Physics 101H

General Physics 1 – Honors

Lecture 4 – 9/7/22

Vectors

CYPRESS

https://ultiworld.com/2022/08/30/universe-point-suny-binghamton-vs-william-mary/

Are you interested in playing ultimate frisbee?

Get in touch! Speak to me or email womensultimatewm@gmail.com

Welcome!

I am Prof. Monahan

Pronouns: **he/him/his**

Email: **cjmonahan@wm.edu**

Office: **Small Hall 326C**

Am I in the right room?

This course: for students who **intend to major in physics or physical sciences**

I assume you have a strong preparation in mathematics

- Comfortable with **calculus**

PHYSICS 101 (not this course!) does not assume knowledge of calculus

- Held at the same time
- Uses the same textbook
- Add/Drop deadline is **11:59 pm** on **Monday September 12**

DO NOT MISS THIS DEADLINE

Problem sets

Problem Set 1 has been posted on **Blackboard**

Due by the **start of class** (i.e. 10:59 am) on **Wednesday 14 September**

Remember

- I will **drop the lowest grade** on your weekly Problem Sets

You can also find tutorials on how to navigate Expert TA (until Sep 30)

Problem sets: Expert TA

You must register for Expert TA

- Sign up for PHYS 101-Honors using this registration link http://goeta.link/USA48VA-007792-2VY
- 14 day free trial period
- Single semester cost ~$33

SCAN ME

Problem sets: Expert TA

http://goeta.link/USA48VA-007792-2VY

SCAN ME

How-to-Register

Course Registration

When registering for a class your instructor will provide you with a registration URL that is unique to that class. It will look similar to the one below.

http://goeta.link/DEI56MO-AB1234-567

After entering your URL you will see the initial Course Registration page.

Registration Information

Code: [redacted] **Role:** Student
Class [redacted] **Description:** [redacted]
Wrong class? Click **here** to enter a new class code.

Step 2: Enter a valid email address.
You must enter the address exactly the same in both fields for confirmation.
Note: Most college and universities require you to use your college or university email address (i.e. not your Yahoo or Gmail account). Please use your university e-mail address unless your instructor has directed you otherwise.

Email Address:
Confirm Email:

Continue

Note: The entry form above works for both new and existing accounts. If you enter an email address that exists in the system then you will be prompted to enter your password. Ideally, if you have made an account before then you should continue using that account anytime you register for a new class.

– New Expert TA User Registration

Problem sets: Expert TA

Expert TA problems:

- Ten tries
- You should be able to submit answers to parts of questions
- No partial credit for parts of questions, a part is either right or wrong
- You should be able to access problem sets up to 20 times within the week

Problem sets: handwritten problem sets

Handwritten problems:

- Partial credit **is** available – make sure you include your working!
- Graded by a graduate student grader

Hints:

- You will lose points if your solution is illegible or a mess
- Pen or pencil acceptable
- If you use a pen, cross through entire lines with a single line
- I strongly recommend you **underline** or **circle** your **final answer**

