Chapter 1: Science Practices

These maths and science practices skills activities are integrated throughout chapters where they are relevant.

Chapter 2: Structure and Properties of Matter

Date	Duration Time / No. of periods	Activity number(s)	Notes	Lab / Practical activity	Formative or Summative Assessment
	1	17	**Anchoring Phenomenon**: What are the underlying causes of the different properties of compounds?	Have models of each of the crystal shapes. Have students use their hands to model what the cleavage planes are for each crystal shape (pictured or modelled).	• What do your students already know about the topic? • Are there any gaps or misconceptions?
	1	18	**Key Question (KQ)**: How do we define matter? What are the different types of matter and how can we classify them? **Vocab**: matter, substance, mixture, element, atom, compound,		• Use your own and another students flow chart / dichotomous key to classify the pictured items on p34.
	1	19	**KQ**: What is an atom and what is it made of? **Vocab**: *a-, -tomos,* atom, chemical properties, protons, neutrons, electrons	Students could build an atom using the simulation link provided: https://phet.colorado.edu/en/simulations/build-an-atom	• What determines the identity of an atom? How is this related to an element?
	3	20	**KQ**: How was the current model of the atom developed? **Vocab**: Brownian motion, subatomic particles, nucleus, atomic mass, nuclear charge, orbital	Students could complete a simulation of Rutherford's experiment using the link provided: https://phet.colorado.edu/sims/html/rutherford-scattering/latest/rutherford-scattering_all.html	• Research 1 (or all) of the scientists listed on p36. Describe the experiment they did, the results they observed, the conclusions they drew and how this changed the understanding (the model) of the atom. Share your results with the class.
	1.5	21	**KQ**: What kinds of models of the atom are there and how are they useful? **Vocab**: nuclear reactions, chemical reactions, neutral atoms, electron shells, atomic number, *Z*, mass number, *A*, nuclide, nucleons, isotopes, neutral,	Review: Students could build an atom using the simulation link to visually assist with answering the questions: https://phet.colorado.edu/en/simulations/build-an-atom	• Find examples of different models depicting atoms. What do they all have in common?

	1	22	**KQ**: Where are the electrons found and why is their location important? **Vocab**: quantum atom, probability, valence shell, spin, electron configuration, orbitals, *s, p, d, f.*		• Explain how a full out electron shell is achieved if electrons are lost. • PE: HS-PS1-1
	2	23	**KQ**: What is the periodic table and what is the significance of its structure? **Vocab**: periodic, Mendeleev, groups, periods	Find alternative versions of the traditional periodic table. How do they compare to the table commonly used today?	• Use the shapes and pictures on page 44 to describe patterns and trends.
	3	24	**KQ**: What trends can be seen in the periodic table, and what do they mean? **Vocab**: trend, radius, ionization energy, electronegativity, electron affinity	Use second hand data to graph atomic radius and ionization energy.	• Describe trends seen in the data graphed for atomic radius and ionization energy. • Graphically summarize the trends seen in the periodic table using simple arrows. • PE: HS-PS1-1
	1	25	**KQ**: Why are some metals more reactive than others? **Vocab**: reactivity		• PE: HS-PS1-1
	.5	26	**KQ**: What are some of the ways atoms bind together? **Vocab**: metallic bonding, covalent bonding, ionic bonding, ion		• Explain the bonding observed in sodium chloride.
	1.5	27	**KQ**: How do ions form and how do they bind together to form ionic compounds? **Vocab**: cation, anion, polyatomic ions		• Explain the difference between cations and anions. • What are polyatomic ions? Provide examples.
	1.5	28	**KQ**: How can atoms complete their valence shell without exchanging electrons? **Vocab**: molecule, Lewis structures, covalent bond, double bond, triple bond, space filling model, ball and stick model		• Use a Lewis dot diagram to show the electron configuration of H_2O, O_2, CH_4, NH_3, C_2H_6, C_2H_4, and NH_4^+.
	2	29	**KQ**: How does the sharing of electrons in molecules affect a molecule's shape?	**Investigation 2.1**: Repulsion theory	• What is the relationship between stability and energy? • Why did the balloons form the shape they did in your investigative model?

