PHY1300: Key Concepts for Mid-Term Exam

last update: October 16, 2015

While many of the topics in the course readings for the pre-lecture quizzes overlap with what was covered in class, these readings will not be on the exam. The exam will be on material covered during lectures. The lecture slides are all available on Blackboard. You could be asked a question on anything from the lectures, however, most of the exam questions will cover the "key concepts" listed below. The exam covers everything up to and including lecture 11.

Lecture 1: Introduction

- What is Science?
- What is Physics?
- Physics has to do with all types of interactions (forces, all four types) on all scales (different sizes).

Material from this lecture won't be on the exam.

Lecture 2: Cosmology and the Big Bang

- What is the cosmology?
- What is The Pale Blue Dot?
- What is a galaxy? What is the shape of the galaxy that we are in?
- Explain Olber's paradox.
- What type of star is the astronomical "equivalent" of a light bulb?
- What is Hubble's law and how was it found?
- List the key evidence that the Big Bang occurred. Briefly explain each piece of evidence.
- How were the elements created?

Lecture 3: Cosmic Microwave Background and The Life Cycle of Stars

- Where did the Cosmic Microwave Background come from? How can it be easily observed?
- What type of star is our sun? What type is it going to be? How do we know?
- There are several different types of stars. List them and their characteristics.
- Are black holes like vacuum cleaners?
- How are stars and planets formed?

Lecture 4: Supernova, Black Holes, and the Shape and Fate of the Universe

- According to Alan Guth's version of Big Bang Theory, what initially followed the Big Bang?
- How fast can gravitational waves travel in empty space?
- What is a supernova? There are two types of supernova, what's the difference between them?
- A black hole has never been "seen". How can their presence be detected?
- What are dark matter and dark energy?

• What are MACHOs?

Lecture 5: Dark Matter, Special Relativity, and Gravity

• What are WIMPs?
• According to our present understanding, what will be the fate of the universe?
• What is the shape of the universe?
• Where in Canada have neutrinos been detected? What did these measurements prove about neutrinos?
• According to Einstein, what was his greatest blunder?
• The Michelson-Morley experiment is one of the most important experiments in the history of physics. It showed that something didn't exist, what was it?
• What are the two postulates of special relativity?
• What were the consequences of special relativity on time and length? What about mass and energy?

Lecture 6: Gravity and General Relativity

• Johannes Kepler carefully tracked the motion of planets in the 17th century. What shape did he determine planetary orbits to be?
• Aristotle believed that heavier objects accelerate faster towards the ground than lighter objects. Who proved that he was incorrect? How did he do it?
• Newton established that the motion of the planets and the falling of objects towards the Earth are caused by the same force: gravity. Is gravitational attraction between two objects stronger the closer they are together. Does the gravitational force depend on the mass of an object?
• Why was the orbit of Mercury around the Sun a problem for Newton's gravity?
• How did special relativity conflict with Newton's theory of gravity?
• General relativity is about accelerated reference frames, special relativity is about inertial reference frames (no acceleration).
• General Relativity came from Einstein wondering how gravity fits within special relativity.
• Who proved that Einstein's theory of General Relativity is correct? How did he do it?
• What happens to time the closer you are to a large mass (like a black hole)?
• What is another name for a wormhole?

Lecture 7: The Nature and Propagation of Light

• Light scattering from objects is our primary mechanism of physical observation.
• Light is part of the electromagnetic spectrum.
• Approximating light as a ray, as done in geometric optics, can give us a good understanding of how lenses and mirrors form images.
• What type of light scattering makes the sky look blue?
• How does the Hubble telescope capture images in colour? How many types of cone cells are in the human eye?

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- Our eyes are lenses, the images formed on our retina of objects we look at are upside down. Our brain, not the optics of our eye, turns the images right side up.
- What's the difference between a reflected and a refracted light ray?
- How can squinting help us see?
- What type of telescope is the Hubble telescope?
- When white light passes through a prism, what happens? What is this called?
- What type of light scattering makes clouds look white?
- The formation of a rainbow is due to the combined effects of dispersion, refraction, and reflection.
- In a double rainbow, the light you see coming from the second rainbow underwent two refractions and two internal reflections.

Lecture 8: Photons and the Wave Nature of Particles

- Joseph Fraunhofer was an expert prism maker. Why, for a time, did he think there was a problem with his prisms? He had in fact observed the absorption spectra of the sun.
- The photoelectric effect showed that light is not just a wave, it is also composed of particles called photons. What did Einstein initially call photons?
- Sending one photon at a time through a slit will eventually form the same pattern on a screen (when they are added together) as sending many photons through at the same time. This type of pattern is called a diffraction pattern.
- What is the Heisenberg uncertainty principle?
- A diffraction pattern can be viewed as what kind of distribution?
- When a photon is shot at a half-silvered mirror, what does it do? Does it go through the mirror, or does it reflect off it?
- Particles like electrons can also behave like waves, when traveling through a slit or a double slit they form a diffraction pattern just like light.
- The definitions of particle position, momentum, energy and time are all probabilistic!

Lecture 9: The Atom

- What is the difference between an emission spectrum and an absorption spectrum? How did Neils Bohr explain these spectra?
- According to classical physics, what should an electron orbiting around a nucleus do?
- How is it that the wavelength of laser light can all be one wavelength?
- Who discovered the electron? Describe his model of the atom.
- Who discovered X-rays? How was this discovery significant for our understanding of crystal structure?

Lecture 10: The Atom and Quantum Strangeness

- The discovery of X-rays enabled us to determine the structure of matter (the way that atoms organize themselves in different materials) for the first time. For example, X-ray images led to the discovery of the double helical structure of DNA.
- What did Laue find when he beamed X-rays at a crystal?
- What is the significance of Bragg's law?

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- According to the Schrodinger's equation, a free particle is a wave packet.
- According to the Copenhagen interpretation of quantum mechanics, The observer is not an external viewer separated from the world that's being watched. You can never completely separate the observer from the system he or she is measuring.
- What does it mean when we say that a wave function collapses?
- How does Schrodinger's Cat thought experiment work?
- How did Einstein feel about quantum mechanics?
- According to quantum mechanics, particles can tunnel through energy barriers. They are never completely trapped. This is shown by wave functions that go outside the walls of energy "wells" or "boxes", or directly through energy barriers. It is most likely that a particle will not pass through a large energy barrier. The probability of it passing through a smaller energy barrier is greater.
- The key concept for the scanning tunneling microscope is the current created by electrons tunneling through an energy barrier. The barrier in this case is the space between the sample and the tip of the microscope.
- Who came up with the term "spooky action at a distance"? What does it refer to?

Lecture 11: Nuclear Physics

- Who discovered radioactivity?
- What is radioactivity?
- What new element did Marie and Pierre Curie discover in pitchblende?
- What is an isotope? Do isotopes always have the same number of protons in their nucleus? Do isotopes always have the same number of neutrons in their nucleus?
- What are the three main types of radiation from radioactive elements?
- What is an alpha particle?
- What is a beta particle?
- What is gamma radiation?
- Why does radioactivity primarily occur in larger nuclei?
- Who made the discovery of the nucleus? How was it discovered?