The Shocking Truth About Smartphones and Internet Routers

Using a Radio Frequency Meter to measure electromagnetic waves

Suhani Bansal
7th grade
Sandpiper School
Belmont-Redwood Shores School District (BRSSD)

SAN MATEO COUNTY OFFICE OF EDUCATION

Abstract

Purpose	The purpose of the project is to identify the most ideal distance and mode to use smartphones and internet routers to minimize their negative health impacts (headaches, anxiety, etc) when your body absorbs electromagnetic radiation.
Hypothesis	The electromagnetic radiation from your smartphone and internet router will be less dangerous the farther you are from them. Your phone is the most dangerous when it's in calling mode, followed by texting, stationary (front), and stationary (back).
Variables, controls/ constants	**Independent Variables:** The smartphone's mode and the distance of the radio frequency (Radio Frequency/EMF) meter to the smartphone/internet router. **Dependent Variable:** The measure of electromagnetic waves. **Controls:** The location of the internet router, the phone being used, and the phone's location.
Experiment Procedure	Determine the strength of electromagnetic waves using RF(Radio Frequency/EMF meter) meter keeping phone and internet router at varying distances and modes. Average these measurements and create a data table. Draw conclusions with these measurements.
Results & Analysis & Conclusion	• The electromagnetic waves are less dangerous the farther you are from them. • Facing your phone backward is less damaging when you are not using it • Using calling mode on your phone emits the most electromagnetic waves. Therefore, it is most harmful for all humans.

Purpose Statement

Purpose - To identify the most ideal distance and modes to use smartphones and internet routers to minimize their negative health impacts (headaches, anxiety, etc). This project will prove how we can use technology effectively without getting impacted by its ill effects.

Motivation/Why - I see everybody, from little kids to elderly people with smartphones 24/7. Even most of my classmates have smartphones. I was interested to research if these devices are harmful to human health.

Problem - Technology has brought us together and made our lives much easier. We are surrounded by smartphones and routers all the time. Globally, the average screen time stands at 6 hours 58 minutes per day, which is alarming, considering most experts say that it should be limited to less than two hours. Our body absorbs some of the radiation, and there are quite a few health issues associated with this.

We have to balance the uses of technology so that we can maximize its benefits and minimize its ill effect on health.

Benefits/Outcomes - This project will help determine the most ideal distance and modes to place your internet router and smartphone to make electromagnetic radiation the least harmful.

***Refer to Slides 19 - 21 for more information about electromagnetic radiation and electromagnetic waves

Hypothesis

Hypothesis 1: Distance of the Phone
When you place a phone farther and face it away from yourself, then the electromagnetic radiation will be less intense.

Hypothesis 2: Mode of the Phone
When your phone is in calling mode, it transmits the most electromagnetic radiation, followed by texting mode, stationary (front), and stationary (back).

Hypothesis 3: Distance of the Router
If you are farther away from your internet router, the router's electromagnetic radiation will be less harmful to you.

Experimental Procedures and Materials

Measuring Tape
(To measure the distance of the RF meter to the internet router and phone)

2 smartphones
(Devices that transmit electromagnetic waves and can be measured with the RF meter)

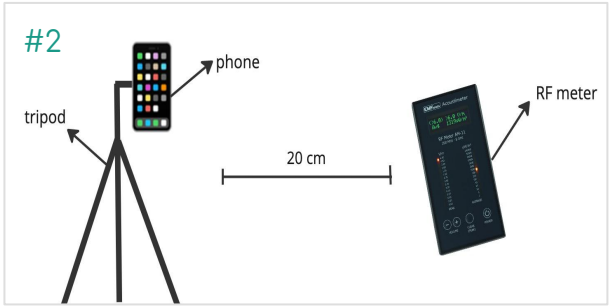
Radio Frequency (RF) Meter (Acoustimeter AM-11)
(To measure the electromagnetic waves)