			Vocab: VSEPR theory, equilibrium, linear, bent, trigonal planar, tetrahedral, trigonal pyramidal, symmetry, asymmetry		• Use Lewis diagrams to predict the shape of O_2, CO_2, CCl_4, and H_2O.
	1.5	30	**KQ**: What kinds of forces are there within and between molecules and how does this affect the way they interact? **Vocab**: ions, polar covalent bond, polarity, dipole, intramolecular forces, intermolecular forces, van der Waals, hydrogen bonding, dipole-dipole forces, induced dipole-dipole forces	**Investigation 2.2**: Polarity	• How does the shape of a molecule affect polarity? • What are intermolecular forces (van der Walls forces)? How do they differ from intramolecular forces? • Define hydrogen bonds and induced dipole-dipole forces.
	1.5	31	**KQ**: What does the comparison of the properties of substances tell us about their structure? **Vocab**: malleability, viscosity,	**Investigation 2.3**: Properties of matter	• Use the properties of substances to group them based on similarity. • How do intermolecular forces impact condensation? • What does the boiling point (condensation point) tell us about the intermolecular forces in a substance? • PE: HS-PS1-3
	1	32	Review Your Understanding **Anchoring Phenomenon revisited**		Can students fully explain the Key Question for the chapter anchoring phenomenon: What are the underlying causes of the different properties of compounds?
	1	33	Summing Up		Summative Assessment PE: HS-PS1-1

Chapter 3: Chemical Reactions

Date	Duration Time / No. of periods	Activity number(s)	Notes	Lab / Practical activity	Formative or Summative Assessment
	1	34	**Anchoring Phenomenon**: Antacid Chemistry There are many antacid formulas on the market. How do they work?		• What do your students already know about the topic? • Are there any gaps or misconceptions?
	1.5	35	**KQ**: How can we use mass to determine quantity and how might this be useful? **Vocab**: mole	Demo or in student groups: Weigh out 10 small objects, (jelly bean, pennies, dried beans) then weigh and unknown quantity and calculate the number of items	• Given the mass of a known quantity of some object, calculate the (unknown) quantity of a different mass of that object. • Q. Why did we weigh out 10 objects, rather than just 1? A. To have an average mass to work from. • PE: HS-PS1-7
	1.5	36	**KQ**: What is mole and how is it useful in chemistry? **Vocab**: mass (m), isotopes, moles (n), relative atomic mass (A_r), relative molecular mass (M_r), Avogadro's constant, chemical formulas, Avogadro's number: 6.02×10^{23}	**Investigation 3.1**: Molar mass **Practice: C**alculations questions 2-3 **Practice:** Interpreting chemical formulas questions 4-6	• Calculate molecular mass. • Explain a molecular formula. • PE: HS-PS1-7
	2	37	**KQ**: How can the mole and molar mass be used to find chemical formula? **Vocab**: molar mass, mole	**Investigation 3.2**: Finding the formula **Investigation 3.3**: Hydrated copper sulfate	• PE: HS-PS1-7
	1	38	**KQ**: How can an empirical formula be used to determine a molecular formula? **Vocab**: empirical formula, molecular formula	**Practice** calculations Q 1 and 2	• What is the difference between an empirical formula and a molecular formula? • Given sample data, determine a molecular formula.
	1	39	**KQ**: What is percentage composition and how can it be used? **Vocab**: percent composition	**Practice** calculations	• Given sample data, calculate an empirical and molecular formula. • Given sample data, calculate percent composition.

	2	40	**KQ**: What notation can we use to show that all the atoms and elements in the reactants before a reaction are present in the products after a reaction? **Vocab**: combination (synthesis) reaction or synthesis, decomposition reaction, combustion reaction, displacement reaction, neutralization reaction, states = solid, liquid, gas, aqueous	**Practice** calculations and writing formulas and balancing equations **Write generic** equations for each type of reaction: A + B → AB combination/synthesis AB → A + B decomposition AB + O_2 → AO + BO combustion CD + G → CG + D or CD + FG → CG + FD HN + MOH → MN + H_2O Identify the key features of each type of reaction.	• Describe the differences between different types or reactions. • Given a sample reaction, identify what type of reaction it is; defend your answer with features.
	1.5	41	**KQ**: How does balancing a chemical equation help us work out the yield of product that should be present after a reaction? **Vocab**: stoichiometry, yield, percentage yield	**Investigation 3.4**: The cycling of copper ions through a series of reactions Calculate expected mass of products for a reaction.	• Given a reaction and the amount of one reactant, calculate the expected yield. • Given an actual yield for that reaction, calculate a percent yield. • PE: HS-PS1-7
	1	42	**KQ**: What is concentration and how do we express the concentration of solutions? **Vocab**: concentration, solution		• Use sample data to calculate concentration. • PE: HS-PS1-2, HS-PS1-7
	2	43 7	**KQ**: How can the concentration of a solution be calculated? How does knowing the concentration of one solution help calculate the concentrations of another solution? **Vocab**: standard solution, volumetric flask, titration, indicator	**Investigation 3.5**: Making a standard **Investigation 3.6**: Standardizing HCl	• How can the equation c = n/V be used to calculate concentrations?
	1.5	44	**KQ**: How can we use standardized solutions to verify the claims made by the manufacturers of products? **Vocab**: standard solution, ethanoic acid/acetic acid, titration, phenolphthalein indicator	**Investigation 3.7**: Standardizing NaOH **Investigation 3.8**: Analyzing vinegar	• Use and rearrange the equation c = n/V appropriately. • PE: HS-PS1-7
	1.5	45	**KQ**: During reactions, atoms must collide. How does the way they do this affect a reaction? **Vocab**: collision theory, intramolecular bonds, activation energy, catalytic converter, catalyst	**Investigation 3.9**: Reaction rates	• Explain collision theory. • Relate how each factor that alters reaction rate can be explained by collision theory.

