Unit Plan SPH3U – Kinematics

For this unit students will learn kinematics. Kinematics is the study of objects in motion without considering the cause of these motions (forces) which is covered in another unit. This unit will be essential to understanding energy and momentum in grade 12 physics. Students will begin by learning the difference between position and distance by understanding the fundamental principles of scalars and vector quantities and apply this to speed and velocity. The drawing of position-time and velocity-time graphs can be very useful in determining the characteristics of an objects motion and will be essential to deriving the kinematic equations of motion. These equations are very useful with a wide range of applications in 1-D and 2-D. We will apply these equations to projectile motion problems. We will conduct lab experiments and activities to solidify the concepts that will be taught.

Achievement Chart

Knowledge and Understanding

- Knowledge of content
- Understanding of content

Thinking and Investigation

- use of initiating and planning skills and strategies
- use of processing skills and strategies
- use of critical/creative thinking processes, skills, and strategies

Communication

- expression and organization of ideas and information in oral, visual, and/or written forms
- communication for different audiences and purposes in oral, visual, and/or written forms
- use of conventions, vocabulary, and terminology of the discipline in oral, visual, and written forms

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Application

- application of knowledge and skills in familiar contexts
- transfer of knowledge and skills to unfamiliar contexts
- making connections between science, technology, society, and the environment
- proposing courses of practical action to deal with problems relating to science, technology, society, and the environment

Learning Skills

<table>
<thead>
<tr>
<th>Responsibility</th>
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</thead>
<tbody>
<tr>
<td>Responsibility</td>
<td>Completes and submits class work, homework, and assignments according to agreed-upon timelines;</td>
</tr>
<tr>
<td></td>
<td>Takes responsibility for and manages own behaviour.</td>
</tr>
<tr>
<td>Organization</td>
<td>devises and follows a plan and process for completing work and tasks;</td>
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<tr>
<td></td>
<td>establishes priorities and manages time to complete tasks and achieve goals;</td>
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<tr>
<td></td>
<td>Identifies, gathers, evaluates, and uses information, technology, and resources to complete tasks.</td>
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<tr>
<td>Independent Work</td>
<td>independently monitors, assesses, and revises plans to complete tasks and meet goals;</td>
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<tr>
<td></td>
<td>uses class time appropriately to complete tasks;</td>
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<tr>
<td></td>
<td>Follows instructions with minimal supervision.</td>
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<tr>
<td>Collaboration</td>
<td>accepts various roles and an equitable share of work in a group;</td>
</tr>
<tr>
<td></td>
<td>responds positively to the ideas, opinions, values, and traditions of others;</td>
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<td></td>
<td>builds healthy peer-to-peer relationships through personal and media-assisted interactions;</td>
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<tr>
<td></td>
<td>works with others to resolve conflicts and build consensus to achieve group goals;</td>
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<tr>
<td></td>
<td>Shares information, resources, and expertise and promotes critical thinking to solve problems and make decisions.</td>
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<tr>
<td>Initiative</td>
<td>looks for and acts on new ideas and opportunities for learning;</td>
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<td></td>
<td>demonstrates the capacity for innovation and a willingness to take risks;</td>
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<td></td>
<td>demonstrates curiosity and interest in learning;</td>
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<td></td>
<td>approaches new tasks with a positive attitude;</td>
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<td></td>
<td>recognizes and advocates appropriately for the rights of self and others.</td>
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<tr>
<td>Self-Regulation</td>
<td>sets own individual goals and monitors progress towards achieving them;</td>
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</tbody>
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Mark Breakdown

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Achievement Chart Category</th>
<th>Percentage of Final Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labs + Write-ups</td>
<td>Application, Communication</td>
<td>25%</td>
</tr>
<tr>
<td>Homework Completion</td>
<td>Knowledge/Understanding, Application, Communication</td>
<td>10%</td>
</tr>
<tr>
<td>Tests, Quizzes</td>
<td>Knowledge/Understanding, Application, Communication</td>
<td>20%</td>
</tr>
<tr>
<td>Research + Presentations</td>
<td>Application, Communication, Thinking/Investigation</td>
<td>15%</td>
</tr>
</tbody>
</table>

Strand Analysis

Overall Expectation

B1. Analyse technologies that apply concepts related to kinematics, and assess the technologies’ social and environmental impact;

B2. Investigate, in qualitative and quantitative terms, uniform and non-uniform linear motion, and solve related problems;

B3. Demonstrate an understanding of uniform and non-uniform linear motion, in one and two dimensions.

