Morris School District Curriculum Map

Course: Physics **Grade Level:9**

Content/Objective	Essential Questions/ Enduring Understandings	Suggested Activity/ Appropriate Materials-Equipment	Evaluation/Assessment
Newton's Laws of Motion The learner will: • Define force as the interaction between two objects • Understand that changes in speed or direction of motion are caused by forces. • Define the 4-fundamental forces and how they manifest themselves in the universe • State Newton's laws of motion and apply them to everyday situations • Define and differentiate between static and dynamic equilibrium • Define mass and weight and differentiate between them • Identify Action-Reaction force pairs • Define vector and scalar • Add/subtract two or more vectors both graphically and with components • Optional: Resolving vectors into components • Use free body diagrams to solve dynamics problems in one and (**Optional: two dimensions**)	**Essential Questions:** • What phenomena can be explained by the strong nuclear, weak nuclear, electromagnetic and gravitational forces? • What causes objects to change speed or direction? • What is the difference between mass and weight? • What is the mathematical relationship between force, mass and acceleration? • How does direction affect the nature of a mathematical quantity? • Which physical quantities are vectors and which are scalars? **Enduring Understandings:** • The strong and weak forces are important in describing nuclear reactions. • The electromagnetic force describes the interaction of charged particles, and gravity describes the interaction between masses.	**Unit 1**: The study of forces as interactions that cause changes in the speed and/or direction of motion. Essential to this is the understanding of Newton's 3 Laws of Motion which can be used to analyze and explain any type of motion. Vectors are an important tool in analyzing motion in 2D. **Optional**: By using trigonometry to resolve the position, velocity and acceleration vectors into x and y components, motion can thereby be modeled mathematically in 2 (or 3) dimensions. **Instructional Strategies – Sample:** Display Newton's Laws of Motion by performing various demonstrations. Newton's1st Law is demonstrated by pulling a tablecloth from beneath a place setting. The benefits of wearing a seat belt and using a head rest are also discussed in the context of Newton's 1^{st} law. Newton's 2^{nd} and 3^{rd} Laws are demonstrated by using two dynamics carts of varying masses. **Optional**: Demonstrate that the graphical (ruler and protractor) method of adding vectors and the mathematical component (trigonometric) method of adding vectors are equivalent. **Performance Assessment Task – Sample:** Using a broom, students push a bowling ball down the hallway to recognize that a net force causes acceleration. A student pulls with a varying force on another student who is standing on a skateboard to demonstrate the direct relationship between force and acceleration. The mass of the student on the skate board is varied to demonstrate the inverse relationship between force and mass.	Do nows, group WebAssigns, WebAssign home assessment, oral questioning, lab reports, quizzes, formative assessments using Personal Response System "clickers", closure. Benchmark: Unit summative test.

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	• The mass of an object is a measure of its inertia and is independent of the object's external environment. • The weight of an object is the gravitational force exerted on that object. The weight of an object depends upon its external environment. • A force is not required to keep an object in motion. • Acceleration is directly proportional to force and inversely proportional to mass. • Forces occur in action-reaction pairs and are equal in nature and magnitude. • An object can be moving and have a net force of zero (dynamic equilibrium) • Vector quantities have both magnitude and direction. • Scalar quantities are completely described by a single number. • Vectors are necessary to model 2D motion.		

