

Moving Through Math

Latin Ballroom Dancing through the Lens of Math

Lida Tetyusheva

AGENDA

INSPIRATION

FRACTIONS

GRAPHING

CALCULUS

GEOMETRY

ANGLES

EXPLORATION

TAKEAWAYS

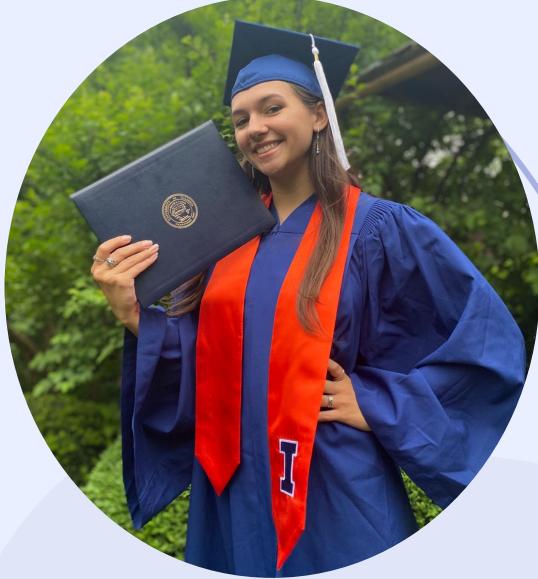
GRAPH THEORY

PHYSICS



- Dancing since I was 4
- Teaching for over 5 years

ABOUT ME



- Undergrad in Statistics
- Data Analyst at Viatris
- MSDS Student

INSPIRATION



Math and Data are Involved in Everything!

MSDS 400: Math for Data Modelers

← TEDTalk by Roger Antonsen: Math is the Hidden Secret to Understanding the World

Math is the Science of Patterns and Patterns are an Integral Part of Dancing!

FRACTIONS

Tempo, Time Signature, Notes and Beats

FRACTIONS

Tempo

$$\text{Tempo} = \frac{\text{\# of Beats}}{\text{Minute}}$$

Cha Cha: 120-128 bpm

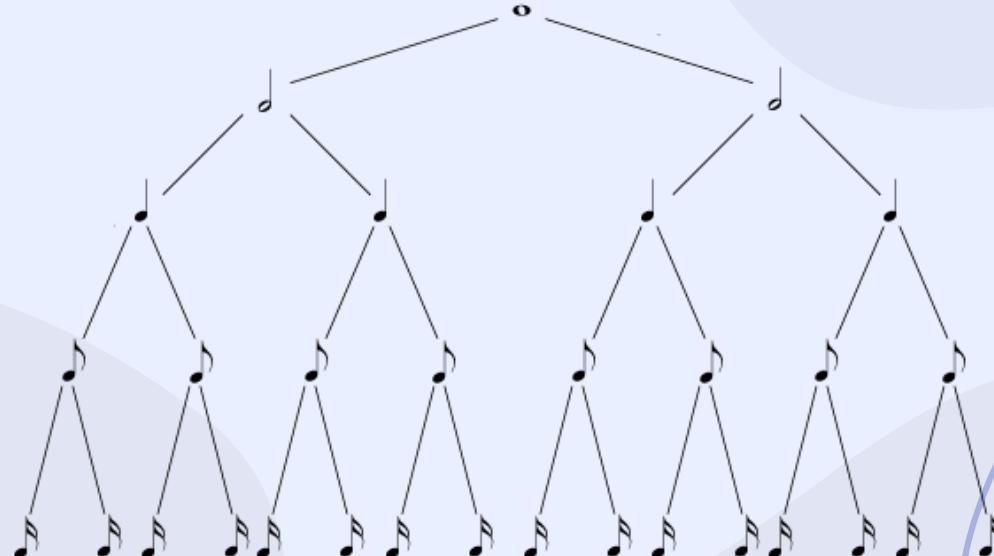
Rumba: 100-124 bpm

Waltz: 84-90 bpm

FRACTIONS

Music Notes

Music Notes are Fractions!