<table>
<thead>
<tr>
<th>Exp.</th>
<th>Expectation</th>
<th>Importance</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>analyse, on the basis of research, a technology that applies concepts related to kinematics</td>
<td>Medium</td>
<td>Some students who are interested in pursuing an Engineering program in College/University may be interested in studying the applications of kinematics in everyday life.</td>
</tr>
<tr>
<td>1.2</td>
<td>assess the impact on society and the environment of a technology that applies concepts related to kinematics</td>
<td>Medium</td>
<td>May only be interesting for students who are planning to pursue a science degree</td>
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<tr>
<td>2.1</td>
<td>use appropriate terminology related to kinematics, including, but not limited to: <em>time, distance, position, displacement, speed, velocity, and acceleration</em></td>
<td>Low</td>
<td>This is an important expectation but this will be taught on an ongoing basis since it relates to 2.2-2.9.</td>
</tr>
<tr>
<td>2.2</td>
<td>analyse and interpret position–time, velocity– time, and acceleration–time graphs of motion in one dimension</td>
<td>High</td>
<td>Ensuring students understand this expectation is vital for the course. It is necessary for the derivation and application of the kinematic equations</td>
</tr>
<tr>
<td>2.3</td>
<td>use a velocity–time graph for constant acceleration to derive the equation for average velocity</td>
<td>Medium</td>
<td>This is an important concept but can be taught with 2.2.</td>
</tr>
<tr>
<td>2.4</td>
<td>conduct an inquiry into the uniform and non-uniform linear motion of an object</td>
<td>Medium</td>
<td>This is important to help illustrate the difference between uniform and non-uniform motion. Can be done through a demo.</td>
</tr>
<tr>
<td>2.5</td>
<td>solve problems involving distance, position, and displacement</td>
<td>High</td>
<td>Very important to help illustrates the differences between scalar (distance) and vector (position/displacement) quantities</td>
</tr>
<tr>
<td>2.6</td>
<td>plan and conduct an inquiry into the motion of objects in one dimension, using vector diagrams and uniform acceleration equations</td>
<td>Medium</td>
<td>This can be combined with 2.5</td>
</tr>
<tr>
<td>2.7</td>
<td>solve problems involving uniform and non-uniform linear motion in one and two dimensions, using graphical analysis and algebraic equations</td>
<td>High</td>
<td>Combines several aspects of Kinematics; some strategies may be more effective for problem-solving. This links to 2.8</td>
</tr>
<tr>
<td>2.8</td>
<td>use kinematic equations to solve problems related to the horizontal and vertical components of the motion of a projectile</td>
<td>High</td>
<td>Extremely important. These problems vary in complexity, so students can get a lot of practice with problem-solving and the skills learned are important for 12U physics</td>
</tr>
</tbody>
</table>
2.9 conduct an inquiry into the projectile motion of an object, and analyse, in qualitative and quantitative terms, the relationship between the horizontal and vertical components | High | This is an important activity to make projectile motion less abstract. Helps them to “visualize” projectile motion and its variety of applications (eg. sports)

3.1 distinguish between the terms constant, instantaneous, and average with reference to speed, velocity, and acceleration, and provide examples to illustrate each term | Low | This can be taught with other expectations (2.2, 3.2, 2.7)

3.2 distinguish between, and provide examples of, scalar and vector quantities as they relate to the description of uniform and non-uniform linear motion | High | This is a very important concept that will create valuable skills for higher level maths and physics.

3.3 describe the characteristics and give examples of a projectile’s motion in vertical and horizontal planes | Low | This can be taught with 2.9

### Daily Plan

<table>
<thead>
<tr>
<th>Topic</th>
<th># of Classes</th>
<th>Exp.</th>
<th>Success Criteria</th>
<th>Instructional Strategy</th>
<th>Assessment</th>
</tr>
</thead>
</table>
| Math Review    | 5            |      | - Students will demonstrate their proficiency in linear and quadratic functions, trigonometry (Pythagorean Theorem, sine law) | - Lecture  
- Diagnostic Quiz (algebra and trigonometry)  
- Review basic math operations (rearrange equations, factor and expanding, graphing equation of a line, quadratics, scientific notation)  
- Homework: Example problems | Formative – Class performance and terminology, diagnostic testing of their math skills.  
Summative – Math quiz at end of the week |
### Distance, Position, and Displacement

- **Nelson Physics 11**
- B2.1, B2.5, B3.2
- Explain how distance, position, and displacement are different
- Explain the difference between scalars and vectors
- Calculate the displacement of an object algebraically and by a vector scalar diagram

