**Honors Physics**
DATE OF APPROVAL

# Unit 1 - Kinematics and Newton's Laws

| STAGE 1 \| DESIRED RESULTS | | |
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| **Standards** | **Transfer** | |
| 3.2.9-12.I 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.<br><br>Forces and Motion Newton's second law accurately predicts changes in the motion of macroscopic objects. | *Students will be able to independently use their learning to…*<br>❑ Locate objects in a frame of reference and predict, using mathematical models, where they will be in the future.<br>❑ Predict, using mathematical models, changes in motion due to a net external force. | |
| | **Meaning** | |
| | UNDERSTANDINGS<br>*Students will understand that…*<br>❑ Motion is relative.<br>❑ Motion can be described using position, velocity, acceleration and time.<br>❑ Mathematical and graphical models can be used to describe and predict an object's motion.<br>❑ Force and net force are not the same.<br>❑ Net force affects the motion of a mass.<br>❑ An object's state of motion cannot change when there is no net force on a mass.<br>❑ Types of forces vary based on interactions between objects. | ESSENTIAL QUESTIONS<br>*Students will keep considering…*<br>❑ How can an object's motion be described and predicted?<br>❑ What causes objects to move in different ways?<br>❑ What causes objects to change the ways in which they move? |
| | **Acquisition(need to align with above and standards)** | |
| | *Students will know…*<br>❑ Definitions for frame of reference, position, displacement, distance, speed, velocity, and acceleration<br>❑ Definitions for linear and two dimensional motion (including freefall and projectile motion) | *Students will be skilled at…*<br>❑ Describe motion by generating graphs using observable data.<br>❑ Identify trends and sources of error using experimental data.<br>❑ Predict and explain everyday phenomena using equations and graphs derived from data. |

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| | ❑ Definitions of scalar and vector quantities<br>❑ SI units for distance, time, velocity, acceleration, force, mass, and weight<br>❑ Definition of a projectile (object launched with an initial velocity which travels through the air affected only by gravity; no air resistance)<br>❑ Definitions and examples of contact and field forces<br>❑ Newton's Laws of Motion<br>❑ Definition of net force<br>❑ Difference between mass and weight<br>❑ Definitions of types of forces | ❑ Analyze motion and make predictions using kinematic equations and data.<br>❑ Distinguish between scalar and vector quantities<br>❑ Define position as a signed number relative to an origin.<br>❑ Calculate displacement ($\Delta x$) as the change in position of an object.<br>❑ Identify the frame of reference used to describe motion.<br>❑ Calculate speed as the distance traveled divided by the elapsed time.<br>❑ Calculate velocity as the change in position divided by the elapsed time.<br>❑ Identify cases where average speed does not equal average velocity.<br>❑ Describe motion in which velocity is negative.<br>❑ Calculate acceleration as the change in velocity divided by the elapsed time.<br>❑ Interpret and analyze position versus time and velocity versus time graphs for linear and accelerated motion (constant acceleration only).<br>❑ Apply kinematic equations to linear and two-dimensional motion, including free fall and projectile motion.<br>❑ Analyze the motion of a projectile using x and y-components of velocity and acceleration using kinematic equations |

# Unit 2 - Work and Energy

| STAGE 1 \| DESIRED RESULTS | |
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| **Standards** | **Transfer** |
| 3.2.9-12.O Create a computational model to calculate the change in the energy of | *Students will be able to independently use their learning to understand…*<br>❑ In a closed system, energy is conserved. |

