EAST PENN
SCHOOL DISTRICT

Physics 1
DATE OF APPROVAL

Physics 1 Unit 1 - Kinematics and Newton's Laws

STAGE 1 | DESIRED RESULTS

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.	*Students will be able to independently use their learning to...* ☐ Locate objects in a frame of reference and predict, using mathematical models, where they will be in the future. ☐ Objects maintain their state of motion unless acted upon by a net external force. ☐ Predict, using mathematical models, changes in motion due to a net external force.	
	Meaning	
	UNDERSTANDINGS *Students will understand that...* ☐ Motion is relative. ☐ Motion can be described using position, velocity, acceleration and time. ☐ Mathematical and graphical models can be used to describe and predict an object's motion. ☐ Force and net force are not the same. ☐ Net force affects the motion of a mass. ☐ An object's state of motion cannot change when there is no net force on a mass. ☐ Types of forces vary based on interactions between objects.	ESSENTIAL QUESTIONS *Students will keep considering...* ☐ How can an object's motion be described and predicted? ☐ What causes objects to move in different ways? ☐ What causes objects to change the ways in which they move?
	Acquisition(need to align with above and standards)	
	Students will know... **PS2.A: Forces and Motion** ☐ Newton's second law accurately predicts changes in the motion of macroscopic objects Other knowledge:	*Students will be skilled at...* ☐ *Develop and use models/graphs of observable data to describe motion.* ☐ *Use mathematical and computational thinking to identify trends and sources of error using experimental data.*

	☐ Definitions for frame of reference, position, displacement, distance, speed, velocity, and acceleration
	☐ Definitions for linear and two dimensional motion (including freefall and projectile motion)
	☐ Definitions of scalar and vector quantities
	☐ SI units for distance, time, velocity, acceleration, force, mass, and weight
	☐ Definition of a projectile (object launched with an initial velocity which travels through the air affected only by gravity; no air resistance)
	☐ Definitions and examples of contact and field forces
	☐ Newton's Laws of Motion
	☐ Definition of net force
	☐ Difference between mass and weight
	☐ Definitions of types of forces
	☐ Newton's second law accurately predicts changes in the motion of macroscopic objects.
	☐ Position is a signed number relative to an origin
	☐ Force is not something that an object "has", but is a characteristic of the interaction between objects.
	☐ When one object applies a force to a second object, then the second object simultaneously applies an equal and opposite force to the first object (Newton's Third Law).
		☐ Construct evidence-based explanations of everyday phenomena using quantitative data, motion graphs, and kinematic equations.
		☐ Use mathematical and computational tools to analyze motion and make predictions using kinematic equations and data.
		☐ Use mathematical and computational thinking to calculate displacement (Δx) as the change in position of an object.
		☐ Identify the frame of reference used to describe motion.
		☐ Use mathematical and computational thinking to calculate speed as the distance traveled divided by the elapsed time.
		☐ Use mathematical and computational thinking to calculate velocity as the change in position divided by the elapsed time.
		☐ Identify cases where average speed does not equal average velocity.
		☐ Construct an explanation for motion in which velocity is negative.
		☐ Use mathematical and computational thinking to calculate acceleration as the change in velocity divided by the elapsed time.
		☐ Interpret and analyze position versus time and velocity versus time graphs for linear and accelerated motion (constant acceleration only).
		☐ Use mathematical and computational thinking to apply kinematic equations to linear and two-dimensional motion, including free fall and projectile motion.
		☐ Use mathematical and computational thinking to analyze the motion of a projectile using x and y-components of velocity and acceleration using kinematic equations
		☐ Construct an argument distinguishing:
		    ☐ scalar and vector quantities
		    ☐ contact forces and field forces

		☐ *constant velocity (balanced forces or equilibrium) and accelerated (net force) motions using Newton's Laws* ☐ *Use mathematical and computational thinking to perform vector addition using the tip-to-tail method, Pythagorean Theorem, and Trigonometric functions.* ☐ *Use mathematical and computational thinking to determine the components of a vector using geometry and trigonometric functions.* ☐ *Use mathematical and computational thinking and apply vector concepts to solve problems using forces and projectile motion* ☐ *Apply Newton's Second Law, $a = F/m$, to physical situations to explain qualitatively and quantitatively how one variable is affected by a change in another If force increases, then acceleration increases (with constant mass). If mass increases, then acceleration decreases (with constant force).* ☐ *Apply Newton's Laws to solving problems using forces and motion*

Physics 1 Unit 2 - Work and Energy

<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.O Create a computational model to calculate the change in the energy of 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.

