**RICHMOND HILL HIGH SCHOOL**

**Science Department**

CURRICULUM MAP & PACING GUIDE FOR PHYSICS

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| **Unit Number** | **Units of Study/ Topics** | **Key Idea** | **Essential Questions** | **Common Core Aligned Tasks** | **Formative and Summative Assessments** | **Vocabulary** |
| 1 | **Scientific Method, Experimental Design, Units and Scientific Notation**   * Problem and Hypothesis Writing * Variables and Controls * Designing Controlled * Experiments * Lab Procedures * Data Tables * Graphs and Charts * Graphical Analysis and Interpretation * Drawing Conclusions * Consensus & Peer Review * SI System of Units * Unit Conversion * Scientific Notation and Significant Figures * Algebraic Manipulation | The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing and creative process.  Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations involving the use of conventional techniques and procedures and usually requiring considerable ingenuity.  The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into natural phenomena.  Use algebraic and geometric representations to describe and compare data such as:   * scaled diagrams to represent and manipulate vector quantities * graphs of real-world data (scatter plots, line or curve of best fit) * equations to solve for unknowns * dimensional analysis to confirm algebraic solutions   Interpret graphs to determine the mathematical relationship between the variables.  Explain the physical relevance of properties of a graphical representation of real world data, e.g., slope, intercepts, area under the curve.  Transposing equations for solving | How can we formulate testable research questions?  Why is a testable hypothesis in an experiment important?  How can we design an experiment to test a hypothesis?  How is a dependent variable related to an independent variable? \*(Bloom’s IV)  How is a control group different from experimental group?  How do we use graphs and charts to organize and interpret information?  How do we analyze data in order to formulate a conclusion?  How do we show our understanding of convert metric units? \*(Bloom’s III) | **LDC module**: **Lab Report Writing**  Read a scientific journal article, annotate and write an objective summary  Student-to-student, evidence-based discussions utilizing M.A.X. Teaching Framework for SI system of units, linear measurement, velocity & acceleration.  Research ideas through library investigations, including electronic information retrieval and reviews of the literature, and through peer feedback obtained from review and discussion.  Develop and present proposals including formal hypotheses to test explanations; i.e., predict what should be observed under specific conditions if the explanation is true.  Video: Powers of 10  LAB Themes:  Math toolkit  Linear Measurement  Velocity  Acceleration | Utilize Part C Regents questions as formative assessment.  Benchmark #1  Presentation for Ball Bounce Lab  Quiz: Powers of Ten  Homework  Minor: Significant Figures and Scientific Notation  Major: Physics Skills | Area  Bias  Conclusion  Control group  Controlled conditions  Conversion  Chromatography  Dependent variable  Ethical  Experiment  Falsify  Hypothesis  Independent variable  Observation  Prediction  Reproducibility  Resultant  Sample size  Significant difference  Theory  Variable |
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| 2 | **Kinematics**   * Scalar vs. vector * Displacement/distance * Velocity/speed * Acceleration | Measured quantities can be classified as either vector or scalar.  A vector may be resolved into perpendicular components.  Scaled diagrams represent vector quantities.  The resultant of two or more vectors, acting at any angle, is determined by vector addition. | How to we determine the resultant of 2 or more vectors?  How is distance related to displacement? \*(Bloom’s IV)  What is the relationship between static and dynamic equilibrium? \*(Bloom’s IV) | Student-to-student, evidence-based discussions utilizing M.A.X. Teaching Framework for displacement, velocity, & acceleration. | Utilize Part C Regents questions as formative assessment.  Benchmark #2  Reference Table Equations | |  |  | | --- | --- | |  |  |   Acceleration  Displacement  Distance  Dynamic  Scalar  Static  Vector  Velocity |
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| 3 | **Uniform Accelerated Motion**   * Three equations of motion * Rectilinear (straight-line) motion * Freely falling bodies | An object in linear motion may travel with a constant velocity\* or with acceleration.  *(Note: Testing of acceleration will be limited to cases in which acceleration is constant.)*  An object in free fall accelerates due to the force of gravity.\* Friction and other forces cause the actual motion of a falling object to deviate from its theoretical motion.  *(Note: Initial velocities of objects in free fall may be in any direction.)*  Relationships exist between all three aspects of an object’s motion via slopes/areas/equations.  Motions in one Direction, include:  1. drop  2. throw down  3. vertical launch | What is uniform motion and uniform acceleration?  How does height determine velocity?  How do we calculate acceleration?  How does time affect acceleration?  How does mass affect free fall? | Student-to-student, evidence-based discussions utilizing M.A.X. Teaching Framework for free fall & straight-line.  Lab Themes:  Walk This Way  Rolling Ball Lab  Fancart Lab  Picket Fence Lab  Video: Falling Bodies (download from You Tube for viewing on Smartboard) | Utilize Part C Regents questions as formative assessment.  Benchmark #3 | Velocity-time graph  Acceleration  Average acceleration  Instantaneous acceleration  Free fall  Acceleration due to gravity  Velocity   |  |  | | --- | --- | |  |  | |
