Physics – 9th Grade Science Course
Highland Park High School District 113
Learning Objectives - Targets

I. Learning Objectives and Outcomes for Each Physics Unit

Units with Illinois State Goals (ISG)	Upon completion of each unit, students will be able to:
Unit #1 One-Dimensional Kinematics ISG: 11a 12d 13a,b **Checkpoint Charlie: Weeks 1-6 (@32%)**	1) Distinguish between a *vector quantity* and a *scalar quantity*, and give examples of each and draw *vector diagrams* for forces, velocities, accelerations, and any vector quantity. 2) Explain that the idea of motion is relative and give ideas of *relative motion.* 3) Distinguish between distance (d) and displacement (Δd). 4) Define *speed* and give examples of speed. 5) Distinguish between *instantaneous speed* and *average speed*. (describe both as a rate) 6) Distinguish between *speed* and *velocity*. $v = \Delta d / \Delta t$ 7) Discern between *positive* and *negative* velocities and accelerations. 8) Define *acceleration* (as a rate of a rate) and give examples of acceleration, including determining whether or not velocity is changing. $a = \Delta v / \Delta t$ 9) Apply the *Four kinematic equations* → $\Delta d = v_i(\Delta t) + a(\Delta t)^2/2$ $\quad\quad$ $\Delta d = (1/2)(v_i + v_f)(\Delta t)$ $v_f^2 = v_i^2 + 2a(\Delta d)$ $\quad\quad$ $v_f = v_i + a(\Delta t)$ 10) Describe the motion of an object in *free fall* (y-direction) from rest using words, equations, and diagrams. (use: $g = 9.8\ m/s^2$). 11) Describe the motion of an object thrown up vertically (while neglecting air resistance) using words, equations, and diagrams. 12) Describe how *air resistance* affects the motion of falling objects, including *terminal velocity*.

Unit #2 Two-Dimensional Kinematics ISG: 11a 12d 13a,b **Checkpoint Charlie: Weeks 7-8 (@11%)**	1) Distinguish between a *vector quantity* and a *scalar quantity*, and give examples of each. 2) Draw *vector diagrams* for forces, velocities, accelerations, and any vector quantity. 3) Use the *component*, *parallelogram*, and *tip-to-tail* methods to determine the *resultant vector* of two or more vectors. 4) Given a vector, resolve it into *horizontal and vertical components* using *SOH CAH TOA* trigonometry. $A_x = A\cos\theta$ $A_y = A\sin\theta$ 5) Describe the motion of a horizontally launched object based upon time of flight. 6) Find the *X and Y components* of a projectiles velocity as well as the distance traveled in the X and Y directions at any given time using the *TNEOM* equations. (substitute: $a = g = -9.8 m/s^2$ in the y-direction) 7) Draw a vector diagram of a *projectile launched up and down* indicating both velocity and acceleration. 8) Describe the motion of a projectile launched on an angle. 9) Distinguish between the *ideal path* and the *actual path* of a projectile launched at various angles. 10) Explain how a satellite that orbits Earth is similar to a *horizontally launched projectile.*
Unit #3 Newton's First Law ISG: 11a 12c,d,e 13a **Checkpoint Charlie: Weeks 9-10 (@11%)**	1) Define *inertia* and state *Newton's First Law*. 2) Distinguish between *mass, volume* and *weight*. 3) Discern the *Kilogram* from the *Newton* as a unit of measurement. (use: *1 kg = 9.8 N*). Weight (F_g) = *mg* *4)* Define *net force* and find the net force in given situations. 5) Understand and describe the following forces: *applied force (F_A), normal force (F_N), gravitational force (F_G), spring force ($F_{spring} = kx$), friction ($F_f = \mu F_N$), tension (F_T), and air resistance ($F_{air} = v^2(area)$)* 6) Define *equilibrium* ($F_{net} = 0$) and explain when and why it exists for a given situation. Solve problems involving equilibrium. 7) Draw a *free-body diagram* (FBD) for all forces acting on a given object. 8) Analyze the forces of an object sitting on an *incline*. $F_x = mg(\cos\theta)$ $F_y = mg(\sin\theta)$, *where* $a = g$
Unit #4 Newtons's Second Law	*1)* State and describe the relationships between *acceleration, net force, and mass* and solve for them *qualitatively* and *quantitatively*. $a = F_{net} / m$ 2) Identify and describe the effect of *friction* on moving objects.

