Problem Set I

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1 Proton Number, Neutron Number, Mass Number

Nuclei	**Z**	**N**	**A**	**Applications**
Carbon-14	6	8	14	Radio-dating up to 50,000 years
Phosphorus-32	15	17	32	Radio-tagging DNA segments metabolic Pathway Tracing
Cobalt-60	27	33	60	Hard Gamma Emitter Sterilize Medical Equipment My favorite isotope
Technetium-99	43	56	99	Meta-Stable (^{99m}Tc) used widely for medical imaging
Lead-208	82	126	208	Ratio of Pb-208:Pb-204 used to determine past presence Radio-Nuclides: Uranium/Thorium/Plutonium.
Radium-226	88	138	226	Daughter of ^{238}U Decay A Leading Cause of Lung Cancer
Uranium-235	92	143	235	Naturally in Uranium Ore 0.72% When Enriched to a high percent of Uranium Can be used on Nuclear Power Plants Or Nuclear Weapon

Reaction	**Z**	**N**	**Pos**
$^{226}Ra \rightarrow {}^{222}Rn + \alpha$	$88 = 86 + 2$	$138 = 136 + 2$	Yes
$^{235}U + n \rightarrow {}^{138}Xe + {}^{94}Sr + 4n$	$92 + 1 \neq 54 + 38 + 0$	$143 + 0 \neq 84 + 56 + 4$	No
$^{239}Pu \rightarrow {}^{140}Cs + {}^{98}Zr + n$	$94 \neq 55 + 40 + 1$	$145 \neq 85 + 58 + 1$	No

2 Cyclotron

Given: $p = 200\text{MeV}$, $m = 938\text{MeV}$, $\Delta T = 100\text{KV}$, $k = e$

$$E^2 = p^2 + m^2 \tag{1}$$

$$T = E - m \tag{2}$$

$$T = \sqrt{p^2 + m^2} - m \tag{3}$$

$$T = \sqrt{(200\text{MeV})^2 + (938\text{MeV})^2} - 938\text{MeV} = 21.1\text{MeV} \tag{4}$$

$$T = kn\Delta T \tag{5}$$

$$n = \frac{T}{k\Delta T}\frac{21.1\text{MeV}}{e * 100\text{KV}} = 211 \tag{6}$$

$$\boxed{\textbf{211 Revolutions}}$$

3 Cross section of a Disk

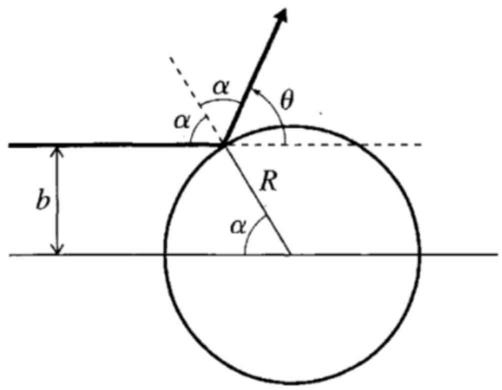

Figure 1: Credit to http://web.physics.ucsb.edu/ fratus/phys103/LN/Scattering.pdf for image.

A particle traveling towards a disk of radius R. Travelling parallel to an axis passing through the center of the disk. At a distance b from the axis.

$$b = R\sin\alpha \tag{7}$$

$$\Theta = \pi - 2\alpha \tag{8}$$

$$\alpha = \frac{\pi - \Theta}{2} \tag{9}$$

$$b = R\sin\frac{\pi - \Theta}{2} \tag{10}$$

$$\frac{db}{d\Theta} = -\frac{R}{2}\sin\frac{\Theta}{2} \tag{11}$$

$$\int_{-2\pi}^{0} -\frac{R}{2}\sin\frac{\Theta}{2} = 2R \tag{12}$$

This means that for the entire scattering range, b must cover the whole range of $(-R, R)$. Or that the target size is equal to the Length $2R$.

4 Spherical Cross Section

We can plug equation (10) into $d\sigma = b \cdot db \cdot d\alpha$ to get:

$$d\sigma = R \sin \frac{\pi - \Theta}{2} \cdot db \cdot d\phi \tag{13}$$

$$\oint d\sigma = \int_0^{2\pi} \int_0^R R \sin \frac{\pi - \Theta}{2} \cdot db \cdot d\phi \tag{14}$$

$$\sigma = 2\pi R^2 \sin \frac{\pi - \Theta}{2} \tag{15}$$

$$\frac{d\sigma}{d\Theta} - \pi R^2 \sin \frac{\Theta}{2} \tag{16}$$

$$\oint \frac{d\sigma}{d\Theta} = \int_\pi^0 -\pi R^2 \sin \frac{\Theta}{2} d\Theta \tag{17}$$

$$\sigma = \pi R^2 \tag{18}$$

Therefore the apparent cross-section of a sphere is the area of a shadow cast by it.

5 Computational

Here is the scattering Histogram for an equilateral Triage foil.