Subject	Physics
Unit	Unit 2-3: Forces and Motion
Est. Length	~18 lessons (9/11-10/23)
Big Idea	Objects change their motion when they experience unbalanced forces.
Essential Questions	1. What makes objects change their motion? a. How can free body diagrams (FBD) be used to describe forces on an object? b. How are net force, mass and acceleration related? c. What are Newton's three laws of motion and how can they be used to describe how objects move? d. How can motion data tables and graphs help us analyze and describe motion?
MA State Standards *Power standards in bold	**HS-PS2-1. Analyze data to support the claim that Newton's second law of motion is a mathematical model describing change in motion (the acceleration) of objects when acted on by a net force.** ● Clarification Statements: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, and a moving object being pulled by a constant force. Forces can include contact forces, including friction, and forces acting at a

	distance, such as gravity and magnetic forces. ● State Assessment Boundary: Variable forces are not expected in state assessment. HS-PS2-10(MA). Use free-body force diagrams and algebraic expressions representing Newton's laws of motion to predict changes to velocity and acceleration for an object moving in one dimension in various situations. ● Clarification Statements: Predictions of changes in motion can be made numerically, graphically, and algebraically using basic equations for velocity, constant acceleration, and Newton's first and second laws. Forces can include contact forces including friction, and forces acting at a distance, such as gravity and magnetic forces cut static/kinetic, vector/scalar, dist/disp but not yet
Common Core State Standards (CCSS)	● RST.9-10.2 Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text., ● RST.9-10.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics., ● RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. ● WHST.9-10.1 Write arguments focused on discipline-specific content., ● WHST.9-10.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. ● WHST.9-10.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. ● WHST.9-10.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience., ● WHST.9-10.6 Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically., ● HSA.CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law V = IR to highlight resistance R. ● HSA.REI.B.3 Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters., ● HSF.BF.A.1 Write a function that describes a relationship between two quantities.* ● HSF.LE.B.5 Interpret the parameters in a linear or exponential function in terms of a context.

Science Practices (SP)	**1. Asking scientific questions & defining engineering problems** 2. Developing & using models 3. Planning & carrying out investigations **4. Analyzing & interpreting data** 5. Using mathematics & computational thinking 6. Constructing scientific explanations & designing engineering solutions **7. Engaging in argument from evidence** 8. Obtaining, evaluating, and communicating information
Assessment Alignment	Minor assessments • Quiz - draw free body diagrams and read motion graphs for 1st law • Quiz - draw FBDs, read motion graphs, and do calculations for 2nd law • Quiz - identify which of Newton's laws is relevant for a story Major assessments • Open response - draw and use free body diagrams • Open response - distance and displacement, speed and velocity • Open response - motion graphs • Unit 1-3 test
Honors Assignments	Force Question Poster: Students create a poster answering more in-depth questions about forces. Motion Equations Packet: Students use a guided inquiry page to derive commonly used motion equations. Motion Graphs Brochure: Students create a brochure with motion graphs for people walking, biking, etc. around a neighborhood.
20 Key Vocabulary Words	force, mass, Newton's Laws, inertia, normal, friction, weight, tension, kinetic, static, accelerating, balanced, unbalanced, constant, velocity, at rest, distance, displacement, position, steep, shallow, axis

Prior knowledge that students have entering this unit
Students learned about Newton's first and second law at the end of 8th grade science. They have also learned a little about constant velocity position vs. time graphs in 8th grade. In the new middle school curriculum maps as of 2017-18, middle school students will also be learning about Newton's 3rd law.

Where this knowledge goes next
Students will develop their intuitions about inertial and accelerated motion until they can confidently predict the motion of any object based on a free body diagram. They will also learn to represent inertial motion and accelerated motion graphically, and to calculate distance and displacement. After the forces unit, students use their knowledge of speed and velocity to develop a model for how momentum is conserved in collisions. The concepts of forces and motion are necessary prerequisites for students to understand most parts of the energy unit and are still relevant throughout all of the units in semester 2.

Descriptive outline narrative of unit
Students will engage in investigations and discussions to challenge and develop their intuitions about forces and motion. They will also be introduced to key problem solving tools (Given, Find, Equation and the magic triangle) as they begin solving problems about Newton's 2nd law. Students will represent motion graphically, use strategies to solve motion equations, and connect their understanding of motion with their understanding of forces. In the beginning of the unit students spend two weeks using free body diagrams and motion graphs to analyze and describe objects following Newton's 1st law (constant velocity motion, balanced forces). This is the first time they are learning how to draw these models so it makes sense to start with a limited set of examples and really focus on building conceptual intuition about Newton's 1st law. Next, starting in the third week of the unit, students analyze and describe objects following Newton's 2nd law. They continue to use the same models from before (FBD's and motion graphs) but with some added complexity. For unbalanced FBD's, students can calculate the net force. For accelerated motion, students can begin to describe acceleration quantitatively as the rate of change of velocity. Finally, students can draw a connection between measurements of acceleration and measurements of unbalanced force to understand and apply Newton's 2nd law equation. At the end of the unit students learn about Newton's 3rd law, and add more detail to their understanding of motion vocabulary by distinguishing scalar quantities (distance, average speed) from vectors (displacement, average velocity). Specifically, students learn to calculate distance and displacement from a short story or diagram, then learn to calculate average speed and average velocity by dividing total distance or displacement respectively by time. The unit ends with a test. There is a practice test before the test, so students can see which skills they need to study the most. Then there is a study day and then the test.

Day	Lesson #/name	MA	CCSS	Content Objective	Language Objective	Science practice(s)
1	N1L	HS-PS 2-10(MA).	RST.9-10.7	SWBAT use Newton's 1st law to predict whether motion will continue when the forces are balanced.	(R): Use the definitions of keywords (inertia, magnitude, force) in multiple choice problems to select the best answer	SP2. Developing & using models
2	Balanced	HS-PS 2-10(MA).	RST.9-10.7	SWBAT draw balanced FBD's that included labeled forces and the direction and magnitude of the force.	(W) Use the word "force" and its abbreviations to label a FBD	SP7. Engaging in argument from evidence
3	Weight	HS-PS 2-10(MA).	HSA.CED.A.4	SWBAT calculate weight from mass and include the magnitude of the normal force on FBD's.	(R,W):Use the definitions of key words (mass, weight) and their units to make a list of given information	SP5. Using mathematics & computational thinking
4	Friction	HS-PS 2-10(MA).	WHST.9-10.1	SWBAT add static or kinetic friction to balanced FBDs and describe differences between static and kinetic friction.	(S) use the words "kinetic" "moving" "static" and "stuck" to name which kind of friction is happening and explain why	SP6. Constructing scientific explanations & designing engineering solutions
5	CV	HS-PS 2-1.	RST.9-10.7	SWBAT describe constant velocity motion based on a position vs. time graph or data table.	(W) use the words constant, forward, back, slow, fast, stopped to annotate each part of a position vs. time graph	SP2. Develop & use models
6	Define v	HS-PS 2-1.	HSF.LE.B.5	SWBAT define velocity as the rate of change of position and draw velocity vs. time graphs.	(R): Identify key phrases in word problems (speed, how far, how fast, how long) to make a list of given information and what to find	SP2. Develop & use models
7	Graph v	HS-PS 2-1.	RST.9-10.7	SWBAT describe constant velocity motion based on a velocity vs. time graph.	(W) use the words constant, forward, back, slow, fast, stopped to annotate each part of a velocity vs. time graph	SP2. Develop & use models
8	N2L	HS-PS 2-10(M	RST.9-10.7	SWBAT calculate net force when given a FBD, and use Newton's 2nd law to predict	(S): Use the words "unbalanced" "accelerate" "change" to convince	SP2. Develop & use models

