

PHYS-101 WEEK 1

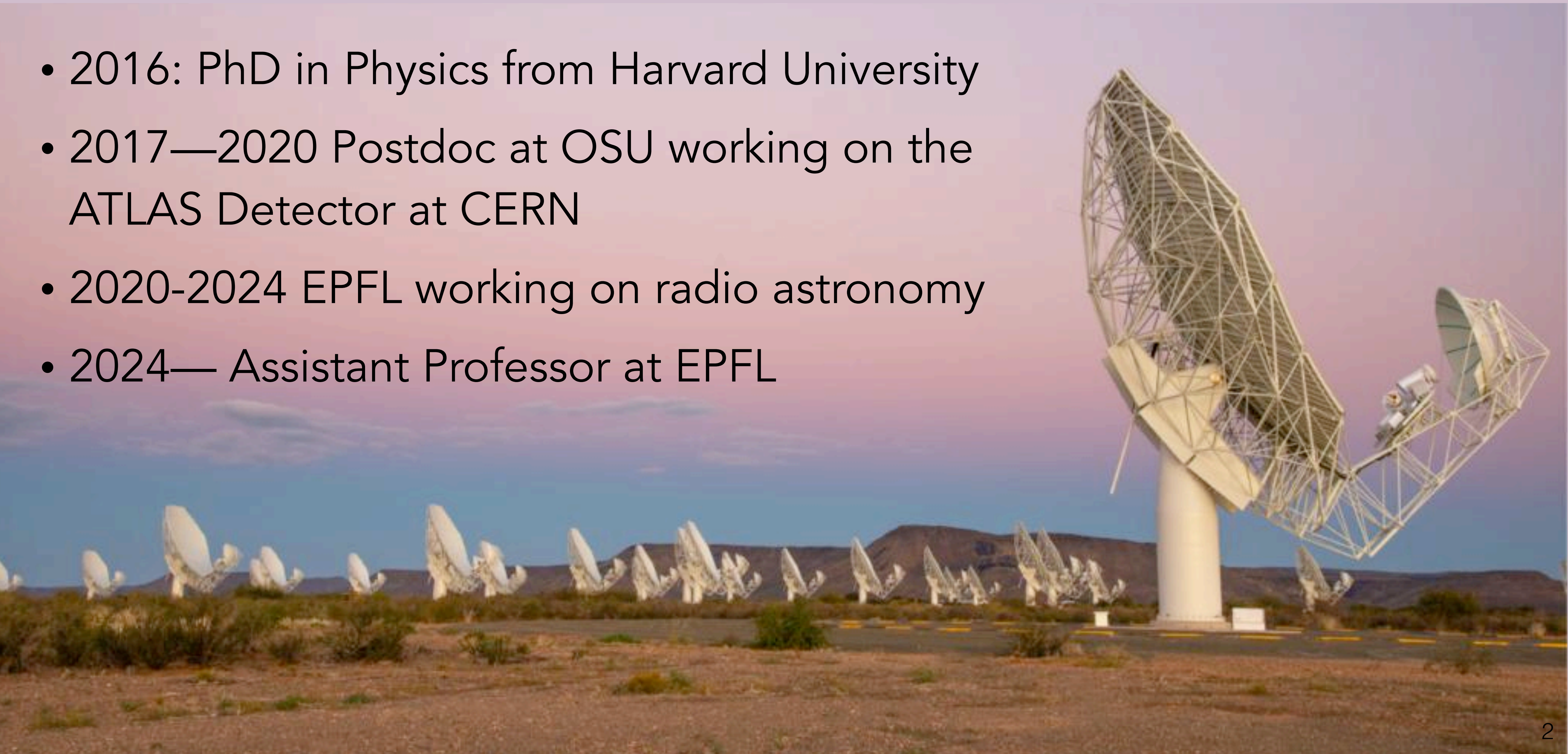


Physique générale : mécanique (classe inversée en anglais)

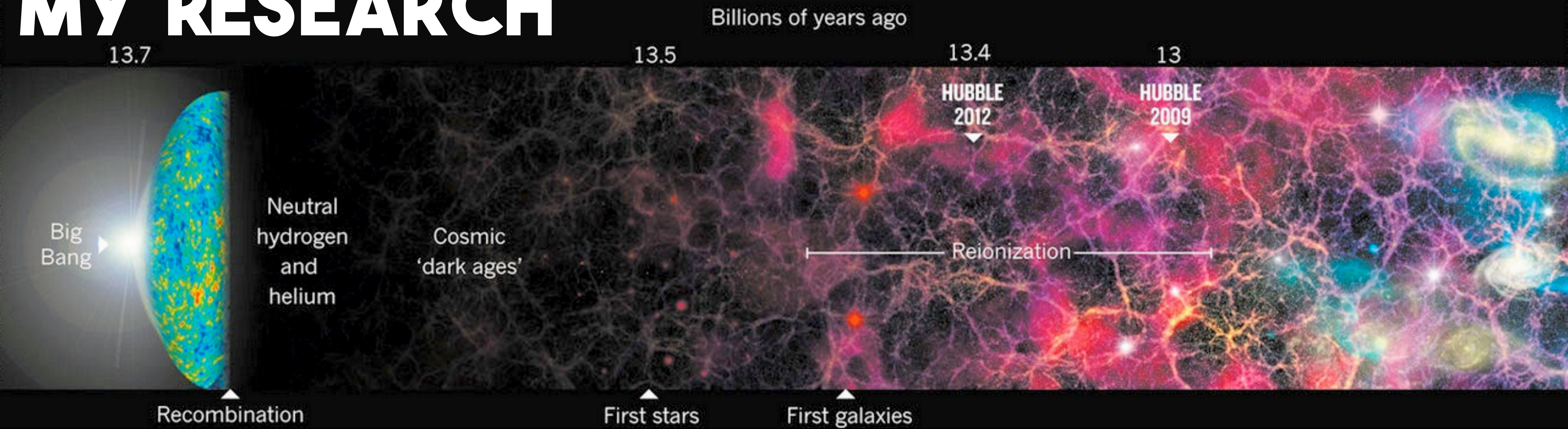
Prof. Emma Tolley, 8 September 2025

MY BACKGROUND

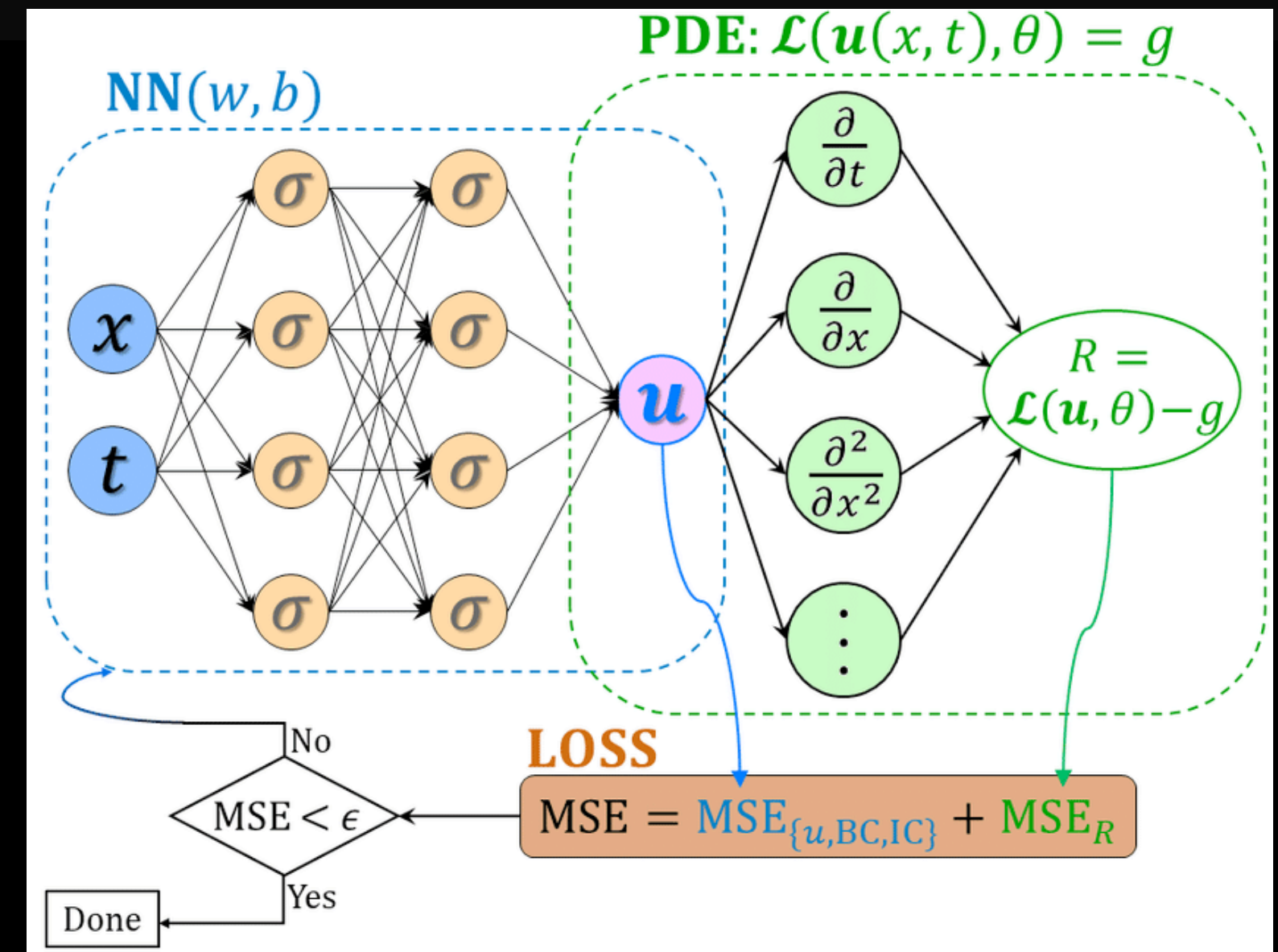
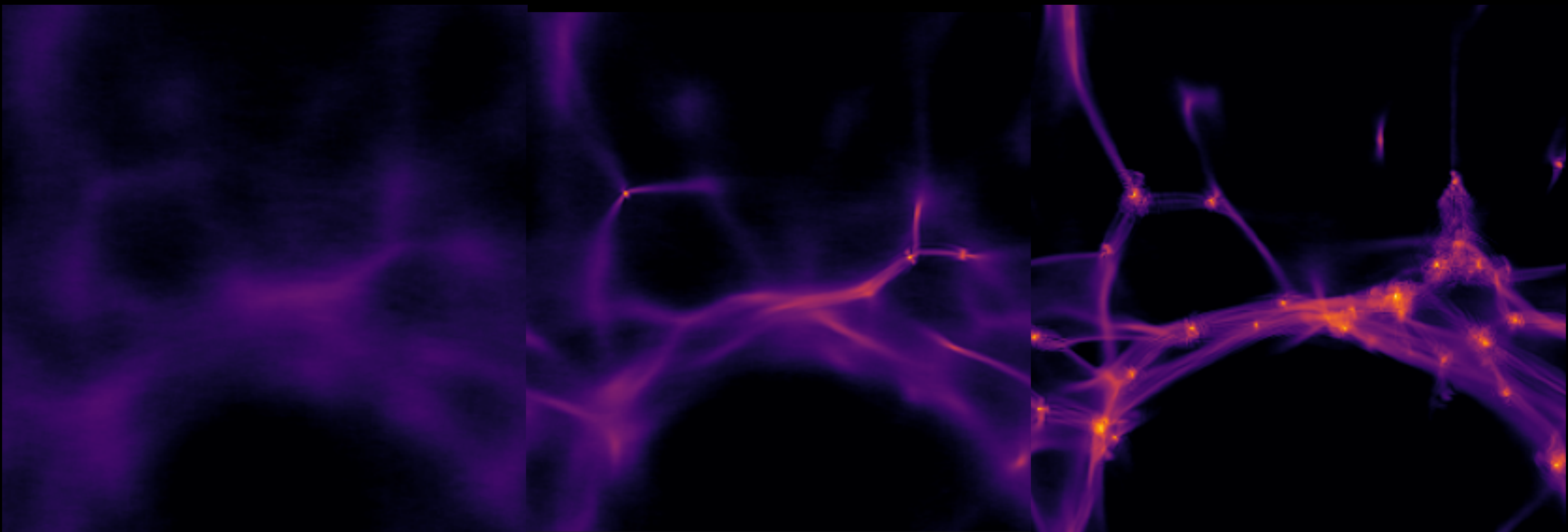
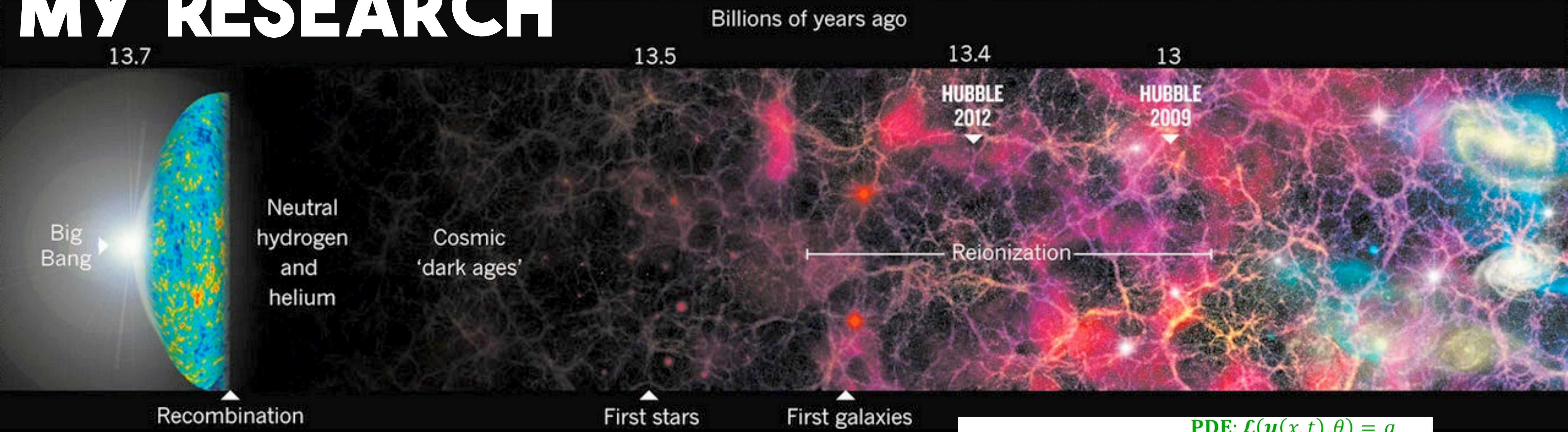
- 2016: PhD in Physics from Harvard University
- 2017—2020 Postdoc at OSU working on the ATLAS Detector at CERN
- 2020-2024 EPFL working on radio astronomy
- 2024— Assistant Professor at EPFL