					• What are catalysts and what role do they play in chemical reactions? • PE: HS-PS1-5
	1.5	46	**KQ**: What is the difference between exothermic and endothermic reactions and where does the energy come from or go to in these reactions? **Vocab**: exothermic, endothermic	**Investigation 3.10**: Endothermic and exothermic reactions	• Clearly define the differences between exothermic and endothermic reactions. • PE: HS-PS1-4
	1.5	47 15	**KQ**: What is enthalpy and why is it important in chemical reactions? **Vocab**: enthalpy *(H)*, specific heat, percentage error, reaction energy ΔH_r	**Investigation 3.11**: Investigating enthalpy **Investigation 3.12**: Energy from alcohols	• Calculate enthalpy of combustion for a range of alcohols. • Write balanced equations for the combustion of named alcohols. • PE: HS-PS1-4
	1	48	**KQ**: How can we use the energy stored in bonds to predict or calculate the energy in a reaction? **Vocab**: bond energies, bond enthalpy		• Estimate the change in enthalpy (ΔE) for a reaction based on the bond energies of the reactants and products.
	2	49	**KQ**: Some reactions are reversible. Under what conditions do reversible reactions occur? **Vocab**: reversibility, reversible reactions, equilibrium	**Investigation 3.13**: Reversibility **Investigation 3.14**: Equilibrium	• Explain how litmus paper can be used to detect acidic or basic solutions? • What is an equilibrium reaction?
	1	50	**KQ**: How do the conditions of a dynamic equilibrium affect the outcome? **Vocab**: dynamic equilibrium, reactants, products		• Describe equilibrium in terms of the *rates* of the forward and reverse reactions. Describe the concentrations of the reactants and the products. • PE: HS-PS1-6
	1	51	**KQ**: What is the principle behind how chemical equilibria behave? **Vocab**: La Chatelier's principle, saturated, precipitate, pressure, volume		• Use diagrams to explain how changes to temperature, pressure, concentration, or volume affect equilibria. • PE: HS-PS1-6
	1.5	52	**KQ**: How is equilibrium chemistry used in industry? **Vocab**: Haber process, catalyst		• Use the examples provided to describe how to drive an industrial reaction at equilibrium to produce more products • PE: HS-PS1-6
	2	53 7	**KQ**: How is equilibrium involved in the formation of acids and bases?	**Investigation 3.15**: pH scale	• Explain the pH scale. • What ions are associated with acids? with bases?

			Vocab: acid, base, pH, [ ], K, strong acids or bases, weak acids or bases, dissociate / dissociation		• Carry out pH calculations.
	1	54	Review Your Understanding **Anchoring Phenomenon revisited**		Can students fully explain the Key Question for the chapter anchoring phenomenon: There are many antacid formulas on the market. How do they work?
	1	55	Summing Up		Summative Assessment PE: HS-PS1-2, HS-PS1-4, HS-PS1-5, HS-PS1-6, HS-PS1-7

