InspireNC STEM Academy: Physics

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Meeting Times: This course will meet on **Sundays** from **2:00-3:00 PM EDT** and on **Wednesdays** from **5:00-6:00 PM EDT**. It will last for **six weeks**. The first class will be on **Sunday June 20th** and the last class will be on **Wednesday July 28th**.

Time Commitment Outside of Class: Students will be assigned a problem set after every class. Each problem set should require roughly an hour to complete. Thus, students should expect to spend two hours outside of class every week.

Prerequisites: Completion of NC Math 3 or Algebra 2 (or an equivalent math course). A concrete understanding of basic trigonometry and vectors is required.

Suggested Grade Levels: 8-12

Course Overview: This high school level course provides a thorough overview of concepts taught in a first-year mechanics course, covering topics such as forces, work and energy, momentum and collisions, uniform circular motion, rotational motion, and more. This class also introduces relevant physics problem solving skills that will prepare students for the F=ma exam, the preliminary test for the USA Physics Olympiad.

Week 1: Kinematics

- ➢ Understanding the relationship between position, velocity, and acceleration
- ➢ Learning how to interpret plots and analyze key features
- ➢ Working with constant acceleration and DVATs
- ➢ Establishing frame of references and understanding two-dimensional projectile motion
- ➢ Resolving vectors into components to make sense of motion problems

Week 2: Forces, Energy, and Work

- ➢ Developing an intuitive understanding of Newton's laws of motion
- ➢ Considering special and extreme cases to solve problems

- ➢ Drawing free-body diagrams
- ➢ Applying Newton's second and third laws to solve:
  - ○ Normal/contact force problems
  - ○ Inclined plane problems
  - ○ Problems involving kinetic/static friction
  - ○ Tension and pulley problems
- ➢ Defining energy, work, and power
- ➢ Discussing the forms of mechanical energy
- ➢ Understanding how to apply energy conservation
- ➢ Applying the work-energy theorem

<u>Week 3: Momentum and Collisions</u>

- ➢ Defining linear momentum
- ➢ Using momentum conservation to solve different types of collisions and explosions
- ➢ Collisions in two dimensions
- ➢ Defining center of mass
- ➢ Relating the velocity of the center of mass of a set of objects to the total momentum
- ➢ Relating force and momentum

<u>Week 4: Uniform Circular Motion</u>

- ➢ Defining uniform circular motion
- ➢ Understanding centripetal acceleration and centripetal force
- ➢ Using understanding of Newton's second law and centripetal forces to solve:
  - ○ Problems in which a ball on a string travels in horizontal or vertical circles
  - ○ Conical pendulum problems
  - ○ Roller coaster problem
  - ○ Problems in which statics friction provides the centripetal force
  - ○ Banked curve problems

<u>Week 5: Torque and Rotation</u>

- ➢ Understanding rotational kinematics
- ➢ Understanding moment of inertia and applying the parallel axis theorem
- ➢ Understanding that the moment of inertia of an object is additive
- ➢ Defining torque
- ➢ Using torque and related concepts to solve:
  - ○ Problems that involve objects rolling without slipping
  - ○ Pulley/inclined plane problems in which moment of inertia is not negligible

    - Rotational equilibrium problems
- ➢ Applying energy conservation with rotational energy
- ➢ Defining angular momentum and solving problems
- ➢ Relating torque and angular momentum

Week 6: Dimensional Analysis and Error Propagation

- ➢ Understanding the difference between dimensions and units
- ➢ Learning how to apply dimensional analysis
- ➢ Introducing strategies to approach multiple-choice questions
- ➢ Setting up systems of equations to determine the relationship between dimensional variables
- ➢ Making sense of error and uncertainty
- ➢ Understanding absolute and relative error/uncertainty
- ➢ Understanding the effects of scaling on uncertainties
- ➢ Understanding error in power functions
- ➢ Adding in quadrature and finding the error in a sum of measurements
- ➢ Finding the uncertainty in products and quotients of measurements
- ➢ Finding the uncertainty in the average of independent measurements