# OSC014 - ALGEBRA-BASED PHYSICS I (WITH LABS)

**4-5 Semester Hours**

**Co-requisites:** College Algebra and Pre-calculus.

**Related TAGs:**Biology, Chemistry, Civil/Construction Engineering Technology, Electrical Engineering Technology, Mechanical Engineering Technology

Required Components include:

1. **Experiment**
2. **Kinematics**
3. **Dynamics**
4. **Conservation Laws**

Optional Components include:

1. **Oscillations and Waves**
2. **Fluids**
3. **Heat & Thermodynamics**

In order for a course to be approved for OSC0 014- Algebra Based Physics I (with labs), all of the following must be met:

1. All “Required Component” student learning outcomes (SLOs) 1-4 must be met and **at least one out of the three** “Optional Component” SLO’s 5-7 **must be met**.
2. All student learning outcomes (SLOs) embedded within a “Required Component” area are required to meet the entirety of the core component area. This is also true for the “Optional Component” SLO’s. All SLO’s embedded within the optional component are required to meet the entirety of the optional component area however, this is only true when an optional component area is selected by an institution.

### Required Components

1. **Experiment**:

The successful Algebra-Based Physics I (with lab) student will be able to:

1a. Collect data, assess its validity, and interpret its physical meaning for experiments that relate to the topics included in the required learning outcomes in required components 1-4 in OSC 014.

1b. Meet the guidelines for the Natural Sciences Laboratory Requirement for the Ohio Transfer 36, found at the following link [here](https://www.ohiohighered.org/sites/default/files/uploads/transfer/transfer-page/TMNS%20-%20Natural%20Sciences%20Learning%20Outcomes.pdf).

**Sample tasks**

* Demonstrate an understanding of the validity and meaning of data by writing lab reports with data-supported conclusions.
* Represent and analyze data in various forms (e.g., graphs and tables), as well as recognize trends and patterns in data accounting for scatter and outliers.
* Implement and design basic experimental procedures including the choice, variation, and control of variables, as well as recognize the existence of uncertainty and an estimate of the precision of the measurements.
* Analyze data through the use of various mathematical approaches including vector manipulation and analysis, trigonometry, and algebra.
* Validate physics models and principles through collection of real physical data obtained by hands-on measurement.
* Recognize group work is a preferred environment through teamwork for data acquisition, collaborative data analysis, and shared report-writing procedures.

2. **Kinematics**:

The successful Algebra-Based Physics I (with lab) student will be able to:

2a. Make accurate verbal, graphical, and mathematical descriptions of translational and rotational motion in one and two dimensions.

2b. Use algebra and graphical methods to link displacement, velocity, and acceleration.

2c. Solve 1D kinematic problems with constant linear and angular acceleration.

2d. Solve 2D projectile motion problems with start and end points at different heights.

2e. Relate the motion of two objects relative to each other.

**Sample tasks**

* Find the final speed of a particle dropped from rest at a given height.
* Calculate the launch speed required to put a basketball through a hoop.
* Sketch graphs of speed versus time and velocity versus time for an object that is thrown upwards and returns to the starting point.
* Sketch graphs of position versus time for the same motion using two sets of coordinate axes (different origins and/or positive directions).
* Determine the distance traveled by a rolling disk from angular acceleration, initial speed and elapsed time.
* Calculate the number of revolutions made by a spinning wheel slowing to a stop at a constant rate.
* Given a graph of velocity vs. time for a particle in moving in one dimension, interpret the physical meanings of the graph's slope and intercept, then qualitatively sketch the position vs time or acceleration vs time graphs for the same interval.
* Determine the horizontal distance for a soccer ball kicked from the ground to a flat roof, given the height of the roof and the initial velocity (magnitude and direction).
* Explain the difference between average velocity and average speed, using a concrete example of an object moving in one or two dimensions.

3. **Dynamics**:

The successful Algebra-Based Physics I (with lab) student will be able to:

3a. Use Newton’s laws of motion (1st, 2nd, and 3rd) to explain or predict the motion of translating and rotating objects.

**Sample tasks**

* Create a complete and accurate free-body diagram for sign suspended at rest by two cables.
* Determine the acceleration for an Atwood’s machine.
* Determine the minimum coefficient of static friction needed to prevent a car from slipping as it travels around a circular track at constant speed.
* Calculate the internal forces arising among 3 blocks of different masses blocks pushed by a constant horizontal force at a constant speed given the coefficient of kinetic friction.
* Determine the location of a fulcrum to balance 2 different masses on a rigid uniform plank which also has mass.
* For a cord wound around a circular object and a mass tied to the cord, predict how the angular acceleration of a uniform disk differs from a uniform hoop when the mass is released.
* Analyze a system of three wooden blocks in contact while being pushed across a smooth level table, making use of free body diagrams and Newton's laws of motion.
* Draw free-body diagrams of an object on the floor of a rising elevator based on a velocity-time graph of the elevator’s motion.
* Determine the amount of frictional force that acts on an object at rest while it is being pulled, but before it starts to slide.
* Explain why objects on the seat of a car will slide forward when the car abruptly slows down.
* Draw a free body diagram of a falling object as it approaches terminal speed.