		A).		whether motion will change when forces are unbalanced.	classmates in a debate	
9	Unbalanced	HS-PS 2-10(MA).	RST.9-10.7	SWBAT draw unbalanced FBDs showing the direction, type and magnitude of a force.	(W) use the words “friction” “weight” “normal” “tension” and their abbreviations to label a FBD	SP7. Engaging in argument from evidence
10	Accelerated	HS-PS 2-1.	RST.9-10.7	SWBAT describe accelerated motion based on a position vs. time graph or data table.	(S) use the words slow, fast, speeding up, slowing down to describe specific moments on a position vs. time graph	SP2. Develop & use models
11	Accelerated (v vs t)	HS-PS 2-1.	RST.9-10.7	SWBAT describe accelerated motion based on a velocity vs. time graph.	(W) annotate each part of a v vs. t graph with the words speeding up, slowing down, forward, backward	SP2. Develop & use models
12	Define a	HS-PS 2-1.	HSF.LE.B.5	SWBAT define and calculate acceleration as the rate of change of velocity.	(S) use the words difference, subtract, multiply, per to convince someone else that your method of calculating acceleration is correct	SP2. Develop & use models
13	Connect Fnet/a	HS-PS 2-1.	HSA.REI.B.3	SWBAT investigate how force and mass affect an object’s acceleration.	(R) read and follow lab directions including “measure,” “record” and “plot”	SP3. Plan & carry out investigations
14	N2L equation	HS-PS 2-1.	HSA.REI.B.3	SWBAT solve numerical problems using Given, Find, Equation and Newton’s 2nd Law.	(R): Use definitions of given information (net force, mass, acceleration) to solve a problem	SP3. Plan & carry out investigations
15	N3L intro	HS-PS 2-10(MA).	RST.9-10.4	SWBAT state Newton's 3rd law and identify which of Newton’s three Laws are relevant in a scenario.	(R) Use definitions of key words (interact, collide, push, pull) in scenario descriptions to identify scenarios representing N3L	SP4. Analyze & interpret data
16	N3L misconceptions	HS-PS 2-10(MA).	WHST.9-10.1	SWBAT distinguish 3rd law pairs from balanced forces, and predict which object will accelerate faster following a collision.	(S) use the words “lighter” “heavier” “mass” and “inversely related” to justify which object accelerates more in a collision	SP7. Engage in argument from evidence

17	Scalar/ vector	HS-PS 2-1.	RST.9-10.7	SWBAT determine whether a quantity is a scalar or vector, and calculate distance and displacement from a story.	(W) Analyze a scenario using the sentence stems: *The distance is… The displacement is...*	SP4. Analyze & interpret data
18	Speed/ velocit y	HS-PS 2-1.	RST.9-10.7	SWBAT calculate average speed and velocity from a story.	(W) Analyze a scenario using the sentence stems: *The average speed is… The average velocity is…*	SP4. Analyze & interpret data

Subject	Physics
Unit	Unit 4: Momentum
Est. Length	~6 lessons (10/30-11/13)
Big Idea	The quantity that is conserved when objects collide is momentum, the product of velocity and mass.
Essential Questions	1. How do moving objects interact? a. What happens to the total momentum of a system during a collision? b. What equations and models can we use to understand how momentum is transferred?
MA State Standards *Power standards in bold	**HS-PS2-2. Use mathematical representations to show that the total momentum of a system of interacting objects is conserved when there is no net force on the system.** ● Clarification Statement: Emphasis is on the qualitative meaning of the conservation of momentum and the quantitative understanding of the conservation of linear momentum in interactions involving elastic and inelastic collisions between two objects in one dimension.
Common Core State Standards (CCSS)	● RST.9-10.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics., ● WHST.9-10.1 Write arguments focused on discipline-specific content. Write arguments focused on discipline-specific content. ● 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., ● HSA.CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales., ● HSA.REI.B.3 Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.,
Science Practices (SP)	**1. Asking scientific questions & defining engineering problems** 2. Developing & using models 3. Planning & carrying out investigations **4. Analyzing & interpreting data**

	5. Using mathematics & computational thinking 6. Constructing scientific explanations & designing engineering solutions **7. Engaging in argument from evidence** 8. Obtaining, evaluating, and communicating information
Assessment Alignment	<u>Minor Assessments</u> ● Quiz - calculate momentum, mass, velocity ● Quiz - use IF charts to model simple conservation of momentum problems <u>Major Assessments</u> ● Open response - momentum and motion ● Unit 4-5 Test (includes drawing IF charts)
Honors Assignments	None
20 Key Vocabulary Words	collision, before, after, object, momentum, conserved, same, quantity, total, product, sum, equal, inertia, opposite, negative, backwards, model, represent, velocity, mass

Prior knowledge that students have entering this unit
Students know about mass and velocity from the first quarter of this year. They have not learned about momentum in middle school, but in the new middle school curriculum maps as of 1718, they will have learned about inertia, so they will be able to compare and contrast inertia with momentum. During the momentum unit students engage in a process to build a model of momentum conservation. In the forces and motion unit there will have been some references to the idea of science as a set of models, Newton's 2nd law as a model, etc. but the momentum unit provides a much more thorough opportunity for students to experience the modeling process firsthand.

Where this knowledge goes next
Students will learn about momentum and conservation of momentum. In the next unit, students learn about energy and conservation of energy. The IF charts developed in this unit are similar in many ways to the LOL charts of the energy unit and provide students a starting point for developing their intuition about conservation both qualitative and quantitative. Momentum itself is not as relevant in the topics of semester 2 but the idea of modeling is a theme throughout the course.

