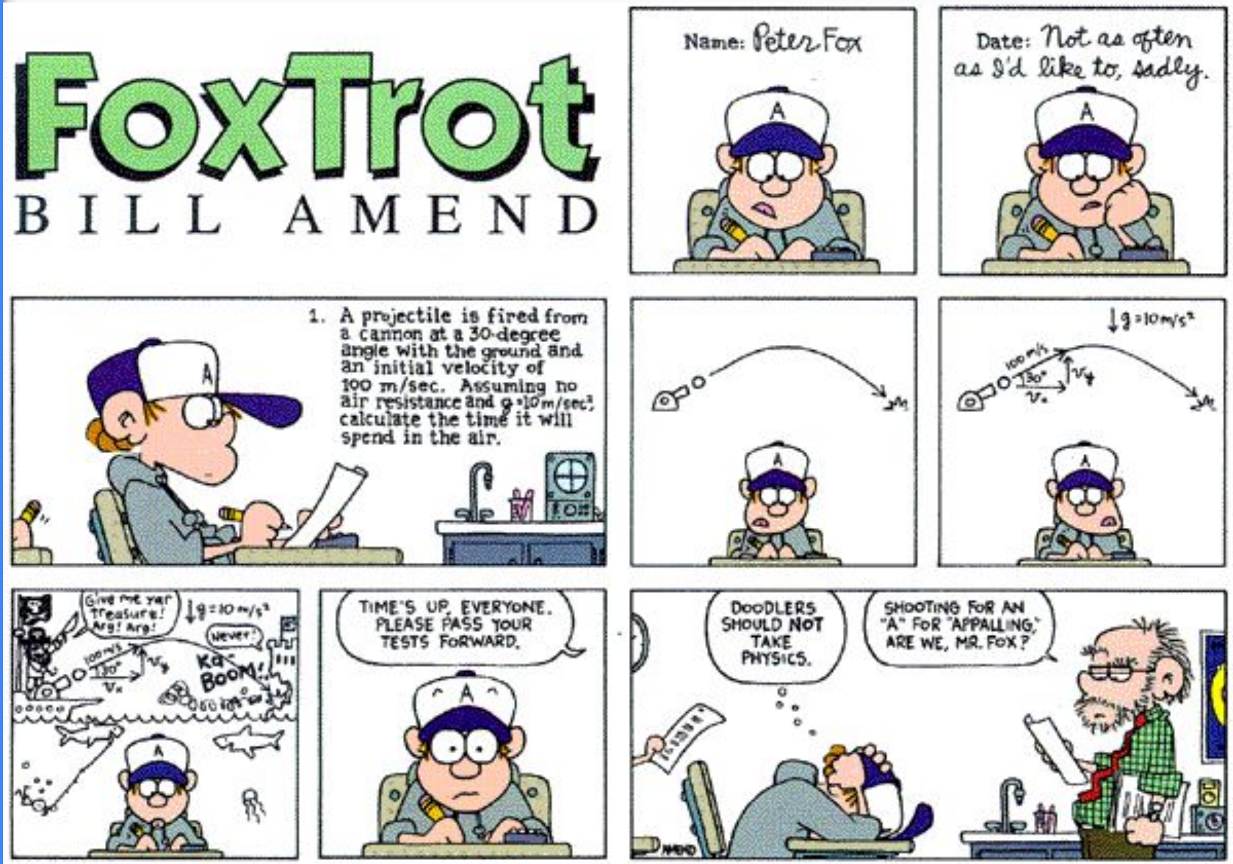
Physics Education Laboratory Lecture 05

Kinematics Concepts and Pedagogical approach

Francesco Longo • 20/10/2020

Real world


FoxTrot
BILL AMEND
Name: Peter Fox
Date: Not as often as I'd like to, sadly.
1. A projectile is fired from a cannon at a 30-degree angle with the ground and an initial velocity of 100 m/sec. Assuming no air resistance and g = 10 m/sec², calculate the time it will spend in the air.
g = 10 m/s²
100 m/s
30°
v_x
v_y
Give me yer treasure! Arg! Arg!
Never!
Ka-Boom!
TIME'S UP, EVERYONE. PLEASE PASS YOUR TESTS FORWARD.
DOODLERS SHOULD NOT TAKE PHYSICS.
SHOOTING FOR AN "A" FOR "APPALLING," ARE WE, MR. FOX?