- Lecture
- Simulation: [Link](https://www.upscale.utoronto.ca/GeneralInterest/Harrison/Flash/ClassMechanics/DisplaceDistance/DisplaceDistance.htm)
- Exit ticket (Knowledge and Understanding)
- MI: Logical, Spatial, Intrapersonal
- Homework: Example problems

### Speed and Velocity

- **Nelson Physics 11**
- B2.1, B3.1, B3.2
- Explain how speed and velocity are different
- Explain the relationship between velocity, displacement, and time
- Determine velocity from position-time graph
- Explain the difference between scalars and vectors

- Lecture
- Activity/Demo – roll an object a long a desk for 3 m and record the time at 20 cm intervals. Have student’s plot the data to determine the slope and verify if the speed is constant.
  - Ball
  - 3 metre sticks
  - Timer
  - Graph paper
  - Handout (Communication and Thinking/Inquiry)
- Exit ticket (Knowledge and Understanding)
- MI: Logical, Spatial, Kinesthetic, Interpersonal, Intrapersonal

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**Formative** – Class performance and terminology

**Summative** – Activity handout
<table>
<thead>
<tr>
<th>Week</th>
<th>Activity Details</th>
<th>Homework: Textbooks</th>
<th>Homework: Example problems</th>
<th>Formative – Class performance and terminology</th>
</tr>
</thead>
</table>
| 3    | **Acceleration** *(Nelson Physics 11)*  | B2.1, B3.1, B3.2    | - Explain the relationship between acceleration, velocity, displacement, and time  
- Determine acceleration from velocity-time graph  
- Determine the difference between average velocity and instantaneous velocity  | - Lecture  
- Exit ticket (Knowledge and Understanding)  
- MI: Logical, Spatial, Intrapersonal  
- Homework: Example problems  | Formative – Class performance and terminology |
| 4    | **Comparing Graphs of Linear Motion** *(Nelson Physics 11)*  | B2.2, B3.1    | - Obtain information from position-time, velocity-time, and acceleration-time graphs  
- Realize that given one type of motion graph, they can construct a different type of graph  | - Lecture  
- Simulation: [http://faraday.physics.utoronto.ca/PVB/Harrison/Flash/ClassMechanics/MotionDiagram/MotionDiagram.html](http://faraday.physics.utoronto.ca/PVB/Harrison/Flash/ClassMechanics/MotionDiagram/MotionDiagram.html)  
- Exit ticket (Knowledge and Understanding)  
- MI: Logical, Spatial, Intrapersonal  
- Homework: Example problems  | Formative – Class performance and terminology |
| 5    | **Five Key Equations for Motion with Uniform Acceleration**  | B1.1, B2.3, B2.4  | - Derive the 5 key equations of motion  
- Solve uniform velocity and uniform acceleration using algebraic methods  | - Lecture  
- Activity/Demo: toss a ball into the air and perform a video analysis of the motion. Compare results to the kinematic equations  
  - Computer with tracker software  
  - Metre stick  
  - Red ball  
  - Handout (Communication and Thinking/Inquiry)  | Formative – Class performance and terminology  
  Summative – Activity handout |
| 6 | Acceleration Near Earth’s Surface (Nelson Physics 11) | 3 | B1.1, B2.6 | - Understand that the symbol of \( g \) is used to represent the acceleration due to gravity. Describe how the acceleration due to gravity affects the motion of objects close to the surface of Earth.  
- Describe how the acceleration due to gravity affects the motion of objects close to the surface of Earth (\( g = 9.8 \text{ m/s}^2 \)).  
- Understand the concept of terminal velocity. | - Exit ticket (Knowledge and Understanding)  
- MI: Logical, Spatial, Kinesthetic, Interpersonal, Intrapersonal  
- Homework: Example problems  
- Lecture  
- Simulation: [http://www.upscale.utoronto.ca/GeneralInterest/Harrison/Flash/ClassMechanics/TwoBallsGravity/TwoBallsGravity.html](http://www.upscale.utoronto.ca/GeneralInterest/Harrison/Flash/ClassMechanics/TwoBallsGravity/TwoBallsGravity.html)  
- Activity/Demo: Drop a ball from a height of 1 metre and perform a video analysis to demonstrate gravity’s acceleration.  
  - Computer with tracker software  
  - Red ball  
  - Metre stick  
  - Handout (Communication and Thinking/Inquiry)  
- Exit ticket (Knowledge and Understanding)  
- MI: Logical, Spatial, Kinesthetic, Interpersonal, Intrapersonal  
- Homework: Example problems | Formative – Class performance and terminology  
Summative – Activity handout |
| 7 | Toy Car on a ramp lab | 1 |  | - Construct ticker tape experiment to explain the motion of a moving car.  
- Construct and obtain information from motion graphs. | - Lab: Students will release a toy car down a ramp attached to a ticker tape. Multiple runs at different ramp elevations.  
  - Masking tape  
  - Ticker-tape and ticker-tape timer  
  - Books  
  - 2 m ramp | Formative - Group collaboration and performance  
Summative - Lab report write up |
### Motion in two Dimensions

