Course: *Physics* **Unit #1:** Kinematics	**Year of Implementation:** 2023-2024

Curriculum Team Members
Matt Bush, mbush@lrhsd.org; Kyle Louis, klouis@lrhsd.org; Brian Mack, bmack@lrhsd.org; Jeffrey Thompson, jthompson@lrhsd.org

Stage One - Desired Results

Link(s) to New Jersey Student Learning Standards for this course:
https://www.state.nj.us/education/cccs/2020/
https://www.state.nj.us/education/cccs/2020/2020%20NJSLS-CLKS.pdf
https://www.nj.gov/education/standards/ela/Docs/2016NJSLS-ELA_Companion9-10.pdf
https://www.nj.gov/education/standards/ela/Docs/2016NJSLS-ELA_Companion11-12.pdf

- **Unit Standards:**
  - ***Content Standards***
    - HS-PS2-1 - Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration
  - ***21st Century Life & Career Standards***
    - 9.4.12.CI.1 - Demonstrate the ability to reflect, analyze and use creative skills and ideas
    - 9.4.12.IML.3 - Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions.
  - ***English Companion Standards***
    - RST.11-12.7 - Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
    - WHST.9-10.2 - Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
    - WHST.11-12.8 - Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific

task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation
    - WHST.9-10.9 - Draw evidence from informational texts to support analysis, reflection, and research

- ***Interdisciplinary Content Standards***
    - MP.2 - Reason abstractly and quantitatively.
    - MP.4 - Model with mathematics.
    - HSN-Q.A.1 - Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
    - HSN-Q.A.2 - Define appropriate quantities for the purpose of descriptive modeling.
    - HSN-Q.A.3 - Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
    - HSA-SSE.A.4 - Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

- ***NJ Statutes:*** NJ State law mandates the inclusion of the following topics in lesson design and instruction as aligned to elementary and secondary curriculum.

  Amistad Law: N.J.S.A. 18A 52:16A-88 Every board of education shall incorporate the information regarding the contributions of African-Americans to our country in an appropriate place in the curriculum of elementary and secondary school students.

  Holocaust Law: N.J.S.A. 18A:35-28 Every board of education shall include instruction on the Holocaust and genocides in an appropriate place in the curriculum of all elementary and secondary school pupils. The instruction shall further emphasize the personal responsibility that each citizen bears to fight racism and hatred whenever and wherever it happens.

  LGBT and Disabilities Law: N.J.S.A. 18A:35-4.35 A board of education shall include instruction on the political, economic, and social contributions of persons with disabilities and lesbian, gay, bisexual, and transgender people, in an appropriate place in the curriculum of middle school and high school students as part of the district's

implementation of the New Jersey Student Learning Standards (N.J.S.A.18A:35-4.36) A board of education shall have policies and procedures in place pertaining to the selection of instructional materials to implement the requirements of N.J.S.A. 18A:35-4.35.

Diversity and Inclusion (N.J.S.A. 18A:35-4.36a) A board of education shall incorporate instruction on diversity and inclusion in an appropriate place in the curriculum of students in grades kindergarten through 12 as part of the district's implementation of the New Jersey Student Learning Standards.

Asian American and Pacific Islanders (AAPI) P.L.2021, c.410 Ensures that the contributions, history, and heritage of Asian Americans and Pacific Islanders (AAPI) are included in the New Jersey Student Learning Standards (NJSLS) for Social Studies in kindergarten through Grade 12 (P.L.2021, c.416)

For additional information, see

NJ Amistad Curriculum: http://www.njamistadcurriculum.net/

Diversity and Inclusion: https://www.nj.gov/education/standards/dei/index.shtml

- *(Sample Activities/ Lessons): https://www.nj.gov/education/standards/dei/samples/index.shtml*

Asian American and Pacific Islanders:

- *Asian American and Pacific Islander Heritage and History in the U.S.*
  A Teacher's Guide from EDSITEment offering a collection of lessons and resources for K-12 social studies, literature and arts classrooms that center around the experiences, achievements and perspectives of Asian Americans and Pacific Islanders across U.S. history.

Transfer Goal: Students will be able to independently use their learning to design, employ, and refine a variety of models to describe and predict the motion of objects.

As aligned with LRHSD Long Term Learning Goal(s):

Students will be better able to:

- design, critique, and carry out experiments in order to investigate scientific questions and/or propose solutions.
- collect, interpret, and analyze data in order to solve a defined problem.
- apply mathematics to express relationships efficiently and accurately.
- draw evidence-based conclusions from data in order to make informed decisions.
- construct, interpret, and refine models (scientific and mathematical) to explain the physical and natural world.