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Kinematics in One Dimension The learner will: • Define coordinate system, distance, position, speed, velocity and acceleration • Sketch position, velocity and acceleration as functions of time for constant velocity and accelerated motion • Determine velocity from position-time graph, and determine acceleration from velocity-time graph • Determine change in velocity from acceleration-time graph, and change in position from velocity-time graph • Use the kinematics equations to calculate the position and velocity of an object moving with a constant acceleration • Define free-fall • Apply the kinematics equations to solve one dimensional free fall problems	**Essential Questions** • How do we qualitatively describe the motion of an object? • How do we quantitatively describe the motion of an object? • What are the mathematical relationships between the position, velocity and acceleration of an object? • What are the equations of motion for an object moving with a constant acceleration? • Can we apply the kinematics equations to predict where an object will be under a given set of circumstances? • Why do heavy objects and light objects fall at the same rate? • What is free-fall? **Enduring Understandings:** • Acceleration is the rate of change of velocity. • All objects fall with the same acceleration, regardless of mass. • The nature of graphs as	**Unit 1:** Kinematics is the quantitative study of motion without regard to the causes of that motion. The kinematics equations for motion with constant acceleration can be used to make predictions about the position and velocity of an object. **Instructional Strategies – Sample:** Students analyze motion diagrams (pictures) in order to qualitatively describe an object's motion. Students are then asked how they can describe the motion quantitatively, and the idea of position and time measurements occurs naturally. **Performance Assessment Task – Sample:** Predict position/velocity/acceleration v. time graphs of motion in videos or using motion detectors . Use video analyzer such as Vernier Video Physics to analyze motion from a scene from YouTube or Hollywood movie. Graph results and analyze data to discern relationships between graphs.	Do nows, group WebAssigns, WebAssign home assessment, oral questioning, lab reports, quizzes, formative assessments using Personal Response System "clickers", closure. Benchmark: Unit summative test.

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	representative models of motion and data that are used to communicate information.		
Kinematics in Two Dimensions (2D) The learner will: • Demonstrate the understanding of the independence of the x- and y-motions of an object • Apply the kinematics equation to solve projectile motion problems • Demonstrate the understanding that all velocity is relative	**Essential Questions:** • Why will a bullet that is fired horizontally and an identical bullet that is dropped both strike the ground at the same time? • **Optional**: What launch angle will result in the greatest horizontal distance? **Enduring Understandings:** • All motion can be separated into x and y components • Motion in the x direction is independent of motion in the y direction. • 2D motion allows us to predict the position of a projectile. • All motion is relative • All constant velocity reference frames are equivalent.	**Unit 3**: Kinematics is the study of motion in a quantitative, mathematical way. Kinematics in 2D builds on and connects the topics of Unit 1 and Unit 2. As the x and y motions of an object are independent of each other, the 1D kinematics equations can be applied to each direction of motion separately. Upon mastering this unit, students will be able to make quantitative predictions about a wider variety of systems. **Instructional Strategies – Sample:** Illustrate independence of projectile motion in the x and y directions through classroom demonstrations, videos and problem-solving. Demonstrations include using a ballistic launcher to demonstrate that an object launched horizontally and another identical object that is dropped will strike the ground simultaneously. **Performance Assessment Task – Sample:** Students must determine the launch speed of a projectile launcher by any method. **Optional**: Students must predict the final position of a projectile launched at a given angle from the launcher, in order to strike a target.	Do nows, group WebAssigns, WebAssign home assessment, oral questioning, lab reports, quizzes, formative assessments using Personal Response System "clickers", closure. Benchmark: Unit summative test.
Circular Motion The learner will: • Derive and apply the relationships among	**Essential Questions:** • Why is an object moving in uniform circular motion accelerating?	**Unit 5**: Circular Motion is an example of 2D motion. Objects moving in a circle at a constant speed (uniform circular motion) are accelerating because the direction of the velocity is changing. The unit connects seemingly different examples	Do nows, group WebAssigns, WebAssign home assessment, oral

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centripetal acceleration, tangential velocity, radius and period for uniform circular motion. • Explain the vector nature of centripetal acceleration and force. • Attribute the centrifugal effect to inertia and Newton's 1st Law. • Apply Newton's Laws to analyze and solve circular motion and force problems.	• What is the direction of the net force on an object moving in uniform circular motion? • Why is there a sensation of being pushed outward when you're moving in a circle? • Optional: Why are some curves banked? How do they help to keep you on the road? • Why is friction between road and tires important when driving? **Enduring Understandings:** • Inertia is responsible for the feeling of being pushed outward when moving in a circle, not force. • An object moving in a circle at a constant speed is accelerating because its velocity is changing. • The net force on an object moving in uniform circular motion is directed radially inward.	of circular motion (e.g. cars moving around traffic circles and planetary motion) through the concept of a "center-seeking force" (centripetal) force. **Instructional Strategies – Sample**: Explain that uniform circular motion is accelerated motion because the direction of velocity is changing. Demonstrate that a "center-seeking" (centripetal) force is needed to cause circular motion by spinning a bucket filled with water in a vertical circle. **Performance Assessment Task – Sample:** Students are asked to use a broom to make a bowling ball move in a circular path. Students must push the bowling ball towards the center of the circle, thus demonstrating the need for a centripetal force. In the absence of the centripetal force, the bowling ball moves tangent to the circle, demonstrating that the ball's velocity is tangent to the circle.	questioning, lab reports, quizzes, formative assessments using Personal Response System "clickers", closure. Benchmark: Unit summative test.
Kepler's Laws and Universal Gravitation The learner will:	**Essential Questions:** • What is the Aristotelian (geocentric) theory of the universe?	**Unit 6:** Kepler's three laws of planetary motion are based on the observational data of Johannes Kepler and Tycho Brahe. Newton's Law of Universal Gravitation describes the strength of gravity between any two masses in the universe and not	Do nows, group WebAssigns, WebAssign home assessment, oral

