Physics Education Laboratory
Lecture 06
MR for Kinematics

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Multiple Representations definition

MR refer to the capacity of scientific discourse to represent the same concepts or processes in different modes (e.g., verbal, visual, mathematical, graphical) while multi-modal representation refers to the integration of different modes to represent scientific processes, findings, and scientific explanations

Tytler et al. (2007) p.314

DEFINING REPRESENTATIONS:

External representations: which are in a form that can be seen by others, such as pictures, text narrations, graphs, symbols, etc.

External representations refer to “the knowledge and structure in the environment, as physical symbols, objects, or dimensions”

Internal representations or **mental models**, which act out as structural analogies of situations or processes.

Ainsworth (1999,2008)

Internal representations refer to “the knowledge and structure in memory, as propositions, productions, schemas, neural networks, or other forms” Zhang (1997)

Building deep learning

Information in external representations can be processed by perceptual operation and refers to information that is directly perceived.

Information in internal representations refers to information retrieved directly from working memory that involves cognitive operation.

Through memorization, an internal representation can be transformed to an external representation.

Multiple Representations

In what ways does the use of MR in instruction support student learning?

MR might serve as a powerful learning strategy in physics education and has a positive impact on undergraduate students' conceptual understanding of physics concepts.

Different representations might be used for different purposes and also depending on students' prior experience with the use of a specific kind of representation.

Multiple Representations

What kinds of representations do students use?

Students use different kinds of representations and the combination or a series of kinds of representations has the potential to support student problem solving and consequently their development of conceptual understandings.

Multiple Representations

What difficulties do students face in using MR?

Even though MR provide an empowering learning tool or learning strategy, students face different difficulties in using MR during the learning process, especially in switching between kinds of representations.

Multiple Representations

What is the relation between students' use of MR and students' problem-solving skills?

The kind of representation used impacts students' problem-solving success.

Multiple Representations

What is the added value of technology integration in teaching with MR?

The potential value of computer-based MR in supporting students' physics learning such as supporting students' conceptual understandings as well as their representational competence.

SUMMARIZING:
how multiple representations (MR) can be used in undergraduate physics education and in physics education research

- MR might serve as a powerful learning strategy in physics education and has a positive impact on undergraduate students' understanding of physics concepts.
- There is no evidence in the literature that one kind representation is better than another in supporting students develop their understandings of physics concepts.
- Students use different kinds of representations and the combination of kinds of representations has the potential to support student problem solving and consequently their development of conceptual understanding.
- Students face different difficulties in using MR during the learning process, especially in switching between kinds of representations.
- Computer-based representations can support students' physics learning, as for example, conceptual understanding and representational competence.

State of PER results:

Research shows that the use of MR might enhance student learning

Research also shows that students have difficulties in relating and integrating the representations and translating information between them

