Ganado Unified School District
(Physics/11-12)

PACING Guide SY 2022-23

Timeline & Resources	AZ College and Career Readiness Standard	Essential Question (HESS Matrix)	Learning Goal	Vocabulary (Content/Academic)
Quarter 1 http://modeling.asu.edu/Projects-Resources.html	**U1: Scientists explain phenomena using evidence obtained from observations and or scientific investigations. Evidence may lead to developing models and or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.**		**Unit 1-Scientific Methods in Experimental Settings** **1.Experimental design** a-Identify and classify experimental variables as independent, dependent or controlled. b-Make qualitative (non-mathematical) predictions about the relationship between variables c-Record the procedure used to gather data from the apparatus d-Construct and label a data table. **2.Data Collection** a-Select appropriate measuring devices. b-Consider accuracy of measuring device and significant figures c-Collect data for the widest reasonable range of independent variable values. d-Use metric units, conversions and prefixes **3.Mathematical Modeling** a-Use (*Logger Pro,TI-84,Plot.ly)* software to perform graphical analysis of data. b-Make test plots of data to find linear	Units, independent variable, dependent variable, parameter/constants, regression, data fit,

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			relationships c-Write mathematical models, in standard y = mx + b form, for linearized data. Replace m and b with constants including units and replace y and x with dependent and independent variable names. d-Provide interpretations for the physical significance of the slope and y-intercept. f-Relate mathematical and graphical expressions e-Use proportional reasoning in problem solving	
Quarter 1	**U1: Scientists explain phenomena using evidence obtained from observations and or scientific investigations. Evidence may lead to developing models and or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.**	What is position? What is a "rate"? What is meant by "rate of change"? Where are rates encountered in real life?	**Unit-2-Particle Moving with Constant Velocity Model** a-You should be able to determine the average velocity of an object in two ways: 1-determining the slope of an x vs. t graph. 2-using the equation b-You should be able to determine the displacement of an object in two ways: 1-finding the area under a v vs. t graph. 2-using the equation c-Given an x vs. t graph: 1-describe the motion of the object (starting position, direction of motion, velocity) 2-draw the corresponding v vs. t	Velocity, change, position, distance, slope, average velocity, speed, motion map,

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			graph 3-draw a motion map for the object. 4-determine the average velocity of the object (slope). 5-write the mathematical model which describes the motion. d-Given a v vs. t graph: 1-describe the motion of the object (direction of motion, how5-write a mathematical model to describe the motion. fast) 2-draw the corresponding x vs. t graph 3-determine the displacement of the object (area under curve). 4-draw a motion map for the object.	
Quarter 2	**Essential HS.P3U1.6** **Collect, analyze, and interpret data** regarding the change in motion of an object or system in one dimension, to construct an explanation using Newton's Laws.	How does the slope of its velocity graph indicate the acceleration of an object? What does the area under the VT graph represent?	**Unit 3-Uniformly Accelerated Particle Model** 1. The slope of a position-time graph is the velocity. If the position-time graph is curved, the slope of a line tangent to the curve tells you the velocity at that time. The velocity at a time is called instantaneous velocity. 2. In general, acceleration is the rate of change in velocity, which is the slope of a velocity-time graph. Mathematically, $a = \Delta v/\Delta t$ 3. The velocity of a uniformly accelerating object increases or decreases by equal amounts each second. 4. The area under a velocity-time graph is the object's change in	Velocity, acceleration, change, position, distance, slope

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			position, or displacement. Mathematically, $\Delta x = 1/2\ a\Delta t2 + vi\Delta t$ 5. Combining the displacement equation and the definition of acceleration yields a third mathematical expression that is independent of time: $v2 = v2 + 2a\Delta x$ 6. The motion map for uniformly accelerated motion features dots whose successive spacing increases or decreases. Draw the dots for the location of the object at equally spaced time intervals, then add the velocity and acceleration vectors.	
Quarter 2	**Plus HS+Phy.P3U1.2** **Develop and use** mathematical **models** of Newton's law of gravitation and Coulomb's law to describe and predict the gravitational and electrostatic forces between objects.	What is inertia? What is mass? What is weight? What is the difference between mass and weight? If the action and reaction between an accelerating car and the Earth are equal, why does only the car seem to accelerate?	**Unit 4-Balanced Force Particle Model** 1-Forces (pushes and pulls) are interactions between two objects. Forces between objects are differentiated by the way in which two objects interact. 2-Newton's First Law, the law of inertia. Newton's First Law: Objects at rest stay at rest, objects in motion stay in motion at constant speed in a straight line unless acted upon by unbalanced forces. 3-Newton's Third Law, forces are interactions (sometimes called the law of action and reaction). Newton's Third Law: All forces come in pairs; paired forces are equal in magnitude, but opposite in direction. FAB = -	Mass, inertia, force, weight, net force, equilibrium.