**Lesson:** Motion in two Dimensions  
**Textbook:** *Nelson Physics 11*  
**Sections:** B2.5, B2.7

<table>
<thead>
<tr>
<th>Topic</th>
<th>Grade</th>
<th>Textbook</th>
<th>Standards</th>
<th>Description</th>
<th>Materials</th>
<th>Exit Assessment</th>
<th>MI</th>
<th>Homework</th>
<th>Assessment</th>
<th>Additional Notes</th>
</tr>
</thead>
</table>
| 8     | 4     | B2.5, B2.7 |  | - Describe how to determine total displacement in 2-dimensions by scalar diagram and by component method  
- Solve problems that involve moving in 2-dimensions  
- Lecture  
- Activity/Demo: Have students (in groups) walk a path of their choice around the classroom. Have them measure the distance, displacement, and position of their final location. Have students graph their “waypoints” on paper.  
  - Metre stick  
  - Graph paper  
  - Handout (Communication and Thinking/Inquiry)  
- Exit ticket (Knowledge and Understanding)  
- MI: Logical, Spatial, Kinesthetic, Interpersonal, Intrapersonal  
- Homework: Example problems | Formative – Class performance and terminology  
Summative – Activity handout |

**Homework:** Example problems

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### Projectile Motion

**Lesson:** Projectile Motion – 1  
**Textbook:** *Nelson Physics 11*  
**Sections:** B1.1, B2.8, B3.3

<table>
<thead>
<tr>
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<th>MI</th>
<th>Homework</th>
<th>Assessment</th>
<th>Additional Notes</th>
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</thead>
</table>
| 9     | 3     | B1.1, B2.8, B3.3 |  | - Determine the factors affecting projectile motion (angle, launching velocity, initial height, gravity, etc.)  
- Lecture  
- Simulation/Activity (Homework worksheet, Knowledge and Understand, Communication, Thinking/Inquiry) [https://phet.colorado.edu/en/simulation/projectile-motion](https://phet.colorado.edu/en/simulation/projectile-motion)  
- Exit ticket (Knowledge and Understanding)  
- MI: Logical, Spatial, Interpersonal, Intrapersonal  
- Homework: Example problems | Formative – Class performance and terminology |

**Homework:** Example problems

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| 10 | Projectile Motion – 2 (*Nelson Physics 11*) | 3 | B1.1, B2.8, B3.3 | - Understand that projectile motion consists of independent horizontal and vertical motions  
   - Understand that the horizontal and vertical motions take the same amount of time  
   - Understand that projectiles move horizontally at a constant velocity, and undergo uniform acceleration vertically  
   - Solve problems related to the horizontal and vertical components of motion of a projectile using kinematic equations (determine the range, maximum height, and time of flight for a projectile’s motion) | - Lecture  
   - Activity/Demo: Have a student ride on a skate board (safety warning) across the room and toss a ball in the air. The ball should be caught by the student demonstrating constant horizontal velocity. Perform a video analysis to verify this concept.  
     o Skate board  
     o Red ball  
     o Computer with tracker software (optional)  
     o Metre stick  
     o Handout (Communication and Thinking/Inquiry)  
   - Exit ticket (Knowledge and Understanding)  
   - MI: Logical, Spatial, Kinesthetic, Interpersonal, Intrapersonal  
   - Homework: Example problems | Formative – Class performance and terminology  
Summative – Activity handout |

| 11 | Projectile Lab | 1 | B3. | - Demonstrate an understanding of projectile motion through launching an | - Lab: Students will construct a “ski jump” out of a tube that is about 1 m in height and release a ball bearing. The “jump” will consider different angles and students will be asked to measure the | Formative - Group collaboration and performance  
Summative - Lab report write up |
object by two methods
- Present a scientifically written lab report
distance traveled. The students are asked to find out the angle the best maximizes the range. Results will be compared to theoretical values. The velocity of the ball bearing will need to be given to the students. Also students will roll the ball off a desk and measure the trajectory
  - Pluming tube
  - Ball bearing
  - Protractor
  - Books for stands
  - Timer
  - Metre stick
  - Lab write up (Communication, Thinking/Inquiry, and Application)
- MI: Logical, Spatial, Kinesthetic, Interpersonal, Intrapersonal