Descriptive outline narrative of unit
Students will use an investigation to develop a model of momentum conservation, then learn a more complex problem solving strategy (before/after comparison) and apply it to conservation of momentum problems. On the first day of this unit students observe a series of collisions and begin creating diagrams to track what quantities are conserved in the collisions. Each new example (e.g. different mass, different initial direction of motion, elastic/inelastic) provides an opportunity for students to question and update their understanding of which quantity is conserved. This day is left open-ended in order to make the modeling experience as genuine as possible and allow for depth to develop rather than forcing it to end at a set point. On the second day of the unit students are introduced to the idea of momentum as the product of mass and velocity and engage in a more traditional lesson structure to practice calculating momentum. It's also important on this day for students to develop their conceptual intuition and make sense of patterns and relationships between mass, momentum, and velocity. On the third day we go back to the process of looking at collisions and continue developing the model of what is conserved, until we recognize that momentum (product of mass and velocity) is what's conserved in collisions. This day focuses primarily on elastic collisions and the practice problems at the end of the lesson will allow students to use their graphical model (aka diagram, problem solving technique, or Initial/Final (IF) chart) to practice solving multiple problems about elastic collisions. It's also important on this day that students practice checking their answers with their intuition about elastic collisions (e.g. larger mass travels slower). On the fourth day students continue using IF charts to solve problems, this time about explosion-type collisions (elastic starting from rest), and develop their conceptual intuitions about these scenarios. On the fifth day students use IF charts to solve problems about inelastic collisions, and develop intuition about those scenarios. The sixth day is review of all the different scenarios.

Day	Lesson #/name	MA	CCSS	Content Objective	Language Objective	Science practice(s)
1	Collide	HS-PS2-2.	HSN.Q.A.1	SWBAT begin to develop initial/final charts to represent the idea of conservation in collisions.	(S): use "stay the same," "before," "after" to state observations about conservation in collisions	SP1. Ask scientific questions & define engineering problems
2	Multiply	HS-PS2-2.	HSN.Q.A.2	SWBAT calculate momentum, mass, or velocity using GFE and the equation p=mv.	(R): read and interpret the words "momentum," "mass," "velocity" in word problems	SP3. Plan & carry out investigations
3	Elastic	HS-PS2-2.	HSN.Q.A.1	SWBAT continue developing Initial/final charts to represent conservation of momentum in elastic collisions.	(S): use "product," "opposite," "total" to state observations about conservation in collisions	SP1. Ask scientific questions & define engineering problems

4	Explosions	HS-PS2-2.	HSN.Q.A.1	SWBAT use initial/final charts to represent conservation of momentum in elastic collisions starting from rest.	(W): label IF charts with “momentum” “velocity” “mass” “before” and “after”	SP1. Ask scientific questions & define engineering problems
5	Inelastic	HS-PS2-2.	HSN.Q.A.1	SWBAT use initial/final charts to represent conservation of momentum in inelastic collisions.	(W): label IF charts with “momentum” “velocity” “mass” “before” and “after”	SP1. Ask scientific questions & define engineering problems
6	Solve	HS-PS2-2.	HSA.REI.B.3	SWBAT use IF charts to determine the unknown mass, velocity, or momentum in a collision.	(R): read and interpret the words “momentum,” “mass,” “velocity” in word problems	SP5. use mathematics & computational thinking

Subject	Physics
Unit	Unit 5: Energy
Est. Length	~19 lessons (11/13-1/22)
Big Idea	Energy can change forms and be transferred between objects, but cannot be created or destroyed.
Essential Questions	1. How does energy transform while also being conserved? 2. How does work affect the energy in a system?
MA State Standards *Power standards in bold	**HS-PS3-1. Use algebraic expressions and the principle of energy conservation to calculate the change in energy of one component of a system when the change in energy of the other component(s) of the system, as well as the total energy of the system including any energy entering or leaving the system, is known. Identify any transformations from one form of energy to another, including thermal, kinetic, gravitational, magnetic, or electrical energy, in the system.** ● Clarification Statement: Systems should be limited to two or three components and to thermal energy, kinetic energy, or the energies in gravitational, magnetic, or electric fields. HS-PS3-2. Develop and use a model to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles and objects or energy stored in fields. ● Clarification Statements: Examples of phenomena at the macroscopic scale could include evaporation and condensation, the conversion of kinetic energy to thermal energy, the gravitational potential energy stored due to position of an object above the Earth, and the stored energy (electrical potential) of a charged object's position within an electrical field. Examples of models could include diagrams, drawings, descriptions, and computer simulations. HS-PS3-3. Design and evaluate a device that works within given constraints to convert one form of energy into another form of energy.* ● Clarification Statements: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency. ● State Assessment Boundary: Quantitative evaluations will be limited to total output for a given input in state assessment.

	cut power but not yet
Common Core State Standards (CCSS)	● RST.9-10.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text., ● RST.9-10.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics., ● RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. ● WHST.9-10.1 Write arguments focused on discipline-specific content. Write arguments focused on discipline-specific content. ● WHST.9-10.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes., ● WHST.9-10.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience., ● WHST.9-10.1 Write arguments focused on discipline-specific content.0, ● HSA.CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law V = IR to highlight resistance R., ● HSA.REI.B.3 Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters., ● HSF.LE.B.5 Interpret the parameters in a linear or exponential function in terms of a context., ● 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., ● HSA.REI.B.3 Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.,
Science Practices (SP)	**1. Asking scientific questions & defining engineering problems** 2. Developing & using models 3. Planning & carrying out investigations **4. Analyzing & interpreting data** 5. Using mathematics & computational thinking 6. Constructing scientific explanations & designing engineering solutions **7. Engaging in argument from evidence** 8. Obtaining, evaluating, and communicating information

Assessment Alignment	<u>Minor Assessments</u> • Quiz - solve problems about work, power, force, distance and time • Quiz - use pie charts to solve conservation of energy problems • Quiz - use LOL charts to solve conservation of energy problems <u>Major Assessments</u> • Open response - quantitative conservation of energy problem (rollercoaster) • Open response - qualitative, emphasizes descriptive writing (bowling ball pendulum) • Rollercoaster • Unit 4-5 Test (includes drawing LOL charts)
Honors Assignments	KE Derivation: Students use a guided inquiry worksheet to derive the equation for kinetic energy. Power Lab Extension: Students continue investigating the relationships between force, power, work, distance and time.
20 Key Vocabulary Words	kinetic, potential, motion, height, velocity, mass, ground, difference, delta, conservation, total, same, before, after, transfer, transform, convert, work, power, Joules

Prior knowledge that students have entering this unit
Students know about kinetic and potential energy from middle school science. In the new curriculum maps as of 1718, students learn about energy in 7th grade. They learn about kinetic energy changing when energy is added or removed from an object; relationships between mass, velocity and KE; and relationships between KE and PE. Having learned about forces and displacement in unit 2-3, students are prepared for the first lesson of this unit which investigates what happens when force is applied over a distance.