Chapter 4: Nuclear Processes

Date	Duration Time / No. of periods	Activity number(s)	Notes	Lab / Practical activity	Formative or Summative Assessment
	1	56	**Anchoring Phenomenon**: How do you power a city or destroy it with just a few kg of nuclear material?		• What do your students already know about the topic? • Are there any gaps or misconceptions?
	2	57	**KQ**: What is the internal structure of the atomic nucleus? **Vocab**: hadron; quarks; forces: gravitational, weak nuclear, electromagnetic, strong nuclear	**Investigation 4.1**: Modeling the strong nuclear force	• Identify the location and types of quarks.
	1	58	**KQ**: Why are some isotopes more common than others? **Vocab**: isotope, decay	Use the Dynamic Periodic Table on the **BIOZONE Resource Hub** to help with this activity. **Review:** *Build an atom* to assist with the questions https://phet.colorado.edu/en/simulations/build-an-atom	• Compare the isotopes of uranium. Identify the factor contributing to the stability of each isotope.
	2	59	**KQ**: How do unstable atoms decay and release energy? **Vocab**: alpha decay, beta decay, gamma decay, positron emission, electron capture, spontaneous fission; the Law of Conservation of nucleon number, radioactivity, Becquerel (Bq)		• Identify the six types of radioactive decay given on page 123. • Define the law of conservation of nucleon number.
	2	60	**KQ**: How does nuclear fission release energy, and how can we use this to produce electricity? **Vocab**: strong nuclear force, $E=mc^2$, mass (m), energy (e), speed of light (c), chain reaction, fuel rod, moderator, control rod, "neutron poisons"	This link provides an automated "tour" explanation and you can also "run" the reactor https://dalton-nrs.manchester.ac.uk/	• Why is the energy released from a nuclear reaction so much greater than from a conventional (chemical) reaction? • What is a chain reaction? How can it be controlled to produce useable energy (e.g. in a power plant)?
	2	61	**KQ**: How does fission compare to fusion? How does the energy produced by each compare? **Vocab**: fission, fusion,		• Distinguish between fission and fusion reactions. • Use the Binding Energy in Elements graph (p 130) to explain how both

					fusion and fission are able to produce energy.
	1	62	Review Your Understanding **Anchoring Phenomenon revisited**		Can students fully explain the Key Question for the chapter anchoring phenomenon: How do you power a city or destroy it with just a few kg of nuclear material?
	1	63	Summing Up		Summative Assessment PE: HS-PS1-8

Chapter 5: Forces and Motion

Date	Duration Time / No. of periods	Activity number(s)	Notes	Lab / Practical activity	Formative or Summative Assessment
	1	64	**Anchoring Phenomenon**: How is it possible to break many bricks, blocks of ice, or boards of wood stacked on top of one another? What physical principles explain these feats of strength?		• What do your students already know about the topic? • Are there any gaps or misconceptions?
	1	65	**KQ**: What do distance and displacement mean; how are they different; and why is it important to have different ways to describe an object's final position? **Vocab**: distance, displacement, speed, velocity, acceleration, scalar, vector, magnitude, Pythagorean theorem		• Make a T-chart separating the scalar values from the vector values. What is the distinguishing factor between these two types of measurements?
	3	66 7 & 8	**KQ**: In horizontal motion, how do we distinguish between speed and velocity, and how do we represent these concepts mathematically? **Vocab**: Δ, instantaneous speed, average speed	**Investigation 5.1**: Distance, displacement, and velocity	• Construct and understand displacement time graphs and position time graphs. • Use and rearrange the equation displacement = velocity x change in time

	2	67	**KQ**: How do we use what we know about constant acceleration to solve unknown values of displacement, time and velocity? **Vocab**: acceleration		• Define acceleration. • Calculate acceleration using the equation acceleration = change in velocity ÷ change in time • Use and draw velocity-time graphs.
	2	68	**KQ**: What are forces and how do they affect the motion of objects? **Vocab**: force, Newton, N=kg m/s^2 , inertia, Newton's 1st Law of Motion, Law of Inertia, normal force (F_N), Friction, unbalanced forces		• Define force and provide examples of different forces (e.g. contact, long range, normal). • Define friction. • Discuss the relevance of Newton's first law (Law of inertia) on an object's motion.
	3	69 8	**KQ**: What happens to an object when the forces acting on it are not balanced and how do we use what we know about motion to solve forces equations? **Vocab**: Newton's 2nd Law, Definition of Force, mass, weight, force due to gravity, free body diagrams, gravity, free fall, acceleration of gravity, air resistance, drag, terminal velocity	**PhET:** Forces and Motion: Basics https://phet.colorado.edu/en/simulations/forces-and-motion-basics **PhET:** Energy Skate Park: Basics https://phet.colorado.edu/en/simulations/energy-skate-park-basics	• Define Newton's second law (Definition of Force). • Distinguish between weight and mass. • Use and rearrange the equation Force (F) = mass (m) x acceleration (a). • Use and construct free body diagrams. • PE: HS-PS2-1
	1	70	**KQ**: What are the reaction pairs and why do they not cancel each other out? **Vocab**: Newton's 3rd Law, action - reaction pairs, Law of Reciprocity		• Define reaction pairs and explain why they do not cancel each other out. • Define Newton's third law (Law of reciprocity).
	1	71	**KQ**: How do we describe the quantity of motion in an object and how do we use it to explain why some objects are more difficult to stop than others? **Vocab**: momentum	**Investigation 5.2**: Investigating momentum	• Define momentum. • Use the equation momentum (p) = mass of object (m) x velocity of object (v)
	1	72	**KQ**: How do collisions affect the momentum of objects and how do we account for the relative influences mathematically? **Vocab**: collision, elastic collisions, inelastic collisions	**PhET:** Collision Lab https://phet.colorado.edu/en/simulations/collision-lab	• Differentiate between elastic and inelastic collisions.

