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PHYS422 HW.2

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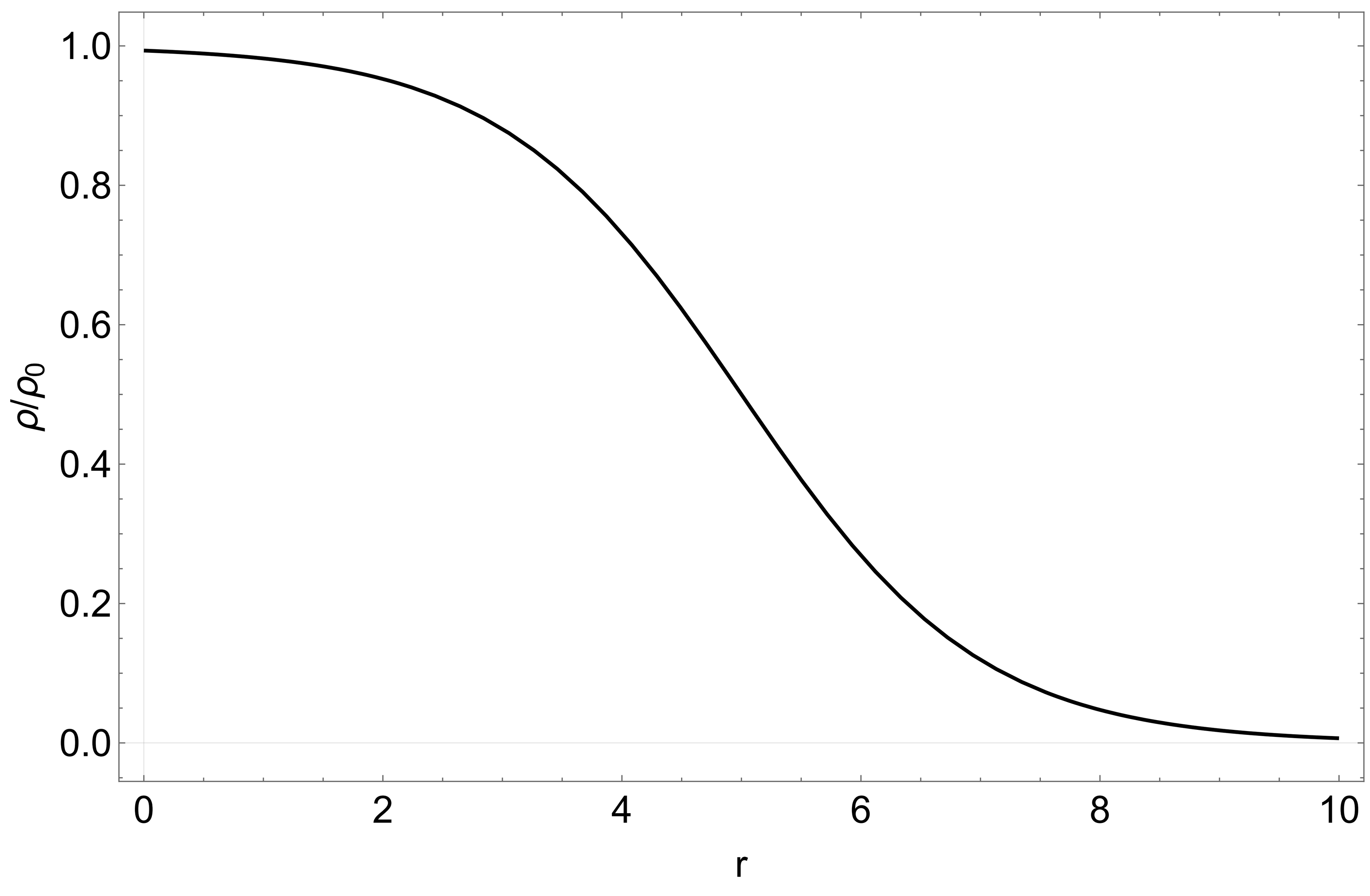
Problem 4):

a):

```
ρ1[r_] := 1/(1 + Exp[(r - R)/a])

Plot[ρ1[r] /. a → 1 /. R → 5, {r, 0, 10}, PlotStyle → Black, PlotTheme → "Scientific", FrameLabel → {"r", "ρ/ρ0"},
 ImageSize → Large, LabelStyle → {16, GrayLevel[0]}]
```



b):

$$\rho\ (t_2) = 0.1\ \rho_0 \Longrightarrow \exp\frac{t_2 - R}{a} = \frac{1}{0.1} - 1$$

$$\rho\ (t_1) = 0.9\ \rho_0 \Longrightarrow \exp\frac{t_1 - R}{a} = \frac{1}{0.9} - 1$$

$$\frac{\rho(t_2)}{\rho(t_1)} = \exp\frac{t_2 - t_1}{a} = \exp\frac{t}{a} = \frac{\frac{1}{0.1} - 1}{\frac{1}{0.9} - 1} \Longrightarrow a = 0.5234\ fm$$

c):

R is the nuclear radius, very significant

d):

From a manual $\langle r^2 \rangle = \frac{\int_0^\infty r^2 \rho(r)\, dr}{\int_0^\infty \rho(r)\, dr}$:

$$\langle r^2 \rangle = \frac{\int_0^\infty r^2 \rho\ (r)\ dr}{\int_0^\infty \rho\ (r)\ dr} \Longrightarrow (Mathematica)\ \langle r^2 \rangle = -\frac{2\, a^2\, \mathrm{Li}_3\left(-e^{R/a}\right)}{\log\left(e^{R/a} + 1\right)}$$

```
Assuming[a > 0, Integrate[r^2/(1+Exp[(r-R)/a]), {r, 0, ∞}] / Integrate[1/(1+Exp[(r-R)/a]), {r, 0, ∞}]] // FullSimplify // TraditionalForm
```

$$-\frac{2 a^2 \mathrm{Li}_3\left(-e^{\frac{R}{a}}\right)}{\log\left(e^{\frac{R}{a}} + 1\right)}$$

Problem 6):

a):

Using Bohr's model, and a friend's help :

$$\frac{1}{\lambda} = \frac{3}{4} R_y\ (1 - Z)^2 \left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right] \frac{m_\mu}{m_e} \Longrightarrow E = 1.32\ MeV$$ **Which is close to the peaks in Figure 3.8**

b):

Using Eq. 3.13 :

```
2/5 * (26^4 * 9 * 10^9 * (1.6 * 10^-19) * (R)^2)/(a^3) /. a → 5.29177210903 * 10^-11 /. R → 1.3 * 10^-15 * 55.847^1/3

1.04029
```

Problem 7):

a):

```
BE[Z_, A_, M_] := (Z * mp + (A - Z) mn - M) cc /. cc → 931.5 /. mp → 1.007825 /. mn → 1.008665
```

Biding energy for ^{15}O in MeV :

```
BE[8, 15, 15.0030654]

111.957
```

Biding energy for ^{15}N in MeV :

```
BE[8, 15, 15.000109]

114.71
```

ΔBE in MeV :

```
BE[7, 15, 15.000109] - BE[8, 15, 15.0030654]

3.53635
```

b):

```
ColoumbEnergy[Z_] := -3/5 * 9 * 10^9 * 1/R (Z^2 * (1.6 * 10^-19))

Reduce[(BE[7, 15, 15.000109] - BE[8, 15, 15.0030654]) * 10^6 == ColoumbEnergy[7] - ColoumbEnergy[8], R]

R == 3.6648 × 10^-15
```