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<tr>
<td rowspan="5">one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.<br><br>3.2.9-12.Q Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.<br><br>3.2.9-12.P Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).<br><br>3.5.9-12.Y (ETS) - Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.<br><br>3.5.9-12.I (ETS) - Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.<br><br>3.5.9-12.K (ETS) - Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.</td>
<td colspan="2">❑ Energy can be transformed from one form to another.<br>❑ If work is done on or by a system, the energy of that system will change.</td>
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<td colspan="2">Meaning</td>
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<td>UNDERSTANDINGS<br>Students will understand that…<br>❑ Energy exists in various forms.<br>❑ Energy is conserved (converted from one form to another).</td>
<td>ESSENTIAL QUESTIONS<br>Students will keep considering…<br>❑ How does an object’s energy change?<br>❑ How do energy conversions occur?</td>
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<td>Students will know…<br>❑ Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system’s total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.<br>❑ Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.<br>❑ Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.<br>❑ Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.<br>❑ The availability of energy limits what can occur in any system.<br>❑ At the macroscopic scale, energy<br>❑ manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.<br>❑ Although energy cannot be destroyed, it can be converted to less useful forms— for example, to thermal energy in the surrounding environment. Criteria and constraints also include satisfying any requirements set by society, such as taking</td>
<td>Students will be skilled at…<br>❑ Define energy in terms of work.<br>❑ Calculate work and power.<br>❑ Analyze work using different paths of motion to demonstrate the relationship between an applied force and distance through which the force is applied.<br>❑ Define and calculate kinetic energy values based on an object’s motion.<br>❑ Define and calculate gravitational potential energy values based on an object’s position.<br>❑ State and apply the relationship between work and changes in kinetic energy when no opposing forces are applied.<br>❑ State and apply the relationship between work done against gravity and the change in gravitational potential energy.<br>❑ Define and calculate mechanical energy as the sum of the kinetic and potential energies.<br>❑ Identify different forms of energy at various points for simple systems such as a swinging pendulum or a car on a frictionless roller coaster.<br>❑ Describe the Law of Conservation of Energy for a system.<br>❑ Apply the Law of Conservation of Energy to a system in which friction and air resistance are ignored.</td>
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| | issues of risk mitigation into account, and they should be quantified to the extent possible and state.<br>❑ Definitions for work, power, and energy.<br>❑ Definitions for various forms of energy<br>❑ SI units for work, energy and power<br>❑ Definition of a system<br>❑ Definition for the Law of Conservation of Energy<br>❑ Definition of elastic potential energy | |

# Unit 3 - Momentum and Impulse

<table>
<tr><th colspan="3">STAGE 1 | DESIRED RESULTS</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer</th></tr>
<tr><td rowspan="5">3.2.9-12.J Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.<br><br>3.2.9-12.K Apply scientific and engineering ideas to design, evaluate and refine a device that minimizes the force on a macroscopic object during a collision.<br><br>3.5.9-12.Y (ETS) - Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.<br><br>3.5.9-12.I (ETS) - Evaluate a solution to a complex real-world problem</td><td colspan="2">Students will be able to independently use their learning to understand…<br>❑ Momentum is conserved in all collisions.<br>❑ The force experienced in a collision can be increased or decreased due to the duration of the collision.</td></tr>
<tr><th colspan="2">Meaning</th></tr>
<tr><td>UNDERSTANDINGS<br>Students will understand that…<br>❑ A change in motion of interacting objects can be explained and predicted by forces.</td><td>ESSENTIAL QUESTIONS<br>Students will keep considering…<br>❑ How do mass and velocity affect momentum?<br>❑ How is momentum transferred during a collision?<br>❑ What factors affect the force on an object during a collision?<br>❑ How is energy conservation related to the type of collision?<br>❑ What affects the motion of two objects which undergo a collision?<br>❑ How can an object be protected in a collision?</td></tr>
<tr><th colspan="2">Acquisition(need to align with above and standards)</th></tr>
<tr><td>Students will know…</td><td>Students will be skilled at…</td></tr>
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| based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.<br><br>3.5.9-12.K (ETS) - Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. | ❑ If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.<br>❑ Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.<br>❑ Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.<br>❑ Definitions for momentum and impulse<br>❑ Definition for the Law of Conservation of Momentum<br>❑ Definitions for elastic collision, inelastic collision, and explosion<br>❑ Definition for Conservation of Kinetic Energy<br>❑ SI Units for momentum | ❑ Calculate an object's momentum.<br>❑ Calculate impulse<br>❑ Calculate the change in momentum for an object when a force is applied.<br>❑ Apply conceptual understanding of an impulse to explain why collisions exert smaller forces when applied over longer time intervals<br>❑ Mathematically demonstrate how the magnitude of a force decreases when impact time is increased<br>❑ Analyze a scenario and choose a system to determine whether the forces are internal or external to that system.<br>❑ Explain that a conserved quantity is a quantity that remains numerically constant.<br>❑ Apply the concepts of elastic collisions, inelastic collisions, and explosions to determine which model to use for analyzing a scenario.<br>❑ Describe the Law of Conservation of Momentum and apply it scenarios to solve one-dimensional explosion and collision problems |

