PHYS 1301 IDEAS OF MODERN PHYSICS
HOMEWORK

HW1 DUE FEB 2

1. Explain how observation of the phases of Venus supports the heliocentric model and refutes the geocentric model.
2. Discuss the extent to which an artistic model of reality (Picasso's paintings, Shakespeare's plays, etc.) does or does not follow each of the six features of a scientific model given in the textbook and lecture.
3. If the sailor in Fig. 2.5 of the textbook walks instead at 4 mph east relative to the ship, what is his speed relative to the buoy now (in classical physics)?
4. Give two observations from your daily experience in support of the notion of classical physics that people in relative motion always agree on the rate at which time passes. What is the uncertainty of your observations?

PHYS 1301 IDEAS OF MODERN PHYSICS
HOMEWORK

HW2 DUE FEB 6

1. Suppose you are traveling in an airplane with all the shades pulled down. Describe a simple experiment/observation that you could use to demonstrate to other passengers whether or not the airplane is an inertial frame of reference (ignore effects of gravity).
2. Describe an example from daily driving for each of the pictures in Fig. 2.6 of the textbook.
3. What are the main characteristics of the hypothetical ether and what reasons were given for them?
4. What type of electromagnetic radiation does your cell-phone transmit/receive? (If you don't know, find out!)

PHYS 1301 IDEAS OF MODERN PHYSICS
HOMEWORK

HW3 DUE FEB 13

1. Explain what is meant by an *operational* definition of a concept.
2. Reanalyze the Problem with Many Observers (section 3.5) from Gertrude's inertial reference frame, i.e., as if she were at rest and everything else were moving. How would Gertrude explain your observation that the flashes occur simultaneously?
3. If you set off from Earth at birth on a journey at 1/2 the speed of light, after 100 years as measured by clocks on Earth, what is your biological age according to people on Earth?
4. Reanalyze the Relativity of Length Measurements (section 3.8) from Gertrude's inertial reference frame, i.e., as if she were at rest and everything else were moving. How would Gertrude explain your observation that the car fits in the tunnel when, according to her, it does not?

PHYS 1301 IDEAS OF MODERN PHYSICS

HOMEWORK

HW4 DUE FEB 20

1. Why is Relativity so named?
2. Explain why the speed of light is an ultimate speed for any massive object.
3. Explain why the *twin paradox* is not actually a paradox.
4. Give a hypothetical example of a violation of causality (cause after effect) and explain how it could be exploited to produce a real paradox (a logical inconsistency).

PHYS 1301 IDEAS OF MODERN PHYSICS

HOMEWORK

HW5 DUE FEB 27

1. Why is Special Relativity 'special' and General Relativity must incorporate a model of gravity?
2. You are in an elevator when the cable snaps and you begin to fall. At the instant the cable snapped, you dropped a ball. Describe what you would see happening to the ball. Your falling elevator is called a 'local inertial frame'. Why 'inertial' and why 'local'?
3. Give two pieces of experimental/observational evidence in support of Einstein's General Relativity.
4. Explain how General Relativity's law of motion is similar to Newton's 1st law of motion and how it differs from Newton's 2nd law of motion. [Hard]

PHYS 1301 IDEAS OF MODERN PHYSICS

HOMEWORK

HW 6 DUE MAR 6

1. Describe the shape and appearance of the various kinds of galaxy observed in the universe.
2. What is the Hubble Relation?
3. How can space be both finite and unbounded? (Use the surface analogy if you wish).
4. What are the three different kinds of expanding universe allowed by GR and what are the criteria for them to occur? (Ignore possible effects of Dark Energy and a Cosmological Constant).

PHYS 1301 IDEAS OF MODERN PHYSICS

HOMEWORK

HW 7 DUE MAR 20

1. Explain why the double-slit experiment provides evidence that light is a wave.
2. What are some of the applications of quantum mechanics to modern technology?
3. What evidence is there that photons and electrons arrive at the detection screen in a double-slit experiment like individual particles?
4. Discuss how quantum mechanics calls into question the objective reality of things.

PHYS 1301 IDEAS OF MODERN PHYSICS

HOMEWORK

HW 8 DUE MAR 27

1. What is observed on the screen in a double-slit experiment using electrons

(a) when you **don't** observe which slit each electron goes through?

(b) when you **do** observe which slit each electron goes through?

(c) Why does the mere act of observing the electron alter its path?

2. Does Heisenberg's Uncertainty equation mean we can never measure the position of something with arbitrarily good precision? Explain.

3. Einstein and Planck suggested that light (which had been thought of as waves) could also be thought of as particles (photons). How did de Broglie extend that idea?

4. Why is it possible to see much more detail with an electron microscope than with an optical microscope that uses visible light?

PHYS 1301 IDEAS OF MODERN PHYSICS

HOMEWORK

HW9 DUE APR 3

1. Describe the experiment and reasoning Rutherford used to arrive at his model of the atom.
2. What were the theoretical and experimental problems with Rutherford's model?
3. Carefully draw a one-dimensional standing wave representing (a) the fundamental vibration (b) the 2^{nd} harmonic. Label the places on each where there is no movement (the nodes).
4. How did Schrodinger explain the discreteness of allowed electron energies in the atom and hence atomic stability and the discrete observed spectrum of emitted and absorbed light?

PHYS 1301 IDEAS OF MODERN PHYSICS

HOMEWORK

HW10 DUE APR 13

1. Explain how the operation of a laser is an example of quantum cooperation.
2. List a few technological applications of lasers that are NOT in the textbook chap.7.
3. The Kelvin temperature scale is used in science. The Fahrenheit scale is used for the weather in the USA. Why do you think that is? (The answer is not in the book – I want to see YOUR reasoning.).
4. Describe a couple of the bizarre properties of liquid Helium due to Bose-Einstein condensation of its atoms.

PHYS 1301 IDEAS OF MODERN PHYSICS

HOMEWORK

HW11 DUE APR 17

1. Use a rollercoaster analogy to explain the difference between the behavior of a classical and quantum object in regard to (energy) barriers.
2. Briefly describe how a Scanning Tunneling Microscope works.
3. Giving a specific example of each, describe what is meant by nuclear *fusion* and nuclear *fission.*
4. In nuclear reactions and radioactive decay, the end products are often moving very fast. Explain where this (kinetic) energy of motion come from?

PHYS 1301 IDEAS OF MODERN PHYSICS

HOMEWORK

HW 12 DUE APR 24

1. What was Schrodinger trying to convey about quantum mechanics by suggesting his cat experiment?
2. List at least three different interpretations of the quantum measurement problem, with a one-sentence explanation for each.
3. Although the 'Dirac Equation' successfully combined quantum mechanics with relativity and the 'Dirac sea' interpretation of negative energies enabled the prediction of anti-matter, why were these ideas not entirely consistent? (Give 2 reasons).
4. Draw a spacetime Feynman diagram for each of the following processes:
   (a) An electron that changes into a photon and an electron which then recombine to form just an electron again. (This one is in the textbook).
   (b) An electron and a photon combine to form just an electron which then splits back into a photon and an electron. (This is called 'Compton Scattering' – drawn in lecture).

PHYS 1301 IDEAS OF MODERN PHYSICS

HOMEWORK

HW 13 DUE MAY 1

1. What is meant by gauge invariance? (Use the electron diffraction experiment as an example)
2. Draw a Feynman diagram representing an electron and a positron changing into two photons.
3. Why does chapter 12 refer to W and Z particles as weak photons? In other words, what are the similarities and differences between the properties of W or Z's and photons?
4. Explain what is meant by `Quark Confinement'.