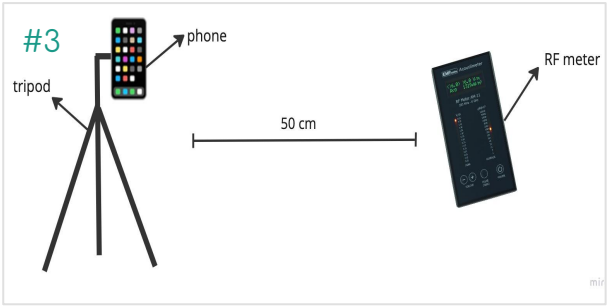
Internet Router
(A device that transmits electromagnetic waves and can be measured with the RF meter)

Tripod
(This object is used to hold the phone in place while measuring)

Experimental Procedures and Materials (Smartphone)

**Refer to Slide 22 for the experimental setup and a video showcasing the procedure





1. Place a tripod to securely and accurately hold one of the phones. Securely mount the phone onto the tripod.
2. Hold the RF meter 2 cm away from the phone (distance of the phone when close to your ear).
3. Make sure that the phone is stationary and facing forward.
4. Using the RF meter, take measurements in V/m (volts per meter) three times.
5. Find the average of the three measurements.

Video link: http://bit.ly/3jJRJU1

You can move on to the next slide for the next steps

Experimental Procedures and Materials (Smartphone)

6. Reposition the phone on the tripod so it is facing backward and stationary
7. Repeat steps 4 and 5
8. Use the other phone to call the phone that is securely mounted on the tripod.
9. Repeat steps 4 and 5
10. Use the other phone to start a text conversation with the phone mounted on the tripod
11. Repeat step 4 and 5
12. Record the results and the averages on a data table in V/m
13. Hold the RF meter 20 cm away from the phone (distance of phone when on speaker mode)
14. Repeat Steps 3-12
15. Hold the RF meter 50 cm away from the phone (distance of phone when plugged into earphones)
16. Repeat Step 3-12

Controls and variables throughout the experiment

Controls:

- The phone
- The phone's location

Independent Variables:

- Smartphone's mode
- The distance of the radio frequency (RF/EMF) meter to the phone.

Dependent Variables:

- Measure of electromagnetic waves (V/m)

Experimental Results (Smartphone)

V/m = volts per meter
cm = centimeters

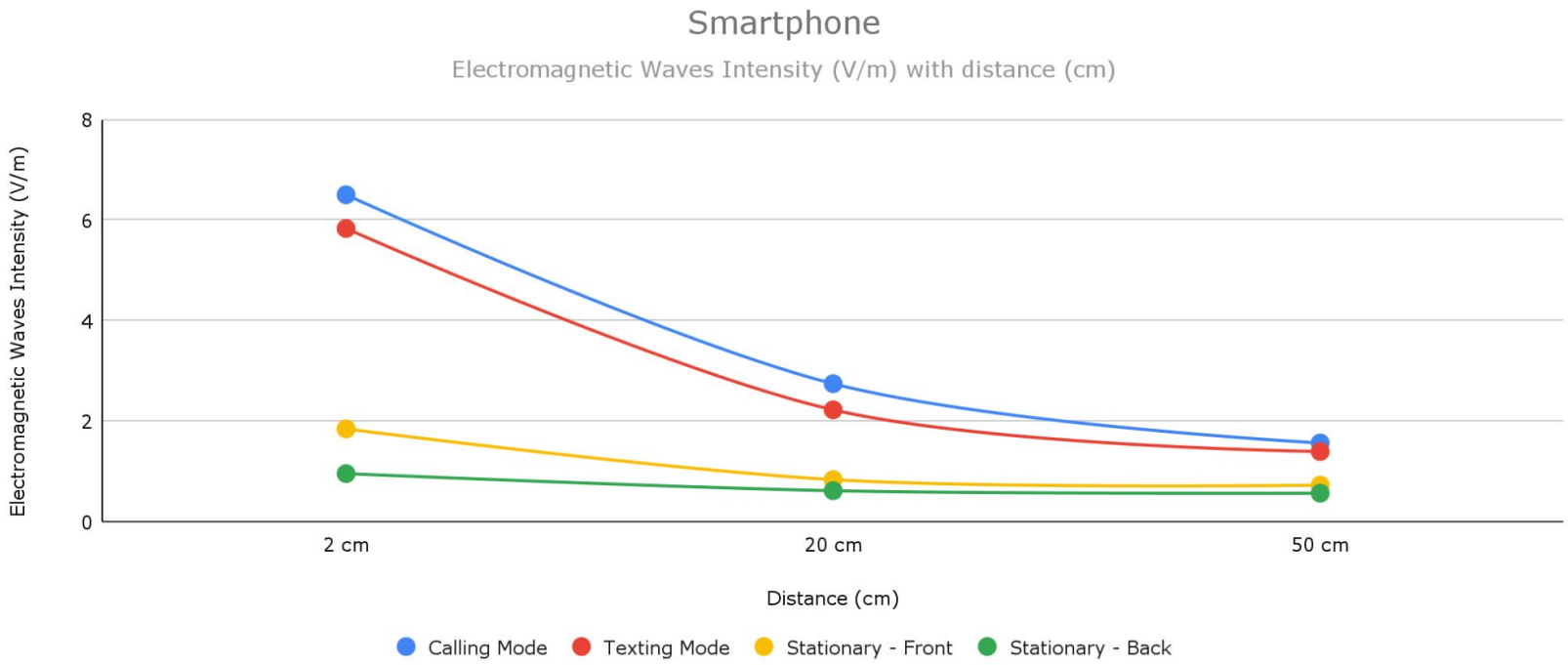
This table shows intensity of electromagnetic waves in V/m when phone at different distances and modes

