Order-of-Magnitude Physics – Problem Set 2

Guidelines:

- If a question is ill-defined, it is your responsibility to quantify it.
- Please cite any resources used. If you get the information off the web, cite the website.

Problem 1. Going Solar

Can UC Berkeley satisfy its energy requirements by on-campus solar power?

Problem 2. The Vegetarian's Solution to the Omnivore's Dilemma

If all of humanity were to become vegetarian, by what fraction would worldwide greenhouse gas output be reduced?

Problem 3. Rubbery Neutron Star Crusts

Taken from Blandford and Thorne's *Applications of Classical Physics*:

Neutron stars are collapsed objects weighing a few solar masses and having radii of about 10 km.

Neutron star crusts (uppermost 1 km) are supported against gravity by relativistic, degenerate electrons stripped from iron nuclei ($A = 56$, $Z = 26$). These free electrons constitute a fluid with zero shear modulus but finite (and large) bulk modulus.

(a) Estimate the bulk modulus K of the neutron star crust. Express symbolically in terms of the number density of free electrons n_e and fundamental constants. You need not provide a number.

(b) The bare iron nuclei are not relativistic. They arrange themselves into a body-centered-cubic (bcc) lattice. This lattice can support shear. Estimate the shear modulus μ of the neutron star crust. Express in terms of n_e, Z, and fundamental constants. You need not provide a number.

(c) Estimate numerically the ratio μ/K.

Problem 4. Energy Storage

Quantify and rank order the *maximum* energy densities (in kW hr / kg) of the following devices:

- State-of-the-art carbon-fiber composite flywheel
- Lithium-ion battery
- Conventional capacitor with dielectric spacer
- Hot clay brick

Problem 5. Ask Your Own Question

Ask an OOM question of your own. You don't have to answer it.