get ignored) Pl. check website at least a day before the Friday quizzes and the final exam.
- All lecture slides will be posted there as will the HW and Quiz solutions
- Helpful animated web-tutorials on 2A problem solving techniques at: **http://solved.ucsd.edu**

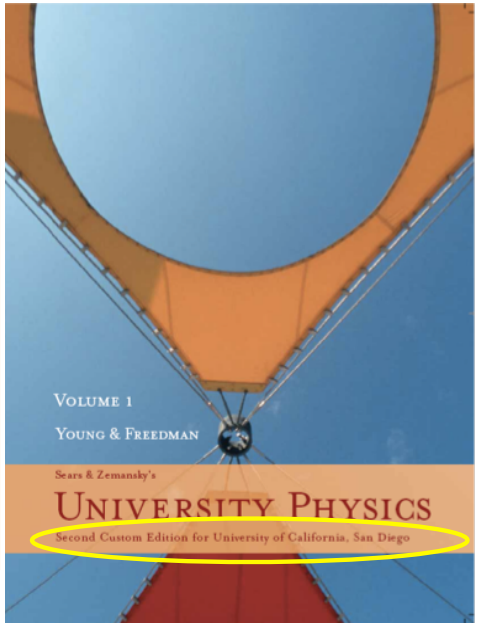
An Excellent Textbook !

Customized low price package for UCSD of *University Physics*, 12/e by Young & Freedman

available at bookstore

400 packages available

Book is essential for course



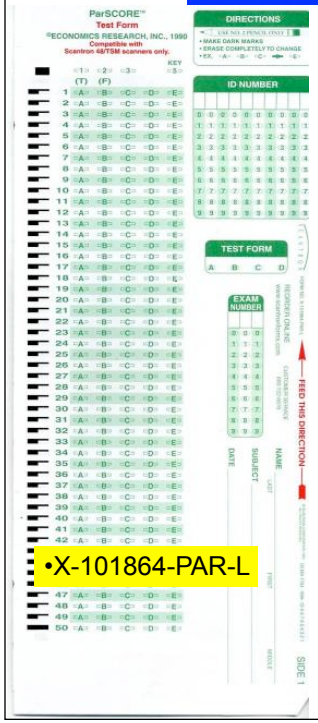
Home Work

- Home work problem sets will be assigned on class web Fridays.
- Will typically contain a dozen end-of-chapter problems from book
- Solutions will be posted the following Thursday afternoon.
- Very important that you diligently attempt the HW YOURSELF. If you can **do** the HW problems, quiz will be a cakewalk!
- HW will not be collected or graded but will be discussed in the PB session on Thursday. Be there. TA teaches prob solving skills !
- Follow these guidelines before/while attempting HW problems
  - Attend lectures and take notes (print out the lecture slides from website)
  - Study the relevant text & the solved problems in the book one-by-one
  - Close the book, recall the problem and now try to solve it yourself. **If you can't after few attempts, visit the TA/Prof for help.**
  - Problem solving skills are acquired by doing them. Its like learning how to drive. Cant learn to drive by simply looking at your friend drive !
  - Do not look at the posted HW solution till you have spent fair amount of time attempting the problems yourself. Don't give up early ! Time spent doing HW is the best way to prepare for the quiz!
  - After you look at the HW solutions, "hide it" and try to do problems by yourself by reconstructing the logic used.

Quizzes

- 8 weekly quizzes starting Friday **October 1st**
  - Make sure you get your course code by Sept 29th
- Will take best 6 scores towards final grade
- There will be no makeup Quiz for **ANY** reason
- Quizzes will be multiple choice, will last 40 minutes
- You must bring a scantron card (#X101864) & #2 pencil
- You must write your course code # on the Scantron card
- You may use a calculator, bring paper to workout quiz problem before entering the final answer in scantron card
- Closed book exam, You may bring a 5x7 "cheat-card"
- Bring your ID card, proctors will be checking identity

At Every Exam Bring These



•X-101864-PAR-L

Check Battery!

Sheets of Blank paper

UCSD ID CARD

A 5x7 inch

Cheat-card

Ok to write on both sides

A clear mind

Final Exam

- Wednesday December 8, 3-6pm. There will be **no makeup final** for any reason.
- The final exam will cover the material from all 13 chapters. You may bring a double sided cheat-sheet to the exam.

Registration & Obtaining Your Course Code

You **must** obtain a secret course code by registering with our physics server. This code will be your primary identifier for this course. You will need/use it for Quiz & final exam.

Deadline for obtaining course code # is 17:00 hrs 29th September !

No code # means no Quiz

Academic Dishonesty Policy

- Pl. read the UCSD policy on *integrity of Scholarship* at http://www.ucsd.edu/catalog/front/AcadRegu.html
- Do not engage in any activity that involves attempting to receive a grade by means other than your honest effort. **UCSD rules will be rigidly enforced**
- For this course academic dishonesty includes, among others: submitting another person's work as your own for grade consideration, any alteration for reconsideration, copying from another student, and the use of any unauthorized materials during the exam.

