

Welcome to the Challenge!



Astronaut Sunita Williams, aboard the International Space Station, invites you to help NASA chart *your* pathway to Mars!



Exploration Design Challenge



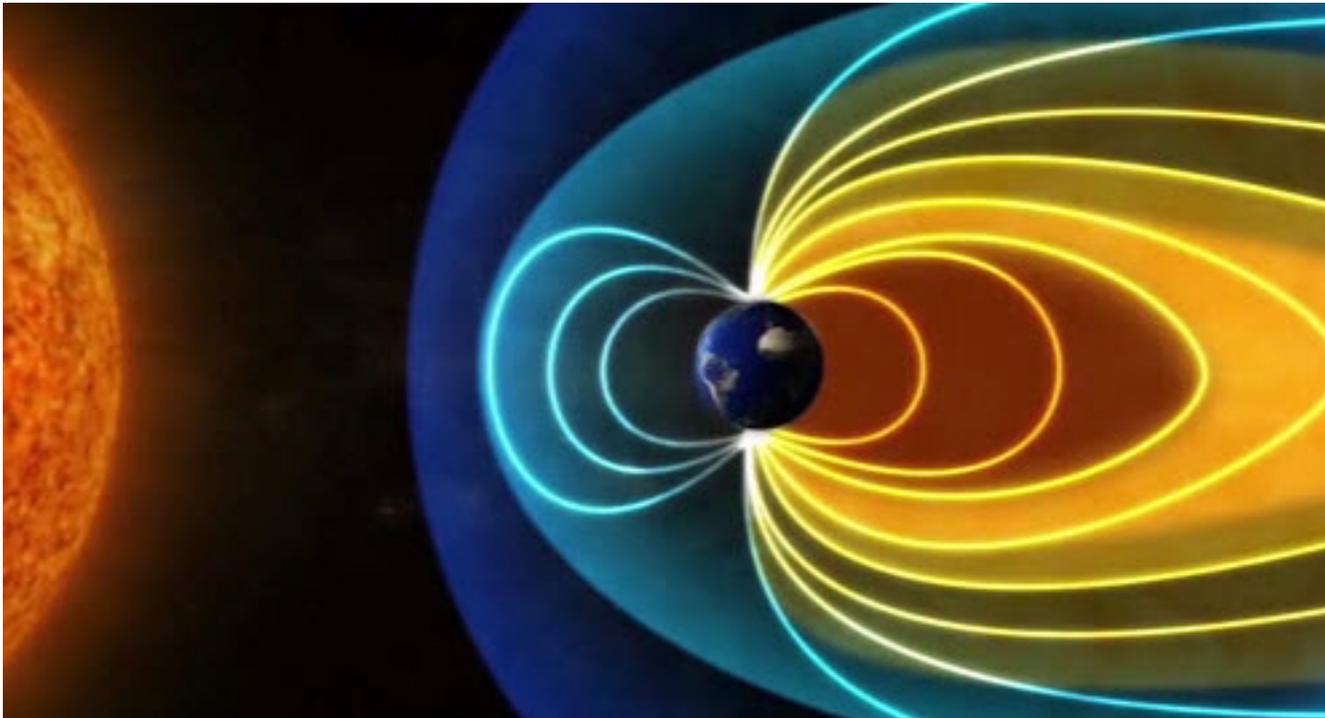
Our Sun



Animation:

<http://sdo.gsfc.nasa.gov/gallery/animations/item/248>

Protection from Radiation



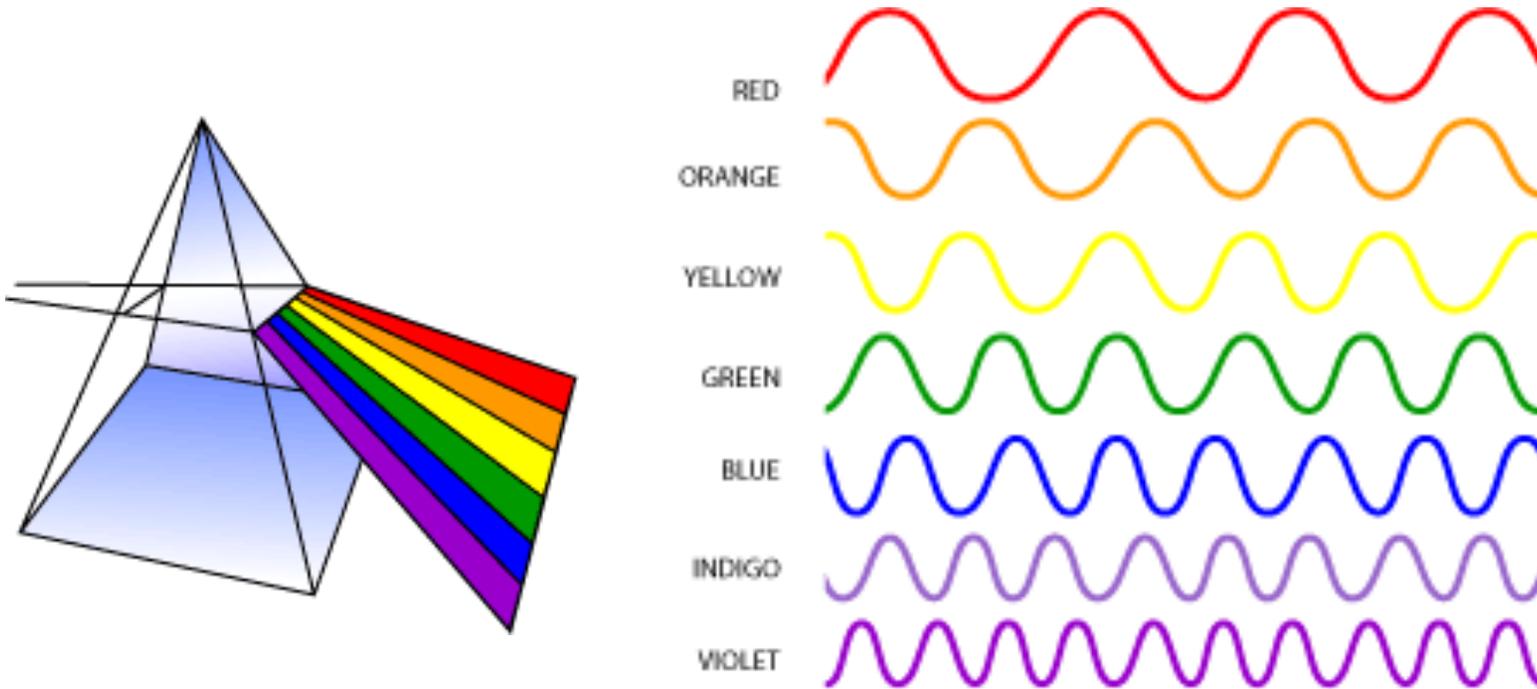
How do Earth's atmosphere and magnetosphere protect us from radiation?

Mars



Mars Science Laboratory

What is Radiation?



Think first about visible light:

Organized by wavelength

Red waves are long – not much energy

Violet are short – lots of energy

Electromagnetic Spectrum

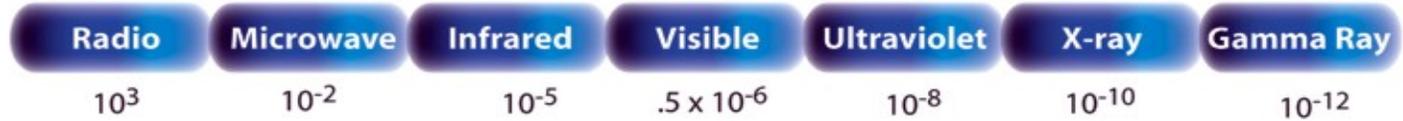


THE ELECTROMAGNETIC SPECTRUM

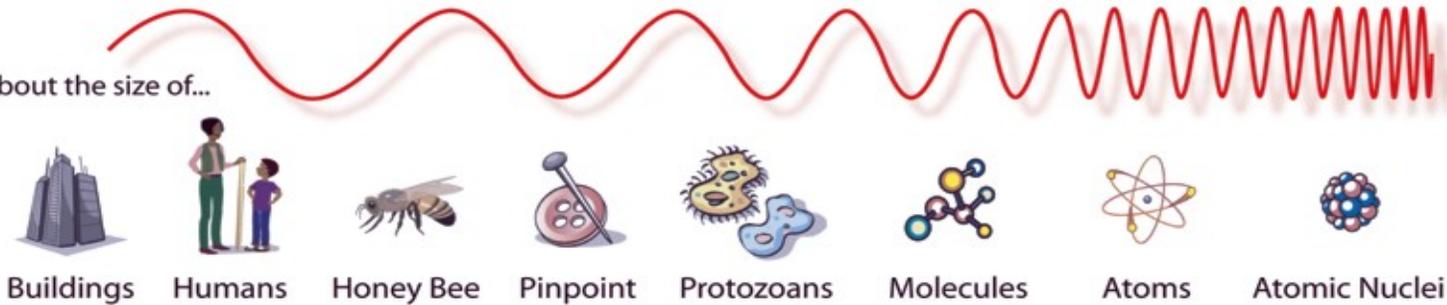
Penetrates Earth Atmosphere?