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			FBA. 4-Quantitatively, forces are measured in Newtons (pounds in the English system). Mass is measured in kilograms. 5-Earth's gravitational field strength at its surface is 10 Newtons of force on every kilogram of mass. The force gravity exerts on an object is called its weight. Weight = 10 N/kg * mass. 6-When analyzing the forces acting on an object: a. Draw and label a force diagram for the object b. Choose the simplest coordinate axis for analysis: horizontal-vertical or parallel-perpendicular c. break forces not aligned with your coordinate axis into components using trigonometry. d. Qualitatively use marks on the vectors to indicate equality and inequality e. Write equations for the vector equality force values f. State whether the velocity of the object is constant (balanced forces) or changing (unbalanced forces)	
Quarter 2&3			prepare for science fair	
Quarter 3	**Essential HS.P3U1.6** **Collect, analyze, and interpret data** regarding the change in motion of an	What is the sum of forces on a stationary object? What is the sum of forces on an object, which is	**Unit 5-Net Force Particle Model** 1. The amount by which the forces acting on an object are unbalanced is called the *net force*. 2. When the forces acting on an object	Force, Friction, free fall, pressure

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	object or system in one dimension, to construct an explanation using Newton's Laws. **Plus HS+Phy.P3U1.2** **Develop and use** mathematical **models** of Newton's law of gravitation and Coulomb's law to describe and predict the gravitational and electrostatic forces between objects. **Plus HS+Phy.P3U1.3** **Develop a** mathematical **model**, using Newton's laws, to predict the motion of an object or system in two dimensions (projectile and circular motion).	traveling at constant velocity? What is the role of friction?	are unbalanced, the object will accelerate. Because acceleration is a change in velocity, and velocity includes both speed and direction, an net force will change the speed and/or the direction of an object's motion. 3. Newton's 2nd Law: The net force on an object divided by its mass equals its acceleration, or Fnet = m*a 4. Force is measured in units of Newtons. One Newton of net force on a one-kilogram object produces an acceleration of 1 m/s^2. Therefore, a Newton is the same as a kilogram*meter/$second^2$. (N = kgm/s^2) 5. Use Newton's 2nd Law to qualitatively describe the relationship between m and a, F and a, m and F. (For example, if you double the mass, the acceleration will change by a factor of. . ?) 6. Solve quantitative problems involving forces, mass and acceleration using Newton's 2nd Law. a. use force diagram analysis to find the net (unbalanced) amount of force. b. list knowns and unknowns for force and motion variables. c. The variable that ties both lists of variables together is acceleration. Depending on the variables you know, use either the force or motion mathematical models to solve for	

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			acceleration, and then use the acceleration value to solve for the unknown quantity. 7. For a given pair of surfaces, the friction force is generally some fraction of the normal force, where that fraction is called the coefficient of friction, μ (Greek letter mu). Therefore, $F_{fr} = \mu F_N$. Every pair of surfaces has its own coefficient of friction. 8. Pressure is the force per unit area. P = F/A. Pressure is measured in Newtons/meter2, which is also called a Pascal.	
Quarter 3	**Plus HS+Phy.P3U1.3** **Develop a** mathematical **model**, using Newton's laws, to predict the motion of an object or system in two dimensions (projectile and circular motion).	How does a scalar quantity differ from a vector quantity? Why can we not simply add vector components to get their sums when analyzing motion in two directions? What shape is traced out by an object in projectile motion? What two factors affect the range of a projectile? Which pair of initial angles will yield the same range for a projectile of a given velocity?	**Unit 6-Particle Models in Two Dimensions** 1. We are restricting our study of two-dimensional motion to that of projectile motion. (Circular motion will be addressed in the next unit.) 2. A projectile moves both horizontally and vertically, and, in the absence of air resistance, traces out a parabolic path. 3. The horizontal and vertical motions of a projectile are completely independent of one another. a. In the absence of air resistance, there is no net horizontal force on the projectile; therefore the projectile travels with a constant horizontal velocity. b. In the absence of air resistance, gravity is the only vertical force on	Component, resultant, vector addition, sine, cosine, tangent, Projectile, initial velocity, range, hang-time, altitude

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		Which initial angle always gives the maximum range for a given velocity?	the projectile; therefore the projectile travels with a uniformly accelerated vertical motion. Every second, the vertical velocity of the projectile changes by 9.8 m/s. 4. The motion map for a projectile is best drawn with horizontal and vertical component vectors of the velocity. The horizontal spacing of the motion map dots is uniform and the horizontal velocity vectors are equal in length. The vertical spacing of the motion map dots and the length of the vertical velocity vectors will increase or decrease as the object's vertical speed increases or decreases due to gravitational acceleration. 5. Projectile motion problem solving: Divide the motion into horizontal and vertical components and solve each component separately. a. Draw a picture of the situation and label all known numerical information on the picture. b. List knowns and unknowns for horizontal and vertical motion variables. Trigonometry may be needed to break initial velocities at an angle into horizontal and vertical components. c. Consistently assign algebraic signs (+ and -) to the vertical motion variables. A good system to use is to call upward velocities and displacement positive and downward	

