PHYS1502Q-006
Physics for Engineers II

Course Introduction & Vector Review

Instructor:
Dave Perry (dave.perry@uconn.edu)

Spring 2022

PHYS 1502-006 instructional team

Course and Instructor Information

Instructor: Dave Perry
E-mail: dave.perry@uconn.edu

Office: S104 in Gant South

Class Meeting times: 8 AM – 9:55 AM
Class Location: Tuesday and Thursday in GP-110. Friday in GP-113
Office Hours: By Appointment only

Teaching Assistants:
Dani Lipmen (dani.Lipman@uconn.edu)
Abhirup Dutta (abhirup.dutta@uconn.edu)
Gabriel Kovacs (gabriel.kovacs@uconn.edu)

Overview of course components

- Lecture: Theory, Examples, and Active Learning (**Tues/Thurs 8 AM – 9:55 AM**)
- Reading Assignments: ExpertTA (**due Sunday 11:59 PM**)
- Homework: ExpertTA (**due Monday 11:59 PM**)
- Textbook: Halliday, Resnick & Walker, Fundamentals of Physics, and OpenStax
- Participation: Tutorials and iClicker
- Paper Quizzes: Will become available during semester, submitted individually
- Exams: Two midterms and a final.
- Labs: Group exploration of physical phenomena (**Fri 8:00 AM – 9:55 PM**)

  Prelab due **at start** of each lab & Colab notebook due **at end** of each lab
- Course Website: **HuskyCT – Check often!**

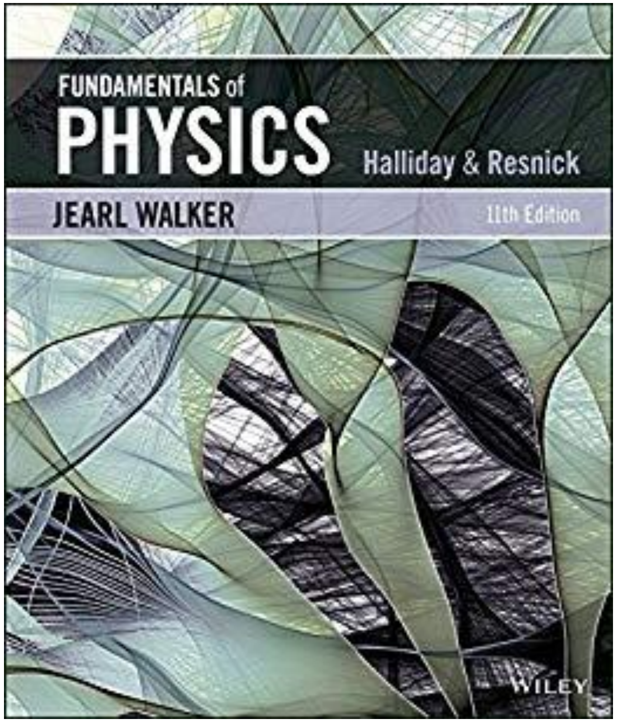
Typical weekly schedule, Spring 2022, class starting Monday

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1^{st} hour			Interactive Lecture		Interactive Lecture	Quantitative Lab*	
2^{nd} hour			Tutorials		Tutorials	Quantitative Lab*	
Out of class	Reading Assignment Due 11:59pm	Homework Due 11:59pm				Prelab Due before lab	

*Except for this first week when we'll have lecture **AND** a short lab on Friday.

Textbook

- Halliday, Resnick, Walker: Fundamentals of Physics, 11th Edition
- Entire volume has 44 chapters – Phys1502 covers chapters 21–36



- Open Source Textbook Alternative:
  - OpenStax University Physics vols. 2 and 3

https://openstax.org/details/books/university-physics-volume-2
(Electricity and Magnetism)

https://openstax.org/details/books/university-physics-volume-3
(Optics and Modern Physics)

Tutorials and Class Participation

- We will be using the iClicker reef app in order to make our class time more engaging.

- Worth 10% of final course grade

- iClicker scoring is as follows:
  - Incorrect answers to questions are given 1.0 point for participation.
  - Correct answers are given an additional 1.0 point, for a total of 2.0 points.
  - To account for excused absences or other reasons, grading will be based on a maximum of 75% of the maximum accumulated score.

- **Read the syllabus for more information**

Homework

- **Worth 15% of final grade**
- We will use *ExpertTA* (theexpertta.com)
- Registration must be done using the link “Expert TA” on the left side of HuskyCT
- Typically due **every Monday by 11:59 PM**. Check *ExpertTA* often to know deadlines
- 10% late penalty per day

Every student also gets one free homework extension for the semester, no questions asked, at no grade penalty!