Distance	Trials	Calling Mode (V/m)	Texting Mode (V/m)	Stationary - Front (V/m)	Stationary - Back (V/m)
2 cm (close to ear)	Trial 1	6.60	5.28	3.80	1.32
	Trial 2	6.43	6.00	0.64	1.09
	Trial 3	6.67	6.12	1.09	0.65
	Average	**6.5**	**5.83**	**1.84**	**0.95**
20 cm (when on speaker mode)	Trial 1	2.50	3.04	0.95	0.54
	Trial 2	3.08	1.80	0.99	0.68
	Trial 3	2.65	1.82	0.55	0.62
	Average	**2.74**	**2.22**	**0.83**	**0.61**
50 cm (when plugged into earphones)	Trial 1	1.28	1.20	0.46	0.77
	Trial 2	1.46	1.15	0.75	0.45
	Trial 3	1.93	1.81	0.94	0.47
	Average	**1.56**	**1.39**	**0.72**	**0.56**

Experimental Results (Smartphone)

V/m = volts per meter
cm = centimeters

This graph shows intensity of electromagnetic waves in V/m when phone at different distances and modes

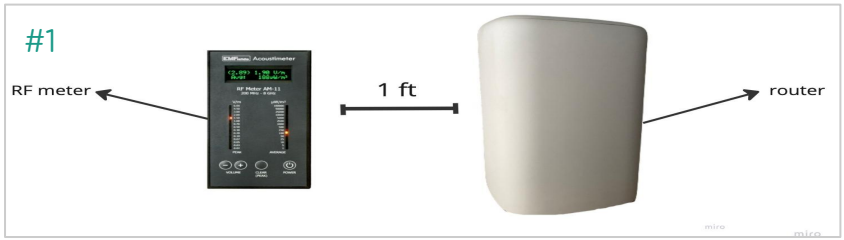


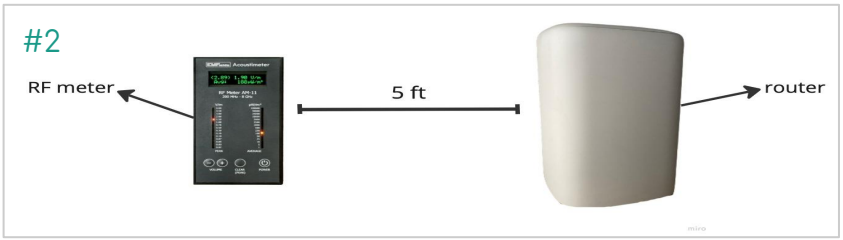
Analysis of Experimental Results (smartphone)