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			velocities, acceleration, and displacement negative. d. The variable that ties both lists of variables together is time. Depending on the variables you know, use either the horizontal or vertical motion information to solve for time, then use the time to solve for the unknown quantity. e. Solving for time will sometimes require the use of the quadratic equation. Program it into your calculator to make this computation easier.	
Quarter 4	**Plus HS+Phy.P3U1.3** **Develop a** mathematical **model,** using Newton's laws, to predict the motion of an object or system in two dimensions (projectile and circular motion).		**Unit 7-Central Net Force Model** 1. The period of an object in circular motion is the time needed for the object to make one complete circle or orbit. Period, T, is equal to the orbit circumference divided by the tangential velocity. $T = 2\pi r/v$ 2. As an object travels in a curved path, the *direction* of its velocity changes. Centripetal acceleration is the name given to a change in velocity due to curved motion. Centripetal acceleration is directed toward the center of the circle. $ac = v^2/r$ 3. The net force needed to curve an object away from straight line motion is directly proportional to the object's mass, directly proportional to the square of the object's velocity and inversely proportional to the radius of	Centripetal, Centrifugal,

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			the object's path. Fnet = m v^2/r 4. A net force causing circular motion is also called centripetal force = F_c = forces toward the center of the circle - forces away from the center of the circle. 5. Force diagrams for circular motion show a net force toward the center of the circle. 6. Centripetal and centrifugal force are different concepts. *Centripetal force is the name for the "net force toward the center of the circle" that causes circular motion to occur.* *Centrifugal force is the name for the apparent force that "pushes" objects away from the center of a circle from the viewpoint of the object that is undergoing circular motion. Of course, there is no force pushing an object away from the center of the circle, it is simply the object traveling in a straight line, tangent to the circle as described by the law of inertia.* 7. The central net force for an object in orbital motion is provided by gravity. 8. Newton's Law of Universal Gravitation quantifies the gravitational attraction between two objects:$F_g = G\ m_1 m_2/r^2$ where G = 6.67 x 10^{-11} N m^2/kg^2 (Cavendish's constant) m1m2 are the masses of the two objects in kg. r is	

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			the separation distance between the centers of the two objects in meters 9. "Weightlessness" refers to situations of freefall where the gravitational force is present, but there is no normal force. Your sense of weight arises from the normal force on you. 10. G's or Force Factor = F_N/F_g tells how many times heavier than usual a person feels.	
Quarter 4	**Essential HS.P4U1.8** **Engage in argument from evidence** that the net change of energy in a system is always equal to the total energy exchanged between the system and the surroundings. **Plus HS+Phy.P4U1.6** **Analyze and interpret data** to quantitatively describe changes in energy within a system and/or energy flows in and out of a system.	How many forms of energy can you name? describe each of the these forms as either kinetic or potential energy. What is the difference between work and power? Who can do more work, and NFL lineman or a ballerina? Which of the two can produce more power?	**Unit 8-Energy** 1.-View energy interactions in terms of transfer and storage. Develop concept of relationship among kinetic, potential & internal energy as modes of energy storage emphasis on various tools (especially pie charts) to represent energy storage apply conservation of energy to mechanical systems 2.-Variable force of spring model (see lab notes: spring-stretching lab) Interpret graphical models area under curve on F vs x graph is defined as elastic energy stored in spring. Develop mathematical models F = kx $E_{el} = 1/2kx^2$ 3.-Develop concept of working as energy transfer mechanism. Introduce conservation of energy focus on $W = \Delta E$ in this unit. Working is the transfer of energy into or out of a system by means of an external force. The energy transferred,	kinetic, potential, internal energy, work/working,

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			W is computed by $W = F_{\parallel} * \Delta x$ the area under an F-x graph, where F is the force transferring energy. Energy bar graphs and system schema represent the relationship between energy transfer and storage 4.-Contrast conservative vs non-conservative forces. Energy transfers by conservative forces are reversible. 5.-Conservation of energy lab investigation - (see lab notes: 3 optional approaches) 6.-Power (no specific labs) Define power- rate at which energy is transferred: $P = W/t$. SI unit: watt	
Quarter 4	**Plus HS+Phy.P3U1.4** **Engage in argument from evidence** regarding the claim that the total momentum of a system is conserved when there is no net force on the system. **Plus HS+Phy.P3U2.5** **Design, evaluate, and refine a device** that minimizes or maximizes the force on a macroscopic object during a collision.	What is required to change momentum? How does the time required for a change in momentum relate to acceleration?	**UNIT 9-IMPULSIVE FORCE MODEL** 1. Momentum Define momentum and distinguish between momentum and velocity. momentum = (mass)(velocity) 2. Impulse Define impulse; distinguish between impulse and force. $I = F\Delta t$ Determine the impulse acting on an object via a F vs t graph given the change in momentum. Determine the force acting on an object, given its change in momentum. $F = m\Delta v/\Delta t$ 3. Conservation of Momentum Show that the system momentum before a collision is equal to the	Momentum, impulse, conservation

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			system momentum after the collision. (system momentum = constant) Show that the total system momentum after an explosion remains zero. Distinguish between elastic and inelastic collisions ($\Delta Ek1 \neq \Delta Ek2$) Use conservation principles to solve momentum problems involving elastic and inelastic collisions for initial velocity, final velocity or mass, given the other values.	