# Unit 4 - Rotational Motion

| STAGE 1 \| DESIRED RESULTS | |
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| **Standards** | **Transfer** |
| 3.2.9-12.L Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational | *Students will be able to independently use their learning to understand...*<br>❑ Centripetal force is needed for motion along a curved path.<br>❑ A net torque is required to cause a change in rotation of an object.<br>**Meaning** |

and electrostatic forces between objects.

3.5.9-12.Y (ETS) - Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

3.5.9-12.I (ETS) - Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

3.5.9-12.K (ETS) - Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

UNDERSTANDINGS

*Students will understand that...*

- ❑ A torque depends on the application of a force and where the force is applied in relation to an axis
- ❑ A net torque causes a change in rotation
- ❑ A centripetal force is required for motion along a curved path

ESSENTIAL QUESTIONS

*Students will keep considering...*

- ❑ What is the difference between an object that rotates and one that follows a curved path?
- ❑ What causes an object to rotate or follow a curved path?

**Acquisition(need to align with above and standards)**

*Students will know...*

- ❑ Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects.
- ❑ Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.
- ❑ Definitions for torque and moment arm (or lever arm)
- ❑ Definition for moment of inertia
- ❑ Definitions for tangential velocity and angular velocity
- ❑ Definitions for centripetal acceleration and centripetal force
- ❑ SI Units for torque, tangential velocity, centripetal acceleration, and centripetal force
- ❑ Definition for Newton's Universal Law of Gravitation
- ❑ Definition of rotational kinetic energy
- ❑ Definition of angular momentum

*Students will be skilled at...*

- ❑ Explain the relationship between torque and moment of inertia.
- ❑ Analyze situations of objects rolling (as opposed to sliding) down a hill.
- ❑ Calculate the net force for a system in equilibrium.
- ❑ Explain the difference between center of mass and gravity.
- ❑ Explain the relationship between moment of inertia and angular velocity.
- ❑ Demonstrate the relationship between torque and angular acceleration.
- ❑ Calculate the centripetal force for a mass traveling in a vertical and horizontal circular path.
- ❑ Explain the relationship of g-force to speed, radius, and centripetal force.
- ❑ Algebraically analyze the centripetal force which acts on an object in uniform circular motion.
- ❑ Identify a centrifugal force as a fictitious force and explain how it results from an accelerated frame of reference.
- ❑ Determine the directions for velocity, acceleration, and net force vectors for an object in uniform circular motion.
- ❑ Apply the proportional relationship of Newton's Law of Universal Gravitation
- ❑ Use Newton's Second Law and Newton's Universal Law of Gravitation to explain free

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| | | fall acceleration for objects near the surface of the earth<br>❑ Apply the conservation of energy using rotational kinetic energy.<br>❑ Apply the conservation of angular momentum.<br>❑ Explain how the tangential velocity of a rolling object is less than if it were skidding.<br>❑ Use the conservation of angular momentum to explain how the angular velocity changes when the rotational inertia changes. |