Research shows that students who copy homework (from classmates, internet, etc.) earn lower final grades*

The first homework is due Monday, Jan 31st by 11:59 PM

*Source: https://journals.aps.org/prper/pdf/10.1103/PhysRevSTPER.6.010104

Reading Assignments

- You will read related topics from one of the textbooks recommended in the syllabus and then take the reading assignment on ExpertTA
- Purpose: Help students assess their learning of the course concepts prior to class so that lectures can be laid out more effectively
- Reading assignments are typically due **every Sunday at 11:59 PM (except during the 1st week of classes)**
- They are worth **10%** of total grade
- **The first reading assignment is due Sunday, January 23rd by 11:59 pm**
- You can use trial version of ExpertTA for 14 days if you are unsure that you will stay in the course

Quizzes

- Short, individual assessment.
- Usually done once per week, typically on Thursdays
- They are worth **10% of total grade.**
- The first quiz will likely be in the third week of classes (you will be notified)

Labs

- **Pre-labs:** These will be provided in Google Colab format, and must be submitted **before each lab** online. No collaboration between students is permitted on the pre-labs.

- **Colab Notebooks:** For each lab, you will be required to complete a Google Colab worksheet about the lab. These digital lab notebooks are due at the end of the lab session and are to be submitted online to HuskyCT as a group. Students are encouraged to work with their lab groups to complete these lab notebooks.

- Students who miss more than 2 labs will receive an “F” for the lab portion of the course and will, by departmental policy, fail the entire course.

- Expectations for the lab are:
  - Complete the pre-lab activity **before** your lab session starts. (5%)
  - Complete the lab activity with your group **during** the lab session. (15%)

The first prelab exercise is due this Friday before lab

Exams

- Exams will be a combination of conceptual, symbolic, and numerical problems, and will be modeled after in-class examples and homework questions.

- There will be 2 midterm exams (10% each):

  - Exam 1: Friday, February 18 4-6 PM

  - Exam 2: Friday, March 25 4-6 PM

  - An equation sheet will be provided with every exam.

- Final exam (15%): Date to be determined by the **Office of the Registrar**. The final exam is cumulative but may slightly emphasize material seen after the second midterm.

Course Structure

Grade Component	Weight
Reading Assignments	10%
Tutorials and Clicker Questions	10%
Paper Quizzes	10%
Homework	15%
Laboratory (Pre-labs 5% + Colab Notebooks 15%)	20%
Midterms 1 & 2	10% each (20% total)
Final Exam	15%
Total	**100%**

Course Expectations

- This is a studio-style class, which means a portion of the course will include small group discussions. Here are the expectations:
  - Respect others at all times
  - Honor group assignments
  - At all times, course communication with fellow students, instructor and TAs are to be professional and courteous.

Additional Resources

There are two other places you can go for help (free):

- **Q-Center:** (online tutoring hours). http://qcenter.uconn.edu/
- **Physics Learning Resource Center (PLRC):**
  - Physics graduate students waiting to answer your questions, help you prepare, teach some tricks
  - **Schedule is posted on HuskyCT**
  - Created to help YOU with specific questions about problems and general concepts that you feel you may not understand
  - Ask for help!

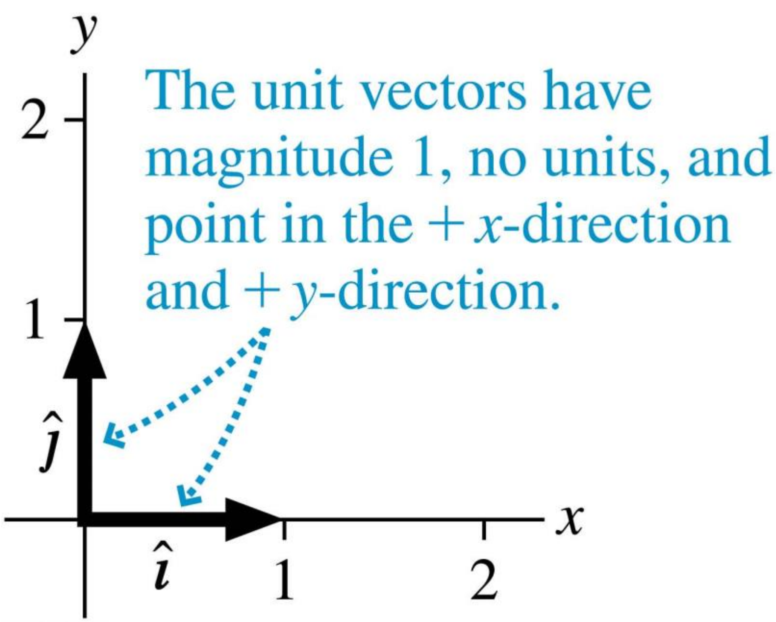
Scope of PHYS1502Q-002

- **Electromagnetism**
  - Electric Charge and Force
  - Electric Fields
  - Electric Currents
  - Magnetic Force
  - Electromagnetic Induction
  - Electromagnetic Waves
  - Applications
- **Optics**
  - Geometrical Optics
  - Wave Optics

