Materials ScienceExploration - Challenge n°2 - 40'

COOL ROOFS: PAINT IT COOL!

Rising energy costs, pronounced urban heat-island effect and global warming, increase the need for intelligent solar heat management solutions such as cool paints. Roughly 50 % of solar radiation are absorbed at the Earth's surface. Black surfaces usually absorb up to 90 % of this energy and therefore get hot. White surfaces, on the other hand, absorb only up to 25 % and tend to stay much cooler. The impact in building can be dramatic. It's a well known experience that rooms directly under the roof become suffocating and stuffy. Cool paints may help in that.
But white is not always an option, much more often colour and especially dark shades are desirable (like in cars) or even required. Cool roof paints have a very high reflectance together with a high emissivity.

On the desk you have a model village with 4 houses. Their roofs have been painted with different colours.
Q1. Which house do you think will reach the highest temperature inside if exposed to light/IR? Which one the lowest? Why?
Q2. Take a picture with the thermal camera of the four roofs BEFORE switching on the light. What do you observe? Can you explain it?

At your disposal you have:

- 4 sensors:
  a. a temperature probe (placed under the roof - inside) - **Arduino1**
  b. a surface temperature probe (placed on the roof - outside) - **Arduino2**
  c. 2 IR contactless temperature probes (a little over the roof, one directed upward, measuring IR incoming radiation on the roof; the second directed downward, measuring IR outgoing radiation from the roof, both reflected and/or emitted) - **Arduino2**
  [*NOTE: they should measure temperature, but actually they do this by measuring IR radiation: so, by dividing the two measures, we will get the (percent) ratio between outgoing and ingoing IR radiation – doing so we don't have to care about unit of measure*]
- Arduino connected with the four sensors: you can read the measures of the four sensors on the serial monitor of Arduino on the PC connected to them (time sampling is set on 1 sample/5 sec)

A Choose one roof, position the halogen lamp focusing on it (this will be our "sun") and:
1. Write down the (initial) temperature both inside and outside;
2. Write down the measures of the IR probes, both upward and downward;
3. Switch on the light and leave it on for exactly 5 minutes;
4. During the illumination time (let's say approximately at half the time) write down the measures of the IR probes, both upwards and downwards;
5. Just before switching off the light, write down the (final) temperature, both inside and outside;
6. Just after having switched off the light (it will be our "night"), write down the measures of the IR probes, both upwards and downwards;

B Fill in the Table (on the Answer sheet) with all the data collected and do the requested calculation.
C Repeat experiment A (from point 1 to 6) for the other roofs.

Warning:

- *BE SURE that the distance from the lamp and the roof is the same during all 4 Data Collections!*
- *During each measurement be sure that light DO NOT fall on the other "houses" that you are not testing (otherwise they will warm up!): protect them from incident light with a cardboard.*

Q3. After you have completed the test with all 4 houses, can you tell which/which ones are "cool paints"? Why? Justify your answer basing on the collected data.

☞ **OUTPUT WANTED : Answer to Q1 ... Q3 + Data Tables + 1 photo of apparatus and/or detail**

 Funded by EU under the Erasmus+ KA2 grant N° 2014-1-IT02-KA201-003604_1.

Answer sheet

GROUP N°___________

COOL ROOFS: PAINT IT COOL!

Q1

Q2

House n.	**Colour and texture of roof:**				
	T inside	**T outside**	**IR incoming**	**IR outgoing**	**R% = IR_{out}/IR_{in} 100**
Initial ->T_i *[Before lightening]*					
[During lightening]	###	###			
Final ->T_f *[Just **before** turning light off]*			###	###	###
Final *[Just **after** turning light off]*	###	###			
Temperature change **$\Delta T = T_f - T_i$**			###	###	###

House n.	**Colour and texture of roof:**				
	T inside	**T outside**	**IR incoming**	**IR outgoing**	**R% = IR_{out}/IR_{in} 100**
Initial ->T_i *[Before lightening]*					
[During lightening]	###	###			
Final ->T_f *[Just **before** turning light off]*			###	###	###
Final *[Just **after** turning light off]*	###	###			
Temperature change **$\Delta T = T_f - T_i$**			###	###	###

 Funded by EU under the Erasmus+ KA2 grant N° 2014-1-IT02-KA201-003604_1.

Answersheet

GROUP N°___________

COOL ROOFS: PAINT IT COOL!

House n.	**Colour and texture of roof:**				
	T inside	**T outside**	**IR incoming**	**IR outgoing**	**R% = IR_{out}/IR_{in} 100**
Initial ->T_i *[Before lightening]*					
[During lightening]	###	###			
Final ->T_f *[Just* ***before*** *turning light off]*			###	###	###
Final *[Just* ***after*** *turning light off]*	###	###			
Temperature change $\Delta T = T_f - T_i$			###	###	###

House n.	**Colour and texture of roof:**				
	T inside	**T outside**	**IR incoming**	**IR outgoing**	**R% = IR_{out}/IR_{in} 100**
Initial ->T_i *[Before lightening]*					
[During lightening]	###	###			
Final ->T_f *[Just* ***before*** *turning light off]*			###	###	###
Final *[Just* ***after*** *turning light off]*	###	###			
Temperature change $\Delta T = T_f - T_i$			###	###	###

Q3

PICTURES ***[Sent by Whatsapp to your group – See general instruction to share pictures or files]***

- **Pictures description:**

agenzia per l'energia e lo sviluppo sostenibile

Co-funded by the Erasmus+ Programme of the European Union

This project has received funding from the European Union's Erasmus + Programme for Education under KA2 grant 2014-1-IT02-KA201-003604. The European Commission support for the production of these didactical materials does not constitute an endorsement of the contents which reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

