Class: Weekly Physics Round Table **Instructor:** David Hodge

Goal: Prepare students for Honors and AP Physics by providing preemptive learning strategies and modalities for rapid mastery of the subject on both a conceptual and analytical level.

Objective: Students will learn advanced preemptive learning strategies for Physics. Through application of these strategies, students will master topics in Physics while preparing for their AP and/or SAT 2® subject exams.

Time commitment: 1.5 hours/session

Prerequisites:

Mathematics: Precalculus (current enrollment) or higher

Program Definition:

In the hope of preparing young minds for Science Technology Engineering and Mechanics (STEM) careers, we introduce the weekly Physics Round Table. I invite you to join Instructor David Hodge as we embark on a journey to learn of things both great and small. Our primary goal is to provide students with a functional method for evaluating a complex subject: Physics. With this goal in mind, students will acquire strategies to rapidly master the material in preparation for both the AP exam and the SAT II Subject test in Physics. On a weekly basis, we will meet as a group and discuss Physics topics pertinent to the standardized exams. The discussing will take place in a manner where we will learn problem-solving strategies and consider the contextual applications of Physics formulae. Moreover, we will discuss the implications of these formulae on a grand scale and how to relate the way Physics utilizes mathematics as a modeling tool. In such, a student learns how to experimentally apply the Scientific Method. Additionally, students will be given diagnostic exams to ascertain their present level of understanding and determine any deficiencies/inconsistencies in their logic. Practice material and resources will be provided to correct (supplement) any deficiency/inconsistency. Overall, the student receives an enriching experience that will provide them the necessary tools to excel in high school, college and beyond.

Cost:

Individual lessons: $90.00/lesson ($60/hr)

Monthly prepayment: $300/month ($50.00/hr)

Introduction:

The scientific method has revealed much about the world around us. One enduring tenet is that complex things are made up of simpler fundamental building blocks. The cell is the building block of all living things, atoms are the building blocks of all matter, citizens are the building blocks of government. Understanding how these fundamental building blocks physically interact to create complex systems is the subject matter of Physics. The power of Physics resides in its ability to answer the questions of how and why? Physics first introduces a method for evaluating how things move and the role of force in an object's motion. Regarded as the primordial forms of energy, motion and position represent a way to describe the behavior of entire systems. By describing a system, it is possible to interpret its internal and external interactions with its surrounding environment. Thermodynamics introduces these same ideas of potential and kinetic energy, yet on a more profound level and, thereby, presents new quantities which allow a system's behavior to even be predicted. Based on the notion that increasing disorder is a result of any process occurring within a system and its surroundings, it is possible to gain an insight about a system's actions. The principles of thermodynamics describe both large and small systems. In this light, we even discover how an object's motion and interactions become influenced by its innate wave behavior. At the quantum level, the nature of matter and light becomes intertwined and even the impossible may seem plausible. I invite you to join me as we embark on a journey to learn of things both great and small. In the hope of preparing young minds for Science Technology Engineering and Mechanics (STEM) careers, we introduce the weekly Physics Round Table.

Subject Outline:

Introduction to Physics

1. **Syllabus: Schedule of Topics**
    a. **Measurements & Estimation**
        i. Scientific Method
        ii. Significant Figures
        iii. Dimensional Analysis

    b. **Kinematics**
        i. Vectors
        ii. Equations & the Matrix Method for evaluating kinematics
            1. Introduction and equations: Matrix method
        iii. One Dimensional motion: Week
            1. PhET
                a. The Moving Man
            2. Matrix Method
                a. Four Kinematic Equations
                b. Constant Acceleration
                c. Freely falling objects and gravitation

        iv. **Two-Dimensional motion**:
            1. PhET
                a. Projectile Motion
                b. The Quadratic equation in kinematics: Parabolic motion

    c. **Dynamics**
        i. Newton's Laws of Motion: motionPhET
        ii. Models: Force & Friction: Forces and Motion: Basics
            1. Free-body diagrams: describing forces
            2. PhET Simulation: Forces and Motion: Basics
                a. Motion
                b. Acceleration
                c. Friction
            3. Surfaces
            4. Inclined Planes
                a. PhET: Ramp: Forces and motion
                b. PhET: The Ramp
            5. Atwood machine
            6. Elevator

    d. **Circular Motion and Gravitation**
        i. Centripetal Force: Linear Forces and circular motion: PhET Simulations