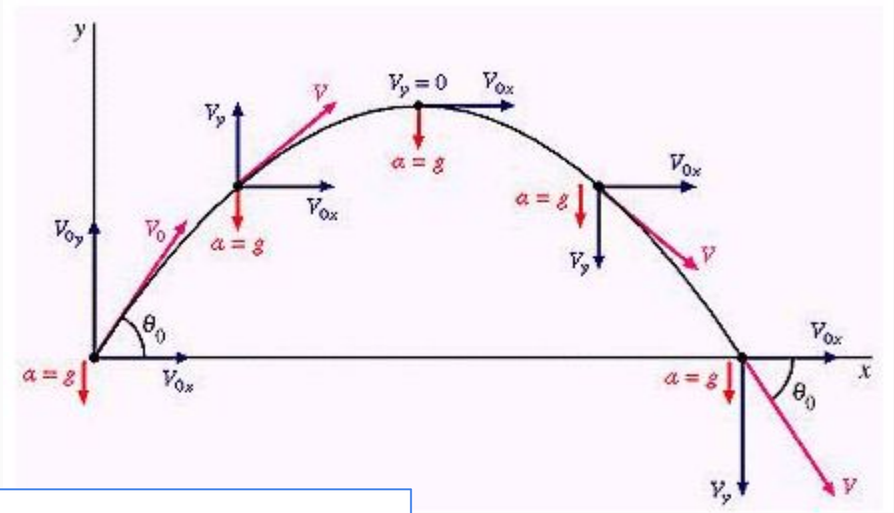
Key-concepts in kinematics

Defining quantities/variables for describing motion (position, displacement, speed, velocity, acceleration)

Frame of reference and observers

From one dimensional to bi-dimensional motion (from scalars to vectors)

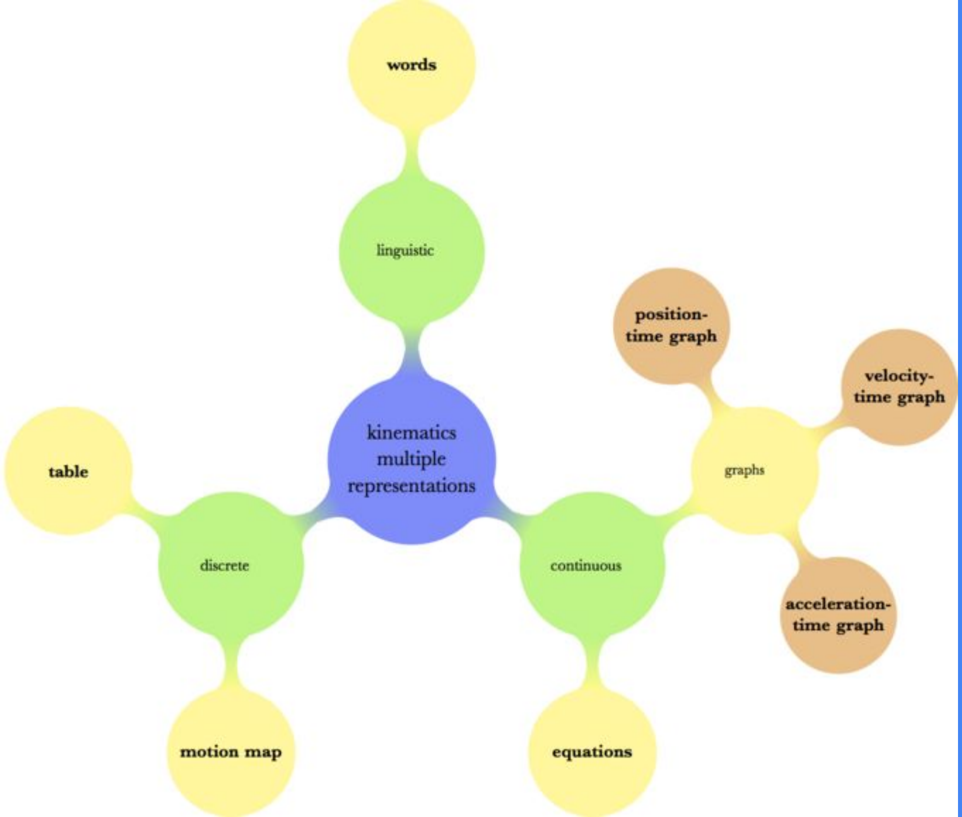
Relative motion



Knowledge of curricula

Key-concepts in Kinematics with Multiple Representations

Orientation toward science teaching



https://fockphysics.wordpress.com/2013/06/15/sbg-and-multiple-representations-in-kinematics/

Misconceptions

Knowledge of students' prior understandings

- Zero velocity implies zero acceleration, even for an instant.
- Velocity decreasing means something slows down. (Failure to account for vector character of velocity.)
- Constant circular speed implies zero acceleration. (#VectorFail)
- Distance and displacement are often confused.
- Position and displacement are often confused when making graphs.
- Position, velocity, and acceleration are "undifferentiated".
- Same velocity means same position.
- The meaning of the slope (in s-t graphs, in v-t graphs, in y-x graphs).