Enduring Understandings Students will understand that. . .	*Essential Questions*
EU 1 the motion of objects moving in a straight line can be described both qualitatively and quantitatively by the use of equations, graphs, and other models.	*EU 1* ● What type of model best represents motion? ● How can understanding the properties about motion be useful in our everyday lives? ● How can gravity change the motion of an object?
EU 2 a projectile's motion can be modeled by considering its horizontal and vertical motion independently.	*EU 2* ● How do we qualitatively and quantitatively describe motion? ● Why is it necessary to have vector quantities? ● How does the motion of a falling bowling ball compare to a falling golf ball? ● What is the best way to throw a projectile for distance?
Knowledge *Students will know . . .*	*Skills* *Students will be able to. . .*

EU 1 ● a variety of models can be used to predict and show relationships among variables. (PS2.A) ● several computational models (kinematics equations) that can be used to predict the motion of an object under a variety of circumstances. ● the value of the variables in a science problem can be explicitly stated or implied (assumed). ● displacement is the overall change in position of an object and may differ from the total distance that it travels. ● average speed is the rate of change of the position of an object. ● average velocity is a vector quantity and is the rate of change of an object's displacement. ● acceleration is the rate of change of velocity. (PS2.A) ● a freely falling object accelerates at 9.8 m/s^2. (PS2.A) ● objects that accelerate in the opposite direction of their motion will slow down. (PS2.A) ● slope represents velocity on a position-time graph and acceleration on a velocity-time graph. ● the area under the curve of a velocity-time graph represents the displacement of an object. *EU 2* ● vectors are useful in physics to model two-dimensional motion.	*EU 1* ● describe the motion of an object in terms of its position, velocity and acceleration. ● develop and use models to illustrate the relationship among the fundamental variables of motion. (SEP2) ● use mathematical and computational thinking to determine the variables in a kinematics problem and select an appropriate equation to make predictions about an object's motion. (SEP5) ● employ graphs to model the motion of an object traveling at a constant speed. (SEP2) ● employ graphs to model the motion of an object that is accelerating uniformly. (SEP2) ● plan and carry out an investigation that determines the average speed of a moving object (pendulum, toy car, motor, person). (SEP3) ● analyze and interpret data gathered from a scientific investigation. (SEP4) *EU 2* ● use a graphical model to determine the sum of several vectors. (SEP2) ● employ mathematics and use computational thinking to calculate a vector's components. (SEP5)

● a resultant vector is a vector sum and can be determined both graphically and analytically. ● a vector's components are its projections along a set of defined axes. ● that in order to model projectile motion, the one-dimensional motion equations will be applied to each dimension separately. (PS2.A) ● the horizontal acceleration of a projectile is zero and its vertical acceleration is due to gravity. (PS2.A) ● a horizontally launched object will hit the ground at the same time as an object dropped vertically from that same height. ● that the launch angle affects the range of a projectile.	● use a mathematical model to determine the sum of two or more vectors analytically. (SEP2) ● construct an explanation for the independence in the horizontal and vertical motion of a projectile. (SEP6) ● depict projectile motion both graphically and mathematically. ● define the problem and design a solution to the task of predicting the motion of a projectile. (SEP6) ● evaluate the outcomes of a scientific investigation and construct an explanation for any unexpected results. (SEP6)
Stage Two - Assessment	
Stage Three - Instruction	

Learning Plan: **Suggested Learning Activities to Include Differentiated Instruction and Interdisciplinary Connections: Each learning activity listed must be accompanied by a learning goal of A= Acquiring basic knowledge and skills, M= Making meaning and/or a T= Transfer.** *{place A, M and/or T along with the applicable EU number in parentheses after each statement} All knowledge and skills must be addressed in this section with a corresponding lesson/activity which teaches each concept. The following color codes are used to notate activities that correspond with interdisciplinary connections and 21st Century Life & Career Connections (which involves Technology Literacy): Red = Interdisciplinary Connection; Purple = 21st Century Life & Career Connection*

PHENOMENON*:* Usain Bolt 100m Dash (A/M, EU1)
GOAL: Students will discover that an object's straight line motion can be described by mathematical quantities and graphical analysis.

