AP Physics-C Summer Assignment 2017-2018

The AP Physics-C summer assignment is to **complete the first three sections** of an archived version of MIT's OpenCourseWare (OCW) Physics 1 course found here:

http://ocw.polytechnic.edu.na/courses/physics/8-01sc-physics-i-classical-mechanics-fall-2010/index.htm

Also watch the following video lecture:

https://www.youtube.com/watch?v=X9c0MRooBzQ

(This lecture references that rather famous Powers of Ten movie found here: https://youtu.be/H8SOKmh_Fmc)

Also read the accompanying notes:

Scalar and Vector Notation we will use in our course.

There will be assessments on this material including working with scalar quantities with units, evaluated forms in scientific notation with significant figures, dimensional analysis, and especially on section 3 (Vectors), beginning during the first week of school.

Completing the OCW portion of the summer assignment requires **reading the course notes**, **watching the lectures and tutorial videos**, **doing the learning exercises** and **performing all self-assessments**. Most if not all of this material should be review from previous TJ Chemistry and Math classes. Links to some additional learning/review resources are provided on the 2nd page of this assignment.

To be explicit, complete

Section 1: Units and Dimensional Analysis
http://ocw.polytechnic.edu.na/courses/physics/8-01sc-physics-i-classical-mechanics-fall-2010/introduction-to-mechanics/units-and-dimensional-analysis/

Section 2: Problem Solving and Estimation
http://ocw.polytechnic.edu.na/courses/physics/8-01sc-physics-i-classical-mechanics-fall-2010/introduction-to-mechanics/problem-solving-and-estimation/

Section 3: Cartesian Coordinates and Vectors
http://ocw.polytechnic.edu.na/courses/physics/8-01sc-physics-i-classical-mechanics-fall-2010/mathematics-the-language-of-science/cartesian-coordinates-and-vectors/

Three-dimensional vectors play an important mathematical role throughout the AP Physics-C course. We will use vectors to describe the motion of objects in space and the time dependent quantities $\overrightarrow{position}$, $\overrightarrow{velocity}$, and $\overrightarrow{acceleration}$ will play a central role in our quantitative description of motion. Beyond describing motion, vector quantities will also be used to represent the dynamical quantities linear momentum and force, ideas at the heart of Newtonian mechanics. Further on we will describe angular momentum as a vector quantity and during the second semester Electric and Magnetic Fields; both vector quantities. So it is absolutely essential that students start off AP Physics-C with a good foundation in the 3-D vectors. ***If you feel that your mathematical experience and familiarity with vectors is not so solid, then spend at least a few weeks over the summer becoming more familiar with these ideas and adept at calculating with them***. This is the true value vectors: they give us a precise way to incorporate geometric ideas in a form that is easily adapted to expression and calculation with the measureable quantities we will use to construct the foundations of Newtonian Physics and later Electromagnetism.

Additional Review Resources IF YOU NEED TO START FROM THE BEGINNING

Scientific Notation, Units, and Dimensional Analysis

Some Khan Academy Videos

https://www.khanacademy.org/math/pre-algebra/pre-algebra-exponents-radicals/pre-algebra-scientific-notation/v/scientific-notation-old

https://www.khanacademy.org/math/algebra/units-in-modeling/rate-conversion/v/dimensional-analysis-units-algebraically

A little deeper Dimensional Analysis

http://web.mit.edu/8.01t/www/materials/modules/chapter02.pdf

Vectors

Relevant Khan Academy Videos on Vectors

https://www.khanacademy.org/math/linear-algebra/vectors-and-spaces/vectors/v/vector-introduction-linear-algebra

https://www.khanacademy.org/math/linear-algebra/vectors-and-spaces/dot-cross-products/v/vector-dot-product-and-vector-length

A Checklist of Vector Concepts:

It is extremely common in AP Physics-C to formulate a model of a physical process in terms of *relationships* between vector quantities in the model. We use equations between quantities that are not identically the same as our major method for stipulating relationships. Famous examples are Newton's 2nd Law and Conservation of Linear Momentum. Both of these 'laws' is precisely stated as a vector **equation**. There are many more examples. A complete physical model typically takes the form of a collection of vector equations with some additional scalar conditions. To manipulate the model in order to make predictions or extract relationships, one projects these vector equations into a system of scalar equations, manipulates and solves this system for desired quantities or derived relationships, interprets the mathematical results, and typically translates some or all of the results back into vector form as part of the physical interpretation.

For these reasons, it is an *absolute requirement* that students understand and become proficient at formulating and using quantitative models expressed in part or wholly in vector language. Assessments in the course (i.e. Quizzes and Tests) will usually entail student use of vector concepts.

