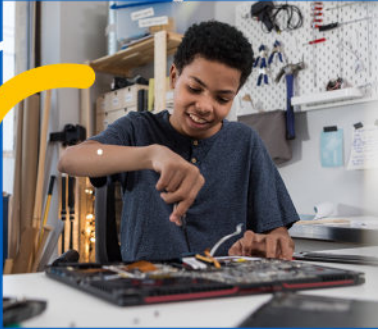


NEXT ENGINEERS



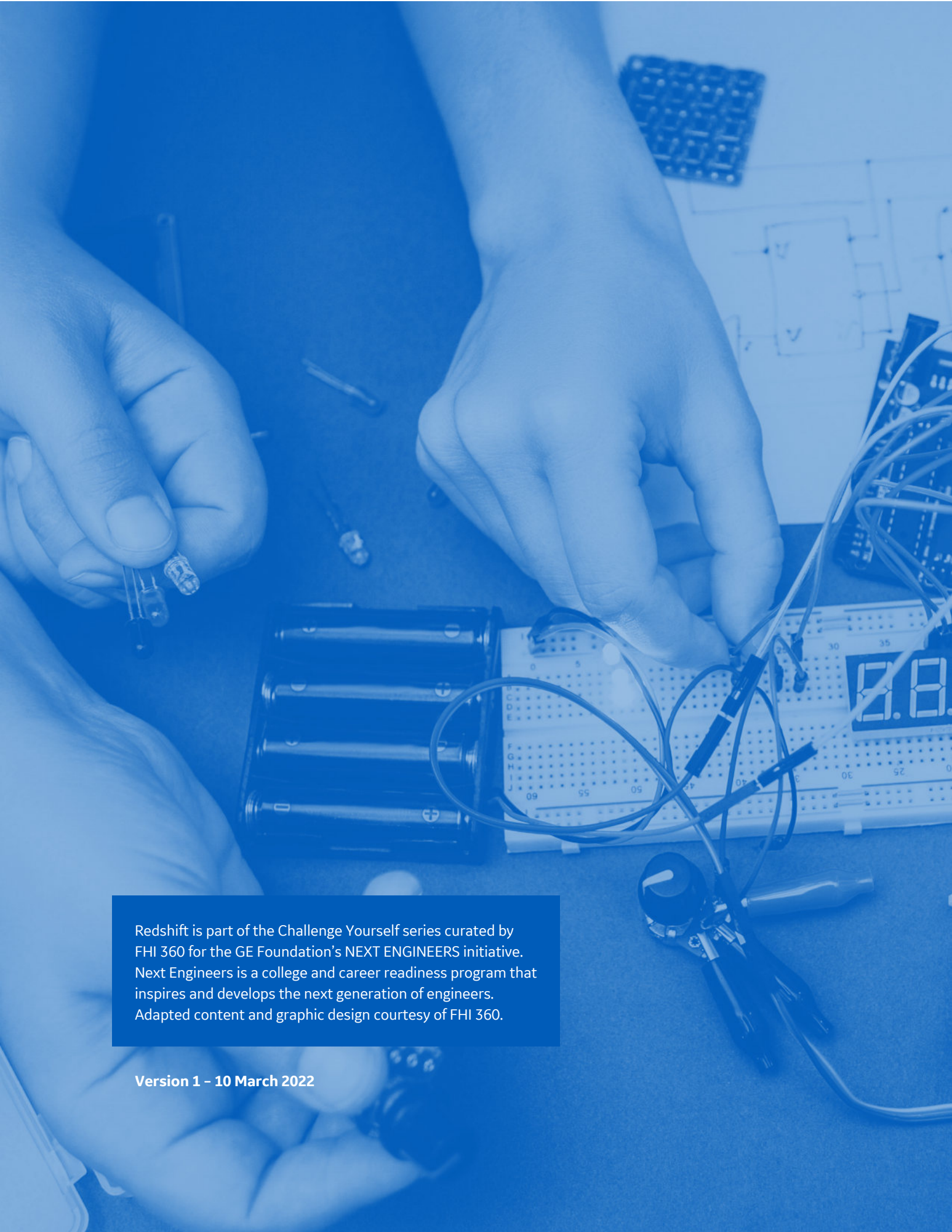
CHALLENGE YOURSELF

The James Webb Space Telescope Part 4: Redshift

Aerospace Engineering



GE Foundation



Redshift is part of the Challenge Yourself series curated by FHI 360 for the GE Foundation's NEXT ENGINEERS initiative. Next Engineers is a college and career readiness program that inspires and develops the next generation of engineers. Adapted content and graphic design courtesy of FHI 360.

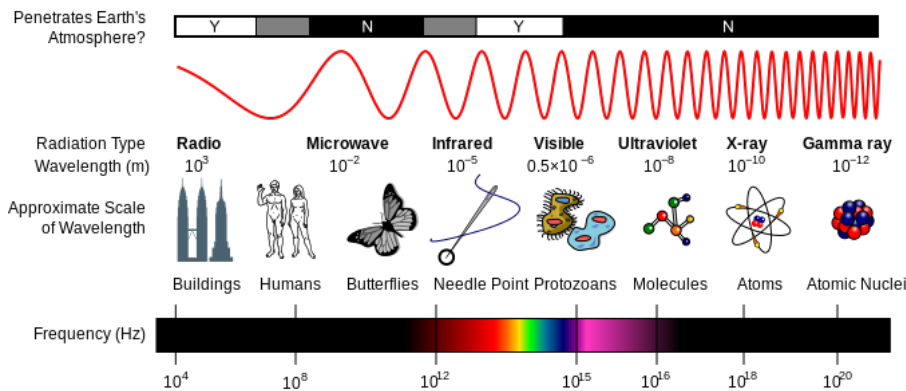
Version 1 - 10 March 2022



The James Webb Space Telescope Part 4: Redshift

NERD OUT

The James Webb Space Telescope does not see the universe as we see it. The light we see is only a small part of a much larger spectrum called the **electromagnetic spectrum**. We call the part of the spectrum we see visible light. But everything from radio waves to microwaves to gamma rays are all part of the same spectrum. The only difference between a radio wave and a gamma ray is the wavelength. Wavelength is the distance between the peaks of the waves.