MAKING SURE YOUR WORK IS LEGIBLE IS *YOUR* RESPONSIBILITY

Problem sets: handwritten problem sets

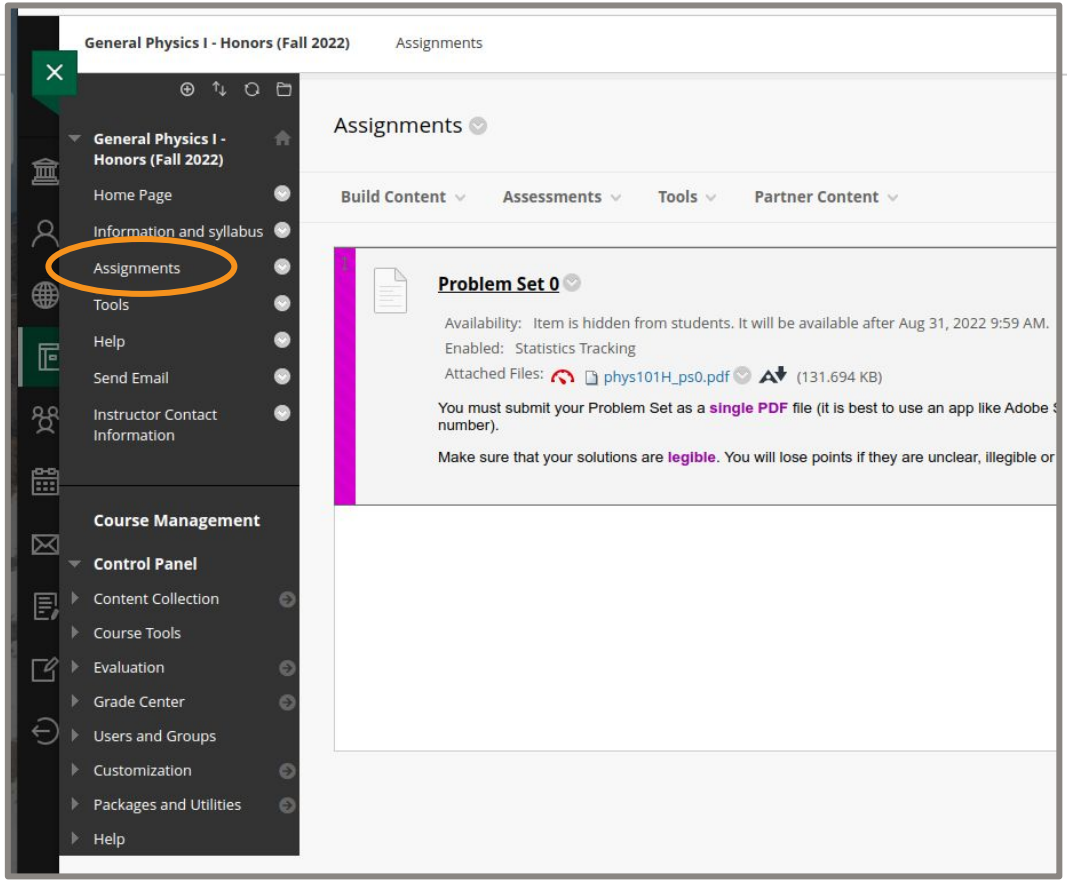
Submitting handwritten problem sets:

- Produce a **single PDF** of your written notes
  - If you have a scanner, then that is the best option
  - Photos will work – use an app like Adobe Scan to make them legible
- Name your **single PDF file** `lastname_hwXX.pdf`
  - Replace "`lastname`" with your last name
  - Replace "`XX`" with the problem set number
- Submit your **single PDF file called** `lastname_hwXX.pdf` to **Blackboard**
  - Go to the appropriate assignment in Blackboard
  - Drag and drop your pdf file to the Attach Files section
  - Hit submit

Problem sets

Submitting problem sets:

- Produce a **single PDF**
- Name your **single PDF file** `lastname_hwXX.pdf`
- Submit your **single PDF file** `lastname_hwXX.pdf` to **Blackboard**



Problem sets: philosophy

I strongly encourage you to **work together** on problem sets

MAKE SURE YOU CAN HONESTLY DO THE PROBLEM ON YOUR OWN AFTERWARDS

- Don't look at the solution until you have **tried** to solve the problem
- Try to use the solution as **hint** to get started or to get the next step
- Even if you rely heavily on the solution or other sources, try to work through **every step** of the problem yourself
- As you work through the solution, take it one step at a time and try to **predict the next step** in the solution
- If you miss a problem, try to **rework it** and think through what went wrong the first time

Understanding physics requires solving problems!

You can improve your ability to solve problems through practice

Practising problem solving improves your knowledge and understanding of physics

You will have lots of opportunities to practice problem solving in this course

You **can** get better at physics!

Summary

Topics

Last week
- Course introduction
- Problem solving
- Mechanics survey

This week
- Vectors
- Kinematics in 1D
- Kinematics in 2D

Today: vectors [chapter 2]
- Definitions
- Operations
- Representations
- Products

Announcements

Today: **Problem set 0 due**
Problem set 1 assigned

Scalars and vectors

Scalar – number (without direction)

Vectors – number and a direction

- Abstract mathematical object
- Exist independently of reference frame
- Can be represented by an arrow

Vectors

Two vectors are **equal** if they have the same **magnitude** and **direction**

Vectors live in a **vector space** (an abstract mathematical space), so it does not matter where they are in real space: you can **translate** a vector through real space as long as you don't stretch it or rotate it.

SEE MATH 211!

