



# Purpose & Hypothesis

## **Purpose:**

Which household-material design keeps an enclosed space the coolest over time without electricity?

## **Hypothesis:**

If four boxes (plain cardboard, aluminum foil-covered, Styrofoam-covered, and wet paper towel covered) are tested under the same heat source, then the wet paper towel box will stay the coolest due to evaporative cooling.

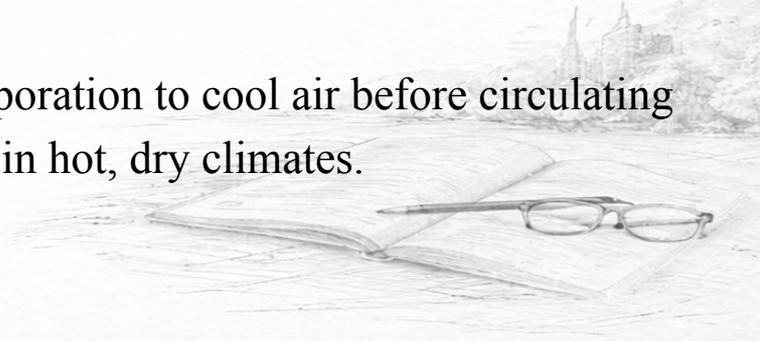
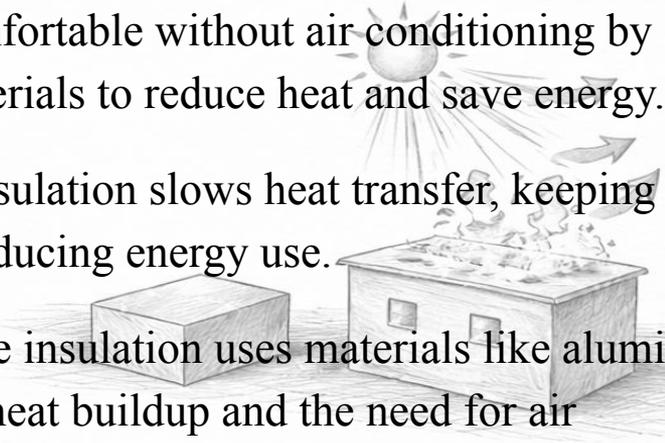
# Research

**Passive Cooling:** Passive cooling keeps buildings comfortable without air conditioning by using shade, insulated, evaporative, and reflective materials to reduce heat and save energy.

**Insulated Cooling (Thermal Insulation):** Thermal insulation slows heat transfer, keeping buildings cool in summer and warm in winter while reducing energy use.

**Reflective Cooling (Reflective Insulation):** Reflective insulation uses materials like aluminum to reflect sunlight away from roofs or walls, reducing heat buildup and the need for air conditioning.

**Evaporative Cooling:** Evaporative cooling uses water evaporation to cool air before circulating it through a building. It uses less electricity and works best in hot, dry climates.



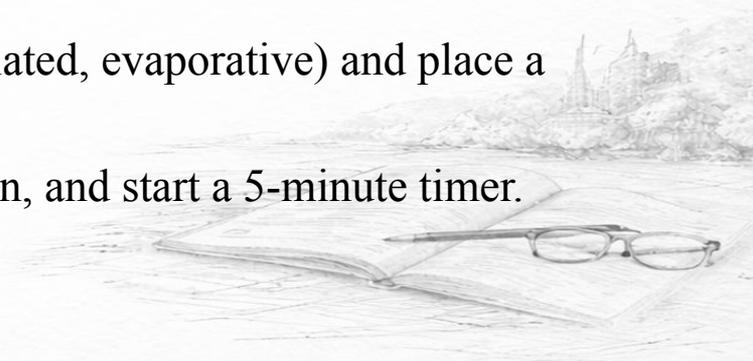
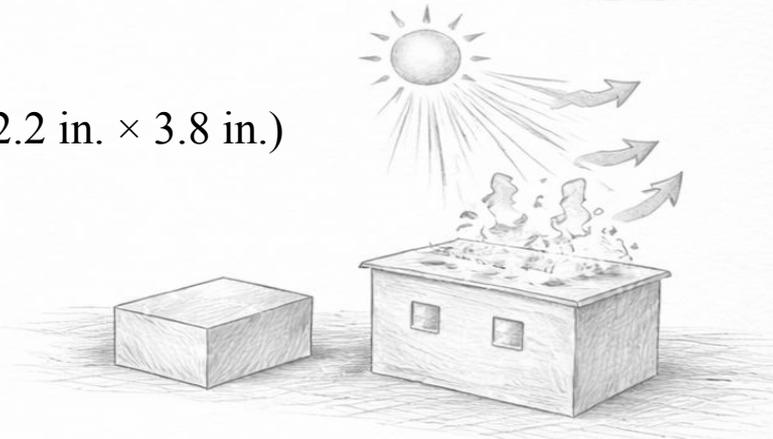
# Materials & Procedures