  Please do not cheat and do not encourage cheating. The consequences of being caught are very harsh and we will be very vigilant in our enforcement.

How to Do Well In PHYS2A

- This is a hard course, it will require substantial investment of your time. Consider taking this course another time if you are overloaded with other commitments.
- Read the assigned text from book before and after lectures. Attending lectures is not enough !
- Don't accept any concept without understanding the logic. Ask questions in lectures, discussion and PB session
- Do your homework on time, don't rush it. Do as many end of chapter problems as possible.
- Don't be shy, come to my or TA office hours and get the help you need.
- Be sure to attend the first 7 quizzes, they are the easiest !

Physics Tutorial Center in Mayer Hall

Wonderful resource for students, located at 2702, Mayer Hall Addition on Revelle campus

- Manned by caring, intelligent and enthusiastic tutors who are there to help you with concepts, problems solving methods etc for free ! http://physics.ucsd.edu/students/courses/tutorialcenter/
- Remember: HW should be done by Tuesday, Quiz is on Wednesday. These guys are available to help with HW when you need them !
  - **Sunday thru Thursday 15:00-20:00 hrs !**
- **Check them out! You will be very happy you did.**

Solved ! : Learn Problem Solving From Pros

- Past 2A student input:
  - solved problems in the book are simple
  - home work problems are much harder !
- Solution:
  - Custom made set of (2 x 13 = 26) **hard** problems solved step by step : helps enhance your problem solving skills
  - available on web as narrated and animated videos
  - designed by some of the best Physics TAs at UCSD
  - See http://solved.ucsd.edu/week1
    - Quicktime movie
    - Can download to your computer for offline viewing

UCSD Physics

Solved!: Methods in Mechanics

Home Problems

http://solved.ucsd.edu/week1/

Ryan Kelley

Matt Lebourgeois

Course Review Sessions

Problem	Topic	QuickTime	iPod
Review Session Tape 1	Vectors		

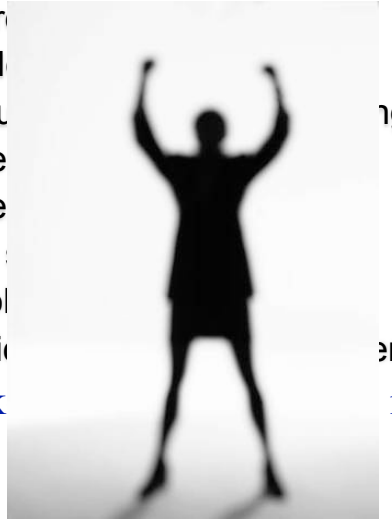
Problem List

Problem	Topic	QuickTime	iPod
Scoring a Touchdown!	Vectors		
Canoeing on a Lake	Vectors		
Dropping Eggs on the Prof	1-D Motion		
Newton's Crazy Apple	1-D Motion		
Tanks at War	2-D Motion		
Romeo Saves Juliet	2-D Motion		
Stunt Plane	Circular Motion		
Oil Tanker Crash	Newton's Laws I		
Chain Link Fun	Newton's Laws I		
Crazy Block System!	Newton's Laws II		
Even More Blocks!	Newton's Laws II		
Blocks and Frictions	Work-Energy Theorem		
College Books	Work-Energy Theorem		
Tarzan and Jane	Conservation of Energy		
Spring and Block	Conservation of Energy		
Car Collision	Conservation of Momentum		
Baseball and Basketball	Conservation of Momentum		
Racing Truck	Rotational Kinematics		
Torquing Discs	Rotational Energy/Kinematics		
The YoYo	Rotational Dynamics		
Lancelot and Guinevere	Equilibrium		
Barnyard Gate	Equilibrium		
Binary Stars	Gravitation		
Mechanical Bull	Harmonic Motion		
Mechanical Pendulum	Harmonic Motion		

What Does It Take to Excel ?

- We will provide lots of resources for you to succeed in this course
  - Well prepar
  - Lecture slid
  - 24/7 Web tu ng
  - Excellent te
  - Excellent te
  - Discussion
  - Problem sol
  - Flexible offi er open on weekends
- But it will tak important person to succeed ..

You !



Reading Assignments For This Week

"How to succeed in physics by really trying"

&

"Using your textbook"

&

Review algebra & trig. in the appendix

&

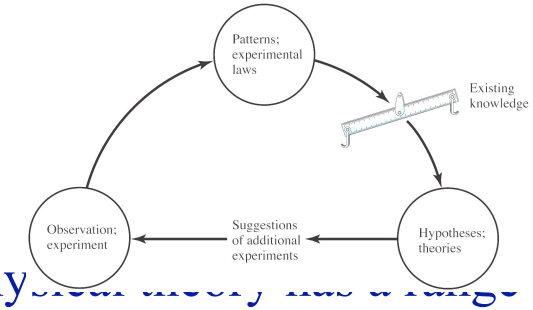
Chapters 1 and 2

Today : Start Gathering Tools

- Nature of Physics
- Idealized Models
- Standard & Units
- Measurement Error
- Order of magnitude
- Significant figures
- Scalars & Vectors

Nature of Physics

- Physics is experiment driven science
- Observe phenomena, find patterns & principles (physical theory) that relate and explain diverse observed phenomena



- Every physical theory has a range of validity outside which it is not applicable

Problem Solving...I SEE

- 1) Identify the relevant concepts.
- 2) Set up the problem.
- 3) Execute the solution (do the math).
- 4) Evaluate your answer. Make sense?