	1	73	**KQ**: What is the law of conservation of momentum and how does it explain why force pairs do not cancel each other out? **Vocab**: law of conservation of momentum		• Explain how momentum is always conserved.
	2	74	**KQ**: How does changing the time over which a force is applied to an object influence this object? **Vocab**: impulse (J)	**Investigation 5.3**: Investigating impulse	• Use the equation: Impulse (J) = FDt = D*mv* • PE: HS-PS2-2
	3	75	**KQ**: How are the principles of momentum and impulse applied to limit damage to sensitive objects and save lives? **Vocab**: crumple zone	**Investigation 5.4**: Building a lander	• PE: HS-PS2-3, HS-ETS1-2, HS-ETS1-3
	1	76	Review Your Understanding **Anchoring Phenomenon revisited**		Can students fully explain the Key Question for the chapter anchoring phenomenon: How is it possible to break many bricks, blocks of ice, or boards of wood stacked on top of one another? What physical principles explain these feats of strength?
	1	77	Summing Up	xx	Summative Assessment PE: HS-PS2-1, PE: HS-PS2-2

Chapter 6: Types of Interactions

Date	Duration Time / No. of periods	Activity number(s)	Notes	Lab / Practical activity	Formative or Summative Assessment
	1	78	**Anchoring Phenomenon**: Why does a swinging magnetic pendulum not hit against a copper plate?		• What do your students already know about the topic? • Are there any gaps or misconceptions?
	1	79	**KQ**: What is gravity and what does it do? **Vocab**: gravity (g), weight (W), mass (m), gravitational constant (G)	PhET: Gravity Force Lab - Basics https://phet.colorado.edu/en/simulations/gravity-force-lab-basics PhET: Gravity Force Lab https://phet.colorado.edu/en/simulations/gravity-force-lab	• Define gravity and explain how an object's mass influences it gravitational force.
	3	80 5, 7	**KQ**: How do we calculate the strength of the force of attraction between objects? **Vocab**: Kepler's third law, period (T), average distance from the Sun (a), centripetal force, gravitational constant (G)	PhET: Gravity and Orbits https://phet.colorado.edu/en/simulations/gravity-and-orbits	• Explain how the Sun's gravitational pull results in planets orbiting around it. • Explain centripetal force. • Use diagrams to explain the inverse square law. • PE: HS-PS2-4
	2	81	**KQ**: What causes some objects to attract to each other and others to repel? **Vocab**: electrostatics, coulomb (C), conductivity, conductors, insulators, semiconductors, polarization	**Investigation 6.1**: Balloon electrostatics **Investigation 6.2**: Threading the needle	• Use balloon models to explain electrostatic forces. • Distinguish between conductors, insulators, and semiconductors. • Define polarization. How does it differ from electric charge?
	2	82 5	**KQ**: How is force influenced by the magnitude of charge on particles and the distance between them? **Vocab**: charge (q), Coulomb's constant (k), inverse square law	PhET: Coulomb's Law https://phet.colorado.edu/en/simulations/coulombs-law	• Use diagrams and equations to describe Coulomb's law. • Use provided data to apply the inverse square law to investigate force between two objects. • PE: HS-PS2-4
	2	83	**KQ**: How do the electric fields of charged particles affect their interactions? **Vocab**: electric fields	PhET: Charges and fields https://phet.colorado.edu/en/simulations/charges-and-fields	• Use provided data to calculate the strength of electrical fields. • PE: HS-PS3-5