FRACTIONS

Basic Steps

Slow = 2 beats

Rumba:

Slow Quick Quick = $2 + 1 + 1 = 4$ beats

$$\frac{1}{2} + \frac{1}{4} + \frac{1}{4} = 1 \text{ measure}$$

Quick = 1 beat

Foxtrot:

Slow Slow Quick Quick = $2 + 2 + 1 + 1 = 6$ beats

$$\frac{1}{2} + \frac{1}{2} + \frac{1}{4} + \frac{1}{4} = 1.5 \text{ measures}$$

FRACTIONS

Basic Steps

increase in step complexity = increase in fractions

Basic Steps



Quick-Quick-Slow-Quick-Quick-Slow

Higher Level Steps



Slow-Quick-Quick-and-Slow-Quick-Quick-Slow-Quick-and-Quick-and-Slow

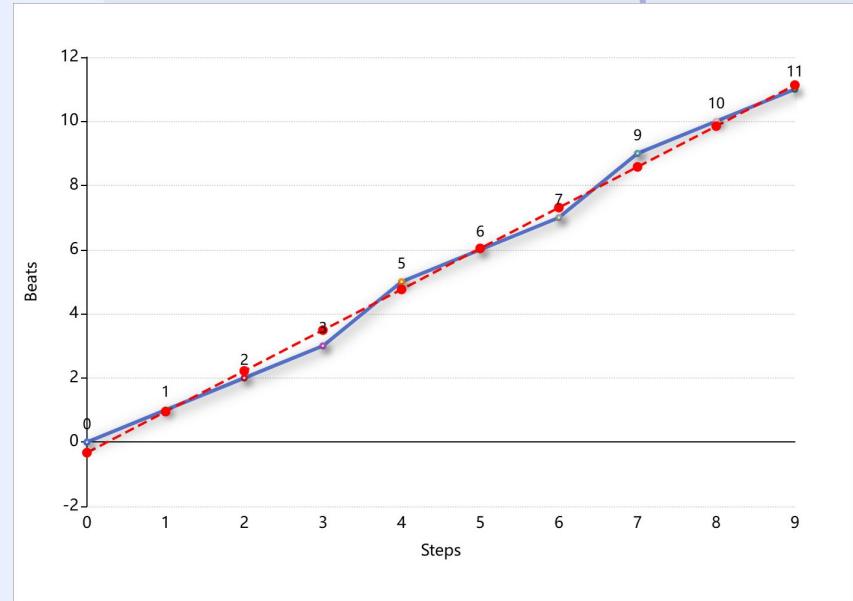
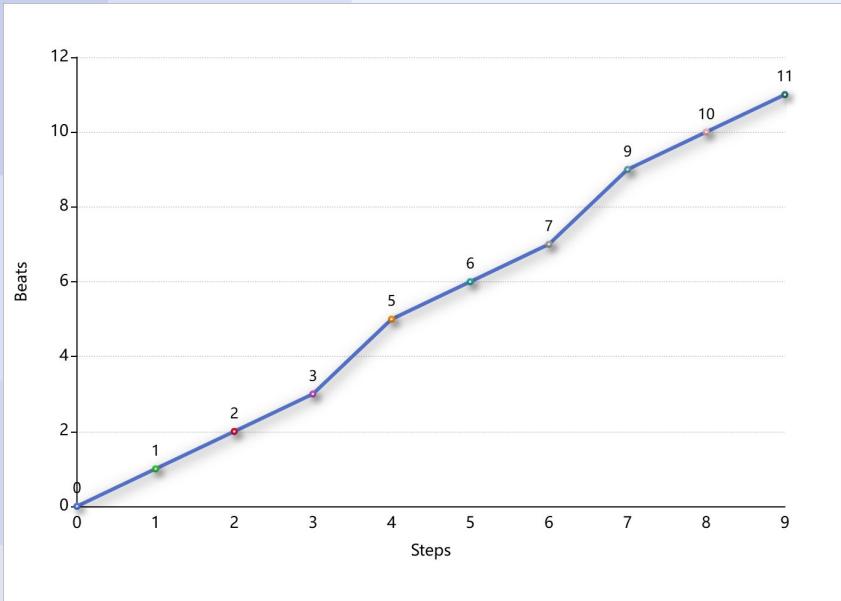
GRAPHING

