Spring 2017 Modern Physics Project – Mission to Mars

Part III: Students will form teams of two (or three), with one student coming from the "shielding" group, and one student coming from the "human exposure" group. Each team will design a radiation shield to protect astronauts from Galactic Cosmic Rays (GCR) during a mission to Mars.

1. Your shield must be spherical and protect a 6.2 m radius region where the astronauts will be living during the voyage to and from Mars.

2. Your shield can extend as far as you would like beyond the 6.2 m inner radius, but it cannot extend into the 6.2 m radius volume inhabited by the astronauts.

3. Your shield must have fewer than 11 layers, these layers can be of any thickness, and be made out of any material.

4. You will need to calculate the mass of your shield, and based on that the cost of the materials to construct your shield. I will give the cost/kg of some common materials later in this document, if you want to use a material that is not listed then email me and I will add that material to the list.

5. Your shield will be assigned a score based on 4 criteria: total radiation dose received by the astronauts, mass of your shield, cost of your shield, and any safety/feasibility/durability issues of your shield.

$$Your\ score = \left(\frac{50\times10^6}{cost}\right)^{1/4} \times \frac{(0.5 - dose)}{(0.1 + dose)^3} \times \left(\frac{2.2\times10^6}{mass}\right)^2 \times S$$

   Where *cost* is in dollars, *mass* is in kg, *dose* is in Sv, and the safety/feasibility factor *S* is a scale factor between 0 and 1.

6. I expect that most shields will have an *S* factor of 1. However shields that could be harmful to the astronauts or impossible to build will get a smaller *S* factor.

7. After you design your shield I will run it through a computer simulation which will calculate the total dose absorbed by the astronauts. Your design will be tested by simulating a 500 day voyage to Mars and back with a crew of 8 astronauts.

8. This will be a competitive assignment; teams will get some points towards their grades based on how well their shield does compared to the shield designs developed by other teams.

9. After your first shield design you will have three chances to improve on your design. Your grade will be based on your best score out of your four shield designs.

10. Your first shield design is due on 4/5.

Material	Density in kg/m^3	Cost in $/kg
aluminum	2700	1.65
beryllium	1840	930
bismuth	9750	18.7
brass	8520	2.0
cobalt	8746	46
copper	8940	5.8
gold	19320	39960
iridium	22650	24755
iron	7850	.2
lead	11340	1.25
lithium	534	270
magnesium	1738	5.8
manganese	7440	1.5
nickel	8908	9.9
osmium	22610	12860
platinum	21400	31089
silver	10490	573.6
tin	7280	2.0
titanium	4500	8
tungsten	19600	200
uranium (depleted)	18900	11
zinc	7135	2.8
carbon	2140	1.2
cement	2800	.2
polyethylene	2300	1.4
boron	2370	5000
silicon	2330	3
silicon dioxide	2650	30
water	1000	.05
air (nitrogen gas)	1.22	.1
boron nitride	3450	20

Material	Density in kg/m^3	Cost in $/kg	
tantaulum	16700	81	
paper	800	2	
boric acid	1440	3.2	
cadmium	8650	3	
liquid hydrogen	71+(200)	4+(500)	the ( ) numbers refer the necessary cryogenic systems
polypropylene	946	4.2	
boron carbide	2520	540	