	2	84	**KQ**: How do magnets work and what types of materials do magnets attract? **Vocab**: magnet, magnetism	**Investigation 6.3**: Charges and magnets **Investigation 6.4**: Magnetic fields **Investigation 6.5**: Strength of a magnetic field	• Describe the polar configuration of magnets. Use diagrams or magnets to predict how magnets will behave towards each other in a variety of configurations. • Use models to explain how magnetic fields form. • PE: HS-PS3-5
	2	85	**KQ**: Why are some materials able to produce magnetic fields while others are not? **Vocab**: electric current, ferromagnetic materials	**Investigation 6.6**: Making a magnet Hund's Rule and Orbital filling	• How does electron spin product a magnetic field? • Describe examples of ferromagnetic materials.
	2	86	**KQ**: What is the relationship between current electricity and magnetism? **Vocab**: Ampere's right hand grip rule	**Investigation 6.7**: Electricity affects a compass part 1 **Investigation 6.8**: Electricity affects a compass part 2 **Investigation 6.9**: Electricity affects a compass part 3	• Explain why current electricity creates magnetic fields which can influence magnets. • Use models to describe how a magnetic field affects a compass. • Explain Ampere's right hand rule for detecting the direction of magnetic deflection. • PE: HS-PS3-5
	1	87	**KQ**: How does a magnetic field affect the motion of a conductor carrying a current? **Vocab**: magnetic field, current electricity, circuit, right hand rule		• Use diagrams (models) to show how a magnetic field can affect the motion of a current carrying conductor. • PE: HS-PS3-5
	2	88	**KQ**: How do we use the relationship between magnetism and electricity to generate usable electricity? **Vocab**: AC current, DC current, electromagnetic induction, electromagnetic induction, motor	**Investigation 6.10**: Electricity from magnets **Investigation 6.11**: Making a motor	• Design a model to show how electricity can be generated using magnets. • Distinguish between AC and DC outputs. • Define electromagnetic induction. • PE: HS-PS2-5, HS-PS3-3
	2	89	**KQ**: How do the atomic characteristics of materials affect the properties of the material? **Vocab**: metallic bond, crystal lattice, covalent bonds, network molecules	**Investigation 6.12**: What is used where	• Investigate how the properties of varying materials are influenced by their atomic characteristics. • PE: HS-PS2-6

	1	90	Review Your Understanding **Anchoring Phenomenon revisited**		Can students fully explain the Key Question for the chapter anchoring phenomenon: Why does a swinging magnetic pendulum not hit against a copper plate?
	1	91	Summing Up		Summative Assessment PE: HS-PS2-4, HS-PS2-6, HS-PS3-5

Chapter 7: Definitions of Energy

Date	Duration Time / No. of periods	Activity number(s)	Notes	Lab / Practical activity	Formative or Summative Assessment
	1	92	**Anchoring Phenomenon**: How are the relationships between work, kinetic energy and potential energy applied in amusement park rides?		• What do your students already know about the topic? • Are there any gaps or misconceptions?
	1	93	**KQ**: What are the wo categories used to describe energy and how are they related? **Vocab**: kinetic energy, potential energy, mechanical energy, chemical energy, electrical energy, thermal energy, nuclear energy, radiant energy		• Define the following types of energy: mechanical, chemical, electrical, thermal (heat), nuclear, radiant. Classify each as kinetic or potential energy.
	2	94	**KQ**: When is work being done? **Vocab**: work (W), $W = Fd \cos \theta$, or $W = Fd$		• Define work. • Use the equation $W = F d \cos \theta$
	2	95	**KQ**: What is the relationship between work and energy? **Vocab**: kinetic energy, $E_k = ½ m v^2$		• What is kinetic energy?
	1	96	**KQ**: In what ways can energy be stored and how can we calculate potential energy? **Vocab**: gravitational potential energy, elastic potential energy		• What is potential energy? • Define gravitational potential energy.

	2	97	**KQ**: How does the law of conservation of energy explain changes in the energy that is available to do work? **Vocab**: The Law of Conservation of Energy	**Investigation 7.1**: Investigating work and energy	• Relate the law of the Conservation of Energy to how energy can be used to do work. • PE: HS-PS3-2
	2	98	**KQ**: How is energy conserved in a pendulum? **Vocab**: Pendulum, ossilation, kinetic energy, potential energy $E_{total} = E_p + E_k$, $F_{g,x,} = -m\ g \sin \theta$, $T = 2\pi\ (L / g)^{-2}$	PhET: Pendulums https://phet.colorado.edu/en/simulations/pendulum-lab	• Use models (equations and diagrams) to explain how energy is conserved in a pendulum. • Explain why the energy in a pendulum is always the same, no matter where it is in its swing. • PE: HS-PS3-2
	1	99	**KQ**: Why is there never as much energy after the transformation as before? Where did it go? **Vocab**: Efficiency		• Most systems are not 100% energy efficient? Explain the reason for this.
	1	100	Review Your Understanding **Anchoring Phenomenon revisited**		Can students fully explain the Key Question for the chapter anchoring phenomenon: How are the relationships between work, kinetic energy and potential energy applied in amusement park rides?
	1	101	Summing Up		Summative Assessment PE: HS-PS3-1