Beats in Basic Steps

GRAPHING

Time Taken in a Basic Step - Rumba

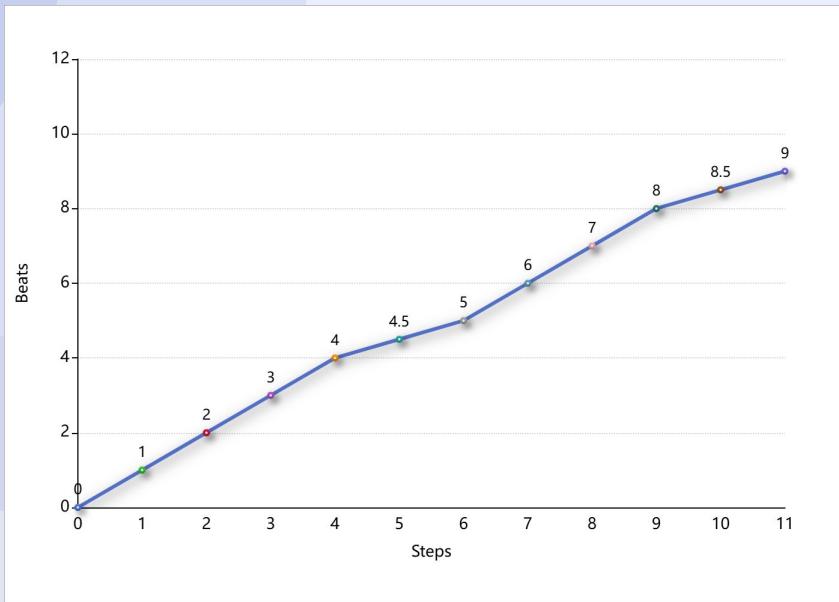
$$(11 - 1)/(9-1) = 10/8 = 1.25 \text{ beat average for rumba basic step}$$



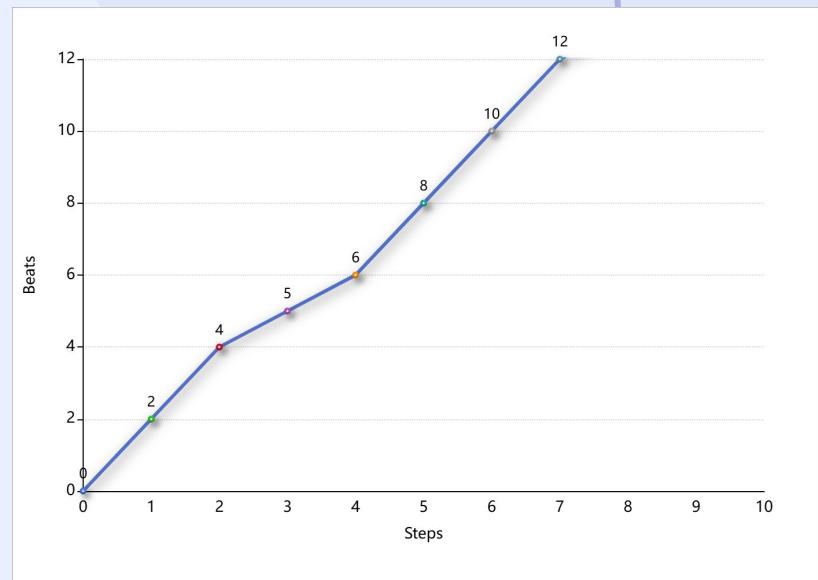
GRAPHING

Time Taken in a Basic Step - Cha Cha and Tango

$(9-1)/(11-1) = 4/5 = 0.8$ beat average for
Cha Cha basic step



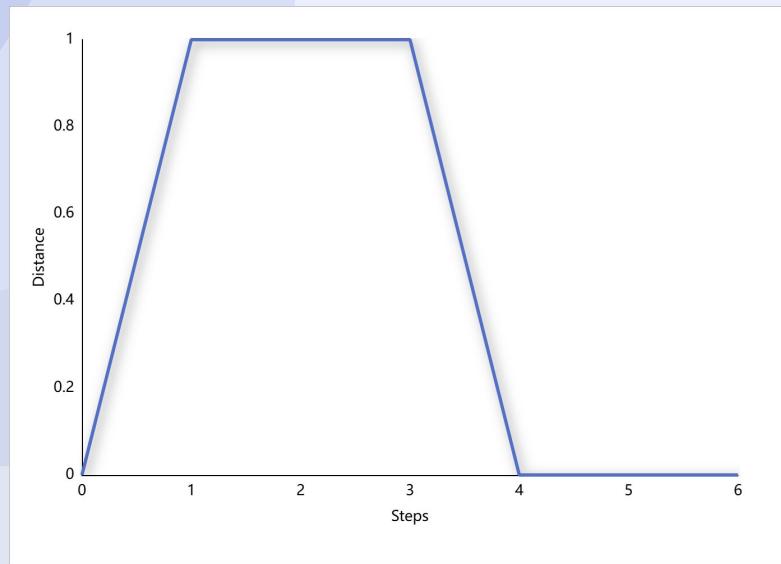
$(16-2)/(10-1) = 14/9 = \sim 1.56$ beat
average for Tango basic step



