Demonstration of the Addition Theorem

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Creative Project 3

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Review: Explanation of Angular Velocity

Velocity is the direction and magnitude it takes to get from point a to point b in a straight line.

Angular velocity is a measure of how fast something is rotating. The “direction” of rotation is the axis about which it is rotating. Positive and negative rotations are determined by the Right-Hand Rule.

Addition Theorem

- What if there are more than one rotations going on?
- Addition theorem:

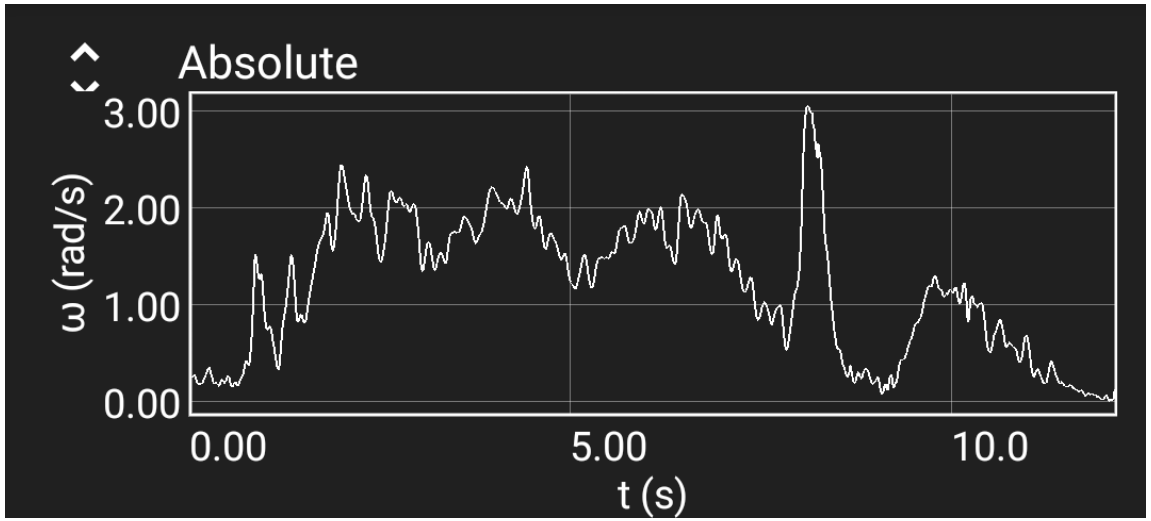
$$\vec{\omega}_{B/A} = \vec{\omega}_{B/C} + \vec{\omega}_{C/A}$$

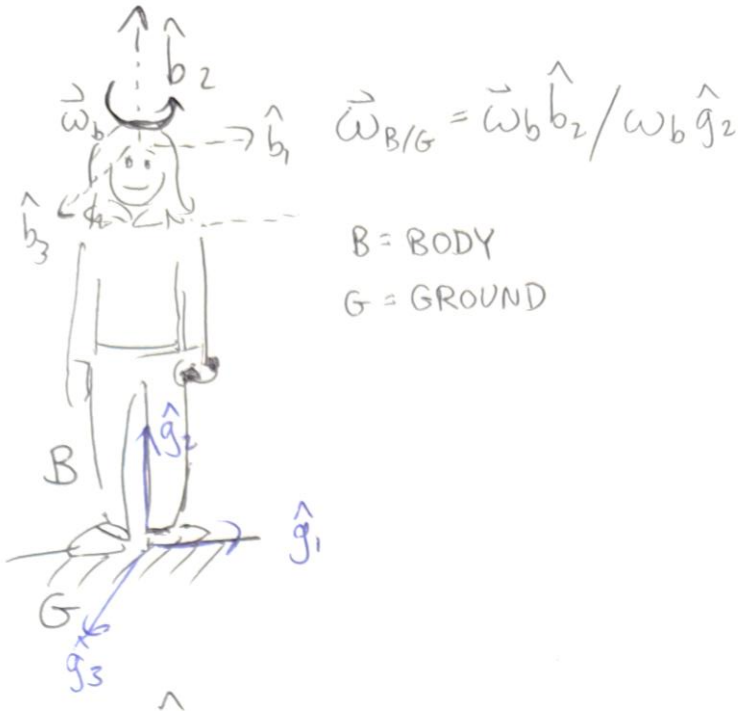
Experiment:

- One (1) Cell phone
- Phyphox
- Yourself!

