22.01 Quiz 3

Quiz Instructions: Answers can be given symbolically or graphically, no calculation is necessary. ***No devices, or anything else allowed, except for one calculator and one double-sided, 8.5 x 11 inch or A4 sheet of paper.*** Define any intermediate variables or symbols which you need to complete the problems. Generous partial credit will be given for correct methodology, even if the solution is not given.

---

5 (70 points) Short Answers, 10 points each

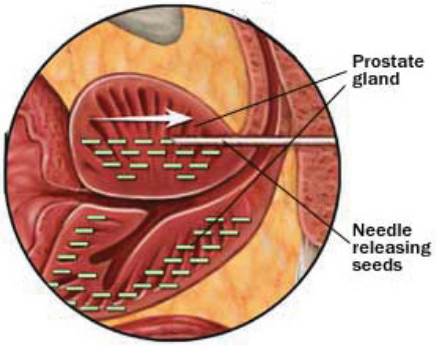
Each of these problems can be solved with one sentence, one equation, or one graph.

5.1 Give three reasons why you irradiate yourself more than a person standing next to you.

5.2 Describe how you could roughly gauge the acute radiation dose to which someone was exposed by timing their symptoms. Just give the patterns, not numbers.

5.3 Describe the most likely mechanism by which DNA is damaged following a gamma ray entering an organism. Explain the origin of the unit processes in your answer.

5.4 **Explain, using arguments from stopping power and range, which type and rough energy of radiation would be ideal for brachytherapy as shown in the diagram below.**



© Mayo Foundation for Medical Education and Research. All rights reserved. This content is excluded from our Creative Commons license. For more information, see https://ocw.mit.edu/help/faq-fair-use.

5.5 **Explain why irradiating food does not cause it to become radioactive or more toxic, yet can decrease its nutritional content while making it safer to eat.**

5.6 **Why, mathematically speaking, don't we know whether very low doses of radiation increase the risk of contracting cancer?**

5.7 **Explain the possible biological origins of radiation hormesis.**

6 (30 points) Set up, but do not solve, an expression to calculate the total excess dose in Sieverts you would receive by taking an international flight at height of h meters above sea level for t seconds. Define any symbols you need, and assume that:

- Uniform fluxes Φ_γ and Φ_p of 50 MeV gamma rays and 50 MeV protons, respectively, strike the high upper atmosphere
- Some of the protons produce 50 MeV spallation neutrons very high in the atmosphere, with a microscopic cross section of $\sigma_{(p,n)}$
- The density of the atmosphere varies with some arbitrary function $\rho(z)$, varying between 0.001 $\frac{g}{cm^3}$ at sea level and 0 at an infinite distance up, while the composition of the atmosphere is a constant 80% nitrogen, 20% oxygen
- There is no variation in cosmic ray flux with latitude, and you instantly reach your cruising altitude

7 Bonus Question (10 points): Why are there no neutrons in the cosmic ray spectrum? In other words, how do we know that *all* cosmic ray neutrons which reach us are produced by spallation in the Earth's atmosphere (and perhaps the sun), and *not* from distant stars?

MIT OpenCourseWare
https://ocw.mit.edu

22.01 Introduction to Nuclear Engineering and Ionizing Radiation

Fall 2016

For information about citing these materials or our Terms of Use, visit: https://ocw.mit.edu/terms.