Syllabus for PHY 104
Physics for Future Presidents

PHY 104. Physics for Future Presidents (3) Prerequisites: None. Physics is the liberal arts of high technology. Understand physics, and technological advances will never again intimidate you. The purpose of this course is to teach the physics one would need to know to be an effective world leader. It is designed to make physics understandable to the less math- and science-inclined.

A. **Instructor:** Professor John M. Morrison

Goals: Energy, global warming, terrorism and counter-terrorism, health, internet, satellites, remote sensing, DVDs and HDTVs -- economic and political issues increasingly have a strong high tech content. Misjudge the science and chances are you will make a wrong decision. Yet many of our leaders never studied physics, and do not understand science and technology. Physics is the liberal arts of high technology. Understand physics, and never again be intimidated by technological advances. This course is to teach the physics needed to know to be an effective world leader. It is designed to make physics understandable to the less math- and science-inclined. The most interesting and important topics in physics are presented, stressing conceptual understanding rather than math, with applications to current events.

B. **Resources:** Liberal use of the internet and external readings.

C. **Course Prerequisites or Restrictive Statements:** *May be taken for basic studies OR as PHY elective for majors but not both.* No prior physics is required. In fact, even if you had no physics in high school, you will not be at a disadvantage. Moreover, even if you are a physics major, you will find that most of the material is new. This course is open for physics majors too, in fact, it is an excellent supplement for other physics courses.

D. **Basic Studies Requirements:** *Scientific Approached to the Nature World*

E. **Student Learning Outcome:** The purpose of this course is to teach the physics needed to be a critically thinking, scientifically literate citizen with the ability to evaluate and develop sound evidence-based decisions and discern decisions that are not evidence-based when dealing with technology. The course is inquiry based. Topics usually begin with a story, anecdote, or puzzling fact. The purpose is to make the student wonder, "how can that be?" Then the issue is addressed using sound qualitative and quantitative solutions requiring knowledge of physical principles. Class discussions and written critiques of scientific articles require the students to use basic oral and written communication skills to confidently present their case and argue their conclusions using basic physical principles.

1. Students will demonstrate the ability, both oral and written, to think critically and to use appropriate concepts to analyze qualitatively problems or

situations involving the application of the fundamental principles of physics to real world situations. ***[SAN 1]***

2. Students will analyze numerous examples of qualitative and quantitative solutions to real world problems that demonstrate the importance of the material being learned and how it might be applied to real world situations. ***[SAN 2]***
3. Students will demonstrate ability and knowledge to discuss the material clearly and objectively both orally and in writing in this course. ***[SAN3]***
4. Students will show their understanding and knowledge of the fundamental physical concepts that they may need to make informed decisions in a highly technical world. ***[SAN1], [SAN 4]***

F. Textbooks: Muller, Richard. Physics and Technology for Future Presidents: An Introduction to the Essential Physics Every World Leader Needs to Know**.** Princeton University Press, ISBN 0697-78615-3, Hardcover -- $45.00. [Available March 2010]

G. Course Organization and Scope:

Course is designed to cover the most interesting and important topics in physics, with applications to current events.

Energy and Power, and the physics of explosions.

Calorie, Joule, and kilowatt-hour. Energy in various substances. Surprises: TNT and cookies, gasoline and batteries, electric car hype, hybrid non-hype. Fuel cells. Hydrogen as a means of transporting energy. Uranium, gasoline, and TNT. Cheap coal. Forms of energy. Power. Conservation of energy. Horsepower. Human power. Solar power. Exercise and diet. Wind power. Cost of energy. Kinetic energy. Anti-ballistic-missile systems: Smart rocks and brilliant pebbles. The demise of the dinosaurs.

Atoms and Heat.

Quandaries. Atoms and molecules and the meaning of heat. Periodic table. Speed of sound and light. Energy in heat. Hiss and noise. Temperature. Laws of thermodynamics. Hydrogen escape from atmosphere. Cold death. Temperature scales: F, C, K. Thermal expansion. Global warming and sea level rise. Thermometers. Space Shuttle tragedy. Solid, liquid, gas, and plasma. Solid, liquid, gas, and plasma. Explosions. Ideal gas law. Airbags, sautéing, firewalking. Heat engines. Wasted energy. Refrigerators and heat pumps. Laws of Thermodynamics. Heat flow. Entropy and disorder.