Vector operations

We can add vectors! Vector addition is

- **Commutative**
- **Associative**

We can multiply vectors by constants (numbers/scalars)

We can define negative vectors (multiplication by negative one)

Vector subtraction is the same as adding a negative vector

Unit vectors

Unit vectors are vectors with a direction and magnitude = one

- provide a way to describe direction, without worrying about length

Representing vectors

Drawing arrows is not the only way to represent vectors

Can be more quantitative by defining **components** in a **reference frame**

Free to choose a **convenient** reference frame

Example: You drive from a coffee shop 2.0 km north and 3.0 km east of your home to the library 4.0 km north and 1.0 km east of your home. What are the magnitude and direction of the displacement vector of your journey?

Vector operations (again)

We can add vectors by adding components

We can also multiply components by a scalar (i.e. a constant)

What was the most important concept we covered today?

Summary

Topics

This week
- Vectors
- Kinematics in 1D
- Kinematics in 2D

Tomorrow: kinematics in 1D
- Vector products
- Describing motion
- Position, velocity, acceleration

Today: vectors [chapter 2]
- Definitions
- Operations
- Representations

Announcements

Today: **Problem set 0 due**
Problem set 1 assigned

PHYSICS 101 - HONORS

Lecture 4 9/7/22

Scalars and vectors (slide 15)

Vectors ← represent as an arrow
has magnitude (length)
points in a direction

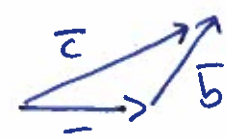
Symbolically: $\vec{a}$ or $\bar{a}$ or **bold a**
Magnitude is a or $|\bar{a}|$ or $\|\bar{a}\|$

Vectors (slide 16)

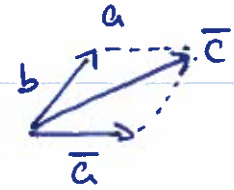
$\bar{a} = \bar{b}$ means $\bar{a}$ and $\bar{b}$ are parallel and have the same magnitude

Vector addition (slide 17)

$\bar{c} = \bar{a} + \bar{b}$ head-to-tail method



parallelogram method

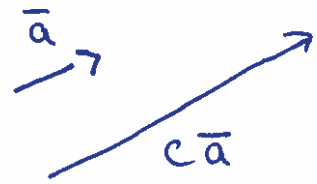


commutative $\bar{a} + \bar{b} = \bar{b} + \bar{a}$

associative $(\bar{a} + \bar{b}) + \bar{c} = \bar{a} + (\bar{b} + \bar{c})$

Vector multiplication (slide 17)

If $\bar{a}$ is a vector then $c\,\bar{a}$ is also a vector, in the same direction, but with magnitude $c|\bar{a}|$



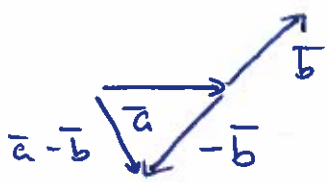
Negative vectors (slide 17)

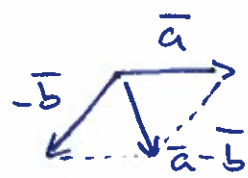
$$-\bar{a} = (-1)\cdot\bar{a}$$

$\bar{a}$ and $-\bar{a}$ are antiparallel

$$\bar{a}-\bar{b} = \bar{a}+(-\bar{b}) = \bar{a}+(-1)\,\bar{b}$$

Head-to-tail





Unit vectors (slide 18)

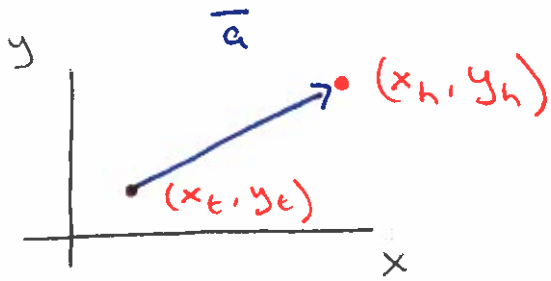
$$\hat{a} = \frac{1}{|\bar{a}|}\,\bar{a} = \frac{\bar{a}}{|\bar{a}|}$$

← to create a unit vector divide a vector by its magnitude

↑ denote unit vector with a "hat"

Representing vectors (slide 19)

