AP Physics 1 and 2 Syllabus

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Curricular Requirement 2: The course design provides opportunities for students to develop understanding of the AP Physics 2 foundational physics principles in the context of the big ideas that organize the curriculum framework	**3-12**
Curricular Requirement 3: Students have opportunities to apply AP Physics 1 and 2 learning objectives connecting across enduring understandings as described in the curriculum framework. These opportunities must occur in addition to those within laboratory investigations.	**5, 8,9**
Curricular Requirement 4: The course provides students with opportunities to apply their knowledge of physics principles to real world questions or scenarios (including societal issues or technological innovations) to help them become scientifically literate citizens.	**5,8, 10, 11**
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Curricular Requirement 6: Students are provided the opportunity to engage in inquiry-based laboratory investigations that support the foundational principles and apply all seven science practices defined in the curriculum framework.	**4-5, 7-8, 12 (written as SP after each lab)**
Curricular Requirement 7: The course provides opportunities for students to develop their communication skills by recording evidence of their research of literature or scientific investigations through verbal, written, and graphic presentations.	**2, 5,8,12**

Course Overview

Advanced Placement Physics 1 and Physics 2 are offered at Fredericton High School in a unique configuration over three 90 h courses. (Previously Physics 111, Physics 121 and AP Physics B 120; will now be called Physics 111, Physics 121 and AP Physics 2 120). The content for AP Physics 1 is divided between Physics 111 and Physics 121 (as per provincial curriculum guidelines) while the content for AP Physics 2 is divided between Physics 121 and AP Physics 2. While we do not title a course AP Physics 1, the curricular content and values are in line with AP guidelines. **The one exception to AP guidelines rests in our third course, in which there is limited time for student labs prior to the AP exam. Instead, the last 1/3 of the course is an open inquiry in which students must design, research and conduct an experiment of the form "How does A affect B". They present their results in the form of a one hour oral defense in front of university physics professors.** While this covers the time guideline, labs are not always conducted in all topics. I have found this to be a particularly valuable exercise with students, and most would agree that it is the most valuable aspect of the three courses, as they actually bring an open ended research question to some sort of conclusion. I am hopeful that this will satisfy the lab requirements of AP Physics 2. Students are required to keep a file with all their labs in it for evidence.

The teacher has numerous demonstrations for each unit of study—some simple devices purchased from scientific catalogs to illustrate specific concepts but most constructed by the teacher from easily vailable materials. Class demonstrations are used to clarify concepts and generate interest for students. In every case, the demonstration is meant to inspire questions and responses from students in an open discussion that reinforces concepts, brings out misconceptions, and illustrates real world applications.

Textbooks

Edwards, Lois, et. al. *Physics*. Toronto, ON: McGraw-Hill Ryerson (2003) (grade 11 book)

Giancoli, Douglas C. *Physics, 5th ed.* Upper Saddle River, NJ: Prentice Hall (1998) (primary grade 12)

Urone, Paul Peter and Hinrichs, Roger, et. al. *College Physics.* Openstax College (2012) (secondary resource)

Curricular Requirement 1: Students and teachers have access to college-level resources including college-level textbooks and reference materials in print or electronic format.

Homework

Homework is a regular part of all three courses. In Physics 111, homework is assigned daily – sometimes evaluated, sometimes used in formative assessment and sometimes simply to inspire questions and observations. In Physics 121 and AP Physics 2, students are assigned homework questions and problems unit by unit and are provided the opportunity in class to work on them, discuss them, strategize and peer teach. Students also spend a considerable amount of time outside class doing lab reports, devising demonstrations, preparing methods of investigations and doing projects and writing a major essay (Question: What advance in physics do you feel has had the greatest impact on history? Discuss the advance and justify your reasoning).

Labs

Students are required to keep a section of their binder for labs. Lab reports include calculations, but a significant part is dedicated to sources of error and error analysis so that students can see and predict the validity (or lack thereof) of their results. In grade 11, most labs are teacher directed (1D Kinematics, Dynamics and waves), in grade 12 the majority of the labs are open inquiry with students simply being given a question. Students are required to develop appropriate procedures and collect data with error analysis. In the final course, 1/3 of the course is dedicated to a completely open inquiry which is student directed to (attempt to) answer a question in the form "How does A affect B?"

Curricular Requirement 7: The course provides opportunities for students to develop their communication skills by recording evidence of their research of literature or scientific investigations through verbal, written, and graphic presentations.