4. **Conservation Laws**:

The successful Algebra-Based Physics I (with lab) student will be able to:

4a. Explain or predict the motion of translating and/or rotating objects using conservation of energy.

4b. Explain or predict the motion of translating and/or rotation of objects in 1D using the conservation of momentum.

4c. Explain or predict the outcome of collisions.

4d. Determine the center of mass of extended objects.

4e. Determine the moment of inertia of rigidly connected masses.

4f. Use the parallel axis theorem in the solution of problems of extended objects of simple symmetries rotating about an axis that is not through their center of mass.

**Sample tasks**

* Compare the speeds of a roller-coaster at various points of different elevations along its track, assuming that friction and air resistances are negligible.
* Explain why rolling objects of the same mass and radius, but different shapes, do not all reach the bottom of a ramp at the same time.
* Calculate the height necessary for a disk rolling down an incline to achieve the same speed at the bottom of the incline as a sphere achieves rolling down the same incline at a given height.
* Determine the outcome of a one-dimensional totally inelastic collision given the masses and the initial velocities.
* Decide whether or not a one-dimensional collision is totally elastic given the initial speeds of, the masses, and the final speed of one of the objects.
* Predict whether a rotating platform will speed up or slow down as a passenger walks inward or outward along the platform’s radius.

### Optional Components

1. **Oscillations and Waves**:

The successful Algebra-Based Physics I (with lab) student will be able to:

5a. Explain or predict motion of objects in simple harmonic motion.

5b. Explain or predict mechanical wave phenomena in terms of frequency, wavelength, wave speed, and simple harmonic motion.

5c. Use superposition in solving problems with interference of two waves.

5d. Describe standing wave patterns and how their confinement determines the wavelength allowed.

5e. Describe and predict the addition of two waves of similar but not identical frequency aka the beating of waves.

5f. Solve problems where the frequency of a sound detected is affected by the motion of the source and/or the receiver relative to the medium (Doppler Effect).

**Sample tasks**

* Describe the motion (position, velocity, acceleration) of a simple pendulum in regard to length and frequency.
* Describe the motion (position, velocity, acceleration) of a mass connected to a spring (horizontal and vertical).
* Describe the motion (position, velocity, acceleration) of a mass connected to two or more springs (horizontal and vertical).
* Describe the motion (position, velocity, acceleration) of a physical pendulum.
* Describe the motion of the above systems via conservation of energy
* Explain how an understanding of transverse and longitudinal earthquake waves helps us understand the makeup of the earth specifically that there is a solid core surrounded by a liquid core.
* Calculate the observed frequency for a moving observer given the speed of the observer towards or away from the sound source and the frequency of the sound produced by the source.
* Compare the maximum speed of a traveling wave along a string to the maximum speed of a point on the string.
* Find the resonant frequencies of the standing waves for an open pipe and a closed pipe of the same length, given the speed of sound in air.

1. **Fluids**:

The successful Algebra-Based Physics I (with lab) student will be able to:

6a. Describe how the pressure in a fluid varies as a function of depth interns of the pressure relative to the surface of the fluid and the absolute pressure in the fluid.

6b. Predict whether and object will sink or float in a fluid.

6c. Predict the variation in velocity and pressure as an incompressible fluid flows though pipes of varying diameter and height.

6d. Predict the apparent weight of objects partially or fully immersed in a fluid.

6e. Explain the physics underlying hydraulic lifts.

**Sample tasks**

* Determine the force exerted by the atmosphere on the palm of a hand.
* Explain why the pressure on a swimmer’s eardrum increases as the swimmer moves downward.
* Predict the maximum load a raft can support without sinking in water.
* Predict the velocities of a fluid at several points along a pipe with varying diameter.
* Calculate the pressure required to push a fluid through a pipe from a lower position to an open storage tank on top of a hill.
* Determine the make-up up of a two-component system from the apparent weight in two different fluids.
* Calculate the wind speed necessary to lift the roof off a house.

1. **Heat & Thermodynamics**:

The successful Algebra-Based Physics I (with lab) student will be able to:

7a. Describe the effect of heat on the properties of materials.