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| 4 | **Two-Dimensional Motion**   * Trajectories * Vector Components | The path of a projectile is the result of the simultaneous effect of the horizontal and vertical components of its motion; these components act independently.  A projectile’s time of flight is dependent upon the vertical component of its motion.  The horizontal displacement of a projectile is dependent upon the horizontal component of its motion and its time of flight.  Measured quantities can be classified as either vector or scalar.  A vector may be resolved into perpendicular components.  The resultant of two or more vectors, acting at any angle, is determined by vector addition. | What are vectors and how are they used?  What are the differences between vector and scalar quantities?  How does an object move in two dimensions?  How do we determine headings and velocities using vector analysis?  How can we use vector analysis to determine the horizontal & vertical components of a projectile? | Student-to-student, evidence-based discussions utilizing M.A.X. Teaching Framework for free-fall & projectile motion.  Lab Themes:  Equilibrium Lab  Force Table Lab  Graphical vector contruction | Utilize Part C Regents questions as formative assessment.  Benchmark #4 | Projectile  Trajectory  Reference point  Gravity  Two dimensional object  Air resistance  Terminal velocity |
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| 5 | **Static Forces**   * Newton’s First Law * Equilibrium * Gravitational forces * Frictional forces * Spring force | According to Newton’s First Law, the inertia of an object is directly proportional to its mass. An object remains at rest or moves with constant velocity, unless acted upon by an unbalanced force.  When the net force on a system is zero, the system is in equilibrium.  Weight is the gravitational force with which a planet attracts a mass.  The mass of an object is independent of the gravitational field in which it is located.  Weight is the gravitational force with which a planet attracts a mass.  The mass of an object is independent of the gravitational field in which it is located.  The elongation or compression of a spring depends upon the nature of the spring (its spring constant) and the magnitude of the applied force.  Kinetic friction\* is a force that opposes motion.  Field strength\* and direction are determined using a suitable test particle. (The gravitational field near the surface of Earth and the electrical field between two oppositely charged parallel plates are treated as uniform.)  Gravitational forces are only attractive, whereas electrical and magnetic forces can be attractive or repulsive.  The inverse square law applies to electrical\* and gravitational\* fields produced by point sources. | What causes objects to move?  How can we compare and contrast contact versus non-contact forces?  How do we use free body diagrams to analyze motions of objects?  What are the four fundamental forces?  How are weight, mass, and gravity related? | Student-to-student, evidence-based discussions utilizing M.A.X. Teaching Framework for Newton’s 1st Law, Gravity, friction, & spring force.  Lab Themes:  Force Lab  Friction lab  Video: Newton’s Laws | Utilize Part C Regents questions as formative assessment.  Benchmark #5 | Friction  Newton  Net force  Unbalanced force  Static friction  Sliding friction  Rolling friction  Fluid friction  Newton’s 1st law |
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| 6 | **Dynamic Forces**   * Newton’s Second Law * Newton’s Third Law * Free Body Diagrams * Uniform Circular Motion | According to Newton’s Second Law, an unbalanced force causes a mass to accelerate.  Centripetal force\* is the net force which produces centripetal acceleration.\* In uniform circular motion, the centripetal force is perpendicular to the tangential velocity.  According to Newton’s Third Law, forces occur in action/reaction pairs. When one object exerts a force on a second, the second exerts a force on the first that is equal in magnitude and opposite in direction. | How can we analyze vector diagrams of nonequilibrium mechanical systems to find the net force?  How do we contrast horizontal motion with motion on an inclined plane?  How can we identify the directions of centripetal force, centripetal acceleration and velocity vectors for objects in circular motion?  How do we identify reaction forces in free body diagrams? | Student-to-student, evidence-based discussions utilizing M.A.X. Teaching Framework for Newton’s Laws & Momenum  Lab Themes:  Coefficient of Friction  Hooke’s Law  Centripetal Force | Utilize Part C Regents questions as formative assessment.  Benchmark #6 | dynamic equilibrium  unbalanced, outside force  free body diagram  dynamics  static equilibrium |