Testing

Students are tested on each unit in all three classes. Regular quizzes also occur in Physics 111 in particular, to act as a more formative assessment. A summative exam is given in Physics 111 (2 hours), Physics 121 (3 hours) and students completing AP Physics 2 will write a summative practice AP Physics 1 and AP Physics 2 exam.

Chart 1: Course Timeline with Topics Correlated to Physics 1 and 2 Curriculum Framework for Physics 111

Curriculum Requirement 2: The course design provides opportunities for students to develop understanding of the AP Physics 1 and 2 foundational physics principles in the context of the big ideas that organize the curriculum framework.

Course: Physics 111

Time	Topic/Subtopic	Correlation to Curricular Framework
2 hours	Overview of physics – including history, philosophy, big picture [CR	BI 1,4,5,6,7
20 hours	One dimensional kinematics and vectors [CR2a]	BI 2,3
15 hours	Newton’s Laws in 1 dimension [CR2b]	BI 1, 2, 3, 4
8 hours	Momentum, Impulse and Conservation of Momentum [CR2e]	BI 3, 4, 5
10 hours	Work, Energy, Conservation of Energy and Power [CR2f]	BI 3, 4, 5
15 hours	Mechanical Waves and Sound [CR2j]	BI 6
10 hours	Light, Interference and Refraction [CR2f]	BI 6

Class work:

- Students analyze both d-t and v-t graphs of motion, including “real life” situations.
- Students/teacher derive equations of motion from v-t graphs and are used to solve 1-D kinematics question.
- Newton’s Laws are stated and developed, linking forces to motion, solving 1-D dynamics and kinematics questions.
- Students understand the difference between mass and weight and the implications of each.
- Students are introduced to the concept of vectors and are able to differentiate between vectors and scalars.
- Students are able to add perpendicular vectors to describe motion in two dimensions.
- Students resolve vectors into components for 1-D kinematics and dynamics questions.
- Conservation of momentum equations are derived from Newton’s laws, and the momentum-impulse equation and conservations laws are applied to 1-D interactions.

- Conservation of energy and energy transformations are applied to kinematics problems and real world situations. Power as the rate of transformation of energy is used in problems and related to real world situations including electrical energy.
- Students investigate a simple spring and can discuss it's motion in terms of forces and the convervation of energy.
- Students investigate wave motion and can describe it in terms of energy and compare it to the motion of a simple spring.
- The wave equation is derived and students use it to solve problems and describe wave motion.
- Students examine properties of waves qualitatively and quantitatively, including relection, refraction, interference and diffraction.
- Light is investigated as to its wave properties with reference to the historical debate over the wave/particle nature of light.

Included laboratories, investigations, student demonstrations and project:

Curricular Requirement 5: Students are provided with the opportunity to spend a minimum of 25 percent of instructional time engaging in hands-on laboratory work with an emphasis on inquiry-based investigations.

1) Modelling Lab – Students examine six experiments and create models (visual, written, algebraic) of the experiment based upon observation. [SP1.1, 1.2, 1.3, 6.1, 6.2, 6.4, 6.5]
2) Motion is investigated by students sketching d-t and v-t graphs of various motions. They describe the motion of an object based upon the d-t or v-t graph. [SP1.4, 4.4,5.1]
3) Determining speed of a constant motion cart: Students determine the speed of a constant motion cart using ticker tape, meter stick and graphing. *Structured Inquiry* [SP 1.1,1.5,2.2,2.3,3.3,4.3, 5.1.5.2,5.3]
4) Determine acceleration of gravity of a falling object: Students determine instantaneous speeds and acceleration of a falling object using ticker tape, meter stick and graphing. *Structured Inquiry* [SP 1.1,1.5,2.2,2.3,3.3,4.3, 5.1.5.2,5.3]
5) Relative motion investigation: A qualitative investigation in which students develop an understanding that motion is relative and that the appearance of motion is based upon frame of reference. *Guided Inquiry* [SP 1.4,6.4]
6) Friction lab: Students measure the coefficient of friction between two surface using spring balances and graphing. *Structured Inquiry* [SP 1.2, 1.4, 2.2, 3.1, 3.3, 4.3, 5.1, 5.3, 6.1,6.5]
7) Momentum Impulse demonstration: Students develop and explain an interaction in which the momentum-impulse theorem is demonstrated and present it to the class. *Guided Inquiry* [SP 1.1, 1.2, 1.3, 1.4, 6.2,6.3]
8) Hooke's Law Experiment: Students determine the relationship between distance stretched and force required *Structured Inquiry* [SP 1.4, 2(all), 3.3, 4.3, 5.1, 5.2, 5.3, 6.1]
9) Climbing Power: Students determine the amount of work and energy required to climb stairs at different rates, relating potential energy with work done and power. Students are required to determine the procedure to accomplish this. *Guided Inquiry* [SP 2.1, 2.2, 3.1, 3.3, 4(all), 5.1]

