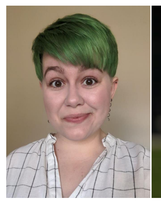
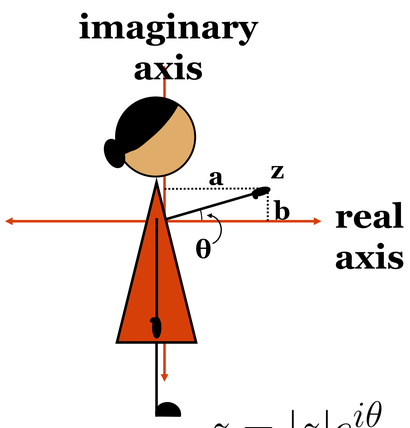
Teaching Relative & Overall Phase with the Arms Representation




Kelby T. Hahn **Elizabeth Gire**

AAPT Talk on Arms Activities
https://beav.es/3B9
Pedagogy
paradigms.oregonstate.edu
Research
osuper.science.oregonstate.edu

Basics Of The Arms Representation

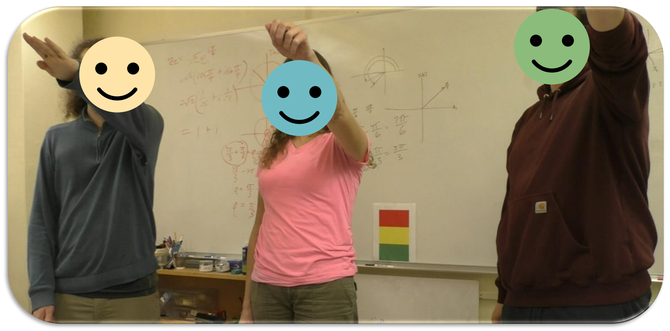


$$z = |z|e^{i\theta}$$
$$z = a + bi$$

- Rotating left arm sweeps out the complex plane
- Forward, ∥ to ground is the real axis
- Up, ⊥ to ground is the imaginary axis
- Left arm represents the complex number
- Looking over the left shoulder looks like Argand diagram
- Multiplication by a phase is a counter-clockwise rotation
- Students work together to represent complex-valued vectors

Co-locating Origins With Argand Diagrams May Be Helpful But Is Difficult To Interpret

Int: I want you to work together, all 3 of you, to represent for me, **with your arms**, a complex vector that has a **relative phase of zero**.

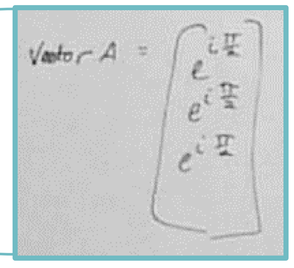


A Few minutes later ...

Int: Can you write this vector on the board for me and label it vector A?

Brandon: What would you say that angle was? About pi over six?

Vivian: I guess we can use any right?

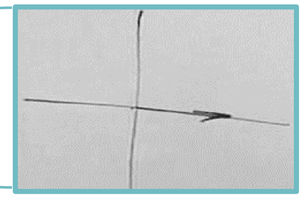


Ox: Were you wanting us to do it, like graphically, or was that what you were looking for?

Int: Both are good. What would it look like if you were going to graph it?

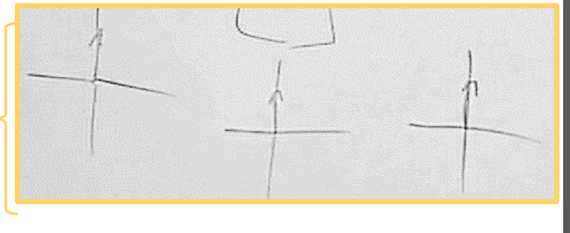
Ox: I have no clue...cause it's 3 dimensional.

Vivian: Well to graph it you would just. You'd have all 3 of them pointing in the same direction.



Ox: Oh, I was thinking of the entire matrix as a whole, cause it's 3 dimensional.

Brandon: Yeah, but we can certainly write 3 little graphs like that next to each other....why not?



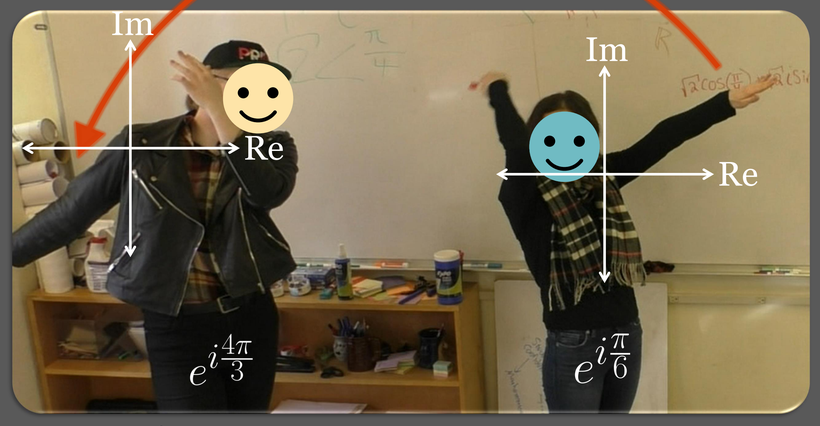
Ox: Because that vector lives in **long pause** it's got 3 components so you need **long pause** I dunno how things with complex numbers look, like graphically, cause you need a complex axis.

Brandon: This is a 6 dimensional graph if you combine this all together...hard to visualize.

Co-locating Origins With Arms Helps Students Interpret Relative Phase Angle

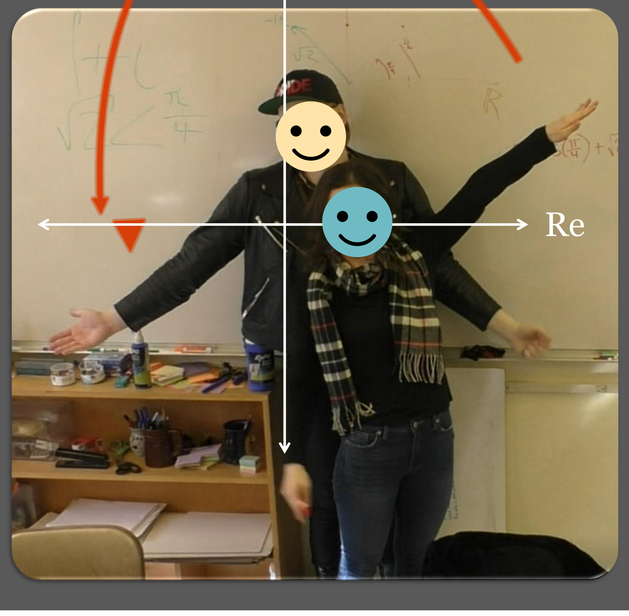
Int: With your arms, can you show me where the **relative phase angle** would be?

Zoe: Well, between our two arms.



Jenny: Hang on, let's just... **spontaneously moves**

lots of giggling



Zoe: Yeah, there we go.