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<tr><td>• Optional: Explain Kepler's 3 Laws of planetary motion
• Explain and apply Newton's Law of Universal Gravitation
• Describe the motion of satellites in terms of orbital radius, orbital period, orbital speed and their dependence upon central mass
• Describe the inverse square nature of the law of gravitation, and demonstrate understanding and implications
• Compare and contrast Newton's Law of Gravitation with Coulomb's Law of electrostatic force.</td><td>• What is the Copernican (heliocentric) theory of the solar system and what astronomical observations provided evidence for the heliocentric model?
• How are planets kept in orbit around the Sun?
• How do we know the acceleration due to gravity on the surface of other planets?
• How fast do satellites, moons and space stations need to travel when orbiting a planet?
• How are we able to calculate the mass of the Earth?
• How are the gravitational force and electric force different? How are they similar?

Enduring Understandings:
• Gravity is an attractive interaction between any two objects with mass.
• Gravity is a very weak force as compared to the electromagnetic force.
• The strength of both gravitational and electric forces is inversely</td><td>only provides an explanation for the motion of objects in free fall near Earth, but also can be used to derive Kepler's laws.

Instructional Strategies – Sample: Provide students with a historical overview of the various theories of planetary motion. Through this discussion, students are exposed to the idea that although science seeks to uncover truths about nature, the process is rarely, if ever, direct. The use of simulations and animations also provides a visual representation of the geocentric and heliocentric models of the solar system.

Performance Assessment Task – Sample: Students select a planet and research its orbital radius and mass. Using this information they must determine the force of gravity between the planet and Sun, and the planet's orbital period and orbital speed.</td><td>questioning, lab reports, quizzes, formative assessments using Personal Response System "clickers", closure.

Benchmark: Unit summative test.</td></tr>
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<tr><td></td><td>proportional to distance.
• The gravitational force is always attractive and electric force can either be attractive or repulsive.
• Planets move in elliptical, almost circular orbits around the sun.
• Newton's Law of Gravitation explains the observed motion of the planets.</td><td></td><td></td></tr>
<tr><td>Work & Energy
The learner will:
• Define work and kinetic energy and explain their relationship through the work-kinetic energy theorem
• Define power as the rate at which work is done
• Define gravitational and (Optional: elastic potential energy.)
• Identify types of energy in a given situation and observe the conversion from one form to another.
• Explain the law of conservation of energy and apply it to analyze everyday situations</td><td>Essential Questions:
• What is the relationship between 'work' and the everyday notion of 'burning calories'?
• What kinds of energy exist in the universe and how do we convert one to another?
• How is energy conserved and not created nor destroyed?
• Where does useful, mechanical energy go when the motion of an object stops?
Enduring Understandings:
• Most objects possess some form(s) of energy
• Energy cannot be created nor destroyed. Energy can only transform from</td><td>Unit 7: The concept of work is useful in describing how energy is transferred from one object to another. As energy can only be transferred between objects, the total energy of a system is always conserved. The concepts of work and energy provide students with an additional framework to that of forces which students can use to explain the behavior of a system of interacting objects. These two frameworks are complementary and equivalent.

Instructional Strategies – Sample: Estimate the amount of force needed to run at a specified pace and calculate the amount of work done and thus energy expended. Based on the number of calories in a fast food meal, calculate how far someone would need to run to "burn off" that number of calories.