Where this knowledge goes next
Students will develop their conceptual understanding of energy conservation and transformation, as well as their quantitative problem solving skills. After this unit, the topic changes to electrostatics and circuits. Although those topics are for the most part unrelated to the specific skills learned in the energy unit, there are some deep conceptual links which will be investigated in varying levels of detail. For example, the comparison between universal gravitation and Coulomb's law has to do with the idea of potential energy: whereas with gravity, energy is stored in a system with two masses held at a distance, in electrostatics it is stored in a system with two opposite charges held at a distance; the forces that

result from these different kinds of potential energy share the mathematical structure of an inverse square dependence on distance.

Descriptive outline narrative of unit
Students will use before/after comparison to solve problems about energy conservation, then build a model roller coaster to demonstrate conservation of energy in real life. In the first few lessons of this unit, students develop equations and names for work and power, and reflect on the relationships between work, power, and their constituent variables. Then they measure and calculate power, see the theoretical relationships in practice in their data, and analyze sources of error that affect the relationships observed. Next, students are introduced to the concepts of potential and kinetic energy (if there's time, teacher will show how these can be derived from work done perpendicular or parallel to the earth respectively). They use pie charts to analyze how the energy composition of a system can change over time while the total energy in the system is conserved. Then, they switch to using a LOL chart model. The LOL chart is two qualitative bar graphs ("L" is just for the shape of the axes when setting up a bar graph) on which students diagram the energy composition of the system at 2 moments in time. The circle in the middle (the "O") allows students to model work done on or by the system by using an arrow to represent energy "entering or leaving" the diagram at that point. The engineering section of this unit involves designing, building, and making measurements on a model roller coaster made of foam tubing and other materials. It will be done in groups with roles and specific goals for progress each day. After the conclusion of the rollercoaster project, one day is spent with students demonstrating physics concepts from all of semester 1 on ice skates at the local skating rink. They take short videos of themselves demonstrating one of the concepts from the semester such as constant velocity motion, inelastic collision, etc.

Day	Lesson #/name	MA	CCSS	Content Objective	Language Objective	Science practice(s)
1	Work	HS-PS3-1.	HSN.Q.A.1	SWBAT determine that work is done when force affects the displacement of an object.	(W): use the words force, displacement, and work in writing to explain why work occurs.	SP4. Analyze & interpret data
2	Power	HS-PS3-1.	HSN.Q.A.2	SWBAT use GFE to calculate work, force, displacement, power and time.	(R): read word problems and identify given "work" "force" "displacement" "power" "time"	SP5. Use mathematics & computational thinking
3	Relation ships	HS-PS3-1.	HSF.LE.B.5	SWBAT explain mathematically and graphically the relationships between work, power, force, displacement, and	(S): use "increase" "decrease" "direct" "inverse" to describe relationships between variables	SP6. Construct scientific explanations & design engineering solutions

				time.		
4	Measure	HS-PS3-1.	RST.9-10.3	SWBAT measure force and distance to calculate the power generated when lifting weights.	(S,L): use “force” “distance” “parallel” to ask and answer questions while developing lab procedure	SP1. Ask scientific questions & define engineering problems
5	Analyze	HS-PS3-1.	WHST.9-10.1	SWBAT determine whether a graph shows an inverse or direct relationship and describe how errors affected the data.	(W): use “increase” “decrease” “direct” “inverse” to explain direct or inverse relationship	SP3. Plan & carry out investigations
6	KE,PE	HS-PS3-1.	HSA.CED.A.4	SWBAT use GFE to solve problems about kinetic and potential energy.	(R): use the words “velocity” “height” “mass” in a word problem to identify given information	SP5. use mathematics & computational thinking
7	Draw Pie charts	HS-PS3-2.	RST.9-10.7	SWBAT state the Law of Conservation of Energy and use it to draw pie charts of PE, KE and thermal energy at different times.	(W): label pie chart with “PE” “KE” “before” and “after”	SP2. Develop & use models
8	Use pie charts	HS-PS3-2.	HSA.REI.B.3	SWBAT use pie charts to determine KE and PE values at different times.	(R):use the words “PE” “KE” “before” “after” to identify given information in a word problem	SP5. use mathematics & computational thinking
9	Draw LOL	HS-PS3-2.	RST.9-10.7	SWBAT draw LOL bar graphs to represent relative shares of PE, KE and thermal energy at different times.	(W): label LOL chart with “PE” “KE” “before” “after”	SP2. Develop & use models
10	Use LOL	HS-PS3-2.	HST.REI.B.3	SWBAT use LOL bar graphs and conservation of energy to determine KE and PE values at various points in time.	(R):use “PE” “KE” “before” “after” to identify given information in a word problem	SP5. use mathematics & computational thinking
11	LOL with work	HS-PS3-2.	WHST.9-10.1	SWBAT use LOL bar graphs and the work-energy theorem to determine KE and PE values at various points in time.	(R): use “PE” “KE” “work” “add” “remove” “before” “after” to identify given information in a word problem	SP7. Engage in argument from evidence
12	Enginee	HS-PS3-3.	WHST.9-10.1	SWBAT work efficiently in groups to	(S): use "if/then/because" sentence	SP1. Ask scientific

	ring			complete an engineering challenge.	structure to advocate for design choices and role	questions & define engineering problems
13	Prototype	HS-PS3-3.	WHST.9-10.10	SWBAT generate a prototype for their roller coaster .	(S): use "if/then/because" sentence structure to compare and contrast possible design choices	SP6. Construct scientific explanations & design engineering solutions
14	Redesign	HS-PS3-3.	WHST.9-10.2	SWBAT test and redesign their roller coaster prototype.	(S): use past tense verbs (including conditionals) to justify design choices based on criteria/constraints	SP6. Construct scientific explanations & design engineering solutions
15	Measure	HS-PS3-3.	RST.9-10.3	SWBAT record quantitative data (mass, displacement, and height) for their roller coaster.	(W): use the words mass, displacement, height to record data in a graphic organizer	SP8. Obtain, evaluate, and communicate information
16	Photogate	HS-PS3-3.	RST.9-10.3	SWBAT use photogate data to calculate the velocity of a marble exiting a roller coaster.	(W): use the words time, distance and velocity to record data in a graphic organizer	SP3. plan & carry out investigations
17	Analyze	HS-PS3-3.	HSA.REI.B.3	SWBAT use a LOL bar graph and the Law of Conservation of Energy to calculate friction along part of roller coaster.	(W): make a claim about friction, use LOL chart as evidence, and give reasoning to connect the evidence with the claim	SP4. analyze & interpret data
18	Present	HS-PS3-3.	WHST.9-10.4	SWBAT present to their peers a rationale for their engineering design choices and explain energy transformations in their roller coaster design solution.	(S): use past tense verbs (including conditionals) to describe steps of engineering and modeling	SP8. Obtain, evaluate, and communicate information
19	Ice skating	N/A	WHST.9-10.4	SWBAT use ice skating to demonstrate examples of motion, forces, momentum and energy conservation.	(S): use present tense verbs and the words move, force, conserved to describe examples	SP8. Obtain, evaluate, and communicate information

