

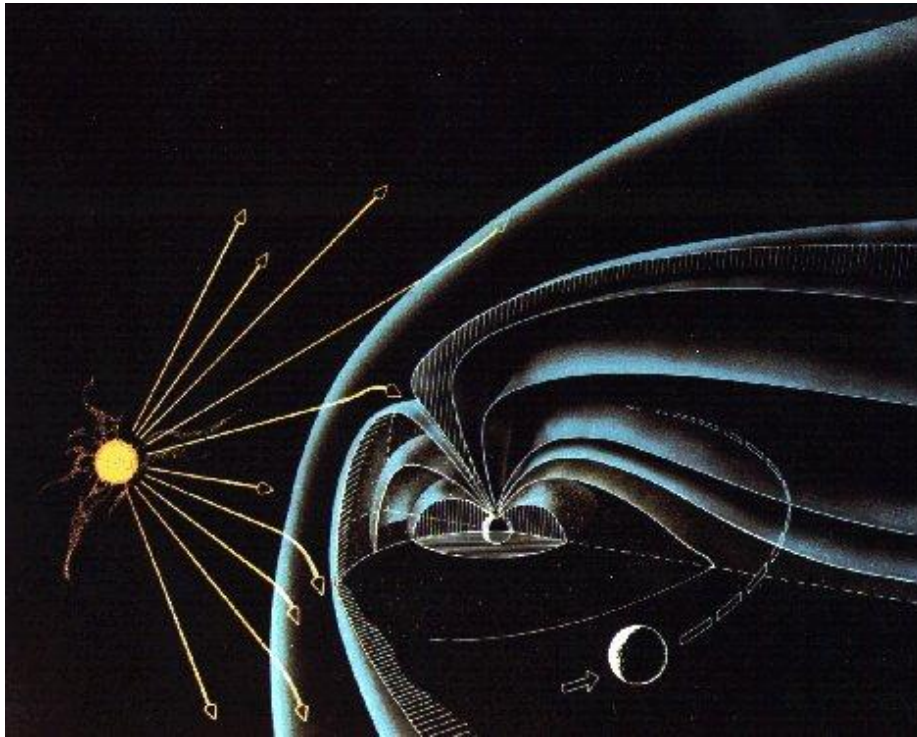
# Invisibility and the Real World

**Subject Area(s):** Science & Technology

**Associated Unit:** Nanotechnology, Optics

**Lesson Title** Invisibility and the Real World

Header Insert Image 1 here, centered



**Image 1**

**ADA Description:** This image shows how the earth has a magnetosphere that redirects light. This same concept is how invisibility is being created through engineers and scientists.

**Caption:** None

**Image file:** earth\_invisibility.jpg

**Source/Rights:** Copyright © Nasa

[http://science.nasa.gov/media/medialibrary/1997/12/09/ast09dec97\\_3\\_resource](http://science.nasa.gov/media/medialibrary/1997/12/09/ast09dec97_3_resource)

**Grade Level** 8 (7-9)

**Lesson #** 1 of 1

**Lesson Dependency** None

**Time Required:** 40 minutes

### **Summary:**

Building off the curiosity students have with superpowers and magical events, students will learn about the role nanotechnology has in implementing real world invisibility. By acquiring knowledge about the manipulation of light and the optics behind invisibility or camouflage, students will be taught how engineers are addressing this advancement through the creation of metamaterial. Afterwards, students will also be encouraged to think about the moral implications of this technology.

### **Engineering Connection**

Material engineers along with electrical engineers have been researching the area of carbon nanotubes and metamaterials for many years now. The application of nanotechnology has been used by engineers in food, clothing, and buildings. In the area of invisibility and camouflage, engineers have been able to use the principles of light refraction to allow light to pass right through an object (metamaterials).

### **Engineering Category = #1**

Choose the category that best describes this lesson's amount/depth of engineering content:

1. Relating science and/or math concept(s) to engineering
2. Engineering analysis or partial design
3. Engineering design process

### **Keywords**

Nanotechnology, refraction, optics, metamaterials,

### **Educational Standards**

#### **International Technology and Engineering Educators Association (ITEEA) Standards**

Standard 1, Grade Level 6-8, F. New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology.

