

Lesson Plan: Teaching Planck's Law and Blackbody Radiation through Climate-related Examples

As a **high school** or **undergraduate Physics** teacher, you can use this set of computer-based tools to help you in teaching **Planck's Law**, the **Stefan-Boltzmann Law**, and **Blackbody Radiation**.

This lesson plan allows students to visualize the emission spectra associated with particular temperatures, to understand how Planck's Law can be used to plot blackbody curves of objects with different temperatures, and to learn the relationship between temperature and peak wavelengths in the electromagnetic spectrum. The activity also introduces the topic of planetary temperatures of objects in the solar system and shows the greenhouse effect of Earth's atmosphere.

Thus, the use of this toolkit allows you to integrate the teaching of a climate science topic with a core topic in Physics.

Use this lesson plan to help your students find answers to:

- *How can Planck's Law be used to plot blackbody curves of objects at different temperatures?*
- *How can the Stefan-Boltzmann Law be used to calculate the surface temperature of blackbodies?*
- *Why does the surface temperature of Earth increase due to the greenhouse effect of the Earth's atmosphere?*

About the Lesson Plan

Grade Level

High School, Undergraduate

Discipline

Physics

Topic(s) in Discipline	Planck's Law, Wien's Law, Blackbody Radiation, Stefan-Boltzmann Law, Relationship between Temperature and Peak Wavelength of the Electromagnetic Spectrum, Planetary Temperatures as a function of solar energy received, Greenhouse Effect of Earth's Atmosphere
Climate Topic	Planetary Climates, Planetary Energy Balance, The Greenhouse Effect
Location	Global
Access	Online, Offline
Language(s)	English
Approximate Time Required	120 – 150 min

1 Contents

1. Visualization and associated activity (~ 45 min)

A visualization and associated activity to explain how Planck's Law can be used to plot blackbody curves of objects with different temperatures, the relationship between temperature and peak wavelengths in the electromagnetic spectrum, and the greenhouse effect of Earth's atmosphere.

Visualization:

<https://phet.colorado.edu/en/simulation/blackbody-spectrum>

Associated Activity:

<http://static.nsta.org/connections/highschool/201512Worksheets.pdf>

2. Classroom/Laboratory activity (60 – 90 min)

A classroom/laboratory activity to understand the energy balance of planet earth, the Stefan-Boltzmann Law, and the solar energy flux received by planet Earth to calculate its surface temperature. This resource can be used to demonstrate the greenhouse effect of the atmosphere.

<http://cybele.bu.edu/courses/gg612fall99/gg612lab/lab1.html>

3. Suggested questions/assignments for learning evaluation

- How can Planck's Law be used to plot blackbody curves of objects at different temperatures?
- How can the Stefan-Boltzmann Law be used to calculate the surface temperature of blackbodies?
- Why does the surface temperature of Earth increase due to the greenhouse effect of the Earth's atmosphere?

2 Step-by-step User Guide



Here is a step-by-step guide to using this lesson plan in the classroom/laboratory. We have suggested these steps as a possible plan of action. You may customize the lesson plan according to your preferences and requirements.

1. Introduce the topic

- Discuss the concept of electromagnetic radiation.
- Proceed with your existing lesson plan to explain Planck's Law.

2. Conduct an activity using an interactive visualization tool

- Next, discuss how the Planck equation can be used to plot blackbody curves of objects with different temperatures and the relationship between temperature and peak wavelengths in the electromagnetic spectrum.

Now, explore the topic in an interactive and engaging manner through a visualization tool and associated activity:

- Download PhET's tool, "Blackbody Spectrum", from <https://phet.colorado.edu/en/simulation/blackbody-spectrum>.
- Download an activity developed by the National Science Teaching Association titled "Exploring Planck's Law" that was designed to be used with PhET's "Blackbody Radiation" tool. This activity can be downloaded from <http://static.nsta.org/connections/highschool/201512Worksheets.pdf>.

With the help of this activity, you can explain how Planck's Law can be used to plot blackbody curves of objects with different temperatures, and the relationship between temperature and peak wavelengths in the electromagnetic spectrum.

