PHYSICS 252: TEST 1 STUDY SHEET

You should know how to do the following:

1. Know the electromagnetic spectrum. Know the visible spectrum.

2. Use the Law of Reflection and Snell's Law at an interface between two media. Find the critical angle and understand what happens in TIR.

3. Tell if light speeds up or slows down as it leaves one medium and enters another medium. Tell what happens to the frequency and wavelength of the light as it enters the new medium.

4. Find the apparent depth of the image of an object that is immersed in water. Sketch the rays coming from the object to show how the image is formed.

5. Describe what we mean by "dispersion". Explain why it occurs.

6. Use the lens maker's equation to design a lens with a certain focal length. Know whether a lens is a positive (converging) lens or a negative (diverging) lens based on its shape.

7. Use the thin lens equation and equations for lateral and angular magnification to analyze the formation of an image using a single lens.

8. Perform a ray trace.

9. Be familiar with a simple camera, a simple projector, a simple magnifier.

10. Find the focal length or lens power of a single lens necessary to correct near-sightedness or far-sightedness.

11. Be familiar with a microscope. [Homework Problem]

12. Describe what is meant by spherical aberration and chromatic aberration. Sketch pictures to demonstrate these conditions. Describe standard attempts to correct these aberrations.

PHYSICS 252: TEST 2 STUDY SHEET

You should know how to do the following:

1. Analyze the interference pattern on a screen a far distance from two slits (Young's double slit set-up).

2. Analyze the operation of a diffraction grating.

3. Analyze the interference due to reflections off of a thin film. Know how to design an antireflection coating for a lens.

4. Sketch and describe the operation of a Michelson interferometer. Know what happens if one of the mirrors is moved toward or away from the beam splitter.

5. Analyze the diffraction pattern for a single slit or circular aperture. Find the width of the central diffraction peak (or Airy disk for a circular aperture).

6. Find the resolution angle for an optical system. Find the minimum separation distance that can be resolved on the object and the corresponding minimum distance on the image for an optical system (eye, camera, projector).

7. Know how a dichroic polarizer works to produce linearly polarized light. Know the Law of Malus.

8. Know how unpolarized light can become polarized upon reflection (Brewster's Law).

9. Know what is meant by a "birefringent material" and know what such a material can do to the polarization of incoming light.

PHYSICS 252: TEST 3 STUDY SHEET

1. You should know the answers to the "Quantum Physics Study Questions" that appear on the next page of this document.

In addition, you should know how to do the following quantitative problems:

2. Find the total power emitted by an object using Stefan's Law or find the total power absorbed by an object from its surroundings. Find the peak wavelength in the thermal emission of an object using Wien's displacement law.

3. Find the energy of a photon. Find the photon rate in a beam of light given the wavelength and power.

4. Find the maximum kinetic energy of a photoelectron emitted from a metal or find the stopping potential. Find the gain of a PMT and the current produced at the anode.

5. Find the wavelength shift of an x-ray as it is scattered off of an electron (Compton scattering).

6. Know how to use the results of the Bohr Model of the Hydrogen atom to find different quantities such as atomic energy levels, radii of the electron, emitted or absorbed photon energies and wavelengths.

7. Find the deBroglie wavelength and frequency for a particle of mass m traveling at speed v.

8. Find the smallest uncertainty in simultaneously measuring the position of a particle given information about the uncertainty in its speed measurement. Find the smallest uncertainty in simultaneously measuring the energy of a particle given information about the uncertainty in the measured time that the particle has this energy.

9. Use the results of the Schroedinger Equation applied to an infinite square well to find the allowed energies of a particle in such a well or the allowed deBroglie wavelengths of the particle.

10. Find the shortest wavelength produced by an x-ray tube given the accelerating voltage.

QUANTUM PHYSICS STUDY QUESTIONS

1) Sketch the intensity vs. wavelength curves for blackbody radiation obtained from classical wave theory and Planck's quantum theory. Explain why the classical curve is incorrect. What was Planck's key assumption in his quantum model? (What did he quantize?)

2) What is the photoelectric effect? Give at least two observed characteristics of the photoelectric effect that cannot be explained by the classical wave theory of light. Describe how the photon model explains these characteristics.

3) What is Compton scattering? Is Compton scattering explained by the classical wave model of light or by the photon model?

4) List Bohr's four postulates in his model of the Hydrogen atom. What physical quantities are quantized?

5) Describe a physical phenomenon that supports the wave nature of light. Describe a physical phenomenon that supports the particle nature of light.

6) Describe a physical phenomenon that supports the particle nature of matter. Describe a physical phenomenon that supports the wave nature of matter.

7) Why aren't we aware of the wave nature of macroscopic objects?