Standard 1, Grade Level 6-8, G. The development of technology is a human activity and is the result of individual and collective needs and the ability to be creative.

Standard 3, Grade Level 6-8, F. Knowledge gained from other fields of study has a direct effect on the development of technological products and systems.

Standard 4, Grade Level 6-8, E. Technology, by itself, is neither good nor bad, but decisions about the use of products and systems can result in desirable or undesirable consequences.

Standard 4, Grade Level 6-8, F. The development and use of technology poses ethical issues.

## **Texas Essential Knowledge and Skills (TEKS)**

### Technology Applications

126.12 (c) (1) (D) identify the impact of technology applications on society through research, interviews, and personal observation; and

126.12 (c) (1) (E) demonstrate knowledge of the relevancy of technology to future careers, life-long learning, and daily living for individuals of all ages.

126.16 (c) (6) (A) define and use current technology terminology appropriately

126.16 (c) (6) (I) evaluate the relevance of technology as it applies to college and career readiness, life-long learning, and daily living;

## **Pre-Requisite Knowledge**

Basic understand of what nanotechnology is and general concept of optics (See Associated Activities)

## **Learning Objectives**

After this lesson, students should be able to:

- Name one examples of how nanotechnology can make the real world invisible.
- Explain how invisibility exists in everyday life.
- Explain the science behind invisibility.
- Be able to give an opinion on the ethical dilemma associated with nanotechnology and invisibility.

## **Introduction / Motivation**

Does the world of Harry Potter exist in our world? (Call on one student who said yes and one student who said no and have them give their reasoning). While some of the actions that occur in Harry Potter seem beyond our world, other actions are closer to reality than you might think. Present on the board four magical actions that occur in the Harry Potter series: 1) Invisible Clock 2) Flying Broomsticks 3) Spells 4) Talking Animals. Which of these seems the most likely to be real? (Poll the students and call one of the students who did not choose invisibility and ask that student why it is not realistic) Believe it or not, invisibility has been going on in our world of many years. How did Harry Potter use invisibility? (Show a scene from Harry Potter and the Sorcerer's Stone where Harry uses the invisible clock). While it may not be as simple as throwing a blanket over oneself, invisibility occur in nature and can also occur by great advancements in engineering.

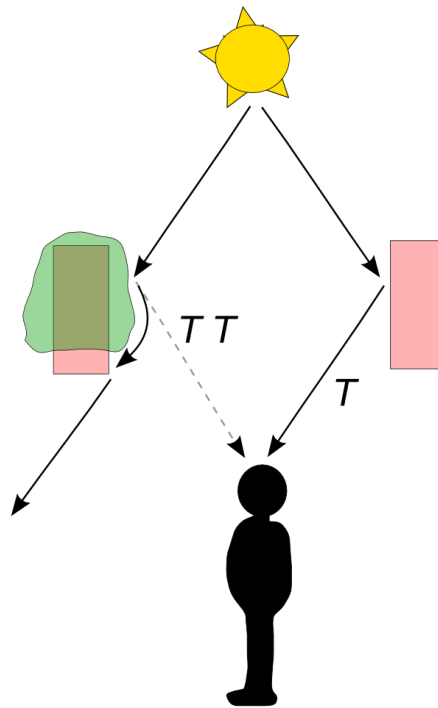
Today I am going to make you a believer in invisibility.

## **Lesson Background & Concepts for Teachers**

### The Optics of Invisibility

How do we see things? Simply, the reflection of light from one object by to our eyes allows us to see. Take this image for example (Image 2, right), for something to be visible it requires two items, (1) light and (2) a surface that reflects. So what happens if we eliminate that surface? How would that make a difference? A clear window is an example of this (if available, hold up a piece of glass). Glass or similar products allow us to look straight through them because the light passes straight through the material allow the object behind it to be reflected back.

**Image** Insert Image 2, right justified, wrapped with text



**Figure 2**

**ADA Description:** This image shows how an invisible cloak works.

**Caption:** Figure 2. (Right) Light reflects of an object making it visible (Left) Light is redirected so the object is invisible.