(McDermott et al, 1987)

Math difficulties

- Discriminating the slope and height of a graph and interpreting changes in height and changes in slope
- Identifying slope with the angle between straight line and the x axis
- Evaluate the sign of the slope according to the quadrant in which the line is drawn
- Interval/point confusion

Knowledge of instructional strategies

(Planinic M. et al, 2012)

Phys difficulties

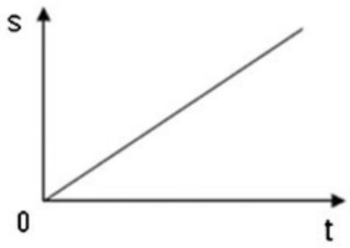
- Interpretation of the meaning of line graph slope in a physics context
- The slope of the line constantly increase (or decrease) in s-t graphs, that means a change in velocity
- Students who have not yet reached the formal operational stage of cognitive development are likely to view graphs as something concrete rather than indicators of abstract trends
- Spatial imagery vs visual imagery

Phys difficulties

Math difficulties

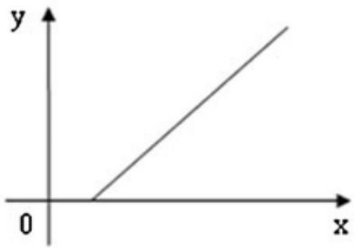
Knowledge of instructional strategies

P1. Distance – time graph of an object's motion is shown below. Which statement best describes this motion?



A. The object is not moving.
B. The object is moving at a constant velocity.
C. The object is moving with a uniformly decreasing velocity.
D. The object is moving with a uniformly increasing velocity.

M1. Consider the following line (ray) in the coordinate system. Which statement is correct?



A. The slope of the line is constant and different from zero.
B. The slope of the line is constant and equal to zero.
C. The slope of the line is constantly increasing.
D. The slope of the line is constantly decreasing.

(Planinic M. et al, 2012)

Students' difficulties in kinematics graphs

Knowledge of students' prior understanding

(Beichner, 1994)

Graph as Picture Errors
The graph is considered to be like a photograph of the situation. It is not seen to be an abstract mathematical representation, but rather a concrete duplication of the motion event.

Slope/Height Confusion
Students often read values off the axes and directly assign them to the slope.

Variable Confusion
Students do not distinguish between distance, velocity, and acceleration. They often believe that graphs of these variables should be identical and appear to readily switch axis labels from one variable to another without recognizing that the graphed line should also change.

Nonorigin Slope Errors
Students successfully find the slope of lines which pass through the origin. However, they have difficulty determining the slope of a line (or the appropriate tangent line) if it does not go through zero.

Area Ignorance
Students do not recognize the meaning of areas under kinematics graph curves.

Area/Slope/Height Confusion
Students often perform slope calculations or inappropriately use axis values when area calculations are required.

Quantitative/Qualitative problem solving in symbol representation

formats, are crucial. It is well known that the application of quantitative strategy (manipulation of equations for attempting problems) does not imply comprehension of concepts presented in the tasks as well as the underlying physics principles of the equations used. According to the Johnson-Laird cognitive framework of sense making [45], it is argued that comprehension occurs with the construction of a mental model which is a key element in the learning process [46,47]. However, although the application of external representations promotes the construction of a mental model, the strategies used by the students when attempting tasks with different representational formats play a crucial role. The study by Greca and Moreira [48] characterized students with a mental model as focusing on comprehension and identifying physics ideas, using a qualitative appr

ing visual repr
with the equati
problem solving
taught and pro
various ways i
representations
on the use of q
central role of v
ing as well as f
be highlighted.
constructing m
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Moreover, the
with the differ
decoding, inter
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across different
These are some
et al. [17] whic

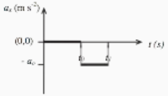

FIG. 1. Kinematic task with graphical format requesting qualitative solution.

immediately apply the brakes and your car starts slowing down at 0.8 m s^{-2}. Determine whether a collision will take place.

