Comprehensive Course Syllabus – Spring 2018

Course Title: Scientific Inquiries – Physics

Course Number: SCI115

Course Description: Scientific Inquiries – Physics is a one semester course required of all IMSA sophomores who have not taken a high school level physics course and have not passed the IMSA physics placement exam. The course addresses the fundamental principles of classical mechanics including Newton's laws of motion and the conservation laws of momentum and energy. Students learn concepts and skills through a combination of lab activities and experiments, guided inquiry, group discussion, collaborative problem solving and direct instruction.

Course Instructors:

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Meeting Days, Time and Room(s)

SI Physics HELP Session on I Days in B116 from 1:00-3:00 PM

All SI Physics Classes Meet in B116 (Labs in B114)

Text/Materials:

Textbook:	Conceptual Physics by Paul G. Hewitt, available by student request
Materials:	Laptop Computer, Calculator, Notebook, Pencils

Essential Content:

1. Free Body Diagrams
2. Newton's 1st and 2nd laws
3. Newton's 3rd law
4. Graphing motion
5. Equations of motion
6. Universal Gravitation
7. Weight vs. Mass
8. Free fall motion
9. Impulse and Momentum
10. Conservation of Momentum

11. Work and energy
12. Conservation of energy
13. Fields
14. Waves

Learning Objectives:
For each of the following units, students must be able to:

Newton's Laws of Motion:
1. Draw a Free Body Diagrams using arrows of relative appropriate lengths to indicate the forces acting on an object.
2. Add together the forces acting on an object to determine the net force.
3. Explain everyday phenomena, identify examples, and solve problems with Newton's first and second laws of motion.
4. Explain Newton's third law and how that affects the motion of an object, including identifying the third law pair to a force.

Kinematics:
1. Define position, distance, displacement, speed, velocity and acceleration.
2. Demonstrate an understanding of difference between instantaneous and average quantities.
3. Perform unit conversions using dimensional analysis.
4. Interpret and analyze graphical data to understand the motion of an object.
5. Use mathematical equations to solve 1-D kinematics problems.
6. Solve integrative problems containing kinematics and other topics and concepts.
Lab skills:
7. Use computer software to create a properly labeled data table and graph (s) with trend lines appropriate to the data. (Buggy lab)
8. Insert a formula into a spreadsheet to make calculations. (Sparky lab)
9. Interpret graphs and trend lines (including appropriate labels/units) and utilize equations generated to make predictions. (Buggy, Sparky, and Detector lab)

Gravitation:
1. Show an understanding of and solve problems with Newton's Universal Law of Gravitation.
2. Define and solve problems with gravitational field strength.
3. Differentiate between mass and weight and be able to convert from one to the other.
4. Demonstrate understanding of the motion of a falling body near the surface of the earth.
5. Use Newton's second law to explain why all objects fall in a uniform gravitational field with the same acceleration.
6. Solve free fall problems using the kinematic equations of motion.
7. Solve integrative problems containing free fall, gravitation, and other topics and concepts.

Momentum and Impulse:
1. Understand the difference between scalar and vector quantities.
2. Calculate the change in a quantity (final value – initial value).
3. Define momentum and impulse, including knowing units for each.
4. Solve problems and explain scenarios conceptually using the impulse-momentum theorem.
5. Solve problems and explain scenarios conceptually using the law of conservation of momentum.

Lab skills:

6. Use data collection tools including motion sensors and force probes and analyze the data collected to solve for an unknown quantity.

Energy:
1. Define work, mechanical energy, kinetic energy, and gravitational potential energy.
2. Know the unit for all of the above is the joule. Define the joule in basic SI units.
3. Understand and apply the concept of conservation of energy to solve problems
4. Determine an appropriate height in the system to label as zero and understand that this choice is arbitrary.
5. Understand and apply the work-kinetic energy theorem to solve problems
6. Experimentally derive the relationship between stopping distance and initial velocity (lab)
7. Solve integrative problems containing energy and other topics and concepts.

Fields and Waves:
1. Draw a vector field, given a set of data
2. Differentiate between a scalar and vector field
3. Given a field, interpolate the value of an unknown point, assuming a linear gradient
4. Perform calculations in which the field is dependent on distance from the source (linear and inverse)
5. Understand that a change in a field propagates at a finite speed and is called a wave
6. Understand that the properties of the field determine the speed of the wave
7. Understand that waves are the motion of energy.
8. Know the difference between longitudinal and transverse waves
9. Know the relationship between frequency and wavelength

Instructional Design and Approach:

Students learn the material through a multifaceted approach of classroom discussion, problem-solving, demonstration, laboratory activities and experiments. Both large and small group discussions are used to provide the students the opportunity to learn from each other.