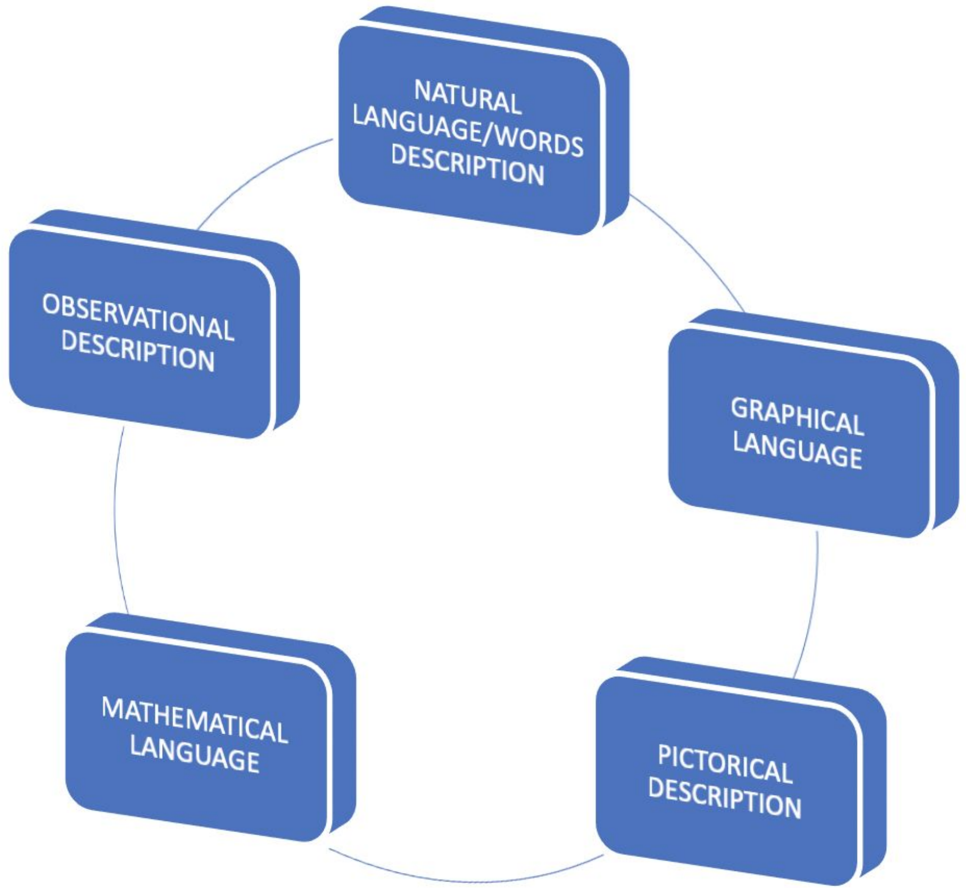
Learning outcomes: MR might have **three** distinct roles in learning.

- MR serve a **complementary role** given that using texts and pictures together will complement each other
  - Students can choose what the best way is for them to learn
  - Students can also combine representations that can make learning easier
  - Students can use texts, pictures, graphs, tables and other representations. This means that one problem can be solved with the use of several representations.
- MR supports the development of a deeper conceptual understanding.
  - This role relates to the ways in which MR might enhance abstraction, extension, and relation.
  - The students who have a deep understanding of certain concepts can transform one kind of representation into another kind of representation
- MR employs common representations and by using inherent properties of one (common) representation to develop the interpretation of the second representation (uncommon)

“MR have a great potential in supporting student learning of physics concepts because students learn easier when problems include MR, hence, the use of MR can maximize the results of students’ learning processes. “

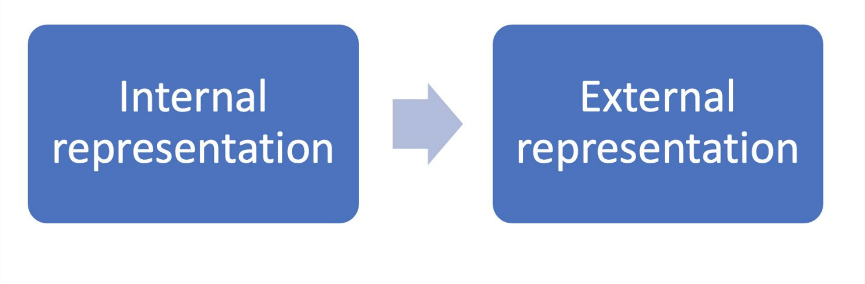
Opfermann M., Schmeck A., Fischer H.E. (2017) Multiple Representations in Physics and Science Education – Why Should We Use Them?. In: Treagust D., Duit R., Fischer H. (eds) **Multiple Representations in Physics Education. Models and Modeling in Science Education**, vol 10. Springer, Cham. https://doi.org/10.1007/978-3-319-58914-5_1

Kinematics with
Multiple Representations
DESCRIPTIONS OR
DISCIPLINE’S LANGUAGES?