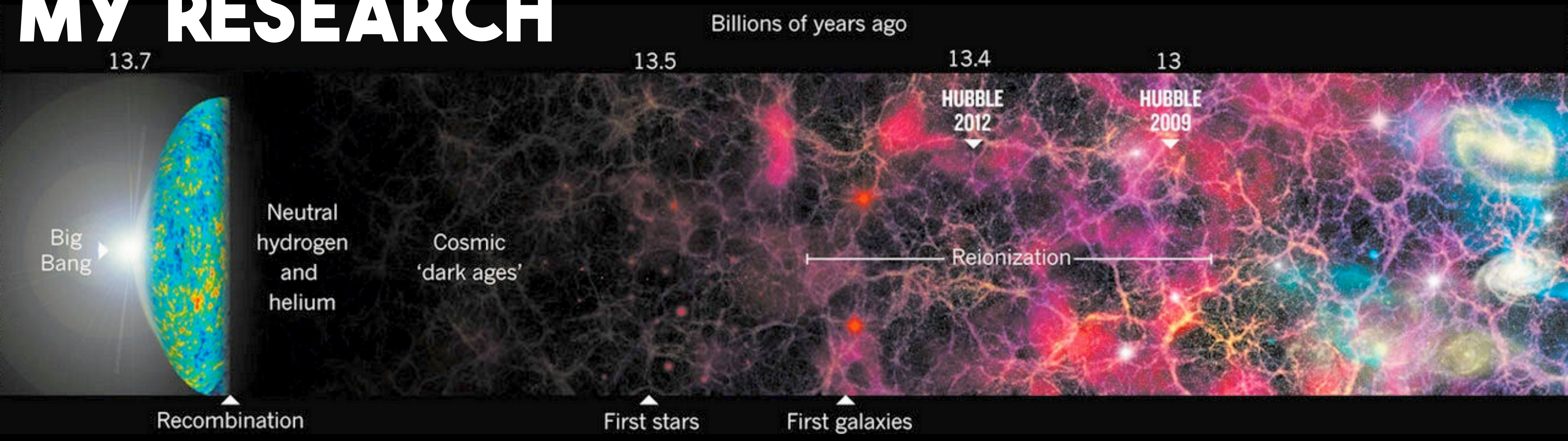
MY RESEARCH



MY RESEARCH



MY RESEARCH

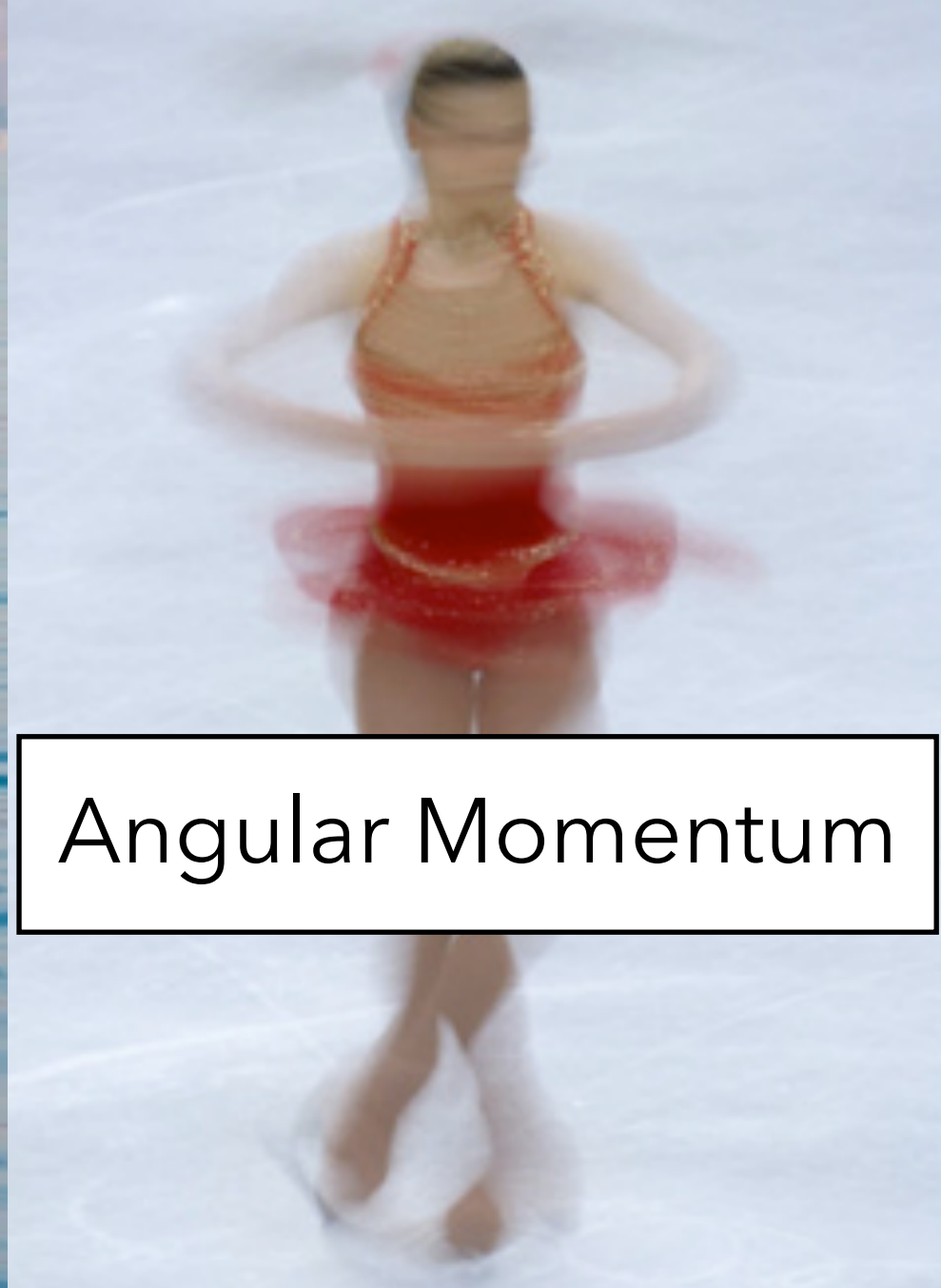


PHYSICS-101

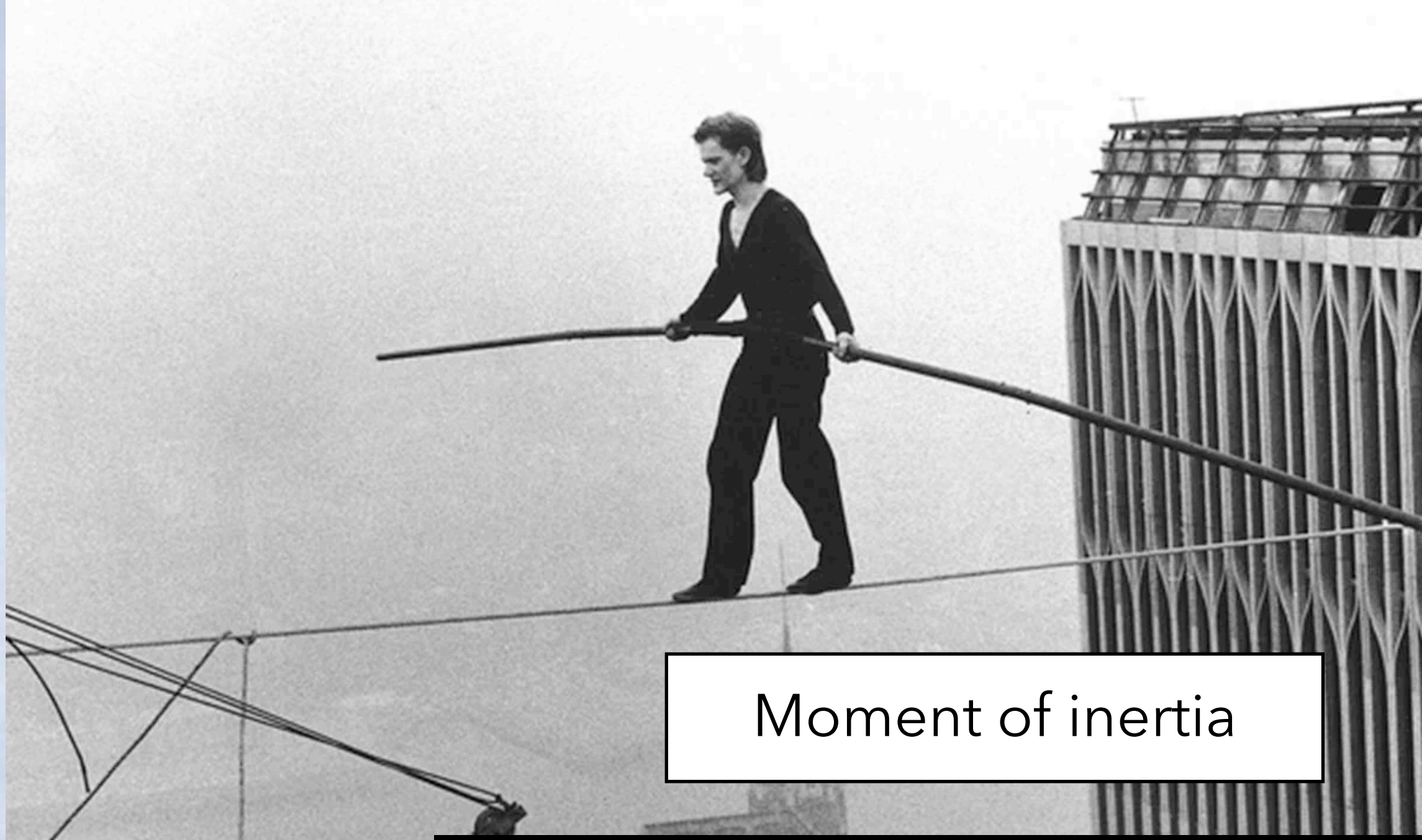
Why physics-101?



