Problem 1: Refractive index

1. Nowadays, global telecommunications networks are based on transmission through optical fibers made from glass with a refractive index of about 1.45. Neglecting other delays, what is the time needed for a signal to travel in such a fiber halfway around the earth between two antipodal points?
2. In the fast-paced transactions of international finance, transmission times are not negligible. Some have therefore tried to replace fibers by radio communication. For signalling halfway around the earth, how much time could be saved by switching from fiber to radio waves that propagate in air (and bend around the earth thanks to the ionosphere)?

Problem 2: Solid angle

1. An ant of negligible size is crawling across the floor towards a wall which, for the ant, has nearly infinite length. What is the solid angle subtended by the wall, as seen from the ant, in the limit where the ant reaches the wall?
2. The ant then crawls along the wall towards a corner where two walls meet at right angles. What is the solid angle subtended by the two walls in the limit where the ant reaches the corner?
3. The ant then crawls upwards along the corner between the two walls. What is the solid angle subtended by the walls when the small ant is halfway to the ceiling?
4. Calculate the diameter of the sun, in degrees, and the solid angle subtended by the sun, in steradians, when viewed from Venus, Earth and Mars. Look up the data you need.

Problem 3: Planck's law of radiation

1. Starting from the Planck spectral irradiance $E_\lambda(\lambda)$ derived in the notes, write an expression for the photon spectral irradiance $E_{\lambda p}(\lambda)$.
2. Using a method of your choice, find the wavelength at the peak of $E_{\lambda p}(\lambda)$ for temperatures of 300, 1000, 3000 and 6000 K. Formulate a variant of the Wien displacement law for photon spectral radiance.

Problem 4: Absorption length, and an estimate of electron movement

The tungsten filament in a classical incandescent lamp emits light thanks to the thermal movement of electrons, but how much do they move? Make a rough estimate of the amount of movement by following this outline:

1. Assume a filament temperature of $3000\,\mathrm{K}$ and calculate the exitance according to the Stefan-Boltzmann law.
2. The complex refractive index of tungsten at 1 μm wavelength is $N = 3.05 + i3.39$ (according to "Optical constants of solids" by Palik). Calculate the absorption length of light at this wavelength in tungsten.
3. Then make the very coarse assumption that the tungsten surface emits this exitance at a wavelength of $1\,\mu$m, the peak of the Planck spectrum. Further assume that the light is emitted by a layer of tungsten atoms equal in thickness to the absorption layer. Assume that one electron

per atom emits like a dipole, in the direction of maximum radiation. Look up data about tungsten and estimate the distance each of the electrons needs to oscillate to produce the exitance calculated above.