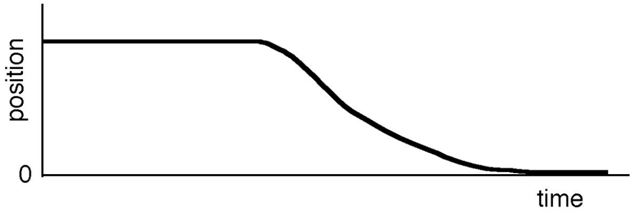

NATURAL LANGUAGE/WORDS DESCRIPTION
GRAPHICAL LANGUAGE
PICTORICAL DESCRIPTION
MATHEMATICAL LANGUAGE
OBSERVATIONAL DESCRIPTION

Interpreting representation and translating

FROM GRAPHICAL TO WORDS



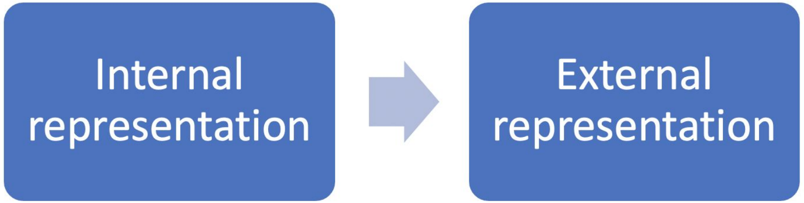
6. Here is a graph of an object's motion. Which sentence is a correct interpretation?



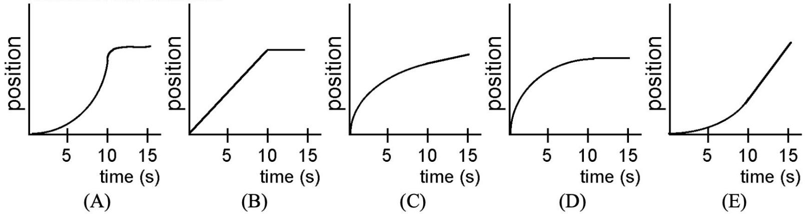
A) The object rolls along a flat surface. Then it rolls forward down a hill, and then finally stops.
B) The object doesn't move at first. Then it rolls forward down a hill and finally stops.
C) The object is moving at a constant velocity. Then it slows down and stops.
D) The object doesn't move at first. Then it moves backwards and then finally stops.
E) The object moves along a flat area, moves backwards down a hill, and then it keeps moving.

Interpreting representation and translating

FROM WORDS TO GRAPHICAL

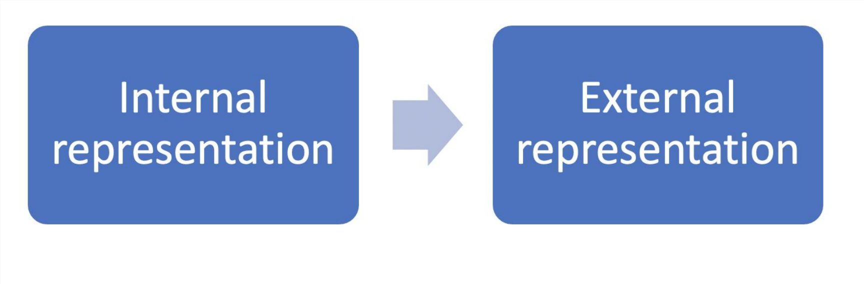


7. An object starts from rest and undergoes a positive, constant acceleration for ten seconds. It then continues on with constant positive velocity. Which of the following graphs correctly describes this situation?



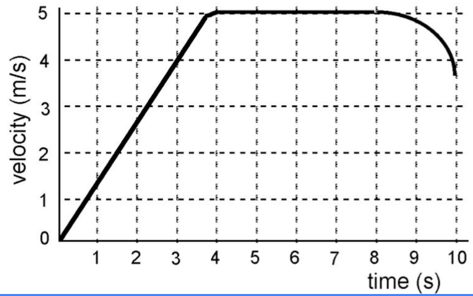
Interpreting representation and translating

FROM WORDS THROUGH GRAPHICAL TO MATHEMATICAL



3. An elevator moves from the basement to the tenth floor of a building. The mass of the elevator is 1000 kg and it moves as shown in the velocity-time graph below. How far does it move during the first three seconds of motion?