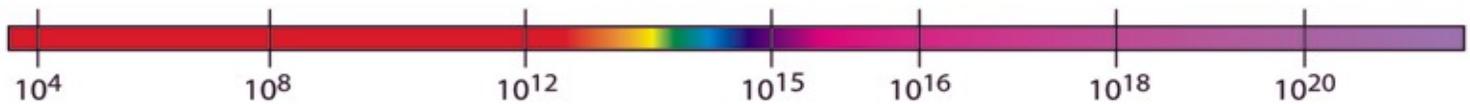
Wavelength (meters)



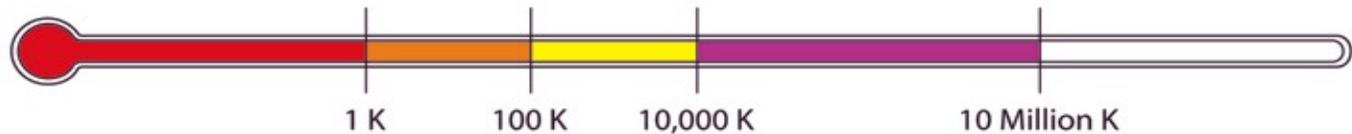
About the size of...



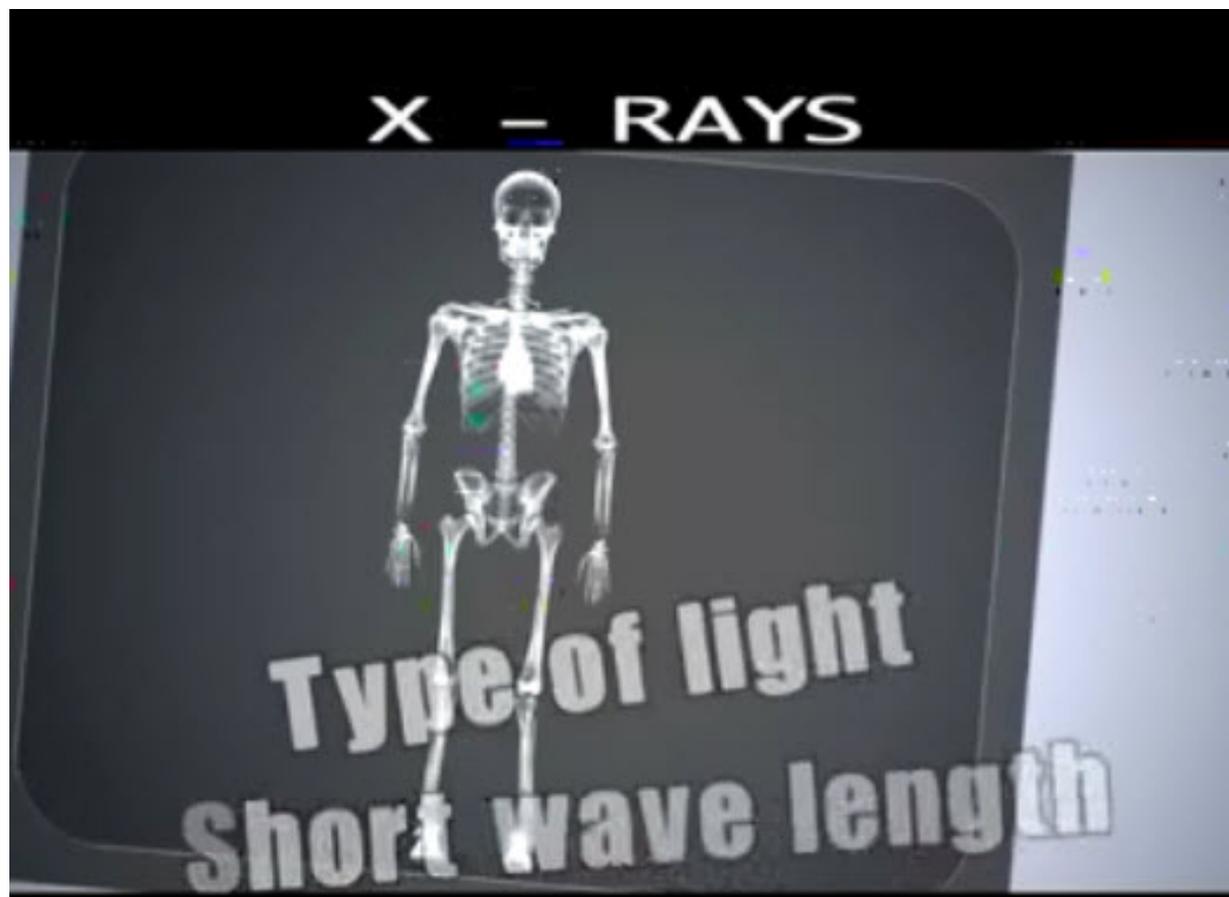
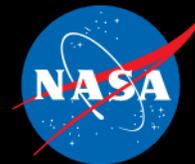
Frequency (Hz)



