

NS102 Learning Objectives

[Fall 2019]

Module 1: "Can we stop/reverse climate change?"

CLT 1: Why is there a "Climate Debate?" How should we interpret data?

By the end of this week, you should be able to:

Determine the best-fit line to actual data related to the Earth's climate to assess if climate is changing, and suggest a cause using the concepts of correlation and causation

1. Given a time dependent data, make a data vs. time plot or given a time plot of a data, find the best-fitting line using spreadsheet software and comment on the **type and degree of correlation**.
2. Given the findings of various studies, find the conflicting data and use them to make an **argument for global warming**.
3. Given the effects of parameters on the outcome of an experiment, be able to determine the **correlation** or **causation** between two parameters.

CLT2: The Earth has an "Energy Budget" that is kept in balance.

Make general calculations on Earth's energy balance and use data to describe the role of greenhouse effect in climate change

1. List the types of **radiation** that affect the earth's energy balance and compare their magnitude using the electromagnetic spectrum.
2. Describe **blackbody radiation**, calculate the radiation from a given object and relate the blackbody radiation to the greenhouse effect.
3. Using the data on solar flux and albedo values, find the **effective temperature** and the extent of the **greenhouse effect** of a given planet.

CLT3: Human activities that increase the concentration of greenhouse gases in the atmosphere contribute to climate change.

Describe greenhouse effect in terms of interaction of molecules and IR radiation, and relate gas laws to weather

1. List the **greenhouse gases** in the atmosphere and explain what makes a gas a greenhouse gas.
2. Describe the assumptions leading to the **ideal gas equation** of state, and explain why these are sufficient to explain the behavior of gases involved in climate science calculations.
3. Explain the terms in the **van der waals gas equation** and list the differences between ideal and van der waals gas laws in terms of the conditions for which they apply.

CLT4: Atmospheric temperature rise seems to be mild, not because of the lack of climate change, but because of the warming of the oceans.

Relate work done on a system and heat transferred to the internal energy of the system and solve problems that relate the 1st law of thermodynamics to climate

1. Calculate **work** done by or on a gaseous system using the pressure-volume diagram.
2. Distinguish between **state function** and **path function**, and apply the concept to analyze thermodynamic systems.
3. Discuss the effects of **heat capacities** of oceans and land on climate change.
4. Relate work and heat to the **internal energy** of a system and give an example of the 1st law of thermodynamics.
5. Calculate the change in **enthalpy** for an ideal gas in an isothermal or constant pressure process

CLT5: Does the climate change theory contradict the second law of thermodynamics?

Make an argument on the relation between the 2nd law of thermodynamics and greenhouse effect.

1. Identify "**spontaneous**" and "**nonspontaneous**" processes and explain how they are associated with entropy.
2. Calculate the changes in **entropy** of the system and the surroundings in reversible and irreversible processes.
3. Give examples of processes where the **2nd law of thermodynamics** is violated and explain why.

CLT6: Humans choose to burn fossil fuels not just because they generate a lot of energy, but also because they do it fast.

Identify Gibbs free energy as the quantity that defines the equilibrium state of a system, and discuss the factors affecting the spontaneity and rate of reactions contributing to climate change

1. Calculate the change in **Gibbs free energy** of the system from the changes in its enthalpy and entropy.
2. Predict whether or not a physical or chemical change is **spontaneous** given the temperature, from the Gibbs energy
3. Identify the **most stable phase** of a system, given its Gibbs energy vs. temperature graph
4. Distinguish between **kinetic** and thermodynamic parameters in a chemical or physical process based on energy diagrams (= reaction profiles)

CLT7: Do Humans Contribute to Climate Change?

1. Discuss how humans are contributing to the climate change, by giving examples with **scientific evidences**
2. List, compare and contrast the benefits and downsides of at least three **alternative energy resources**