NOTES 1: **Numbers and vectors.**

- These are supplementary notes only, they do not take the place of reading the text book.
- Like learning to ride a bicycle, you can only learn physics by practicing. There are worked examples in the book, homework problems, problems worked in class, and problems worked in the student study guide to help you practice.

What will we cover:

- P221: Mechanics which is: Vectors, kinematics (how things move), dynamics (why things move), Newton's laws, the 4 fundamental forces, one day on relativity and a little bit of thermodynamics including: statistical mechanics, the first and second laws.
- P222: Electricity and magnetism which includes: Maxwell's equations and optics; a little bit about waves and a little bit about quantum mechanics.

Why take physics:

- Physics is the basis for all the other sciences.
- Problem solving (the main goal of a physics class) is a transferable skill; it can be used anywhere.

What students have trouble with in physics:

- The math. Physics is the connection between math and the real world. So it uses math but is more than just math. This means you have to know math and some other stuff.
- Physics isn't History. When you set out to solve a problem, unlike answering a history question, you don't know the answer to start with. Many students make the mistake of looking at a problem and saying “I don't know how to solve that problem.” At that point they quit. But NOBODY knows how to solve a problem beforehand, not me, not Einstein, no one. You just have to dig in, write down what you know, plug along until something turns up. So you are always in the dark a little when you are doing physics and this bothers some people.

Key concepts:

1. When we use numbers to describe things in the physical world we are always counting something. So every number in this class should have a letter or letters next (called a unit) to it reminding us what it is we are counting. In a math class an answer of 2 will be counted right if you did the math right. In a physics class this will not be correct because we don't know if it means 2 meters, 2 yards, 2 miles or what.
2. As a further example, 2 + 2 = 4 in a math class but 2 meters + 2 yards does not equal 4 of anything. You cannot add or subtract numbers with different units. This can help you remember equations. For example suppose you are not sure if it is $E = mc^2$ or $E = mc^3$. If E (energy) is measured in Joules (= kg m^2/s^2) and m (mass) is measured in kg and c (the speed of light) in m/s then the only possible equation is $E = mc^2$ so that the units on both sides are the same.
3. In a math class 2 and 2.0 mean the same thing but in physics they do not. Because numbers are always counting something 2 meters means you measured the object to be plus or minus half a meter and 2 was closest number so your wrote down 2m. But if you write 2.0 meters you mean your measurement was withing 5 cm (+/- 0.05 meters). Significant figures tell you something about how accurately you have measured something.
4. In order to describe objects in nature and their behavior we need more than just numbers. Sometimes we need a magnitude (a number or scalar) and a direction. The mathematical object which contains both magnitude and direction is called a vector. To distinguish between scalars and vectors,

vectors are either in bold type (in the text book) or are written with an arrow over them (on the board or on your paper).

5. In order to locate objects in the real world we need a coordinate system and position vectors. The most common coordinate system uses three perpendicular axises labeled x, y and z. Position vectors in this coordinate system are labeled with unit vectors **i**, **j**, **k** along the x, y, z directions.
6. A unit vector is a vector of length (magnitude) one (one meter, one yard, one whatever).
7. So a position vector (let's call it vector **A**) which takes me from the origin of the coordinate system (0, 0, 0) to a point that is 3m along the x direction, 4m along the y direction and 2 meters along the z direction is given by **A** = 3m **i** + 4m **j** + 2m **k**. The components of the vector are $A_x = 3m$, $A_y = 4m$ and $A_z = 2m$.
8. The magnitude or length of a vector is given by $|\mathbf{A}| = \sqrt{A_x^2 - A_y^2 - A_z^2}$.
9. You can add, subtract and multiply vectors. To add (or subtract) you add (or subtract) the individual components. So **A** – **B** means $(A_x - B_x)$ **i** + $(A_y - B_y)$ **j** + $(A_z - B_z)$ **k**. There are two different ways to multiply vectors which we will see later. There is no vector division.
10. There are other kinds of vectors besides position vectors. For example if we want to specify an objects speed and direction we would use a velocity vector: **v** = v_x **i** + v_y **j** + v_z **k** where v_x is the amount (or component) of velocity in the x direction, etc. Other examples of vectors include acceleration, force, electric and magnetic field. Examples of quantities which are scalar are temperature, speed, distance, electric potential.

Applications and examples done in class, on quizzes, etc:

1. Converting units (yards to meters, Joules to calories, etc.).
2. Significant figures (in lab).
3. Adding, subtracting vectors, finding components, magnitudes, angles.