Solar Energy Transfer

ENSC 162 Solar Energy Lab

Purpose of the experiment

- Explore the principle of the transfer of heat energy from the sun.
- Compare and contrast different material for capturing solar energy.
- [fyi]

[fyi] Ketchup was sold in the 1830s as medicine.

Table of Contents

Equipment List

- Solar Energy transfer box
- Digital multimeter
- Ring stand
- Banana cables
- Stopwatch
- Sunny day! ☺

Background

The Energy Transfer-Solar box can be used for demonstrating the concept of solar heating, including the greenhouse effect. The clear, plastic cover snaps onto the Solar box and acts as an insulator to isolate and trap air inside, reduce convection currents, and demonstrate the greenhouse effect. The cover is very transparent to visible light but not infrared light. The aluminum plate is painted a non-reflective flat black that absorbs light very well. The hot aluminum plate re-radiates in the far infrared region, and thus the heat energy is trapped under the cover. The reverse side of the aluminum plate is not painted. The plate can be flipped inside the box to study differences in solar heating and/or cooling between the aluminum and black surfaces. The aluminum plate can be removed to measure its mass. The white, plastic knob also serves as an indicator for the sun's angle. When the sun is perpendicular to the aluminum plate, no indicator shadow appears on the plate. The Solar Box holds the aluminum plate and plastic cover. On the side of the box is a rod clamp for mounting the box to a rod stand. When mounted to a rod stand, the box can be adjusted to the sun's angle. Inside the Solar Box is a 10K thermistor for measuring temperature. The thermistor cables are not removable from the box. The thermistor contact (metal lug) is fastened in the center, on the underside of the aluminum plate. The side jacks on the Solar Box allow you to connect an ohmmeter; the resistance of the thermistor is proportional to the temperature.

The Lab

Equipment Setup

1. Remove the thumbscrew on the aluminum plate. Place the thermistor lug underneath the center hole on the aluminum side of the plate. Insert the thumbscrew through the hole. On the black side, put the shadow indicator over the screw and tighten (See Figure 1).

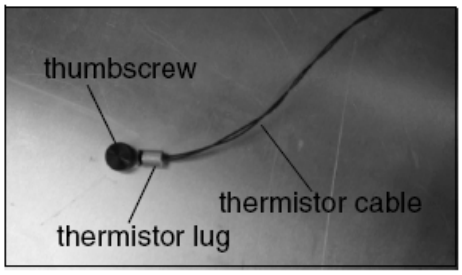


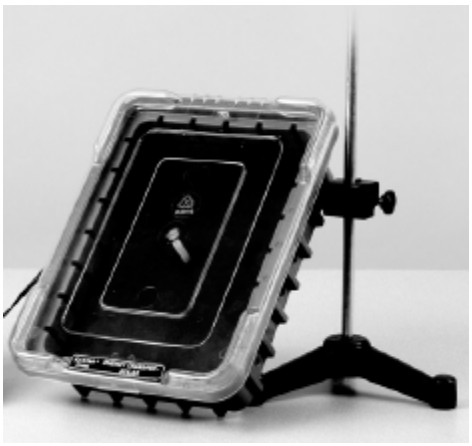
Figure 1: Thermistor position

2. Place the aluminum plate inside the Solar Box, with the black side face up. (**Note:** Keep the thermistor contact on the underside of the plate.)

3. Snap the bottom and top tabs of the clear, plastic cover onto the Solar Box.

4. Connect the Temperature Sensor outputs using banana cables to the digital multimeter (make sure the meter is set to record resistance (Ω)) Figure 2.

5. Use the rod clamp (on the side of the Solar Box) to mount the base of the Solar Box to a rod stand (Figure 3).



6. Adjust the angle of the box such that the sun's rays enter the box perpendicularly. Use the white knob indicator as a guide.

   Note: If there is no shadow on the plate, the sun's rays are perpendicular to the plate.

WARNING: *To avoid burns or bodily injury, when heating the box, do not overheat the box (above 100ºC) and do not touch either side of the aluminum plate or the thermistor contact.*

CAUTION: *Overheating the box may permanently damage the thermistor and the plastic lid. The thermistor's maximum temperature capacity is 135ºC.*

7. If you are using an ohmmeter, turn on the meter and take a resistance measurement. To find the temperature, use the resistance-to-temperature conversion chart in Appendix A.