7b. Describe/predict the transfer of energy between a system and its environment using the first law of thermodynamics.

7c. Describe an ideal gas in terms of volume, pressure, temperature, and number of moles.

7d. Relate macroscopic and microscopic properties of matter using the kinetic theory of gases.

7e. Predict the efficiency of a heat engine and its maximum efficiency.

7f. Describe and predict properties of gases using the ideal gas law.

7g. Describe properties of phases of matter (solid, liquid, and gas) and their transformations.

7h. Transfer of heat by conduction, convection, and radiation.

7i. Distinguish between reversible and irreversible processes.

**Sample tasks**

* Explain the difference between *temperature* and *heat*.
* Calculate the temperature rise required to make a copper rod expand by 1 mm.
* Given the coefficients of linear expansion of two metals, predict which way a bimetallic strip composed of those two metals will bend when heated.
* Given the initial temperature and pressure in an inflated tire, determine whether the tire’s pressure will exceed its maximum safe level when heated to a specific temperature.
* Calculate the number of moles of gas at certain volume, pressure, and temperature.
* Calculate the heat required to bring a gallon of room-temperature water to boil.
* Describe molecular processes associated with the melting of a substance.
* Predict whether it would take more heat to melt the same mass of solid copper or water ice, if both are already at their melting points.
* Calculate the equilibrium state of two gases in two different compartments when the separating wall was removed.
* Calculate the work done by a gas as it undergoes thermal processes (e.g., isothermal expansion).
* Classify a given process as either reversible or irreversible, based on heat flow.
* Use the concepts of heat, work, and internal energy to describe the operation of a heat engine.
* Describe simple thermodynamic process in one or more graphs (*PV*, *PT*, and *VT*).
* Explain why the freezing point is lowered by adding a solute (e.g., salt).
* Calculate the radiated and absorbed heat of a human body and explain the difference.

# OSC015 - ALGEBRA-BASED PHYSICS II (WITH LABS)

**4-5 Semester Hours**

**Co-requisites:** College Algebra and Pre-calculus.

**Related TAGs:**Chemistry, Civil/Construction Engineering Technology, Electrical Engineering Technology, Mechanical Engineering Technology

Required Components include:

1. **Experiment**
2. **Electromagnetism**
3. **Electrical Devices and Circuits**
4. **Geometric and Physical Optics**

Optional Components include:

1. **Special Relativity**
2. **Quantum Physics**
3. **Nuclear Physics**

In order for a course to be approved for OSC0015- Algebra Based Physics II (with labs), all of the following must be met:

1. All “Required Component” student learning outcomes (SLOs) 1-4 must be met and **at least one out of the three** “Optional Component” SLO’s 5-7 **must be met**.
2. All student learning outcomes (SLOs) embedded within a “Required Component” area are required to meet the entirety of the core component area. This is also true for the “Optional Component” SLO’s. All SLO’s embedded within the optional component are required to meet the entirety of the optional component area however, this is only true when an optional component area is selected by an institution.

### Required Components

1. **Experiment**:

The successful Algebra-Based Physics II (with lab) student will be able to:

1a. Collect data, assess its validity, and interpret its physical meaning for experiments that relate to the topics included in the required learning outcomes in required components 1-4 in OSC 015.

1b. Meet the guidelines for the Natural Sciences Laboratory Requirement for the Ohio Transfer 36, found at the following link [here](https://www.ohiohighered.org/sites/default/files/uploads/transfer/transfer-page/TMNS%20-%20Natural%20Sciences%20Learning%20Outcomes.pdf).

**Sample tasks**

* + Demonstrate an understanding of how to write lab reports including data-supported conclusions.
  + Represent and analyze data in various forms (e.g., graphs, tables), as well as recognize trends and patterns in data accounting for scatter and outliers.
  + Implement and design basic experimental procedures including the choice, variation and control of variables, as well as recognize the existence of uncertainty and an estimate of the precision of the measurements.
  + Analyze data through the use of various mathematical approaches including vector manipulation and analysis, trigonometry, and algebra.
  + Validate physics models and principles through collection of real physical data obtained by hands-on measurement.
  + Recognize group work is a preferred environment.

1. **Electromagnetism:**

The successful Algebra-Based Physics II (with lab) student will be able to:

2a. Describe the motion of charged particles in external electric fields in terms of forces and energy.

2b. Describe electric fields and electrostatic potentials produced by simple charge distributions [point charges, charged plates, and parallel-plate capacitors].

2c. Relate the electrostatic energy stored in a capacitor to the energy density of the electric field.

2d. Relate electric field lines to equipotential lines.