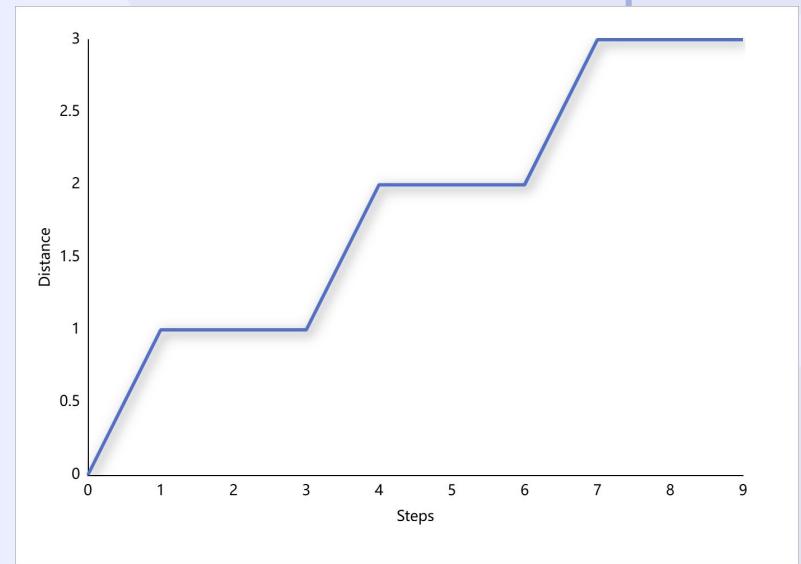
GRAPHING

Distance from Starting Point

Rumba Basic



Waltz Basic



CALCULUS

Derivatives

CALCULUS

Derivatives - Rise and Fall of Waltz

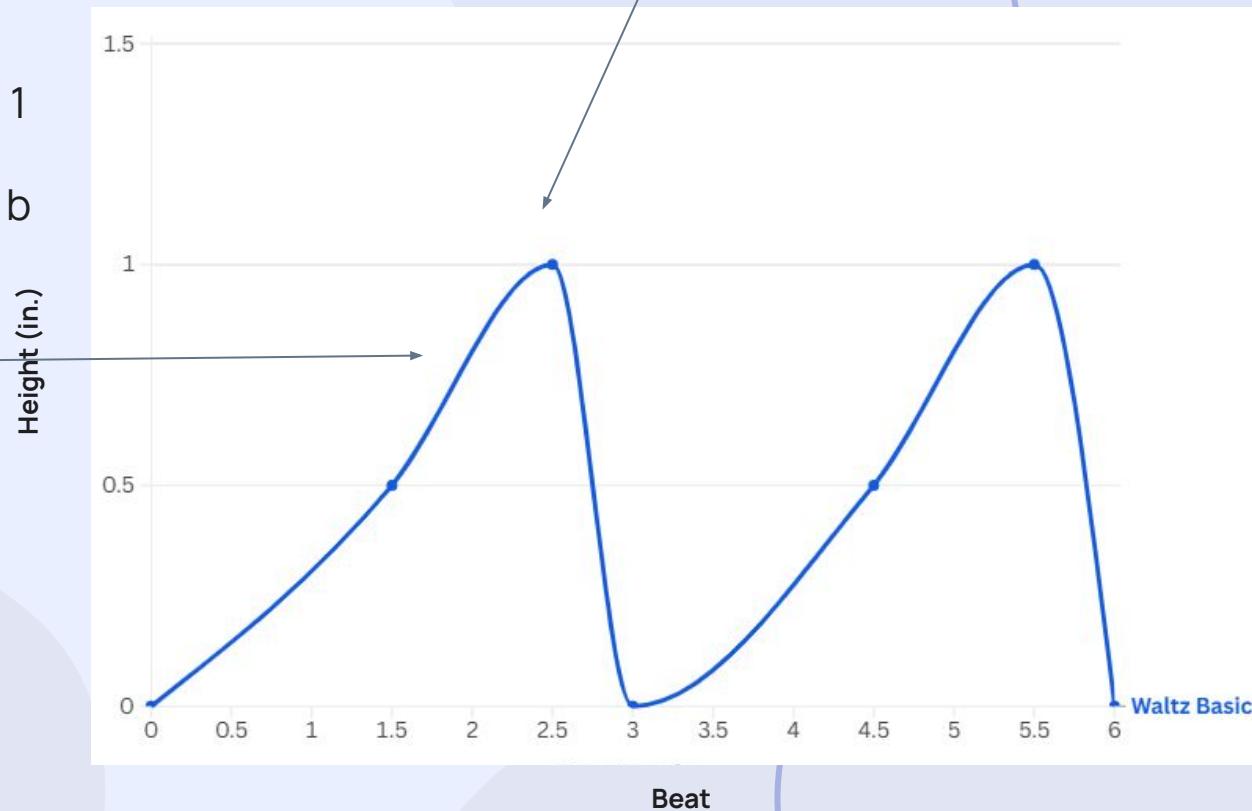
$$\text{Height} = -0.5(\text{Beats} - 2.5)^2 + 1$$

$$dh/db = -0.5 \cdot 2(b - 2.5) = 2.5 - b$$

"The rate of change in height per beat at beat 2 is 0.5 inches per beat.