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.

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).

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</td><td colspan="2">Students will be able to independently use their learning to...
☐ In a closed system, energy is conserved.
☐ Energy can be converted from one form to another.
☐ If work is done on or by a system, the energy of that system will change.</td></tr>
<tr><th colspan="2">Meaning</th></tr>
<tr><td>UNDERSTANDINGS
Students will understand that...
☐ Energy exists in various forms.
☐ Energy is conserved (converted from one form to another).</td><td>ESSENTIAL QUESTIONS
Students will keep considering...
☐ How do energy conversions occur?
☐ How does the energy of an object change?</td></tr>
<tr><th colspan="2">Acquisition(need to align with above and standards)</th></tr>
<tr><td>Students will know...

PS3.A - Definitions of Energy
☐ 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.
☐ At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.
☐ These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space

PS3.B - Conservation of Energy and Energy Transfer</td><td>Students will be skilled at...
☐ Use mathematical and computational thinking to calculate work and power.
☐ Analyze and interpret work using different paths of motion to demonstrate the relationship between an applied force and distance through which the force is applied.
☐ Use mathematical and computational thinking to calculate kinetic energy values based on an object’s motion.
☐ Use mathematical and computational thinking to calculate gravitational potential energy values based on an object’s position.
☐ Construct an argument to state and apply the relationship between work and changes in kinetic energy when no opposing forces are applied.
☐ Construct an argument to state and apply the relationship between work done against gravity and the change in gravitational potential energy.</td></tr>
</table>

relevant to the problem. 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.	☐ 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. ☐ Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. ☐ 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. ☐ The availability of energy limits what can occur in any system. **PS3.D - Energy in Chemical Processes** ☐ Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. **ETS1.A - Defining and Delimiting an Engineering Problem** ☐ Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and state. **ETS1.B - Developing Possible Solutions** ☐ 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. Other knowledge: ☐ Definitions for work, power, and energy. ☐ Definitions for various forms of energy ☐ SI units for work, energy and power ☐ Definition of a system ☐ Definition for the Law of Conservation of Energy ☐ Newton's second law accurately predicts changes in the motion of macroscopic objects.	☐ *Use mathematical and computational thinking to calculate mechanical energy as the sum of the kinetic and potential energies.* ☐ *Communicate scientific and technical information to identify different forms of energy at various points for simple systems such as a swinging pendulum or a car on a frictionless roller coaster.* ☐ *Communicate scientific and technical information to describe the Law of Conservation of Energy for a system.* ☐ *Use mathematical and computational thinking and apply the Law of Conservation of Energy to a system in which friction and air resistance are ignored.* ☐ *Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects.* ☐ *Create a computational model or simulation of a phenomenon, designed device, process, or system.* ☐ *Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.* ☐ *Design, build and refine a device that works within given constraints to convert one form of energy into another form of energy.*

	☐ Science assumes the universe is a vast single system in which basic laws are consistent. ☐ Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.	

Physics 1 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.

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.