Temperature of bodies emitting the wavelength (K)



X-Rays



Transportation Capabilities to Enable Human Space Exploration



Suborbital	Low-Earth Orbit (LEO)	GEO	Trans-Lunar	Deep Space				
Technology payloads and commercial passengers	Scientific research and technology testing that improves life on Earth and enables future deep space exploration	Location for communications support to LEO missions	Space environment to test and prove exploration capabilities and operations	Human journeys of exploration and discovery, taking us farther into space than ever before				
	<p><i>International Space Station (ISS)</i></p>	<p><i>TDRS-K</i></p>	<p><i>Asteroid Retrieval Mission</i></p>	<p><i>Curiosity (Robotic Precursor to Human Exploration)</i></p>				
<table border="1"> <thead> <tr> <th>Commercial Cargo</th> <th>Commercial Crew</th> </tr> </thead> <tbody> <tr> <td> <p><i>Dragon</i> <i>Cygnus</i> <i>Falcon 9</i> <i>Antares</i></p> <p>SpaceX Orbital Sciences</p> </td> <td> <p><i>CST-100</i> <i>Dragon</i> <i>Dream Chaser</i> <i>Atlas V</i> <i>Falcon 9</i> <i>Atlas V</i></p> <p>Boeing SpaceX Sierra Nevada Corp.</p> </td> </tr> </tbody> </table>		Commercial Cargo	Commercial Crew	<p><i>Dragon</i> <i>Cygnus</i> <i>Falcon 9</i> <i>Antares</i></p> <p>SpaceX Orbital Sciences</p>	<p><i>CST-100</i> <i>Dragon</i> <i>Dream Chaser</i> <i>Atlas V</i> <i>Falcon 9</i> <i>Atlas V</i></p> <p>Boeing SpaceX Sierra Nevada Corp.</p>	<p><i>Orion Crew Vehicle</i> <i>Space Launch System (SLS)</i></p>		
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Why Do Humans Explore?

Discovery | Scientific Knowledge | Returning Benefits To Humanity
 Technology & Economic Growth | Expansion of Human Civilization | International Cooperation | Public Engagement

Last Updated:
05/03/2013

What Do You Know?





