Physics for future Presidents

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Homework 6, due in lecture on Wednesday, Sep 25th

Radiation Doses

Around 4:00 am on the morning of March 28, 1979, water pumps in the non-nuclear section of Three Mile Islands' Unit 2 nuclear power plant stopped working. This prevented the steam generators from removing heat from the plant and initiated an automatic shutdown of the reactor. The possiblity that the melting of fuel rods could result in a release of radioactivity to the surroundings was of great concern. The Nuclear Regulatory Commission was alerted at 8:00 am and the White House was alerted at 9:15 am. By 11:00 am, all non-essential personnel were evacuated from the facility. The remaining personnel worked to bring the situation under control over the next several days.

According to the U.S. Nuclear Regulatory Commission, this accident, "was the most serious in U.S. commercial power plant operating history, even though it led to no deaths or injuries to plant workers or members of the nearby community. But it brought sweeping changes involving emergency response planning, reactor operator training, human factors engineering, radiation protection, and many other areas of nuclear power plant operations."

`http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html`

1. The NRC quotes several independent studies that estimate that the average dose to about 2 million people was 1 mrem each.
   a) Consider one person out of these 2 million. Use the linear no-threshold hypothesis to estimate probability that this one person would get cancer due to this exposure.
   b) What is the expected increase in the number of cancer cases in this population of 2 million people?
   c) If 10,000 of the local residents moved from the Harrisburg area to Denver for 10 years to get away from the scene of this industrial accident, what is the expected increase in the cases of cancer that would be expected for this group? Note that the natural background levels in Denver is about 80 mrem/ year higher than in Harrisburg.
   d) How many of the 2 million would be expected to die from cancer even if they had not been exposed to this radiation?

2. During the accident, radioactive gas was building up in the reactor's containment vessel. At one point, there was some worry that the gas might explode and rupture the vessel; an NRC representative calculated that a rupture could result in a radiation level of 1.2 *rem*/hour at ground level. Fortunately, this did not happen. But suppose it had happened and 10 workers were exposed to this level of radiation for 8 hours because they stayed at the plant to continue their work to control the situation while everyone else evacuated the area.

   a) Is it likely that any of these hypothetical workers would experience radiation poisoning that would make them ill or cause their death shortly after the accident?

   b) Is it likely that any of these hypothetical workers would eventually have a form of cancer because of this event?