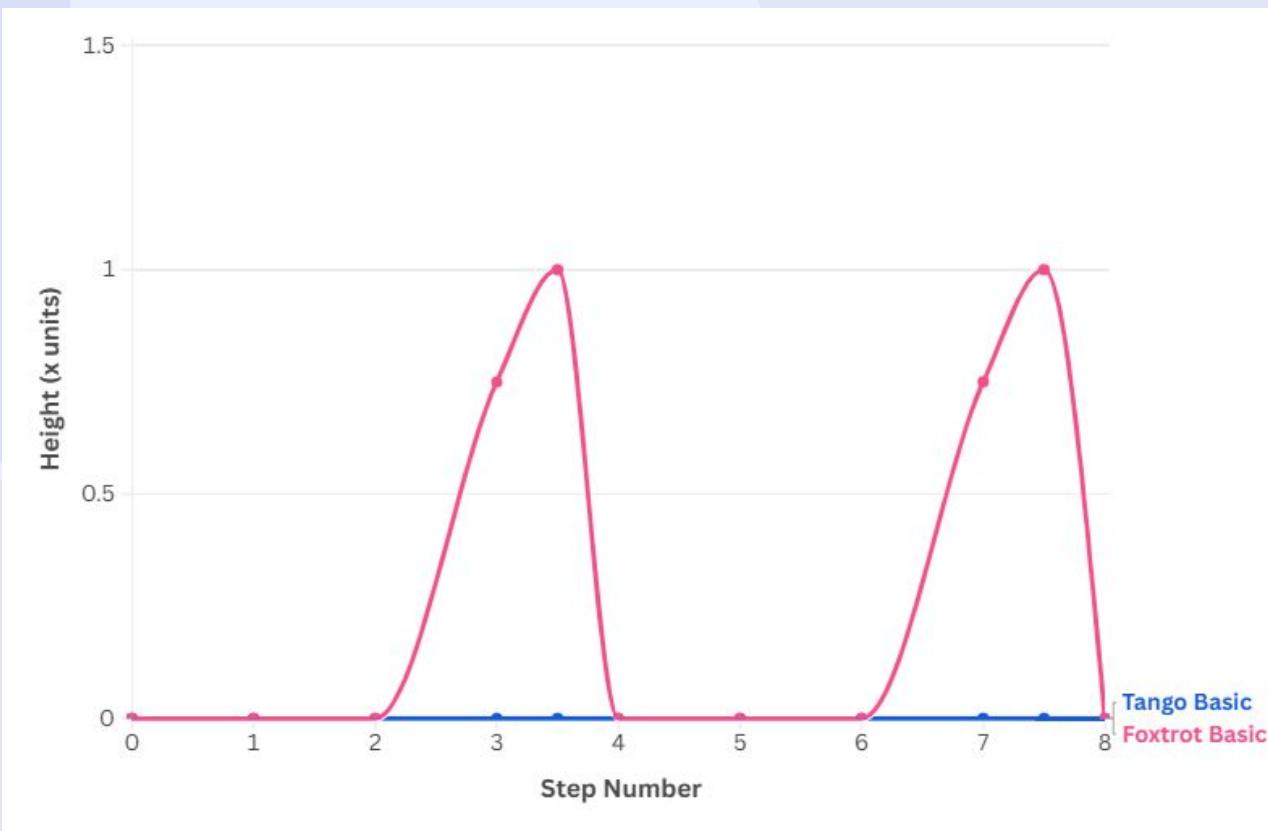
At beat 2 I should still be actively rising in my step.