| 12 | Review Class | 1 | B2. B3. | - Go over the key concepts of the unit
- Clarify any outstanding issues |
| 13 | Unit Test | 1 | All | - Individually students will write the unit test (Knowledge and Understanding, Communication, Thinking/Inquiry, and Application) | Summative – Unit test |

Accommodations
- Students will be accommodated and/or receive modified course material as outlined in their IEP
- Due dates and dates for the test will be negotiated with the class to help relieve some stress
- ELL students will be given extra time on tests and lab reports
References


Kinematics – Unit Test

Name: ___________________
Date: ___________________

Score: ___/67

Achievement Categories

Knowledge/Understanding [K/U]: ___/25 marks
Application [A]: ___/24 marks
Communication [C]: ___/8 marks
Thinking/Investigation [T/I]: ___/10 marks

1. Which of the following quantities are vectors, and which are scalars? Be sure to explain the reasoning for your answer. (4 marks)

(a) A bird flies a distance of 25 m. [K/U] (1 mark)
(b) A bus is travelling at 120 km/h due north. [K/U] (1 mark)

(c) It takes an athlete 10.52 s to run 105 m [K/U]. (1 mark)

(d) Which of these lines is steeper? Why? [K/U] (1 mark)

2. A subway train travels 72.8 km due west before stopping at the last station. It then travels 23 km due east. (4 marks)

(a) Draw a vector-scale diagram for this scenario [K/U] (2 marks)

(b) Calculate the train’s final displacement [K/U] (2 marks)

3. An eastbound Durham Transit bus travels to Oshawa Centre at 42.5 km/h and westbound toward Ajax at 30 km/h. (6 marks)

(a) What is the total speed of the bus? [K/U] (2 marks)
(b) What is the total velocity of the bus? [K/U] (2 marks)

(c) Sketch a position-time graph that represents the bus’s trip [A] (2 marks)

4. A brick is dropped from the roof of the Empire State Building, which is approximately 381 m high. (11 marks)
(a) What is the initial velocity of the brick? [K/U] (2 marks)

(b) How long does the brick take to reach the ground? [K/U] (2 marks)

(c) What is the final velocity of the brick? [K/U] (2 marks)

(d) How would the final velocity change if the initial velocity was changed? (increase/decrease) [C] (3 marks)

(e) Calculate the final velocity if the brick is thrown downwards with an initial velocity of 2.8 m/s. [A] (2 marks)
5. A Boeing 747 airplane takes off from Pearson International Airport and flies 23.6 km [S]. After encountering turbulence, the pilot alters the flightpath. The plane now travels 52.7 km [N 32° W]. (12 marks)

Note: You may use either the scalar diagram approach or the algebraic approach to solve this problem.

Scale: 1 cm = 10 km

(a) Draw a scale diagram to represent the plane’s flight path [A] (5 marks)

(b) Calculate the plane’s resultant displacement. [A] (7 marks)
6. A beanbag is thrown from a window 12.6 m above the ground with an initial horizontal velocity of 3.5 m/s. (14 marks)

(a) Draw a diagram that represents the beanbag's trajectory. Be sure to include all vectors and labels [C] (5 marks)

(b) How long will it take the beanbag to reach the ground? That is, what is its time of flight? [K/U] (4 marks)

(c) How far will the beanbag travel horizontally? That is, what is its range? [A] (5 marks)
7. A soccer player running on a level playing field kicks a soccer ball with a velocity of 10.2 m/s at an angle of 37.8° above the horizontal. Determine the soccer ball’s (6 marks)

(a) time of flight [K/U] (2 marks)

(b) range [K/U] (1 mark)

(c) maximum height [A] (3 marks)
8. A golfer is trying to improve the range of her shot. To do so she drives a golf ball from the top of a steep cliff, 30.0 m above the ground where the ball will land. If the ball has an initial velocity of 25 m/s and is launched at an angle of 50° above the horizontal, determine the ball’s time of flight, its range, and its final velocity just before it hits the ground. Figure 8 shows the motion of the golf ball. For this solution we will combine the horizontal and vertical given statements. [T/I] (10 marks)