WS2
WOMEN SUPPORTING
WOMEN IN THE SCIENCES

Training for Educators
Energy Transfer

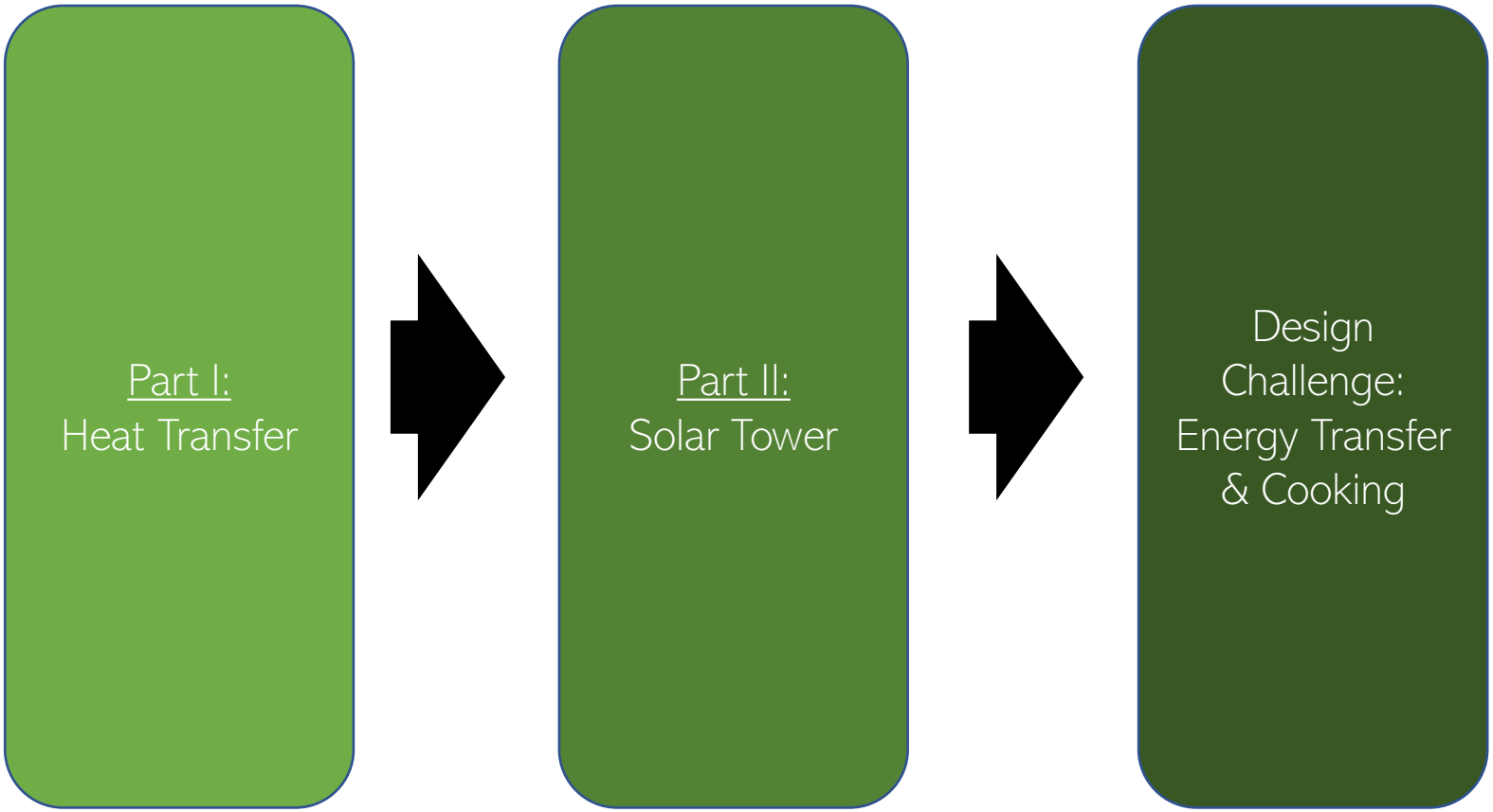
Secondary Level

Ages 12-18

Mission of the lab

- This laboratory will teach energy transfer concepts related to energy transformation, energy conservation, and thermodynamics.
- The main takeaways are:
  - Heat transfer occurs when heat flows from a hot object to cooler object via conduction.
  - Energy can be transformed to different forms and manipulating the material can influence how well the energy can be transferred.
  - The ways heat or energy are transferred within the solar tower can help students identify how to link these concepts to real world applications, like cooking.