1. Based on Inertia, constant velocity without the application of forces. How do we apply forces (friction, tension, gravity, electrical, magnetic, direct application)? The centripetal force is a resultant force.
    a. PhET: Gravity and Orbits

e. Energy: Potential and Kinetic Energy

- **i.** Conservation of Energy
- **ii.** Total Mechanical Energy
    1. PhET: Energy Skate Park
    2. A simpler way to describe changes in the state of a system.
- **iii.** Work-Energy Theorem
- **iv.** Thermodynamics: Heat and Work
    1. Laws of Thermodynamics
        a. Thermodynamic forms of potential and kinetic energy
        b. Temperature, Absolute Zero and Entropy

f. **Linear Momentum**:

- **i.** Conservation of momentum
- **ii.** States of Velocity
- **iii.** Impulse
    1. PhET: Collisions Lab

g. **Static Equilibrium**:

- **i.** Stability balance and Torque
- **ii.** Elasticity: Stress and Strain

h. Torque and Rotational Motion

- **i.** Translational versus Rotational motion
- **ii.** Force versus Torque:
    1. PhET: Torque

i. Vibration and Waves

- **i.** Simple Harmonic Motion
- **ii.** Restoring Forces:
    1. PhET: Hooke's Law
    2. Pendulum
    3. Waves: Transverse/Longitudinal
    4. Refraction, Diffraction

j. Sound

- **i.** Intensity of Sound: Decibels
- **ii.** Doppler Effect
- **iii.** Interference of Sound Waves
- **iv.** Standing Waves

k. Temperature and Kinetic Theory
- **i.** Atomic Theory of Matter
- **ii.** Gas Laws
- **iii.** Kinetic Molecular Theory of Gases

l. Heat
- **i.** Heat as Energy transfer
- **ii.** Internal energy
- **iii.** Specific heat
- **iv.** Heat transfer: Conduction, Convection, Radiation

m. The Laws of Thermodynamics
- **i.** First Law of Thermodynamics: DU = Dq - Dw
- **ii.** Thermodynamic processes
- **iii.** Second Law of Thermodynamics: Entropy

n. Torque and Rotational Motion
- **i.** Translational versus Rotational motion
- **ii.** Force versus Torque:
    1. PhET: Torque
- **iii.** Conservation of Angular Momentum

o. Electric Charge, Electric Forces and Fields
- **i.** PhET: Coulomb's Law
- **ii.** Electric Fields, Electric potential
- **iii.** Capacitance

p. Electric Currents
- **i.** DC Circuits
- **ii.** PhET: Circuit Construction Kit
- **iii.** Ohm's Law
- **iv.** Power

q. DC Circuits
- **i.** Electromotive Force
- **ii.** Kirchhoff's Laws
- **iii.**

r. Magnetism
- **i.** Magnetic fields and forces
- **ii.** Electric Currents produce magnetic fields
- **iii.** Ampere's Law

s. Electromagnetic Induction
- **i.** Lenz Law
- **ii.** Transformer mechanics
- **iii.** Electric generators

t. Electromagnetic Waves
- **i.** Maxwell's Equation's
- **ii.** Measuring the speed of light

u. Optics
- **i.** Reflection: Law of Reflection
- **ii.** Refraction: Snell's Law
- **iii.** Mirrors: Ray Tracing diagrams
- **iv.** Convex and Concave Lenses: Ray tracing diagrams
- **v.** Thin Lens equation

v. Wave Nature of Light
- **i.** Young's Double Slit experiment
- **ii.** Diffraction

w. Relativity
- **i.**

x. Mechanical Waves and Sound
- **i.** PhET: Wave Interference
- **ii.** PhET: Wave on a string
- **iii.** PhET: Sound

2. Textbook/Reading Resources

a. **5 Steps to a 5**: Algebra 1 based Physics, 500 Questions to know by Exam day
b. **5 Steps to a 5**: Physics B & C
c. **Barron's AP Physics** prep book: **SAT 2 Subject Tests**
d. **Textbooks**: Physics: Principles with Applications (Douglas Giancoli)