Brief Vector Review

Math Review: Unit Vectors

- Each vector in the figure to the right has a magnitude of 1, no units, and is parallel to a coordinate axis



- A vector with these properties is called a **unit vector**

- These unit vectors have the special symbols:

$$\hat{\imath} \equiv (1, \text{positive } x\text{-direction})$$

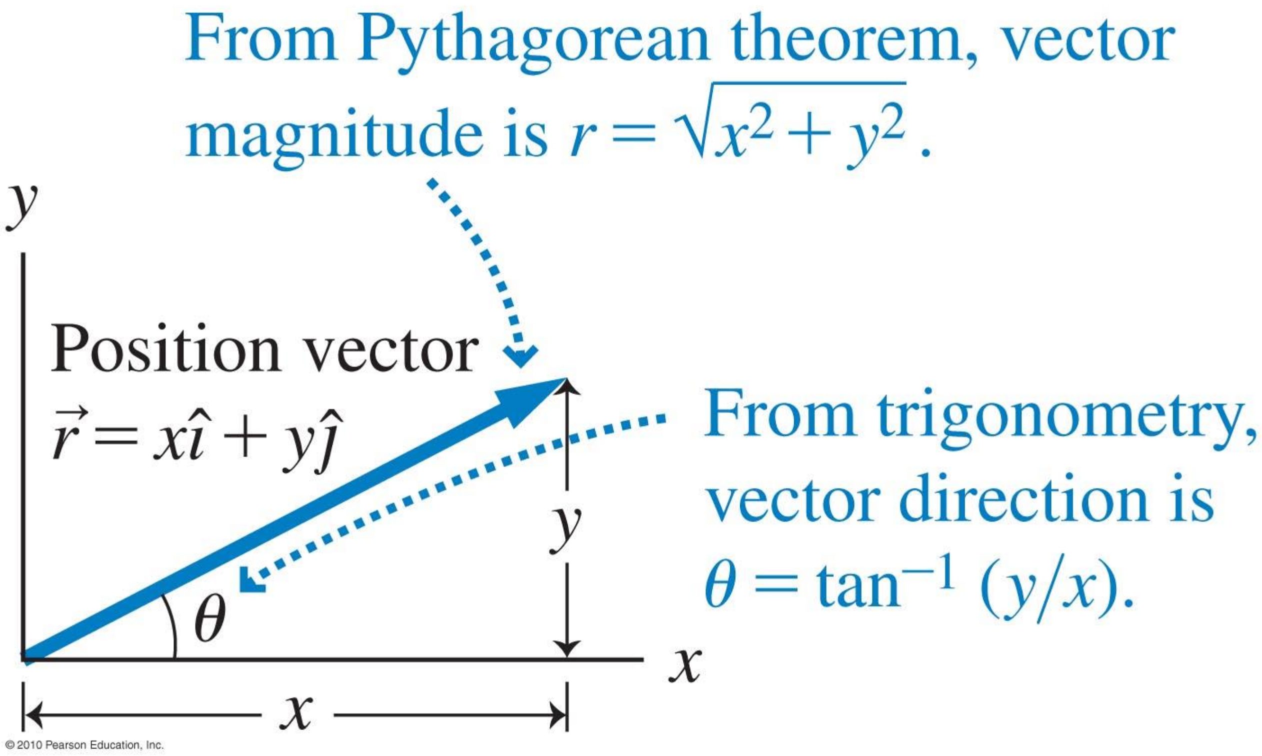
$$\hat{\jmath} \equiv (1, \text{positive } y\text{-direction})$$

$$\hat{k} \equiv (1, \text{positive z-direction})$$

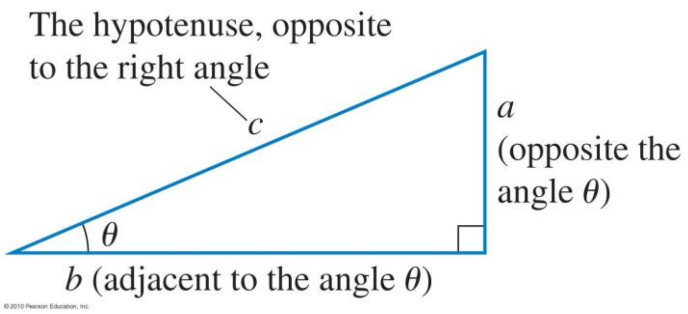
$$\boxed{\hat{x} = \frac{\vec{x}}{|\vec{x}|}}$$

- Unit vectors establish the directions of the positive axes of the coordinate system

Vectors (Review)