Subject	Physics
Unit	Unit 6: Electrostatics
Est. Length	~9 lessons (1/22-2/12)
Big Idea	Electric charge causes objects to repel or attract in inverse proportion to their distance.
Essential Questions	1. How do objects become charged, and how do charged objects interact? a. How does Coulomb's law affect the strength of the electrostatic force between objects? b. How is this similar to Newton's law of gravitation?
MA State Standards *Power standards in bold	**HS-PS2-4. Use mathematical representations of Newton's law of gravitation and Coulomb's law to both qualitatively and quantitatively describe and predict the effects of gravitational and electrostatic forces between objects.** ● Clarification Statement: Emphasis is on the relative changes when distance, mass or charge. ● State Assessment Boundaries: State assessment will be limited to systems with two objects. Permittivity of free space is not expected in state assessment. cut circular motion, insulator/conductor but not yet (and what about charging methods??)
Common Core State Standards (CCSS)	● RST.9-10.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics. ● RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. ● WHST.9-10.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes., ● HSA.REI.B.3 Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.,
Science Practices (SP)	**1. Asking scientific questions & defining engineering problems** 2. Developing & using models 3. Planning & carrying out investigations **4. Analyzing & interpreting data** 5. Using mathematics & computational thinking 6. Constructing scientific explanations & designing engineering solutions

	7. **Engaging in argument from evidence** 8. Obtaining, evaluating, and communicating information
Assessment Alignment	<u>Minor Assessments</u> ● Quiz - answer conceptual multiple choice problems about charging by friction and polarization <u>Major Assessments</u> ● Open response - Coulomb's law comparisons ● Unit 6-7 Test
Honors Assignments	Coulomb's Law Lab: Students use what they know about geometry and Coulomb's law to determine how many electrons are actually transferred when they charge a balloon by friction. PhET Simulation: Students use PhET simulations to do more research on charging by friction. Universal Gravitation Packet: Students solve problems about gravity on other planets.
20 Key Vocabulary Words	Conductor, insulator, Coulomb force, Proton, Neutron, Electron, Atom, Charge, Net charge, Attract, Repel, gravity, mass, inverse square, nucleus, fixed, freely, metal, distribute, stationary

Prior knowledge that students have entering this unit
The following objectives are from the physical science unit in middle school science: 1. Differentiate between attractive and repulsive forces. 2. Define positive and negative charges and give an example of what each looks like. 3. Compare and contrast what happens when two unlike forces (+ /-) meet and two like forces (+ /+ or - / -) meet. 4. Describe the effect of distance and magnitude of electric charge and current on the size of electromagnetic forces. Students coming into the 9th grade will have learned about magnets in 6th-7th grade but have never learned about electric charges.

Where this knowledge goes next
After learning about electrostatics in this unit, students will learn about circuits in the next unit. Their understanding of circuits will build on their understanding of electrostatics because they will need to know that electric current consists of electrons flowing through a closed loop of

conductive materials.

Descriptive outline narrative of unit
Students first learn about subatomic particles, then expand their understanding to macroscopic objects with a net charge. Next, students will learn about conductors and insulators, then attractive and repulsive forces. In the last week of the unit, students use Coulomb's law to calculate the strength of the electrostatic force between two charged objects, think more about the inverse square relationship in Coulomb's law, and finally learn about circular motion by comparing Coulomb's law to Newton's law of universal gravitation.

Day	Lesson #/name	MA	CCSS	Content Objective	Language Objective	Science practice(s)
1	Inside the atom	HS-PS3-5.	RST.9-10.4	SWBAT describe how positively charged protons and negatively charged electrons interact and whether they can move away from an atom.	(L/S): use the phrase "like charges" or "opposite charges" to justify predictions about whether charges will attract or repel	SP2. Develop & use models
2	Insulator/conductor	HS-PS2-4.	RST.9-10.4	SWBAT analyze how electrons move in insulators vs. conductors. SWBAT use the E button on a scientific calculator to solve multiplication and division problems with scientific notation	(L/S): use the vocabulary "flow" or "move freely" to describe how electrons move in conductors	SP5. use mathematics & computational thinking
3	Charging by friction	HS-PS3-5.	WHST.9-10.2	SWBAT analyze in writing and drawings how insulators acquire net charge by friction.	(L/S): use transition words such as "first," "next," "therefore," and vocabulary words "electron," "insulator" and "net charge" to discuss the steps of charging by friction	SP3. plan & carry out investigations
4	Polarization	HS-PS3-5.	WHST.9-10.2	SWBAT analyze in writing and drawings how neutral objects can become polarized.	(L/S): use transition words such as "first," "next," "therefore," and vocabulary words "electron," "neutral" and "net charge" to discuss the steps of polarization	SP1. Ask scientific questions & define engineering problems

5	Distance	HS-PS3-5.	RST.9-10.7	SWBAT predict whether changing the charge or distance between objects will strengthen or weaken their attraction.	LO(reading/listening): translate the phrases "closer," "farther apart," "smaller/decreasing distance" and "larger/increasing distance" into drawings	SP7. Engage in argument from evidence
6	Coulomb's law	HS-PS2-4.	HSA.REI.B.3	SWBAT use Coulomb's Law to calculate the force between two charges.	(R/W): identify and list given information (charges, signs, distance) in question	SP5. Use mathematics & computational thinking
7	Gravity	HS-PS2-4.	HSA.REI.B.3	SWBAT use Newton's Law of Universal Gravitation to determine the force between two masses.	(R/W): identify given information (masses, distance) in question, list given information and use it to solve the problem	SP5. use mathematics & computational thinking
8	Inverse square	HS-PS2-4.	RST.9-10.4	SWBAT compare the inverse square dependence on distance in Coulomb's Law and Newton's Law of Gravitation.	(R/W): translate the phrases "closer," "farther apart," "smaller/decreasing distance" and "larger/increasing distance" into numerical comparisons	SP7. Engage in argument from evidence
9	Circular motion	HS-PS2-4.	RST.9-10.4	SWBAT predict the direction of the force during and following the release from circular motion**.**	(S/W): use "if/then" sentence structure to predict direction of release	SP6. Construct scientific explanations & design engineering solutions