Humans vs computers: humans win on steps 1,2,4 (fortunately! Why there are jobs for scientists and engineers!); computers win at step 3. We'll try to exercise all steps, especially thinking like a human.

Models in Physics

- Model is a simplified version of a physical system that would be too complicated to analyze in full detail
- In a model, we overlook the minor effects to concentrate on the most important feature of the system it describes, e.g. analyzing motion of a baseball thrown in air
- The predictions based on a model are only as good as the features present in the model
- Will use models of phenomena throughout the course to learn about its essential features

An Example of Idealization/Modeling

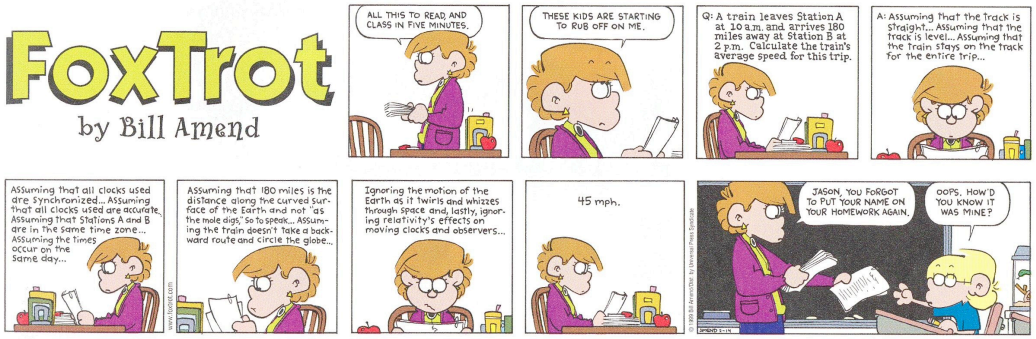


FIGURE I-1 ■ Jason being explicit about all the simplifications he is being asked to make.

Unit of Physical Quantities

- Physics is an experimental science, experiments require measurements
- A number used to describe a physical phenomenon quantitatively are called *physical quantities*. e.g. your height and weight
- When measuring a quantity, we compare it with some reference standard. Such a standard defines a unit of the quantity
  - e.g: SI Units

Length	Time	Mass
Meter (m)	Second (s)	Kilogram

  - units of measurements must be calibrated:

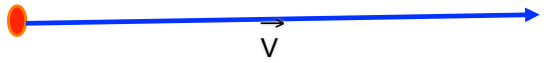
    ⇒ exactly the same in all parts of the universe !

Describing Physical Quantities

- Scalars → Quantities such as time, temperature, mass, speed can be described by just one number with an appropriate unit
  - math is simple: 2kg +3kg = 5kg (always!)
- Vectors → Quantities with direction associated with them such as those quantifying motion (displacement, velocity)
  - needs a magnitude (how large or small)
  - needs a pointing direction (which way?)
  - math for these objects is more complicated

The Displacement Vector

- Describes net change in position of an object
- An example of a displacement vector



- Example of same displacement vector but with a different path

- Apologies to Robert Frost, both paths taken arrive at the same point ⇒ same magnitude, directions, although paths very different

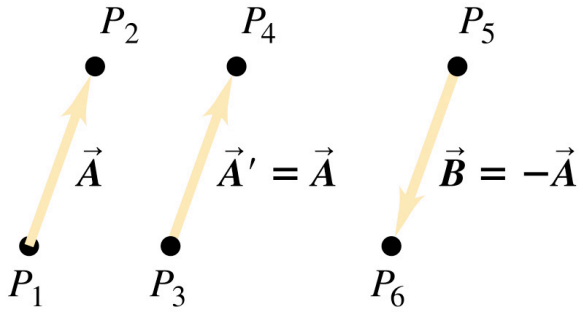
The Zero Vector

Equal, Parallel & Anti Parallel Vectors

length of a vector $\vec{A}$ = its magnitude = $|\vec{A}|$

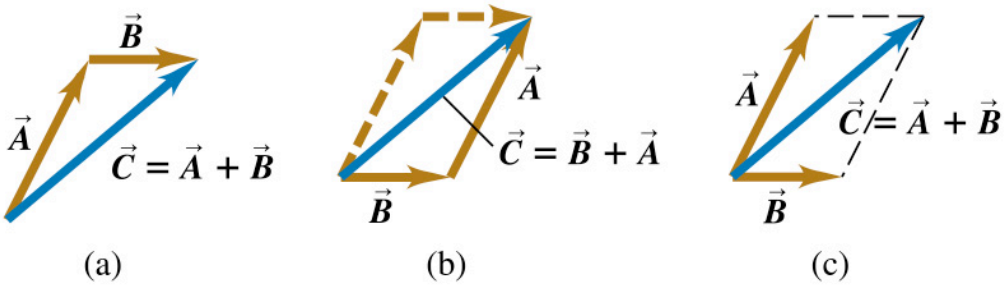
If two vectors have the same direction (whether or not they have the same magnitude) then they are parallel (↑↑)

If two vectors have the opposite direction (again, regardless of the magnitude) then they are anti-parallel (↑ ↓)



Vector Addition Is Commutative

- Imagine a particle goes thru two consecutive displacements. Where is the particle at now ?