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| 7 | **Impulse & Momentum**   * Momentum * Impulse * Conservation of momentum | The impulse imparted to an object causes a change in its momentum.  Momentum is conserved in a closed system. | How do we analyze the motions of objects before and after collisions?  How do we describe momentum?  How is impulse related to time?  How can we compare and contrast impulse versus momentum?  Why might we think of momentum as being a measure of ‘moving inertia’?  How the concept of impulse is used in everyday life applications?  How do we distinguish between elastic and inelastic collisions?  What is the law of conservation of linear momentum, and when do we use it?  In reality, why is there no such thing as a perfectly elastic collision?    Why is linear momentum conserved in any collision (assuming no rotational effects for now)? Understand this using the 3rd law of motion.  What can we learn from a force-time graph? What is the general shape of such a graph for an object in a collision?  Why do we say conservation applies to systems, but impulse applies to individual objects? | Student-to-student, evidence-based discussions utilizing M.A.X. Teaching Framework for Impulse, momentum & conservation of momentum  Lab Themes:  Conservation of Momentum | Utilize Part C Regents questions as formative assessment.  Benchmark #7 | Momentum  Impulse  Conservation of momentum  Linear momentum vs angular momentum  Center of mass/gravity  Elastic  Inelastic  Inertia |
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| 8 | **Work, Energy, & Power**   * Work and Power * Kinetic Energy * Gravitational Potential Energy * Elastic Potential Energy * Work-Energy Theorem | Potential energy is the energy an object possesses by virtue of its position or condition. Types of potential energy include gravitational and elastic.  Kinetic energy is the energy an object possesses by virtue of its motion.  In an ideal mechanical system, the sum of the macroscopic kinetic and potential energies (mechanical energy) is constant.  In a non-ideal mechanical system, as mechanical energy decreases there is a corresponding increase in other energies such as internal energy.  When work is done on or by a system, there is a change in the total energy of the system.  Work done against friction results in an increase in the internal energy of the system.  Power is the time-rate at which work is done or energy is expended. | What is work and how do we measure it?  What is power and how is it measured?  What is horsepower and how do we measure it?  How can we compare and contrast mechanical energy and work?  How do we describe potential energy?  What two ways can mechanical systems store energy?  How do we describe kinetic energy? | Student-to-student, evidence-based discussions utilizing M.A.X. Teaching Framework for work/power, potential/kinetic energy, work-energy theorem.  Lab Themes:  Power  Energy Stored in a Spring  Period of a Pendulum | Utilize Part C Regents questions as formative assessment.  Benchmark #8 | Energy  Kinetic  Potential  Power  Joule  Watt  Elastic energy  Mechanical Work |

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| 9 | **Conservation of Energy**   * Conservation of Energy | All energy transfers are governed by the law of conservation of energy.  Energy may be converted among mechanical, electromagnetic, nuclear, and thermal forms. | What is the law of conservation of mechanical energy and how do we apply it?  How do simple machines work?  What is meant by “efficiency in mechanical systems”?  What do we define efficiency of any energy transforming machine? | Student-to-student, evidence-based discussions utilizing M.A.X. Teaching Framework for Conservation of Energy  Lab Themes:  Conservation of Energy | Utilize Part C Regents questions as formative assessment.  Benchmark #9 | Conservation of Energy  Simple machine  Inclined plane  Lever  Pulley  Mechanical Advantage |

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| 10 | **Electrostatics**   * Atomic structure * Conservation of Charge * Elementary charge * Electric fields * Potential difference | Energy may be stored in electric or magnetic fields. This energy may be transferred through conductors or space and may be converted to other forms of energy.  Field strength and direction are determined using a suitable test particle. (Notes: 1. Calculations are limited to electrostatic and gravitational fields.  2. The gravitational field near the surface of Earth and the electrical field between two oppositely charged parallel plates are treated as uniform.)  Gravitational forces are only attractive, whereas electrical and magnetic forces can be attractive or repulsive.  The inverse square law applies to electrical and gravitational fields produced by point sources. | How do we describe static electricity?  Why are there two types of charges (positive and negative)?  How is electric charge distributed in atoms and molecules?  What is the difference in the way various materials handle moving charge?  How do we describe conductors?  How do we describe insulators?  How can we compare and contrast semiconductors to conductors?  How do we use the electroscope to demonstrate movement of static charge? | Student-to-student, evidence-based discussions utilizing M.A.X. Teaching Framework for electrostatics, elementary charge, and electric fields.  Lab Themes:  Electrostatics | Utilize Part C Regents questions as formative assessment.  Benchmark #10 | Static Electricity  positive  negative  Electric Charge  Conductors  Insulators  Semiconductors  Electroscope  Electric Force  Electric Field Lines |
