Kinematics

NJ-OER TOPIC-2

Learning Outcomes

Recognize the definition of velocity and acceleration and their vector nature

Identify the mathematical quantities which effect the kinematics and be able to calculate distance travelled, final velocity, and acceleration from given quantities

Define gravitational acceleration, indicate its units and relate its significance to projectile motion in 1-D

Identify motion parameters of a system of two objects and predict meeting time, velocity at the time of meeting or the distance between the objects

Understand the graphical interpretation of the motion

Concepts

xf = final position in x
xi = initial position in x
tf =final time
ti = initial time
vavg = average velocity
a = average acceleration
Δ x = displacement in x
vo = initial velocity
t = time or duration
a= constant acceleration
vf =final velocity

Δ y = displacement in y

Δ y is negative if the object moves downward

voy = initial velocity in y
vfy = final velocity in y

g= gravitational acceleration

Units

Position and displacement are in meters “m”
Velocity and speed are in “m/s”
Acceleration is in “m/s^2”
Time is in seconds

Formulas

$\Delta x = vot + 1/2at^2$

$vf = vo + at$

$vf^2 = vo^2 + 2a\Delta x$

$\Delta y = vot - 1/2gt^2$

$v = vo - gt$

$vf^2 = vo^2 - 2g\Delta x$

$g = 9.8\ m/s^2$

DISCLAIMER

All the motion parameters can be negative except time

Gravitational acceleration is a positive quantity yet it's in the –y direction

KEY STRATEGIES

Draw the motion diagram

Extract values from the word problem

Identify the unknowns

Find the right starting equation

Plug in the values and do the algebra

There are 5 variables and 3 equations. Each equation is missing one variable.

$\Delta x = vot + 1/2at^2$

This equation can't be used for finding vf

$vf = vo + at$

This equation can't be used for finding Δx

$vf^2 = vo^2 + 2a\Delta x$

This equation can't be used for finding t

KEY WORDS THAT IMPLIES NUMBERS

- Constant velocity or constant speed in 1-D, implies a=0
- At rest implies vo=0
- Stops implies vf=0

1-D Motion in x, timeless equation of motion

Q1) A bike moving with 6.0 m/s suddenly hits the break and stops in 12 meters.

What was its acceleration?

What would be the stopping distance if acceleration was doubled?

1-D Motion in x

Q2) A car is initially going East with 2.0 m/s accelerates with a rate of 1.2 m/s^2 for 5.0 seconds. A) What is the displacement?
B)What is the final velocity?

vo=2.0 m/s

t=5.0 s

a=1.2 m/s^2

Δx=? vf=?

ACTIVITY
1-D Motion in x

Q2) A red car is initially going with 2.0 m/s accelerates with a rate of 1.2 m/s^2 for 5.0 seconds.

A) What is the displacement?

B)What is the final velocity?

Open https://ophysics.com/k7.html

Set the blue car to
xo=200,vo=0,a=0

Set the red car to
to xo=0 vo=2 a=1.2

Hit "run" button and hit "pause" after 5 seconds. You may click step buttons to adjust. Observe the motion.
Compare simulation's results with your results

SELF ACTIVITY
1-D Motion in x

Open https://ophysics.com/k7.html

Repeat the activity with various motion parameters. Calculate the displacement and the final velocity? Run the simulation and compare

Q3a) A red car is initially going with 4.0 m/s slows down with a rate of 0.4 m/s^2 for 4.2 seconds. Hint: Slow down means a has opposite sign as vo

Q3b) A red car initially at rest accelerates with 2.2m/s^2 for 2.5 seconds

Q3c) A red car initially going with 4.2 m/s stops in 2.0 seconds. (Find a first)

Q3d) xo= 0 m vo=5.2 m/s a=-2.1 m/s^2 t=3.2 t

Q3e) Come up with your own problems. Change the motion parameters and run the simulation. Compare your calculations with the simulation.

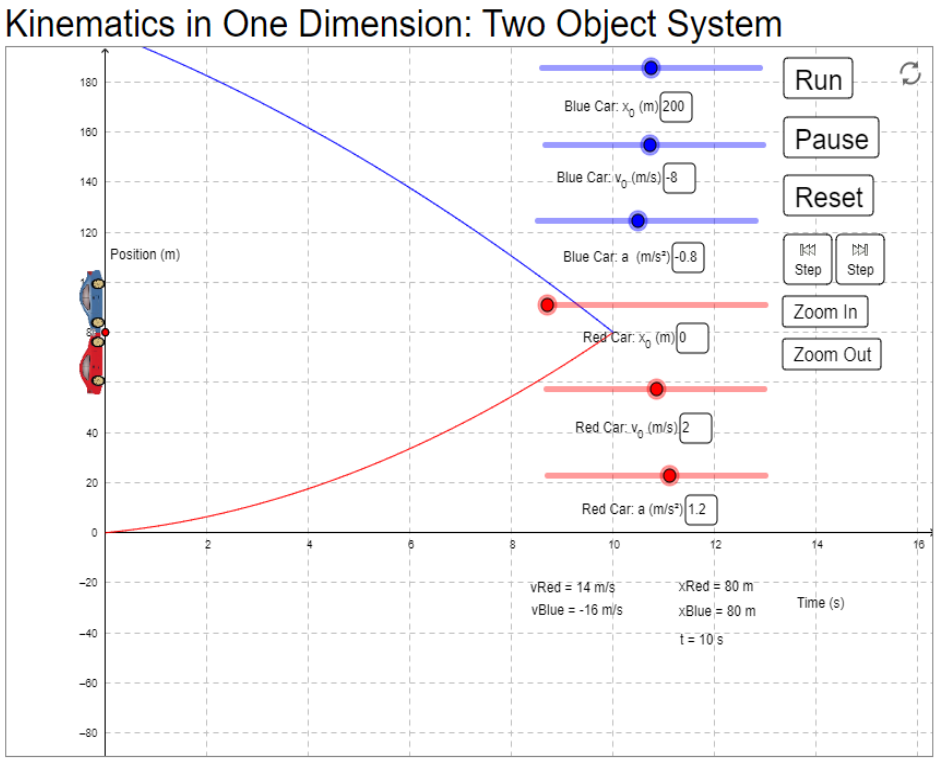
ACTIVITY OPHYSICS SIMULATION
2 OBJECT SYSTEMS

Q4) A red car is initially going with 2.0 m/s accelerates with a rate of 1.2 m/s^2 .

A blue car initially going with 8.0 m/s in the opposite direction accelerates with 0.8 m/s^2. Blue car d=200 meters ahead

When will they meet? Solve for t

What are their velocities when they meet?



Quadratic Equation

Solution t=10 seconds. v1f=14m/s v2f=-16m/s

This problem can be simulated using ophysics
https://ophysics.com/k7.html

SELF ACTIVITY OPHYSICS SIMULATION
2 OBJECT SYSTEMS

Make your own problems by changing a1,a2,v1o,v2o and d

Q5) A red car is initially going with v1o accelerates with a rate of a1 .

A blue car initially going with v2o m/s in the opposite direction accelerates with a2 m/s^2. Blue car "d" meters ahead

When will they meet? Solve for t, you may use quadratic solver

What are their velocities when they meet?

Solve the problem and compare it with the simulation

https://ophysics.com/k7.html

Keyword Wordle

REFERENCES

- References:
- Slide 1: Adobe id=187545875 bicycle rider in the city in motion blur By Christian Müller
- Slide 13: Screenshot from Ophysics and Geogebra by Tom Walsh
- Slide 15: Edwordle by 2017 Yunhai Wang
- Open Stax College Physics online textbook