We are used to seeing the world around us in visible light. However, there are many other types of light, including x-rays, gamma rays, ultraviolet, infrared, microwaves and radio waves, which we cannot see with our eyes. Each of these types of light gives us a unique view of the world around us. Infrared is emitted by any object which has a temperature. Infrared images give us special information that we cannot get from visible light pictures. In these lessons a special infrared camera was used to create infrared images which will be used to help students learn about infrared light. Infrared images of everyday objects will provide students with a unique and interesting view of the infrared world.

In this lesson:
Learners investigate and discuss infrared images of various day-to-day objects like toasters, hairdryers, and running water to learn about infrared imaging technology and infrared images.

Brought to you by:

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I. GENERAL INFORMATION

Title: Exploring Infrared Image Technology

Brief Description: Learners investigate and discuss infrared images of various day-to-day objects like toasters, hairdryers, and running water to learn about infrared imaging technology and infrared images.

Primary Goal: Use these activities to introduce learners to infrared imaging technology and the information that such images contain. Observation, compare and contrast, and reasoning skills are emphasized.

Activity Description: Learners are presented with infrared images of a blowing hairdryer, a popsicle, and a toaster. Their questions about the false-color images help lead a discussion about "what they are" and how they are different than visible light images. With the help of the ***Background Knowledge and Resources for the Instructor*** section, found in Section II (Getting Ready) of this lesson, a brief instructor presentation is given on infrared images, false-color maps, and infrared image technology. The lesson concludes with learners investigating the differences between infrared and visible light images of cups of hot and cold water, a pair of shoes just after being worn, and hot and cold running water.

Learning Goals: This lesson serves as an introduction to infrared imaging and is integrated into all of the Infrared Zoo and Infrared Yellowstone lessons. At the conclusion of this exploration, your learners should understand the following:

- Infrared cameras can detect how much infrared light an object is emitting.
- Infrared images (like the ones here) show how much infrared light was detected by the camera. The infrared light can be used to measure the temperature of these objects. This measurement is transferred to color codes and is equivalent to degrees Fahrenheit.
- The image has been scaled to show the temperature of the various areas of the object using a false-color map.
- False-color maps, like the infrared images here, come with a legend that tells the observer which temperatures are associated with which colors. This is how someone can accurately interpret the image.
- By looking at or observing the images, one can determine warmer or cooler areas. One is unable to do this with visible light images.

Target Audience: grades 5-12

Teacher Preparation Time: 2-3 hours the first time, negligible time for subsequent use

Estimated Activity Time: 25-45 minutes

Materials Needed:

- Ability to download large files off the internet
- Ability to open, view, and print PDF files
- Ability to print in color (Resolution is at 72 dpi. PDF files are print-ready for any professional printing establishment (e.g., Kinko's or OfficeMax)
- Ability to laminate or otherwise protect printed images
- Optional: Internet ready classroom with projection unit
- Optional: Powerpoint presentation capabilities and projection unit
- Optional: Internet workstations for extension activities

Authors and Idea Makers:

The ideas presented in this lesson are the collaborative effort of the teachers in the *Invisible Universe Online* course during the Spring 2003 semester. This particular lesson has been organized and written by Adrienne

Gauthier (Instructional Technology Specialist, University of Arizona) with the help of Linda Hermans-Killam (Spitzer Science Center/Caltech) and Doris Daou (Spitzer Science Center/Caltech) This lesson has been evaluated by the Origins Education Forum at the Space Telescope Science Institute.

National Science Education Standards (NSES):

Changing Emphases (…More Emphasis On…)

The NSES envision change through out the system. Below are descriptions of how this lesson supports the changing emphases:

- Understanding scientific concepts and developing abilities of inquiry.
- Learning subject matter disciplines in the context of inquiry, technology, science in personal and social perspectives, and history and nature of science.
- Implementing inquiry as instructional strategies, abilities, and ideas to be learned.

Changing emphases to promote inquiry:

- Investigations over extended periods of time.
- Communicating science explanations.
- Doing more investigations in order to develop understanding, ability, values of inquiry and knowledge of science content.
- Public communication of student ideas and work to classmates.