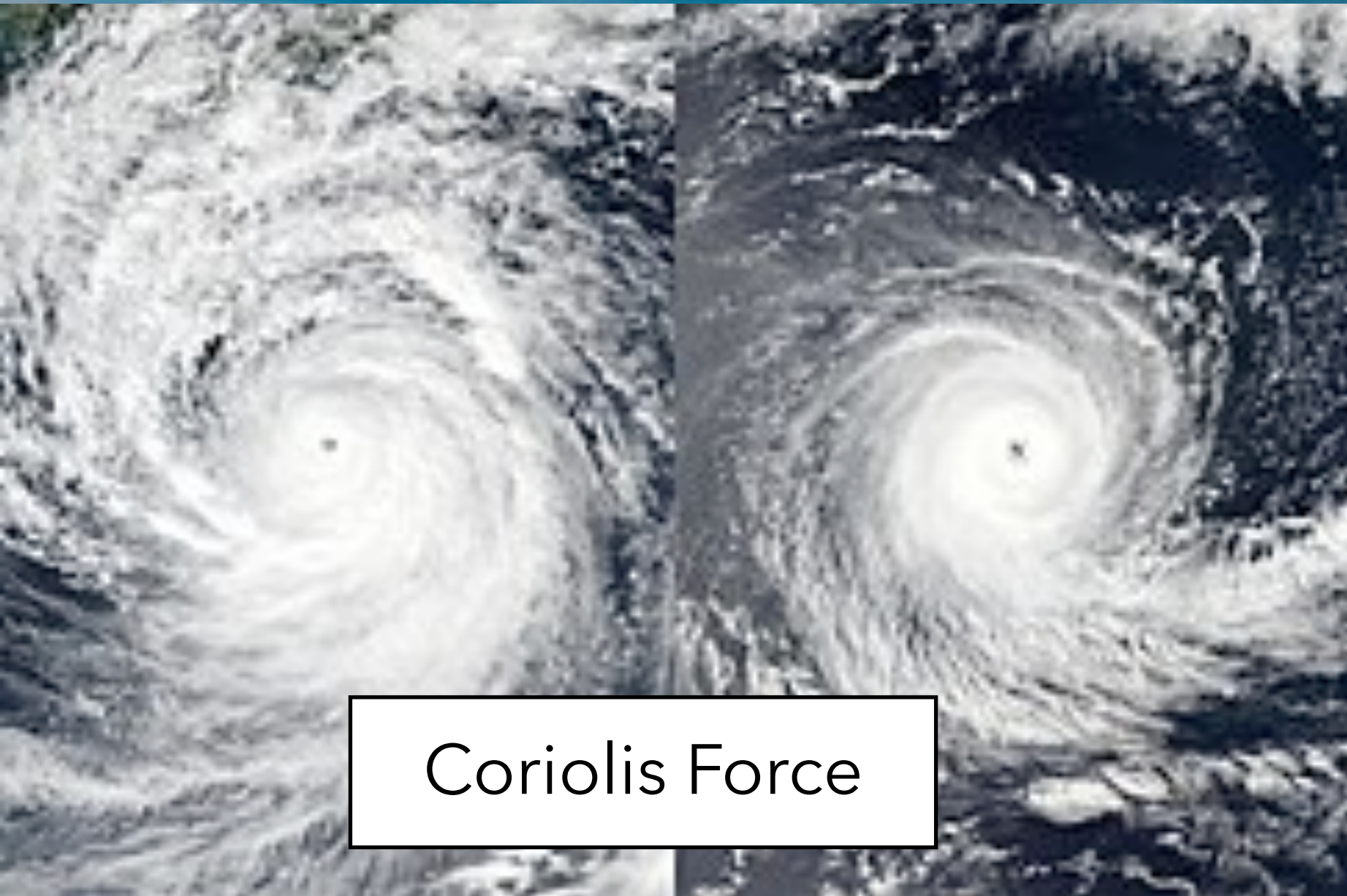
Archimedes' Principle



Angular Momentum



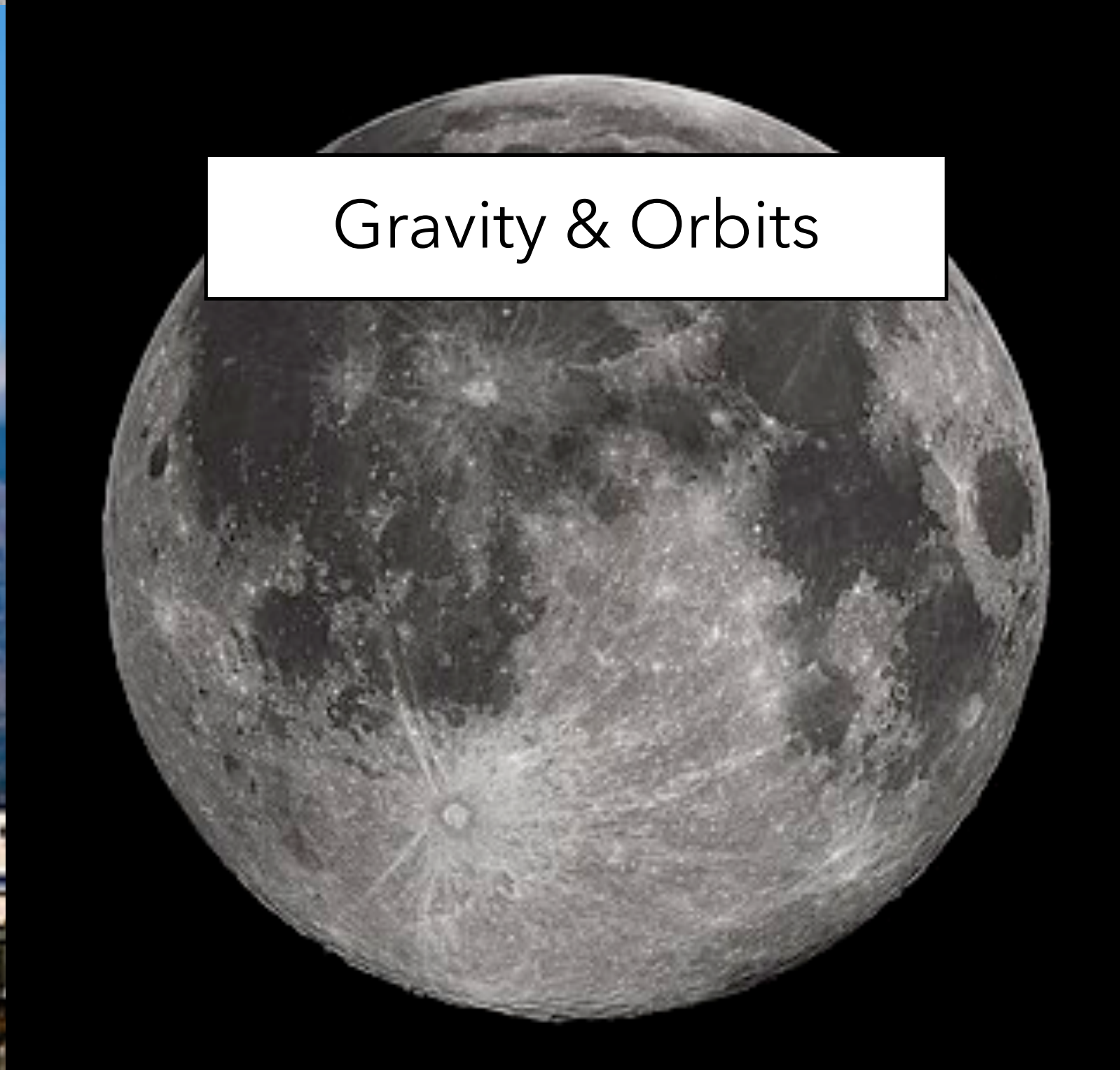
Moment of inertia



Coriolis Force



Air Friction



Gravity & Orbits

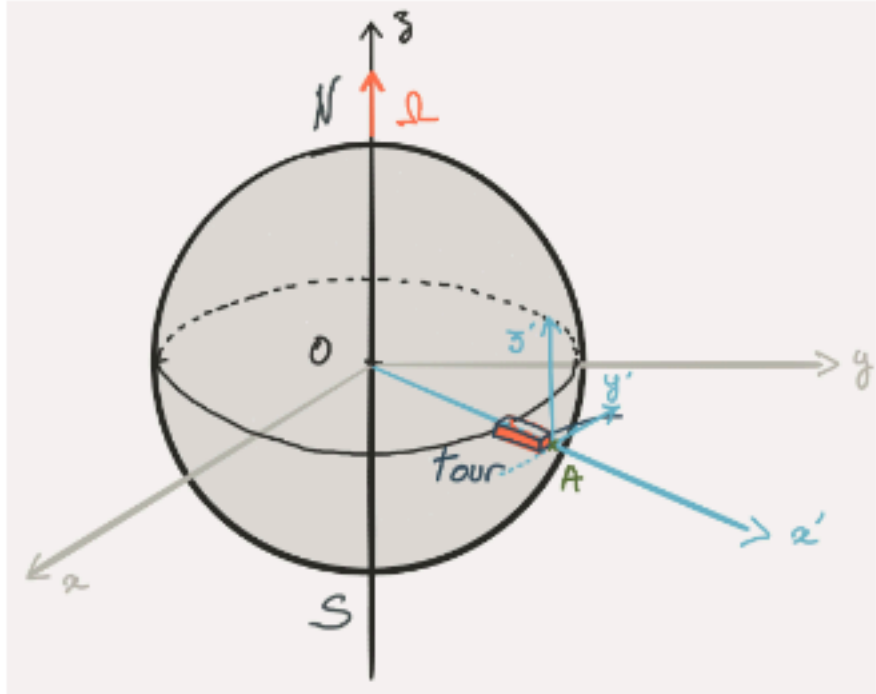
PHYSICS-101

$$\text{Daus } \mathcal{R} \quad \sum \vec{F} = m \vec{a}_R(P) = m \vec{g}$$



PHYSICS-101

On prend un repère $\mathcal{R}(O, x, y, z)$ fixe avec O centre de la Terre et un repère lié à la tour $\mathcal{R}'(A, x', y', z')$. A est le sommet de la tour (point d'où on lâche la pierre).



Dans \mathcal{R} $\sum \vec{F} = m\vec{a}_R(P) = m\vec{g}$

$$\vec{\Omega} = \Omega \vec{e}_z = \Omega \vec{e}_{z'}$$

$$\vec{g} = -g \vec{e}_{x'}$$

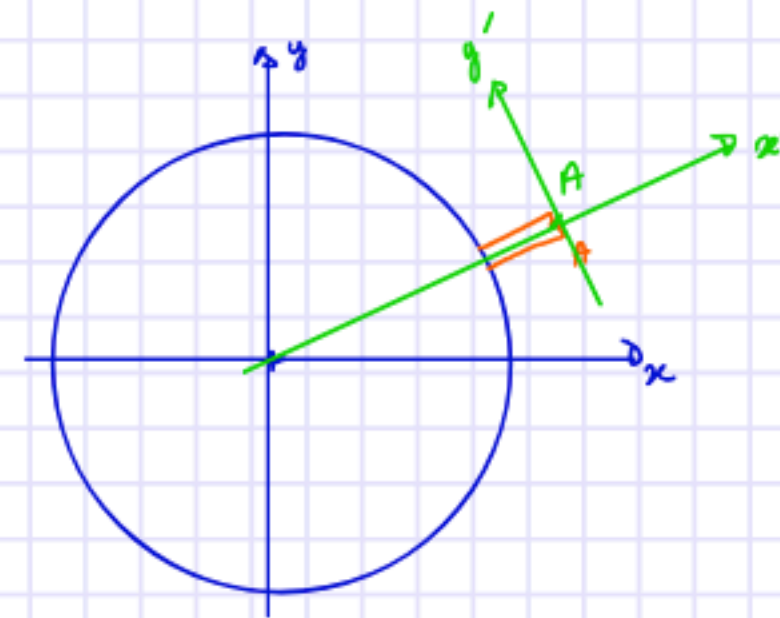
$$\vec{a}_R(P) = \vec{a}_{R'}(P) + \underbrace{\vec{a}_R(A) + \underbrace{\frac{d}{dt}(\vec{\Omega} \wedge \vec{AP})}_{-\vec{\Omega} \wedge (\vec{\Omega} \wedge \vec{AP})}}_{\vec{\Omega} \wedge (\vec{\Omega} \wedge \vec{OP})} + 2 \vec{\Omega} \wedge \vec{v}_{R'}(P)$$

$$\vec{a}_{R'}(P) = \vec{a}_R(P) - \vec{\Omega} \wedge (\vec{\Omega} \wedge \vec{OP}) - 2 \vec{\Omega} \wedge \vec{v}_{R'}(P)$$

$$\sum \vec{F} = m\vec{a}_R(P) = m\vec{g}$$

$$\vec{a}_{R'}(P) = \underbrace{\vec{g}}_{-g_{\text{eff}} \vec{e}_{x'}} - \vec{\Omega} \wedge (\vec{\Omega} \wedge \vec{OP}) - 2 \vec{\Omega} \wedge \vec{v}_{R'}(P)$$

$$\vec{a}_{R'}(P) = -g_{\text{eff}} \vec{e}_{x'} - 2 \vec{\Omega} \wedge \vec{v}_{R'}(P)$$