A) 0.75 m
B) 1.33 m
C) 4.0 m
D) 6.0 m
E) 12.0 m



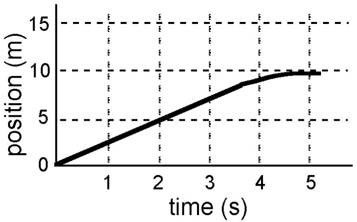
Collecting data and elaborating

FROM GRAPHICAL TO MATHEMATICAL

Internal representation → External representation

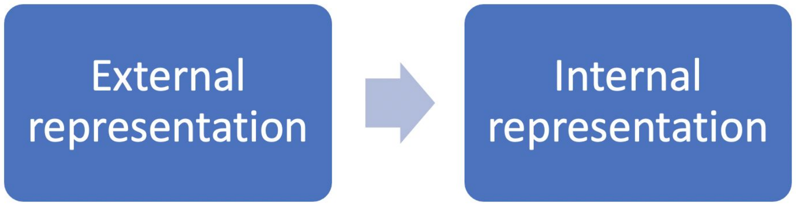
4. The velocity at the 2 second point is:

A) 0.4 m/s
B) 2.0 m/s
C) 2.5 m/s
D) 5.0 m/s
E) 10.0 m/s

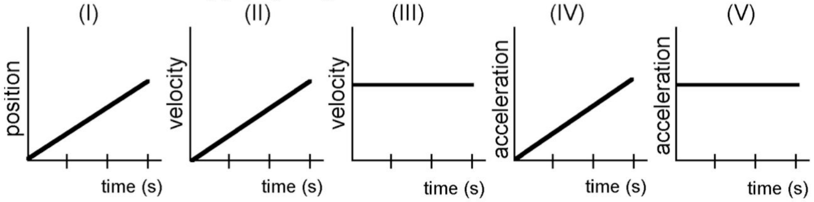


Interpreting representation and modelling concept

FROM GRAPHICAL TO CONCEPT MODEL



9. Consider the following graphs, noting the different axes:

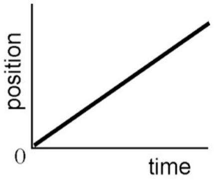


Which of these represent(s) motion at constant velocity?

A) I, II, and IV
B) I and III
C) II and V
D) IV only
E) V only

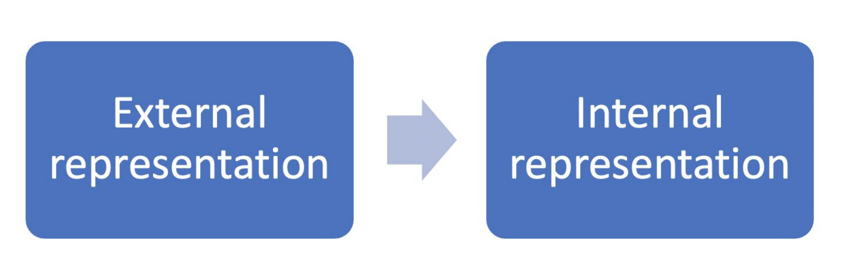
2. To the right is a graph of an object's motion.
Which is the best interpretation?

A) The object is moving with a constant, non-zero acceleration.
B) The object does not move.
C) The object is moving with a uniformly increasing velocity.
D) The object is moving at a constant velocity.
E) The object is moving with a uniformly increasing acceleration.