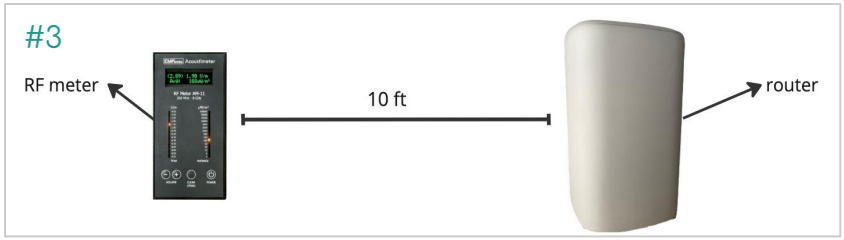
- **The results for the smartphone show:**
  - The farther you are from your smartphone, the less impactful the electromagnetic waves are. This was proven by the decreased reading of the electromagnetic radiation in the V/m.
  - Calling mode transmits the most electromagnetic radiation followed by texting, stationary (front), and stationary (back).
- **Takeaways of the results**
  - Try to use earphones or wireless headphones as much as you can, especially when you are on long calls. If you do put your phone close to your ear, make sure you don't do that for to long.
  - Try not to leave your phone right next to you, especially when you're sleeping or taking a nap.
  - If possible, try to keep your phone facing down (the screen not facing toward you)

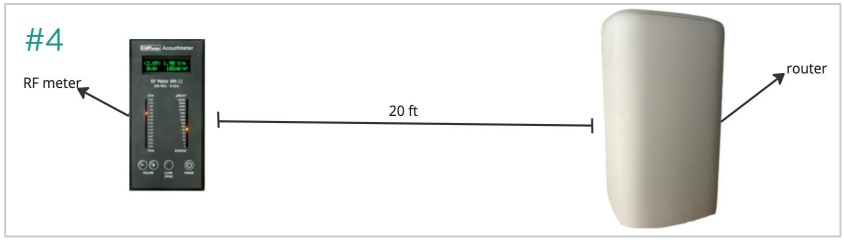
Experimental Procedures and Materials (Internet Router)

**Refer to Slide 23 for the experimental setup









You can move on to the next slide for more detailed information on these diagrams

Experimental Procedures and Materials (Internet Router)

1. Hold the RF meter 1 foot away from the internet router, to measure the V/m (volts per meter) when up close.
2. Take three measurements in V/m from the same distance.
3. Find the average of the three measurements.
4. Record the results and the averages on a data table in V/m.
5. Hold the RF meter 5 feet away from the internet router, to measure the V/m (volts per meter) when mildly away.
6. Repeat steps 2-4.
7. Hold the RF meter 10 feet away from the internet router, to measure the V/m (volts per meter) when far away.
8. Repeat steps 2-4.
9. Hold the RF meter 20 feet away from the internet router to measure when outside of the room.
10. Repeat step 2-4.

Controls and variables throughout the experiment

Controls:

- The router
- The router's location

Independent Variable:

- The distance of the radio frequency (RF/EMF) meter to the router.

Dependent Variables:

- Measure of electromagnetic waves (V/m)

Experimental Results (Internet Router)