Key to the experience of Scientific Inquiries in Physics is a student's development of experimental skills and practices fundamental to inquiry based learning. Students work individually and cooperatively to build models and develop mathematical relations from observations and quantitative data and to communicate their conclusions and explanations in written and oral form.

Student Expectations:

1. Students are responsible for checking email, Moodle and PowerSchool on a regular basis.
2. Students are expected to arrive to class on time. Unexcused tardies in excess of 5 minutes will be treated as unexcused absences. Please refer to the Attendance and Tardiness Procedures section of the handbook.
3. When in class, students are expected to be alert, to listen intently, and to actively participate in class activities.
4. Students are expected to take notes during class lessons on paper. All computers will be closed during this time.
5. Students are expected to follow all safety rules as they are working in the laboratory. Each member of the lab group is expected to take an active role in collecting the data and performing the experiment. Raw data may be exchanged between lab partners, but each student is expected to do the analysis individually and answer the analysis questions in their own words. Laboratory reports must be submitted on turnitin.com for credit.
6. Collaborating on labs:
   You may:
   a. Collect data together.
   b. Use the same Logger Pro graphs/data tables—and email the Logger Pro data to each other.
   c. DISCUSS how to answer questions, but write answers in your own words.
   d. DISCUSS how to do calculations, but write them out yourself.

   You may not:
   a. Use the same Excel files.
   b. Copy answers to questions from other people directly.
   c. Copy calculations from other people directly.
   d. Email each other a copy of the lab.
   e. Submit the same document as someone else.

7. There will be a 10% late penalty for each day an assignment is turned in after the due date. After two weeks, the assignment will no longer be accepted.
8. Students complete problem sets electronically through Quest, a program from the University of Texas. Assignments should be completed in a timely manner.
9. Honesty is a key component of scientific work, whether on the forefront of scientific research or in an IMSA course. Consequently any violation of the honesty policy is considered a serious offense. Please see the Academic Integrity section in the student handbook for more specific information.
10. Students are expected to get help early. Options include:
    a. Office hours / appointment with instructor
    b. Peer tutor
    c. SI Physics help session
    d. E-mail

Assessment Practices, Procedures, and Processes:

The students earn grades based on their ability in knowing, understanding and applying the concepts and skills learned in the course. Students have multiple chances to show evidence of their understanding in each concept or skill.

An **A** in the course indicates that the student has exceeded the expectations of the course. The student has a thorough understanding of the concepts in the course and can apply them in familiar and novel situations.

A **B** in the course indicates that the student has met the expectations of the course. The student has a good understanding of the concepts in the course and can apply them in a familiar context.

A **C** in the course indicates that the student has an understanding of the basic concepts in the course.

A **D** in the course indicates that the student has not met the minimum expectations of the course.

Each unit of study includes online homework, laboratory experiences, and a summative assessment. Assessments from the second unit on include integrated problems which test the students' ability to draw upon the topics covered thus far. If a student does not submit a lab, complete a problem set, or take an exam, a zero will be entered for the assignment. Students will be able to retake one test each quarter.

The assignments are grouped by category; the categories are weighted as follows:

50% Tests and Quizzes
15% Labs
10% Integrative problems

10% Quest problem sets
15% Final exam

Sequence of Topics and Activities: (See Moodle)

Newton's Laws of Motion and Kinematics

- Motion exploratory stations and follow-up questions for each of Newton's Laws
- Class discussion
- Tutorials: Newton's three laws of motion
- Free Body Diagram tutorial and worksheet
- Quest problem sets
- Unit conversions tutorial and problem set
- Class discussions: Kinematic variables and derivation of equations
- Buggy and Sparky lab
- Graphing with detectors
- Kinematics problem sets

Gravitation and Freefall

- Scientific notation tutorial and problem set
- Class discussion: Newton's universal law of gravitation
- Gravitation problem set
- Mass vs. weight lab and problem set
- Video analysis lab
- Class discussion: Free Fall
- Free fall problem set

Energy and Momentum

- Class discussion: Work, Work-KE theorem
- Lab: Work-energy theorem
- Work-Kinetic energy problem set
- Class discussion: Conservation of energy
- Lab: Conservation of energy
- Conservation of energy problem set
- Class discussion: Impulse and Momentum
- Impulse-momentum lab
- Class discussion: Conservation of Momentum
- Conservation of Momentum lab Air
- Problem sets

