Gary Bent

Advanced Physics
Detail for climate change unit:

X. Climate Change – I start the unit immediately after covering thermal equilibrium, black bodies, emissivity, absorptivity, and the Stefan-Boltzmann Law. Before this I have also covered evaporation, condensation, and saturation, heat of vaporization, heat of fusion, first law of themodynamics, specific heat, relative humidity, dew point, heat transfer by conduction, convection, and radiation. I skip the second law of thermodynamics to make room for this unit.

Introduction
Slide set: GaryBent0_SlowTrainWreck.pptx
This first slide set I use as an introduction to the unit. I am trying to make several points with these slides:

1. Civilization developed during the past 10,000 year. During that time the Earth's temperature, sea level, precipitation levels, and arable land has remained remarkably stable.
2. In the distant past (millions of years ago) climate was much more variable. Paleoclimatology has revealed that average temperature changes of 2 degrees Celsius over a span of 10,000 years has resulted in extinction of species and large sea level changes.
3. This century will have a temperature change of 2 degrees Celsius or greater in 100 years.
4. Even when we stop emitting carbon dioxide, it will take over 1,000 years for the warming to stop.
5. We are already experiencing the effects of global warming.

A Greenhouse gas lab
GaryBentA_GHeffectLab.doc
GaryBentA_GHGabsorptionOfIR2.doc
The Greenhouse Effect Lab I use after the introduction powerpoint, "Slow Train Coming". It takes about a period to do. I assign "Greenhouse Gas Absorption of Infrared" for outside reading. In class we then discuss the lab and the reading.

B Equilibrium temperature of the Earth
Slides:
GaryBentB_equilibriumTempOfEarth.ppt
Equilibrium Temperature of Earth – This powerpoint uses the Stefan-Boltzmann Law to calculate the equilibrium temperature of the Earth assuming there are no greenhouse gases in the atmosphere. I wrote this for students of various math levels so it goes though the calculation in many steps.

C Greenhouse effect
Slides:
GaryBentC_GHeffect.pptx

D Greenhouse gases
Slides:
GaryBentD_GHgases.pptx
In this slide set, I have crossed out the lifetime for carbon dioxide in the atmosphere that is in the table on the first slide because different techniques give different values. The lifetime that was in the table was 100 years determined by the time for a pulse of carbon dioxide injected into the atmosphere to decay to 1/e of its initial value. The lifetime that I see most often is 300 to 1000 years that is the estimated time to permanently remove carbon dioxide from the atmosphere. The permanent removal is accomplished by carbon dioxide going from the surface ocean to the deep ocean (see last slide) or the weathering of rocks that produces calcium carbonate. Both of these processes are very slow. The

Advanced Physics
Overall Course Outline

I Preliminaries, states of matter, mass, uncertainty
II One-dimensional forces
III One-dimenional motion
IV Two-dimensional motion
V Impulse-momentum theorem
VI Two-dimensional forces
VII Conservation of momentum
VIII Conservation of energy
IX Thermal physics
  - A First law of themodynamics
  - B Evaporation, Condensation, and Saturation
  - C Conduction, convection, and radiation
  - D Stefan-Boltzmann Law and black bodies

X Climate Change
XI Coulomb force and the electric field
XII Electrical potential energy and potential
XIII Biot-Savart Law and magnetic field
XIV Microscopic circuit theory
XV Circuits, Ohm's Law, Kirchkoff"s Laws
XVI Capacitors
XVII Faraday's Law and Lenz' Law
XVIII Motors and generators
XIX Inductors and transformers
XX Electromagnetic waves
XXI Optics
XXII Quantum physics

average time to remove a molecule of carbon dioxide into the soils or surface ocean is 12 years, but in about 12 years that molecule reappears. Thus there is a steady-state cycle with permanent removal taking the 300 to 1000 years.
GaryBentE_equilibriumTempWithGHG.pptx

E **Temperature of the Earth**
Slides:
GaryBentE_TempOfEarth.pptx
This slide set I use to introduce my students to the modeling of the climate that is done to predict future climate. It is a simple box model with the atmosphere split between the troposphere and the bottom of the stratosphere. Again I do the math for a variety of math abilities in the students.

F Predicting the future
Slides:
GaryBentF_PredictingTheFuture.pptx

G **Future climate change**
Slides:
GaryBentF_FutureClimateChangeHS.pptx

H **Skeptics**
Slides: GaryBentH_Skeptics.pptx
Movie: GaryBentMovieCO2doublingModel_gfdl.mpeg

I **Possible solutions to climate change**
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