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.</td><td colspan="2">Students will be able to independently use their learning to…
☐ Momentum is conserved in all collisions.
☐ The force experienced in a collision can be increased or decreased based on the duration of the collision.</td></tr>
<tr><th colspan="2">Meaning</th></tr>
<tr><td>UNDERSTANDINGS
Students will understand that…
☐ A change in motion of interacting objects can be explained and predicted by forces.</td><td>ESSENTIAL QUESTIONS
Students will keep considering…
☐ What affects the motion of two objects which undergo a collision?
☐ How can an object be protected in a collision?
☐ How do mass and velocity affect momentum?
☐ How is momentum transferred during a collision?
☐ What factors affect the force on an object during a collision?
☐ How is energy conservation related to the type of collision?</td></tr>
<tr><th colspan="2">Acquisition(need to align with above and standards)</th></tr>
<tr><td>Students will know…

PS2.A: Forces and Motion
☐ Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. If a system interacts with</td><td>Students will be skilled at…
☐ Use mathematical and computational thinking to calculate an object’s</td></tr>
</table>

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.	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. ☐ 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. **ETS1.A - Defining and Delimiting an Engineering Problem** ☐ Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and state. **ETS1.B - Developing Possible Solutions** ☐ When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. ☐ 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. *Other knowledge:* ☐ Definitions for momentum and impulse ☐ Definition for the Law of Conservation of Momentum ☐ Definitions for elastic collision, inelastic collision, and explosion ☐ Definition for Conservation of Kinetic Energy ☐ SI Units for momentum ☐ Newton's second law accurately predicts changes in the motion of macroscopic objects. ☐ 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. ☐ 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.	momentum and to calculate impulse ☐ Use mathematical and computational thinking to calculate the change in momentum for an object when a force is applied. ☐ Construct an argument with evidence to explain why collisions exert smaller forces when applied over longer time intervals ☐ Use mathematical and computational thinking to mathematically demonstrate how the magnitude of a force decreases when impact time is increased ☐ Analyze and interpret a scenario and choose a system to determine whether the forces are internal or external to that system. ☐ Construct an argument that explains that a conserved quantity is a quantity that remains numerically constant. ☐ Analyze, interpret, and apply the concepts of elastic collisions, inelastic collisions, and explosions to determine which model to use for analyzing a scenario. ☐ Construct an argument using the Law of Conservation of Momentum and apply it scenarios to solve one-dimensional explosion and collision problems

Physics 1 Unit 4 - Rotational Motion

STAGE 1 | DESIRED RESULTS

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 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.	*Students will be able to independently use their learning to...* ☐ Centripetal force is needed for motion along a curved path. ☐ A net torque is required to cause a change in rotation of an object.	
	Meaning	
	UNDERSTANDINGS *Students will understand that...* ☐ Rorque 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... **PS2.B: Types of Interactions** ☐ 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. **ETS1.A - Defining and Delimiting an Engineering Problem** ☐ Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be	*Students will be skilled at...* ☐ Construct an argument to explain the relationship between torque and moment of inertia. ☐ Analyze and interpret situations of objects rolling (as opposed to sliding) down a hill. ☐ Use mathematical and computational thinking to calculate the net force for a system in equilibrium. ☐ Construct an argument to explain the difference between center of mass and gravity. ☐ Construct an argument to explain the relationship between moment of inertia and angular velocity. ☐ Develop and use a model to demonstrate the relationship between torque and angular acceleration.

	quantified to the extent possible and state. **ETS1.B - Developing Possible Solutions** ☐ When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. ☐ 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. **ETS1.C - Optimizing the Design Solution** ☐ Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. Other knowledge: ☐ 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 ☐ Newton's second law accurately predicts changes in the motion of macroscopic objects. ☐ If a system interacts with objects outside itself, the total momentum of the system can change;	☐ Use mathematical and computational thinking to calculate the centripetal force for a mass traveling in a vertical and horizontal circular path. ☐ Construct an argument to explain the relationship of g-force to speed, radius, and centripetal force. ☐ Use mathematical and computational thinking to algebraically analyze the centripetal force which acts on an object in uniform circular motion. ☐ Construct an argument to explain how the centrifugal force results from an accelerated frame of reference and Identify a centrifugal force as a fictitious force ☐ Use mathematical and computational thinking to 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 construct an argument to explain free fall acceleration for objects near the surface of the earth

	however, any such change is balanced by changes in the momentum of objects outside the system. ☐ 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	