10) Ballistics Pendulum: students determine the initial speed of a "bullet" using conservation of momentum and conservation of energy (kinetic and potential). *Guided Inquiry* [SP 2.1, 2.2, 3 (all), 4.3, 4.4, 5(all)]
11) Beats and Standing Waves: students determine how beats and standing waves are produced using springs and sound equipment. [SP 1(all), 2.3, 3(all) 4(all)]
12) Resonance Apparatus Lab: students determine the speed of sound by using resonance in a tube. *Structured Inquiry* [SP 2.1, 2.2, 3.1, 3.3, 4.3, 4.4]
13) Index of refraction lab: Students determine the index of refraction of a liquid by measuring angles of incidence and refraction. *Structured Inquiry* [SP 2.1, 2.2, 3.1, 3.3, 4.3, 4.4]
14) Single slit interference: Students exam the single slit interference pattern produced by different frequencies of laser light and compare them. [SP 3(all), 4.4, 6(all), 7.2]
15) Double slit Interference Lab: Students determine the separation of slits using a laser of known wavelength and determine the wavelength of a laser of unknown frequency using these slits. *Guided Inquiry as an independent study.* [SP 1.5, 2 (all), 3(all), 4.1, 4.3, 4.4, 5(all), 6.1 6.4, 7.1]
16) Research Report/Article: Choice of three topics – Automobile Safety, Energy Alternatives or Physics of a musical instrument. Students relate physics to real world situations (Newton's laws and conservation of momentum to Automobile Safety; Energy transformation and conservation to various energy sources; Waves theory and wave motion to how a musical instrument works). [SP 1.2, 3(all), 4.4, 5.3, 7(all)]

Curricular Requirement 4: The course provides students with opportunities to apply their knowledge of physics principles to real world questions or scenarios (including societal issues or technological innovations) to help them become scientifically literate citizens.

Curricular Requirement 3: Students have opportunities to apply AP Physics 1 learning objectives connecting across enduring understandings as described in the curriculum framework.
Research report/article: LO 3.A.1.1; 3.A.3.4; LO 4.C.2.2; LO 5.A.2.1

Curricular Requirement 7: The course provides opportunities for students to develop their communication skills by recording evidence of their research of literature or scientific investigations through verbal, written, and graphic presentations.

Chart 2: Course Timeline with Topics Correlated to Physics 1 and 2 Curriculum Framework for Physics 121

Curriculum Requirement 2: The course design provides opportunities for students to develop understanding of the AP Physics 1 and 2 foundational physics principles in the context of the big ideas that organize the curriculum framework.

Course: Physics 121

Time	Topic/Subtopic	Correlation to Curricular Framework
11 hours	Geometric Optics [CR2f (Phys 2)]	BI 6
13 hours	Two dimensional kinematics and dynamics with energy [CR2a, b, f (Phys 1)]	BI 1,2,3,4
12 hours	Circular Motion, Kepler's Laws and Universal Gravitation [CR2c (Phys 1)]	BI 1,2,3,4
12 hours	Angular motion and torque, rotational statics, angular momentum and rotational energy [CR2g (Phys 1)]	BI 3,4,5
12 hours	Simple Harmonic Oscillators, Conservation of Momentum in 2-D [CR2d,e (Phys 1)]	BI 3,4,5
10 hours	Electrostatics and Electric Fields [CR2h (Phys 1); CR2c (Phys 2)]	BI 1,2,3,4,5
10 hours	Electric Potential and Capacitance [CR2c, d(Phys 2)]	BI 1,2,3,4,5
10 hours	Electric Circuits [CR2i (Phys 1); CRC2d (Phys 2)]	BI 1,4,5

Class work:

- Students derive the lens/mirror equation and apply it to problems, including real life problems such as cameras, telescopes and microscopes.
- Students can design a microscope given desired optical magnification
- Students reflect on qualitative questions surrounding mirror and lens use, spherical and chromatic aberration and practical functions of each type of device, including questions regarding the function of the eye.
- Students solve problems for horizontal, symmetrical and asymmetrical projectiles in both general and specific form.
- Students apply Newton's laws and free body diagrams inclined planes and multiple body problems with and without (massless and frictionless) pulleys.
- Students use Kepler's laws and Newton's law of universal gravitation to solve problems, including real world problems (such as where to place geostationary satellites).
- Students recognize a gravitational field in terms of force per mass, as a change in the space around a mass and as the equivalent of gravitational acceleration.
- Students relate angular kinematics equations and dynamics equations to their linear counterparts, and use these to solve rotational kinematics and statics problems.