Content Standard A: Science as Inquiry

5-8 *UNDERSTANDINGS ABOUT SCIENTIFIC INQUIRY*:

- Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects, organisms, or events; some involve collecting specimens; some involve experiments; some involve seeking more information; some involve discovery of new objects and phenomena; and some involve making models.
- Technology used to gather data enhances accuracy and allows scientists to analyze and quantify results of investigations.

II. GETTING READY

Pre-requisite Skills for Learners:

Your learners should have the following skills in order to participate efficiently and smoothly in this lesson:

- Ability to work in small collaborative groups of 3-4 students each
- Ability to work independent of direct instructor facilitation as the instructor will be wandering the classroom and helping all groups
- Ability to communicate findings, reasoning, and work to others
- Cognitive ability to recognize patterns that have not been introduced/explained before hand
- Prior experience with inquiry-based and explorative learning

Pre-requisite Content Knowledge for Learners:

Prior to this lesson, learners should be familiar with the following concepts:

- Temperature is a measure of the level of heat.
- Heat can move from place to place.
- (optional) Prior experience using color-coded or false-color maps (like meteorologist weather temperature maps used on the evening news)

Preparation Work for the Instructor:

1. Determine how you will present the images to your learners for these activities.
   - If projecting through a computer and internet connection, preload and bookmark pages you will need.

     a. Infrared Popsicle, http://coolcosmos.ipac.caltech.edu/image_galleries/popsicle.html
     b. Infrared Toaster, http://coolcosmos.ipac.caltech.edu/image_galleries/toaster.html
     c. Infrared Blow Dryer, http://coolcosmos.ipac.caltech.edu/image_galleries/blowdryer.html
     d. Cups Containing Hot and Cold Water, http://coolcosmos.ipac.caltech.edu/image_galleries/cups.html
     e. Faucet Running Hot and Cold Water, http://coolcosmos.ipac.caltech.edu/image_galleries/faucet.html
     f. Shoe Just After Being Worn, http://coolcosmos.ipac.caltech.edu/image_galleries/shoe.html

   - If you do not have internet access in the classroom to use, download and save on disk/CD the images you will need and then make a PowerPoint presentation to run the activity.
   - If you cannot project via computer, make color transparencies for an overhead projector. Printable images are in the ***Image Appendix*** for this lesson.
   - If you wish each group to have images, then color print and laminate images from the ***Image Appendix*** for this lesson.

   Note: The ***Image Appendix*** is available as either an MS Word or pdf file:
   http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/ExplIRImgTech_ImgAppx.doc
   http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/ExplIRImgTech_ImgAppx.pdf

2. With the help of the ***Background Knowledge and Resources for the Instructor*** section of this lesson, put together a short presentation/lecture on the following (suggested) topics that fits it with your own curriculum goals:

   a. Infrared Light – What is infrared light? How is it different than visible light?
   b. Infrared Cameras – How do they work? How/why are they different from visible light cameras? What is the technology that makes them work?
   c. False color images – What specifically do infrared images reveal?
   d. Interpreting false color images – How do you read a temperature scale?

3. Design an evaluation rubric for this lesson based upon your learners, how you have tailored this lesson, and where this lesson falls into your curriculum. We do not provide an "evaluation" activity/rubric in this lesson, but we do provide sample learning goals generic to this lesson "as is".

   The sample learning goals are listed in the General Information section (section I) of this lesson.

Background Knowledge and Resources for the Instructor:

Provided below are some internet resources to help you get a better grasp on infrared light and image technology. Please note that we have compiled a **Cool Cosmos Teachers Guide to the Infrared** that can be found http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/background.html

Infrared Tutorial
http://coolcosmos.ipac.caltech.edu/cosmic_classroom/ir_tutorial/

Video- Infrared: More Than Your Eyes Can See
http://coolcosmos.ipac.caltech.edu/videos/more_than_your/

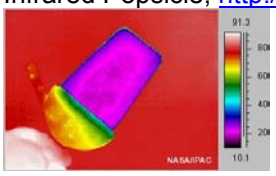
Heat and Temperature
http://coolcosmos.ipac.caltech.edu/cosmic_classroom/light_lessons/thermal/

III. EXPLORING INFRARED IMAGE TECHNOLOGY

Activity Time: 25-45 minutes

1. Project (via computer or overhead transparency) one of the following pictures from the *Cool Cosmos: Our Infrared World Image Gallery*, http://coolcosmos.ipac.caltech.edu/image_galleries/our_ir_world_gallery.html. Initially show the picture with the temperature scale covered/hidden.

