

MODERN PHYSICS
LEVEL - H

FULL YEAR: 2011-2012

MR. NICASTRO
LAB CREDIT

One can laugh without being composed of laughing particles, can think and proffer learned arguments though sprung from seeds neither thoughtful nor eloquent. Why then cannot the things that we see gifted with sensation be compounded of seeds that are wholly senseless?
Lucretius, *On the Nature of the Universe* (Translated by R.E. Latham)

"The most beautiful thing we can experience is the mysterious. It is the source of all true art and science."
Albert Einstein

Classical physics is the collective name for the traditional studies of mechanics, heat, sound, light, electricity, and magnetism. These branches of physics are several hundred years old. Of necessity, classical physics was restricted to description of the behavior of objects that could be *observed directly* with the aid of microscopes or telescopes. Only during the past century have research tools been developed to enable physicists to investigate some of the interactions taking place at the atomic and subatomic level, as well as at the galactic and intergalactic scale. It has also opened our minds by stretching theory to the limit of our imagination. The results of these investigations and the applications of the principles developed from them constitute **modern physics**. This course will focus on those topics, and how modern physics has changed the world we live in.

This is one of the very few courses dealing with these areas being taught at the high school level. In order to do this effectively, I believe that a brief review of carefully selected topics leading into the 20th century transformation of physics is necessary.

The underlying mechanism that will hopefully tie this material into a more cohesive and meaningful survey is threefold:

- 1. ROOTS.** To show the historical development and evolution leading up to what we now refer to as modern physics, with special emphasis on the people, events, observations, mistakes, misconceptions, and breakthrough experiments - to give you a sense of how we got to this point;
- 2. CURRENT THEORY.** To bring special meaning to, and a basic understanding of, the conceptual and mathematical relationships that define the way we understand the workings of nature and the universe, including those competing theories that are subject to further scrutiny as our technology advances; and, therefore, naturally leading up to . . .
- 3. BENEFITS.** The applications of these theories in the "real world" - that is, how the abstract workings of our universe, from the "microscopic" level to the "macroscopic" can impact our lives today, and in the (hopefully) not-too-distant future. This includes the technological "spinoffs" from our research, as well as the impact on the way we may be forced to modify our existing, or preconceived notions of the universe.

The "beauty" of physics (or as some introductory students may see as a curse) is its treatment of EVERYTHING in the universe - visible or invisible, large or small, animate or inanimate, not restricted to scale, type of underlying energy or driving force. In other words, **PHYSICS ESTABLISHES THE "GROUND RULES" FOR ALL PHENOMENA IN NATURE** (*"the rest is just details"*). All other sciences are essentially narrow or specialized cases of applied physics!

The physicist, whether theoretical or experimental, is, out of necessity a "jack of all trades" in the scientific world. (This is perhaps why so few go on to major in physics, or why so many people regard physics as such a "difficult" subject.) In teaching physics for over thirty years (which translates to many thousands of students), I can say with some pride, that a handful have gone on to major in the field - many more went on to study applied or related fields - and the vast majority of those who carefully managed to avoid further physics courses (I would like to think) left me with a deeper appreciation for the things that physics has brought to society, some to its detriment, many more for its betterment.

As this is a relatively new course (a “bold” experiment itself!), it will experience some “growing pains”, as I learn through your reactions and feedback. What works and what doesn’t, what can be improved or deleted, how far I can “push the package” without frustrating you beyond a point of no return. Hopefully, it will never get that bad - I *really* hope it will be intellectually stimulating and enlightening (in other words, FUN) - and that each of you will accept and embrace the challenges I offer you this year. I do not aspire to make this a college-clone Modern Physics course, as the necessary background and mathematics is typically beyond the scope of the high school senior. And so, I *will* aspire to present some of the most abstract, intricate and counter-intuitive material in the universe WITHOUT *hopelessly* discouraging you (confusion is to be expected - how you react to it should be a positive learning experience).

MODERN PHYSICS GENERAL* SYLLABUS

PART I: BACKGROUND

1ST QUARTER: PHYSICS & MATHEMATICS REVIEW - WAVE THEORY

0. MATHEMATICAL RELATIONSHIPS AND DIMENSIONAL ANALYSIS
1. WAVES AND ENERGY TRANSFER
2. MECHANICAL WAVES
3. NON-MECHANICAL WAVES
4. WAVE PROPERTIES

2ND QUARTER: ELECTRICITY, MAGNETISM AND FIELD THEORY

1. STATIC ELECTRICITY
2. THE ELECTRIC FIELD
3. CURRENT ELECTRICITY
4. DIRECT CURRENT CIRCUITS
5. MAGNETISM AND MAGNETIC FIELD THEORY
6. ELECTROMAGNETIC INDUCTION & THE FIRST MODERN UNIFICATION
7. ALTERNATING CURRENT