The list below is not an exhaustive nor optimized concept list but hopefully enough to get a good start in AP Physics-C .

- Geometric Properties
  - Magnitude (Positive or Zero Scalar)
    - Positive Scalar *with units*
      - Understand how to find from Cartesian components
      - Understand relationship to Dot Product
  - Direction
    - As a unit vector
      - Understand how to find direction unit vector of a non-zero vector
      - Understand how to express in Cartesian components
      - Understand the role of unit vectors in projection of components
    - Characterized by angle cosines
      - Understand why the Cartesian components of a unit vector are cosines
    - Comparing Directions of Vectors with Different Units
      - Understand the angle between two unit vectors
      - Understand special relationships:
        - Co-linear and perpendicular unit vectors
- Operations
  - Addition/Subtraction
    - Geometric Interpretation ("head to tail")
      - Understand how to interpret addition and subtraction on scale diagrams
    - Commutative and Associative
      - Understand why 'tip to tail' addition means addition is commutative and associative.
    - In Cartesian Component Decomposition
      - Understand how to implement addition and subtraction when vectors are represented by Cartesian components.
      - Understand how 'component by component' addition leads to commutative and associative properties.
  - Multiplication by Scalar

- Geometric Interpretation
  - Understand how to interpret multiplication by a positive or negative
  - Understand the effect of multiplication by -1
  - Understand the effect of multiplying by a scalar with units
  - Scalar on scale diagram representation of vectors
- In Cartesian Component Decomposition
  - Understand effect of scalar multiplication on the Cartesian components representing a vector.

Linear Combinations

Direction of a (non-zero) vector

- Understand how to find the Cartesian components of direction unit vector when a vector is expressed in Cartesian form
- Understand how to prove that any two vectors proportional by a positive scalar have the same unit vector direction and two vectors proportional by a negative scalar have opposite unit vector directions.
- Dimensionless Unit Vector from any non-zero vector
  - Geometric Form (Division by Magnitude)
  - Components Obtained in Cartesian Component Form

Dot Product

- Geometric Interpretation
  - Relationship to Magnitude of a Vector
  - Relationship to angle between two vectors
  - Understand the geometric definition of the dot product in terms of magnitudes and angle between two vectors (placed 'tail to tail')
  - Dot Product and Projection
    - into Cartesian Components
    - Projection parallel and perpendicular to a unit vector
- Computed with vectors in Cartesian Component Form
- The meaning of the sign of the dot product
- The units of the dot product
- Dot product distributes over vector addition
  - Understood from the Cartesian form
  - Understood from the geometric definition

Cross Product

- Geometric Interpretation and the Right Hand Rule
- Computation in Cartesian Component Form
- -the meaning of a zero cross product
- -Cross Product and Area for Displacement Vectors
- -Cross product distributes over vector addition.

Triple Products

- A scalar triple product: A dot (B x C)
  - Geometric Interpretation
  - Cyclic Identities
- A vector triple product: A x (B x C)
  - Geometric Interpretation
  - BAC-CAB Identity

Computations in Cartesian (Component) Representation in Particular

- Uniqueness of Representation
  - Understand how we use a basis of vectors to provide a unique way of representing vectors in terms of lists of real quantities.
- Vector Component Notation(s)
  - Understand the vector notation used in the AP Physics-C course and its relationship to the scalar triplet lists often used in math classes at TJ.
- Vector Equations
  - Projection into Equivalent System of Scalar Component Equations
  - Understand how to project a vector equation into a system of scalar equations.
  - Understand the freedom in making such a projection.
- Dimensionless Unit Vector obtained from any non-zero vector
- Addition/Subtraction/Multiplication by Scalar computed in component form
- Dot Product and Magnitude Computation in Cartesian Component Form
  - Understand how to express the dot product in terms of Cartesian components of two vectors as well in terms of the magnitudes of and angle between the two vectors.
- Cross Product Computation in Cartesian Component Form
  - Understand how the formula for the cross product in Cartesian decomposition follows from the geometric definition of the cross product given in terms of a right hand rule and the geometric formula of the magnitude (in terms of magnitude of the two vectors and the angle between n them.)

Vectors and Other Coordinate Systems

- Unit Vectors associated to coordinates
  - Understand unit vectors and naming convention for unit vectors pointing in direction of increasing value of a coordinate in a coordinate system (Cartesian and Polar examples are important).
- Polar Coordinate Example In detail (this will be relevant to circular motion)

Examples/Applications we will care very much about

- (Relative) Position Vectors
- (Relative) Velocity Vectors
- (Relative) Acceleration Vectors
- Constant Acceleration in 2D