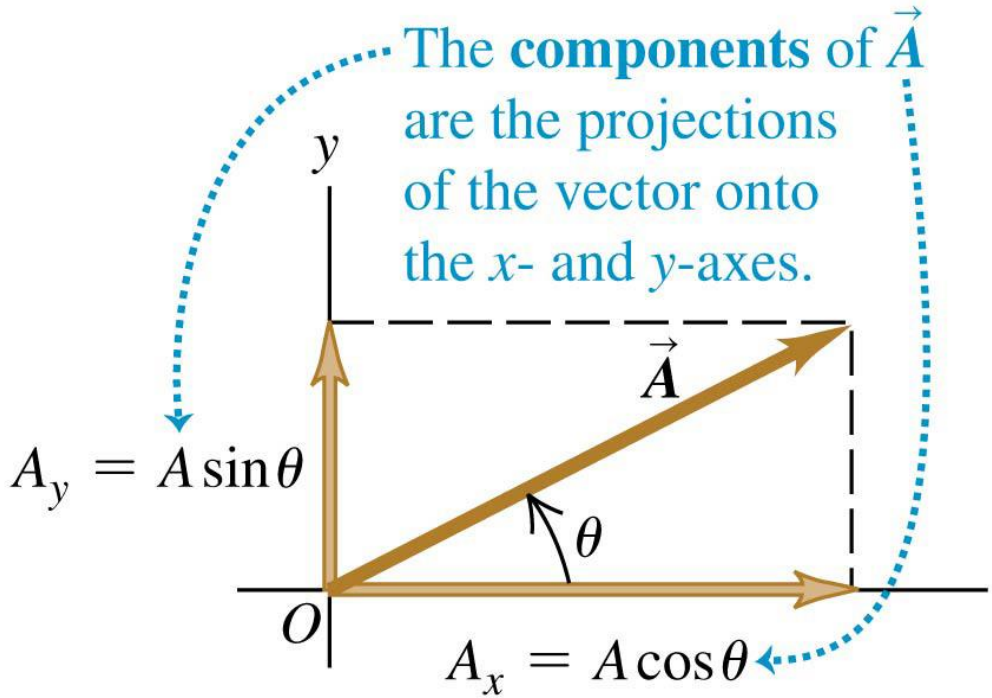
Think of a vector as an arrow.
(An <u>object</u> having both magnitude and direction)



Components of a Vector

- Vector components provide a general method for adding vectors
- Any 2D vector can be represented by an *x*-component A_x and a *y*-component A_y

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

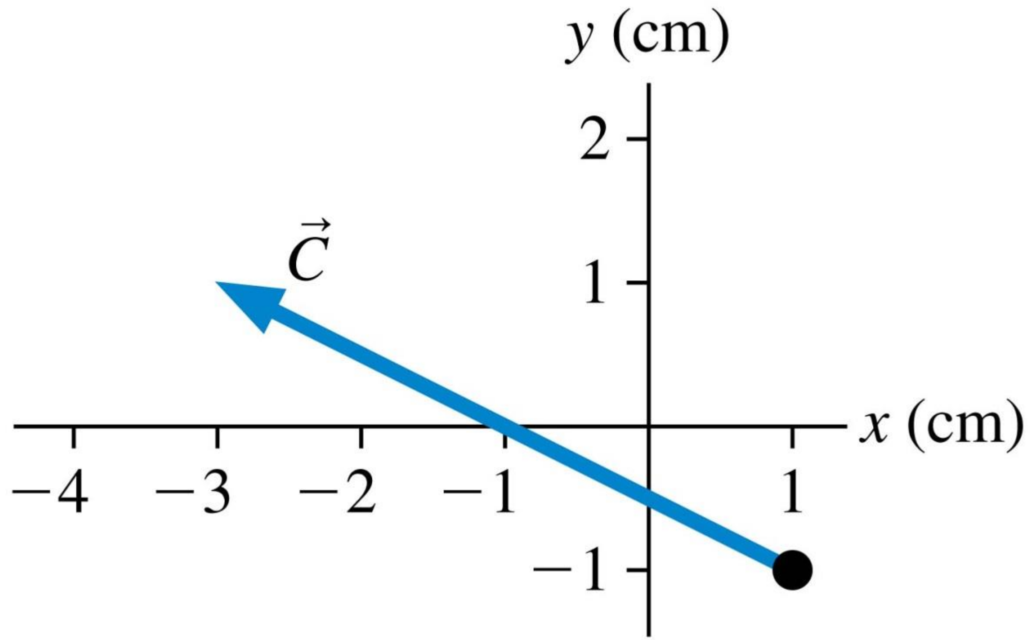


In this case, both A_x and A_y are positive.

Question: Vectors #1

What are the x- and y-components of vector $\vec{C}$?