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| 11 | **Current & Electricity**   * Electric Current * Resistance of a Conductor * Ohm’s Law * Electric Power and Energy | Moving electric charges produce magnetic fields. The relative motion between a conductor and a magnetic field may produce a potential difference in the conductor.  All materials display a range of conductivity. At constant temperature, common metallic conductors obey Ohm’s Law.  The factors affecting resistance in a conductor are length, cross-sectional area, temperature, and resistivity. | How can electrical energy be transformed?  What impact does electricity have on our world?  How does an electric circuit work?  How does energy travel along a circuit? | Student-to-student, evidence-based discussions utilizing M.A.X. Teaching Framework for VIR, Ohm’s Law & Electric Power/Energy  Lab Themes:  Electrostatics  Building an electroscope  Calculating resistivity of conductors | Utilize Part C Regents questions as formative assessment.  Benchmark #11 | Current  Resistance  Voltage  Ohm’s Law  Ampere  Potential  Schematic diagram  Generator  Lamp  Solar cell  Potentiometer |
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| 12 | **Circuits**   * Series Circuits * Parallel Circuits | A circuit is a closed path in which a current can exist. (Note: Use conventional current.)  Circuit components may be connected in series or in parallel. Schematic diagrams are used to represent circuits and circuit elements. | How can we use VIRP tables when making circuits calculations?  How can we use Ohm’s Law to calculate VIR of a circuit?  How are V, I, & R related to one another? | Student-to-student, evidence-based discussions utilizing M.A.X. Teaching Framework for series and parallel circuits  Lab Themes:  VIRP Circuit Studies  Circuit Building | Utilize Part C Regents questions as formative assessment.  Benchmark #12  Series Circuits  …  …  …  Parallel Circuits  …  … | Closed circuit  Open circuit  Battery  Conductor  Switch  Diode  Insulator  Filament |
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| 13 | **Magnetism**   * Magnetic Fields * Electromagnetism * Generators/Motors | Magnets produce a force that can move certain objects without direct contact.  Magnets produce a force that can vary in strength and this force can move certain objects and not others.  Energy may be stored in electric or magnetic fields. This energy may be transferred through conductors or space and may be converted to other forms of energy.  Gravitational forces are only attractive, whereas electrical and magnetic forces can be attractive or repulsive.  The inverse square law applies to electrical and gravitational fields produced by point sources. | How do we describe magnetic fields?  How are electricity & magnetism related?  How can we compare & contrast electricity & magnetism?  How do we define Faraday’s Law?  How can we induce an electric current with a magnetic field?  How do generators work?  How is a generator different from a motor? | Student-to-student, evidence-based discussions utilizing M.A.X. Teaching Framework for magnetism, electromagnetism, magnetic induction, & simple motors/generators  Lab Themes:  Magnetic Field Lines Around a Permanent Magnet  Magnetic Induction | Utilize Part C Regents questions as formative assessment.  Benchmark #13 | Electromagnet  Electromagnetic induction  Faraday’s Law  Magnetic induction  Magnetic fields  Electric motor  Electric generator  Magnetic force |
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| 14 | **Wave Characteristics**   * Mechanical/Electromagnetic Waves * Transverse/ Longitudinal Waves * Period * Wavelength * Amplitude * Speed * Phase * Sound and Light | An oscillating system produces waves. The nature of the system determines the type of wave produced.  Waves carry energy and information without transferring mass. This energy may be carried by pulses or periodic waves.  The model of a wave incorporates the characteristics of amplitude, wavelength, frequency, period, wave speed, and phase.  Mechanical waves require a material medium through which to travel.  Waves are categorized by the direction in which particles in a medium vibrate about an equilibrium position relative to the direction of propagation of the wave, such as transverse and longitudinal waves.  Electromagnetic radiation exhibits wave characteristics. Electromagnetic waves can propagate through a vacuum.  All frequencies of electromagnetic radiation travel at the same speed in a vacuum. | What is a wave?  How are waves produced?  Are there different types of waves?  What are the names of the different parts of a wave?  How are waves, matter, and energy related?  How do the properties of sound waves affect our everyday experiences?  How are the characteristics of waves affected by the type of medium?  How are wavelengths detected by the human eye?  What determines the speed of a wave?  What determines the amplitude of a wave?  What determines the frequency of a wave?  How can the frequency of a wave be changed? | Student-to-student, evidence-based discussions utilizing M.A.X. Teaching Framework for wave characteristics; sound & light  Lab Themes:  Speed of Sound Lab | Utilize Part C Regents questions as formative assessment.  Benchmark #14 | Energy  Mechanical wave  Medium  Vibration  Transverse wave  Longitudinal wave  Crest  Trough  Compression  Rarefaction  Amplitude  Wavelength  Frequency  Hertz  Standing wave  Node antinode |