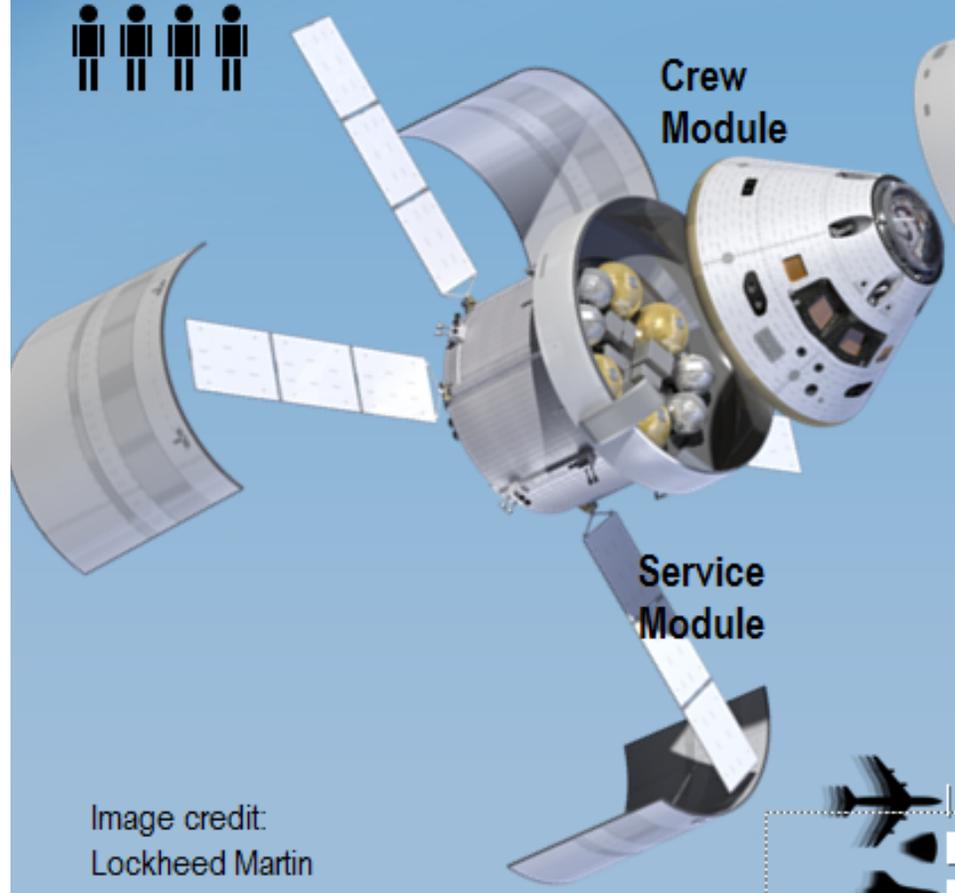
Orion Spacecraft

The Orion vehicle will carry a crew of 4 astronauts and is designed for missions up to 600 days.

The Orion heatshield can withstand temperatures up to **6000° F**, nearly half the temperature on the surface of the sun.



6000°F



Crew Module

Service Module



Launch Abort System

13,000



The crew module returns to earth at a speed of **27,000 miles per hour**, 1.5 times as fast as the space shuttle, and 45 times faster than a commercial airliner.

If the launch abort motor energy could be converted to electric power, it would be enough to power **13,000 houses for an entire day.**

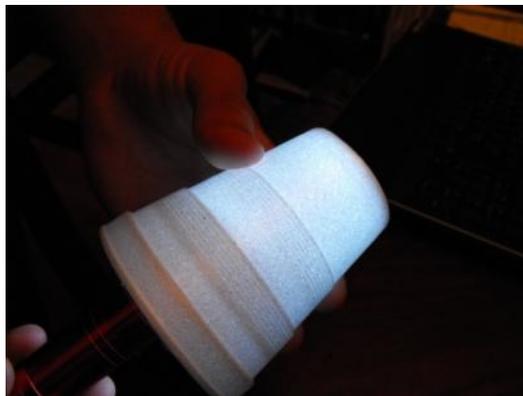
27,000 mph!



Image credit: Lockheed Martin

Footer

Testing – Think Like a Scientist



Teamwork



What are benefits to working in a team?

Record Data and Observations



Record Data

PART 1:

Ray Shielding Analysis Chart

Dimension of sheets in centimeters:

Length _____

Width _____

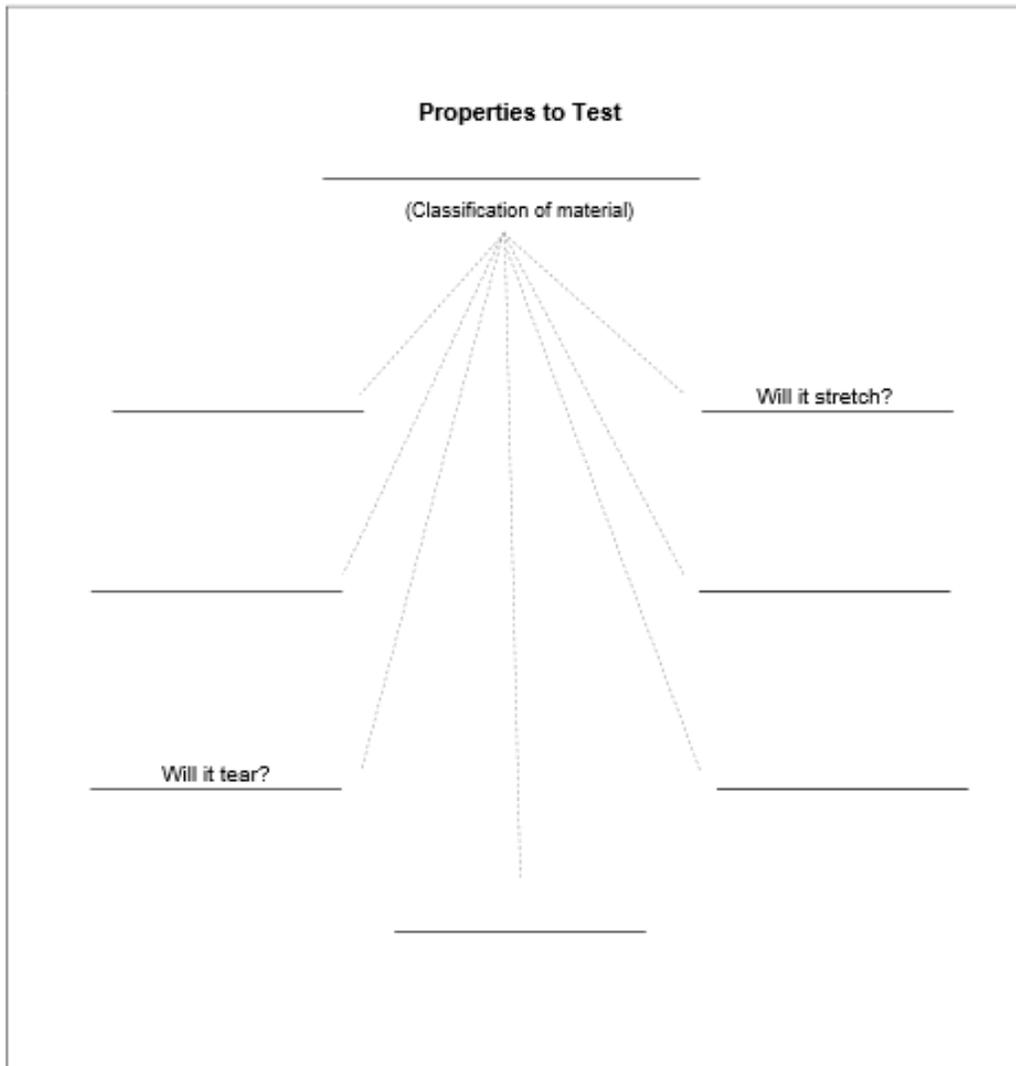
Predict and test to find the number of sheets required to completely block the light from your flashlight.