Chapter 8: Conservation of Energy and Energy Transfer

Date	Duration Time / No. of periods	Activity number(s)	Notes	Lab / Practical activity	Formative or Summative Assessment
	1	102	**Anchoring Phenomenon**: Where does the energy we use in our everyday lives come from and how will we be able to continue to provide that energy for a growing population?		• What do your students already know about the topic? • Are there any gaps or misconceptions?
	2	103	**KQ**: What does the law of conservation of energy say about society's increase in energy demands? **Vocab**: thermodynamics, First Law of Thermodynamics, Law of Conservation of Energy, system, $\Delta U = Q - W$, closed system, open system, isolated system		• The law of conservation of energy states: energy can not be created or destroyed, it can only be transformed from one form to another or transferred from one object to another. Use examples and models (diagrams) to discuss what this means. • Define the first law of thermodynamics. • PE: HS-PS3-1
	2	104	**KQ**: What is entropy and how is it explained by heat flow? **Vocab**: Second Law of Thermodynamics, entropy	**Investigation 8.1**: Indirect energy transfer **Investigation 8.2**: Direct energy transfer	• Use an example to define entropy. • Investigate energy transfer in experimental systems. • PE: HS-PS3-4
	1	105	**KQ**: How does modelling help us understand thermodynamics and energy flow? **Vocab**: Heat, energy, heat flux, conduction	**Investigation 8.3**: Conduction	• Use a simulation to model energy flow. • PE: HS-PS3-1
	1	106	**KQ**: What is power and how are energy, work and power related to each other? **Vocab**: Work, power, resistor	**Investigation 8.4**: The power of Oreos	• Use the equations $P = W \div t$ and $P = F \times v$ to calculate power.
	2	107	**KQ**: How is energy harnessed to do work? **Vocab**: turbine		• Explain some common ways turbines are used to convert energy can be used to do work. • Explain the role of a generator in energy conversion.
	2	108	**KQ**: In what ways can energy be converted to accomplish a specific task?	**Investigation 8.5**: Building a Rube Goldberg machine	• Design a Rube Goldberg machine to achieve a specific task. • PE: HS-PS3-3, HS-ETS1-1

			Vocab: Rube Goldberg machine, Efficiency = energy in / energy out		
	1	109	Review Your Understanding **Anchoring Phenomenon revisited**		Can students fully explain the Key Question for the chapter anchoring phenomenon: Where does the energy we use in our everyday lives come from and how will we be able to continue to provide that energy for a growing population?
	1	110	Summing Up		Summative Assessment PE: HS-PS3-1, HS-PS3-2

Chapter 9: Wave Properties

Date	Duration Time / No. of periods	Activity number(s)	Notes	Lab / Practical activity	Formative or Summative Assessment
	1	111	**Anchoring Phenomenon**: How might rogue waves in the ocean form? What principles are behind these phenomena?		• What do your students already know about the topic? • Are there any gaps or misconceptions?
	3	112	**KQ**: How can we describe waves? **Vocab**: transverse waves, longitudinal waves, compression and rarefaction, frequency (f), wavelength (λ), amplitude, period (T), mechanical waves, electromagnetic waves	**Investigation 9.1**: Making waves **Investigation 9.2**: More waves PhET: Waves Intro https://phet.colorado.edu/en/simulations/waves-intro	• Use diagrams and tools to model waves. • Distinguish between transverse and longitudinal waves. • PE: HS-PS4-1
	2	113	**KQ**: How can we calculate the speed of sound by measuring the wavelength and frequency? **Vocab**: pressure wave, sound wave	**Investigation 9.3**: The speed of sound in air	• Describe a sound wave. • Carry out investigations to calculate the speed of sound in air. • PE: HS-PS4-1