$$\int_{t=0}^t \vec{a}_{R'}(P) dt = \int_{t=0}^t -g_{\text{eff}} \vec{e}_{x'} dt - \int_{t=0}^t 2 \vec{\Omega} \wedge \vec{v}_{R'}(P) dt$$

$$\vec{v}_{R'}(P) - \vec{v}_{R'}(P)(t=0) = -g_{\text{eff}} t \vec{e}_{x'} - 2 \vec{\Omega} \wedge (\vec{r}_{R'}(t) - \vec{r}_{R'}(t=0))$$

$$\vec{v}_{R'}(P) = -g_{\text{eff}} t \vec{e}_{x'} - 2 \vec{\Omega} \wedge \vec{AP} \quad \vec{v}_{R'}(P) \begin{vmatrix} \dot{x}' \\ \dot{y}' \\ \dot{z}' \end{vmatrix} \quad \vec{\Omega} \begin{vmatrix} 0 \\ 0 \\ \Omega \end{vmatrix} \quad \vec{AP} \begin{vmatrix} x' \\ y' \\ z' \end{vmatrix}$$

$$\vec{\Omega} \wedge \vec{AP} \quad \vec{\Omega} \begin{vmatrix} 0 \\ 0 \\ \Omega \end{vmatrix} \wedge \vec{AP} \begin{vmatrix} x' \\ y' \\ z' \end{vmatrix} = \begin{vmatrix} -\Omega y' \\ \Omega x' \\ 0 \end{vmatrix} \quad -2 \vec{\Omega} \wedge \vec{AP} \begin{vmatrix} 2 \Omega y' \\ -2 \Omega x' \\ 0 \end{vmatrix}$$

$$\vec{v}_{R'}(P) \begin{vmatrix} \dot{x}' \\ \dot{y}' \\ \dot{z}' \end{vmatrix} = g_{\text{eff}} t \vec{e}_{x'} \begin{vmatrix} -g_{\text{eff}} t \\ 0 \\ 0 \end{vmatrix} + (-2 \vec{\Omega} \wedge \vec{AP}) \begin{vmatrix} 2 \Omega y' \\ -2 \Omega x' \\ 0 \end{vmatrix} \quad \begin{cases} \dot{x}' = -g_{\text{eff}} t + 2 \Omega y' \\ \dot{y}' = -2 \Omega x' \\ \dot{z}' = 0 \end{cases}$$

$$\dot{z}' = 0 \Rightarrow z' = ct = z'(t=0) = 0 \quad \dot{z}' = 0 \text{ pas de déviation N-S}$$

$$\dot{x}' = -g_{\text{eff}} t + 2 \Omega y' \text{ négligeable devant } g_{\text{eff}} t \Rightarrow \dot{x}' = -g_{\text{eff}} t$$

$$\dot{y}' = -2 \Omega x'$$

$$\ddot{y}' = -2 \Omega \left(-\frac{1}{2} g_{\text{eff}} t^2 \right) = \Omega g_{\text{eff}} t^2$$

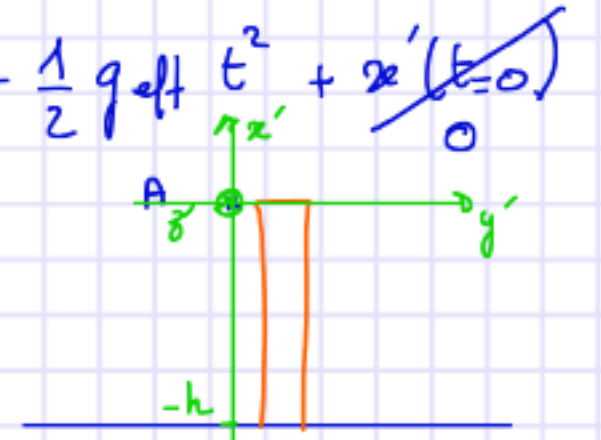
$$y' = \Omega g_{\text{eff}} \frac{1}{3} t^3 + y'(t=0)$$

$$\vec{AP} \begin{vmatrix} -\frac{1}{2} g_{\text{eff}} t^2 \\ \Omega g_{\text{eff}} t^3 \\ 0 \end{vmatrix}$$

t_f = temps auquel la pierre est arrêtée

$$-h = -\frac{1}{2} g_{\text{eff}} t_f^2 \Rightarrow t_f = \sqrt{\frac{2h}{g_{\text{eff}}}} \quad \text{Déviation} = y'(t_f) = \frac{\Omega g_{\text{eff}} t_f^3}{3} = \frac{\Omega g_{\text{eff}}}{3} \frac{2h}{g_{\text{eff}}} \sqrt{\frac{2h}{g_{\text{eff}}}}$$

$$\text{Déviation} = \frac{2}{3} \Omega h \sqrt{\frac{2h}{g_{\text{eff}}}}$$



PHYSICS-101

- ➔ Learn about the **dynamics** that govern many phenomena in the world
- ➔ Learn the **methodology** for solving these problems

COURSE ORGANIZATION

- Inverted course structure:
 - **Recorded lectures** available on the Moodle
 - ~70' of video each week
 - **Watch these before the amphitheater session on Monday!**
 - **Monday 16h15-18h in CE 1 1: Amphitheater session**
 - Demonstrations, discussion, quizzes, example problems
 - **Monday 18h-19h in CE 1 1: Office hours**
 - Open questions in the amphi
 - **Friday 16h15-17h in AAC 2 31: Recitation**
 - Example problems done by a TA
 - **Friday 17h15-19h in AAC 2 31 & AAC 1 37: Exercise session**
 - Collaborative work in groups

COURSE RESOURCES



×

▾ **General**

Announcements

PHYS-101(n) General Mech...

TA Schedule

Course structure This cours...

▾ **Week 1, Sept 8-14**

Course Material Units & Dim...

Fill & submit group chater

▾ **Week 2, Sept 15-21**

Course Material 1.1&1.2: Posi...

Group Exercises Week 2

▾ **Week 3, Sept 22-28**

Course Material 1.7 Spheric...

Physics (PH) / PH - Bachelor

Physique générale : mécanique (classe inversée en anglais)

[Course](#) [Settings](#) [Participants](#) [Grades](#) [Reports](#) [More ▾](#)

▾ **General**

[Collapse all](#)

General Physics 1 (Mechanics) Inverted Classroom



Announcements



PHYS-101(n) General Mechanics Forum

COURSE RESOURCES

- **Lecture Videos**

- Translated from French to English. Text on slides is still in French, you will to know the French terms/notation for your degree at EPFL!
- Lecture slides for the videos (in French)

- **Lecture notes**

- **Exercises**

- **Practice exercises**
- **Problem sets**
- **Group exercises**

- **The Ed Disussion forum** for quizzes & questions

✓ **Week 1, Sept 8-14**

Introduction

Course overview

Chapter 0, sections 1-5: mathematical review.

Course Material

- **Units & Dimensional analysis**
- **0.1: Vectors (23')**
- **0.2: Trigonometry (13')**
- **0.3 & 0.4: Calculus & Taylor Series(16')**
- **0.5: Right-handed coordinate systems (6')**

Additional Material

- **Chapter 0 course notes**
- Chapter 0 **Blank** and **annotated** video slides (french)
- **Trigonometry geogebra applet**
- **Video explaining Taylor series**
- **Video explaining vector cross product**

