Blank Activity Template

Yellow highlight = required component

Subject Area(s) Physics

Associated Unit Kinematics

Associated Lesson Kinematics in the Immune System Microenvironment

Activity Title Modeling Immune System Cell 2-Dimensional Motion

Header Insert Image 1 here

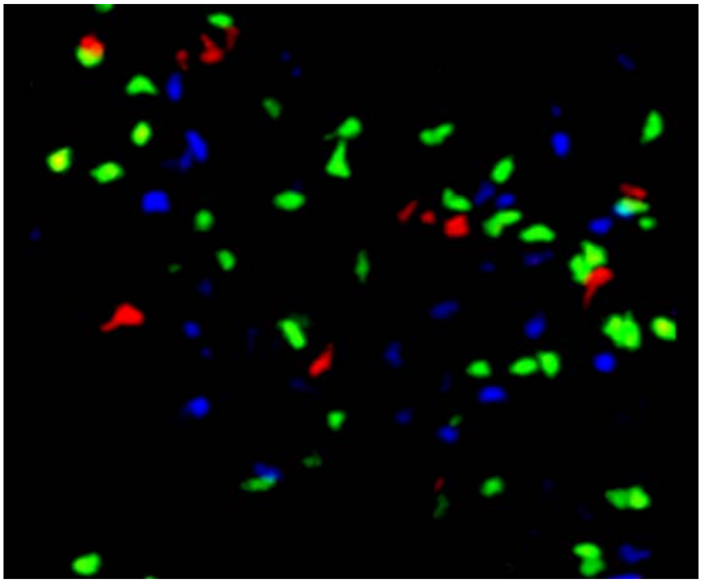
Image 1

Image file: immune_cells.jpg

ADA Description: Image from a fluorescence microscopy movie showing different types of immune cells

Source/Rights: Copyright © http://labs.idi.harvard.edu/vonandrian/Pages/Henricksonvideos-NI.htm

Caption: Antigen-specific P14T cells (green), control OT-I T cells (blue), DC cells (red)



Grade Level 11 (10-12)

Activity Dependency

Time Required 20 minutes

Group Size

Expendable Cost per Group US$___

Summary

In this activity, the students will learn how the kinematics equations learned in the classroom can be applied to real life problems. More specifically, the students will play the role of biomedical engineers by analyzing datasets involving the motion of immune system cells. The analysis procedure involves calculations of motion parameters i.e. velocity and acceleration, graphing and finally modeling cell motion patterns using the kinematics equations.

Engineering Connection

Many types of engineering disciplines use the concepts of physics in their applications, in our case “kinematics”. As a matter of fact, there is a fine line between applied physics and engineering. Mechanical and robotic engineers use kinematics to describe the motion of systems such as engines or robotic arms. Biomedical engineers use their knowledge of kinematics to model motion patterns of macro and micro-organisms such as birds, worms, cells...Etc.

Engineering Category = #1

Choose the category that best describes this activity's amount/depth of engineering content:
1. Relating science and/or math concept(s) to engineering
2. Engineering analysis or partial design
3. Engineering design process

Keywords
Biomedical engineer, speed, velocity, distance, displacement, acceleration, T-cells, cancer cells.

Educational Standards
Texas TEKS

Pre-Requisite Knowledge
algebra, physics skills and familiarity with Microsoft excel.

Learning Objectives
After this activity, students should be able to:

Apply the kinematics equations to immune system cell motion.

Materials List
Each group needs:
- A computer with Microsoft Excel.

To share with the entire class:
- None

Introduction / Motivation
You are a biomedical engineer who works freelance. You just signed a contract with one of the major research labs in the country. You are asked to work with a biologist who is currently studying the effects of injecting a newly designed drug for curing cancer. You will be given data consisting of measurements of moving cells and you will be asked to analyze and quantify the motion patterns of these cells.

Vocabulary / Definitions
Word	Definition

Procedure
Background

Students will be given four different (simulated) datasets containing 2-dimensional coordinates of cell position as a function of time. The students will calculate and graph cell motion parameters i.e. velocity versus time and acceleration versus time for different types of cells.

Before the Activity
- Explain to the students that an immunologist gave us datasets containing x-y positions of four immune cells at different time instants. Initially the cells were located at different positions on the x-y plane at time t=0. After injecting a drug, the cells sensed the presence of a cancer cell located at the origin (x,y) = (0,0), so presumably, the cells started moving towards the origin. The immunologist wants you (the students) to calculate the speed and acceleration of each cell and then describe to him what kind of motion does each cell exhibit.

With the Students

1. Ask the students to graph x-y positions for the four cells in the same graph, the result should look like Figure 1 (a) where each color represents a different cell.
2. From your graph in Figure 1 (a), can you say which cell made it to the origin, in other words to the cancer cell and which didn't?
3. Ask the students to calculate the velocity along the x-direction and the y-direction for each cell assuming the initial velocities at t=0 were 0.
4. Ask the students to graph the velocity along the x-direction of the four cells in the same graph, then do the same with the velocity along the y-direction; the graphs should look like the ones in Figure 1 (b) and (c).
5. From your graphs, specify which cells have a constant, increasing or decreasing velocity as a function of time?
6. Ask the students to calculate the acceleration along the x-direction and the y-direction for each cell assuming the initial accelerations at t=0 and t=1 were 0.
7. Ask the students to graph the acceleration along the x-direction of the four cells in the same graph, then do the same with the acceleration along the y-direction; the graphs should look like the ones in Figure 1 (d) and (e).
8. Again from your graphs, specify which cells have a constant, increasing or decreasing acceleration as a function of time?
9. What can you conclude about each cell motion?
10. Write the kinematics equation for each cell along both directions x and y using the measurements you calculated in the previous questions.

