A Perspective on Radiation Dosages

Space travel is understandably a risky business. One of the most well-studied, and worrisome, hazards is the radiation environment. The sun produces streams of high-energy particles and flares, while the universe itself also rains particles down upon us from distant supernova explosions and other energetic phenomena. But how bad is space travel compared to just staying on Earth?

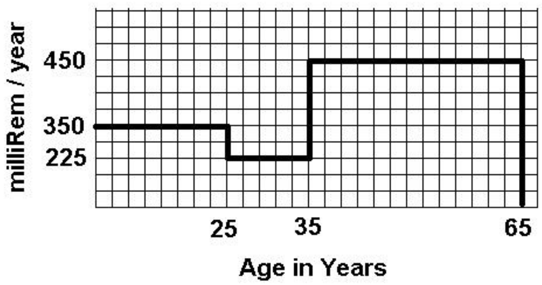
For the following problems, plot how the radiation environment changes for a person living in Denver, on the Space Station, on the Moon, and on a journey to Mars and back. Calculate the total radiation dosage by computing the area under the respective curves.

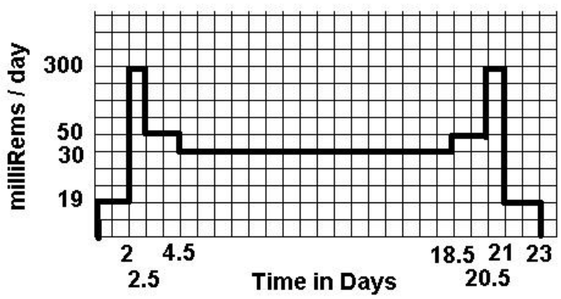
1. Nancy was born and raised in Denver where her radiation dosage was 350 milliRems/year. At age 25, she moved to Houston where her dosage was 225 milliRems/year, then moved to South Dakota 10 years later where her dosage was 450 milliRems/year until she retired at age 65. Create a plot showing 'YEAR' on the horizontal axis and 'Dosage' on the vertical axis. Prove that the product of the vertical axis units times the horizontal axis units is the total dose in milliRems. Plot Nancy's annual dosages and calculate her total dosage by age 65.

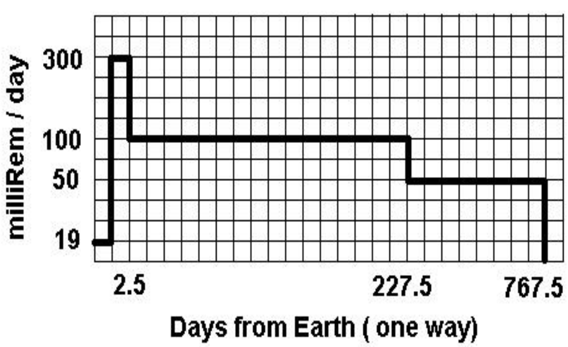
2. An astronaut travels to the Moon on NASA's Orion Crew Vehicle, and spends two weeks on the lunar surface before returning to Earth. The radiation dosage is 19 milliRem/day in Earth orbit for each of two days. The 1/2 day trip through the van Allen belts is 300 milliRem/day. The journey to the Moon takes two days at 50 milliRem/day. The stay on the lunar surface under shielded conditions is 30 milliRem/day. The astronaut returns to Earth retracing the previous conditions, followed by a 2-day stay at the International Space Station, where the dosage is 1.5 milliRem/hour. Plot her dosage history and calculate the total dosage in Rems.

3. An astronaut journeys to Mars. The radiation dosage is 19 milliRem/day at the International Space Station for each of two days. The 1/2 day trip through the van Allen belts was 300 milliRem/day. The crew spends 225 days traveling to Mars, during which time the dosages are 100 milliRems/day. On Mars, for a planned stay of 540 days, the dosage will be about 50 milliRem/day. This is followed by a similar 225-day return to earth, 1/2-day trip through the van Allen Belts, and a 2-day stay at the Space Station. Plot her dosage history and calculate the dosages.

Answer Key:







Problem 1:

<u>Denver to Houston to South Dakota:</u>

(350 mRem/yr x 25 yrs) + (225 mRem/yr x 10 yrs) + (450 mRem/yr x 30 yrs) = **24.8 Rem**

Problem 2:

<u>Roundtrip:</u>

(19 mRem/day x 2 days) + (300 mRem/day x 0.5 days) + (50 mRem/day x 2 days) + (30 mRem/day x 14 days) + (50 mRem/day x 2 days) + (300 mRem/day x 0.5 days) + (19 mRem/day x 2 days) = **1.1 Rem**

Problem 3:

<u>Earth to Mars:</u>

(19 mRem/day x 2 days) + (300 mRem/day x 0.5 days) + (100 mRem/day x 225 days) + (50 mRem/day x 540 days) = 49.7 Rem

<u>Return Trip</u> = **22.7 Rem**

<u>Total Trip =</u> 49.7 Rem + 22.7 Rem = 72.4 Rem

<u>Note to Teacher:</u>

The total lifetime radiation dosages for the trips in Problem 2 and 3 will be in ADDITION to the total dosages that the astronauts receive on the ground before and after the trip into space. For example, if an astronaut lives in Houston all his life (70 years) where the environmental and lifestyle dosage is 300 milliRems/year, the normal lifetime dosage will be 300 milliRems/year x 70 years = 21.0 Rems.

In Problem 3, an astronaut travels to Mars and back, taking (2.5 + 225 + 540 + 225 + 2.5)= 995 days or 2.7 years their total Mars dosage will be 72.4 Rem added to (70-2.7)x 300 milliRems/year = 20.2 Rems on the ground for a total lifetime dosage of 92.6 Rems!

Another way to look at this is to recognize that a trip to Mars will equal about 72.4 Rem/0.300 Rem = 241 years of normal background radiation living on Earth (in Houston)…but accumulated in only 2.7 years!