1. Watch video of Usain Bolt's record breaking 100m dash
    - Describe this 100m of motion from the beginning to end.
        - Do this independently for a few minutes, then have a paired discussion. (A, EU1)
        - Name similarities and differences between Usain's dash and someone who is jogging for 100m. (M, EU1)
        - Consider graphing the motion: speed vs distance traveled, speed vs time, distance vs time (A/M, EU1)
        - Result: identify the different types of motion of objects in motion (T, EU1)
2. Identify student knowledge on graphing.
        - Students will create KWL charts about graphs. (A/M, EU1)
        - Teacher-led discussion on why graphs are useful and what information do we need to construct a graph. (A, EU1)
3. Students will analyze various position vs. time graphs (M, EU1)
4. Students will analyze various velocity vs. time graphs (M, EU1)
5. Relate back to phenomena of Usain bolt 100m graph (M/T, EU1)
    - Teacher-led steps in choosing the correct kinematic equation and calculating various variables. (A, EU1)
6. Activity: Students will determine the average speed and velocity of a fellow student who walks the length of a hallway and part of the way back. (M, EU1)
7. Activity: Buggy Car (constant speed vehicles) (A/M, EU1)
        - Graph the motion of the buggy car at different speeds (1 battery vs 2 batteries) (M, EU1)
        - Students must perform/act out a position vs time graph and velocity vs time graph in front of the class (T, EU1)

PHENOMENON: Bowling ball vs Feather - https://youtu.be/E43-CfukEgs (A/M, EU1)
GOAL: Students will investigate and discover that all objects in freefall undergo constant acceleration.

1. Perform demonstration of dropping a heavy object vs a light object in the classroom (ex: book vs paper). (A, EU1)

- Compare motions with each other. (M, EU1)
- Predict, observe, discuss. (M, EU1)

2. Watch video of bowling ball vs feather to understand the effect of air resistance on objects falling.
    - Refer back to Usain Bolt's motion graph (M, EU1)
    - Compare and contrast the position vs time graphs and velocity vs time graphs of the dropped objects to the motion of Usain Bolt. (M, EU1)
3. Discussion: How do we know objects accelerate toward the center of the earth? (A, EU1)
4. Students will view a slow-motion video or strobe photo of different objects dropped in a vacuum to verify that the acceleration due to gravity is constant. (A, EU1)
5. Students will apply kinematic equations by determining their reaction time using a dropped ruler. (T, EU1)
6. Refer back to phenomena: lead a discussion comparing horizontal motion with vertical motion. (M, EU1)
7. Students will develop a procedure for determining the height of a tall ceiling using just a ball and a stopwatch (or other objects). (T, EU1)
8. Laboratory Investigation: Design an experiment to determine the acceleration due to gravity. (T, EU1)

PHENOMENON*:* Any projectile motion launch such as those used in sports or launching a cannonball (M/T, EU 2)
GOAL: Students will investigate and discover that horizontal and vertical motion are independent.

1. Watch video of Evil Knievel jumping buses (or similar video). (A/M, EU2)
2. After showing an appropriate projectile launch video or demonstration, have student-led discussions on what they see. (M, EU2)
3. Have students write an explanation of what is happening. (M, EU2)
    - The concept of x,y motion being independent of one another needs to be emphasized.
4. Students will view a slow-motion video or strobe photo of a dropped object and a horizontally projected object in order to compare and contrast the motion. (A, EU2)
5. Students will apply horizontal and vertical equations to solve two-dimensional motion problems. (M, EU1, 2)

Additional suggested ideas:

- Students will model a projectile in flight using vectors (A/M, EU2)
    - Projectile Simulator Interactive
- Students will use a ballistic launcher to verify the time in the air of a dropped and horizontally launched projectile is the same. (M, EU2)

- Think, Pair, Share - Is there a scenario where an object can accelerate while traveling at a constant speed, but not at a constant velocity? (M, EU1)
- Jigsaw Activities - Worksheets on velocity, acceleration, half trajectory and full trajectory projectile motion problems (M, EU2)

Pacing Guide

Unit #	*Title of Unit*	*Approximate # of teaching days*
1	Kinematics	40
2	Newton's Laws & Forces	40
3	Energy	30
4	Electricity and Magnetism	40
5	Waves	30

Instructional Materials

A fully equipped physics lab including but not limited to the following:
PASCO equipment
constant speed vehicles
projectile launchers
pendulums
various types of balls: soccer, tennis, etc.
Physicsclassroom.com subscription for each student

Accommodations

Special Education: The curriculum will be modified as per the Individualized Education Plan (IEP). Students will be accommodated based on specific accommodations listed in the IEP.
Students with 504 Plans: Students will be accommodated based on specific accommodations listed in the 504 Plan.
English Language Learners: Students will be accommodated based on individual need and in consultation with the ELL teacher.
Students at Risk of School Failure: Students will be accommodated based on individual need and provided various structural supports through their school.
Gifted and Talented Students: Students will be challenged to enhance their knowledge and skills through acceleration and additional independent research on the subject matter.