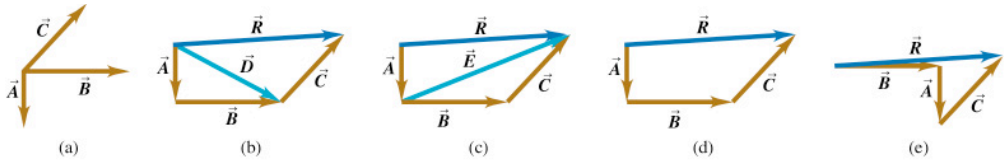


(a) (b) (c)

Vector addition is **commutative**, order of addition does not matter

Many-Vector Addition/Subtraction

To find the sum of many vectors, first find vector sum of any two, add the resultant vector to the next one vectorially and keep going

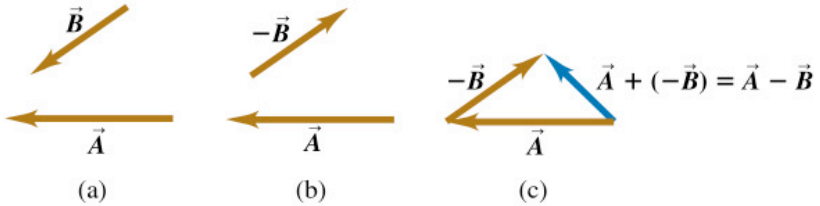


Many ways to get to the same answer, as you could have guessed

Difference Of Two Vectors

Effectively an addition of two vectors: $\vec{A}$ and $-\vec{B}$

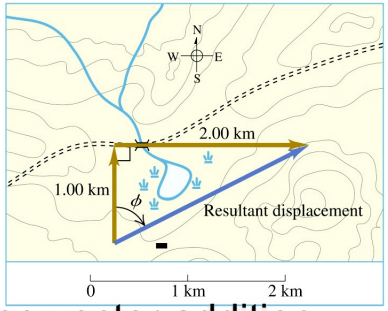
Just put tail of $-\vec{B}$ at the head of A



Check: $(\vec{A} - \vec{B}) + \vec{B} = \vec{A}$

Vector Addition: Using Scale Diagram

A skier skies 1.00km north then 2.00 km east on a horizontal ski field
(a) how far and in what direction is she from the starting point ?
(b) what is the magnitude and direction of her net displacement ?



- Draw a picture of the situation, use vector addition
- Vectors form a right triangle, length and direction of the hypotenuse = resultant displacement vector

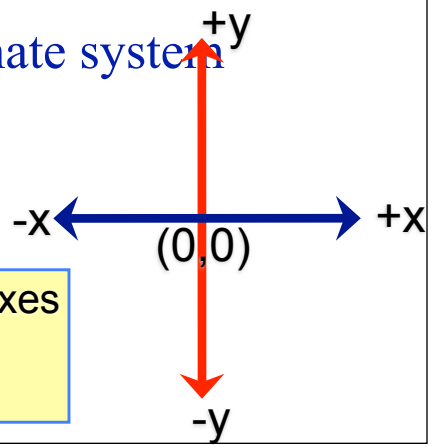
$$\text{Pythogoras Theorem} \Rightarrow \text{length} = \sqrt{(1.00\text{km})^2 + (2.00\text{km})^2} = 2.24 \text{ km}$$

$$\tan\phi = \frac{\text{opposite side}}{\text{adjacent side}} = \frac{2.00 \text{ km}}{1.00 \text{ km}} \Rightarrow \varphi = \tan^{-1}(2) = 63.4^{\circ}$$

Answer : 2.24km, 63.4° East of North or 26.6° North of East

Vector Addition: A General Method

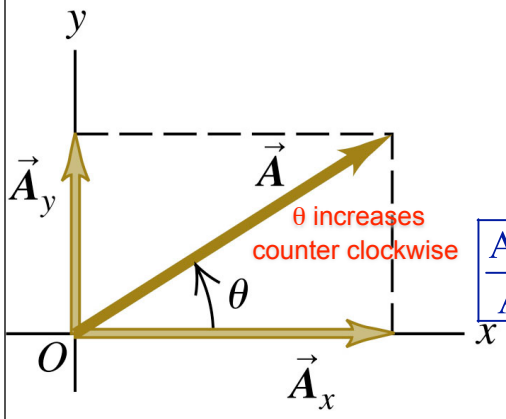
- Got lucky last time, the two vectors were ⊥ but in general they wont be ⇒ need a general method
  - Method of *Components*
- Use an orthogonal coordinate system



Cartesian coordinate system of axes
In 2 dimension, also called
Rectangular coordinate system