ISG: 11a,b 12c,d,e 13a,b **Checkpoint Charlie: 11-12 (@11%)**	3) Distinguish and solve for static and kinetic frictional forces and the coefficients of static versus kinetic friction. $F_{friction} = \mu F_N$ 4) Distinguish *force* from *pressure* (*P = Force / Area*). 5) Apply *Newton's Second Law* to explain why the acceleration of an object in *free fall* does not depend upon the mass of the object. 6) Describe what happens to the acceleration of an object when there is air resistance using words, force vectors, equilibrium and equations. 7) Calculate and graphically represent *complex mass-pulley systems*.
Unit #5 Newton's Third Law ISG: 11a 12c,d 13a **Checkpoint Charlie: 13 (@5%)**	1) Explain why at least two objects are involved whenever a force acts. 2) Define and explain *Newton's Third Law* of motion. 3) Given an *action force*, identify the *reaction force* and recognize that forces always act in pairs. 4) Recognize the relationship between mass and acceleration when two equal and opposite forces occur on a system. 5) Explain why the reaction force does not cancel an action force.
Unit #6 Momentum ISG: 11a,b 12c,d 13a,b**Checkpoint Charlie: 14 (@5%)**	1) Define *momentum* as a vector quantity (*p = mv*). 2) Define and give examples of *impulse* and relate it to momentum algebraically. *Impulse = F(Δt)* or *F(Δt) = m(Δv)* 3) Correctly pair the applied force to its appropriate time interval. 4) Determine the impulse of objects bouncing (changing velocity) versus coming to a stop. 5) Define and describe the *conservation of momentum*. $mv_{before} = mv_{after}$ 6) Distinguish between *elastic* and *inelastic collisions*. 7) Solve linear collision problems using the conservation of momentum.
Unit #7 Work, Power, Energy & Machines	1) Determine the amount of *work* done given the force and distance moved (*Work = Fd*). 2) Determine the amount of *power* required given the work done and time required (*Power = Work / time*). 3) Define *energy* in terms of the *work-energy theorem*. (*Net work = change in kinetic energy*) $Work_{net} = \Delta KE$

ISG: 11a,b 12c,d 13a,b **Checkpoint Charlie: 15-19 (@21%)**	4) Distinguish amongst *mechanical energy*, *potential energy*, and *kinetic energy*. $PE_{Gravitational} = mgh$ $PE_{Elastic} = \frac{1}{2} kx^2$ $KE = \frac{1}{2} mv$. Total energy → $ME = KE + PE$. 5) Explain *conservation of energy* and solve problems (with and without frictional influences). 6) Describe the function of *simple machines* such as a *lever (all three classes)*, *pulley*, *inclined plane*, and *screw*. Ideal machine → $Work_{in} = Work_{out}$ 7) Define, solve, and give examples in which the *mechanical advantage* (MA) of a machine is greater than one ($MA > 1$) versus less than one ($MA < 1$). ($MA = force_{out} / force_{in}$) 8) Calculate *efficiency*, and explain why no machine can have an efficiency of 100%. ($Efficiency = work_{out} / work_{in}$)
Unit #8 Electrostatics ISG: 11a 12c 13a,b	1) Describe the *electrical forces* between objects. (Coulomb's law) 2) Explain how an object becomes *positively or negatively charged* by *electron transfer*, and how this affects *net charge*. Understand *Conservation of charge* as a subset of conservation of mass. 3) Describe the relation among the electrical force between two charged objects, their charge, and the distance between the objects. Express the magnitude of the electrical force inversely to the square of the distance between the charges. 4) Compare the strengths of the *electrical forces* and *gravitational forces* between charged objects. 5) Distinguish between a *conductor* and an *insulator*, and provide examples of each. 6) Describe how an insulator can be *charged by friction*. 7) Describe how a conductor can be *charged by contact*. 8) Describe how a conductor can be *charged without contact (induction)*. 9) Describe how an insulator can be charged by *charge polarization*. 10) Describe the difference between *electric potential energy*, *electric potential*, and *potential difference*. (*volt = joule / coulomb)*
Unit #9	1) Describe the conditions necessary for *flow of electric charge*.