V/m = volts per meter
ft = feet

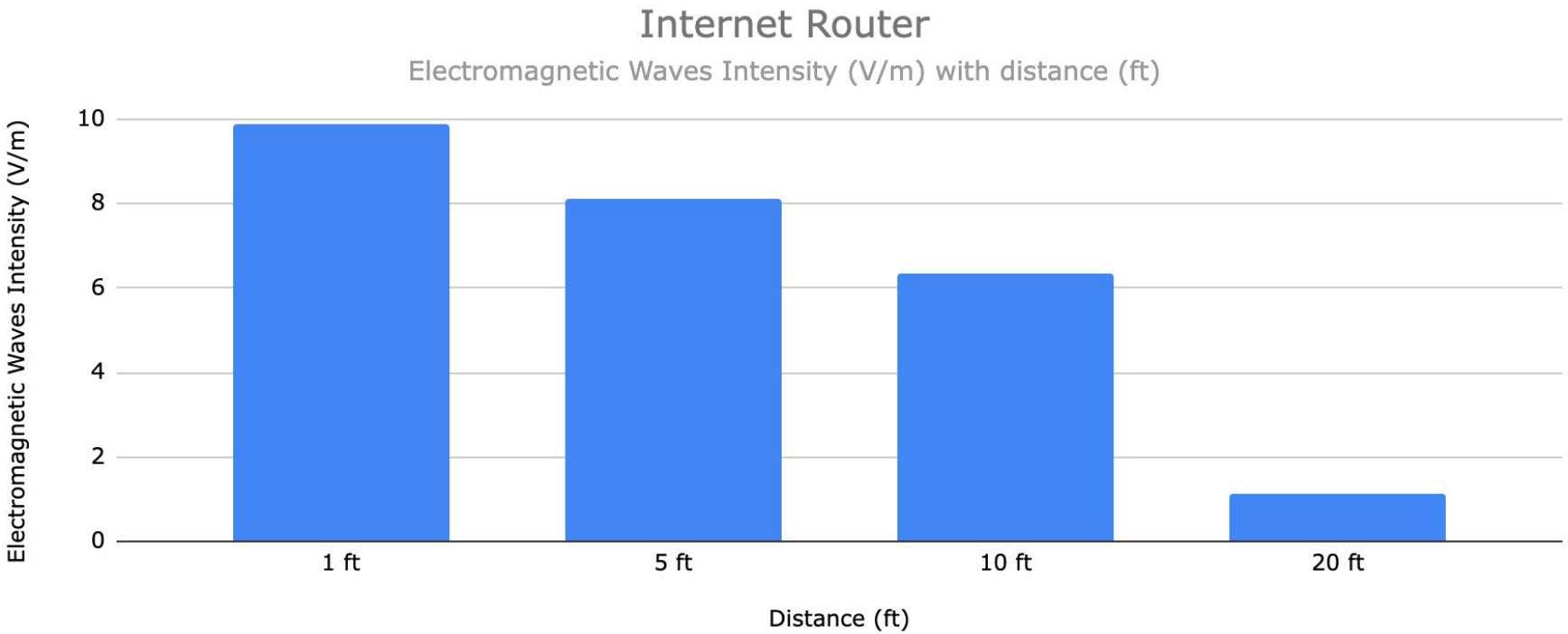
This table shows intensity of electromagnetic waves in V/m when internet router is at different distances.

Distance	Trials	Readings (V/m)
1 ft (distance when close to the router)	Trial 1	9.75
	Trial 2	9.95
	Trial 3	>10
	Average	**≈ 9.9**
5 ft (distance when away from the router)	Trial 1	8.73
	Trial 2	8.07
	Trial 3	7.53
	Average	**8.11**
10 ft (distance when far away from the router)	Trial 1	6.65
	Trial 2	5.57
	Trial 3	6.79
	Average	**6.34**
20 ft (distance when outside of the room)	Trial 1	1.37
	Trial 2	1.00
	Trial 3	1.01
	Average	**1.13**

Experimental Results (Internet Router)

V/m = volts per meter
ft = feet

This graph shows intensity of electromagnetic waves in V/m when the internet router is at different distances.



Analysis of Experimental Results (Internet Router)

- These experimental results prove that **the farther away you are from your internet router, the less impactful the electromagnetic radiation is.**
- **Takeaways**
  - Try to place the router in an open area, like your living room because it is more likely that you are going to be farther away from the internet router.
  - Try not to place your internet router in your bedroom because you spend a lot of time there, and you don't want to absorb the radiation in higher doses.
    - If you still need to keep it in your bedroom, try not to sleep right next to it.

Conclusions

**Refer to slide #24 to review some of the FAQs about this experiment.

Technology is very useful. It is difficult to avoid it. So, we need to find ways to minimize the negative health impacts.

Hypothesis	Learning
• The farther away you are from your smartphone, the less impactful electromagnetic radiation will be for humans.	• Try to stay as far as possible from your smartphone (using earphones or wireless headsets).
• When your smartphone is in calling mode, electromagnetic radiation will be more harmful, followed by texting mode, stationary mode (forward), then stationary mode (backward).	• Try to face the screen of your phone away from yourself, when you are not using it or when you are on a call.
• The farther away you are from your internet router, the less impactful the electromagnetic radiation will be.	• Try to place your wireless internet router in an open area so you can stay as far away as possible.