Performance Assessment Task – Sample: Students must walk or run up the Heritage stairs. By measuring their weight and the height of the stairs, students calculate how much work they have done and thus how much energy they have expended in units of Joules and calories. By also measuring the time, the students calculate their power output in units of</td><td>Do nows, group WebAssigns, WebAssign home assessment, oral questioning, lab reports, quizzes, formative assessments using Personal Response System "clickers", closure.

Benchmark: Unit summative test.</td></tr>
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	one form to another. Total energy is always conserved. • The human body has its own energy balance between energy in (food) and energy out (work done). • Mechanical energy is conserved when there are only conservative, non-dissipative forces doing work on a system. • Heat is the "last stop" in the cycle of energy transformations in the universe.	Watts and horsepower.	
Momentum The learner will: • Define momentum and impulse and explain their relationship through the Impulse-Momentum theorem • **Optional**: Derive the law of conservation of momentum by combining Newton's 3^{rd} Law and the Impulse-Momentum theorem • Define and differentiate between elastic and inelastic collisions • Apply the law of	**Essential Questions**: • How does safety equipment in cars and sports protect us? • Why is follow-through important when swinging a bat, racket or club? • Why do guns recoil? • How do objects transfer their momentum to each other? **Enduring Understandings:** • Momentum is inertia in motion. • Decreasing the time of a	**Unit 8:** The momentum of an object is its inertia in motion, and the total momentum of an isolated system is conserved. The impulse-momentum theorem states that the force that acts on an object during a collision multiplied by the time duration of the collision is equal to the change in an object's momentum. This unit connects the concept of momentum to conservation of energy through the discussion of elastic and inelastic collisions. **Instructional Strategies – Sample:** Demonstrate the impulse-momentum theorem by having students attempt to break a raw egg by throwing it at a bed sheet. An immediate connection is made to the safety benefits of seat belts and air bags in vehicles and protective equipment in sports. **Performance Assessment Task – Sample:** Students design	Do nows, group WebAssigns, WebAssign home assessment, oral questioning, lab reports, quizzes, formative assessments using Personal Response System "clickers", closure. Benchmark: Unit summative test.

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conservation of momentum to analyze everyday situations involving collisions.	collision increases the force and vice versa. • People in cars and in sports equipment can be made safer by increasing the time it takes them to stop in a collision. • Follow-through in a swing increases the time of impact when swinging a club, bat or racket, and will increase the impulse, change in momentum and final velocity of the ball. • **Optional**: Force is the rate of change of momentum • Momentum is conserved when there is no net external force on a system.	and construct a protective container based on an analysis using the impulse-momentum theorem. The container must protect a raw egg when dropped from rest from various heights.	
Waves, Sound, Light The learner will: • Define a 'wave' as energy transfer and differentiate between mechanical and electromagnetic waves • Explain the relationship between the period, frequency, speed and wavelength of a wave • Calculate the period, frequency, speed and wavelength of a wave	**Essential Questions**: • What are waves, and what kinds of waves do we come in contact with in our lives? • Why are tsunamis and earthquakes so dangerous? • What is sound? • What is light? • How do musical instruments work?	**Unit 9:** Waves are disturbances that transfer energy from one location to another without the transfer of matter. Mechanical waves require a medium, but electromagnetic waves may exist in a vacuum. The interaction of waves, including the formation of standing waves, can be explained in terms of constructive and destructive interference. **Instructional Strategies – Sample:** Demonstrate transverse and longitudinal waves, reflection and transmission, constructive and destructive interference, speed, wavelength, and period and frequency by creating waves in a stretched slinky.	Do nows, group WebAssigns, WebAssign home assessment, oral questioning, lab reports, quizzes, formative assessments using Personal Response System "clickers", closure. Benchmark: Unit

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• Define transverse and longitudinal waves and provide examples of each • Explain the principle of superposition and its relationship to wave interference • Differentiate the nature of sound v. light • **Optional**: Standing waves in open & closed tubes, on strings (music) • Resonance, beats • Doppler effect • Shock waves, sonic boom	• How do polarized sunglasses work? • What is the Doppler effect? • What is a sonic boom? • How do we know the universe is expanding? **Enduring Understandings:** • Waves are disturbances that transport energy. • Mechanical waves require a medium, electromagnetic waves do not. • Light is a transverse electromagnetic wave. • Sound is a longitudinal mechanical (pressure) wave in air, and travels faster through denser media and cannot travel through a vacuum. • The interference of waves in wind and string instruments creates standing waves. The standing wave frequencies are the musical notes you hear. • The frequency of sound correlates with pitch and amplitude correlates with	**Performance Assessment Task – Sample:** Using a tuning fork, students must create standing sound waves in a large, graduated cylinder by adjusting the water level in the cylinder. Based on their measurements, students can determine the speed of sound and compare their result to the theoretical value.	summative test.