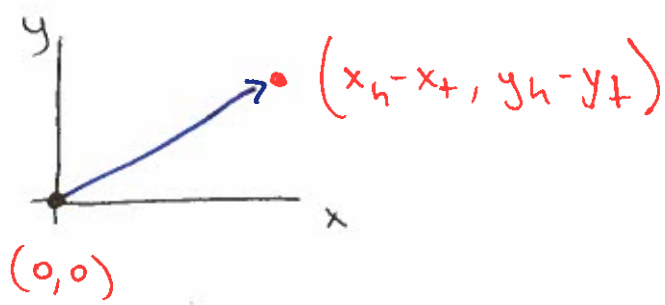
Start with a reference frame



head and tail specified by pairs of points in space

But we are free to choose a <u>convenient</u> reference frame.

For example we can define the origin as the start of the vector (equivalent to subtracting coordinates of the tail)



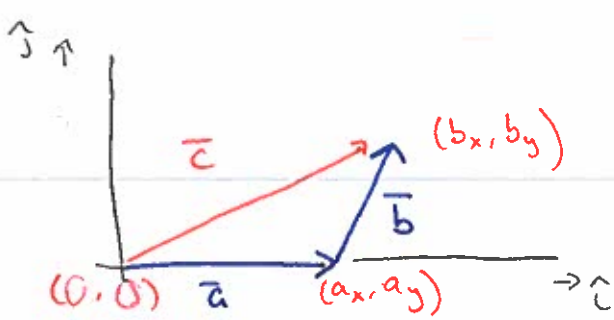
(slide 18)

Adding vectors (slide 21)

$\bar{a} = a_x \hat{\imath} + a_y \hat{\jmath}$

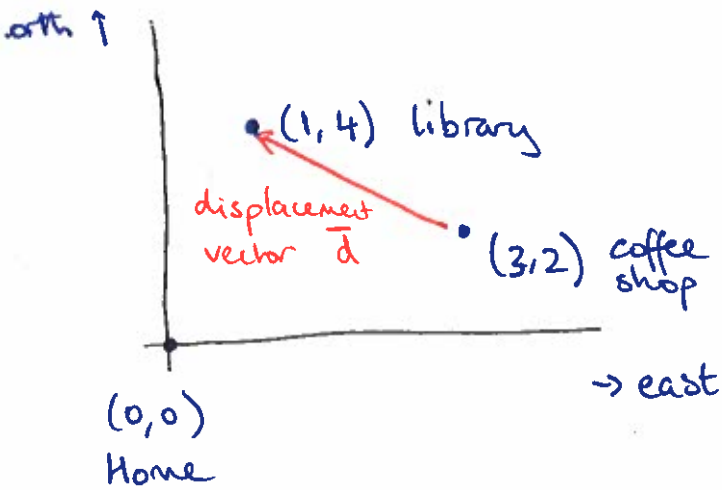
$\bar{b} = b_x \hat{\imath} + b_y \hat{\jmath}$

$\bar{c} = \bar{a} + \bar{b} = (a_x + b_x)\hat{\imath} + (a_y + b_y)\hat{\jmath}$



Vector example (slide 20)

Step 1. Choose reference frame ← set origin = home !



$$\bar{d} = (1,4) - (3,2)$$
$$= (1-3,\ 4-2) = (-2,2) \text{ km}$$

Magnitude is

$$|\bar{d}| = \sqrt{(-2)^2 + 2^2} = \sqrt{8} \simeq \boxed{2.8 \text{ km}}$$

direction is
−2 km east, 2 km north

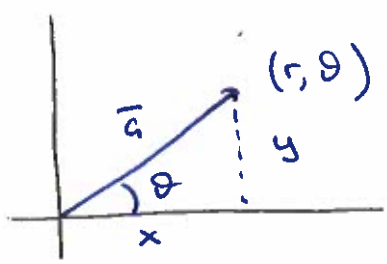
Vector multiplication (slide 21)

$$c\bar{a} = c(a_x \hat{\imath} + a_y \hat{\jmath})$$
$$= (ca_x)\hat{\imath} + (ca_y)\hat{\jmath}$$

just multiply each component!

Polar coordinates

see Lecture 5



$$r = |\bar{a}| = \sqrt{x^2 + y^2}$$

and

$$\tan\theta = \frac{y}{x}$$

or

$$x = r\cos\theta \qquad y = r\sin\theta$$