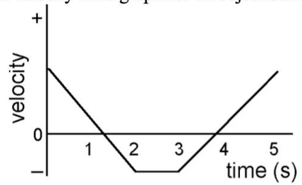


Interpreting representation and modelling concept

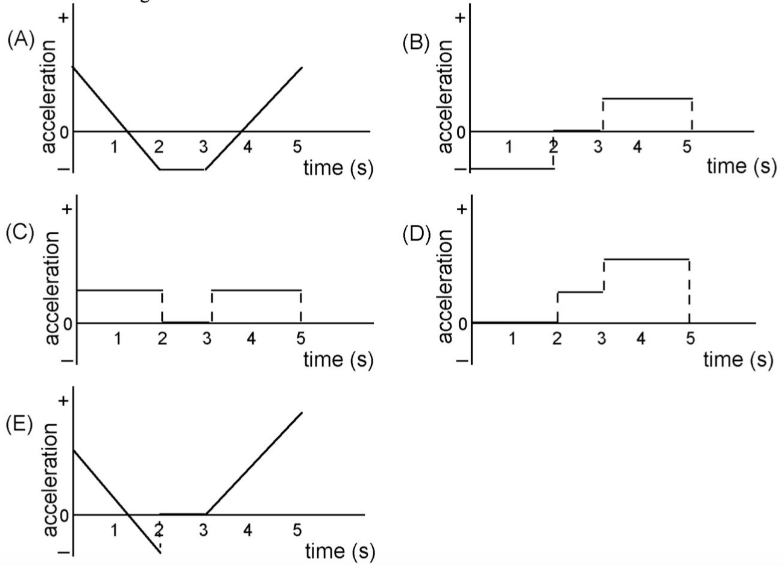
FROM GRAPHICAL TO CONCEPT MODEL

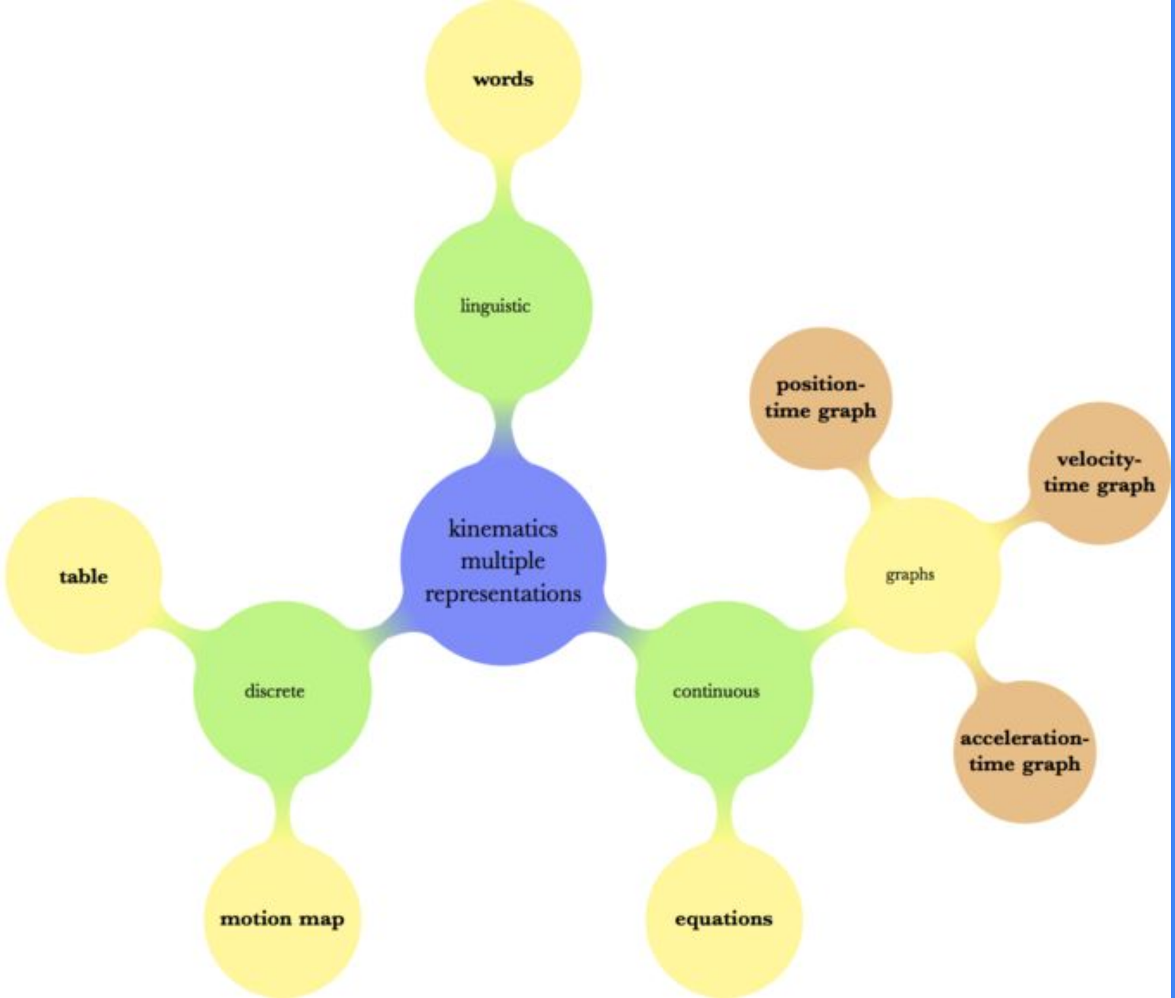


11. The following represents a velocity-time graph for an object during a 5 s interval.



Which one of the following graphs of acceleration vs time would best represent the object's motion during the same time interval

