Cornell University
Prison Education Program

Conceptual Physics Syllabus
Condensed Version

Instructor: Ms. Quinn

February 12, 2018

Changes to Course Outline

In order to accommodate ending on **April 30th**, three classes needed to be removed. Do do so, the following changes were made:

- Remove the 2 review classes.
- Condense relativity section (special and general) from 2 classes to one. As a result, there will be 2 reading quizzes due that week instead of 1.
- Bring up the dates of the partial tests
- Questions on the first partial test will be slightly different, so that solutions can be handed out without impacting the other students (who will be taking it later).
- Have probability and quantum mechanics be the first thing covered in part 2, rather than the last. In doing so, 3 classes in part 2 will align (Atomic theory and Light, Fields of Force, and Special Relativity).
- Homework 3 and Homework 5 will now be due the day of the partial tests. As a result, no solutions for those homeworks will be provided before the partial test which covers that material. As a compromise, formal solutions to the in-class problems for the missed material will be provided.
- Homework 6 will now be moved to be due before homework 4 (since it covers probability and quantum mechanics). It will also contain slightly different problems, so that solutions can be handed out without impacting the other students (who will be working on Homework 6 later in the semester).

As a comparison, the following table illustrates the changes:

Date	**Original Timeline**	**Shifted Timeline**
Week 1	Philosophy of Science	Philosophy of Science
Feb. 2		
Week 2	Units	Units
Feb. 9	RQ 1	RQ 1
Week 3	Kinematics	Kinematics
Feb. 16	RQ 2, HW 1	RQ 2, HW 1
Week 4	Graphs	Graphs
Feb. 23	RQ 3	RQ 3
Week 5	Forces	Forces
March 2	RQ 4, HW 2	RQ 4, HW 2
Week 6	Energy and Momentum	Energy and Momentum
March 16	RQ 5	RQ 5
Week 7	Review	**First Partial Test**
March 23	HW 3	HW 3
Week 8	**First Partial Test**	Probability and Quantum Mechanics
March 30		RQ 10
Week 9	Atomic Theory and Light	Atomic Theory and Light
April 6	RQ 6	RQ 6, HW 6
Week 10	Fields of Force	Fields of Force
April 13	RQ 7	RQ 7
Week 11	Special Relativity	Relativity (Special and General)
April 20	RQ 8, HW 4	RQ 8, RQ 9, HW 4
Week 12	General Relativity and *Cosmology*	**Second Partial Test**
April 25	RQ 9	HW 5
Week 13	Probability and Quantum Mechanics	
May 4	RQ 10, HW 5	
Week 14	Review	
May 11	HW 6	
Week 15	**Second Partial Test**	
May 18		

Part 1

Philosophy of Science

What does it mean to *be scientific*? How do theory and ideology differ? What makes a theory scientific? At its core, science is a way of thinking, an attitude we adopt when we try to understand and/or predict the behavior of something. We will discuss the scientific method, the cycle between theory and experiment, and analyze its strengths and weaknesses. We will look at the heliocentric (Sun-centered) vs. geocentric (Earth-centered) view of the solar system, specifically discussing the kinds of experiments we can design to test these models.

In class reading: M. Fuller, *Is Science an Ideology?* Philosophy Now **15** (1996)

Units

Reading: Chapter 0 (Sections 5, 8 and 9) of *Light and Matter*

In physics, we want to quantitatively describe the world around us. In order to do this, how do we measure quantities? How can we compare measurements, if two people measure things differently? In this class we will discuss *units*, what they are and how we can convert between them. We will introduce the concept of *scientific notation*. From this, we will engage in an invention task that will introduce the notion of ratios, in order to characterize things like *speed* and *velocity*.

Math Concepts: ratios, powers of 10, positive and negative numbers

Kinematics

Reading: Chapter 2 (Sections 1, 2 and 5) of *Light and Matter*, Chapter 2 (Sections 1 to 5) of *College Physics*, Chapter 3 (Sections 1 to 4, 6) of *Light and Matter*

Everywhere we look things are in motion. We will look at ways of characterizing this motion: Using *coordinate systems* to describe space, we will look at *position*, *velocity* and *acceleration* to describe how objects move within it. Furthermore, while we live in a 3D world, we will confine ourselves to considering motion only in 1 dimension. We will work on an invention task centered on acceleration.