Infrared Popsicle, http://coolcosmos.ipac.caltech.edu/image_galleries/popsicle.html



Infrared Toaster, http://coolcosmos.ipac.caltech.edu/image_galleries/toaster.html

Infrared Blowdryer, http://coolcosmos.ipac.caltech.edu/image_galleries/blowdryer.html

2. Prompt discussion by asking questions. Guide the discussion to allow for learner questions. Use the Infrared Image Gallery to help guide their inquiry during the second activity. Included below are some example questions and responses that should be discussed before moving forward.

- What is this a picture of?
  Popsicle, toaster, hairdryer

- How/why does it not look like a "regular" picture?
  - the colors are not right for what is seen with our eyes

- What could the different colors mean? Think about the object that has been photographed.
  - a popsicle is cold, does purple mean cold?
  - the hot part of the toaster is a different color than the outside/cooler part
  - the hot part of the hairdryer is a different color than the cooler parts
  - the hot air from the hairdryer is a different color…we can't usually see the hot air, but we can feel it

  NOW SHOW THEM THE TEMPERATURE SCALES

- What part of this (popsicle, toaster, hairdryer) is the hottest? Coolest?
  - can have learners point out the various parts

- Return to the question, what could the different colors mean in the pictures?
  - each color means a different temperature

- What information can we gather from these special pictures?
  - the temperature of an object or how much heat it is radiating

  NOW SHOW THEM A VISIBLE LIGHT IMAGE OF THE POPSICLE, TOASTER,

HAIRDRYER

- What information can we gather from these visible light (like our eyes) pictures?
  - size, shape, color that our eyes see
  - cannot tell if it's hot or cold

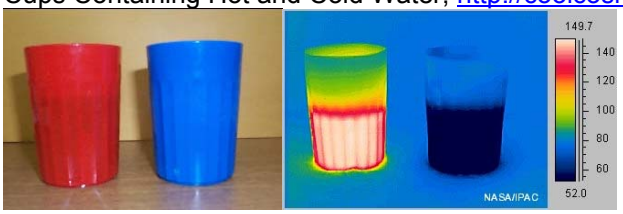
THEY SHOULD MAKE THE CONNECTION THAT INFRARED IMAGES CAN GIVE US IMPORTAT INFORMATION ABOUT AN OBJECT THAT OUR EYES CANNOT!

3. Have a short presentation on infrared cameras, false-color images, and how to interpret false-color images. This need only be a few minutes so that your learners have a brief introduction to the technology.

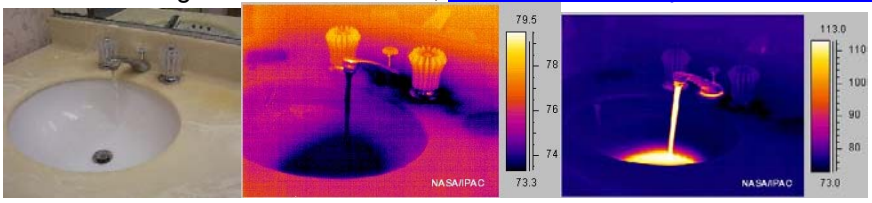
4. As a follow-up to the initial discussion and the short presentation, use the following sets of images in an open discussion of comparing and contrasting. This brief activity should be used to solidify their new and basic knowledge of the false-color infrared images. This may also be done in small groups. Some questions for learners to answer:

- What information can one gather from the visible light photo?
- What new information can one gather from the infrared image?
- Label the hotter areas of the infrared image. How do they compare to the same areas in the visible light photo?
- Label the cooler areas of the infrared image. How do they compare to the same areas in the visible light photo?
- What are some reasons that infrared imaging is important?
- Think about the possibilities with infrared imaging. What are some ways it can be used in the world today?

Cups Containing Hot and Cold Water, http://coolcosmos.ipac.caltech.edu/image_galleries/cups.html



Faucet Running Hot and Cold Water, http://coolcosmos.ipac.caltech.edu/image_galleries/faucet.html



Shoe Just After Being Worn, http://coolcosmos.ipac.caltech.edu/image_galleries/shoe.html

5. Have groups present their work or hold another discussion to wrap up these aspects of infrared imaging.