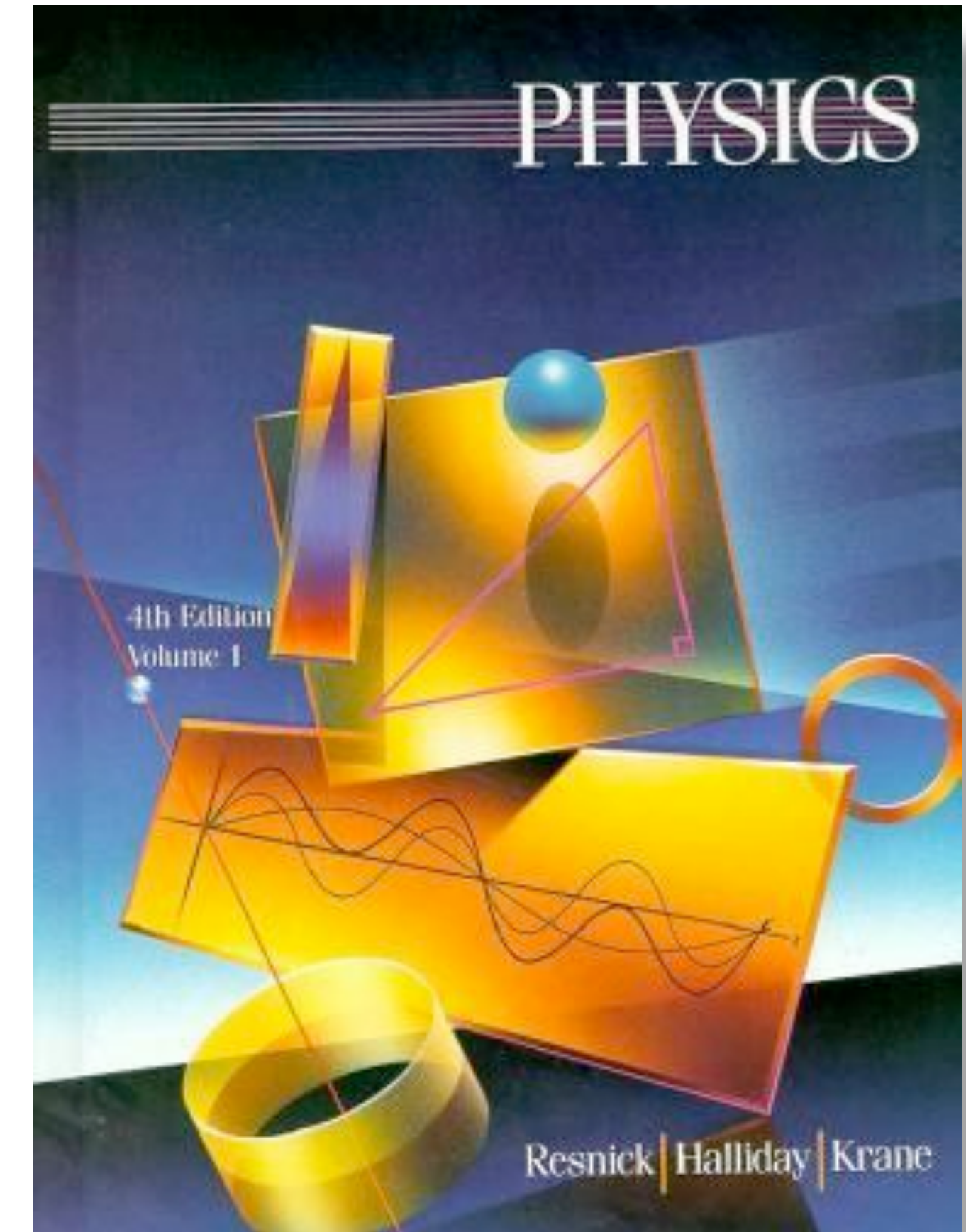
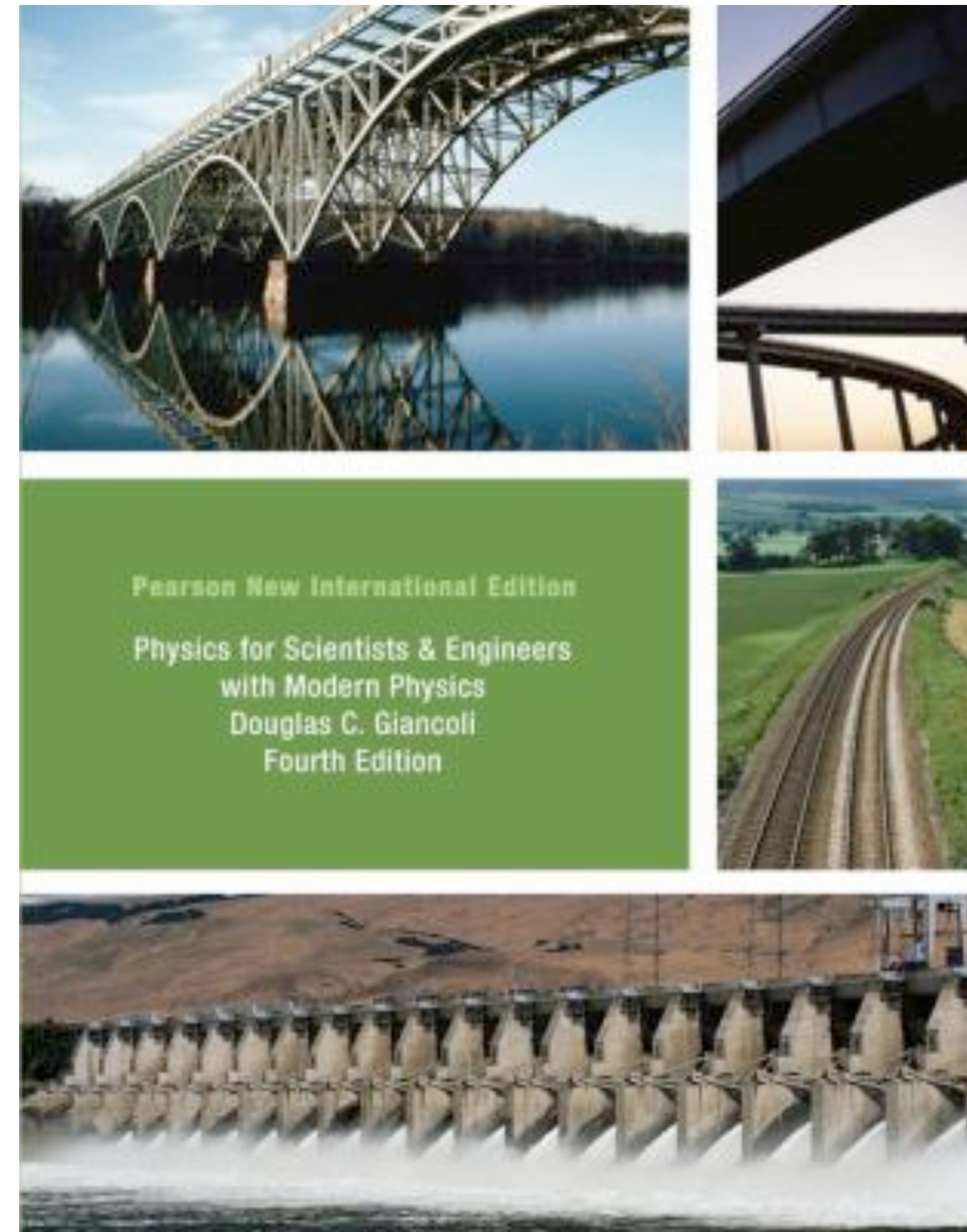
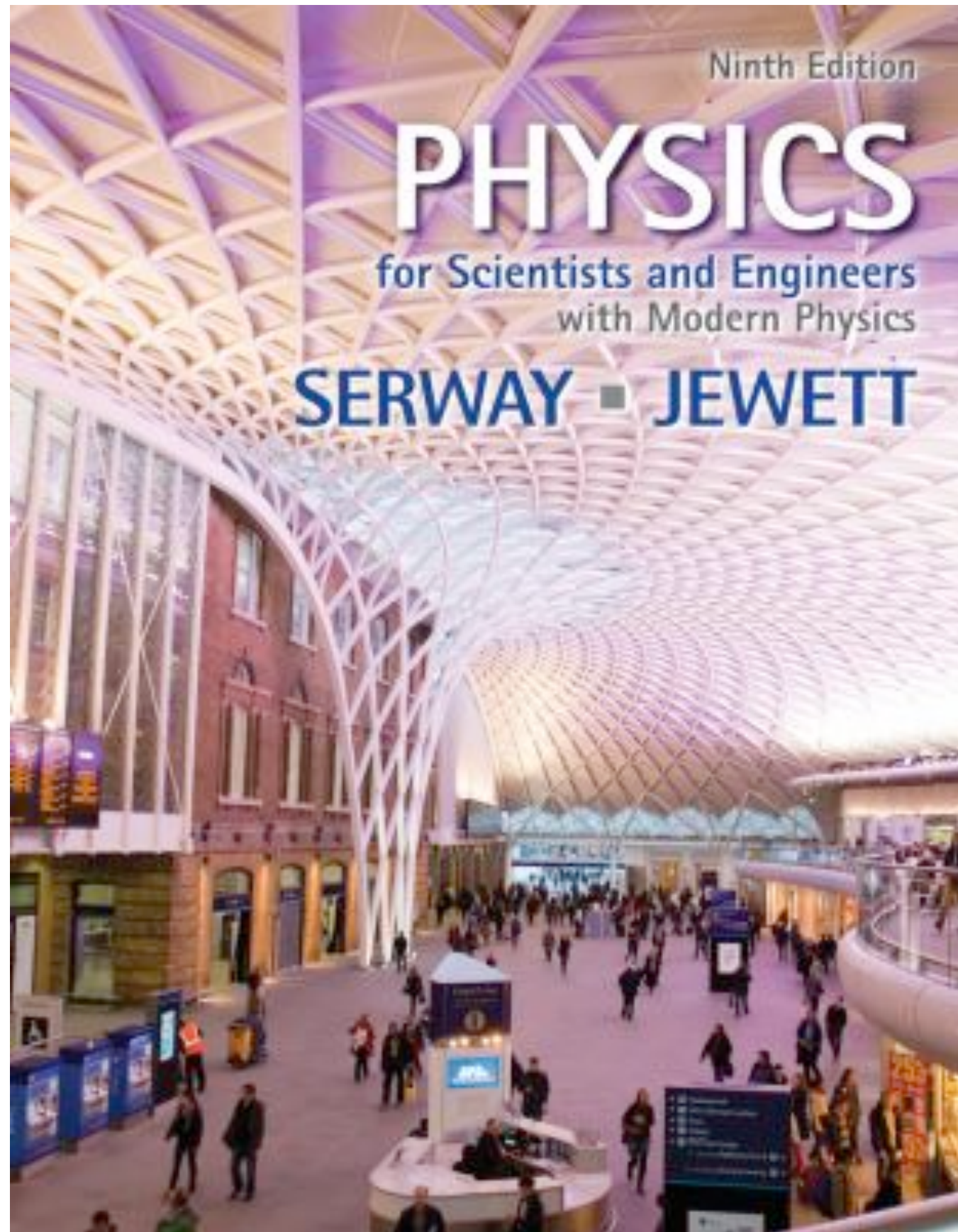
Exercises

- **Week 1 practice exercises**
- **Week 1 problem set**
- **Week 1 problem set solutions**



Fill & submit group chater

BOOKS



[Serway, Physics for Scientists and Engineers.](#)

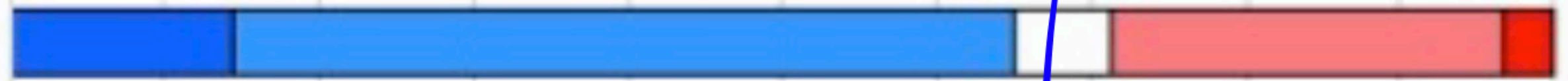
[Douglas Giancoli. Physics for Scientists and Engineers. 4th Edition](#)

[D. Halliday, R. Resnick, K. S. Krane. Physics, Volume 1](#)

THE EXERCISES

Commentaires des étudiants de 1ère année:

14. Les exercices sont bien adaptés en degré de...



“les exercices sont trop difficiles”

THE EXERCISES

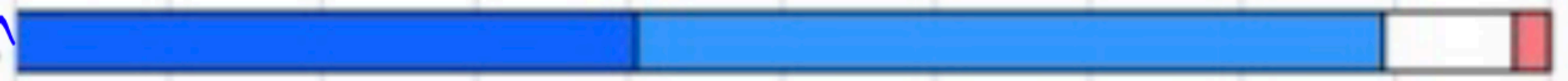
Commentaires des étudiants de 2ème année:

Appréciation du niveau du cours et des exercices

10. Pour me préparer pour la deuxième année, le...



11. Pour me préparer pour la deuxième année, le...



THE EXERCISES

- Exercises are a critical part of the course. You need to know *how* to do them, not just memorize them!
- Spend *a long time* on an exercise before looking at the solution. Leave it aside, come back to it, discuss it with the group, ask questions in office hours, or at the exercise sessions.
- You can also find additional information in the books.

GROUP EXERCISES

- This course includes group exercises with group submissions.
- Small groups of 4-6 students, fixed for the semester.
- Each group is assigned to one assistant each week. Each assistant will oversee 2–3 groups.
- The group will submit one exercise each week, which will get feedback from the assistant. Important to prepare for the exam!
- Participation in groups is **strongly encouraged**, but participation is **optional** and group exercises **do not count towards the grade**.
- **Friday:** creation of groups & registration on Moodle.

GRADING & EXAM

- **The final exam determines your entire grade.**
- The exam has **50 points**:
 - **12 points** multiple-choice
 - **38 points** for written exercises (3 small or 2 large)
- A **form containing standard formulas** will be provided, and will be posted on the course moodle later in the semester
- **Calculators, telephones, etc are prohibited.**
- You can only bring a single-sided A4 handwritten sheet containing **whatever you want**.
 - (NB: the exam will not exactly replicate any of the exercises)

LEARNING OUTCOMES

- What skills should this course give you?
 - ➡ Understand the basics of Newtonian mechanics for the point particle and the rigid body
 - ➡ Learn to model **mathematically**
 - ➡ Learn to solve complex problems
 - ➡ Learn to critically analyze your result
- You will be assessed on both conceptual understanding **and** on the ability to model, solve, and evaluate the result.

COURSE SCHEDULE

Week	Topic	Amphi Session	Exercise Session
1	Math Review	TODAY!	Sept 12
2	Kinematics	Sept 15	Sept 19
3	Kinematics	(no lecture)	Sept 26
4	Newton's Laws	Sept 29	Oct 3
5	Newton's Laws & Applications	Oct 6	Oct 10
6	Newton's Laws & Applications	Oct 13	Oct 17
7	Mid-term break		
8	Work & energy	Oct 27	Oct 31
9	Collisions	Nov 3	Nov 7
10	Oscillators	Nov 10	Nov 14
11	Oscillators	Nov 17	Nov 21
12	Angular Momentum	Nov 24	Nov 28
13	Solids	Dec 1	Dec 5
14	Solids	Dec 8	Dec 12
15	Review	Dec 15	Dec 19


QUESTIONS?

DIMENSIONAL ANALYSIS



An object is falling freely without any air resistance. It is dropped without any initial velocity from a height h in meters and is subject to the acceleration due to gravity $g = 9.81 \text{ m/s}^2$.

We know that one of these expressions for the fall time is correct, but which one is it?

 Which is the correct expression for the fall time t in seconds? ...