Waves and Fields

- Class discussions, Tutorials

- Labs
- Quest problem sets

Disciplinary Learning Standards Addressed in Course: **A. Students studying science at IMSA engage in the process of scientific inquiry by:** A.1 applying the skills of observation (describe, compare, and contrast characteristics; identify parameters, precisely observe phenomena) and accurately recording findings. A.2 designing and planning investigations and constructing questions which further understanding, forge connections, and deepen meaning. A.3 carrying out investigations that develop skills, concepts, and processes that support and enable complex thought. A.4 using appropriate technologies to collect, analyze and present information. A.5 employing scientific reasoning to evaluate the soundness and relevance of information. A.6 supporting judgments and constructing models based on evidence. A.7 sharing results by communicating orally, in writing, and through display with power, economy, and elegance.
B. Students studying science at IMSA demonstrate understanding of energy and matter by: B.3 applying the principles of conservation of mass, conservation of charge, and conservation of energy to a variety of problems and situations. B.5 applying the relationships between work, heat and energy to analyze the behavior of systems.
C. Students studying science at IMSA demonstrate understanding of force and motion by: C.1 using graphical and mathematical representations to analyze and predict the motion of objects. C.2 using Newton's Laws to relate force and motion. C.3 applying Newton's Laws and observation of the Earth, Moon and Sun system to construct a model.

SSLs and Outcomes:

IA. Students expected to demonstrate automaticity in skills, concepts, and processes that enable complex thought by

- completing homework activities and assigned problem sets. **FA**
- completing assigned reading to support content. **IA**
- demonstrating proper use of laboratory equipment. **IA**
- demonstrating competence on quizzes. **FA**

- applying content knowledge to alternative scenarios and new problems. **FA**

IB. Students expected to construct questions which further understanding, forge connections and deepen meaning by

- setting up laboratory experiments appropriately. **IA**
- analyzing data to draw conclusions. **FA**
- discussing labs and problem sets with peers. **NA**
- modeling systems supported by data/observations. **FA**

IC. Students expected to precisely observe phenomena and accurately record findings through

- data collection and observations. **FA**
- analysis of data generated from experiments. **FA**

ID. Students expected to evaluate the soundness and relevance of information and reasoning by

- drawing conclusions from laboratory data. **FA**
- evaluating the reasonableness of answers. **FA**
- explaining, analyzing and developing models to explain phenomena in physics. **FA**

IIA. Students identify unexamined personal assumptions and misconceptions that impede and skew inquiry

- by completing pre-assessments to solicit misconceptions. **NA**
- by reconciling data/observations and preconceptions. **FA**
- through assessment questions targeted at misconceptions. **FA**
- periodic journaling to reflect on their learning and understanding of concepts. **IA**

IIIA. Students use appropriate technologies as extensions of the mind through

- daily use of tablet computers for completing work and referencing resources. **NA**
- use of calculators for problem solving. **NA**
- use of computer to collect and analyze data. **IA/FA**
- use of laboratory equipment for data collection and analysis. **NA/IA**

IIIB. Students recognize, pursue, and explain substantive connections within and among areas of knowledge by

- connecting previous concepts in physics to current concepts through work in lab and problem sets and classroom discussions. **IA/FA**

IIIC. Students recreate beautiful conceptions that give coherence to structures of thought by

- exploring the development of models (mathematical and conceptual). **IA**
- connecting concepts in physics to real world scenarios. **FA**
- using observations and data to develop, derive, discover and/or verify laws of physics. **FA**

IVA. Students construct and support judgments based on evidence by

- drawing appropriate conclusions in lab work supported by data/analysis. **FA**
- by analyzing individual data points using the concepts of accuracy, precision and uncertainty in measurement. **FA /IA**
- by analyzing graphical data trends through understanding of regression coefficients and goodness of fit criteria. **FA /IA**

IVB. Students write and speak with power, economy, and elegance by

- communicating effectively in lab work/reports. **IA**
- explaining problems and asking questions during group discussions. **NA**
- showing work to clearly communicate problem solutions. **IA**

IVC. Students identify and characterize composing elements of systems

- through effectively laboratory set-ups to collect data appropriate to question. **IA**
- by breaking down a complicated problem in order to solve it. **IA**

VB. In order for students to make reasoned decisions which reflect ethical standards, and act in accordance with those decisions, students

- are made aware of what plagiarism is, its ethical implications, and repercussions of plagiarizing. **IA**
- are made aware of the scientific and ethical significance of accurately representing data (vs. not skewing data to fit expectations). **IA**
- are assessed for the authenticity of written work and the efficacy of analysis of lab experimentation. **FA**