Subject	Physics
Unit	Unit 7: Circuits
Est. Length	~14 lessons (2/12-3/26)
Big Idea	Voltage causes current to flow through circuits.
Essential Questions	1. How does current flow in series and parallel circuits? a. How do changing currents and magnetic fields affect one another?
MA State Standards *Power standards in bold	**HS-PS2-9(MA). Evaluate simple series and parallel circuits to predict changes to voltage, current, or resistance when simple changes are made to a circuit.** ● Clarification Statements: Predictions of changes can be represented numerically, graphically, or algebraically using Ohm's Law. Simple changes to a circuit may include adding a component, changing the resistance of a load of a component, and adding a parallel path in circuits with batteries and common loads. Simple circuits can be represented in schematic diagrams. ● State Assessment Boundary: Use of measurement devices and predictions of changes in power are not expected in state assessment. HS-PS2-5. Provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. ● Clarification Statement: Examples of evidence can include movement of a magnetic compass when placed in the vicinity of a current-carrying wire, a magnet passing through a coil that turns on the light of a Faraday flashlight. ● State Assessment Boundary: Explanations of motors or generators are not expected in state assessment. cut power but not yet
Common Core State Standards (CCSS)	● RST.9-10.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics., ● RST.9-10.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text., ● RST.9-10.2 Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.,

	• WHST.9-10.1 Write arguments focused on discipline-specific content., • WHST.9-10.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. • HSA.REI.B.3 Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters., • HSF.LE.B.5 Interpret the parameters in a linear or exponential function in terms of a context.,
Science Practices (SP)	**1. Asking scientific questions & defining engineering problems** 2. Developing & using models 3. Planning & carrying out investigations **4. Analyzing & interpreting data** 5. Using mathematics & computational thinking 6. Constructing scientific explanations & designing engineering solutions **7. Engaging in argument from evidence** 8. Obtaining, evaluating, and communicating information
Assessment Alignment	Minor Assessments • Quiz - make predictions about circuit changes and Ohm's law Major Assessments • Open response - experimental design and data analysis • Open response - circuit calculation (variable circuit - checks conceptual understanding of where current flows) • **Friendship Detector (Roundtable Project)** • Unit 6-7 Test
Honors Assignments	Equivalent Resistance Packet: Students solve problems about equivalent resistance in more complex circuits.
20 Key Vocabulary Words	wire, bulb, fuse, switch, resistor, resistance, voltage, power, current, parallel, series, branch, junction, path, Ohm's law, and, or, brass fastener, paper clip, aluminum foil

Prior knowledge that students have entering this unit
Students have studied circuits in 8th grade science.

Where this knowledge goes next
Students will build on their understanding of circuits to include additional components and structures, most importantly parallel and series circuits. After the circuits unit, the topic changes to heat and then waves, and no specific connections are drawn.

Descriptive outline narrative of unit
Students will practice building circuits and drawing circuit diagrams, then complete the friendship detector roundtable project.

Day	Lesson #/name	MA	CCSS	Content Objective	Language Objective	Science practice(s)
1	Testing	HS-PS2-9(MA).	WHST.9-10.1	SWBAT make, explain and test predictions about where current will flow based on a circuit diagram.	(R/W): define key terms "resistor," "bulb," "battery" using the phrase "electron flow"	SP2. Develop & use models
2	Ohm's Law	HS-PS2-9(MA).	HSA.REI.B.3	SWBAT use GFE to solve problems involving Ohm's Law.	(R/W): identify key terms "voltage," "current' "resistance," "potential difference," "power" and use them to solve problems	SP5. use mathematics & computational thinking
3	Changes	HS-PS2-9(MA).	HSF.LE.B.5	SWBAT make, explain, and test predictions about changing V, I, or R in a simple circuit.	(W): write a paragraph in past tense and passive voice about experimental procedure	SP3. plan & carry out investigations
5	Series	HS-PS2-9(MA).	WHST.9-10.1	SWBAT calculate V, I or R in a series circuit and test predictions about adding resistors in series.	(S/W): use complete sentences and the phrase "electron flow" to explain series/parallel	SP4. analyze & interpret data
6	Parallel	HS-PS2-9(MA).	RST.9-10.4	SWBAT calculate V, I or R in a parallel circuit and test predictions about adding branches in parallel.	(S/W): use "current," "resistance," "voltage" to justify predictions	SP3. plan & carry out investigations
7	Measurement	HS-PS2-9(MA).	RST.9-10.4	SWBAT draw ammeters in series and voltmeters and ohmmeters in parallel.		
8	Electromagnetis	HS-PS2-5.	RST.9-10.2	SWBAT use evidence to prove that changing currents and moving	(R/S): identify the main idea of a paragraph and use it to state steps of	SP1. Ask scientific questions & define

	m			magnets affect each other.	lab	engineering problems
9	Applications	HS-PS2-5.	RST.9-10.2	SWBAT describe how electric and magnetic forces are used in motors and generators.	(R/S): identify the main idea of a paragraph and paraphrase it accurately	SP4. analyze & interpret data
10	Planning	HS-PS2-9(MA).	WHST.9-10.1	SWBAT plan the questions, logic, and circuit diagram for their Friendship Detector Circuit.	(R/W): identify key words "and," "or" in problem and use complete sentences to justify choice of series/parallel	SP1. Ask scientific questions & define engineering problems
11	Wires	HS-PS2-9(MA).	RST.9-10.3	SWBAT use foil to build their Friendship Detector, leaving space for the switches, LED, resistor and battery.	(S/L): use "LED," "resistor," "battery" to discuss circuit setup	SP6. Construct scientific explanations & design engineering solutions
12	Other components	HS-PS2-9(MA).	RST.9-10.3	SWBAT add switches, LED, resistor and battery to their Friendship Detector.	(S/L): use "closed" and "open" to discuss debugging process	SP6. Construct scientific explanations & design engineering solutions
13	Testing	HS-PS2-9(MA).	WHST.9-10.2	SWBAT debug and test their Friendship Detector circuits.	(S/L): ask and answer questions to determine friendship compatibility	SP8. Obtain, evaluate, and communicate information
14	RT Reflection	HS-PS2-9(MA).	WHST.9-10.2	SWBAT write thoughtful roundtable reflections about their friendship detector project.	(W): use past tense and structured paragraphs to write a compelling cover letter	SP8. Obtain, evaluate, and communicate information

Subject	Physics
Unit	Unit 8: Heat
Est. Length	~6 lessons (4/2-4/23)
Big Idea	When heat is added to an object, the object's temperature increases in inverse proportion to its specific heat capacity except when the object is undergoing a phase change.
Essential Questions	1. How does heat affect temperature? a. What are the similarities and differences between heat and other kinds of energy transfer (e.g. mechanical work)? b. How does specific heat capacity affect an object's ability to change its temperature? c. What happens to temperature while an object is changing phase?
MA State Standards *Power standards in bold	HS-PS3-2. Develop and use a model to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles and objects or energy stored in fields. ● Clarification Statements: Examples of phenomena at the macroscopic scale could include evaporation and condensation, the conversion of kinetic energy to thermal energy, the gravitational potential energy stored due to position of an object above the Earth, and the stored energy (electrical potential) of a charged object's position within an electrical field. Examples of models could include diagrams, drawings, descriptions, and computer simulations. Eventually integrate with energy
Common Core State Standards (CCSS)	● RST.9-10.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text. ● RST.9-10.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics., ● RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. ● WHST.9-10.1 Write arguments focused on discipline-specific content. Write arguments focused on discipline-specific content. ● HSA.REI.B.3 Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.