If I were to continue this project, I would try:

- Experimenting with internet router boosters (WiFi boosters)
- Experimenting with different models and brands of phones (iPhone 14 Pro/6/X, Google, Samsung, etc..)
- Experimenting with old phones vs new phones (Landline, cell phones, flip phones, etc.)
- Experimenting with other electromagnetic devices (remote controls, TV, lightbulb, etc.)

Acknowledgements

I would like to thank everyone who supported me throughout this project

- My dad, for helping me gather and order the materials and format the slideshow. Thank you for not getting bored of me presenting the slideshow and constantly giving me feedback throughout the process. Thank you for inspiring me to do this project for STEM Fair and supporting me when the project needed improvements.

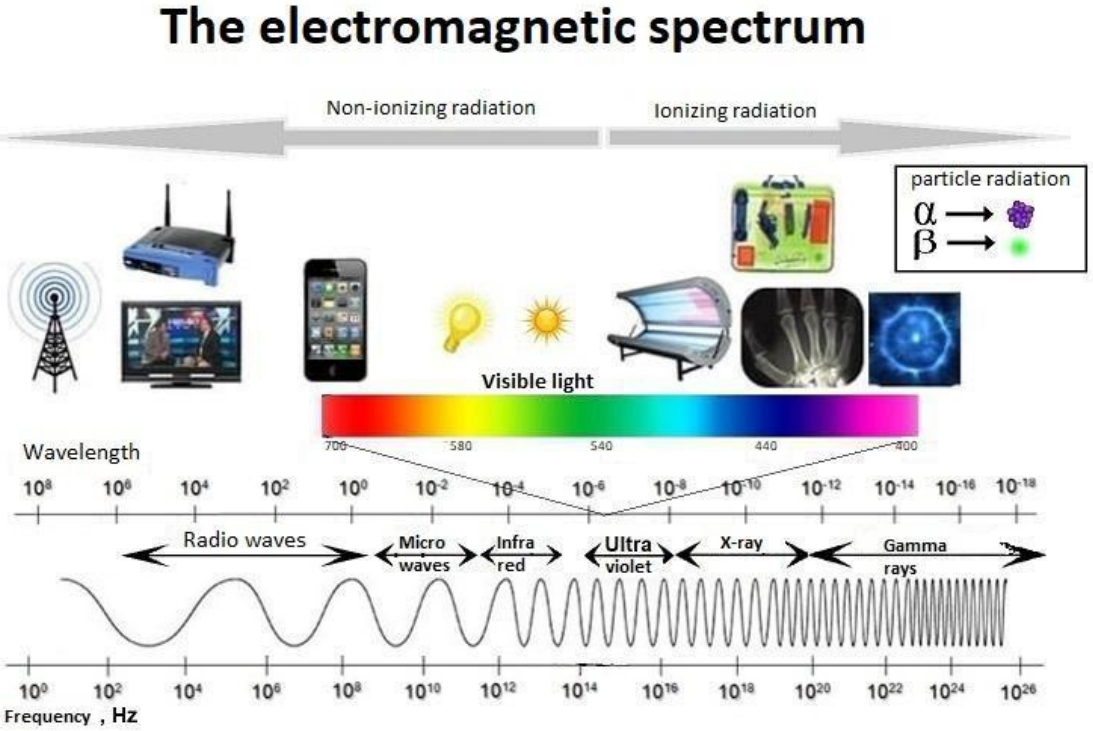
- My mom, for supporting me and helping me. Thank you so much for helping me take pictures and videos to showcase the experiment, and spending time with me to help brainstorm ideas for STEM Fair.

- Mr. Dizon, my science teacher, who guided me throughout this project and gave me useful feedback on this slideshow.