**Image file:** how\_invisibility\_works.png

**Source/Rights:** Copyright © Arimasen, Wikipedia Commons

<http://commons.wikimedia.org/wiki/File:Kasat-mata.png>

However, when talking about invisibility, the discussion really hinges on taking something that is normally seen and making it unseen. Throughout nature, this idea has already been addressed. Figure 3 shows this idea and in nature is known as

camouflage. Camouflage is the art of concealment which is also the ultimate goal of invisibility. Harry Potter used the invisible cloak to hide himself as he moved around Hogwarts. The flounder uses splotches to match the floor of the water to conceal itself from predators. However, true invisibility allows for concealment no matter the background. A flounder like the one shown would not be “invisible” if it was located in water with a red bottom. So nature has gone one step farther through “adaptive camouflage.” [1] Cephalopods (squids, octopuses, etc.) can change their appearance based on their surroundings with quickness and ease. Scientists are currently studying how this type of camouflage works. This example does not allow the object to keep its original look; however, could it be possible to keep your appearance and just become invisible. In nature, invisibility is achieved by camouflage so that the image that is returned to you looks like one. So is it possible to really achieve what Harry Potter was able to do and completely disappear?

**Image** Insert Image 3, left justified, wrapped with text



**Image 3**

**ADA Description:** This image presents invisibility as it exists in nature. The image is of a flounder camouflaged with the gravel floor.

**Caption:** Figure 3. A flounder using the concept of invisibility in nature known as camouflage?

**Image file:** flounder\_camouflage.jpeg

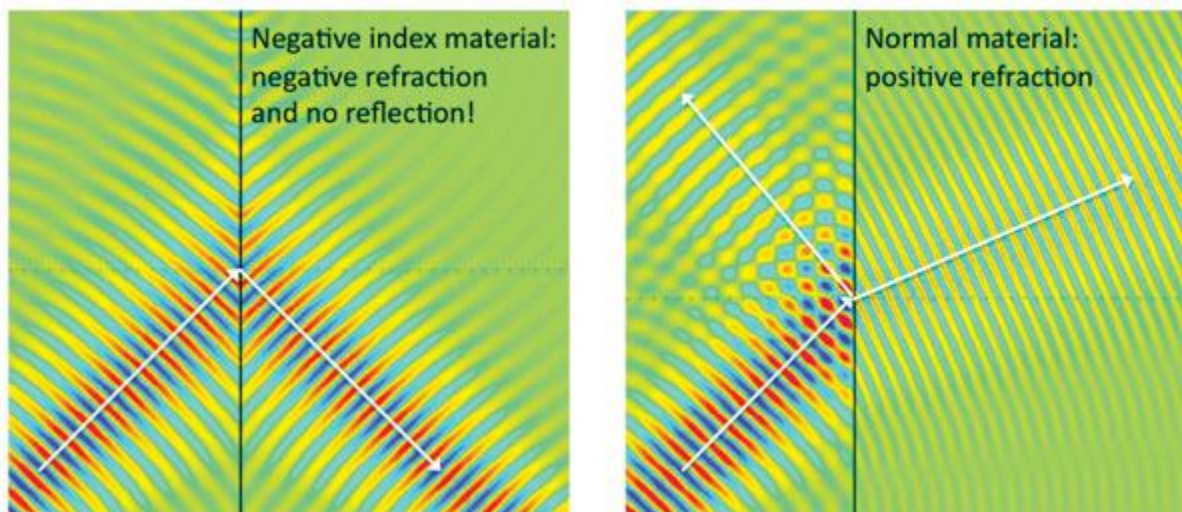
**Source/Rights:** Copyright © User: Moondigger, Wikipedia Commons

[http://commons.wikimedia.org/wiki/File:Flounder\\_camo\\_md.jpg](http://commons.wikimedia.org/wiki/File:Flounder_camo_md.jpg)

Invisibility, like camouflage, manipulates the reflection of light so that it is hidden to the naked eye. As mentioned previously, Figure 2 shows the flow of an image reach a person (right) and how with invisibility must be achieved (left). The left side is where engineers have used nanotechnology to achieve “magical” results. In this lesson, three specific examples of invisibility created through nanotechnology: (1) nano-sunscreen, (2) carbon nanotubes, and (3) metamaterials. Each of these examples provides a unique example of how invisibility is being achieved through engineering and technology.