Summary of experiments



There are 2 experiments in total.

Supplies list

- 1 plastic/Styrofoam cup
- 1 metal can (empty and clean)
- 1 paper cup
- Water, chilled or cool, enough to fill cups/cans
- Optional: thermometer
- Optional: 1 additional metal can, black paint, paintbrush
- 3 metal cans (should be empty and clean, with the top and bottom removed)
- Tape
- 15 cm (~6 inches) of wire
- 1 needle/pin/thumbtack (alternative: sharpened pencil)
- 13x13 cm (~5x5 inch) piece of paper
- 2 books (alternative: any two items of the same height that can be used as a platform to rest the tower on)
- Scissors
- Optional: black paint and paintbrush

Safety considerations

- The needle/pin/thumbtack used can be sharp, so students should use caution when handling it so they do not accidentally prick themselves.
- Cutting the bottom and top of the metal cans can also be dangerous. Take caution if using a sharp razor.
  - It is recommended that the teacher or facilitator perform this task for students ahead of time, if possible.
  - Instead of a razor, teachers can use a can opener to remove the top and bottom of the cans or try another metal can, like aluminum, that is easier to cut.

Setting up your space

- Gather your supplies and separate by experiment(s) on your table.
- These are our recommendations:
  - Every student should have a pencil or pen. Manuals can be printed for all students or shared by small groups.
  - Part I – metal can, plastic/Styrofoam/ceramic cup, paper cup, water
    - Try to use similarly sized cups/cans and place cups/cans in the sunlight to heat up
    - Place water for class (it does not need to be potable) in the shade or a cool location
  - Parts II – 3 metal cans, 1 piece of 15 cm wire, one thumbtack/pin/needle, 1 piece of paper, 2 books, and tape
    - Remove the tops and bottoms of metal cans to be used (use caution with razor or other tool)
    - Cut wire into 15 cm (~6 inch) strips
    - Cut paper into 13x13 cm (~5x5 inch) squares