Electric Current ISG: 11a,b 12c,e 13a,b	2) Describe what is happening inside a *current* carrying wire, and explain why there is no *net charge* in the wire. 3) Give examples of *voltage* sources that can maintain a *potential difference* in an electric circuit. 4) Describe the factors that determine the *resistance* of a wire. 5) Relate the amount of current in a *circuit* to the voltage impressed across the circuit and the resistance of the circuit. *Ohm's law → I = V / R Units → ampere = volt / ohm* 6) Distinguish between *direct current* and *alternating current*. 7) Explain why wet skin increases the likelihood of receiving a damaging *electrical shock* when a faulty electrical device is touched. 8) Compare the *drift speed* of conduction electrons in a current-carrying wire to the *signal speed* of charges in current. 9) Compare the motion of electrons in a wire carrying alternating current to the flow of energy through the wire. 10) Relate the *electric power* used by a device to current and voltage. *Electric power → P = IV Units → watt = (ampere)(volt)* 11) Derive *electric energy* as the product of power and time in units of *kilowatt-hours*. Determine electrical energy demands and costs of household appliances.
Unit #10 Electric Circuits ISG: 11a,b 12c,e 13a,b	1) Determine whether current will pass through a bulb given a diagram showing the bulb connected by a wire to a battery. 2) Distinguish between *series* and *parallel circuits*. 3) Predict what will happen in a series circuit if there is a *break* at any point. 4) Relate the current at any point in a series circuit to the current at any other point. 5) Predict what will happen to the current at any point in a series circuit if an additional device is connected in series. 6) Relate the current in the *lead of a parallel circuit* to the current in

	each *branch*. 7) Predict what will happen in a parallel circuit if there is a break in any branch. 8) Predict what will happen to the current at any point in a parallel circuit if an additional device is connected in parallel. 9) Interpret and create simple *schematic diagrams* of series and parallel circuits. 10) Determine the *equivalent single resistance* for a given circuit with two or more devices of equal resistance connected in *series v. parallel v. combination.* 11) Determine the cause of *overloaded household circuits* and how it can be prevented.
Unit #11 Magnetism ISG: 11a,b 12c,e,f 13a,b	1) Describe the similarities and differences between *magnetic poles* and electric charges. 2) Intrepret the strength of a *magnetic field* at different points near a magnet from the pattern formed by *iron fillings*. 3) Relate the motion of electrons within a material to the ability of the material to become a magnet. 4) Describe what happens to the magnetic domains of iron in the presence of a strong magnet. 5) Explain why magnets lose their magnetism when dropped or heated. 6) Describe the conditions for a magnetic field exerting a force on a charged particle in the field. 7) Describe the *magnetic field produced by a current carrying wire*, and give examples of how the field can be made stronger. 8) Describe some practical applications of a magnetic field exerting a force on a current-carrying wire. 9) Suggest possible causes for the *Earth's magnetic field*.
Unit #12 Waves	1) Distinguish the *period* of a vibration from the *frequency* of a *vibration*.

ISG: 11a 12c,d,f 13a	2) Describe the *inverse relationship* between the *frequency (f)* and *period (T)* of a wave. $f = 1 / T$ *Units* → *Hertz = 1 cycle/ second* 3) Describe what affects the *speed* of a wave. 4) Distinguish between a *transverse wave* and a *longitudinal wave*. 5) Distinguish between *constructive* and *destructive interference*. 6) Define a *standing wave* and how it occurs. 7) Describe the *Doppler effect* for sound and relate it to the blue and red shifts for light. 8) Describe the conditions for a *bow wave* to occur. 9) Describe the conditions for a *sonic boom* to occur.
Unit #13 Sound ISG: 11a,b 12c,f 13a,b	1) Relate the *pitch* of a sound to its *frequency*. 2) Describe what happens to air when sound moves through it. 3) Compare the *transmission of sound* through air with transmission through solids, liquids, and a vacuum. 4) Describe the factors that affect the *speed of sound*. ($v = \lambda f$) 5) Give examples of a *forced vibration*. 6) Describe the conditions necessary for *resonance* to occur. 7) Describe the conditions necessary for *beats* to occur. 8) Use *decibels* to measure *sound intensity* (loudness).
Unit #14 Light ISG: 11a 12c,f 13a,b	1) Describe the *frequencies* and *wavelengths* of *visible light, infrared light, ultraviolet light, radio waves, microwaves, x-rays*, and *gamma rays* on the *electromagnetic spectrum*. 2) Explain how *Roemer* and *Michelson* each experimentally measured the *speed of light*. 3) Explain what happens to light when it enters a substance (*transparent v. opaque*), and how the frequency of the light affects what happens.

