

READ INSTRUCTIONS CAREFULLY! Failure to follow them will result in point deductions.

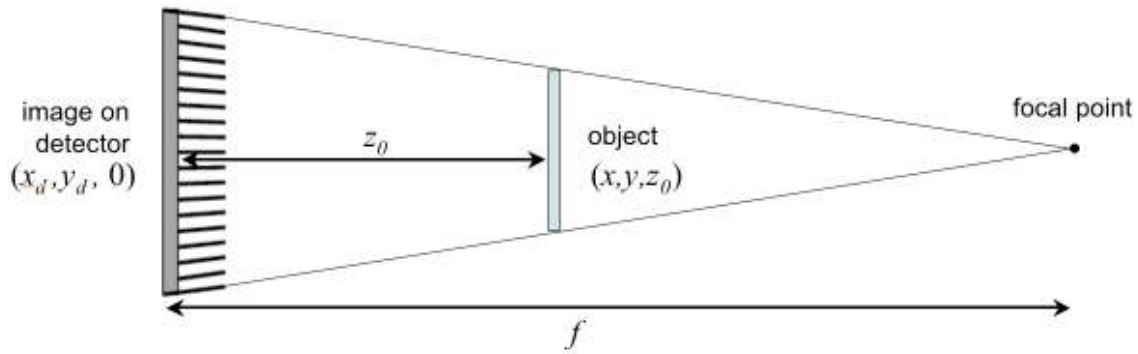
Please complete the following problems, with the following guidelines:

- You are permitted to discuss the questions with each other, but you must independently write your own solutions and abide by the University Honor Code (no sharing of solutions and no plagiarism).
- You may use any resource on the Internet or in the libraries to supplement the text.
- **Show all of your work** for numerical problems, **and explain your reasoning** for all “word” answers.
- Please hand-write your solutions neatly, using only the front side of each page, with your name and assignment number.
- Make sure your problem set is stapled in the upper left-hand corner.
- Late homeworks will receive half credit

1. Given a sample of 2.3×10^{10} atoms of technetium-99, which has a half life of 6 hours.
 - a. What is the radioactivity of the original sample?
 - b. How many atoms can be expected to be present after 12 hours?
 - c. What will be the radioactivity after 12 hours?
2. There are many different radioactive isotopes, with a wide range of half-lives; ismuth-212 (60.5 sec), iodine-123 (13 hours), iodine-131 (8.07 days), uranium-238 (4.5 billion years), what range (order of magnitude) is appropriate for nuclear medicine radioactive tracers? Why?
3. Starting with the imaging equation for a parallel hole collimator in Prince (equation 8.11),

$$\phi(x, y) = A_{z_0}(x, y) \frac{1}{4\pi z_0^2} \exp \left\{ \int_{z_0}^0 \mu(x, y, z'; E) dz' \right\}$$

develop the analogous equation for (x_d, y_d) using the converging collimator (image larger than object) shown below:



Assume the object in the diagram is the planar source in the equation and $x = y = 0$ at the center of the detector. Since the line of projection is no longer perpendicular to the image detector, you should use an integration variable s instead of z' , similar to that in equation 8.7, integrating from 0 to r_0 rather than from z_0 to 0, where

$$r_0 = \sqrt{(x - x_d)^2 + (y - y_d)^2 + z_0^2}$$

and where s is the distance along a path *from* (x, y, z_0) to the detector location $(x_d, y_d, 0)$. See text around equation 8.7 for further explanation of the reversal of integration direction. **Explain the effects of the converging collimator based on the resulting new equation.** (hint: first define the magnification of the object in terms of its z location)

4. Planar scintigraphy is considered the nuclear medicine analog of projection radiography, but still has its differences. Compare and contrast planar scintigraphy and projection radiography.
5. A PET detector is made of NaI(Tl) with a linear attenuation coefficient of 0.343 cm^{-1} at 511 keV, how thick does the detector need to be to stop 90% of the 511 keV photons that strike it?
6. What factors contribute to the likelihood of random coincidences? How?