Lesson Plan Title: Sunlight to Populations

Teacher Name: Christopher Culver

School: Saint Joseph HS

Subject: Honors Physics

Grade Level: 11 and 12

<table>
<thead>
<tr>
<th>Problem statement, Standards, Data and Technology</th>
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</thead>
<tbody>
<tr>
<td><strong>Asking questions and defining problems</strong></td>
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<tr>
<td>Establish driving question for the lesson plan or define problem students will be solving.</td>
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<tr>
<td>Attach any documents used to establish the driving question or define the problem.</td>
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<tr>
<td>How many people can the earth support only using renewable resources?</td>
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</table>

| **Incorporating Next Generation Science Standards, Common Core, or State Standards** |
| State the standards that will be covered during this lesson plan. Include all standards which may apply (NGSS, Common Core, or State Standards). |
| Standards based on Diocese of Fort Wayne, Inc. school district HS Science Department Standards |
| - SWBAT ask questions and define problems (Practice 1). |
| | o Ask questions that arise from examining models or a theory to clarify relationships. |
| | o Analyze complex real-world problems by specifying criteria and constraints for successful solutions. |
| - SWBAT use mathematics, information and computer technology, and computational thinking (Practice 5). |
| | o Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations. |
| | o Use mathematical or computational representations of phenomena to describe explanations. |
| Physics Standards |
| P.2.4 Describe and quantify energy in its different mechanical forms (e.g., kinetic, gravitational potential, elastic potential) and recognize that these forms of energy can be transformed into one another and into non-mechanical forms of energy (e.g., thermal, chemical, nuclear and electromagnetic). |
| Obtaining and evaluating information | - Students will receive Day 1 worksheet (see attached).  
- Students will visit [http://www4.uwsp.edu/cnr/wcee/keep/Mod1/Flow/Index.htm](http://www4.uwsp.edu/cnr/wcee/keep/Mod1/Flow/Index.htm) to learn how sunlight energy is converted to food energy.  
- Students will research questions provided at the end of Day 2 (see attached). |
### Analyzing and interpreting data

**How will students be analyzing and interpreting the collected data?**

Students will collect data on the energy required for 5 human activities. They will evaluate how this energy usage reduces the number of people that the earth can support.

### Use of technology and software

**Indicate the type of technology and software students will be using in order to implement this lesson plan.**

- Calculator
- Laptops and internet to research on the web.
- Presentation software (Power Point, Prezi, etc.)

### Collaboration, critical thinking and communication

#### Collaboration

**Indicate how students will be collaborating during the implementation of the lesson plan**

Students will work in their lab groups to complete assignment. Groups will submit a common answer to the Day 1 worksheet and will present a group presentation to the class on Day 5 answering the questions on the Day 2 handout.

#### Critical Thinking

**How will the students evaluate the question or defined problem to reach an objective conclusion? How will the students being using the learned content and collected data to be able to critically think about the established question and/or problem on this lesson plan?**

Once students determine the number of people the earth can sustain using their calculations, they will evaluate the relative impact of various human activities on the total energy available to the human population.

#### Communication

**How will the students communicate their findings and conclusion regarding the**

Each team will present a written summary of their Day 1 assumptions and calculations for the initial assessment of how many people the earth can support. Top ten ideas from [http://www4.uwsp.edu/cnr/wcee/keep/Mod1/Flow/Index.htm](http://www4.uwsp.edu/cnr/wcee/keep/Mod1/Flow/Index.htm) will be submitted individually and graded.
established question and/or problem? | The second step of evaluating the energy impact of their common energy uses will be presented to the class in 7-9 minute presentation to the rest of the class.