PART II: REDUCTIONISM

3RD QUARTER: MICROSCOPIC UNIVERSE: THE STANDARD MODEL & QUANTUM THEORY

1. ATOMIC PHYSICS
2. NUCLEAR PHYSICS
3. HIGH-ENERGY PARTICLE PHYSICS
4. INTRODUCTION TO STRING THEORY

PART III: UNIFICATION

4TH QUARTER: RELATIVITY AND THE MACROSCOPIC UNIVERSE

1. GALILEAN RELATIVITY
2. EINSTEIN'S SPECIAL RELATIVITY
3. GENERAL RELATIVITY AND ITS CONFLICT WITH QUANTUM MECHANICS
4. ASTROPHYSICS AND COSMOLOGY
5. A THEORY OF EVERYTHING - GRAND UNIFICATION THEORY

***NOTE:** The listing of topics above is arbitrary. The order of their presentation, the depth of their presentation, and the time frames suggested are subject to change based on class response and the judgment of Mr. Nicastro. Certainly, crossover between the topics will occur. The sequence of these topics is at best general, and not intended to be in any way restrictive or all-inclusive.

The topics in the first section of this course are meant to serve as necessary background, review, and reinforcement of physical concepts which should have been introduced in Freshman Physics. The mathematics used in this course is essentially algebra (with trigonometry), however, references to the calculus will be made often even though it will not be requisite to the understanding of the material, or the solution of problems.

TEXTBOOK AND OTHER MATERIALS:

Due to the nature of this course (not to mention budget constraints), there is NO TEXTBOOK specifically used. However, students are urged to keep a binder for all handouts distributed. It is *your* responsibility to keep, maintain and use these handouts in lieu of a textbook. Most testing done in this class will be taken from class discussion, labs and project work based, in large part, from these handouts.

Consider all handouts to be required reading!!!

VIDEOS:

Videos will be used *extensively* throughout the year to supplement the material in this course. It is VERY IMPORTANT that you pay close attention (sit up, eyes OPEN) - as these videos will (or should) help you understand the material presented (also, you may be tested on what you see)! Videos are vital to the depiction and portrayal of abstract concepts - computer graphics, simulations and animations will help YOU understand the concepts better. Watching videos should NOT be a PASSIVE exercise, but rather an ACTIVE source of introduction, simulation, explanation and DISCUSSION. I urge any of you to ask questions that you may have after viewing.

EVALUATION:

Even though this course is being presented on the HONORS level, there will be NO FULL-YEAR PROJECT REQUIREMENT. However, HONORS-LEVEL CREDIT carries with it an expectation of HONORS-LEVEL WORK from you throughout the year.

Evaluation will consist of a combination of:

- *individual classwork and research,
- *group work (consisting of research-based short-term project work and presentation), including labs and possible class projects
- *individual short-term project work,
- *homework, (NOT necessarily every night) - homework may *not* be collected, but ***I will assume that it is done.***
- *occasional (announced) quizzes and/or tests (after a block of material),
An exact breakdown as to what percentage of each contributes to the overall quarterly grade is, in my opinion, not necessary and wasted effort.
- *a mandatory mid-year examination (10%), and a
- *final examination (10% - which, if you are a senior, you may be exempted from, based on your 2nd semester average).

Each evaluative activity will be worth a preannounced number of points.

Your quarterly grade will be based on the ratio of how many points you have earned (including extra credit) to the number of points you have been offered (not including extra credit) as of that time.

Extra credit points *may* be offered *occasionally* and added to the number of points you have earned. There will be no such thing as EXTRA-CREDIT ON DEMAND. All extra credit points will be offered by me under strict restrictions.

Thus, it will be possible to determine your exact (quarterly) grade at any time during the quarter - assuming work has been turned in and graded.

ABSENCE:

Absence does NOT excuse you from responsibility for materials presented, work due or quiz/test evaluation, nor does it excuse you from your responsibilities as a member of a group. (Please make sure to get any missed handouts as well as notes from someone in class that you can rely on. It is a good idea when taking notes to start by writing the date that the notes are being taken on.) Group leaders may be assigned to make sure ALL members of a group are contributing adequately. Everyone should have an opportunity during the year to assume leadership in a group project. An absence on the day of a lab, a quiz or a test will require that you take the quiz or test you have missed on the FIRST DAY YOU RETURN TO CLASS. Since all quizzes and tests will be announced prior to being given, unless you have been absent from the time of the announcement through the day it is given, you are expected to be prepared to take the quiz or test immediately upon returning to class. Please see me if you are absent from class for an extended period of time. We will work out a schedule as fair to you (and me) as possible for making up missed work. Otherwise, I would prefer not wasting my time squabbling over excuses or school policies.

FIELD TRIPS AND GUEST SPEAKERS:

If possible, during the year I will try to schedule field trips that will be meaningful and relevant to our course. I will also try to have experts in various fields (scientists, engineers, etc.) come in to class to speak and answer questions. It will be assumed that you will be exemplary representatives from Wachusett Regional High School, and that this is not merely "time off" from class.

PARENTAL CONTACT

If you or your parents need to contact me for any reason, the best way to do it is through my school email. If you email me, I will get back to you as soon as I can.

My school email address is: **nick_nicastro@wrsd.net**

If your parents request a meeting with me, they should call the Guidance Office and speak to your counsellor to make the arrangements.