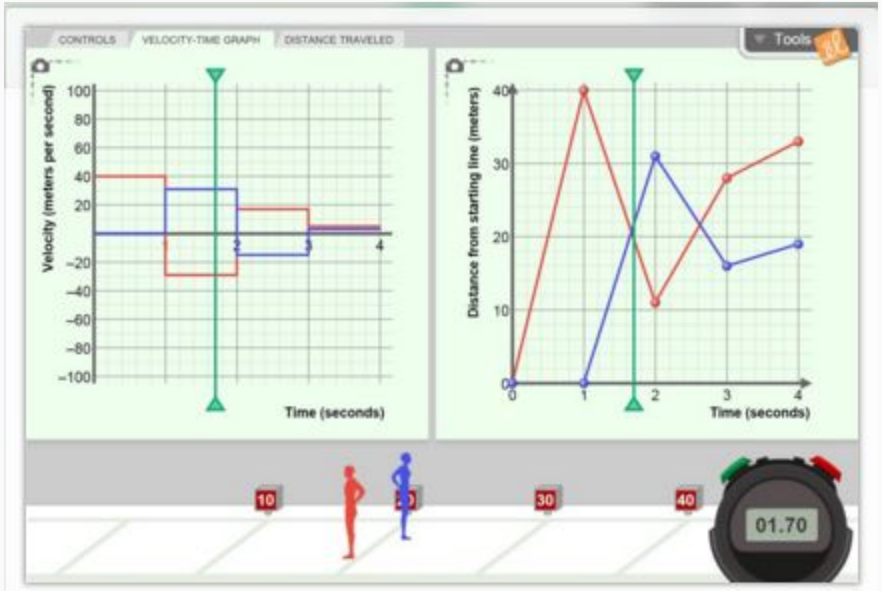




kinematics multiple representations
linguistic
words
discrete
table
motion map
continuous
equations
graphs
position-time graph
velocity-time graph
acceleration-time graph

Distance -Time, Velocity-Time Graphs Metric

Create a graph of a runner's position versus time and watch the runner run a 40-meter dash based on the graph you made. Notice the connection between the slope of the line and the velocity of the runner. Add a second runner (a second graph) and connect real-world meaning to the intersection of two graphs. Also experiment with a graph of velocity versus time for the runners, and also distance traveled versus time.



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Students' Exploration Sheet

Analyze the sheet

Observe the use of Multiple Representations

Recognize the PCK features and the Math/Phys interplay patterns

Add one or more exercises to improve the Multiple Representations usage of this sheet

What's missing?

Student Exploration: Distance-Time and Velocity-Time Graphs

[NOTE TO TEACHERS AND STUDENTS: This lesson was designed as a follow-up to the Distance-Time Graphs Gizmo. We recommend you complete that activity before this one.]

Vocabulary: displacement, distance traveled, slope, speed, velocity

Prior Knowledge Questions (Do these BEFORE using the Gizmo.)
Dora runs one lap around the track, finishing where she started. Clark runs a 100-meter dash along the straight side of the track.

1. Which runner traveled a greater distance? _______________

2. Which runner had a greater change in position, start to finish?

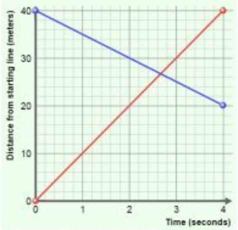
   ____

Gizmo Warm-up
The *Distance-Time Graphs* Gizmo shows a dynamic graph of the position of a runner over time. The *Distance-Time and Velocity-Time Graphs* Gizmo includes that same graph and adds two new ones: a velocity vs. time graph and a distance traveled vs. time graph.

The graph shown below (and in the Gizmo) shows a runner's position (or distance from the starting line) over time. This is most commonly called a *position-time graph*.