- Students use rotational kinetic energy, linear kinetic energy and gravitational potential energy to solve problems and can discuss the transformation of these types of energy.
- Students use conservation of angular momentum to solve rotational collisions.
- Students solve problems involving real pulleys with mass and friction.
- Students analyze the relationship between circular motion and simple harmonic motion and derive equations for simple harmonic motion from circular motion.
- Students can describe the motion of a SHO using sine and cosine functions and can discuss and use conservation of energy to describe the varying states of a SHO.
- Students use conservation of momentum both qualitatively and quantitatively to discuss interactions in two dimensions.
- Students can define charge and elementary charge and understand the law of conservation of charge.
- Students understand, qualitatively, the process and results of Millikan's experiment.
- Students use Coulomb's law to solve problems, including real world problems, involving static electricity in one and two dimensions.
- Students can define the electric field in terms of force per charge, and recognize it as the change in space around a charge. They can use electric fields to solve problems in one and two dimensions.
- Students can define electric potential and relate it to gravitational potential. Students recognize potential difference as voltage and can use it to solve problems both spatially and in circuits.
- Students can define capacitance and are able to solve problems with capacitors in steady state circuits. Students can also determine the capacitance of a device (or combination of devices) based on the voltage-time curve of an RC circuit.
- Students can solve simple and complex resistance circuits using circuit reduction, Ohm's law and Kirchhoff's laws.

Included laboratories, investigations, student demonstrations and project:

17) Students determine the focal length of convex and concave lenses. *Open inquiry.* [SP 1(all), 2.1, 2.2, 3(all), 4(all), 5(all), 6.1, 6.2]
18) Students determine the initial velocity of a projectile launched from a student built launcher (with the criteria that it must launch at a near constant velocity – including direction). *Open Inquiry* [SP 1(all), 2.1, 2.2, 3(all), 4(all), 5(all), 6.1, 6.2, 6.4, 6.5]
19) Students use a force table to show that net force is zero in a static situation. *Guided Inquiry* [SP 1(all), 2(all), 3.1, 3.3, 4.1, 4.3, 4.4 , 5(all), 6.1, 6.2]
20) Students are asked to devise and conduct an experiment to validate the centripetal force equation by measuring centripetal force, radius and period independently. *Open inquiry* [SP 1(all), 2(all), 3(all), 4(all), 5(all), 6.1, 6.2, 6.3, 6.5]

Curriculum Requirement 5: Students are provided with the opportunity to spend a minimum of 25 percent of instructional time engaging in hands-on laboratory work with an emphasis on inquiry-based investigations.

21) Students are asked to measure the spring constant of a spring using Hooke's law as well as the period of oscillation and be able to describe why these produce different results (not taking into account the mass of the spring). Students are asked to determine the quality factor of the spring. *Part Open, Part Guided Inquiry* [SP 1(all), 2(all), 3(all), 4(all), 5(all), 6(all), 7.2]
22) Students qualitatively investigate the effects of static electricity – opposite charges, attraction and repulsion, charging by friction, conduction and induction, and can describe qualitatively why charging by friction works based on atomic and molecular electron configurations. *Guided Inquiry* [SP 1(all), 5(all), 7.1]
23) Students verify the inverse square law of Coulomb's equation. *Guided Inquiry*
24) Students determine the capacitance of capacitors in series/parallel and combination using an RC circuit and the time constant. Students construct circuits from symbolic circuit diagrams, including meters. *Guided Inquiry* [SP 1.1, 1.2, 1.4, 2(all), 3.3, 4.3, 5(all), 6.1, 6.4,7 (all)]
25) Students validate Ohm's law and Kirchoff's laws in series/parallel and combination resistance circuits. Students construct circuits from symbolic circuit diagrams, including meters. *Guided Inquiry* [SP 1.1, 1.2, 1.4, 2(all), 3.3, 4.3, 5(all), 6.1, 6.4,7 (all)]
26) Research/Argumentative Essay: Students answer the question "What development in physics do you believe has had the greatest impact on history. Discuss the advance and justify your reasoning." Students are expected to discuss the physics behind the advance as well as the history of its discovery/invention, as well as relating the discovery/invention to the impact on society (either positively or negatively). [SP 1.4, 1.5, 3(all), 4(all), 5.3, 6.1, 6.3, possibly 6.5 depending on paper, 7.2}