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	loudness (energy). • The Doppler effect as it applies to sound waves accounts for the existence of sonic booms and shock waves, and the perceived change in pitch for a moving object's sound. • The Doppler effect as it applies to light waves accounts for the observation of the expansion of the universe.		
Geometric Optics The learner will: • Explain how the motion of a light wave can be understood in terms of a ray model • Explain and apply the law of reflection • **Optional**: Define refraction and calculate the angle of refraction using Snell's law • Calculate the location of an image formed by plane, spherical, convex and concave mirrors using both a ray diagram and the mirror equations • Calculate the location of an image formed by convex and concave lenses using both a ray diagram and the	**Essential Questions**: • How do eyes work? • How do glasses and contacts correct vision? • Why do diamonds sparkle? • How are rainbows created? • Why is the sky blue and why are sunsets red? • Why do some fun house mirrors make appear larger and others make you appear smaller? • How do telescopes & microscopes work? • How do fiber optic cables work? • Why do side view mirrors on cars say "Objects in	**Unit 10:** Light is an electromagnetic wave whose behavior can be understood using a ray model. The formation of images can be understood by analyzing the reflection of light rays from mirrors and the refraction of light rays through lenses **Instructional Strategies – Sample:** Demonstrate the formation of real and virtual images by convex, concave mirrors and lenses. **Performance Assessment Task – Sample:** Students will build a Galilean telescope and terrestrial telescope using a combination of convex and concave lenses. Students measure the magnification of each telescope by observing an object in the classroom.	Do nows, group WebAssigns, WebAssign home assessment, oral questioning, lab reports, quizzes, formative assessments using Personal Response System "clickers", closure. Benchmark: Unit summative test.

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mirror equation	mirror are closer than they appear"? **Enduring Understandings:** • Light slows down when it moves through denser materials, and bends when it does so. • Refraction allows us to manipulate the bending of light rays to make glasses, contacts, lenses, telescopes, microscopes work. • Ray diagrams are used to determine the type of images formed by mirrors and lenses. • Total internal reflection accounts for fiber optics. • Rayleigh scattering is responsible for blue skies and red sunsets.		
Wave Optics: Unit Optional based on ability to resolve vectors using trigonometry. The learner will: • Explain Huygen's principle • Explain diffraction in terms of Huygen's principle and interference • Calculate the diffraction pattern for a single slit and	**Essential Questions**: • How does light behave like a wave? • How does light behave like a particle? How can it be both? **Enduring Understandings:** • The particle-wave duality of light, and the	**Unit 11:** Diffraction is a phenomenon in which a wave "bends" around an obstruction and interferes with itself. For light waves, diffraction may result in regions of high and low light intensity that are known as "diffraction patterns". The single slit and double slit diffraction patterns can be calculated by applying the ideas of constructive and destructive interference to light waves. **Instructional Strategies – Sample:** Demonstrate how the single slit diffraction pattern depends on the width of the slit and how the double slit diffraction pattern	Do nows, group WebAssigns, WebAssign home assessment, oral questioning, lab reports, quizzes, formative assessments using Personal Response System "clickers",

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double slit • Light's particle-wave duality	experimental findings that underlie this paradox. • The connection between light frequency and energy. • Light has both energy and momentum like a particle. • Light can display interference effects like a wave.	depends on the distance between the slits. Also demonstrate how the diffraction pattern depends on the wavelength of light. **Performance Assessment Task – Sample:** Students observe the diffraction pattern created when laser light is incident on a single human hair. By analyzing the diffraction pattern using the single slit diffraction equations, students determine the width of the hair.	closure. Benchmark: Unit summative test.