A. 4, 2
B. –3, 1
C. 1, –1
D. –4, 2
E. 2, –4



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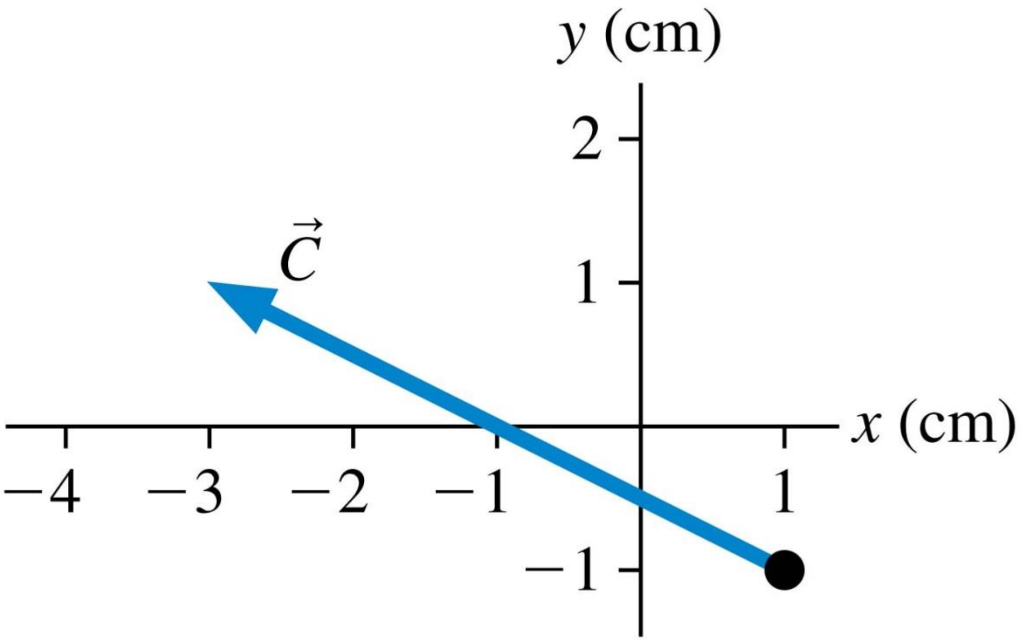