Derivative = 0



CALCULUS

Derivatives - Rise and Fall of Tango and Foxtrot



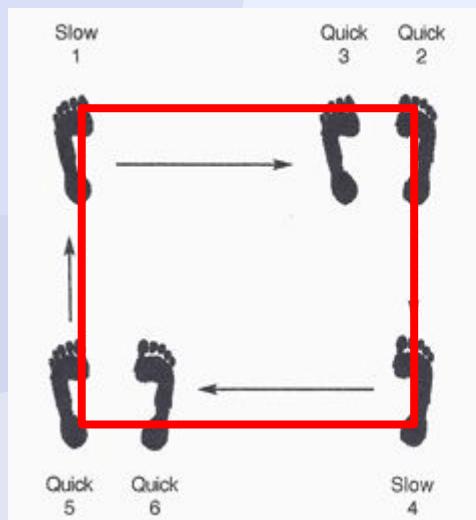
GEOMETRY

Bird's Eye View Shapes

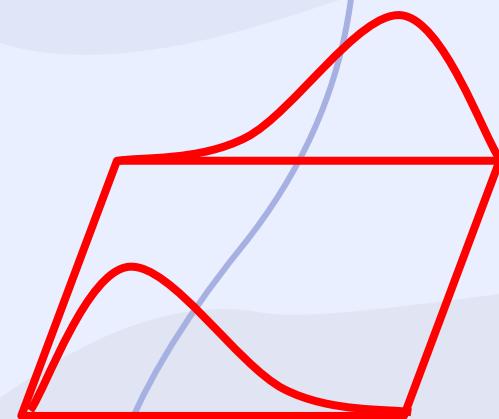
GEOMETRY

Bird's Eye View Shapes - Basic Steps

Rumba