Gravity and force.

Gravity surprises. The force of gravity. Newton's third law. "Weightless" astronaut. Key orbits: LEO, MEO, and HEO. Rock and sling. Geosynchronous. Spy satellites. GPS location. Oil exploration. Manufacturing in space. Escape velocity. Gravity in science fiction. Falling to Earth. The X Prize. Auto air resistance and efficiency. Force and acceleration. The g-rule. Rail gun. Circular acceleration. Escape to space.

Black holes. Momentum. Rockets. Balloons. Skyhook. Ion rockets. Flying: airplanes, helicopters, balloons. Floating on water. Air pressure. Hurricanes and storm surge. Convection, thunderstorms, and heaters. Angular momentum and torque.

Nuclei and radioactivity.

Paradoxes and puzzles. The nucleus and its explosion. Protons, electrons, neutrons, quarks and gluons. Isotopes. Radiation. Cloud chamber. Radiation and death: the "rem". LD50. Poisoning and cancer. Linear hypothesis. Chernobyl. Hiroshima cancer. Denver exposure. Tooth and chest xray doses. Ultrasound. Radiation to cure cancer. Dirty bomb. Alpha, beta, gamma rays and more. Natural radioactivity. Half life rule. Power for satellites from RTGs. Radioisotope dating: potassium-argon, and radiocarbon. Environmental radioactivity. Why aren't all atoms radioactive? Optional: tunneling and the weak force of radioactivity. Forensics: neutron activation. Watch dials. Plutonium. Fission. Fusion. Power from the Sun.

Chain reactions, nuclear reactors, and atomic bombs

Chain reactions and the doubling rule (exponential growth): examples from chess, nuclear bombs, fetal growth, cancer, population (and Malthus), mass extinction recovery, PCR, germs, computer viruses, urban legends, avalanches, sparks and lightning, compound interest, Moore's Law, folding paper, and tree branches. Nuclear weapons basics. Critical mass. Uranium gun bomb. Uranium enrichment; calutron and centrifuges. Plutonium implosion bomb. Thermonuclear "hydrogen bomb". Boosted bombs. Atomic bombs. Fallout. Nuclear reactors. Plutonium production. Breeder reactors. Dangers: cancer, and the plutonium economy. Depleted uranium. Gabon natural reactor. Fuel requirements. Nuclear waste. Yucca Mountain. China syndrome. Three-mile island. Chernobyl. Paradoxes. Present stockpile.

Electricity and magnetism

Compared to gravity. Charge. Current; amps. Wires and electron pipes. Resistance. Conductors, semiconductors and superconductors. Fuses and circuit breakers. High temperature superconductors. Volts. Static electricity. Electric power. Frog legs and Frankenstein. House power. High tension lines. Electricity creates magnetism: Magnets, N & S, permanent, rare-earth, electromagnets. Monopoles? Short range. Electric and magnetic fields. Iron. Magnetic recording; hard drives. Curie temperature. Submarine location. Electric motors. Magnetism creates electricity: electric generators. Dynamos. The Earth, and its magnetic flips. Geology applications. Transformers. The Edison/Tesla competition: AC vs. DC. Magnetic levitation. Rail guns, again. Automobile battery. Flashlight batteries.

Waves

Mysterious uses of waves: UFOs near Roswell, New Mexico, and Sofar rescuing of pilots in World War II. What are waves? Wave packets and quantum physics. Sound. Sound speed. Transverse and longitudinal. Water surface waves. Tsunamis. Period, frequency, and wavelength. Bending. Sound channel in the ocean and atmosphere. Sofar and Roswell explained. Whale songs. GPS again. Ozone layer. Earthquakes. Magnitude and epicenter. P, S, L waves. Estimating distance rule.

Liquid core of the Earth. Bullwhips. Waves cancel, reinforce. Beats. Musical notes. The ear. Noise canceling earphones. Doppler shift. Huygens's principle.