Question: Vectors #2

The angle ϕ that specifies the direction of vector $\vec{C}$ is

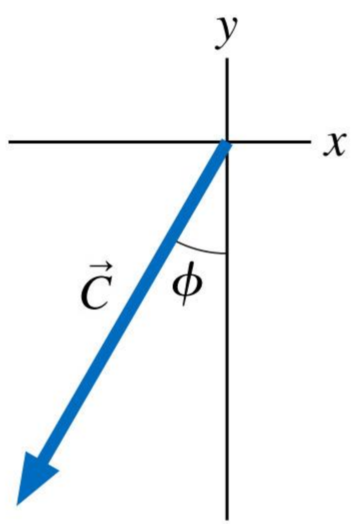
A. $\tan^{-1}(C_x/C_y)$

B. $\tan^{-1}(C_y/C_x)$

C. $\tan^{-1}(|C_x|/C_y)$

D. $\tan^{-1}(|C_x|/|C_y|)$

E. $\tan^{-1}(|C_y|/|C_x|)$



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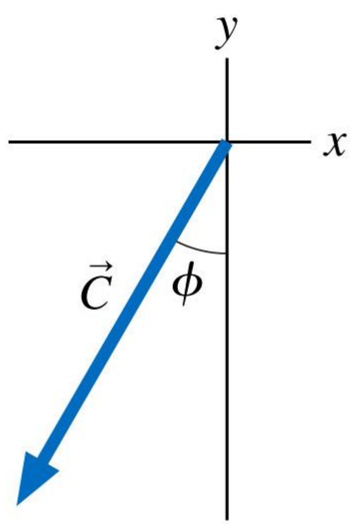
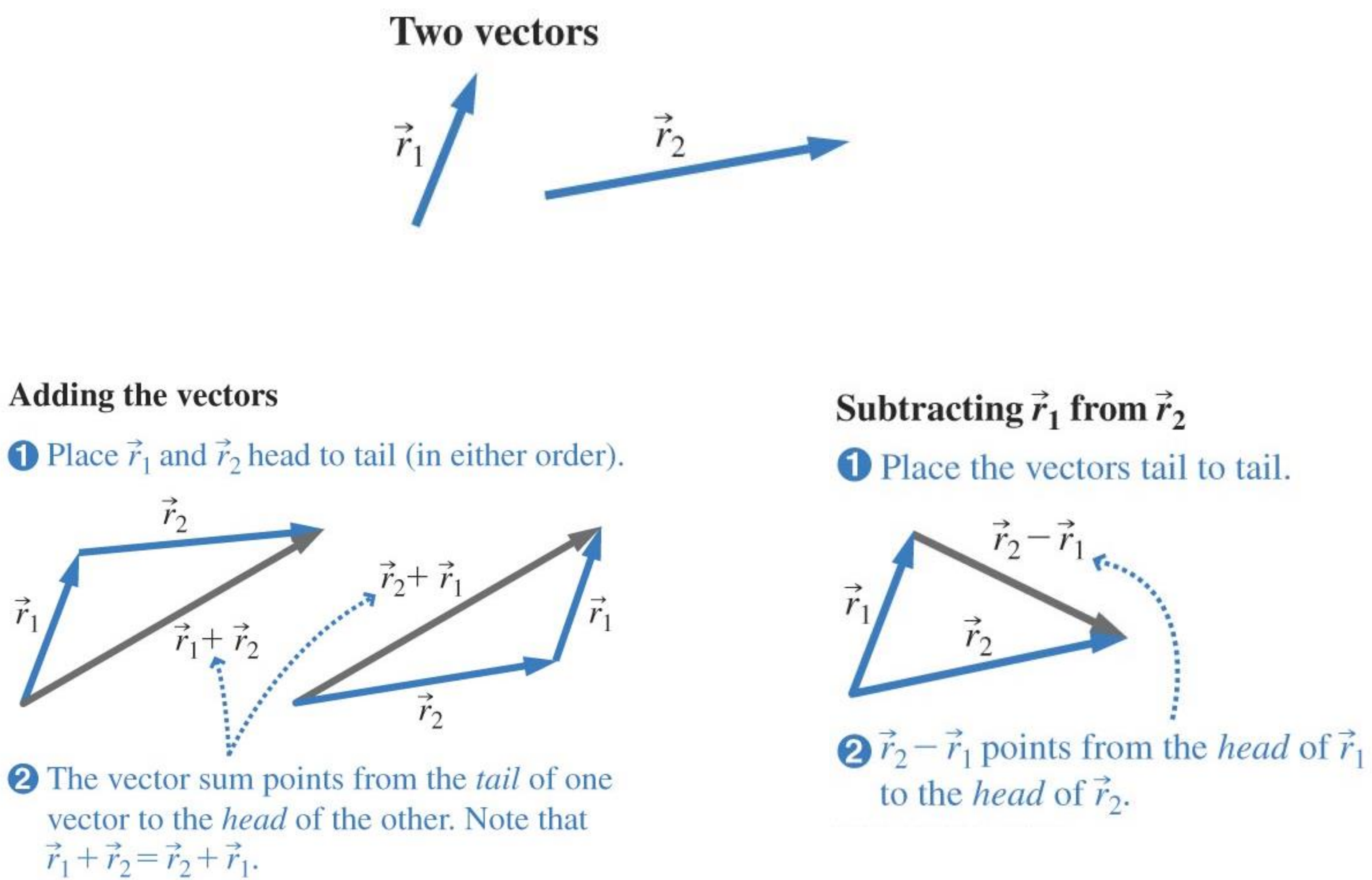


Vector Addition & Subtraction



Vector Addition Using Components

- Consider $\vec{C} = \vec{A} + \vec{B}$

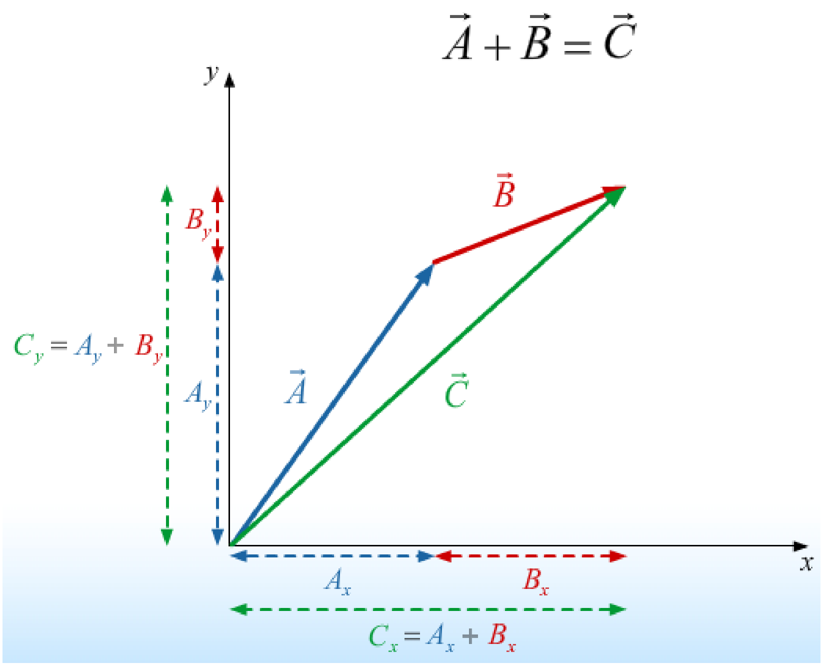
1
$$\vec{C} = (A_x\hat{i} + A_y\hat{j}) + (B_x\hat{i} + B_y\hat{j})$$
$$= (A_x + B_x)\hat{i} + (A_y + B_y)\hat{j}$$