## Materials:

- 4–5 identical small cardboard boxes (7.5 in. × 12.2 in. × 3.8 in.)
- Aluminum foil, Styrofoam, Paper towels
- Thermometer (digital is best, but any works)
- Oven set to 37°C or 98.6°F and a 5-minute timer

## Procedures:

1. Prepare four box conditions, (control, reflective, insulated, evaporative) and place a thermometer in each; starting temperature 23 °C.
2. Place boxes in an oven set to 37 °C / 98.6 °F, turn it on, and start a 5-minute timer.
3. Record the temperature of each box.



# Results & Data

- Insulated: lowest (24.33...°C)
- Evaporative: second (25.0°C)
- Reflective: moderate (28.66...°C)
- Control: highest (30.5°C)

In all three trials, the insulated box remained the coolest. The evaporative box also reduced temperature but was less effective than insulation, while the reflective box showed only a small cooling effect.

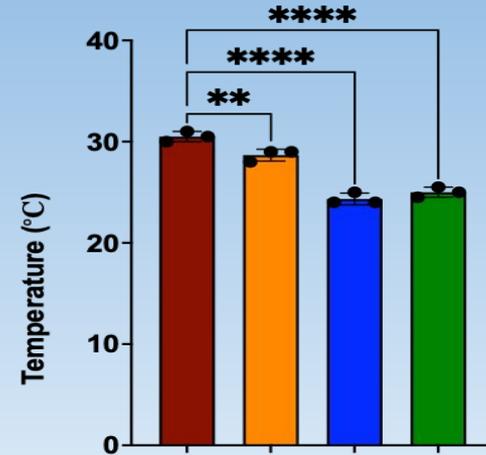
T-tests comparing each design to the control produced all p-values below 0.05, the differences were statistically significant. Overall, insulation was the most effective passive cooling method tested.

Trial	Control	Reflective	Insulated	Evaporative
1	31.0	29.0	24.0	25.0
2	30.0	28.0	24.0	25.5
3	30.5	29.0	25.0	24.5
Average =	30.50	28.67	24.33	25.00
Std. Dev. =	0.35355	0.70711	0.70711	0.70711
T-Test (P value) =		0.01478	0.00017	0.00018

# Graphs & Pictures



Effect of Different Coverings on Temperature



■ Control ■ Reflective ■ Insulated ■ Evaporative

The starting temperature is the same for all four groups: 23°C

Data are mean  $\pm$  SD ( $n = 3$  trials); \*\* $p < 0.01$ , \*\*\*\* $p < 0.0001$ .

# Conclusion

In conclusion, this experiment tested which household-material design could keep an enclosed space the coolest without electricity. Although I predicted evaporative cooling would perform best, the insulated box had the lowest average temperature at 24.3°C.

This shows that reducing heat transfer through insulation is more effective in a closed, heated environment than relying on reflection or evaporation. The evaporative design was limited by low airflow, while the reflective box reduced some radiant heat.

Overall, these results demonstrate that insulation is a highly effective passive cooling strategy in a closed, heated environment and that simple, affordable materials can significantly reduce heat gain and support sustainable cooling solutions.

# What I Learned & Real World Impact

I learned that insulation can be more effective than evaporative cooling in enclosed environments. While evaporative cooling works well in dry, open-air conditions, it depends on airflow, which was limited in this experiment.

I also learned how heat transfers through conduction, convection, and radiation, and how different materials reduce heat in different ways.

Additionally, I used averages and statistical testing (ANOVA) to determine whether my results were scientifically significant.

Overall, this project shows that simple, low-cost materials can reduce heat gain without electricity, which could help improve sustainable cooling solutions, especially in hot climates or areas with limited access to power.

# What I Would Improve & Future Engineering Design



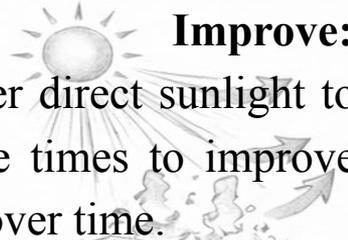
**What**

**I**

**Would**

**Improve:**

If I continued this project, I would test the designs outdoors under direct sunlight to better measure radiant heat. I would also repeat the experiment more times to improve reliability and collect data over a longer period to observe performance over time.



**Future**

**Engineering**

**Design:**

Future designs could combine insulation, reflective materials, and evaporative cooling to create hybrid passive cooling systems. These systems could be used in buildings in hot climates to reduce indoor temperatures without electricity.



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