Components Of A Vector

- In Cartesian coordinate system, you can represent any vector lying in x-y plane as sum of a vector parallel to x-axis and a vector parallel to y-axis



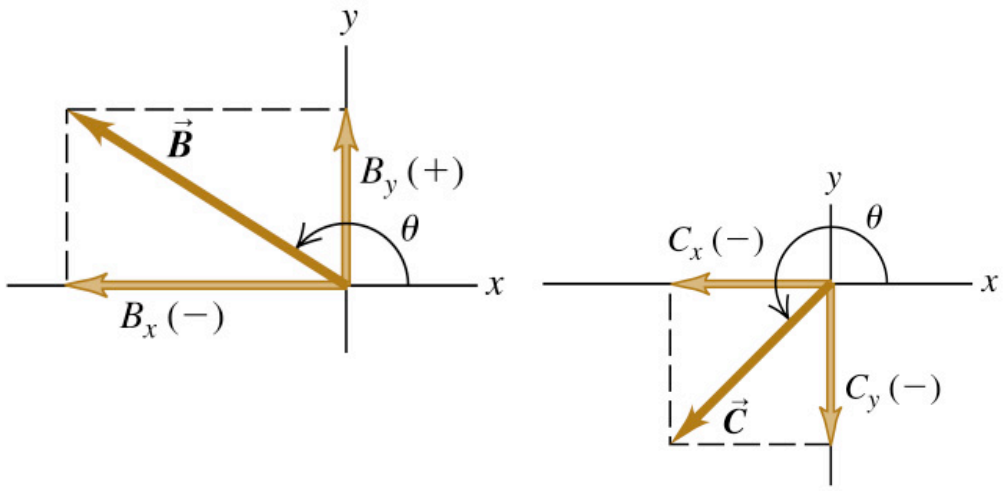
$$\vec{A} = \vec{A}_x + \vec{A}_y$$

Magnitudes A_x & A_y are components of $\vec{A}$

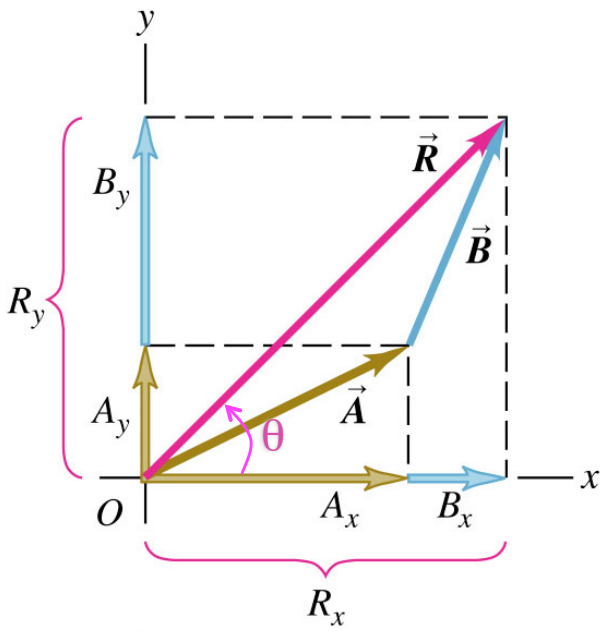
$$\frac{A_x}{A} = \cos\theta \qquad \frac{A_y}{A} = \sin\theta \qquad \frac{A_y}{A_x} = \tan\theta$$

$$A_x = A\cos\theta \; ; \; A_y = A\sin\theta$$

Vector components can be positive or negative depending on the vector orientation



Vector Addition Using Components



$$\vec{R} = \vec{A} + \vec{B}$$

$$\vec{R} = \vec{R}_x + \vec{R}_y$$

$$\boxed{\vec{R}_x = \vec{A}_x + \vec{B}_x}$$

$$\boxed{\vec{R}_y = \vec{A}_y + \vec{B}_y}$$

$$R = \sqrt{R_x^2 + R_y^2}$$

$$\theta = \tan^{-1}\left(\frac{R_y}{R_x}\right)$$

Unit Vectors

Unit vector is just a pointing vector

-describes a direction in space

-has magnitude of 1, with no unit

Unit Vector $\hat{i}$ *points in dir. of* + x

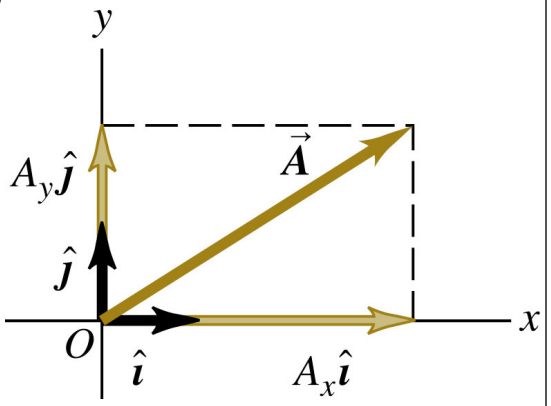
Unit Vector $\hat{j}$ *points in dir. of* + y

