



BASKETBALL MOTION LAB

| Duration | Age | Difficulty |
|--|-------|------------|
| 120 min | 15-16 | Medium |
| #Gravitational acceleration #Video Analysis | | |

DESCRIPTION

This activity aims to analyze the parabolic trajectory of a basketball during a free throw.

It focuses on studying its motion using an app called Tracker, which employs video analysis to extract position data over time. By tracking the ball's displacement frame by frame, we can determine key kinematic variables such as velocity and time of flight, without considering possible factors such as air resistance.

ACTIVITY OBJECTIVES

- Analyze the motion of a basketball in a free throw using video-based tracking
- Determine velocity, displacement, and gravitational acceleration from trajectory data
- Estimate experimental error and interpret results through graphs.
- Highlight the contribution of women athletes in basketball and promote gender equity in STEAM.
- Communicate results using visual and artistic media.

KEY COMPETENCES (EU)

- Mathematical, Scientific
- Scientific and digital competence
- Cultural Awareness and expression competence
- Personal, social and learning to learn competence



MATERIALS



Smartphone
(for filming)



Notebook or
digital device for
note-taking



Provided by students



Provided by the teacher/institution



Downloadable Elements



Computers
with Tracker
installed



Ruler or
measuring tape



A3 sketch
paper, markers,
tactile craft
materials
(optional)



Worksheets
(data table,
graph template,
reflection
prompts)

PREVIOUS PREPARATION

- Teacher ensures Tracker software is installed and functioning.
<https://opensourcephysics.github.io/tracker-website/>
- Students review basic concepts: movement laws.
- Class is divided into diverse teams with rotating roles (analyst, recorder, presenter, technician)



CONTEXTUALIZATION AND ADAPTATION

Students explore a real-world sports scenario: the physics of a basketball free throw. After watching a short video on shooting technique (e.g., "Free Throws: How Hard Can It Be?" by Elena Delle Donne), students discuss the forces involved in launching a ball, and how physics principles apply to sports performance. (YouTube link: <https://www.youtube.com/watch?v=WJxN6snapd0&t=20s>)

Cultural and gender inclusion is introduced through tributes to influential female athletes in basketball, emphasizing how science can analyze and improve performance equitably.

Ask students:

- Where do we see inclined planes in everyday life?
- How does the angle affect the energy required?
- Provide cultural examples (e.g., Inca transport ramps, Egyptian pyramid constructions) and discuss their physics implications.

Complementary tools

HyperPhysics:

Description of motion <http://hyperphysics.phy-astr.gsu.edu/hbase/mot.html#mot1>

Description of Motion in One Dimension

Motion is described in terms of [displacement](#) (x), time (t), [velocity](#) (v), and [acceleration](#) (a). Velocity is the rate of change of displacement and the acceleration is the rate of change of velocity. The average velocity and average acceleration are defined by the relationships:

Average velocity: $\bar{v} = \frac{\Delta x}{\Delta t}$ Average acceleration: $\bar{a} = \frac{\Delta v}{\Delta t}$

where the Greek letter Δ indicates the change in the quantity following it.

Constant acceleration equations.

1. $x = \bar{v} t$ [More Detail](#) $\bar{v} = \frac{v_0 + v}{2}$

2. $v = v_0 + at$

3. $x = v_0 t + \frac{1}{2} at^2$ [Show](#)

4. $v^2 = v_0^2 + 2ax$ [Show](#)

A bar above any quantity indicates that it is the average value of that quantity. If the acceleration is constant, then equations 1, 2 and 3 represent a complete description of the motion. Equation 4 is obtained by a combination of the others. Click on any of the equations for an example.

[Graphing one-dimensional motion](#)



Note for the teacher

Ensure equitable group composition. Encourage girls to take lead roles in data collection and interpretation.



ACTIVITY

1. Divide students into diverse groups (3–4 members). Assign rotating roles: data recorder, analyst, presenter, technician.
2. Students film a classmate executing a free throw (the basketball must remain visible throughout its flight and is not obstructed by any objects).
3. In Tracker define a scale using known distance (e.g., hoop-to-floor) and mark the ball frame by frame.
4. Extract position and velocity graphs. Identify peak height, initial velocity, and calculate gravitational acceleration.
5. Fit a parabolic curve to the data and derive the motion equation.



6. Data recording: Allow the Tracker software to calculate position, velocity, and time data based on the marked points
7. Analyze the trajectory: Review the generated graph and extract the mathematical equation that represents the parabolic path.
8. Teams summarize their experiment visually, including graphs, calculations, and a tribute section
9. Include a visual or artistic component in the final presentation (e.g., infographic, sketch of experiment setup, cultural comparison diagram).

You can find help to understand how Tracker works here:

<https://www.youtube.com/watch?v=n4Eqy60yYUY>

Use this worksheet to record all measurements and observations from your inclined plane experiment. Make sure all values include appropriate units and are recorded clearly.

Group Information

Group Members: _____



Gravitational Acceleration Calculations

| Time (s) | Position (m) | Velocity (m/s) |
|----------|--------------|----------------|
| | | |
| | | |
| | | |
| | | |

Graph Notes

position vs time graph observations:

velocity vs time graph observations:

Motion Equation $y=y_0+v_0+(1/2).g.t^2$

Visual Extension Challenge (Optional)

- Illustrate a comparison between historical and modern free throw forms.
- Highlight physics differences across styles and techniques.

CONCLUSION AND SHARING

Each group creates:

- A final report including all calculations and graphs
- A poster or slide presentation with:
 - Summary of procedure
 - Visual analysis (infographic/chart)
 - Cultural relevance
 - A short tribute to a historical female basketball player



Encourage students to use inclusive language and representation in their final visuals.

Tribute Section (Expanded)

In addition to a written tribute, students are encouraged to include a **visual element** honoring a female or gender-diverse basketball player or a scientist (e.g., timeline, portrait sketch, icon, or quote banner). Examples include *Elena Delle Done*, Senda Bereson, Lisa Leslie.



Reflection Questions

- What factors influenced the accuracy of your results?
- How could your analysis help athletes improve?
- How does physics make sports more inclusive or accessible?
- What did you learn about the role of women in science and sports?

Note for the teacher - Ideas for extension

- Try repeating the experiment with different kind of balls.
- Explore other movements in sports, such as the serve in volleyball or tennis.
- Analyse energy transformations.

Don't forget to take a photo of your experience and share it with us!

#inclinedplaneenergylab



[LinkedIn](#)



[Instagram](#)



[X](#)

BIBLIOGRAPHY AND REFERENCES

- Tracker Software: <https://opensourcephysics.github.io/tracker-website/>
- "Free Throws: How Hard Can It Be?" by Elena Delle Donne
<https://www.youtube.com/watch?v=WJxN6snapd0&t=20s>