2e. Describe the motion of charged particles and current-carrying wire segments in uniform magnetic fields in terms of forces and torques.

2f. Describe the magnetic field produced by current-carrying long thin wires and solenoids.

2g. Describe the motion of charged particles in regions with both electric and magnetic fields.

2h. Relate the magnetostatic energy stored in a solenoid to the energy density of the magnetic field.

2i. Relate the electric field lines to equipotential lines for simple charge distributions.

2j. Describe magnetic field lines for simple situations [wire, bar magnet, and solenoid].

**Sample tasks**

* + Calculate the force on a point charge and its electrostatic potential energy due to one or more point charges.
  + Calculate the force on an electric dipole and its electrostatic potential energy due to an external electric field.
  + Calculate the electric field and electrostatic potential due to a simple distribution of electric charges [such as ions, dipoles, etc.].
  + Draw electric field vectors from electric field lines or equipotential lines.
  + Describe interaction between two charged particles as an elastic collision and calculate their velocities after the ‘collision’ from the velocities before the ‘collision.’
  + Calculate the force between two plates of a charged parallel-plate capacitor.
  + Use the description of charged particle inside a parallel-plate capacitor in 1d and 2d to find the charge on the capacitor.
  + Calculate the electric field from differences in the electrostatic potential.
  + Draw equipotential lines from electric field lines and *vice versa.*
  + Calculate the force between two long current-carrying wires.
  + Calculate the magnetic field due to several long-time wires.
  + Calculate the radius of the circular trajectory of an ion in a mass spectrometer and analyze the dependence of the mass of the ion.

1. **Electrical devices and circuits**:

The successful Algebra-Based Physics II (with lab) student will be able to:

3a. Analyze the voltage drops across and charges on capacitors of a circuit of capacitors arranged in series and parallel.

3b. Analyze the voltage drops across and currents through resistors of a circuit of resistors arranged in series and parallel.

3c. Apply Kirchhoff’s laws to find currents (in magnitude and direction) of multi-loop circuits with multiple batteries.

3d. Describe the powers delivered by batteries and the powers dissipated in resistors in simple circuits.

3e. Describe the time-dependence of the voltage and current through a resistor *R*, capacitor *C*, and an inductor *L*.

**Sample tasks**

* Find the equivalent capacitance of a system of capacitors partially connected in series and

parallel.

* Find the equivalent resistance of a system of resistors partially connected in series and

parallel.

* Solve a system of equations to determine the currents through circuits with two or more loops consisting of batteries and resistors using Kirchhoff’s laws.
* Determine the power dissipated in resistors and the power delivered by batteries in a multi-loop circuit.
* Relate the exponential time-dependence of the voltage and charge on the capacitor in a RC circuit to the time constant.
* Characterize the oscillatory time-dependence of the voltage and current in a LC circuit.
* Describe the oscillation of electric and magnetic energy in a LC circuit.
* Explain phasor diagrams for RC-, RL-, and RCL circuits.
* Relate the power delivered by an AC generator in terms of rms values of voltage and current and the phase.

1. **Geometric and Physical Optics:**

The successful Algebra-Based Physics II (with lab) student will be able to:

4a. Describe light as an electromagnetic wave in terms of frequency, wavelength, and speed of light.

4b. Characterize the spectrum of EM waves in terms of frequency and wavelength.

4c. Describe the speed of light in matter in terms of index of refraction.

4d. Describe the refraction of light at interfaces and relate the angles of incoming and refracted rays in terms of Snells’ law.

4e. Explain the dispersion of light by the frequency dependence of the index of refraction.

4f. Describe the intensity of EM waves in terms of electric and magnetic energy densities and the speed of light.

4g. Analyze the image formed by plane and spherical mirrors using ray tracing and the mirror and magnification equations.

4h. Analyze the image formed by one and two lenses using ray tracing and the lens and magnification equations.

4i. Relate the interference pattern of a double slit to the separation of slits and wavelength.

4j. Relate the resolving power of a lens to the diffraction of light by an opening.

**Sample tasks**

* Use Snell’s law to find the apparent depth of an object below a surface.
* Determine the critical angle of a prism immersed in water.
* Explain everyday optical phenomena [mirages and apparent sun near the horizon] in terms of rays.
* Explain why white light separates into a rainbow of colors when it passes through a prism.
* Given the focal length of a thin lens and the object distance; locate the image, identify it as real or virtual, and calculate its magnification.
* Locate the image of objects placed in front of spherical mirrors.
* Locate and describe the final images of objects placed in front of optical systems consisting of one or two lenses.
* Calculate the change in magnification as distance between lenses is changed.
* Use ray tracing to explain image formation by spherical mirrors and thin lenses.
* Relate far- and near point to description of the human eye in terms of a single lens.
* Determine the prescription of near- and far-sighted person using eyeglasses and contact lenses.
* Calculate the size of a feature on an object that can be observed with a person with his/her naked eyes and a telescope.
* Predict the total number of maxima obtained when light of a specific wavelength is incident on a diffraction grating.
* Explain the red- and blue shift of the electromagnetic spectrum in terms of the Doppler effect.