8) Describe the Heisenberg Uncertainty Principle (HUP) either in terms of a simultaneous measurement of position and momentum or in terms of a simultaneous measurement of energy and time. What is it about particles that gives rise to the HUP?

9) Write the one-dimensional time-independent Schrödinger equation. From where does the equation come?

10) Write down an integral expression for the probability of finding a particle traveling in one dimension in the region between $x=a$ and $x=b$. Write down an integral expression for the normalization condition of a one-dimensional wave function.

11) List the 4 quantum numbers of an atom. Describe what each quantizes and give the range of possible values.

12) State the Pauli Exclusion Principle. Describe how it helps explain the periodic table of elements.

13) Sketch a typical intensity vs. wavelength spectrum obtained in the production of x-rays. What determines the minimum wavelength? What is the source of the characteristic x-ray lines?

14) What are the 3 necessary elements to construct a laser? What does the acronym "laser" stand for?

15) Explain how a 3 level laser works. Make sure you know what is meant by a metastable state, population inversion, spontaneous emission, and stimulated emission.

PHYSICS 252: TEST 4 STUDY SHEET

1. You should the know the answers to the "Special Theory of Relativity Study Questions" and the "Nuclear Physics Study Questions" that appear on the next two pages of this document.

In addition, you should know how to do the following quantitative problems:

2. Find the time interval or length measured by an observer given the time interval or length measured by another observer who is moving relative to the first observer.

3. Use the Lorentz velocity transform to find the velocity of an object measured by an observer given the object's velocity measured by another observer who is moving relative to the first observer.

4. Find the total energy of a moving particle. Find the kinetic energy of a moving particle. Find the momentum of a moving particle.

5. Find the amount of energy required to accelerate a particle to a certain speed.

6. Find the energies of the two gamma rays produced in the annihilation of a particular matter/antimatter pair. Find the minimum energy required for a gamma ray to create a particular matter/antimatter pair. Find the amount of kinetic energy of this pair if the gamma ray has more than the required minimum energy.

7. Find the binding energy of a particular nucleus. (I will give you a copy of the necessary part of the table in App. A so you can look up the atomic masses.)

8. Write down the decay equation for a particular decay given the parent nucleus and type of decay. (I will give you a copy of the necessary part of the table in Appendix A so you can find the symbol for the daughter. You should be able to state if the daughter is stable or unstable.) Find the maximum kinetic energy of an emitted alpha or beta particle in a decay.

9. Find the half-life of a radioactive isotope given the decay constant or vice versa.

10. Use the half-life or decay constant to find the activity or number of unstable nuclei left after some time. Be able to express the activity either in Becquerels (decays/second) or Curies. Find the time required for the activity to reduce to a certain level.

SPECIAL THEORY OF RELATIVITY STUDY QUESTIONS

1) Define a "proper time interval" and a "nonproper time interval". What does the principle of "time dilation" state?

2) How does one make a valid measurement of length?

3) Define a "proper length" and a "nonproper length". What does the principle of "length contraction" state?

4) Define the "rest mass" of a particle.

5) Define the "rest energy" of a particle.

6) Define the "relativistic mass" of a particle.

7) Why can't a particle with a nonzero rest mass travel at the speed of light? You should be able to argue this by either discussing what happens to the mass and acceleration of a particle being accelerated by a constant force or by discussing the energy requirements needed to keep increasing the speed of a particle.

8) What is the rest mass of a photon? Does a photon have momentum? How is the momentum related to the energy of the photon?

NUCLEAR PHYSICS STUDY QUESTIONS

1) What comprises a nucleus of an atom? What is the approximate size of a nucleus? What determines the charge of a nucleus? What is an isotope?

2) What force binds the nucleons together? Describe the characteristics of this force.

3) Why do larger nuclei have more neutrons than protons?

4) Why are all nuclei with more than 83 protons unstable?

5) What is meant by the binding energy of a nucleus? How do you find the binding energy for a nucleus?

6) Describe the three methods of nuclear decay (α, β, γ). For each decay, state what happens to the following as the parent decays into the daughter: proton number, neutron number, mass number, charge.

7) How is the decay constant related to the half-life? Does a long half-life mean a fast or slow decay life time?

8) Distinguish the following units associated with ionizing radiation: *Roentgen, rad, rem*. Which unit of radiation exposure best determines the potential health risk?

9) Which is potentially more dangerous: 100 mrad of gamma rays or 100 mrad of a-particles? Why?

10) What is a typical natural background radiation dose equivalent for one year in the U.S.?

11) Do current nuclear power plants utilize fission or fusion?

12) What isotope is used as the fuel in a nuclear power plant? What is the role of the moderator in a nuclear reactor? What is the role of the control rods?

13) Why is Pu-239 used in nuclear bombs instead of U-235?

14) What is a breeder reactor?

15) What are the advantages of fusion over fission as an energy source?