2
$$\vec{C} = (C_x\hat{i} + C_y\hat{j})$$

- Comparing components of (a) and (b):

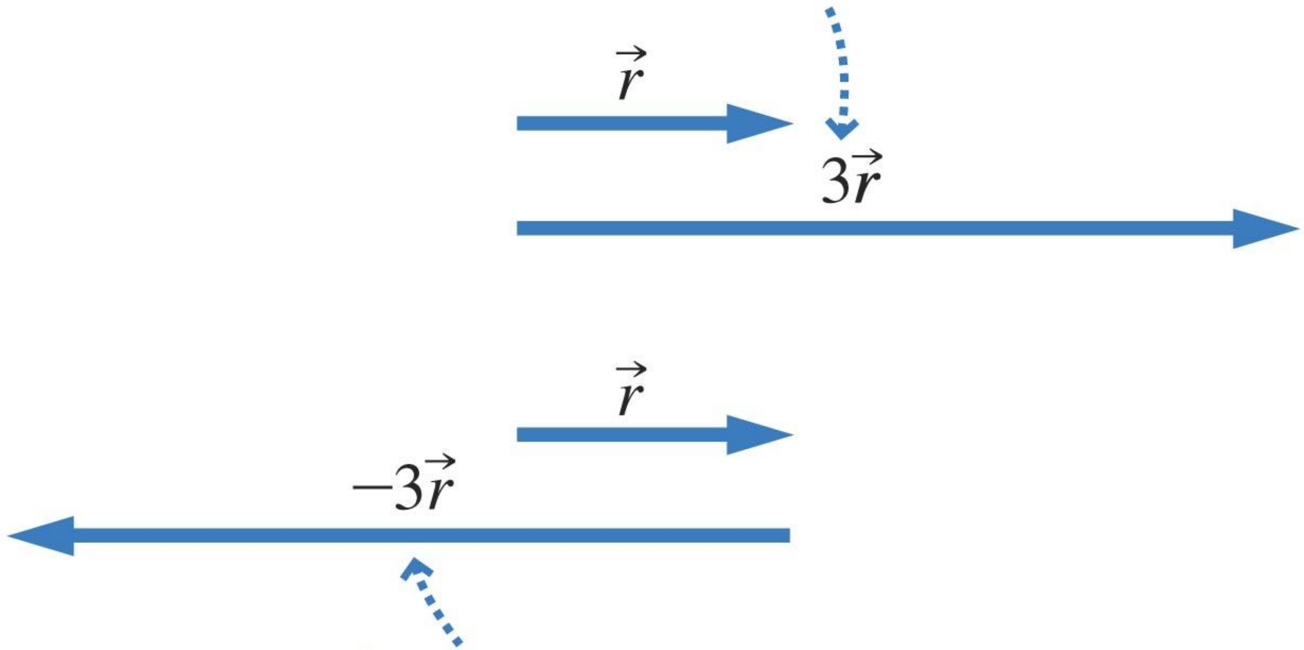
$$C_x = A_x + B_x$$

$$C_y = A_y + B_y$$



Multiplication of Vectors by a Scalar

Multiplying $\vec{r}$ by 3
- increases its magnitude by a factor of 3
- but does not change its direction.



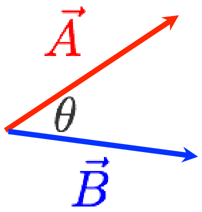
Multiplying $\vec{r}$ by -3
- increases its magnitude by a factor of 3
- and *reverses* its direction.

The Dot Product

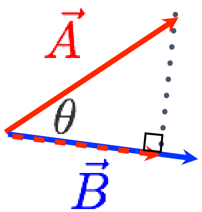
"Dot product" aka "scalar product" aka "inner product" is defined as:

$$\vec{A} \cdot \vec{B} = |\vec{A}||\vec{B}| \cos\theta$$

Angle between vectors A and B



and yields a scalar (i.e., number)

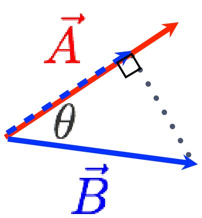


Geometrical Interpretation:

"Projection of vector $\vec{A}$ on vector $\vec{B}$"

or

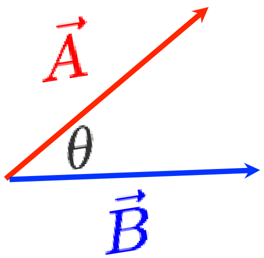
"Projection of vector $\vec{B}$ on vector $\vec{A}$"



How to calculate the dot product

In Cartesian coordinates, the dot product can be calculated by adding the products of each component:

For $\vec{A} = a_x\hat{i} + a_y\hat{j} + a_z\hat{k}$



$$\vec{B} = b_x\hat{i} + b_y\hat{j} + b_z\hat{k}$$

$$\vec{A} \cdot \vec{B} = a_x b_x + a_y b_y + a_z b_z$$

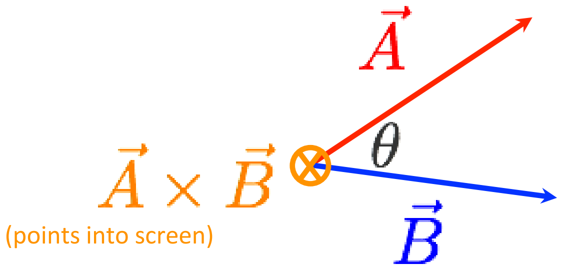
$$\vec{A} \cdot \vec{B} = \vec{B} \cdot \vec{A}$$

Dot product is a commutative operation!

Cross Products

"Cross product" aka "vector product" is defined as

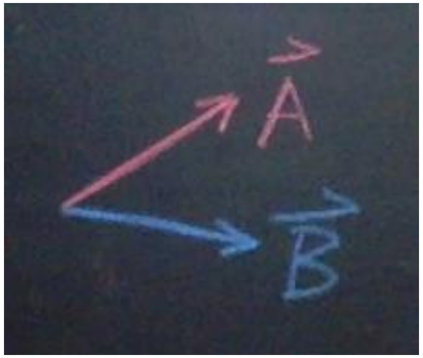
$$\vec{A} \times \vec{B} = |\vec{A}||\vec{B}| \sin\theta \hat{n}$$



Cross product between vectors ***A*** and ***B*** returns a **vector** which is perpendicular to both A and B

Use the "right hand rule" to determine direction

- Right-hand fingers initially point along **A**
- Curl fingers towards **B** (through smaller angle)
- Right thumb then points in direction of **A** x **B**



Cross product between parallel vectors is zero

Cross Product Calculation

Method 1: Determinants

$$\vec{A} \times \vec{B} = \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$$

$$\vec{A} \times \vec{B} = (A_y B_z - A_z B_y)\hat{\imath} - (A_x B_z - A_z B_x)\hat{\jmath} + (A_x B_y - A_y B_x)\hat{k}$$

Method 2: Distributive Method

$$\vec{A} \times \vec{B} = (A_x\hat{\imath} + A_y\hat{\jmath} + A_z\hat{k}) \times (B_x\hat{\imath} + B_y\hat{\jmath} + B_z\hat{k})$$

$$\mathbf{i} \times \mathbf{i} = \mathbf{j} \times \mathbf{j} = \mathbf{k} \times \mathbf{k} = \mathbf{0}$$

$$\mathbf{i} \times \mathbf{j} = \mathbf{k} \qquad \mathbf{j} \times \mathbf{i} = -\mathbf{k}$$
$$\mathbf{j} \times \mathbf{k} = \mathbf{i} \qquad \mathbf{k} \times \mathbf{j} = -\mathbf{i}$$
$$\mathbf{k} \times \mathbf{i} = \mathbf{j} \qquad \mathbf{i} \times \mathbf{k} = -\mathbf{j}$$

Test that these expressions make sense.

Problem: Cross Product #1

What is the vector product, $\vec{A} \times \vec{B}$, if

$$\vec{A} = 2.2\hat{i} + 3.4\hat{j}$$

$$\vec{B} = 4.4\hat{i} + 2.0\hat{j}$$

$$\vec{A} \times \vec{B} = (2.2\hat{i} + 3.4\hat{j}) \times (4.4\hat{i} + 2.0\hat{j})$$

$$= \overset{1}{0} + \overset{2}{4.4\hat{k}} - \overset{3}{15\hat{k}} + \overset{4}{0}$$

$$= -10.6\hat{k}$$

Recall that:

$$\hat{i} \times \hat{i} = \hat{j} \times \hat{j} = 0$$

$$\hat{i} \times \hat{j} = \hat{k}$$

$$\hat{j} \times \hat{i} = -\hat{k}$$

What to do next?

- Register for *ExpertTA* using the link on the left side of HuskyCT
- Obtain Halliday, Resnick and Walker textbook **if you wish**
- Complete the 1st Reading Assignment before **Sunday, Jan 23rd by 11:59 PM** on *ExpertTA.*
- **Complete prelab before tomorrow's shorter lab session.** We will have lecture in the first half of class tomorrow.
- Read the entire syllabus posted in HuskyCT and reach out if you have any questions or concerns.

1.2 Problem-solving Tutorial Session

Vector Algebra Review

Today's tutorial problems can be found at the following HuskyCT location:

Course Contents

- **>> 1 – Introduction to Course; Vector Review; Electric Charges**
  - **>> 1.2 - Introduction to Course; Vector Review**
    - **>> Tutorial 1.2**