Homework

1. What is the mass, rest energy, or the various corresponding quantities for the neutron in the following units: g, eV, cm^{-1}, s^{-1}, Hz, K, cm.

2. In Gaussian units, electric and magnetic dipole moments are measured in the same units. What is the ratio of the neutron's electric and magnetic dipole moments?

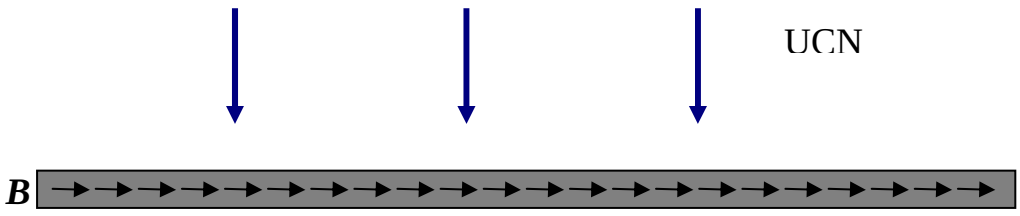
3. Compare the neutron flux in the original Chadwick's experiment in neutrons/cm^2/s with what one can get today at SNS. An order-of-magnitude estimate will suffice.

4. The ability to make quick order of magnitude estimates of any quantity is an essential skill for a good physicist. As an exercise, give order of magnitude estimates of the following quantities:

    a) Number of physicists in the world
    b) The weight of the Campanile tower in Berkeley (in grams)
    c) The number of cucumbers eaten by a person in their lifetime
    d) The height of the Earth's atmosphere
    e) Typical values of electric and magnetic fields on the surface of a nucleus

5. Consider ultra-cold neutrons (UCN) with energy ~10^{-7} eV impinging on a layer of magnetized material with magnetic field B inside the material (see figure).

    a) Neglecting edge effects, what is the magnetic field B_0 outside the material?
    b) Calculate the minimum value of B necessary for this system to work as a UCN spin-polarizer (i.e. transmitting neutrons with one polarization and reflecting those with the opposite polarization).



6. Assuming that the neutron reproduction factor is 1.9, how many generations will it take to fission 10 kg of ^{235}U?

7. Why is ^{235}U fissile, while ^{238}U is not fissile (but both isotopes are fissionable)? Please research this question, and present an explanation supported by quantitative calculations.

8. India is pursuing a nuclear program that involves a nuclear-fuel cycle with thorium. Please research what this is and briefly summarize the key points. The web page of the Indian Department of Atomic Energy may be helpful: http://www.dae.gov.in/publ/daepres/index.htm.

9. How much ^{235}U needs to be consumed (fissioned) in order to run a 1-GW nuclear power plant for a year? Estimate the weight and volume of pure ^{235}U, and also un-enriched uranium that contains an equivalent amount of ^{235}U.

10. In class, we will talk about searches for anomalous interactions of the neutron with the gravitational field. The following calculations will be useful:

    a) Calculate the dimensionless gravitational potential on the surface of the Earth from the Earth and from the Sun. Dimensionless gravitational potential is obtained by dividing the gravitational potential by the square of the speed of light, c^2.
    b) Calculate the ratio of the gravitational pulls (i.e., forces) from the Earth and the Sun on the surface of the Earth.
    c) Finally, to complete the picture, calculate the ratio of the gravitational-field gradients from the Earth and the Sun on the surface of the Earth. Which of the two are important for producing ocean tides?

11. Calculate the change in the potential energy of a neutron when it moves vertically by 1 m in the Earth gravitational field. Compare this value with the kinetic energy range corresponding to ultra-cold neutrons (UCN). Comment on the role of gravity in UCN experiments.