Check that the **Number of Points** is 2. Turn on **Show graph** and **Show animation** for both **Runner 1** and **Runner 2**.

1. Drag the points to create the graph shown to the right.
   - **Runner 1**'s line (the red one) should have endpoints at (0, 0) and (4, 40).
   - **Runner 2**'s line (the blue one) should have endpoints at (0, 40) and (4, 20).



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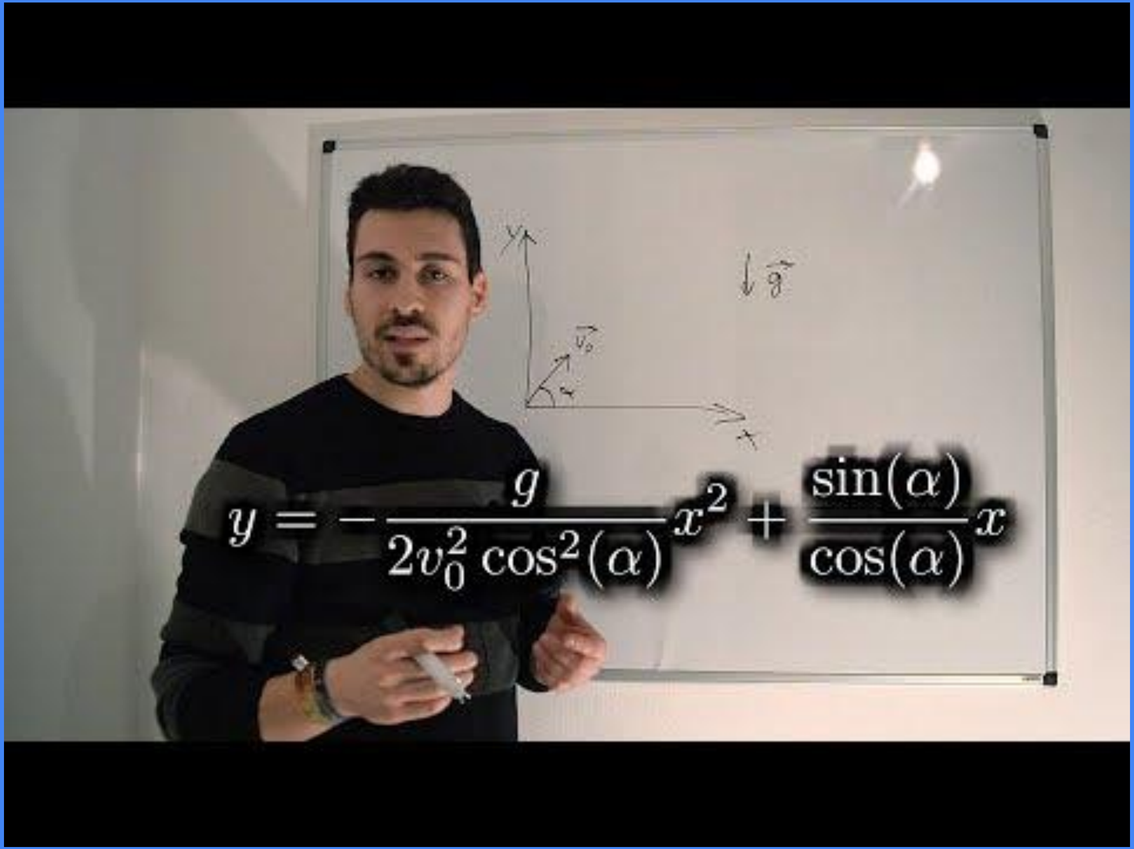
https://docs.google.com/document/d/1j4aRhzRD-f8p0X8tQrwTbU1Fk_-XG2z1eRbJ_dtkWUI/edit?usp=sharing https://www.youtube.com/watch?v=A2cYcQkcJ08



Video on Kinematics

Parabolic motion

https://docs.google.com/document/d/1LlnUZRGfngJUhTTJEsIZuhMYNZ3o6Y72Y_ddkC0JxfA/edit

https://docs.google.com/document/d/1j4aRhzRD-f8p0X8tQrwTbU1Fk_-XG2z1eRbJ_dtkWUI/edit?usp=sharing