

ELECTRIFYING MATH:

An Exploration of Physics, Math and
Connections to the Electrical Trades



The concept for Electrifying Math was born out of a conversation on how to support people in their journey to become electricians. Foundations of Math 11 and Physics 11 are the two highest academic courses required by BC colleges for entry into Level 1 Electrical programs. What would a teaching resource look like that could help make these challenging courses relevant and interesting for learners? Could a thematic approach to learning math and physics concepts through building electrical projects be possible? How can we help teachers guide students in safely experimenting with electricity? Can the FOM 11 and Phys 11 BC curricula be covered in their entirety using experiential learning? Could this resource benefit not only prospective electricians and hands-on learners, but also students with all sorts of learning styles and future career goals? The IBEW and Construction Foundation of BC decided to team up to create such a resource, and this is the result!

Electrifying Math is a series of 12 project resources that can be used individually, or, taught in their entirety, cover the Foundations of Math 11 and Physics 11 BC Curricula. Each of the projects include:

- A materials list, tool list, and procedure steps to build the project prototype
- Safety recommendations specific to each project
- "Guided Exploration"**: a 6-step example lesson flow that teachers can draw from to lead students through the curricular competencies
- Example questions to ask students to pique curiosity and deepen understanding
- A **"Scientific Method Resource"** template for students to design scientific experiments on
- "Suggested Assessment Strategies"**: detailed assessment ideas that cover the required curriculum content, including sample calculations to analyze data
- "Science Challenge Opportunities"**: fun group challenges to help students play with and practice their newfound skills
- "Take it further"**: ways to extend exploration on each topic

We hope you and your students enjoy the projects as much as we enjoyed making them!



GLOSSARY TERMS



- **Accelerate / acceleration** – The rate of change of the velocity of an object with respect to time
- **Ampere's Law** – A scientific law which states that the magnetic field around an electric current is proportional to the electric current, which serves as its source
- **The angle of launch** – the vertical angle (measured above horizontal) of the instantaneous velocity vector of a projectile at the moment of release
- **Anode** – (Battery) the negatively charged electrode/terminal
- **Applied force** – A force applied to an object by another object
- **Arduino UNO** – an open-sourced microcontroller board for electronics projects
- **Ballistics** – The science and study of projectiles
- **Calorie** – a unit of energy equal to 4.19 Joules, or the amount of energy required to raise the temperature of 1 gram of water by 1 degree Celsius. Often used in quantifying the energetic value of food
- **Catapult** – A ballistic device that utilizes stored potential energy to propel/launch an object a great distance
- **Cathode** – (Battery) the positively charged electrode/terminal
- **Central tendency** – A central or typical value for the probability distribution of statistical analysis
- **Coil** – wire arranged in a helical shape (sequence of same-sized rings)
- **Compound Simple Machine** – a machine consisting of two or more simple machines
- **Compression** – the part of a longitudinal wave where the medium's particles are closest together
- **Conservation of energy** – the concept that energy cannot be created nor destroyed, that it is constant in a closed system, and can be transformed between forms or types (i.e., kinetic to heat)
- **Core** – a piece of material with a high magnetic permeability used in electromagnetic devices to strengthen and confine magnetic fields
- **Coulomb** – Coulomb - 6.24×10^{18} electrons
- **Current** – the rate of flow of electrically charged particles past a point, measured in amps



- **Dependent variable** – A variable whose value depends on that of an independent variable. Often assigned the y-variable on a graph
- **Doppler effect** - an effect produced when movement relative to a source of waves produces an apparent shift in wave frequency
- **Dynamo** – a mechanism that transforms kinetic (mechanical) energy into electricity (i.e., a generator)
- **Efficiency** – a comparison (as a %) of how much useful output a device or process can accomplish based on the input required
- **Electrochemical** - relating to the chemical changes brought about by the application of electricity or the production of electricity brought about by chemical change or reaction
- **Electromagnet** – a core of magnetic material wrapped with wire which becomes magnetized when electricity is supplied to the coil of wire and demagnetized when the electricity is removed
- **Force** - any push or pull on an object that changes its velocity (speed or direction)
- **Frequency (electrical)** - the number of times a sine wave repeats or completes a positive to negative cycle in one second
- **Frequency (wave)** - the number of times one wave cycle passes a point in a specified amount of time, often measured in Hertz (Hz)
- **Friction** – The force resisting the relative motion of objects sliding against each other
- **Generator** - a device that transforms energy from one type to another (often kinetic energy into electricity)
- **Graphite** – a crystalline form of carbon
- **Gravitational potential energy** – the amount of energy an object possesses (its ability to do work) based on its position in a gravitational field
- **Gravity** - a universal force of attraction between all objects with mass
- **Helix** - a 3-dimensional shape, similar to a wire spring
- **Hertz / Hz (electrical)** - the number of times a sine wave repeats in one second
- **Hertz / Hz (waves)** - a unit of frequency: the number of times a full wave cycle passes a point in one second, i.e., in sound waves, a “middle C” note is 262 Hz or 262 vibrations per second