<table>
<thead>
<tr>
<th>References</th>
</tr>
</thead>
</table>
| **Teacher’s References**  
Include all references used to develop and implement this lesson plan. | - [http://www4.uwsp.edu/cnr/wcee/keep/Mod1/Flow/Index.htm](http://www4.uwsp.edu/cnr/wcee/keep/Mod1/Flow/Index.htm)  
- Prentice Hall *Earth Science* by Tarbuck and Lutgens. 2006 edition. (for deeper understanding of how energy is used in food production).  
- [https://www.soinc.org/fermi_questions_c](https://www.soinc.org/fermi_questions_c) (for information on Fermi Type questions) |

| **Student’s References**  
Include all references students will need to complete this lesson plan. | Students will be doing research using their own websites.  
Teachers may make recommendations on websites which might include  

<table>
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| **Assessment Plan**  
How will the students be assessed during and/or at the end of the lesson plan? | Students will be graded for completion on the sunlight to populations estimate form the first day.  
The major grade will be their group presentation on Day 4.  
Questions from the assignment will show up on the Energy Test which will take shortly after this assignment is completed.  
Include resources that will be used to assess the students for the lesson plan. |
Resources and Costs

<table>
<thead>
<tr>
<th>Resources Needed</th>
<th>Calculator</th>
<th>Laptop</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>List all the resources needed (equipment, facilities, materials or any other resources).</td>
<td></td>
<td></td>
<td>No costs.</td>
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</tbody>
</table>

Costs
List the estimated cost of implementing this lesson plan.

Include all costs related to equipment, materials and any resource critical to the implementation of the lesson plan.

Implementation Plan

Implementation Plan Timeline
Establish the timeline to implement the lesson plan.

Provide an estimate of time and days in order to complete the lesson plan.

Day 1
Start out by asking students if the world is over populated. Discuss what this might mean. The conversation will eventually lead to the question of how many people the earth can support.

At this point, introduce the problem of transforming sunlight energy into an average consumption of 2000 cal per day per person. Groups will be directed to answer the problem using a Fermi question type-approach. They will be told to make prudent assumptions and reasonable estimates and that there is no pure correct answer to the project.

The Day 1 worksheet will be provided as a guide after the students have spent 10 minutes discussing the question in their groups.

Day 2
Teach will present a solution to the whole class.
Conduct a discussion on why producing other using energy for uses other than food will reduce the total sustainable population. After the discussion, groups will receive the Day 2 handout and begin preparing their presentation.

**Day 3**  
Workday in class.

**Day 4**  
Workday in class.

**Day 5**  
Student will present presentations to the class.

**Day 5.5**  
In their groups, student will spent 15 minutes discussing another group’s assumptions; noting similarities and differences with their approach. (This section will be ungraded). Groups will share their top observation with the class.
Think about all of the types of forms of energy that we use.

**Assuming that a human needs eat only 2000 calories per day to live, how many people can the sunlight reaching the earth support?**

Of course this estimate doesn’t account for the energy required to drive our cars, power our electrical devises, keep us warm and cool and actually cook our food. Doing all of these things reduced the energy available for food production!

Visit [http://www4.uwsp.edu/cnr/wcee/keep/Mod1/Flow/Index.htm](http://www4.uwsp.edu/cnr/wcee/keep/Mod1/Flow/Index.htm) to help you understand how sunlight is converted to food.

**What’s your estimate? Here’s a possible process to think it through ....**

To answer these questions you will need to use:

- The Information Sheet provided at the end of this packet.
- Information from [http://www4.uwsp.edu/cnr/wcee/keep/Mod1/Flow/Index.htm](http://www4.uwsp.edu/cnr/wcee/keep/Mod1/Flow/Index.htm)
- Energy concepts covered in class.

**Fact:** the average amount of energy received at ground level from the sun at the zenith (pointing straight down) is 1004 watts per square meter

Square meters of earth getting zenith sun _________________.

(explain your assumptions to get this value)
% of the earth that is land _______________. (look it up if unknown)

% of the earth that is sea _______________. (look it up if unknown)

Square meters of land getting zenith sun ________________ (calculate using above values)

Square meters of sea getting zenith sun ________________ (calculate using above values)

Total sun energy hitting land every day ________________ (calculate using above values)

Total sun energy hitting the sea in a day ________________ (calculate using above values)
Now think about how this **sun energy** is converted to **food energy**.