Specific strategies to assess students' understandings

ACKNOWLEDGMENTS

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APPENDIX A

Question 1: Kinematics—Qualitative—Symbolic

The equation of motion for an object moving along a straight horizontal path is given by

$$x(t) = 30 + 5t + 2t^2$$

Write down, in words, everything you can say about the motion of the object.

Question 2: Kinematics—Quantitative—Linguistic

You are driving at a speed of 60 m s^{-1} when suddenly you see a van 60 m directly ahead of you also travelling in the same direction at a constant speed of 40 m s^{-1}. You

Question 6: Work—Qualitative—Symbolic

Write down everything you can say from the force equation $\vec{F}(x) = (-4 + x^2)\,\hat{i}$ N applied to move the box from an initial position of 0 m to final position of 4 m.

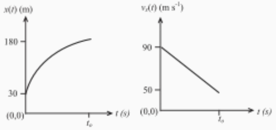


FIG. 2. Kinematic task with graphical format requesting quantitative solutions.

The equation of motion for an object moving along a straight horizontal path is found to be

$$v_x(t) = 3 + 2t$$

If the object was in motion for 5 s, what is the distance travelled and acceleration during this time?

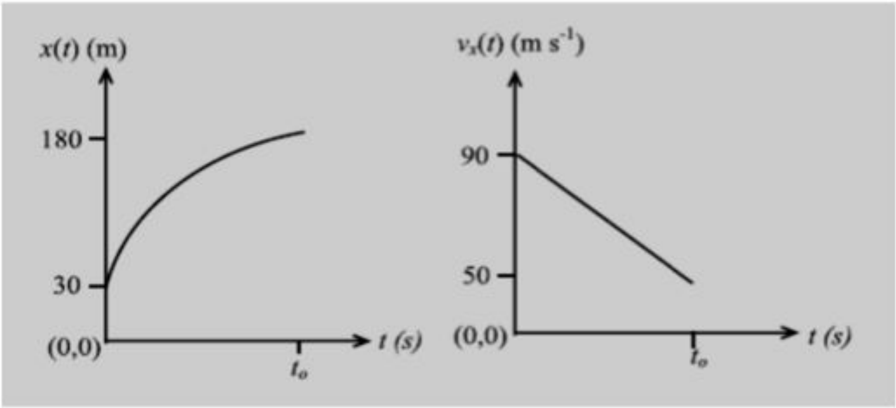
The equation of motion for an object moving along a straight horizontal path is given by

$$x(t) = 30 + 5t + 2t^2$$

Write down, in words, everything you can say about the motion of the object.

(Ibrahim & Rebello, 2012) (Saputra et al. 2019)

Quantitative/Qualitative problem solving in Graphic representation



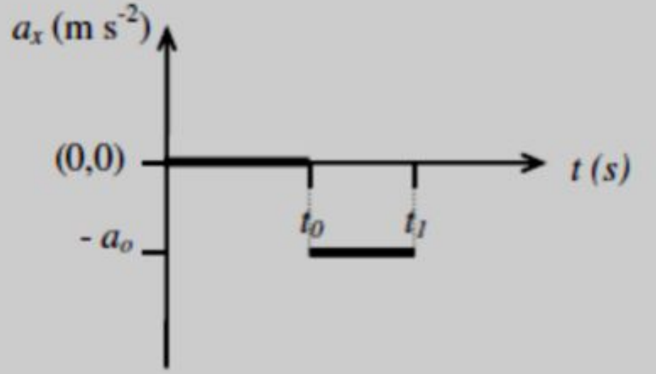
The motion of a truck along a straight horizontal path is shown by the graphs below. Determine the time taken and acceleration of the truck to complete the whole journey

Specific strategies to assess students' understandings

(Ibrahim & Rebello, 2012) (Saputra et al. 2019)

The acceleration-time graph for an object moving along a straight horizontal path is shown in Fig. 4.

Write down, in words, everything you can say about the motion of the object



Questionnaire on Kinematics

https://nhrhs.instructure.com/files/6518/download?download_frd=1

More recently

Knowledge of students' prior understandings

(1) In the stationary objects resultant force is not zero

(2) The average velocity is equal to the average speed

(3) Can not distinguish between acceleration and velocity

(4) The normal force is always equal to gravity and always a straight line

(5) Difficulty on constant velocity → no force

(Isnaini, 2015)