Image Insert Image # or Figure # here (use Figure # if referenced in text)

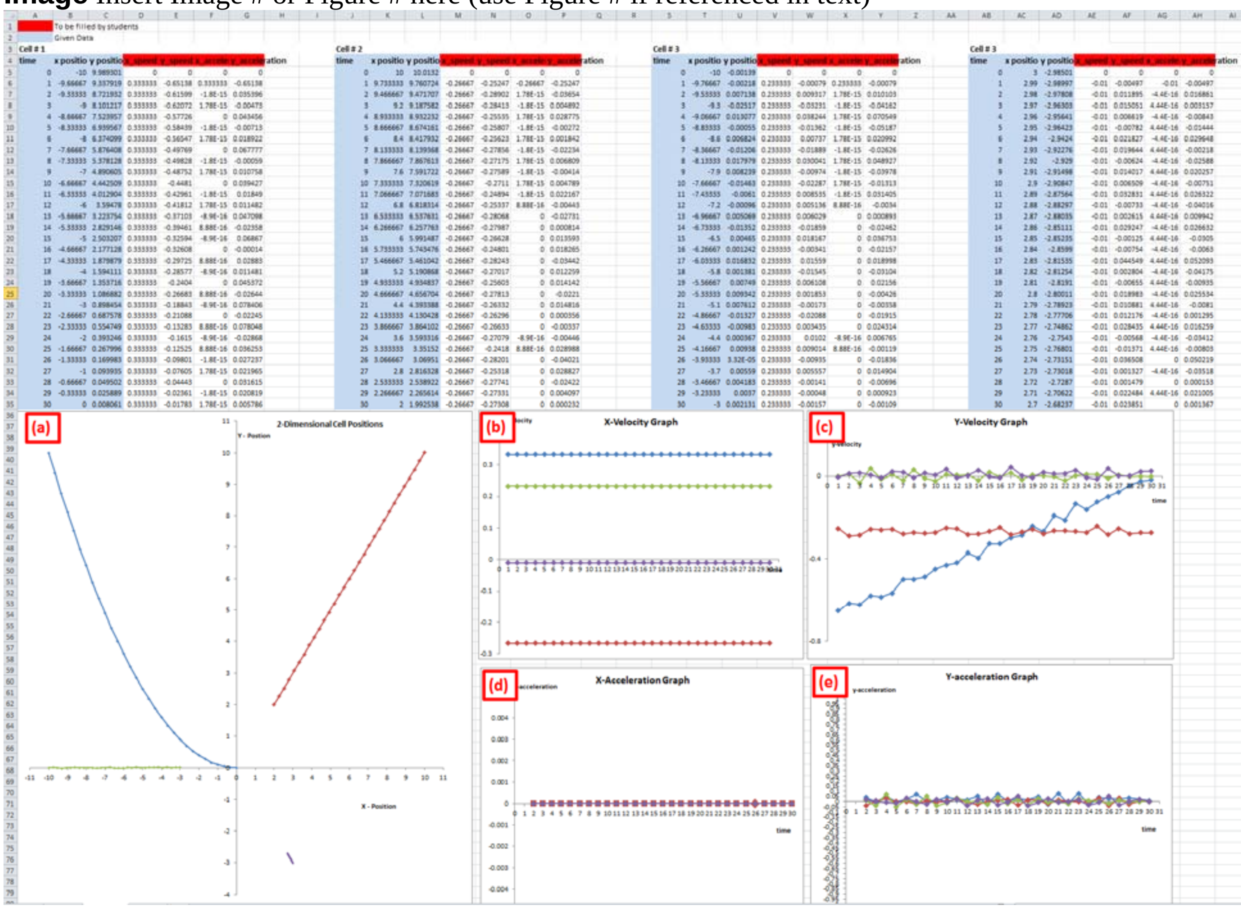


Figure 1 **Image file:** kinematics_graphs.jpg **ADA Description:** Image showing a snapshot of data analysis results of simulated cell motion. **Source/Rights:** Copyright © University of Houston **Caption:** Figure 1: (a) 2-Dimensional Cell Position Graph, (b) and (c) velocity-time graph along the x and y-directions respectively, (d) and (e) acceleration-time graph along the x and y-directions respectively.

Attachments

Kinematics Data (xlsx)

Safety Issues

-

Troubleshooting Tips

Investigating Questions

Assessment

Pre-Activity Assessment

Brainstorming: Discuss how an engineer can use his skills to model the motion of cells.

Activity Embedded Assessment

Class Discussion: While looking at a movie of moving cells, discuss which cells can be classified as accelerating, having constant speed or not moving at all.

Post-Activity Assessment

Writing: The students will write a brief technical report describing their analysis using kinematic equations.

Activity Extensions

This activity could be extended using different datasets with different motion parameters, it could also be used outside the context of cell biology, for instance one can use datasets consisting of position of cars in a city acquired through satellite imaging.

Activity Scaling

- For lower grades, this activity can be conducted by a group of two.
- For upper grades, this activity can be conducted by a group of one.

Additional Multimedia Support

None

References

Immune cell movies: Von Andrian Lab, CBR Institute Harvard Medical School, http://labs.idi.harvard.edu/vonandrian/Pages/Henricksonvideos-NI.htm

Killer T-cell attacking Cancer cell movie: http://www.youtube.com/watch?v=jgJKaP0Sj5U

Rachel Howser, Christine Hawthorne: Hands-on Activity: Magical Motion

http://www.teachengineering.org/view_activity.php?url=collection/uoh_/activities/uoh_hp_motion/uoh_hp_activity_motion.xml

Other

None

Redirect URL

None

Contributors

Amin Merouane, Roberto Dimaliwat

Supporting Program

National Science Foundation GK-12, University of Houston

Classroom Testing Information