**Process for the sea** (Use the information from [http://www4.uwsp.edu/cnr/wcee/keep/Mod1/Flow/Index.htm](http://www4.uwsp.edu/cnr/wcee/keep/Mod1/Flow/Index.htm) to fill out the chart and then calculate the overall efficiency of getting food from the sea.)

<table>
<thead>
<tr>
<th>Organism</th>
<th>Process of conversion</th>
<th>Efficiency</th>
<th>Left over energy is converted into...</th>
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<tbody>
<tr>
<td>Phytoplankton</td>
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<tr>
<td>Tropic Level 3 (small fish)</td>
<td>Eating Phytoplankton</td>
<td></td>
<td>• Heat</td>
</tr>
<tr>
<td>Tropic Level 4 (bigger fish)</td>
<td></td>
<td></td>
<td>• Motion</td>
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<tr>
<td>Tropic Level 5 (human food intake energy. i.e. what’s on the food packaging label)</td>
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<td></td>
<td>• Forming body parts</td>
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<tr>
<td>Overall Efficiency for the sea.</td>
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</tbody>
</table>
**Process for land** (Use the information from [http://www4.uwsp.edu/cnr/wcee/keep/Mod1/Flow/Index.htm](http://www4.uwsp.edu/cnr/wcee/keep/Mod1/Flow/Index.htm) to fill out the chart and then calculate the overall efficiency of getting food from land.)

**NOTE:** You do not need to use all of the squares.

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**Estimate the % of the earth’s available land that produces food**

__________________________  (make an educated guess – what criteria did you use?)
Estimate the % of the earth’s available of sea that produces food
________________________ (make an educated guess – what criteria did you use?)

Calculate the maximum amount of human food energy (in joules) available to the earth in one day. (Assume a 100% efficiency in gathering food … which of course is not realistic.)

HINT: Value for the Sea + Value for the Land

Remember that Energy = Power times Time

Label and show all of your calculations
Convert 2000 Nutritional Calories per day to joules per day.

How many people (maximum) can the earth sustainably support? (assuming we get really good at growing food and harvesting the sea)

Submission

1. One copy of this worksheet from your group will be submitted for a HW grade.
2. Individually each member will submit a List of 10 Key Ideas learned from the Website: http://www4.uwsp.edu/cnr/wcee/keep/ModI/Flow/Index.htm for a grade.
   Submit to www.turnitin.com.
Information Sheet

Radius of the Earth = 6,371 kilometers

1 Nutritional Calorie = 1000 cal

1 cal = 4.18400 Joules

\[
Power = \frac{\text{Change in Energy}}{\text{Time}} = \frac{W}{\Delta t}
\]

\[
I = \frac{\text{Power}}{\text{Area}} = \frac{P}{4\pi r^2}
\]

\[
e = \frac{w_0}{w_i}
\]
Prepare a 7-9 minute presentation that answers the following questions.

1. Research 5 non-food uses of energy in our society/world.
   - Calculate how many less people will be able to live on earth because we use this energy?
   - Show and explain all of your assumptions.
   - Show and explain all of your calculations.
   - For this portion of the assignment students will assume that all electrical energy comes form solar cells and all liquid forms of energy (for example gasoline) comes from a bio fuels.
     Web research will be required to determine how much energy is derived from solar cells and you bio fuel.

2. Pick your Highest and Lowest energy usage from step #1.
   For both of these, answer the following questions.
   - What human need is met by its usage?
   - How important is this energy usage to quality of life?
   - List and explain three ways we could reduce the energy needed to meet this human need?
   - List and explain three concerns that could impact how we meet this human need.

3. We need to move to more renewable sources of energy.
   Investigate how one type of renewable energy is extracted from the environment.
   - Provide a brief description of the steps involved.
   - Show the efficiency on all energy conversions as appropriate.
   - Derive five important implications from your research (impact to humans or the environment etc.)