First, a Spin

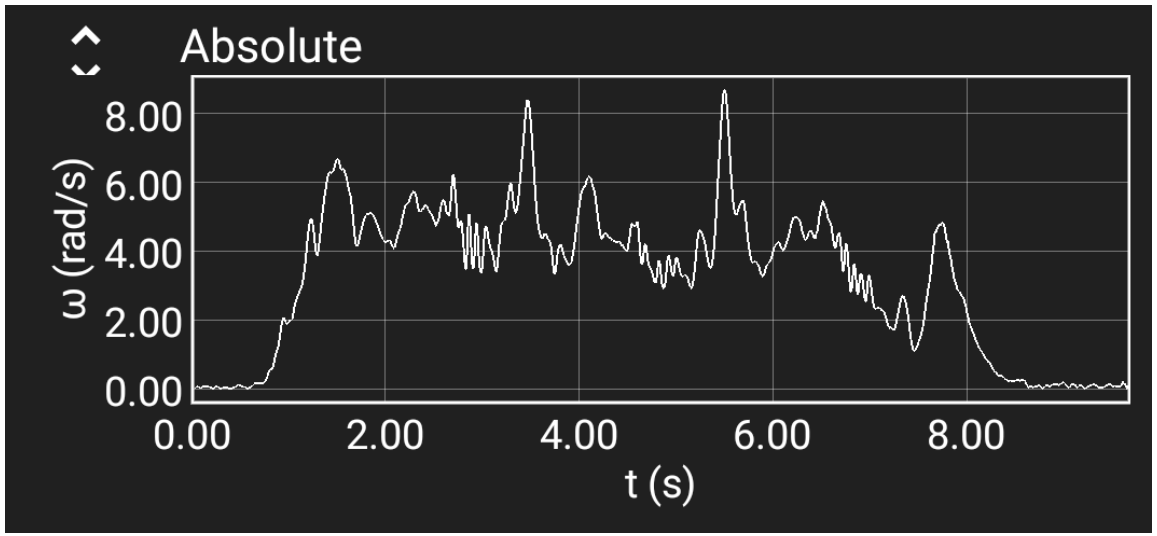
W_B/G = 1.7 rad/s

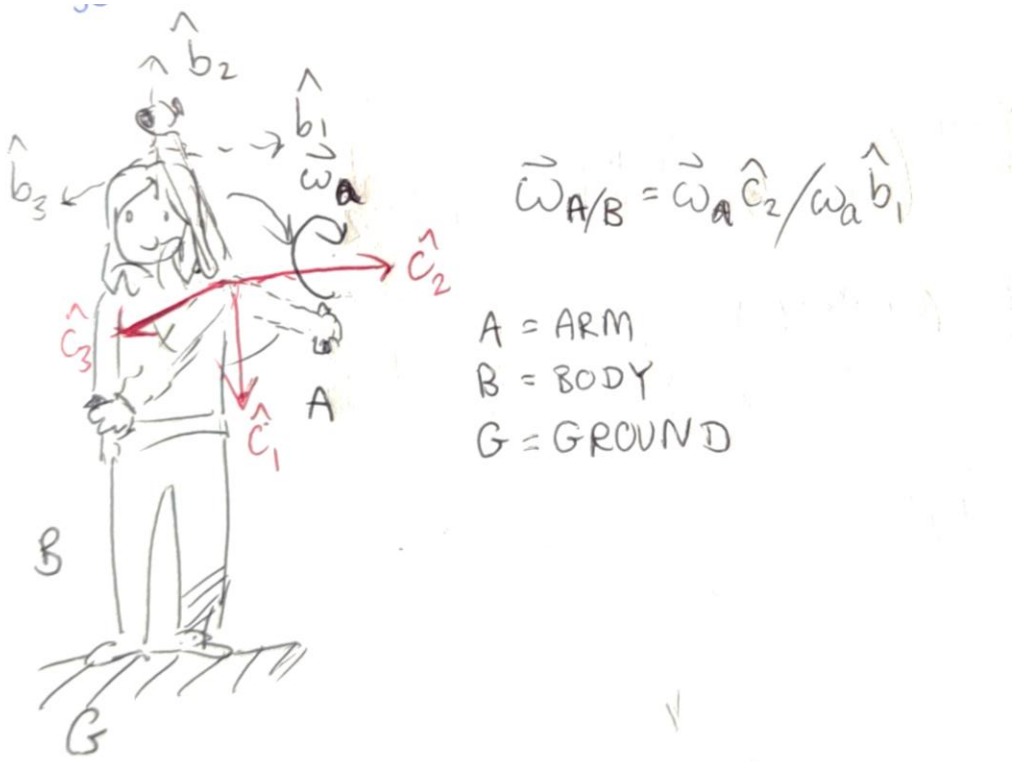




Next, an arm rotation

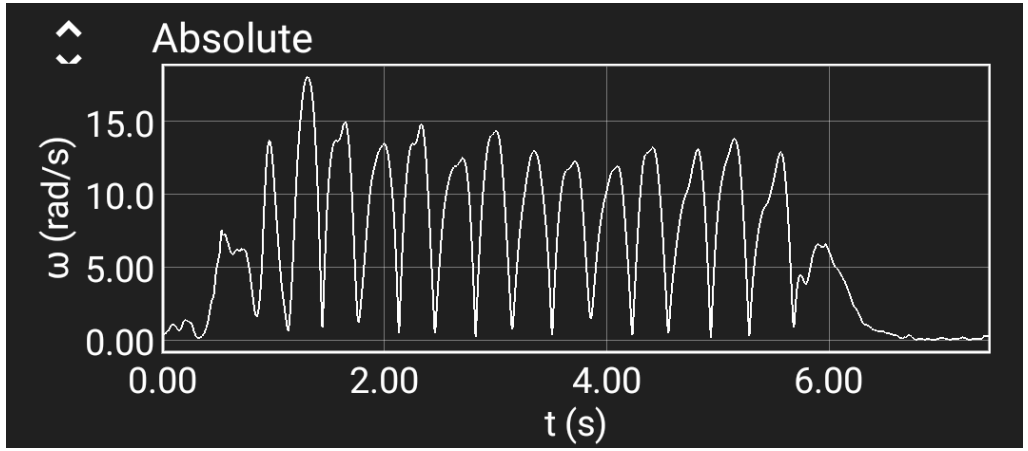
W_A/B = 4.2 rad/s

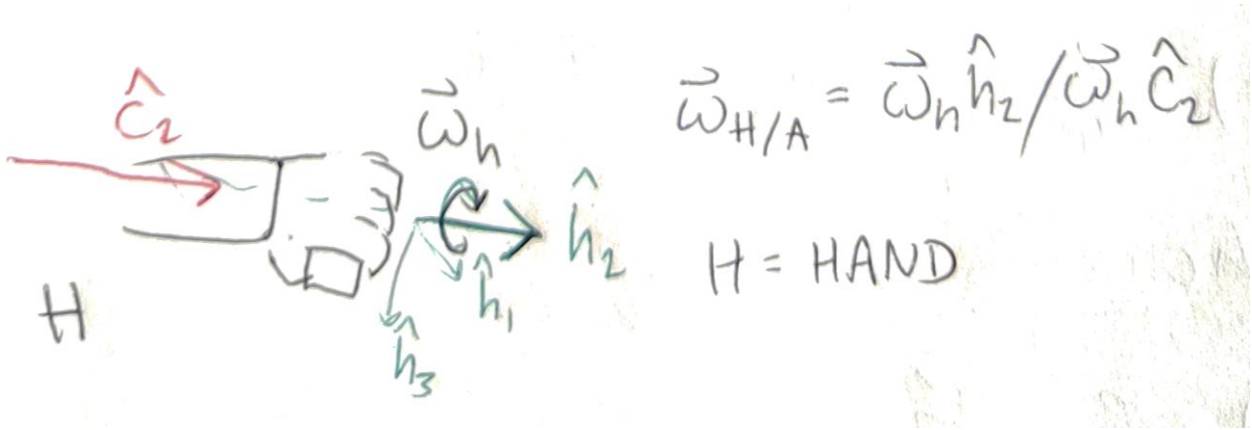




Next, a hand rotation

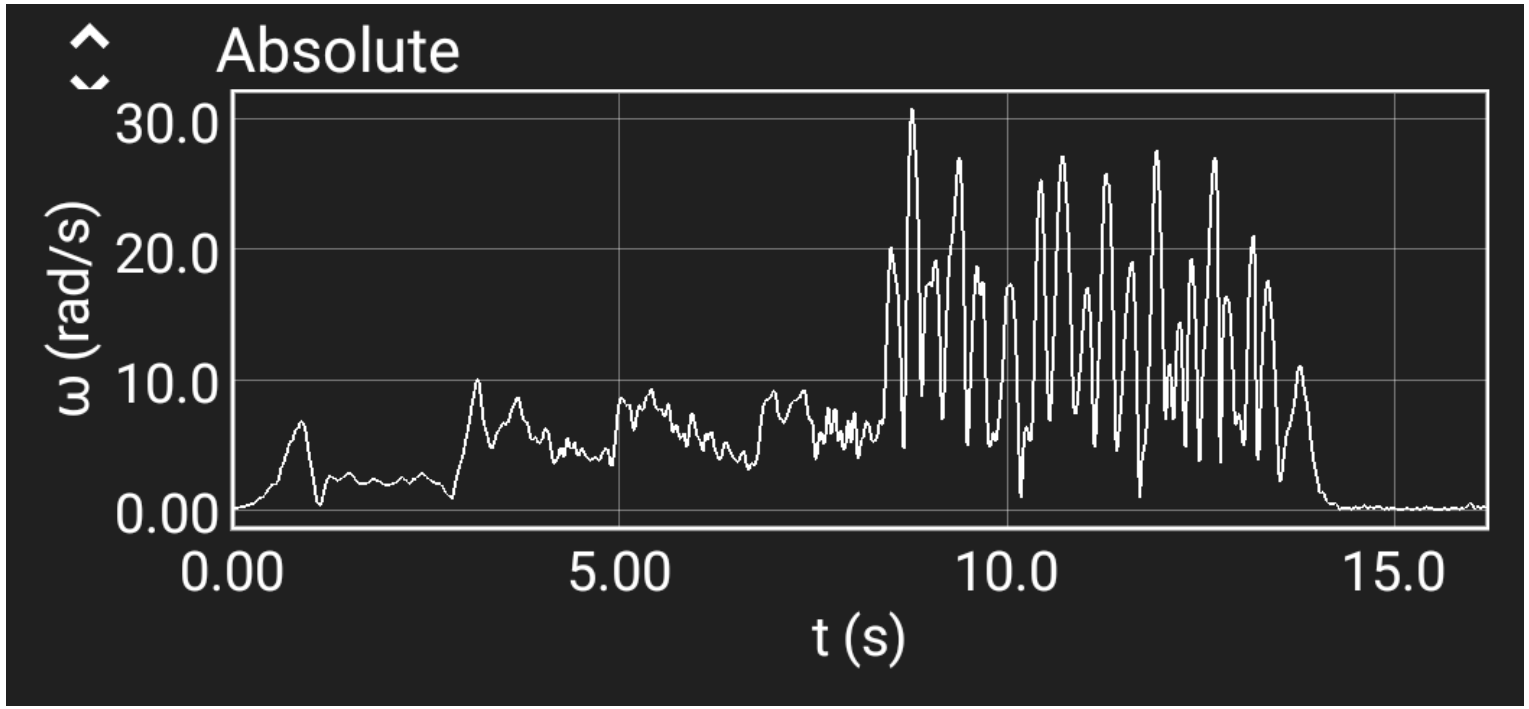
- W_H/A = 10.6 rad/sec





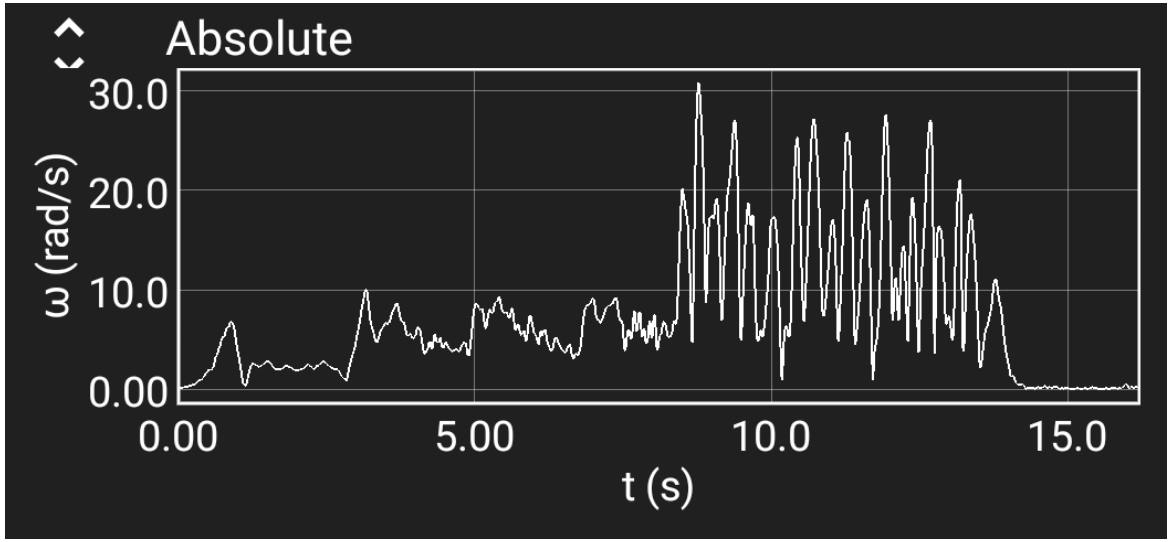
W_H/G = 20 rad/s

Putting it all together…



Comparing it to the math:

- w_H/G = w_B/G + w_A/B + w_H/A
- 10.6 + 4.2 + 1.7 = 16.5 rad/s --- pretty close



Assumptions and inaccuracies

- Uncertain how phyphox works – does it compare everything to a stationary frame?
- Is “Absolute” angular velocity using the addition theorem?
- I can’t move my arm in a perfect circle
- I can’t rotate at a constant speed
- I wish I could rotate my wrist 360 degrees (that would be rad! No pun intended)

Applications to Aerospace

- Angular Velocity is an important component in angular momentum
- Force is equal to the change in momentum – necessary to understand stress
- Structural and Design engineers need to understand forces and stress in order to create designs that take into consideration Aerodynamic and propulsion concerns.

- EX: if an airplane's wings were designed with a very low Aspect Ratio, they would be aerodynamically efficient, but the design would still need to consider what wings and tail will experience under certain maneuvers (spinning, turning, etc) and make sure the wings can hold up to the load

Conclusion

One can see the additive effects

One must be careful when calculating in different frames…make sure it’s all resolved in one reference frame when adding! (the phone did that for me)

One must also be careful when applying the addition theorem to angular acceleration….it’s not strictly additive!