Science Practices (SP)	**1. Asking scientific questions & defining engineering problems** 2. Developing & using models 3. Planning & carrying out investigations **4. Analyzing & interpreting data** 5. Using mathematics & computational thinking 6. Constructing scientific explanations & designing engineering solutions **7. Engaging in argument from evidence** 8. Obtaining, evaluating, and communicating information
Assessment Alignment	Minor Assessments ● Quiz - conceptual multiple choice about heat and temperature Major Assessments ● Unit 8-9 Test
Honors Assignments	None
20 Key Vocabulary Words	conduction, convection, radiation, temperature, heat, thermal energy, phase change, boiling, melting, condensing, evaporating, freezing, specific heat capacity, molecules, mass, difference, change, equilibrium, net, exchange

Prior knowledge that students have entering this unit
Students have studied phase changes in 8th grade science.

Where this knowledge goes next
Students will add precision to their conceptions of temperature and heat by understanding heat as a transfer of energy and temperature as molecular motion. After this unit, the topic changes to waves, and no specific connections are drawn. However, topics and skills from the heat unit are spiraled throughout the waves unit to help students prepare for the unit 8-9 test.

Descriptive outline narrative of unit
Students will engage in guided inquiry to develop their conceptions of heat and temperature, then perform a short calorimetry experiment and analysis.

Day	Lesson #/name	MA	CCSS	Content Objective	Language Objective	Science practice(s)
1	Heat and temperature	HS-PS3-2.	RST.9-10.4	SWBAT compare and contrast heat and temperature	(S/W): use the words "compact," "spread out," to describe the relative density of molecules in solid, liquid and gas phase	SP6. Construct scientific explanations & design engineering solutions
2	Heat transfer	HS-PS3-2.	RST.9-10.4	SWBAT describe how heat transfer occurs by conduction, convection and radiation	(S/W): describe what happens to molecules in each method of heat transfer	SP8. Obtain, evaluate, and communicate information
3	Phase changes	HS-PS3-2.	WHST.9-10.1	SWBAT explain that heat can increase temperature OR cause a phase change.	(S/W): describe what happens on a heating curve when T increases (molecules moving faster) and when phase changes (molecules spread out and/or leave)	SP8. Obtain, evaluate, and communicate information
4	Equation	HS-PS3-2.	HSA.REI.B.3	SWBAT solve problems about heat flow using the equation Q = m*c*deltaT.	LO: use direct/inverse relationships to justify predictions of - which object requires more heat - which object will change T more easily	SP5. use mathematics & computational thinking
5	Data	HS-PS3-2.	RST.9-10.3	SWBAT measure and calculate temperature, mass, heat transfer, and specific heat capacity in order to determine the identity of an unknown material.	(L/W): follow a series of directions for recording temperature and mass	SP3. plan & carry out investigations
6	Analysis	HS-PS3-2.	RST.9-10.7	SWBAT analyze data and use known specific heat capacities to identify an unknown metal.	(R/W): determine which of their data are relevant to solve a series of calculation problems	SP4. analyze & interpret data

Subject	Physics
Unit	Unit 9: Waves
Est. Length	~9 lessons (4/23-5/7)
Big Idea	Waves carry energy without transporting matter.
Essential Questions	1. How do sound and light carry energy? a. How does the frequency of different EM waves make them useful for technology?
MA State Standards *Power standards in bold	**HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. Recognize that electromagnetic waves can travel through empty space (without a medium) as compared to mechanical waves that require a medium.** ● Clarification Statements: Emphasis is on relationships when waves travel within a medium, and comparisons when a wave travels in different media. Examples of situations to consider could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth. Relationships include $v = \lambda f$, $T = 1/f$, and the qualitative comparison of the speed of a transverse (including electromagnetic) or longitudinal mechanical wave in a solid, liquid, gas, or vacuum. ● State Assessment Boundary: Transitions between two media are not expected in state assessment. HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described by either a wave model or a particle model, and that for some situations involving resonance, interference, diffraction, refraction or the photoelectric effect, one model is more useful than the other. ● Clarification Statement: Emphasis is on qualitative reasoning and comparisons of the two models. ● State Assessment Boundary: Calculations of energy levels or resonant frequencies are not expected in state assessment. HS-PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.* ● Clarification Statements: Emphasis is on qualitative information and descriptions. Examples of technological devices could include solar cells capturing light and converting it to electricity, medical imaging, and, communications technology. Examples of principles of wave behavior include resonance, photoelectric effect, and constructive and destructive interference.

	● State Assessment Boundary: Band theory is not expected in state assessment. cut trans/long, refl/refract, doppler, simple harmonic motion but not yet
Common Core State Standards (CCSS)	● RST.9-10.2 Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text., ● RST.9-10.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics., ● RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. ● WHST.9-10.1 Write arguments focused on discipline-specific content., ● HSA.REI.B.3 Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.,
Science Practices (SP)	**1. Asking scientific questions & defining engineering problems** 2. Developing & using models 3. Planning & carrying out investigations **4. Analyzing & interpreting data** 5. Using mathematics & computational thinking 6. Constructing scientific explanations & designing engineering solutions **7. Engaging in argument from evidence** 8. Obtaining, evaluating, and communicating information
Assessment Alignment	Minor Assessments ● Quiz - solve problems about velocity, frequency, period, wavelength (vocabulary embedded in problem wording) Major Assessments ● Open response - camera (draw reflection diagram at a weird angle, tests optics vocabulary) ● Unit 8-9 Test
Honors Assignments	Gummi Bear Wave Machine: Students build and present a 3D model of a wave. Pendulum Lab: Students design and build a pendulum that swings to the beat of their favorite song.
20 Key	velocity, frequency, wavelength, transverse, longitudinal, amplitude, crest, trough, rarefaction, compression,

Vocabulary Words	sound, light, electromagnetic, radio, microwave, gamma, infrared, ultraviolet, visible, spectrum

Prior knowledge that students have entering this unit
Students have studied waves in middle school (6th grade).

Where this knowledge goes next
Students will refresh their conceptual understanding of waves; solve quantitative problems about frequency, velocity and wavelength; and practice writing thorough open response answers about waves. After this unit, we move into review for the MCAS, which will have a special focus on reviewing heat and waves since those are the shortest units in the year.

Descriptive outline narrative of unit
Students will engage in guided inquiry to develop their conceptual understanding of waves, solve problems using the wave equation, and give short presentations about the technological applications of the electromagnetic spectrum based on information from an article.

