Homework Assignment #5

ECE 597UU/697UU, Fall 2009

(Posted on the course website on Thu, 22 Oct; due in class on Thu, 29 Oct)

Problem 1 (4 pts.): *The sun as a nuclear reactor*

(a, 2 pts.) The luminosity of the Sun is $L_S = 3.8 \times 10^{26}\,\mathrm{W}$. The Sun is a nuclear reactor, so it converts mass to radiation. How much mass loses the sun per second?

(b, 2 pts.) How long will it take until the sun has lost 1% of its current mass, assuming the luminosity will not change during that time? Does the result make sense? Explain!

Problem 2 (6 pts.): *Warming up in a microwave oven*

(a, 2 pts.) Imagine a microwave oven of the size of a phone booth. Its power is 1000 W. Your mass is 80 kg, and you consist mostly of water. If you are in the oven and turn it on, how long will it take until your body temperature has increased by 1 K?

(b, 2 pts.) You warm up a cup of water (200 cm^3) in your 1000-W microwave oven. You heat it up from 10°C to 60°C. How long does it take, assuming that the entire microwave energy is converted to heat in the water.

(c, 2 pts.) You are a radar engineer working in front of the antenna of some high-power military radar. Someone turns on the radar inadvertently. Discuss quantitatively what happens. Take into account antenna size, power, exposure time, and wavelength.

Problem 3 (4 pts.): *You don't need a weather man*[1]

You want to use the geostrophic approximation to estimate the wind speed just above the ABL over Amherst with an accuracy of 1 $\mathrm{m\,s}^{-1}$ from barometer data collected on the surface at stations that are 100 km apart from each other. What accuracy is required for the barometer measurements? Is this realistic? Make further assumptions if you need to. Would it make sense to have a grid of barometers with a horizontal spacing of 1 km? Explain!

Problem 4 (4 pts.): *Centrifugal force due to Earth's rotation*

Suppose the Earth were a solid body with a spherically symmetric mass distribution. Suppose the effective gravity g were exactly 10 $\mathrm{m\,s}^{-2}$ at the north pole.

(a, 2 pts.) What were g at the equator and at Amherst?

(b, 2 pts.) How short would the day have to be, such that g at the equator would be zero and everything that is not tied to the ground would move up and leave the planet?

[1] "Better stay away from those / That carry around a fire hose / Keep a clean nose / Watch the plain clothes / You don't need a weather man / To know which way the wind blows." From Bob Dylan, Subterranean Homesick Blues, 1965.