Relation between

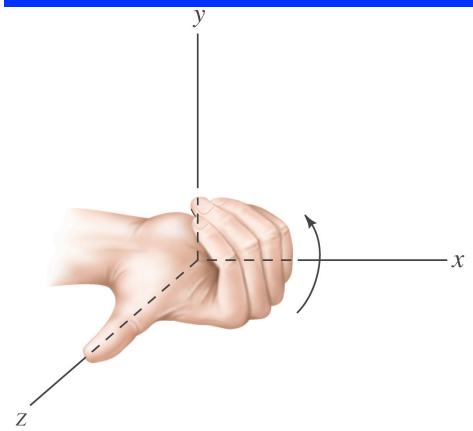
component vectors & component

$\vec{A}_x = A_x \hat{i}$; $\vec{A}_y = A_y \hat{j}$

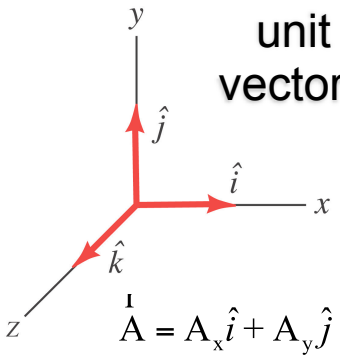
$\vec{A} = A_x \hat{i} + A_y \hat{j}$



Vectors in 3 Dimensional Space



Right hand rule specifies orientation of the 3 axes



unit vectors

$$\vec{A} = A_x\hat{i} + A_y\hat{j} + A_z\hat{k}$$

$$\vec{B} = B_x\hat{i} + B_y\hat{j} + B_z\hat{k}$$

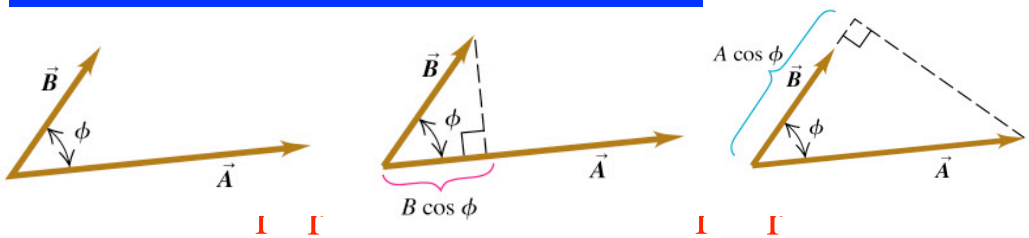
$$\vec{R} = (A_x + B_x)\hat{i} + (A_y + B_y)\hat{j} + (A_z + B_z)\hat{k}$$

$$\boxed{\vec{R} = R_x\hat{i} + R_y\hat{j} + R_z\hat{k}}$$

Multiplying Vectors: Vector Product

- In mechanics, can express many physical relationships by using vector product
- Vector product is not like multiplying #s
- Two different kind of vector products
  - scalar product yields a value that's scalar
  - vector product yields another vector !

Scalar Product Of $\vec{A}$ & $\vec{B}$



Definition : $\vec{A} \cdot \vec{B} = AB\cos\phi = |\vec{A}||\vec{B}|\cos\phi$

$= (B\cos\phi)A \quad = (A\cos\phi)B$

$\vec{A} \cdot \vec{B}$ = magnitude of B x proj of A on B

$\vec{A} \cdot \vec{B}$ = magnitude of A x proj of B on A

Largest when $\vec{A} \parallel \vec{B}$; Zero when $\vec{A} \perp \vec{B}$

$\hat{i} \cdot \hat{i} = 1 = \hat{j} \cdot \hat{j}$; $\hat{i} \cdot \hat{j} = \hat{j} \cdot \hat{i} = 0$

Scalar Product Of $\vec{A}$ & $\vec{B}$

$$\vec{A}\cdot\vec{B} = (A_x\hat{i} + A_y\hat{j} + A_z\hat{k})\cdot(B_x\hat{i} + B_y\hat{j} + B_z\hat{k})$$

$$= A_x\hat{i}\cdot B_x\hat{i} + A_x\hat{i}\cdot B_y\hat{j} + A_x\hat{i}\cdot B_z\hat{k}$$

$$+ A_y\hat{j}\cdot B_x\hat{i} + A_y\hat{j}\cdot B_y\hat{j} + A_y\hat{j}\cdot B_z\hat{k}$$

$$+ A_z\hat{k}\cdot B_x\hat{i} + A_z\hat{k}\cdot B_y\hat{j} + A_z\hat{k}\cdot B_z\hat{k}$$

$$= A_xB_x\hat{i}\cdot\hat{i} + A_xB_y\hat{i}\cdot\hat{j} + A_xB_z\hat{i}\cdot\hat{k}$$