Math Concepts: ratios, powers of 10, variables (x, y, t, etc.), algebra ($5x = 15$), squared numbers (x^2)

Graphs

Reading: Chapter 2 (Section 3) of *Light and Matter*, Chapter 2 (Section 8) of *College Physics*

Graphs, diagrams, figures and pictures all all very useful tools to help us visualize and take in lots of information at once. We will use graphs to visually connect *displacement*, *velocity* and *acceleration*, to describe in a still image an object's motion in time and how all these concepts relate to one another. This will be the most math-heavy class all semester, where we will find *areas* under graphs, looks at *slopes*, and connect these things to physical quantities.

Math Concepts: ratios, variables, areas, *slopes* (no trigonometry), algebra ($5x = 15$), squared numbers (x^2)

Forces

Reading: Handout on *4 Fundamental Forces of Nature*, Chapter 4 of *Light and Matter*

So far, we have been talking about motion without considering its cause. *Forces* cause changes in motion (making things slow down, speed up, stop, push and pull on one another). We will look at the four fundamental forces of nature, build up to *contact forces* (like the ones we experience everyday) and quantify forces with *Newtons*.

Math Concepts: ratios, algebra ($5x = 15$).

Energy and Momentum

Reading: Handout (can skip section 3), Chapter 13 (Section 1) of *Light and Matter* Chapter 7 (Sections 1 to 6) of *College Physics*

We will discuss Noether's theorem, relating symmetries of nature to conserved quantities like *energy* and *momentum*. We will relate this quantities to forces, and introduce the concept of *work* describing the transfer of energy. We will look at different forms of energy: kinetic (energy of motion), potential ("stored" energy and its relation to fundamental forces), and as mass itself (through the mass-energy equivalence, the famous $E = mc^2$). Energy and work will also be introduced in class through an invention activity.

Math Concepts: ratios, algebra ($5x = 15$), squared numbers (x^2), negative numbers

Part 2

Probability and Quantum Mechanics

Reading: Chapter 33 (Sections 1, 2, 4) of *Light and Matter*, Chapter 34 (Section 1 to 3) of *Light and Matter*, Chapter 35 (Section 1) of *Light and Matter*

If we knew the exact location, velocity and all the forces acting on everything in the universe, then could we predict the future (is the universe *deterministic*)? At the atomic scale, all evidence points to *no*. A lot of behavior is described in terms of probabilities. Even stranger, according to the *uncertainty principle* we *cannot* know the exact location and velocity of an object! In this class we will discuss probabilities, and how it relates to quantum mechanics, specifically through radioactive decay. We will talk about the *wave-particle duality*, specifically how light and electrons are both waves and particles.

Math Concepts: ratios, reading graphs

Atomic Theory and Light

Reading: Chapter 17 (Section 1) of *Light and Matter*, Chapter 19 (Section 3 and 4) of *Light and Matter*, Chapter 26 (Section 1, 4) of *Light and Matter*

We will discuss atomic and particle theory, looking at particles like *electrons*, *protons*, *neutrons*, *quarks* and how they come together to form the atom. We will look at the periodic table, and use it as a guide to understanding the differences between atoms (for things like *elements* and *isotopes*). We will then turn our attention to a different kind of particle: *photons* (particles of light). We will discuss light; As a particle (*photon*) and as a wave (as well as the *electro-magnetic spectrum* of all light-waves).

Math Concepts: ratios

Fields of Force

Reading: Chapter 22 (Sections 1 to 3) of *Light and Matter*

How do forces act on objects? The Earth and the Sun are separated by vast amounts of space - exactly *how* to they "communicate" in order to be attracted to one another? Here we will discuss *fields* of force, specifically for gravity and the electric force. We will introduce the concept of a *vector*, to describe the field at every point in space, look at superposition of fields (when there are lots of charges, or lots of masses). We will work on an invention activity that focuses on developing fields.

Math concepts: ratios, vectors

Relativity

Reading (Special Relativity): Chapter 23 (Section 1) of *Light and Matter*, Chapter 28 (Sections 1, 2, 3) of *College Physics*

Reading (General Relativity): Chapter 27 of *Light and Matter*

We live our lives on a very unique length scale; We are minuscule when compared to the Earth, moving at speeds almost non-existent when compared to light. What happens when we consider physics outside of our realm - massive objects moving very, very fast? Intuition is no longer our guide here, as time *dilates* and lengths *contract*, and events that are instantaneous to one observer occur one after another to some other observer. We will look at Einstein's postulates and reference frames.

Math concepts: Little to no math will be used.