	Copy		Tissue		Card stock		Construction	
	Predict	Actual	Predict	Actual	Predict	Actual	Predict	Actual
Total weight of all sheets in grams								
# sheets to block the simulated space radiation								

Record Data and Observations



Record Data
PART 2:
Further Materials Analysis Web



**Decide which
properties you want
to test.**

Record Data and Observations



Record Data
PART 2:
Further Materials Analysis Chart

Record observations about each of the properties you chose to test.

Rank the materials from 0 to 5					
0	1	2	3	4	5
No sign of property		Medium sign of property		Large sign of property	

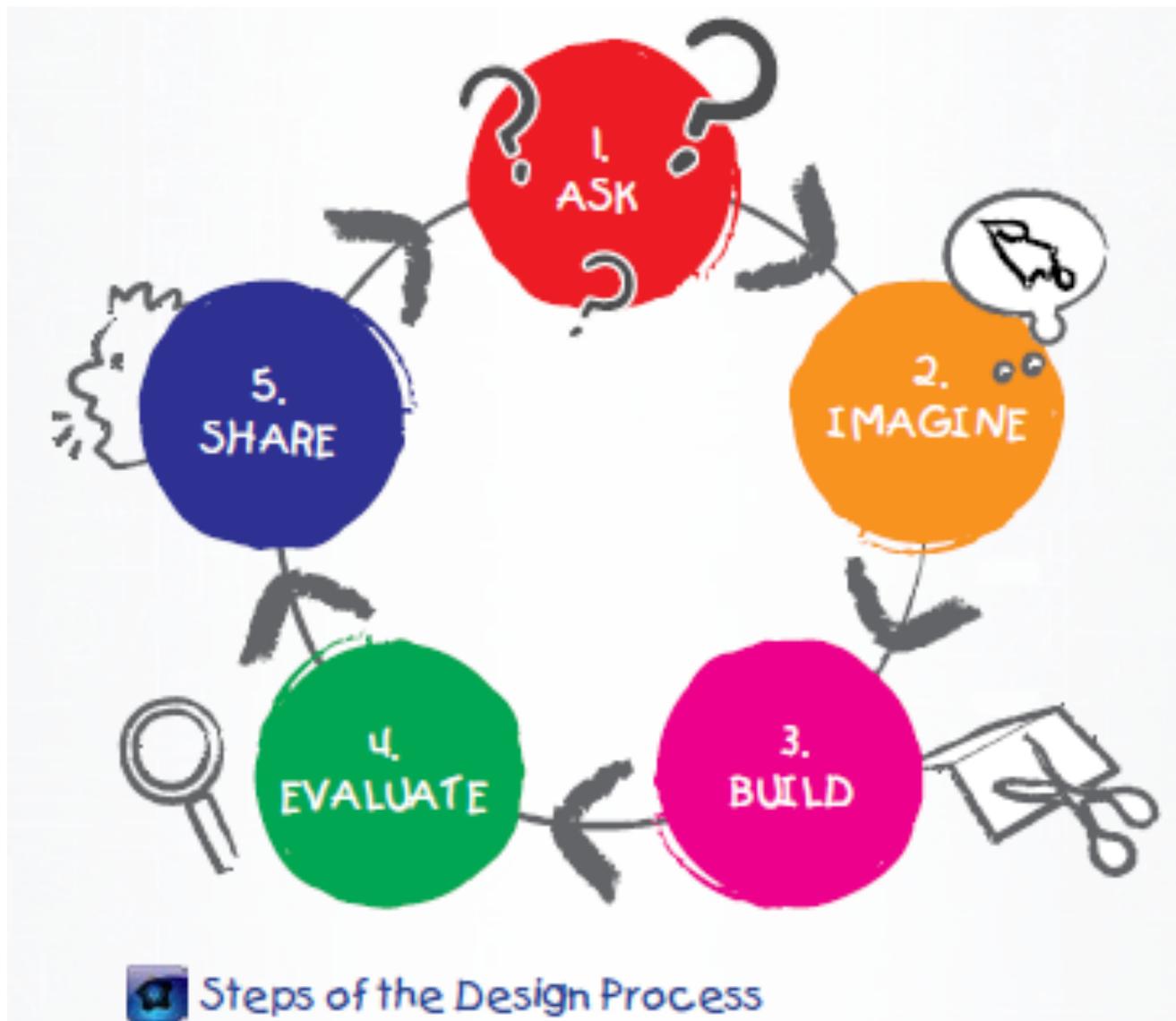
Property to test	Describe the test	Copy	Tissue	Card stock	Construction
Will it tear?	I will tear the material with my hands.				
Will it stretch?	I will pull outward on the sides of the paper.				