Experiment #1 – Solar Heating and the Greenhouse Effect

Part I - Solar Heating

1. Mount the box with plate to a rod stand, such that the Sun's angle is perpendicular to the aluminum plate and the white plastic knob has no shadow. Keep the black side of the aluminum plate facing up (See Figure 4).

Figure 4: Setup for Solar Heating Experiment

2. Have a piece of cardboard available to shade the box while setting up.

3. With the plastic cover on, remove the cardboard cover and begin collecting data. Record the temperature every 30 sec.

4. Let the box heat until the temperature levels off. (The approximate duration is 10 to 30 minutes, depending on the outside temperature and the intensity of the sunlight.)

   Note: Watch the angle of the sun. *The angle of the sun must be 90 degrees to the box while you are collecting data.* You might have to adjust the angle of the box during the run.

5. Replace the cardboard shade over the plate and allow it to cool off. Monitor the temperature wait until it returns to ambient temperature.

6. Repeat step 1-5 with the plastic cover off.

Part II - Solar Heating Comparison: Aluminum vs. Black Surface

- Compare the aluminum side up to black side up with the cover on.

- Repeat the steps above with the shinny aluminum side facing the sun. You will have to move the thermistor to the black side (Step 1 of the Equipment Setup).

- Repeat Steps 1-5 of Part I, and record the temperature of the Aluminum plate with the cover on.

Data Table

Black side - Cover ON		Black side - Cover OFF		Al side - Cover ON	
Time	**Temp (°C)**	**Time**	**Temp (°C)**	**Time**	**Temp (°C)**

Data Analysis

1. Look carefully at both curves at the start of the run. The slope (rate of heating) for the uncovered box should be larger than for the covered box. Why?

2. Which has the highest final temperature, the covered box or the uncovered box? Why?

3. Which curve has a more constant heating rate? Why?

4. Which surface is a better absorber of energy? Explain.

Appendix A: Resistance/Temperature Conversion Table

Resistance (Ohms)	Temperature (Celsius)	Resistance (Ohms)	Temperature (Celsius)	Resistance (Ohms)	Temperature (Celsius)
32,660	0	**6,808**	34	**1,876**	68
31,040	1	**6,532**	35	**1,813**	69
29,500	2	**6,268**	36	**1,751**	70
28,060	3	**6,016**	37	**1,693**	71
26,680	4	**5,776**	38	**1,637**	72
25,400	5	**5,546**	39	**1,582**	73
24,180	6	**5,326**	40	**1,530**	74
23,020	7	**5,118**	41	**1,480**	75
21,920	8	**4,918**	42	**1,432**	76
20,880	9	**4,726**	43	**1,385**	77
19,900	10	**4,544**	44	**1,341**	78
18,970	11	**4,368**	45	**1,298**	79
18,090	12	**4,202**	46	**1,256**	80
17,260	13	**4,042**	47	**1,216**	81
16,460	14	**3,888**	48	**1,178**	82
15,710	15	**3,742**	49	**1,141**	83
15,000	16	**3,602**	50	**1,105**	84
14,320	17	**3,468**	51	**1,071**	85
13,680	18	**3,340**	52	**1,038**	86
13,070	19	**3,216**	53	**1,006**	87
12,490	20	**3,098**	54	**975**	88
11,940	21	**2,986**	55	**945**	89
11,420	22	**2,878**	56	**916**	90
10,920	23	**2,774**	57	**889**	91
10,450	24	**2,674**	58	**862**	92
10,000	25	**2,580**	59	**836**	93
9,574	26	**2,488**	60	**811**	94
9,166	27	**2,400**	61	**787**	95
8,778	28	**2,316**	62	**764**	96
8,408	29	**2,234**	63	**742**	97
8,058	30	**2,158**	64	**720**	98
7,722	31	**2,082**	65	**699**	99
7,404	32	**2,012**	66	**679**	100
7,098	33	**1,942**	67		