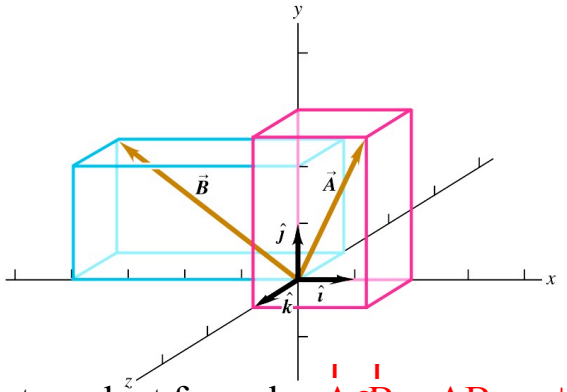
$$+ A_yB_x\hat{j}\cdot\hat{i} + A_yB_y\hat{j}\cdot\hat{j} + A_yB_z\hat{j}\cdot\hat{k}$$

$$+ A_zB_x\hat{k}\cdot\hat{i} + A_zB_y\hat{k}\cdot\hat{j} + A_zB_z\hat{k}\cdot\hat{k}$$

$$\vec{A}\cdot\vec{B} = A_xB_x + A_yB_y + A_zB_z$$

Finding Angle Between Two Vectors

$\vec{A} = 2\hat{i} + 3\hat{j} + \hat{k}$; $\vec{B} = -4\hat{i} + 2\hat{j} - \hat{k}$, What's angle ϕ between them?



Dot product formula : $\vec{A} \cdot \vec{B} = AB\cos\phi = A_x B_x + A_y B_y + A_z B_z$

$$\Rightarrow \cos\phi = \frac{A_x B_x + A_y B_y + A_z B_z}{AB} = \frac{-3}{\sqrt{14}\sqrt{21}} = -0.175$$

$$\Rightarrow \boxed{\phi = \cos^{-1}(-0.175) = 100^{o}}$$

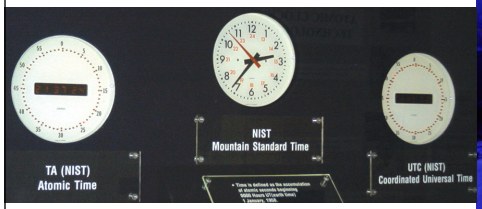
Slides For Self Study By Students

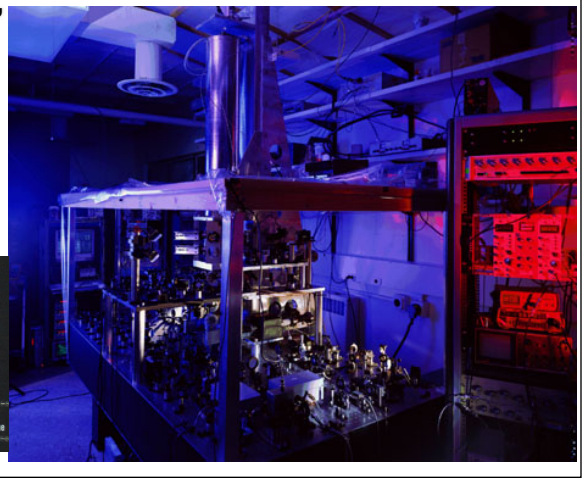
Measurement Standards

- Worldwide, in science we use the SI or metric units, its definitions have evolved with gains in technology
- Second (s) is 9192631770 vibrations of ^{133}Cs atom

NIST-F1 Cesium atom "Fountain" atomic clock in Colorado

Internet needs a standard time else the WEB would collapse as would many other networks





Systeme International (SI) Standards

- Meter (m) is the distance traveled by light in vacuum in $\frac{1}{299792458}$ s ; 3.3 ns

speed of light is a fundamental constant of this universe; could be different in other (parallel?) universes

- Kilogram (kg): The reference kilogram is a cylinder made of platinum–iridium alloy and kept in the International Bureau of Weights and Measures in France. A search continues for a suitable atomic or natural standard for mass

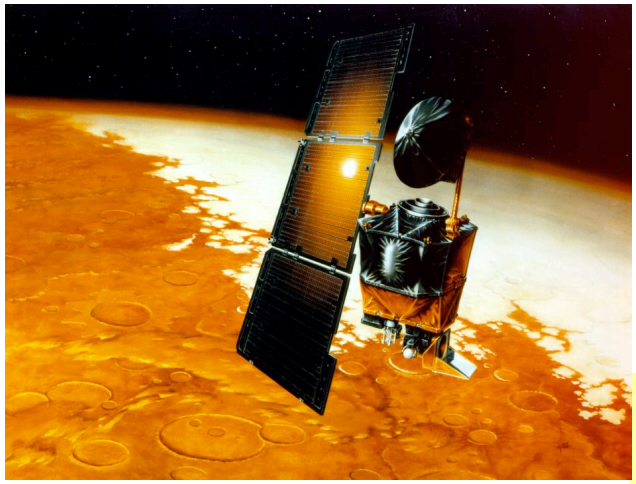
Other (archaic) Units of Measure

- CGS units:second, gram(10^{-3}kg), cm (10^{-2} m)
- British/US: Defined in terms of SI units
  - second
  - inch =2.54cm
  - pound =0.4535 kg at sea level

- In physics we will only use SI (metric units)
- See appendix E of your book for conversion factors.
  - Inconsistent usage of units can be recipe for disaster ! e.g: NASA's Mars mission

Unit Inconsistency ⇒ Disaster !