- **Hypothesis** – An educated guess on an outcome that forms the basis of a scientific experiment
- **Independent variable** – A controlled input variable that is not changed by the other variables measured, controlled input variable. Often assigned the x-axis of a graph
- **Instantaneous velocity** – The velocity of an object in motion at a specific point in time
- **Joule** – a unit of energy equal to one watt-second, or the work done by a 1-newton force acting over a distance of 1 metre
- **Kilowatt hour** – a unit of energy measured as the amount of electricity a 1000-watt device uses in one hour
- **Kinetic energy** - the energy that an object possesses due to its motion
- **Lead** - An electrical connection usually consisting of a wire
- **LED** - Light Emitting Diode – an electronic device that emits light when an electric current pass through it
- **Longitudinal wave** - a wave in which the medium's particles move in a plane parallel to the direction of wave movement, e.g., sound waves
- **Magnetic levitation (maglev)** - A method by which an object is suspended with no support other than magnetic fields
- **Mechanical advantage** - a unitless ratio description of the effective force amplification of a simple machine
- **Negative acceleration** - the rate of change in velocity in the opposite direction to the velocity vector, or “slowing down”
- **Normal force** – The support force exerted on an object in contact with a stable object
- **Ohm's Law** – the principle that the voltage between two points in a conductor is directly proportional to the current running between them and also directly proportional to the resistance between the two points
- **Parabola** - A plane curve that is mirror-symmetrical and approximately U-shaped, described mathematically by a quadratic equation
- **Permanent magnet** – An object made from a magnetized material that creates its own magnetic field
- **Permeability** – The ability of a material to become magnetized



- **Pin socket cables** - formerly “male-to-female jumpers”; connector wires for electronic microcontroller setups
- **Pitch** – The specific quality of a sound in relation to its frequency, i.e., “middle C” played on a piano makes a sound wave with a frequency of 262 Hz. Higher pitched sound waves have a higher frequency, and lower pitched sound waves have a lower frequency
- **Potentiometer** – an adjustable voltage divider
- **Power** - the rate at which work is done (or energy is transferred). Power = work / Δ time, measured in watts
- **Propulsion (verb propel)** - The action or process of pushing or pulling to drive an object forward
- **Quadratic equation** – an equation in the form of $0 = ax^2 + bx + c$ where $a \neq 0$
- **Quadratic function** – a function described by an equation of the form $f(x) = ax^2 + bx + c$ where $a \neq 0$
- **Quadratic root or “zero”**- the x-value solution(s) of a quadratic function, or the x-intercept(s) of a quadratic function graph (where $y = 0$)
- **Quantify** – To measure the size or amount of something and express it as a number
- **Range** - The horizontal displacement of a projectile
- **Rarefaction** - the part of a longitudinal wave where the medium’s particles are furthest apart
- **Repel / repulsion** – Opposite of attraction, a push back or away by force such as magnetism.
- **Resistance (electrical)** - Anything in an electrical circuit that opposes the flow of current
- **Rheostat** – a variable resistor
- **RPM** – rotations per minute
- **Rube Goldberg machine** - a whimsical, overly complicated, and needlessly elaborate system that accomplishes a simple or even trivial goal
- **Servo motor** - a small electric motor with high efficiency and high precision rotary movement, often used in robotics, toys, and aircraft
- **Simple machine** – one of 6 devices (pulley, wheel and axle, wedge, lever, inclined plane, screw) that change the direction or magnitude of a force to perform work on an object
- **Sine Wave** – a graphical representation of the oscillation, from negative to positive of alternating current power



- **Soldering iron** - a heating tool used to join pieces of metal together using melted solder
- **Solenoid** - a coil of wire used as an electromagnet
- **Specific heat capacity** - the amount of heat energy input needed to raise the temperature of a specific amount of a certain material by one degree in temperature, often measured in Joules per kilogram per degree Celsius
- **Terminal** - The point at which an electrical wire or electrical component/device such as a battery comes to an end
- **Ticker tape** - 10mm wide paper strip roll used with ticker timers
- **Ticker timer** - an electric buzzer that makes dots on the ticker tape at a rate of 50 per second; used to quantify velocity and acceleration of objects
- **Trajectory** - The path followed by a projectile flying under the action of given forces
- **Transverse wave** - a wave in which the medium's particles move in a plane perpendicular to the direction of the wave movement, e.g., ripples on a pond
- **Ultrasonic** - sound with a frequency above the upper limit of human perception
- **Voltage** - electromotive force, the difference in electric potential between two points
- **Volume** - the degree of loudness or intensity of a sound, based on the amplitude or how far molecules in the medium are displaced as a longitudinal sound wave passes
- **Velocity** - a vector quantity indicating relative speed and direction
- **Vertex (of a quadratic function)** - the point at which a parabola's curve changes direction
- **Vesicle** - a small, fluid filled sac, e.g., the membrane-bound juice compartment in a citrus fruit
- **Work** - a measure of energy transfer when a force is applied to an object over a distance. $\text{Work} = \text{force} \times \text{displacement}$. Measured in Joules
- **X and Y intercepts (graphing)** - X intercepts are where the line or curve crosses the X-axis, Y intercepts are where the line or curve crosses the Y-axis