The complete electromagnetic spectrum.

Image by NASA released under a GNU Free Document license

https://commons.wikimedia.org/wiki/File:EM_Spectrum_Properties_edit.svg

Learn more about the electromagnetic spectrum by taking a *Tour of the Electromagnetic Spectrum* (5:03) (<https://www.youtube.com/watch?v=lwfJPC-rSXw&list=PL09E558656CA5DF76>).

Webb is designed to see the **infrared** part of the spectrum. But why? There are two main reasons. The first is that infrared light is much better than visible light at passing through the dense clouds of gas that still exist in the universe. This means that seeing in infrared means we can see objects behind these gas clouds much more clearly.



WATCH

Why Infrared? (1:00)
(https://www.youtube.com/watch?v=o_kK6U1RTvw)



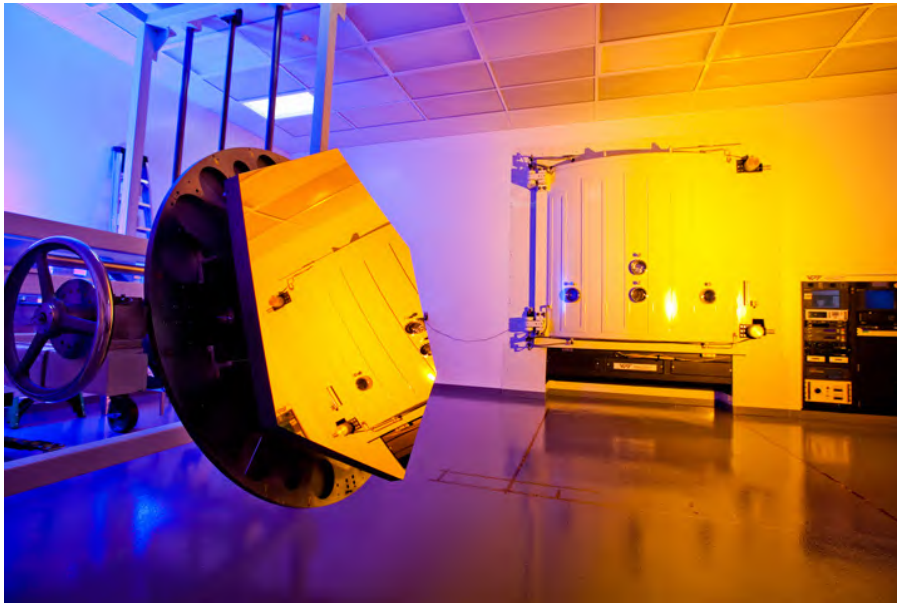
Secondly, since the Big Bang, the universe has been expanding and objects in space have been growing farther apart ever since. But an expanding universe also means that the light travelling through it gets stretched, increasing its wavelength. Visible light that travels through space for millions of years, therefore, becomes infrared. This is called **redshift** and works the same way as the more familiar Doppler shift does with sound.

Listen to a familiar example of the Doppler shift with *Doppler Sound Waves* (0:13) (https://www.youtube.com/watch?v=6lb1P3CKC_w).

Learn more about the Doppler effect and redshift by watching these videos.

- *The Doppler Effect: what does motion do to waves?* (3:02) <https://www.youtube.com/watch?v=h4OnBYrbCjY>
- *Red shift* (3:32) <https://www.youtube.com/watch?v=-mQ41yA6LaA>

You may have wondered why the Webb primary mirror is gold in color. Well, that's because each mirror segment is coated in a very thin layer of pure gold. This is not because the engineers were into bling! It's because gold is an excellent reflector of infrared radiation.



A single mirror segment coated in pure gold
Image by NASA and Drew Noel and used under fair use
<https://webb.nasa.gov/content/observatory/ote/mirrors/index.html>

Learn more about this gold coating process by watching *Behind the Webb: The Golden Touch* (3:48) (<https://www.youtube.com/watch?v=fgn7bKs042Q>).

Explore more at *Webb Space Telescope* (<https://webbtelescope.org>).



DID YOU KNOW

A sonic boom is caused by an object travelling at or faster than the speed of sound and is caused by sound waves bunching up and constructively interfering with each other.

Learn more at *The Doppler Effect and Sonic Boom* (<https://ophysics.com/waves/11.html>) and by watching *The sonic boom problem* (5:43) (https://www.youtube.com/watch?v=JO4_VHM69oI).



GET ACTIVE

Experience the Doppler effect for yourself. You will need a piece of string about 1 m (3.2 ft) long, a strong plastic bag with handles, and a mobile phone.

Start a song or other sound playing on the phone, then put it inside the bag and tie on the piece of string.

Now swing the bag around in a circle next to you. You should hear the pitch of the sound change as the sound source travels towards you (higher) and away from you (lower).