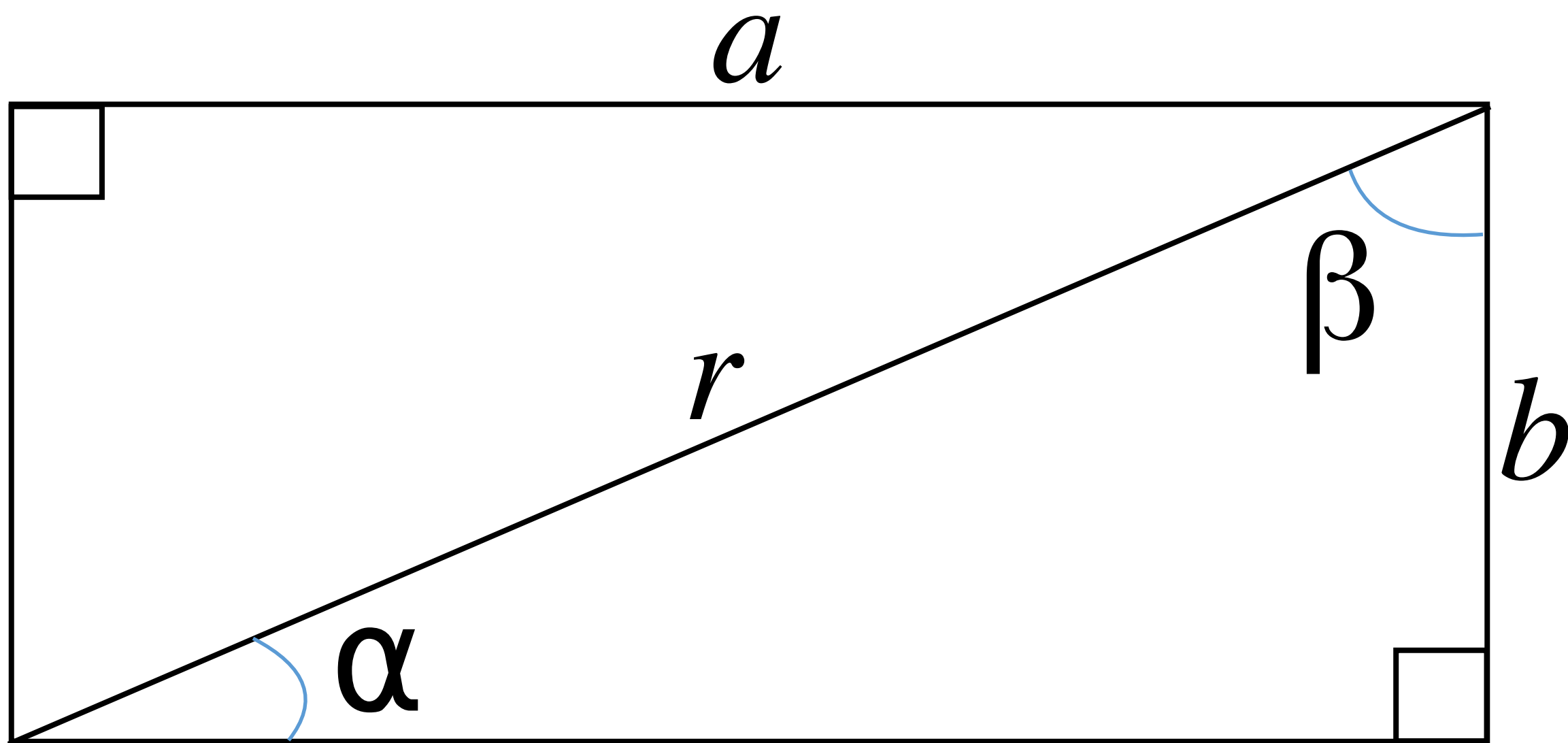
Impossible to know 0%


$t = \sqrt{2gh}$ 0%

$t = \sqrt{2h/g}$ 0%

$t = \sqrt{g/2h}$ 0%

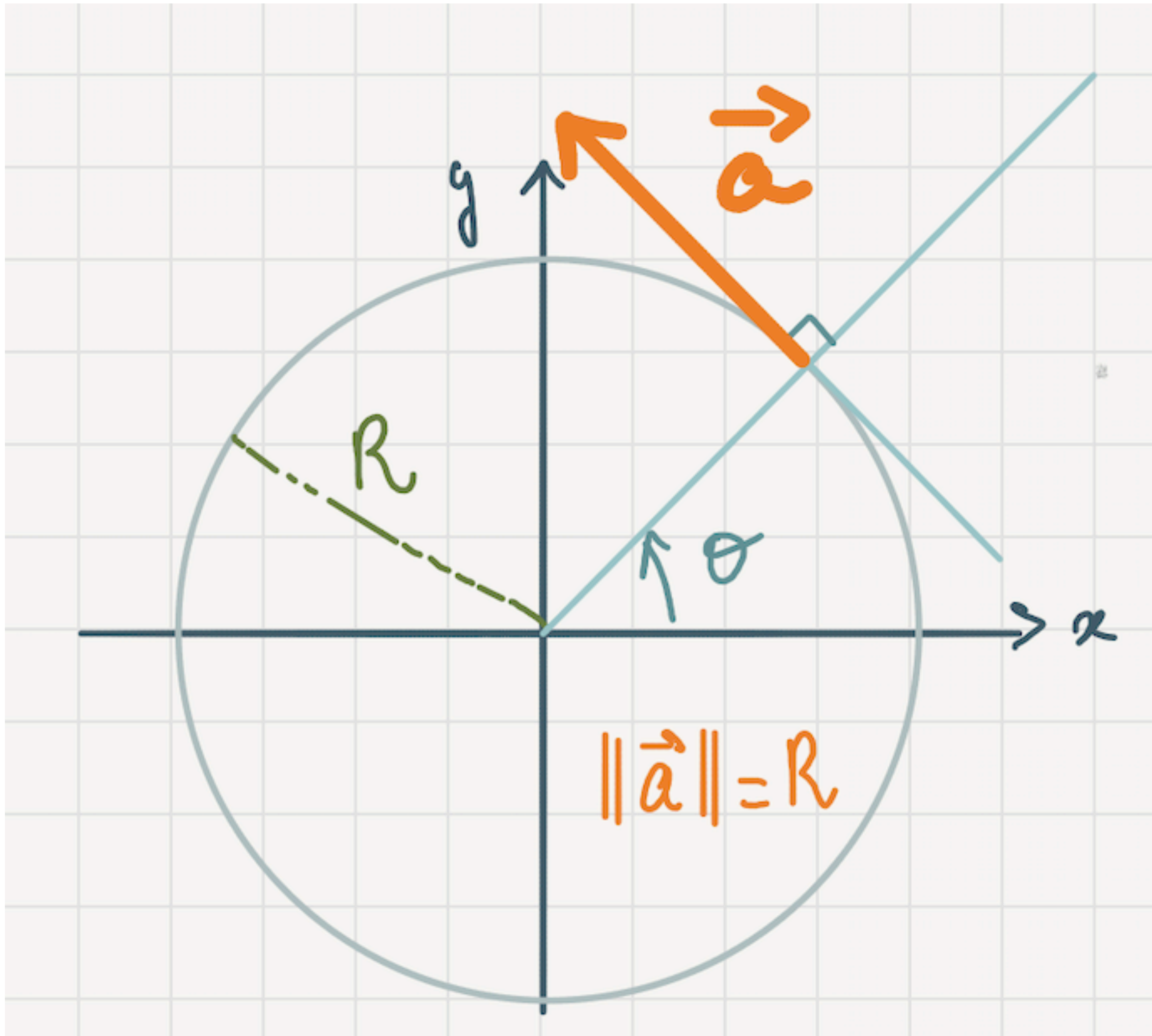
TRIGONOMETRY



 Which of the following relations are correct?
You can select more than one

- $a = r \sin \alpha$ 0%
- $b = r \cos \alpha$ 0%
- $a = b \tan \alpha$ 0%
- $\sin \alpha = \cos \beta$ 0%
- $\sin(\alpha + \beta) = 1$ 0%
- $a = b \tan \beta$ 0%
- $\sin(\alpha + \beta) = 0$ 0%
- $b = r \cos \beta$ 0%

VECTORS



$$A: \vec{a} \begin{vmatrix} R \cos \theta \\ R \sin \theta \end{vmatrix}$$

$$B: \vec{a} \begin{vmatrix} R \sin \theta \\ R \cos \theta \end{vmatrix}$$

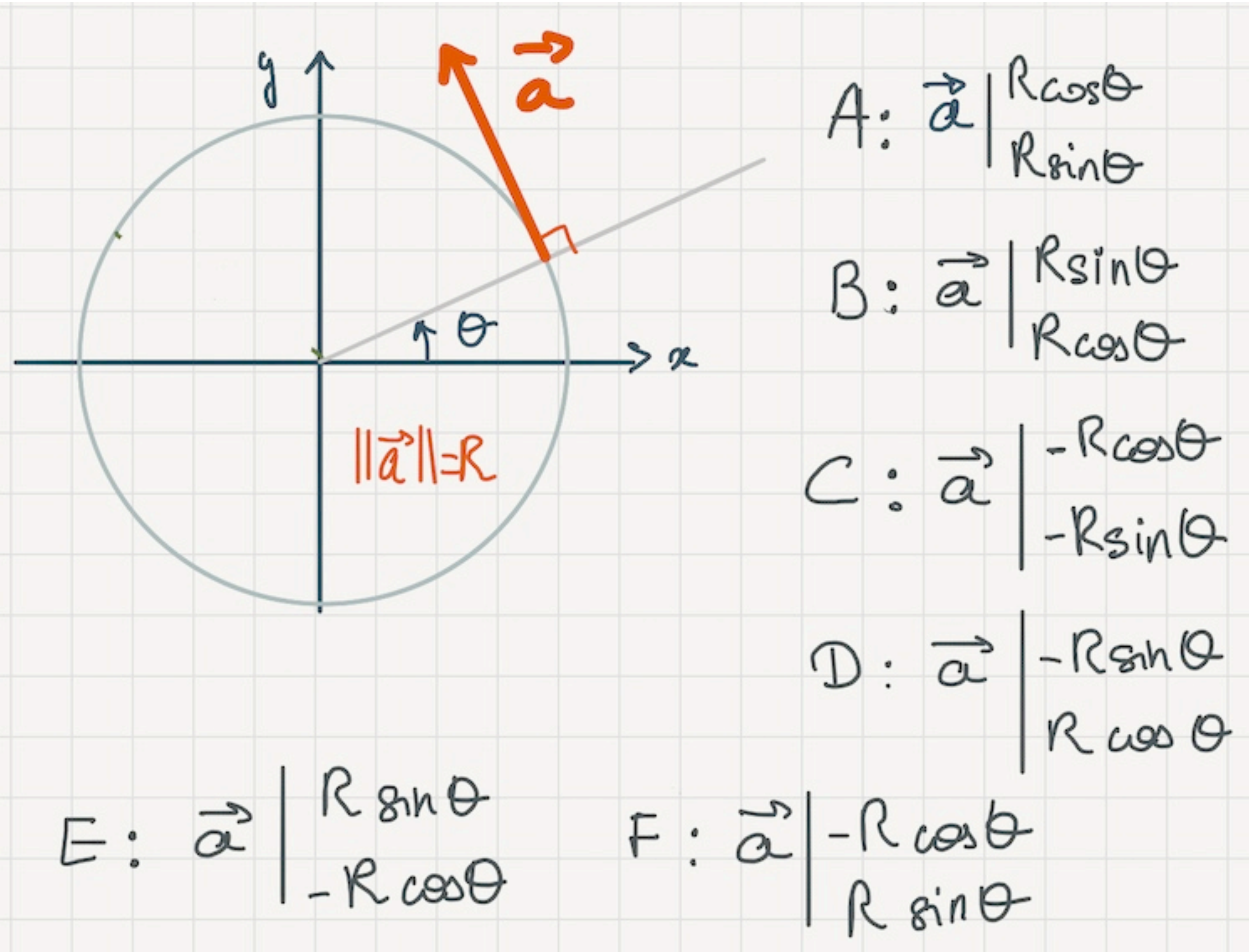
$$C: \vec{a} \begin{vmatrix} -R \cos \theta \\ -R \sin \theta \end{vmatrix}$$

$$D: \vec{a} \begin{vmatrix} -R \sin \theta \\ R \cos \theta \end{vmatrix}$$

$$E: \vec{a} \begin{vmatrix} R \sin \theta \\ -R \cos \theta \end{vmatrix}$$

$$F: \vec{a} \begin{vmatrix} -R \cos \theta \\ R \sin \theta \end{vmatrix}$$

VECTORS



DERIVATIVES

An object is moving at a speed $v(t)$ which depends on time. We are interested in a function $f(v)$ defined as:

$$f(v) = \frac{1}{2} m v^2$$

where m is a constant. We want to calculate the derivative of f with respect to time df/dt .

 Which expression is correct? ...