Problem Statement:

Using the materials tested, how can we design and build a radiation shield that will block visible light?

Engineering Design Process



Evaluate – Improve Your Model



What are low-Z materials?

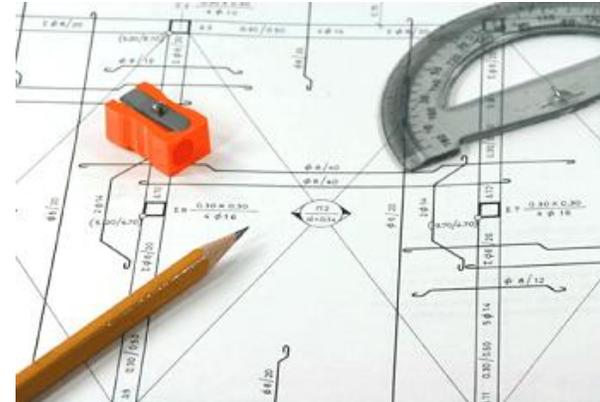
Periodic Table of the Elements

1 1IA 11A	2 IIA 2A											13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	18 VIIIA 8A	
1 H Hydrogen 1.0079																		2 He Helium 4.00260
3 Li Lithium 6.941	4 Be Beryllium 9.01218											5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.00674	8 O Oxygen 15.9994	9 F Fluorine 18.998403	10 Ne Neon 20.1797	
11 Na Sodium 22.989768	12 Mg Magnesium 24.305	3 IIIB 3B	4 IVB 4B	5 VB 5B	6 VIB 6B	7 VIIB 7B	8 VIII 8	9 VIII 8	10 VIII 8	11 IB 1B	12 IIB 2B	13 Al Aluminum 26.981539	14 Si Silicon 28.0855	15 P Phosphorus 30.973762	16 S Sulfur 32.066	17 Cl Chlorine 35.4527	18 Ar Argon 39.948	
19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.95591	22 Ti Titanium 47.88	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938	26 Fe Iron 55.847	27 Co Cobalt 58.9332	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.723	32 Ge Germanium 72.64	33 As Arsenic 74.92159	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80	
37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90585	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.94	43 Tc Technetium 98.9072	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.9055	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.71	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.90447	54 Xe Xenon 131.29	
55 Cs Cesium 132.90543	56 Ba Barium 137.327	57-71 Lanthanide Series	72 Hf Hafnium 178.49	73 Ta Tantalum 180.9479	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.9665	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.98037	84 Po Polonium [209]	85 At Astatine [209]	86 Rn Radon 222.01758	
87 Fr Francium 223.0197	88 Ra Radium 226.0254	89-103 Actinide Series	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [285]	109 Mt Meitnerium [288]	110 Ds Darmstadtium [289]	111 Rg Roentgenium [292]	112 Cn Copernicium [285]	113 Uut Ununtrium unknown	114 Uuq Ununquadium [289]	115 Uup Ununpentium unknown	116 Uuh Ununhexium [288]	117 Uus Ununseptium unknown	118 Uuo Ununoctium unknown	
		57 La Lanthanum 138.9055	58 Ce Cerium 140.116	59 Pr Praseodymium 140.90765	60 Nd Neodymium 144.24	61 Pm Promethium 144.9127	62 Sm Samarium 150.36	63 Eu Europium 151.9654	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92534	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93032	68 Er Erbium 167.26	69 Tm Thulium 168.93402	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967		
		89 Ac Actinium 227.0278	90 Th Thorium 232.0381	91 Pa Protactinium 231.03688	92 U Uranium 238.02891	93 Np Neptunium 237.0482	94 Pu Plutonium 244.0642	95 Am Americium 243.0614	96 Cm Curium 247.0753	97 Bk Berkelium 247.0753	98 Cf Californium 251.0788	99 Es Einsteinium [254]	100 Fm Fermium [257]	101 Md Mendelevium 258.1	102 No Nobelium 259.1009	103 Lr Lawrencium [262]		
	Alkali Metal	Alkaline Earth	Transition Metal	Basic Metal	Semimetals	Nonmetals	Halogens	Noble Gas	Lanthanides	Actinides								