Light

High tech light. Electromagnetic waves. Light communication and information theory: the bit and the baud rate. Color and color perception. Rods and cones. White and pseudo-white. Color blindness. Multispectra. Printed color. Oil slick. Images. Pinhole camera. Eyes. Mirrors. Magic with mirrors. Retroreflectors. Corner reflector. Stealth. Slow light. Index of refraction. Mirages. Diamonds, dispersion, and fire. Prism. Counterfeit diamonds. Other illusions: swimming pools and milk glasses. Rainbows. Lenses. The eye, again. Variable lens. Nearsighted and farsighted. Red eye and stop signs. Microscopes and telescopes. Spreading light. Diffraction. Blurring, and spy satellite limits. Holograms. Polarization. Polarized sunglasses. Crossed polarizers. Liquid crystals and LCD screens. 3-D movies.

Invisible light

Anecdote: illegal immigrants seen in the dark. Infrared. Thermal radiation and temperature. Red, white, and blue-white hot. Brown paint for cool roofs. Power radiated by warm object: 4th power. Tungsten inefficiency. Heat lamps. Dew on sleeping bags. Remote sensing of temperature. Weather satellites. Military special ops: "we own the night". Stinger missiles, pit vipers, and mosquitoes. UV and "black lights". Whiter than white. Sunburn. Germicidal lamps. Windburn. Ozone layer. Freon, CFCs, and the ozone hole. Greenhouse effect and carbon dioxide. Seeing through dust and smoke; firefighting. Electromagnetic spectrum. Radio, radar, microwaves, xrays and gammas. Radar images. Medical imaging: x-rays, MRI (NMR), CAT, PET (antimatter), thermography, ultrasound. Bats. X-ray backscatter. Picking locks.

Quantum physics

High tech is largely based on quantum physics. Electron waves. Spectra, and remote sensing. Einstein discovers photons. Laser – a quantum chain reaction. Laser applications: supermarkets, cleaning, weapons. Controlled thermonuclear fusion using lasers. Lasers and eyes. LASIK surgery. Solar cells and digital cameras. Image intensifiers and night vision. Xerox machines and laser printers. Compact disks and DVDs. More on gamma rays and x-rays. Fiber optics limits from quantum physics. Are photons real? Semiconductor electronics. Light-emitting diodes – LEDs; traffic lights and stadium TV screens. Diode lasers. Diodes to turn AC into DC. Transistor amplifiers and transistor radios. Computer circuits. Superconductors, again. Electron microscope. Quantization of waves. Uncertainty principle. Tunneling and alpha radiation. Tunnel diodes. Scanning tunneling microscopes (STMs). Quantum computers.

Relativity

The nature of time. Fourth dimension. Time dilation. Twin paradox. The Einstein gamma factor. Time depends on velocity. Not all motion is relative. Length "Lorentz" contraction. Relative velocities. Invariance of the speed of light. Energy and mass. E = mc2. Converting energy to mass. Antimatter engines. Zero rest mass of a photon.

Massless particles have no time. Mass of neutrinos. Why you can't get to light speed. Atomic bomb and relativity. Tachyons. Simultaneity. Pondering time.

The Universe

Puzzles. How can the Universe expand? What came before the beginning? The Solar System. Companion star? Planets around other stars. The Milky Way. Galaxies. Dark matter. WIMPs and MACHOs. Extraterrestrial life and Drake's equation. SETI. Looking back in time. Expansion of the Universe. Hubble's Law. The beginning. Dark energy. The Big Bang. The 3K cosmic microwave radiation – created in the Big Bang. Gravity and Relativity. Twins in gravity. Black holes, again. Finite Universe? Before the Big Bang. A Theory of Everything. The Creation (a poem)

H. Projected schedule for reading assignments:

- A schedule will be given out the first day of class. *You will read the entire textbook.* Typically, we will cover one chapter each week. Reading is due by Tuesday lecture. You are NOT required to answer the questions at the ends of the chapters. Those are only to test your knowledge, and are for your own private use. Most of them were taken from previous quizzes or exams.