### ****Optional Components****

**5. Special Relativity**:

The successful Algebra-Based Physics II (with lab) student will be able to:

5a. Predict the relative perception of a time interval [time dilation] or the length [Lorentz contraction] of an object for observers in different inertial reference frames using the Lorentz transformations.

5b. Apply the relativistic momentum-energy principle to objects moving at a speed close the speed of light.

**Sample tasks**

* Relate the key result of the Michelson-Morley experiment to the postulates of special relativity.
* Determine the observed length of an spaceship traveling past an observer on Earth at a relative speed near the speed of light and compare this to the length of the spaceship in the reference frame of the crew.
* Resolve the so-called “twin paradox” of special relativity.
* Calculate the kinetic energy and momentum of a proton accelerated to a speed near *c* and compare these values to their Newtonian counterparts.
* Explain and predict the dynamics of objects moving at high, constant speeds in terms of the principles of special relativity.

1. **Quantum Physics:**

The successful Algebra-Based Physics II (with lab) student will be able to:

6a. Differentiate between wave- and particle-like properties of light and relate them to each other.

6b. Describe the production and properties of photoelectrons with the particle-like property of light.

6c. Relate the intensity of light (EM waves) in terms of the number and frequency of photons.

6d. Determine if the condition under which wave-like properties of particles are relevant.

6e. Relate the wave-like nature of an electrons in its stationary state to the size of a confining potential [particle in a box].

6f. Relate the outcome of the Rutherford experiment to the atomic model.

6g. Determine the resolving power of an electron microscope with the Heisenberg uncertainty principle.

6h. discuss the scattering of a photon off an electron (Compton effect).

6i. Discuss the spontaneous and stimulated emission of light (photons); explain the basic principle underlying a laser.

6j. discuss qualitatively the quantum-mechanical picture of the hydrogen atom.

**Sample tasks**

* Relate the intensity of light (EM waves) in terms of the number and frequency of photons.
* Calculate the longest wavelength of light that can eject electrons from a metal with a known work function.
* Find the wavelength of an electron with a specified momentum or a specified kinetic energy (for speeds well below the speed of light).
* Calculate the energy and frequency of the photon emitted as atomic hydrogen makes a transition from *ni to nf.*
* Determine the series (Lyman, Balmer, Paschen, ... (or basically determine nf)) for a set of hydrogen spectral lines given the frequencies or wavelengths of the set.
* Calculate the wavelength of a thermal neutron.
* Estimate the mass of a particle which only exists long enough to travel across the nucleus of a typical atom at approximately the speed of light.

1. **Nuclear Physics:**

The successful Algebra-Based Physics II (with lab) student will be able to:

7a. Compare the size of atoms and nuclei and the forces between the particles composing them.

7b. Calculate the binding energy per nucleon from mass-defect of atoms.

7c. Recognize the variation in nuclear stability at low and high Z.

7d. Distinguish between fission and fusion in nuclear reactions and explain how energy is “released.”

7e. Describe the initial and final isotopes involved in alpha, beta, and gamma decay.

7f. Describe radioactive decay and activity in terms of half-life and initial number of radioactive isotopes.

**Sample tasks**

* Describe how properties of nuclei reflect properties of the Coulomb- and strong nuclear force.
* Compare the mass of a nucleus to the masses of its components (protons and neutrons) and calculate the binding energy per nucleon.
* Predict the energy yield or particle products of a nuclear reaction.
* Explain why the number of neutrons exceeds the number of protons in high-Z nuclei.
* Characterize the “valley of stability” of nuclei.
* Given a nucleus explain how to determine if the nucleus is stable with respect to a specified decay mode, e.g., alpha decay.
* Describe alpha- and beta-decay as a trajectory towards the valley of stability in a *N*-*vs*-*Z* plot.
* Describe how fission of large nuclei and fusion of small nuclei can release energy.
* Identify the types of particles emitted in beta decay.
* Describe beta decays as a transformation of protons into neutrons and vice versa.
* Predict the number of protons remaining when a nucleus with Z protons ejects an alpha particle.
* Calculate the age of a radioactive sample from its activity and half-life.
* Qualitatively explain biological effects of ionizing radiation.