Evaluate – Improve Your Model



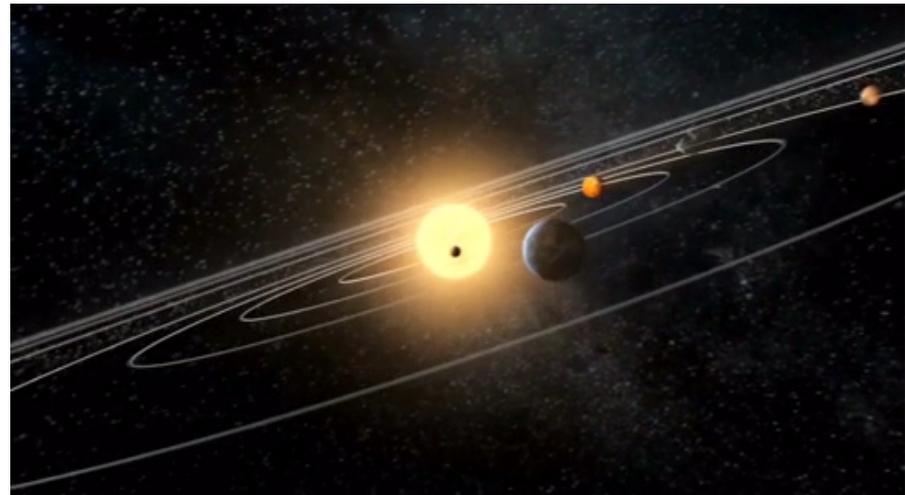
What are some easy-to-find low-Z materials?



Space Radiation



How is radiation in space different from radiation on Earth?



Electromagnetic Spectrum



THE ELECTROMAGNETIC SPECTRUM

Penetrates Earth Atmosphere?



Wavelength (meters)



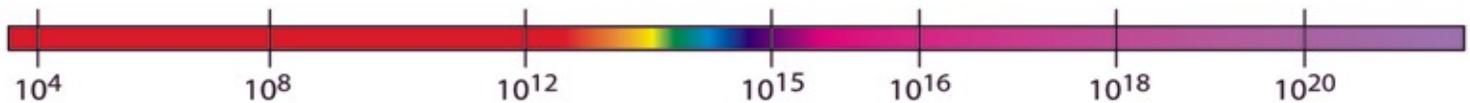
10^3 10^{-2} 10^{-5} $.5 \times 10^{-6}$ 10^{-8} 10^{-10} 10^{-12}

About the size of...

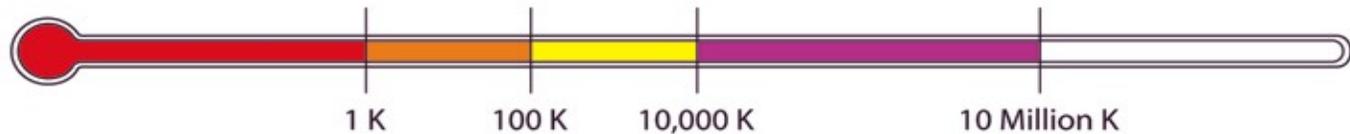


Buildings Humans Honey Bee Pinpoint Protozoans Molecules Atoms Atomic Nuclei

Frequency (Hz)



Temperature of bodies emitting the wavelength (K)



Science and Engineering



How do scientists and engineers work together?

How does what we know about radiation influence the design of Orion?



Re-Design – Think Like an Engineer



Re- design and build a radiation shield that will block both visible and UV light.

Congratulations!