- **Tuesday Email Homework**. Every week you are expected to find and read an article on physics or technology from a newspaper or magazine. It should be a serious article. Good sources are:
  - **The New York Times** (science section every Tuesday) - online at www.nytimes.com
  - **Science News** (a brief but excellent newsletter available in the library.
  - **Popular Science**, **Scientific American**, **Discover**, **New Scientist**, or similar magazine.
  - Watch out for web articles. A large number are superficial and misleading, or just plain wrong.

I. Grading:

• Quizzes	20%
• Mid-terms	20%
• Mid-terms	20%
• Final Exam	20%
• Homework	20%
○ Total	100%

Final grades will be based on a plus/minus grading scale as follows: A = 93-100; A- = 90-92; B+ = 87-89; B = 83-86; B- = 80-82; C+ = 77-79; C = 73-76; C- = 70-72; D+ = 67-69; D = 63-66; D- = 60-62; and F < 60.

J. Late Assignments:

- Extensions for late assignments will be granted individually in consultation with the professor under extenuating circumstances.

K. Absences and Scheduling Makeup Work:

- *Attendance at the lectures is REQUIRED*. So please don't sign up unless you intend to get there for every class.
- Attendance (and reading) will be checked by giving surprise quizzes.
- Absences from quizzes will result in a zero being registered for that quiz except for excused absence.
- Absences from tests will result in a zero being registered for that test except for excused absence.
- Excused Absence: Absence will be excused if email is sent to me before the missed lecture, and if it contains a reasonable excuse (e.g. Case of illness documented with a note from a doctor, you were killed in a terrorist incident, you have to be away to compete in a sporting or some other University sanctioned event). Don't make up excuses; if you do, and I find out, you will get an F in the course. In case of an excused absence, it will be the responsibility of the student to make arrangements with the professor to make up missed work.
- If you have more than 2 unexcused absence (any homeworks that were not emailed in count as an absence) I will lower your grade by 1 grade or more. (Your A+ will become a B+, etc.)

L. Statement on Academic Integrity:

- University Policy on Academic Integrity: The instructor of this course is committed to upholding the University policy on academic integrity, described in the Code of Student Conduct, which can be found at:

http://www.uncw.edu/stuaff/doso/documents/HonorCode09.10.doc

- *"As a student at The University of North Carolina Wilmington, I am committed to honesty and truthfulness in academic inquiry and in the pursuit of knowledge. I pledge to uphold and promote the UNCW Student Academic Honor Code."*

- "It is the responsibility of every faculty member, student, administrator and staff member of the university community to uphold and maintain the highest academic standards and integrity of the university. Any member of the university community who has reasonable grounds to believe that an infraction of the Honor Code has occurred has an obligation to report the alleged violation to the faculty member teaching the class who, in turn, must report the allegation to the Office of the Dean of Students. This obligation is a core value of the Honor Code, and must be fulfilled by each and every member of the university."

- Faculty Expectation: Zero Tolerance.

M. Statement for students with disabilities:

- Students with disabilities are invited to schedule an appointment with the instructor to discuss any needed accommodations. Reasonable accommodations will be made for students with verifiable disabilities.

- In order to take advantage of available accommodations, students must present documentation to Disability Services for Students at Westside Hall, First Floor, Phone: 910-962-7555 - Fax: 910-962-7556 - TDD: 910-962-3853.
  http://www.uncw.edu/stuaff/disability/contact.htm
- For more information on UNCW's policy on working with students with disabilities, please see
  http://www.uncw.edu/stuaff/disability/contact.htm

N. Statement on laboratory safety or risk assumption:

- Any laboratory work associated with this course has no special risks that would make it less safe than any other classroom. The Department of Physics and Physical Oceanography is committed to maintaining an environment in which students can safely pursue their required laboratory assignments.

O. UNCW Policy on violence and harassment: UNCW practices a zero-tolerance policy for violence and harassment of any kind. For emergencies contact UNCW CARE at 962-2273, Campus Police at 962-3184, or Wilmington Police at 911.

For University or community resources visit:
http://uncw.edu/wrc/crisis.htm

P. Statement on extra expenses: There are no significant extra expenses.

Q. Statement on transportation: There will be no additional transportation costs associated with this course.