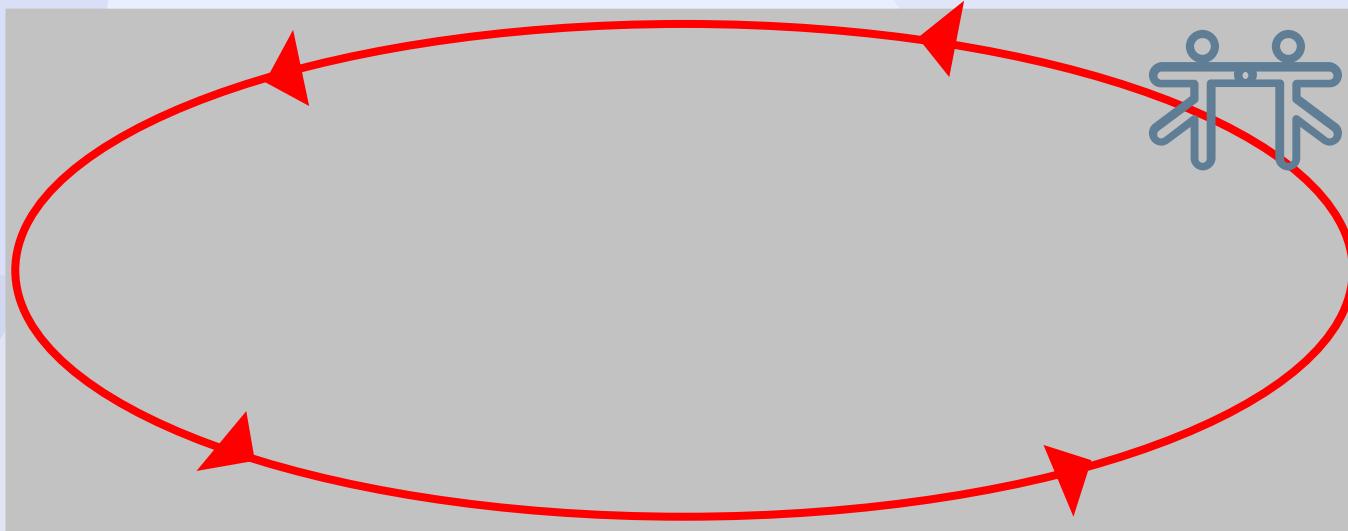
Waltz



GEOMETRY

Bird's Eye View Shapes - Flow Across the Floor

Ballroom Choreography



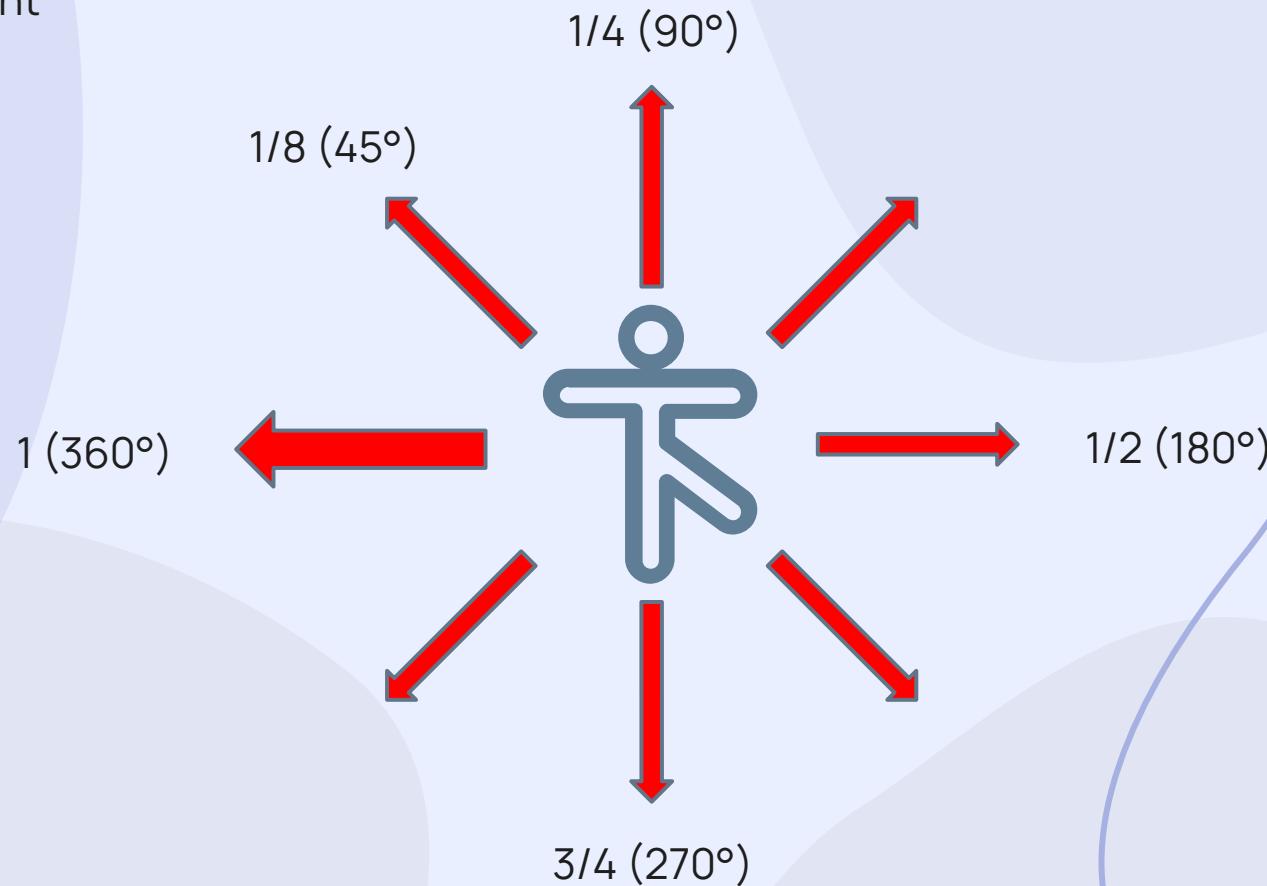
Oriented Curve: A line/curve with a specific and consistent direction of travel