Curricular Requirement 4: The course provides students with opportunities to apply their knowledge of physics principles to real world questions or scenarios (including societal issues or technological innovations) to help them become scientifically literate citizens.

Curriculum Requirement 3: Students have opportunities to apply AP Physics 2 learning objectives connecting across enduring understandings as described in the curriculum framework.
Research Essay: The learning objectives vary by student topic, but *always* involve multiple big ideas.

Curricular Requirement 7: The course provides opportunities for students to develop their communication skills by recording evidence of
their research of literature or scientific investigations through verbal, written, and graphic presentations.

AP Physics 2 120(our third physics course).

Chart 3: Course Timeline with Topics Correlated to Physics 1 and 2 Curriculum Framework for AP Physics 2 120

Curriculum Requirement 2: The course design provides opportunities for students to develop understanding of the AP Physics 1 and 2 foundational physics principles in the context of the big ideas that organize the curriculum framework.

Course: AP Physics 2 120

Time	Topic/Subtopic	Correlation to Curricular Framework
10 hours	Magnetism and Electromagnetism [CR2e(Phys 2)]	BI 2,3,4
8 hours	Electromagnetic Induction [CR2e(Phys 2)]	BI 2,3,4
8 hours	Atomic and quantum physics [CR2g(Phys 2)]	BI 1,3,5,6,7
5 hours	Nuclear Physics [CR2g(Phys 2)]	BI 1,3,5,6,7
13 hours	Thermodynamics [CR2a(Phys 2)]	BI 1,4,5,7
9 hours	Fluid Mechanics [CR2b(Phys 2)]	BI 1,3,5
35 hours	Independent Lab project	BI 3,4 (often several others depending on topic)

Class work:

- Over 25% of class time is spent in laboratory investigations as indicated in the table above.
- A class investigation of properties of magnets, including compasses. This leads to a discussion of similarities and differences between electric charges and magnetic poles, a discussion of dipoles vs. monopoles and domains, as well as the Earth's magnetic field.
- From a discussion of Oerstead's experiment of the effect of a current carrying wire on a compass, students are introduced to the equations relating current and magnetic field to force and moving charges and magnetic field to force and use these to solve problems, including problems related to mass spectroscopy.
- Given the equation for magnetic field from a current carrying wire (derived later with Ampere's law) students derive the equation for the mutual force on current carrying wires.
- Students are introduced to the discrete and integral forms of Ampere's law and use the discreet form to determine the magnetic field in simple, symmetrical cases.
- Students investigate torque on a loop and apply this concept to motors.
- Students use the concepts of magnetic flux, Faraday's law and Lenz's law to determine induced electromotive force, and apply the concept to generators, rail guns and transformers.
- Students undergo a quantitative and qualitative exercise regarding the advantages of AC

Curriculum Requirement 3: Students have opportunities to apply AP Physics 2 learning objectives connecting across enduring understandings as described in the curriculum framework.
AC/DC Transmission and Transformers: LO 4.E.2.1, LO 5.B.4.2., LO 2.D.1.1

transmission over DC transmission, including calculation of power loss and efficiency. [CR4, CR3]

- Concepts of self and mutual inductance are discussed, including the use of self-inductance in devices such as radios and surge protectors.
- Early models of the atom are reviewed, discussing experiments, including Rutherford and Bohr's model of the atom (qualitative discussion).
- Students understand the determination of the mass of the electron through Thompson's calculation of charge to mass ratio coupled with Millikan's experiment.

Curriculum Requirement 4: The course provides students with opportunities to apply their knowledge of physics principles to real world questions or scenarios (including societal issues or technological innovations) to help them become scientifically literate citizens.