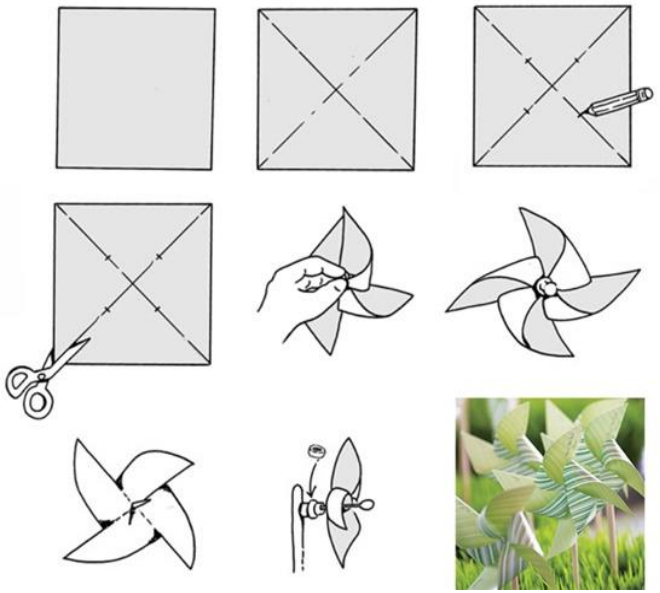
Part I: Heat Transfer

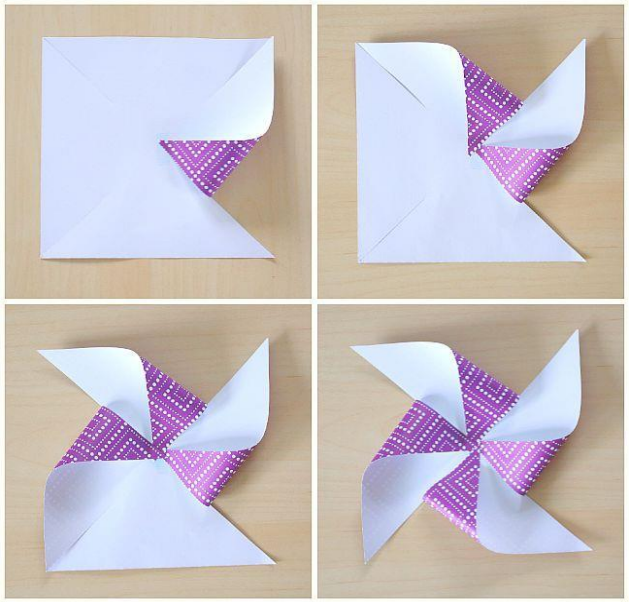
- Set-up:
  - Each group (2-4 students) will need three different cups filled with water: one plastic/styrofoam, one paper, and one metal. If other materials are available, the students can use those but you need at least one metal cup.
- Procedure:
  - The students will work together to measure the temperature of the water at the beginning of the experiment – before the cups sit in the Sun - and after the cups sit in the Sun for various time points.
- Results
  - Students will notice that the temperature changes most for the water in the metal cup and least for plastic.
- The takeaway is that different materials transfer heat better than others. Metals are conductors and can heat up water faster than plastics, which are insulators.

Part II: Solar Tower

- Set-up:
  - Each group (2-4 students) will need 3 metal cans, 1 piece of 15 cm wire, one thumbtack/pin/needle, 1 piece of paper, 2 books, and tape.
- Procedure:
  - The students should assemble the solar tower, including folding a pinwheel (see figures in the next two slides).
  - Upon assembling the solar tower with the freely spinning pinwheel, the students should place the tower in the Sun.
- Results:
  - Students should see that the Sun heats up the air inside the tower, which causes an updraft that turns the pinwheel.
- The takeaway is there are several forms of energy at play in this experiment: solar energy (sunlight), thermal energy (heat), and kinetic energy (spinning pinwheel). The radiative sunlight contacted the solar tower and some of this heat was absorbed, causing it to heat up. The heated air inside the tower rose, creating an updraft which caused the pinwheel to spin. Energy was not created or destroyed because of conservation of energy; instead, it was transformed between several forms.

Part II: Solar Tower





The pinwheel needs to be folded following this diagram. Assuring the paper is a true square is important to make the pinwheel.

Part II: Solar Tower

a)

b)

c)

Assembling the solar tower requires tape and the 3 metal cans for each group. The top and the bottom of each can should be removed prior to the lesson, since you will tape each of the cans together (as shown in a and c). You then place the three taped cans (i.e., tower) on top of two books as shown in a. The last part is using a wire and a thumbtack to hold the pinwheel, shown in b. Then carefully place the middle of the pinwheel on the thumbtack, do not push the thumbtack all the way through the pinwheel. The pinwheel should freely spin if you blow on it.

Part II: Solar Tower (Extension)

a) 

b) 

c) 

Once the students have an initial tower, they are encouraged to change aspects of it to see how it influences how fast/slow the pinwheel spins. The students can change the: height of the books, the color of the tower, the size of the pinwheel, etc. The students can be creative and the biggest point is to observe how the changes influence how fast the pinwheel turns.

Design challenge

- Background
  - Students are asked to design a solar cooker using what they have learned in the two experiments. The students can use heat transfer, energy transformations, etc. to determine different ways to make a cooker. Solar is the example given, but they could be creative in what source they use – the challenge is their design must include at least one energy transformation.
- Questions to ask the students
  - If you were going to design a way to cook food, how would you build it? Did the previous experiments show ways that energy can be transferred in order to cook food?
  - What other information do you need to know in order to design your cooker?

Troubleshooting

- For Part II: Here are a few tips for getting the solar tower to work well:
  - Make sure there are no gaps in between cans.
  - There should be a small gap in between the two books.
  - Pinwheel should be lightly resting on top of the thumbtack. If the pinwheel can't stay on the thumbtack, make a slight indentation in the center of the pinwheel (this will allow the pinwheel to balance better on the thumbtack). The thumbtack should not be pushed through the pinwheel.
  - If it is a cold day or not very sunny, it may take some time for the pinwheel to turn, so be patient.