	4) Describe the conditions for *solar* and *lunar eclipses* as well as *full* and *new moons*. 5) Cite evidence that *light waves* are *transverse* using *polarization*. 6) Explain why *polarizing* sunglasses are helpful in reducing sun glare from horizontal surfaces such as water and roads.
Unit #15 Color ISG: 11a 12c 13a	1) Explain why *white and black are not colors* in the sense that red and green are. 2) Describe why the *interaction of light with atoms* or molecules of a material differs for different frequencies. 3) Describe what factors determine whether a material will *reflect or transmit light* of particular colors. 4) Explain how *color television screens* are able to display pictures in full color even though the television tube produces spots of *red, blue, and green.* 5) Define *complementary colors* and give examples of pairs of complementary colors. 6) Distinguish between *color mixing* by *subtraction* and color mixing by *addition*. 7) Explain why the sky is blue and why it changes color when the sun sets. 8) Explain why water is greenish blue. 9) Explain what the lines in a *line spectrum* represent and how such a spectrum can be used to identify the presence of an element.
Unit #16 Reflection & Refraction ISG: 11a,b 12c,f 13a,b	1) Distinguish between what happens to light when it strikes a metal surface and what happens when it strikes glass or water. 2) Predict the path of *reflected light* using a *ray diagram*, given the direction of light striking a reflective surface. (*Law of reflection*) 3) Explain why the *image* formed by a mirror is a *virtual image*. 4) Describe the conditions for *diffuse reflection*. 5) Give examples of ways to control *reflected sound*.

	6) Explain the change in direction of a water wave when it crosses a boundary between deep and shallow water. 7) Explain the change in direction of a single axle on a car if it crosses a mud-cement boundary. 8) Give examples of *refraction of sound* waves and its effects. 9) Give examples of *refraction of light* and its effects. Calculate *indices of refraction* and apply *Snell's law*. $n(\sin\theta) = n'(\sin\theta')$ 10) Explain how a *prism* separates white light into *colors*. 11) Describe the conditions necessary for a *rainbow* to form. 12) Describe the conditions necessary for *total internal reflection* and its implication for communications technologies (optical fibers).
Unit #17 Lenses ISG: 11a 12c,f 13a,b	1) Distinguish between *converging* and *diverging lenses*. 2) Distinguish between a *real image* and a *virtual image* formed by a lens. 3) Construct a *ray diagram* using the *3 principal rays* that show the position of the image formed by a converging or diverging lens given the *focal length* of the lens and the position of the object. *the thin lens equation* $\rightarrow 1/d_o + 1/d_i = 1/d_f$ 4) Give examples of how some optical instruments use lenses. 5) Explain how the *human eye* focuses light. 6) Explain the causes of *nearsightedness, farsightedness*, and *astigmatism*. 7) Give examples of *image aberrations* created by lenses.
GENERAL UNIT OBJECTIVES	1) Distinguish between relationships that are *directly proportional v. inversely proportional.*

Illinois State Goal References → Based on Early High School Science Learning standards 11, 12, and 13 (Illinois State Board of Education).

State Goal 11A. Know and apply the concepts, principles and processes of scientific inquiry.

State Goal 11B. Know and apply the concepts, principles and processes of technological design.

State Goal 12A. Know and apply concepts that explain how living things function, adapt and change.

State Goal 12B. Know and apply concepts that describe how living things interact with each other and with their environment.

State Goal 12C. Know and apply concepts that describe properties of matter and energy and the interactions between them.

State Goal 12D. Know and apply concepts that describe force and motion and the principles that explain them.

State Goal 12E. Know and apply concepts that describe the features and processes of the Earth and its resources.

State Goal 12F. Know and apply concepts that explain the composition and structure of the universe and Earth's place in it.

State Goal 13A. Know and apply the accepted practices of science.

State Goal 13B. Know and apply concepts that describe the interaction between science, technology, and society.