	1	114	**KQ**: How is sound perceived by animals? How is sound affected by different media? **Vocab**: medium (media)	**What** is the pattern between the frequency range an animal can produce and the frequency range an animal can detect?	• Explain how the speed of sound is affected by the medium it is traveling through. Is there a discernible pattern? • What is the pattern between the frequency range an animal can produce and the frequency range an animal can detect? • PE: HS-PS4-1
	1	115	**KQ**: How are waves affected by the movement of the object producing them? **Vocab**: Doppler effect, Hertz (Hz)		• What does the Doppler effect sound like? • Use wave front diagrams to visually represent the Doppler effect.
	1	116	**KQ**: How do waves interact with their surroundings and each other? **Vocab**: reflection, refraction, interference, destructive interference, constructive interference	**Investigation 9.4**: Boundaries and wave refraction	• What causes "feedback" through a speaker system? How would you eliminate it? (move the microphone OUT of the line of the speaker).
	2	117	**KQ**: What happens to waves when they pass through a narrow gap? **Vocab**: diffraction, interference, node, antinode	**Investigation 9.5**: Two properties unique to waves	• Can you think of an application of destructive interference? (noise cancelling headphones.)
	3	118	**KQ**: How can a sound wave be stored as data and be retrieved to reproduce the sound? **Vocab**: analog, digital	**In binary code,** what is the smallest number of places that you would need to represent the 26 letters of the alphabet? Explain (5; 4 digits only provides you with 15 unique combinations while 5 digits give 31 combinations)	• List examples of digital vs analog media: (paint by number vs painting free form; vinyl record vs CD, clock with hands vs digital clock) • PE: HS-PS4-2, HS-PS4-5
	1	119	Review Your Understanding **Anchoring Phenomenon revisited**		Can students fully explain the Key Question for the chapter anchoring phenomenon: How might rogue waves in the ocean form? What principles are behind these phenomena?
	1	120	Summing Up		Summative Assessment PE: HS-PS4-1

Chapter 10: Electromagnetic Radiation

Date	Duration Time / No. of periods	Activity number(s)	Notes	Lab / Practical activity	Formative or Summative Assessment
	1	121	**Anchoring Phenomenon**: How does the behavior of light explain how photovoltaic cells work?		• What do your students already know about the topic? • Are there any gaps or misconceptions?
	2	122	**KQ**: What are the properties of electromagnetic waves? **Vocab**: transverse wave, amplitude, wavelength, frequency, period, electromagnetic spectrum, absorb, reflect, transmit, refract, emit, inverse square law		• Is all EM radiation detected by "eyes"? Explain • Explain color. • Give an example of energy emission. • Give an example of energy transmission.
	2	123	**KQ**: How can some of the stranger properties of EM radiation be explained? **Vocab**: electroscope, photoelectric effect, photon, duality theory of light, amplitude, frequency	**Investigation 10.1:** The double slit experiment **Tip:** start preparing the slides (painting) when you do Activity 121	• Explain the relationship between the photoelectric effect and the concept of light as particles / photons. • PE: HS-PS4-3
	1	124	**KQ**: How valid are the claims that microwaves from cellular towers and phones can cause human health problems? **Vocab**: ionizing radiation, non-ionizing radiation, x-rays, gamma rays, free radicals, photoelectric effect, E = hf, Planck's constant (h)		• Research claims that EM from microwaves or cell phones can be dangerous to human health. • PE: HS-PS4-4
	1	125	**KQ**: What are the effects of X-rays and gamma rays on human health? **Vocab**: X-rays, Gamma rays, Chernobyl, Sieverts		• How are high energy waves (e.g. x-rays or gamma rays) used in the health service? Why must radiographers take precautions to limit exposure? • PE: HS-PS4-4
	1	126	Review Your Understanding **Anchoring Phenomenon revisited**		Can students fully explain the Key Question for the chapter anchoring phenomenon: How does the behavior of light explain how photovoltaic cells work?
	1	127	Summing Up		Summative Assessment PE: HS-PS4-3

Chapter 11: Information Technologies and Instrumentation

Date	Duration Time / No. of periods	Activity number(s)	Notes	Lab / Practical activity	Formative or Summative Assessment
	1	128	**Anchoring Phenomenon**: How can the properties of EM waves be exploited to transmit large amounts of data?		• What do your students already know about the topic? • Are there any gaps or misconceptions?
	2	129	**KQ**: How does technology use the properties of waves to achieve various outcomes? **Vocab**: CT scan, X-ray, fiber optics, ultrasound, SONAR, radionuclides, scintillator		• Describe how waves are used in medicine and communication. • PE: HS-PS4-5
	2	130	**KQ**: How can EM waves be used to transmit data and how does the frequency of the wave affect the data transmitted? **Vocab**: encoding, decoding, modulation, broadband		• Suggest an explanation for why you can play a standard DVD on a Blu-Ray player, but not a Blu-Ray disc on a standard DVD player • PE: HS-PS4-5
	1	131	Review Your Understanding **Anchoring Phenomenon revisited**		Can students fully explain the Key Question for the chapter anchoring phenomenon: How can the properties of EM waves be exploited to transmit large amounts of data?
	1	132	Summing Up		Summative Assessment PE: HS-PS4-5