Bibliography and Sources

- Wikipedia - "Electromagnetic radiation."
- More About Electromagnetic Radiation - "Radiation: Electromagnetic fields." World Health Organization (WHO), 4 August 2016
- Science Buddies - Does Your Mobile Phone Radiate? Measuring Cell Phone Electromagnetic Radiation | Science Project
- RF Meter Informative Video - "How to Use the Acoustimeter." YouTube, EMF Center, 2016
- RF Meter Summary Video - "Acoustimeter AM-10 & AM-11 RF Meter." YouTube, Safe Living Technologies Inc, 11 July 2020
- Electromagnetic Wave Standards - Neuert, Michael R. "What Level is Safe." EMF Center, 2022
- RF Meter Renting Website - "RF Meter Acoustimeter AM11." Magnetic Sciences
- Average Screen Time Statistics - Howarth, Josh. "Alarming Average Screen Time Statistics (2023)." Exploding Topics
- Screen Time Limits - "Screen Time Limits Aren't Just For Kids. Why Adults Need Them Too." Henry Ford Health, 14 December 2021
- EMF Advice - "Do WiFi Routers and Extenders Emit EMF Radiation Too?"

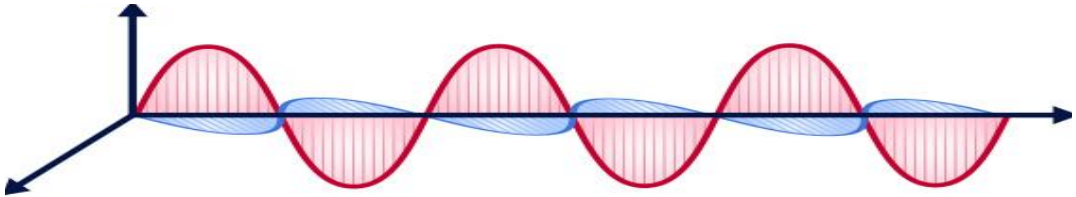
Electromagnetic Radiation



Electromagnetic radiation consists of electromagnetic waves in the electromagnetic field. Electromagnetic radiation and its interaction with matter depends on its frequency.

Lower frequencies have longer wavelengths, and higher frequencies have shorter wavelengths. These frequencies are part of the electromagnetic spectrum, which consists of all frequencies of electromagnetic radiation that spread energy and travel in the form of waves.

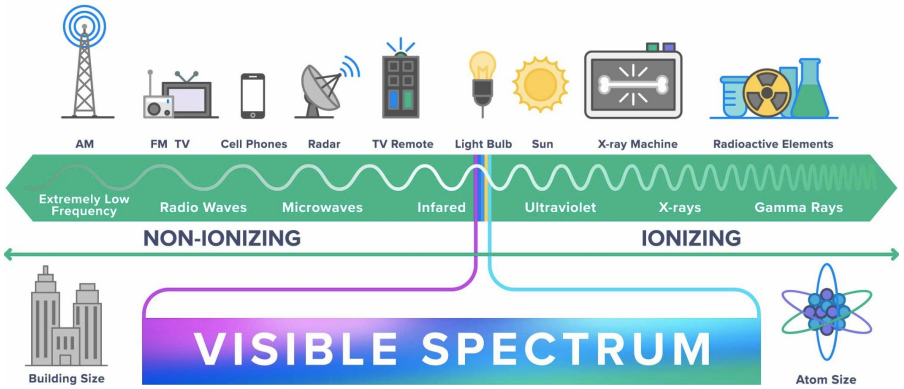
Ill Effects of Electromagnetic Waves



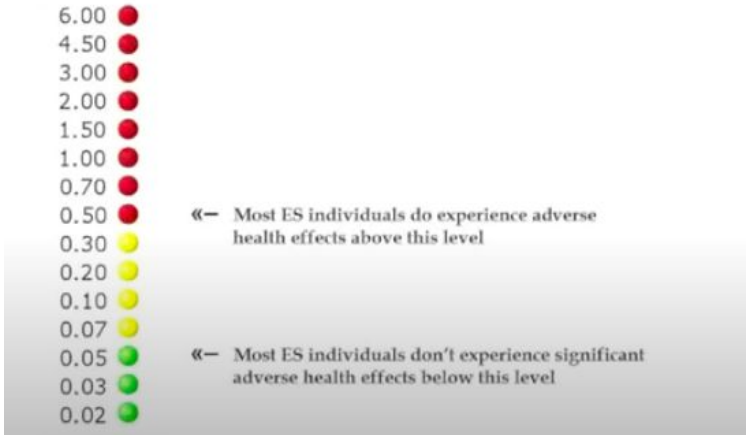
WHO (World Health Organization) states many of the health effects from electromagnetic waves include headaches, anxiety, nausea, etc. Health effects vary based on the frequency of the waves.