The activity contains several questions to be answered while using PhET's "Blackbody Radiation" tool.

- An answer key for teachers can be found at <http://static.nsta.org/connections/highschool/201512WorksheetsKeys.pdf>
- Introduce the Stefan-Boltzmann Law as a means of calculating the total flux of energy emitted by a blackbody. Stress on how this law can be used to calculate surface temperatures of different blackbodies.
- Discuss the topic of energy balance and planetary temperatures in the solar system and stress on calculating surface temperature of planet Earth based on solar energy flux received.
- Introduce the greenhouse effect of Earth's atmosphere and discuss how the surface temperature of Earth increases from a bare blackbody Earth to a blackbody Earth with a 1-layer atmosphere.

3. Conduct a classroom/laboratory activity

Now, explore the topic in detail through a classroom/laboratory activity, "[The Layer Model Approximation to the Greenhouse Effect](#)", designed by David Archer, the University of Chicago:

- Go to <http://cybele.bu.edu/courses/gg612fall99/gg612lab/lab1.html>.
- Conduct the activity in this exercise.

4. Questions/Assignments

Use the tools and the concepts learned so far to discuss and determine answers to the following questions:

- *How can Planck's Law be used to plot blackbody curves of objects at different temperatures?*
- *How can the Stefan-Boltzmann Law be used to calculate the surface temperature of blackbodies?*
- *Why does the surface temperature of Earth increase due to the greenhouse effect of the Earth's atmosphere?*

3 Learning Outcomes

The tools in this lesson plan will help students to:

- apply Planck's Law to plot the blackbody curve of an object at a specific temperature
- apply the Stefan-Boltzmann Law to determine the surface temperature of a blackbody
- calculate the surface temperature of the Earth based on the solar energy flux
- explain the effect of the greenhouse effect of the Earth's atmosphere on the surface temperature of the Earth

4 Additional Resources



If you or your students would like to explore the topic further, these additional resources will be useful.

1. Reading

A reading, "Energy Balance and Planetary Temperatures", from the American Chemical Society (ACS):
<https://www.acs.org/content/acs/en/climatescience/energybalance.html>

2. Reading

A reading, "A Single-Layer Atmosphere Model, How Atmospheric Warming Works", from the American Chemical Society (ACS):
<https://www.acs.org/content/acs/en/climatescience/atmosphericwarming/singlelayermodel.html>

3. Micro-lecture (video)

A micro-lecture (video), "Our First Climate Model Naked Planet", from David Archer, the University of Chicago:
http://www.kaltura.com/index.php/extwidget/preview/partner_id/1090132/uiconf_id/20652192/entry_id/1_9fnkm5sc/embed/auto?

4. **Micro-lecture (video)** A micro-lecture (video), “Energy Balance with a Greenhouse Atmosphere”, from David Archer, the University of Chicago:
http://www.kaltura.com/index.php/extwidget/preview/partner_id/1090132/uiconf_id/20652192/entry_id/1_znqmr7tt/embed/auto?
5. **Visualization** A visualization tool, “Planetary Energy Balance”, from UCAR Center for Science Education:
<https://scied.ucar.edu/planetary-energy-balance>

5 Credits/Copyrights

All the teaching tools in our collated list are owned by the corresponding creators/authors/organizations as listed on their websites. Please view the individual copyright and ownership details for each tool by following the individual links provided.

We have selected and analyzed the tools that align with the overall objective of our project and have provided the corresponding links. We do not claim ownership of or responsibility/liability for any of the listed tools.

1. **Visualization, “Blackbody Spectrum”** PhET Interactive Simulations, the University of Colorado Boulder

AND

Associated Activity, “Exploring Planck’s Law” National Science Teaching Association

2. **Classroom/Laboratory Activity, “The Layer Model Approximation to the Greenhouse Effect”** David Archer, the University of Chicago

3. **Additional Resources** [American Chemical Society](#);
 David Archer, the University of Chicago;

[UCAR Center for Science Education](#)