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| 15 | **Wave Behaviors**   * Reflection * Refraction * Dispersion * Diffraction * Doppler Effect * Interference * Standing Waves * Resonance | Resonance occurs when energy is transferred to a system at its natural frequency.  When a wave strikes a boundary between two media, reflection, transmission, and absorption occur. A transmitted wave may be refracted.  When a wave moves from one medium into another, the wave may refract due to a change in speed. The angle of refraction (measured with respect to the normal) depends on the angle of incidence and the properties of the media (indices of refraction).  The absolute index of refraction is inversely proportional to the speed of a wave.  Diffraction occurs when waves pass by obstacles or through openings. The wavelength of the incident wave and the size of the obstacle or opening affect how the wave spreads out.  When waves of a similar nature meet, the resulting interference may be explained using the principle of superposition. Standing waves are a special case of interference.  When a wave source and an observer are in relative motion, the observed frequency of the waves traveling between them is shifted (Doppler effect). | How can we describe the duality of light? (Light has a particle nature (photoelectric effect) as well as a wave nature (reflection, refraction, diffraction and interference)).  What happens to a wave after it passes through an opening in a barrier?  How is a light wave different from a sound wave?  How is a light wave similar to a sound wave?  What happens to a light wave when it strikes a reflective surface, like a mirror?  How are images formed in a flat mirror?  What are some similarities and differences between plane and curved mirrors?  How are images formed using curved mirrors?  What are some uses for concave mirrors?  What are some uses for convex mirrors?  What can happen to a wave as it changes speed?  How are lenses similar to curved mirrors?  How are lenses different from curved mirrors?  How do lenses form images?  Why do humans see different colors of light? | Student-to-student, evidence-based discussions utilizing M.A.X. Teaching Framework for wave behaviors  Lab Themes:  Reflection of Light  Refraction of Light  Energy Levels of Hydrogen | Utilize Part C Regents questions as formative assessment.  Benchmark #15 | Reflection  Refraction  Diffraction  Law of reflection  Interference  Destructive interference  Constructive interference  Resonance |
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| 16 | **Modern Physics**   * Quantum Physics * Models of the Atom * Hydrogen/Mercury * Energy Level | States of matter and energy are restricted to discrete values (quantized).  Charge is quantized on two levels. On the atomic level, charge is restricted to multiples of the elementary charge (charge on the electron or proton). On the subnuclear level, charge appears as fractional values of the elementary charge (quarks).  On the atomic level, energy is emitted or absorbed in discrete packets called photons.  The energy of a photon is proportional to its frequency.  On the atomic level, energy and matter exhibit the characteristics of both waves and particles.  Among other things, mass-energy and charge are conserved at all levels (from subnuclear to cosmic).  The Standard Model of Particle Physics has evolved from previous attempts to explain the nature of the atom and states that:  • atomic particles are composed of subnuclear particles  • the nucleus is a comglomeration of quarks which manifest themselves as protons and neutrons  • each elementary particle has a corresponding antiparticle  Behaviors and characteristics of matter, from the microscopic to the cosmic levels, are manifestations of its atomic structure. The macroscopic characteristics of matter, such as electrical and optical properties, are the result of microscopic interactions.  The total of the fundamental interactions is responsible for the appearance and behavior of the objects in the universe.  The fundamental source of all energy in the universe is the conversion of mass into energy. | How does quantum mechanics compare to Newtonian physics?  How does quantum mechanics correct Newtonian physics and relativity when matter is very small, moving fast compared to the speed of light, or very large?  How can we compare and contrast Newton’s version of gravity to Einstein?  What was Rutherford's model of the atom?  What are the three basic subatomic particles in an atom?  How do the three basic subatomic particles in an atom compare in charge and mass? | Student-to-student, evidence-based discussions utilizing M.A.X. Teaching Framework for quantum physics, models of the atom, hydrogen/mercury energy levels  Lab Themes:  Half-Life Lab  Spectral Analysis Lab | Utilize Part C Regents questions as formative assessment.  Benchmark #16 | Photon  Plank’s constant  Photoelectric effect  Bohr’s model  Quantum model  Line spectrum  Spectroscopy |