ANGLES

Pointing and Turnout, Floor Alignment, Dance Moves

ANGLES

Floor Alignment



ANGLES

Foot Placement

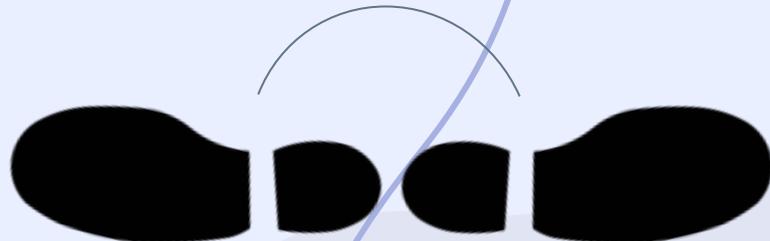
Latin

$30-45^\circ$



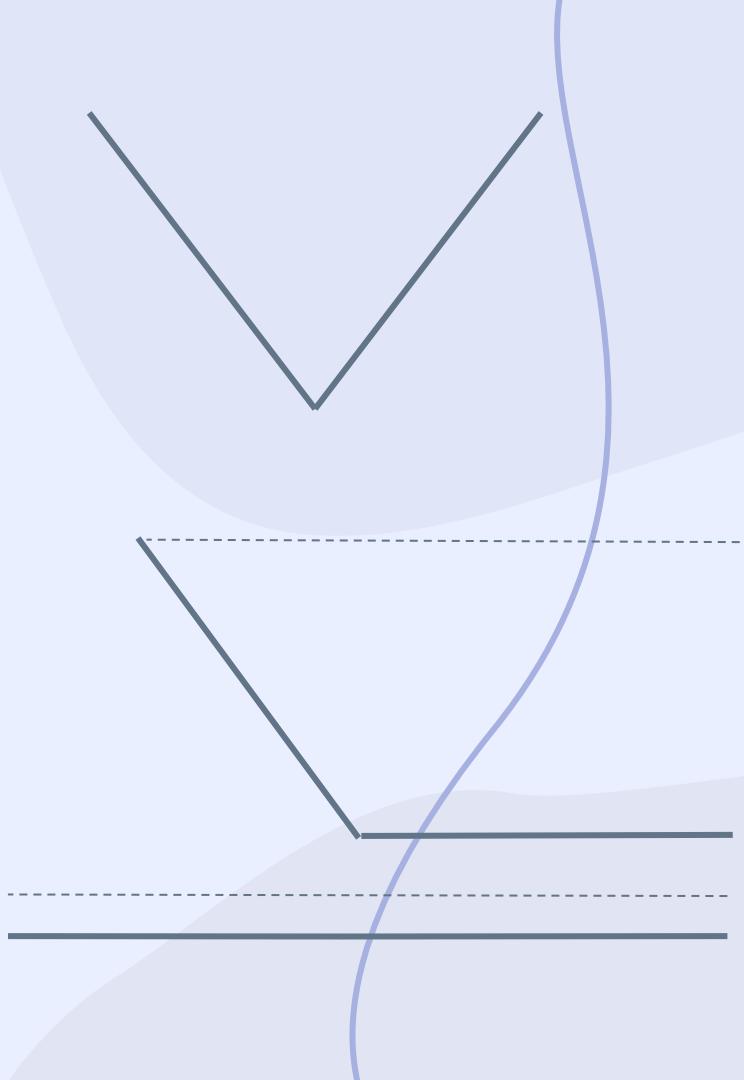
Ballet

180°



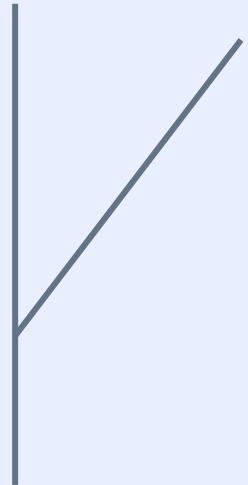
ANGLES

Dance Moves



ANGLES

Dance Moves



PHYSICS

Kinematic Study of World Champion Ballroom Dancers

PHYSICS

Kinematics Math of Waltz Spins

- Researchers measured **world champions vs national dancers** using motion sensors.
- Focus: **step length, pelvic speed, trunk rotation** during spin movements.

What did they find?

Champions ...

- Have **Longer steps** and **faster pelvic motion**.
- Lead with the pelvis and follow with the rib cage (to **build momentum**)
- Have larger trunk **rotation angles**.
- **Balance their velocities** for smoother spins.

GRAPH THEORY

Creating a Graph Database for Choreography Generation

GRAPH THEORY

Creating the Graph Database

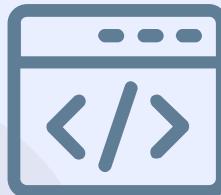


GRAPH THEORY

Creating the Graph Database



Outlined all of the Nodes and Relationships for Waltz Beginner Dance Steps



Converted to Cypher format



Input into Graph Database Software

GRAPH THEORY

The Graph Model

Directed Graph:
Each relationship/edge
has a direction



GRAPH THEORY

Generating a Choreography

```
neo4j$ MATCH p = (s:Step {name:"Natural Turn"})-[:CAN_FOLLOW*4]->(t:Step) WITH p, ran
```

Bookmark

Table RAW

choreography

¹ ["Natural Turn", "Left Closed Change", "Right Closed Change", "Natural Turn", "Basic Weave"]

Started streaming 1 record after 4 ms and completed after 12 ms.

TAKEAWAYS

Hobbies  Expertise  Fun

PERSONAL TAKEAWAYS

- Learned more about dancing **and** math
- Created a tool that I can enhance and use in the future
- Found new ways to teach concepts to my students
- Had fun!

INNOVATIONS



Velcro

Invented by an engineer on a hike with his dog



Roll Film

Developed by a chemist who loved photography

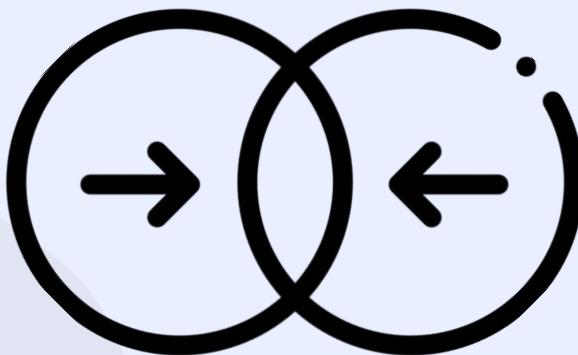


Nylon Rope

Created by chemists for climbing tools

I CHALLENGE YOU!

Hobbies/Interests



Work/Expertise

THANK YOU!

Questions?



Lida Tetyusheva