NASA crashed a $80M Mars Orbiter in 1999 because of usage of mismatched units in navigation software: Metric Vs British units !!



The space probe vanished soon after reaching Mars after a nine and a half month journey - all because NASA scientists overlooked a conversion of measurements from **british** l to metric.

The Mars Climate Orbiter had successfully flown 760 million miles with the error unnoticed but as soon as it began circling the planet the probe vanished.

The mistake in calculations caused the satellite to burn up or break apart by moving too close to Mars.

NASA were apparently given the units for acceleration in pounds of force (imperial) instead of newtons (metric).

For those of you who are interested this is how to convert between the two units:

1 pound of force = 0.225 newtons
4.448 pounds of force= 1 newton

The result was that the changes made to the spacecraft's trajectory were actually **4.4 times greater than what the JPL navigation team believed.**

Unit Prefixes To Quantify Small & Big

- With Standard (Metric) units in hand, can define convenient smaller & larger units for the same quantities….in the powers of 10

Prefix	Symbol	Multiple
Exa†	E	10^{18}
Peta†	P	10^{15}
Tera	T	10^{12}
Giga	G	10^{9}

Prefix	Symbol	Multiple
Deci†	d	10^{-1}
Centi	c	10^{-2}
Milli	m	10^{-3}
Micro	μ	10^{-6}

Prefix	Symbol	Multiple
Mega	M	10^{6}
Kilo	k	10^{3}
Hecto†	h	10^{2}
Deka†	da	10^{1}

Prefix	Symbol	Multiple
Nano	n	10^{-9}
Pico	p	10^{-12}
Femto†	f	10^{-15}
Atto†	a	10^{-18}

The Scale of Things

TABLE 1.5 Some approximate lengths

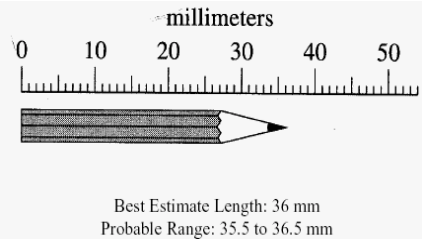
	Length (m)
Circumference of the earth	4×10^{7}
New York to Los Angeles	5×10^{6}
Distance you can drive in 1 hour	1×10^{5}
Altitude of jet planes	1×10^{4}
Distance across a college campus	1000
Length of a football field	100
Length of a classroom	10
Length of your arm	1
Width of a textbook	0.1
Length of your little fingernail	0.01
Diameter of a pencil lead	1×10^{-3}
Thickness of a sheet of paper	1×10^{-4}
Diameter of a dust particle	1×10^{-5}

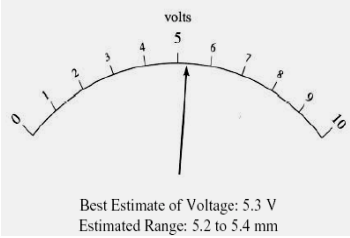
TABLE 1.6 Some approximate masses

	Mass (kg)
Large airliner	1×10^{5}
Small car	1000
Large human	100
Medium-size dog	10
Science textbook	1
Apple	0.1
Pencil	0.01
Raisin	1×10^{-3}
Fly	1×10^{-4}

Know The Error of Thy Ways!

All measurements have uncertainties because of the inherent imprecision in the **measuring device** used e.g.
A ruler, a watch, a weighing machine etc





Length Measure

Voltage (or time) Measure

need to indicate the accuracy of measured value as :
x = meas. value ± uncertainty [to cover the range]

Accuracy and Significant Figures

- The number of significant figures represents the accuracy with which a number is known
- Terminal zeroes after a decimal point are significant figures
  - 2.0 is between 1.95 and 2.05, whereas 2.00 is between 1.995 and 2.005
- Trailing zeroes with no decimal point are not significant:
  - 1200 is between 1150 and 1250, whereas 1200. is between 1199.5 and 1200.5

Don't Be Your Calculator's Slave !

- If numbers are written in a scientific notation, it is clear how many significant figures there are:
  - 6 × 1024 has one
  - 6.1 × 1024 has two
  - 6.14 × 1024 has three
  - …and so on.
- Calculators typically show many more digits than are significant. It is important to know which are accurate and which are meaningless ..dont copy calculator output blindly!
- If measurements are combined to form some quantity, the effect of the uncertainty of each needs to be taken into account in the derived value

Algebra & Significant Figures

- When multiplying or dividing numbers, # of significant figures in the result can be no greater than in the factor with the fewest significant figures
- In add/subtract of numbers, it's the location of the decimal point that matters, NOT the number of significant figures
  - example 123.62+8.9=132.5 (not 132.52)

Precision Vs Accuracy: Know The Diff

- An el cheapo digital watch can display a very *precise* time but if it runs “slow” then it is not very *accurate*

- A Swiss grandpa clock (because of good engineering) might always display *accurate* time (if time synced from US time server at www.nist.gov) but if the clock has no second hand then isn’t very *precise* !