The electromagnetic spectrum is classified into non-ionizing radiation and ionizing radiation.

Usually, non-ionizing radiation is less harmful and causes less severe impacts. Whereas, ionizing radiation is more dangerous, and in high doses, can cause cancer and other harmful side effects.



Permissible Levels of Electromagnetic Waves

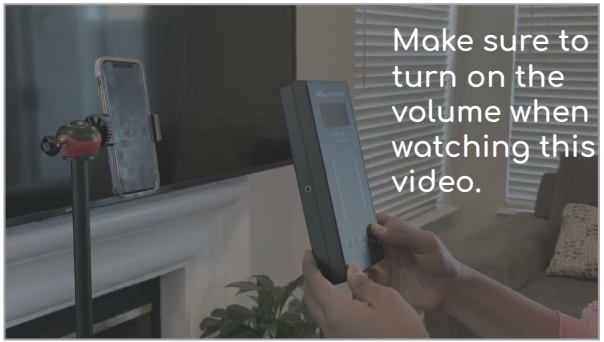


This standardized chart created by Safe Living Technologies Inc showcases that any level above 0.50 V/m is considered harmful to your health.

Unit of Measurement in USA (Abbreviation)	Milligauss (mG)	AC Volts on skin (V or VAC)	Microwatts per meter² (μW/m²)	Microwatts per cm² (μW/cm²)	Volts per meter (V/m)
Lowest Level Linked to Cancer [5, 6]	1.0 (2.0) [5]	unknown	2000 [6]	0.2 [6]	0.87 [6]
Average Level in Homes [7]	0.5 - 1.0	0.5 - 2.0	1 - 5000	0.0001 - 0.5	0.02 - 1.4
Building Biology, Severe Concern [8]	1.0	0.1 (sleep)	10	0.001	0.061
BioInitiative Report [9]	1.0	n/a	3	0.0003	0.034
General Public Precautionary [10]	0.5	1.0 (sleep 0.5)	100	0.01	0.19
EMF Hypersensitivity Advice [11]	0.1	0.1	1	0.0001	0.02
Official FCC Safety Limit [12, 13]	n/a	n/a	10,000,000	1000 [13]	61.4 [13]
ICNIRP for General Public [12]	2000	n/a	10,000,000	1000 [13]	61.4 [13]

There are many studies. Some have high limits, others have low limits.

Experimental Setup (Smartphone)



Video link: https://drive.google.com/file/d/1Arx774hl2ZZ7fp58Ag_4taTJHSIF00Xk/view?usp=sharing

Experimental Setup (Internet Router)

FAQs (Frequently asked Questions)

- **What kind of ill effects can electromagnetic radiation cause?**
  - Depending on the intensity, non-ionizing radiation can cause headaches and anxiety, while ionizing radiation can cause cancer when exposed for a long period of time.
- **What is the electromagnetic spectrum, and how is it related to this experiment?**
  - The electromagnetic spectrum consists of all frequencies of electromagnetic radiation that spread energy and travel in the form of waves. Cell phones and routers fall into the spectrum.
- **Where do smartphones and internet routers fall in the electromagnetic spectrum?**
  - Phones and internet routers both fall in between the radio waves, within the non-ionizing side of the spectrum.
- **How does a Radio Frequency meter work?**
  - After turning the machine on, it will measure the intensity of the electromagnetic waves in V/m (volts per meter).
- **Do internet router boosters transmit electromagnetic waves?**
  - Yes, they do. WiFi boosters, also known as WiFi extenders or repeaters, emit radiation within the radio frequencies.

Thank you!