- Students are introduced to Planck's constant through his study of blackbody radiation. With the photoelectric effect and Einstein's interpretation of the photon, leading to the quantum relationship of light and energy.
- Photon interactions are studied and discussed, qualitatively and quantitatively including Compton effect (scattering), Photoelectric Effect (absorption and displacement of electron), absorption causing change of state of electrons, and pair production.
- Wave-particle duality is revisited with discussion about the double-slit experiment and electrons and de Broglie's wavelength of particles.
- Atomic spectra are viewed for various gases and a quantitative derivation of the Bohr model energy levels derived from quantized angular momentum is developed. Students relate electron energy transitions to specific wavelengths of light (absorption or emission).
- Heisenberg's uncertainty principle is discussed qualitatively and is applied in simple situations.
- Nuclear structure is discussed including subnuclear structure (quarks). Students understand that it is the strong force that holds the nucleus together and dominates the electric repulsion at small distances.
- An investigation of masses of elements and their constituents show that the sum of the whole is less than the sum of the parts. Students are led to the conclusion that the mass is converted to energy, and the concept of binding energy.
- Students calculate binding energy and relate this to the stability of atoms, leading to a discussion of nuclear fusion and fission (and the use of both as sources of energy). [CR4]
- All forms of nuclear decay are investigated qualitatively and quantitatively with energy calculations.
- Students perform calculations of half-life from decay data and determine rates of decay from half-life.
- Nuclear decay is applied to radioactive dating [CR4]
- Atomic theory, including law of definite proportions, Brownian motion and states of matter are reviewed.

Curriculum Requirement 4: The course provides students with opportunities to apply their knowledge of physics principles to real world questions or scenarios (including societal issues or technological innovations) to help them become scientifically literate citizens.

- Temperature and temperature scales are defined. Students can convert between Celsius and Fahrenheit.
- Thermal expansion of solids is investigated and discussed qualitatively, and the mathematics is derived using linear expansion for isotropic solids.
- Students apply ideal gas laws to solve problems.
- Kinetic theory of gases is discussed and it is proven that in the ideal gas case that temperature is a measurement of the average kinetic energy of the molecules.
- The differences between heat, thermal energy and temperature are discussed.
- Students can calculate the internal energy of an ideal monatomic gas.
- Specific heat, latent heat are used to calculate masses or temperatures of substances in calorimetry experiments.
- Methods of heat transfer are discussed qualitatively and investigated in problems.
- The first and second laws of thermodynamics are discussed and applied with simple systems and heat engines (including the Carnot engine). Efficiency of heat engines (such as automobile engines) is discussed. [CR4]
- Density and specific gravity are defined, discussed and used in problems.
- The difference between gauge and absolute pressure is discussed and used in problems.
- Pascal's principle is related to Newton's 3rd law.
- Buoyancy and Archimedes' principle are discussed and used in problems.
- Laminar and Turbulent flow are discussed qualitatively, and the equation of continuity is derived.
- Bernoulli's principle is derived and applied to problems.
- Students are able to apply Bernoulli's principle in qualitative situations, including being able to explain why and airplane flies.

Curriculum Requirement 4: The course provides students with opportunities to apply their knowledge of physics principles to real world questions or scenarios (including societal issues or technological innovations) to help them become scientifically literate citizens.

Included laboratories, investigations, student demonstrations and project:

27) Students conduct an experiment to determine Planck's constant using a variety of LED lights of different frequencies. *Guided Inquiry*
28) Students are required, in pairs, to design, research and conduct an experiment in physics of the form "How does A affect B?" It cannot be any experiment we have conducted in class, and must be beyond basic experiments. Students choose their own topics (vetted by the teacher in case equipment availability is an issue or the experiment is too simple or difficult). Examples of experiments in the past include questions such as

Curriculum Requirement 5: Students are provided with the opportunity to spend a minimum of 25 percent of instructional time engaging in hands-on laboratory work with an emphasis on inquiry-based investigations.

- How does the rotational speed of a propeller relate to force applied?
- How does temperature affect the resistance of a wire?
- How does the intensity of light affect the spin rate of a radiometer?
- How does potential difference affect the strength of an electromagnet (since T increases as V increases, R also increases)?
- How does index of refraction vary with temperature/colour of light?
- How does the shape of an egg affect its breaking strength?

Students are expected to present their results, including background research, experimental design, explicit controls, analysis of data including error analysis and conclusions in front of their peers and university physics professors in a one-hour oral defense. They must then respond to questions related to their experiment from their peers and the professors. [SP 1, 2, 3, 4, 5, 6, 7]

Curricular Requirement 7: The course provides opportunities for students to develop their communication skills by recording evidence of their research of literature or scientific investigations through verbal, written, and graphic presentations.