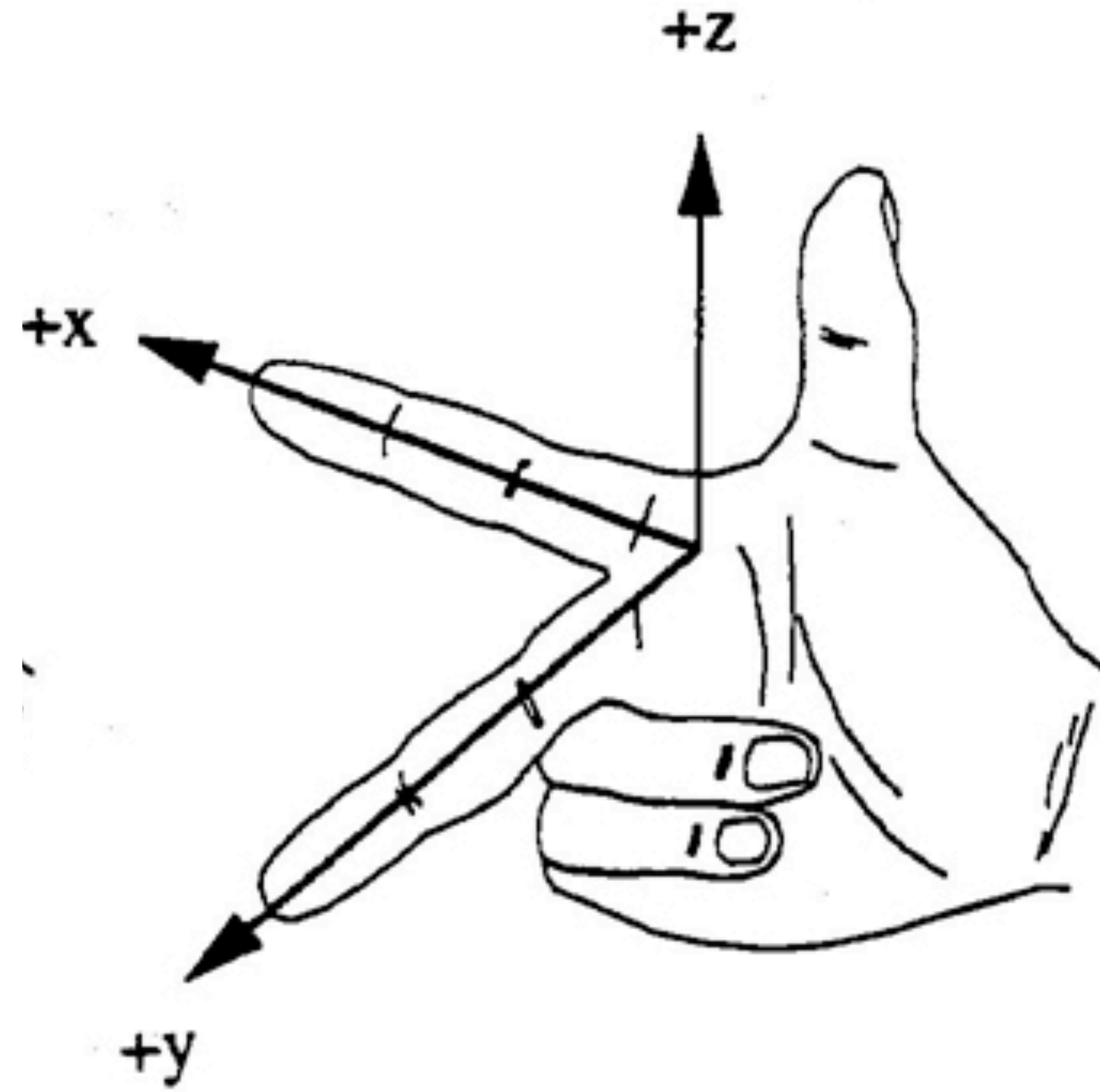
$df/dt = mv$ 0%

$df/dt = mv\dot{v}$ 0%

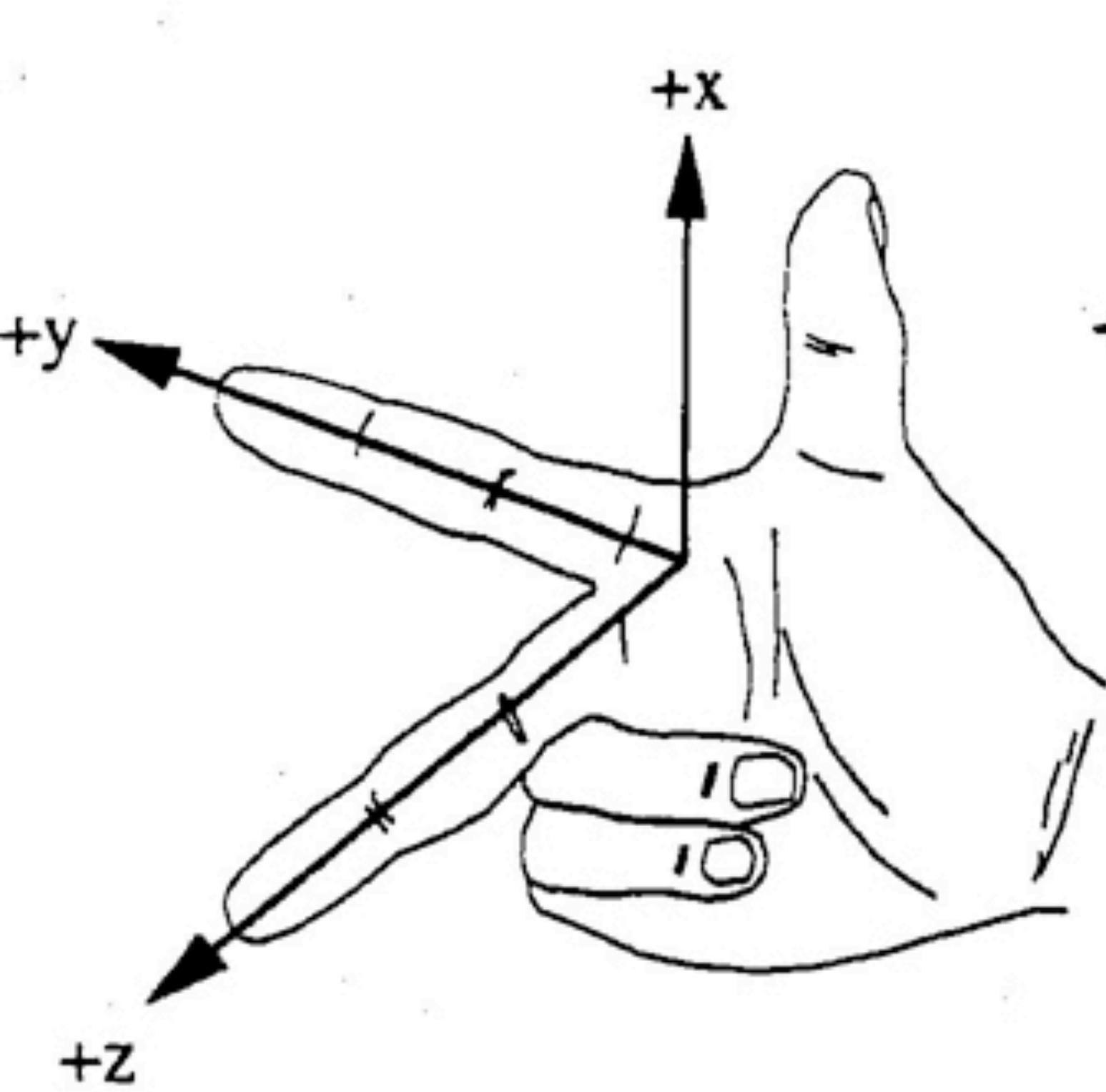
$df/dt = mv \frac{dv}{dt}$ 0%

$df/dt = 0$ 0%

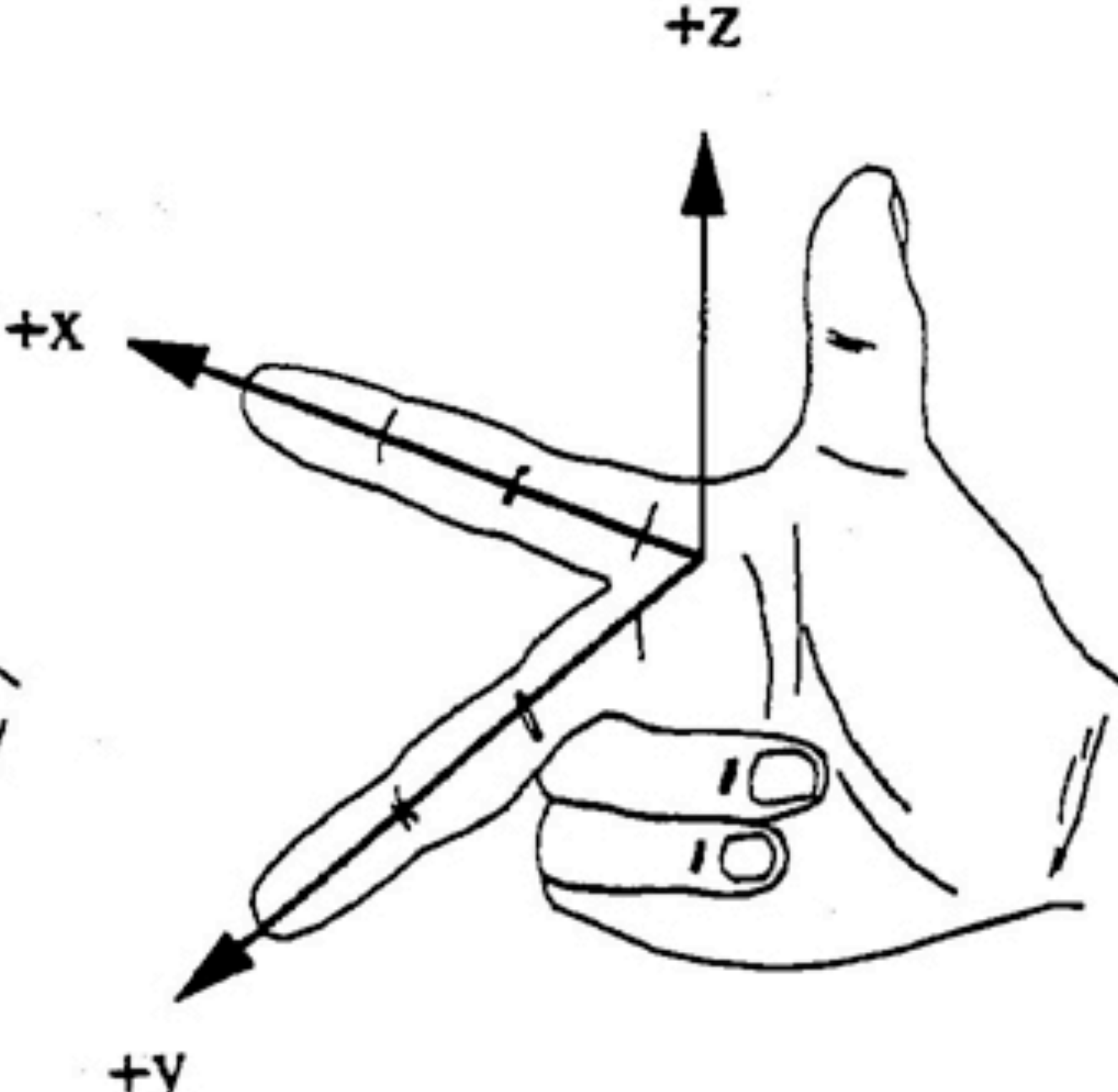
RIGHT-HANDEDNESS



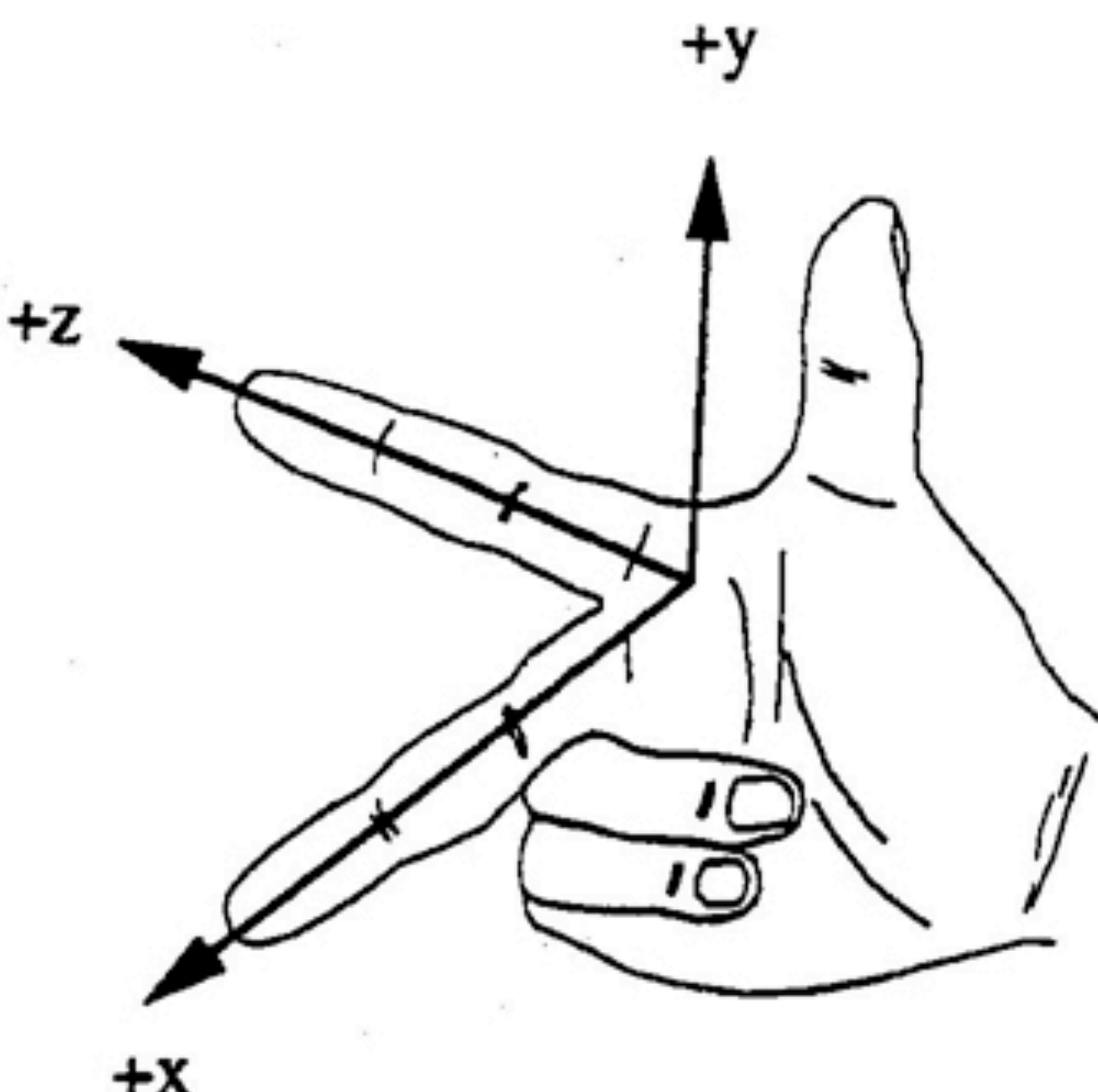
RIGHT-HANDEDNESS



Configuration 1

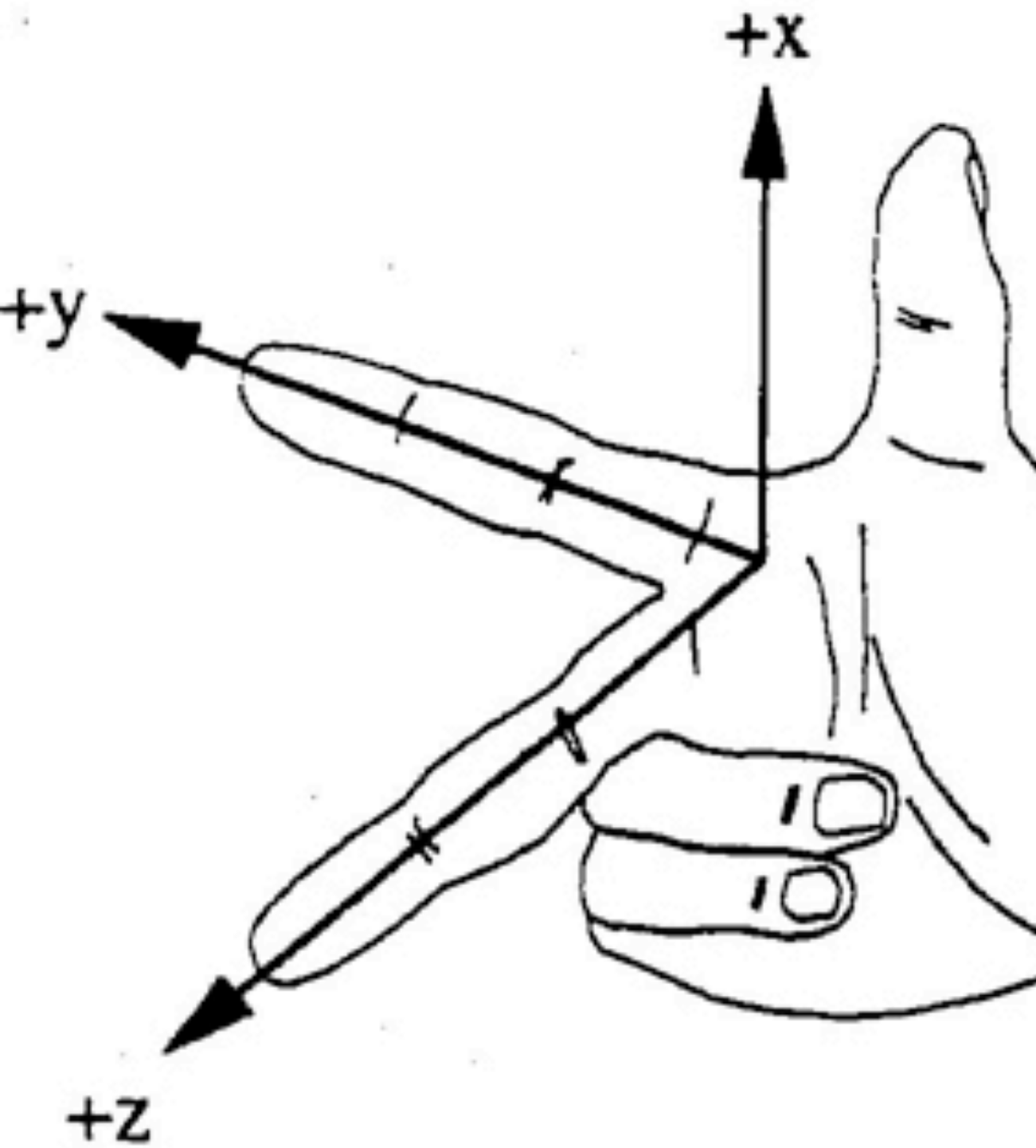


Configuration 2

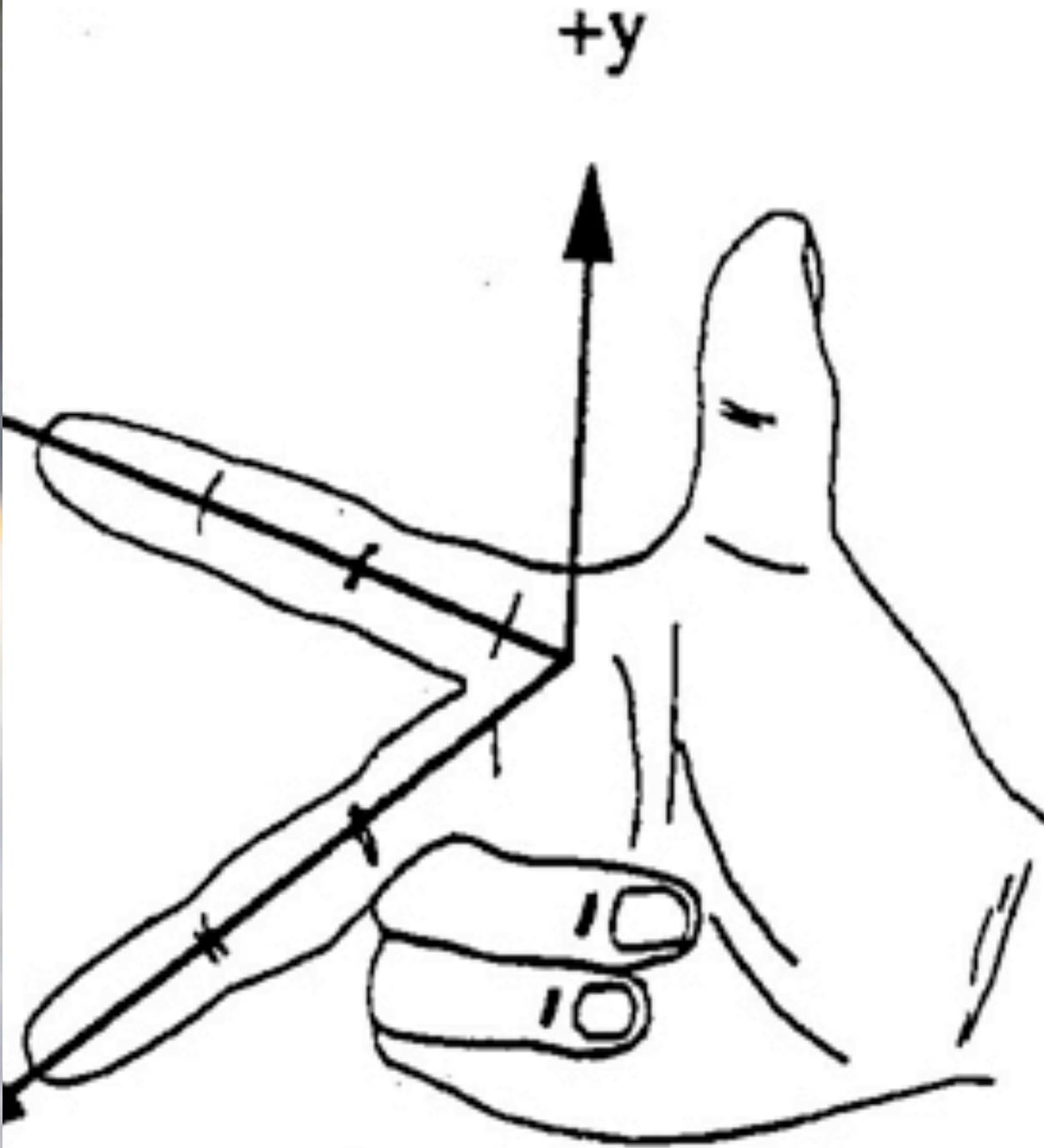


Configuration 3

RIGHT-HANDEDNESS



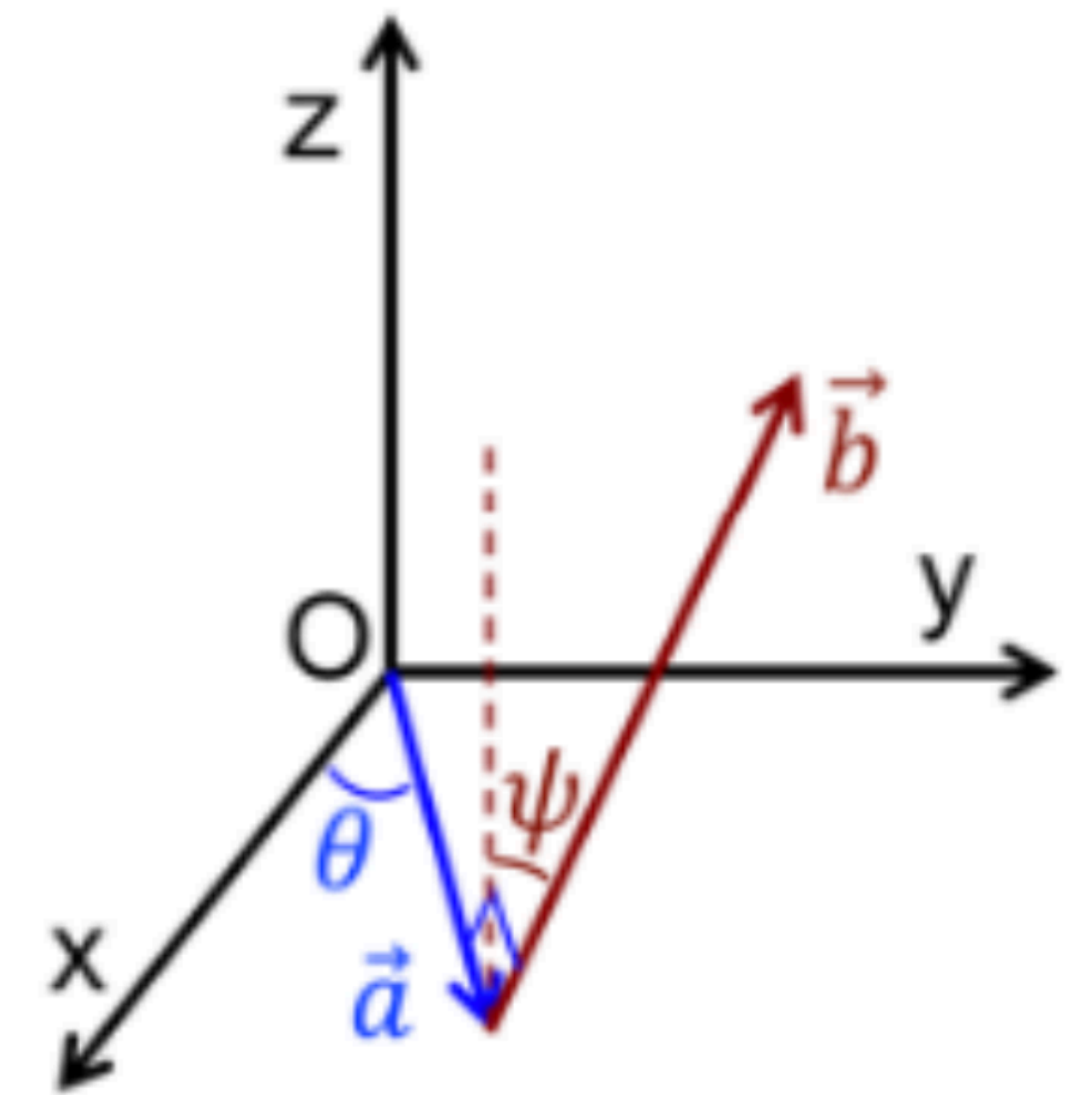
Configuration 1



Configuration 3

EXERCISE

We consider an orthonormal coordinate system (xyz) , with the z -axis as the vertical axis. The vector \vec{a} , with magnitude a , lies in the xy plane and makes an angle θ with the x -axis. The vector \vec{b} , with magnitude b , is perpendicular to \vec{a} and forms an angle ψ with the vertical.



A. Visualize the vectors \vec{a} and \vec{b} in space and find their Cartesian coordinates in (xyz) .

Use sketches to represent the projections of these vectors on the axes.

B. We define a vector $\vec{c} = \vec{a} \wedge \vec{b}$. Calculate the coordinates of \vec{c} by formulating the cross product in (xyz) . Visualize vector \vec{c} in space.

C. Calculate the values of $\vec{c} \cdot \vec{a}$, $\vec{c} \cdot \vec{b}$, and $\|\vec{c}\|$:

- without calculation, relying on simple geometric considerations
- by performing the calculation using the coordinates of \vec{a} , \vec{b} , and \vec{c} found previously.