### Metamaterials

**Image** Insert Image 6, right justified, wrapped with text



**Image 4**

**ADA Description:** This image shows the difference between negative and positive refraction which is the guiding principle for metamaterial.

**Caption:** Figure 4: Negative Refraction

**Image file:** negative\_refraction.jpeg

**Source/Rights:** Copyright © Ames Laboratory

[https://www.ameslab.gov/files/imagepicker/k/kgibson/Graphic\\_IQ-fig1.jpg](https://www.ameslab.gov/files/imagepicker/k/kgibson/Graphic_IQ-fig1.jpg)

Metamaterials were first mentioned in work done by Russian physicist Victor Veselago in 1967 and refer to material that are not found in nature. He discovered nanoparticles that were smaller than a wavelength of light but most importantly, it exhibited negative electromagnetic properties. Let us talk a little bit about why this is important. Light waves interact with a material depending on its refractive index. While most material

have a positive refractive index, using these nanoparticles can change material from positive refraction to negative refraction. This would cause light waves to move around the object and not make it back to the on looker and making the object invisible.

In 2008, engineers at University of California, Berkley created “fishnet” material. This means, at a nanoscale, layers of silver and magnesium fluoride were stacked so that negative refraction would occur. At the beginning of 2011, scientist at MIT created a calcite crystal sheet that when laid with another calcite crystam sheet, bends the light around an object to create a cloaking effect. However, the current methods are limited to two-dimensions and is only invisible from certain directions [2]

### Vocabulary / Definitions

Word	Definition
Nanotechnology	The study and use of structures at a nanoscale
Invisibility	Incapable by nature of being seen (Merriam-Webster Dictionary)
Camouflage	Concealment by means of disguise
Cloaking	Something that conceals
Metamaterials	Material engineered to have properties that may not be found in nature

### Associated Activities

Web of Nano Knowledge – As an introduction to nanotechnology before this lesson.

### Lesson Closure

The objectives of the lesson should be effectively reviewed with the students for a quiz. Leading into a discussion of the ethical responsibility related to this technology. Ask the students, “What was the ethical dilemma with Harry Potter using the invisible cloak?” (Have a couple students give their opinion) What are the ethical dilemmas related to invisibility in the real world? Students responses should be focused on the following points: (1) Since nanotechnology is a new technology, the potential impacts are not fully investigated 2) privacy issues related to invisibility.

### Assessment

Give the students the quiz provided with this lesson (attachment provided). Questions could be changed to be more multiple choice to make the quiz easier or more free-form short answer to make it harder. If you are using this for a technology class, it is recommended that this quiz be an online quiz so that students can use the computers. While this is not required, it would make it easier for collected results of the quiz.

### Lesson Extension Activities

There are additional areas and examples of nanotechnology and invisibility such as nano-sunscreen and carbon nanotubes. Additional activities or lessons could be done on these other examples to create a Nanotechnology Unit.

### **Additional Multimedia Support**

- Harry Potter and the Sorcerer's Stone: video of invisibility cloak

### **References**

1. Highfield, R., *The Science of Harry Potter: How Magic Really Works* 2002, New York, NY: Penguin Books. 322.
2. Chandler, D.L. *Hidden in plain sight: A new approach in invisibility cloaking gets much closer to science-fiction version, using simple and inexpensive materials.* 2011 [cited 2011 December 14, 2011]; Available from: <http://web.mit.edu/newsoffice/2011/invisibility-cloak-0125.html>.

### **Attachments**

1. Invisibility\_quiz.docx
2. Invisibility\_quiz.pdf

### **Other**

None

### **Redirect URL**

None

### **Contributors**

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### **Copyright**

### **Supporting Program**

National Science Foundation AWARD # 0840889, GK-12 Program at the University of Houston: Innovations in Nanotechnology and Nanosciences using a Knowledge, Applications, Research, and Technology (KART) Approach