Day	Lesson #/name	MA	CCSS	Content Objective	Language Objective	Science practice(s)
1	Parts of a wave	HS-PS4-1.	RST.9-10.7	SWBAT locate the crests, troughs, and amplitude of a wave, and calculate period and frequency of a wave.	(S/W): define a wave as energy propagating through a medium by vibrating particles	SP2. Develop & use models
2	Period and frequency	HS-PS4-1.	RST.9-10.7	SWBAT calculate period given frequency and vice versa.	(W): interpret key words in a problem such as "cycle" and use them to calculate T or f	SP2. Develop & use models
3	Wave equation	HS-PS4-1.	HSA.REI.B.3	SWBAT use the wave velocity equation to solve for velocity, frequency, or wavelength.	(W): interpret key words in a word problem and use them to calculate v, f, lambda	SP3. plan & carry out investigations
4	Transverse,lo	HS-PS4-1.	RST.9-10.7	SWBAT use pictures or descriptions to classify waves as transverse or longitudinal.	(S/W): explain that in transverse waves, particles vibrate perpendicular to the	SP6. Construct scientific explanations & design

	ngitudinal				wave, while in longitudinal waves, they vibrate parallel to the wave	engineering solutions
5	Sound properties	HS-PS4-1.	WHST.9-10.1	SWBAT predict how a sound's pitch, volume, and speed will change when the amplitude, frequency, or density/phase of the medium change.	(S/W): justify answers using academic vocabulary "amplitude", "frequency", "dense"	SP4. analyze & interpret data
6	Doppler	HS-PS4-1.	WHST.9-10.1	SWBAT use knowledge of the Doppler effect to predict whether the frequency of a wavelength will be perceived by an observer as higher or lower.	(W): interpret key words in a word problem "towards" "away" "stationary observer" and use them to visualize the Doppler effect	SP7. Engage in argument from evidence
7	EM spectrum	HS-PS4-5.	RST.9-10.2	SWBAT arrange the seven types of EM waves, and seven colors of visible light, in order within the spectrum.	(S/W): describe how each EM wave is used based on its frequency and wavelength	SP8. Obtain, evaluate, and communicate information
8	Sound and light	HS-PS4-3.	WHST.9-10.1	SWBAT compare and contrast wave properties and behaviors between light and sound waves.	(S/L): discuss similarities and differences between light and sound using words listed above	SP8. Obtain, evaluate, and communicate information
9	Reflection,refraction	HS-PS4-3.	RST.9-10.7	SWBAT draw the approximate path and measure the angles of a reflecting or refracting wave	(L/R): follow lab directions including the words "beam", "incident" "refracted" "reflected" to measure angles exactly	SP1. Ask scientific questions & define engineering problems

Subject	Physics
Unit	Unit 10: Review
Est. Length	~12 lessons (5/14-end of year)
Big Idea	Read carefully, choose strategically, use resources, and write thoroughly!
Essential Questions	1. What strategies and skills will help us to do our best work on the MCAS exam?
MA State Standards *Power standards in bold	N/A
Common Core State Standards (CCSS)	• RST.9-10.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text., • RST.9-10.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics. • RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. • WHST.9-10.1 Write arguments focused on discipline-specific content., • HSA.REI.B.3 Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters., • HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.,
Science Practices (SP)	**1. Asking scientific questions & defining engineering problems** 2. Developing & using models 3. Planning & carrying out investigations **4. Analyzing & interpreting data** 5. Using mathematics & computational thinking 6. Constructing scientific explanations & designing engineering solutions **7. Engaging in argument from evidence** 8. Obtaining, evaluating, and communicating information

Assessment Alignment	Minor Assessments • Quizzes
Honors Assignments	N/A
20 Key Vocabulary Words	N/A

Prior knowledge that students have entering this unit
Students have learned about forces, motion, momentum, energy, electrostatics, circuits, heat and waves.

Where this knowledge goes next
Students will refresh their knowledge of all topics covered in physics this year and prepare for the MCAS.

Descriptive outline narrative of unit
Students will take a practice test, then work at their own pace to refresh their understanding of each topic before moving on to mixed practice sets.

Day	Lesson #/name	MA	CCSS	Content Objective	Language Objective	Science practice(s)
1	Practice part 1	N/A	RST.9-10.4	SWBAT answer MC + OR questions on a practice MCAS exam.	LO: Read a scenario and identify starting quantities for an OR answer.	SP5. Use mathematics & computational thinking
2	Practice part 2	N/A	WHST.9-10.1	SWBAT answer MC + OR questions on a practice MCAS exam.	LO: Read a scenario and identify starting quantities for an OR answer.	SP7. Engage in argument from evidence

3	Motion stories	HS-PS 2-1.	RST.9-10 .4	SWBAT solve word problems to determine distance, displacement, average speed and average velocity.	(R/W): Make a map based on key words in the problem	SP4. analyze & interpret data
4	Motion graphs	HS-PS 2-1.	RST.9-10 .7	SWBAT read and draw x vs. t and v vs. t graphs.	(W/S): describe the motion based on the diagram	SP2. Develop & use models
5	Accele ration	HS-PS 2-1.	RST.9-10 .7	SWBAT calculate acceleration from a word problem or v vs. t graph.	(R): pick out key words in the problem ("initial," "final," "change")	SP2. Develop & use models
6	FBD’s	HS-PS 2-10(M A)	RST.9-10 .7	SWBAT draw a FBD based on a scenario and determine net force or the missing force on an object.	(R/W): ID and list important forces in the scenario	SP2. Develop & use models
7	Series	HS-PS 2-9(MA).	HSA.REI. B.3	SWBAT calculate V, I, R in series circuits.	(S): explain why Rtotal must be calculated first in series	SP5. Use mathematics & computational thinking
8	Parall el	HS-PS 2-9(MA).	HSA.REI. B.3	SWBAT calculate V, I, R in parallel circuits.	(S): explain why each branch must be calculated separately in parallel	SP5. Use mathematics & computational thinking
9	Count SF	N/A	HSN.Q.A .3	SWBAT count sig figs.	(R/S): SWBAT determine the main idea and respond to a text about science.	SP5. Use mathematics & computational thinking
10	Round SF	N/A	HSN.Q.A .3	SWBAT round to three sig figs.	(R/S): SWBAT determine the main idea and respond to a text about science.	SP5. Use mathematics & computational thinking
11	Rebuil d	N/A	RST.9-10 .3	SWBAT rebuild and decorate their friendship detector circuits.	(S): SWBAT explain conductors and insulators to an audience.	SP6. Construct scientific explanations & design engineering solutions
12	Decor ate	N/A	RST.9-10 .3	SWBAT rebuild and decorate their friendship detector circuits.	(S): SWBAT explain series and parallel circuits to an audience.	SP6. Construct scientific explanations & design engineering solutions