S-104.1020 Physics II (AUT, BIO, EST, TLT) **Exam, May 14, 2009**

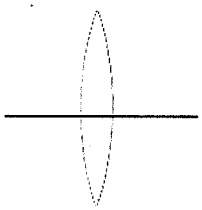
1. By using Gauss's law calculate the electric field caused by a long straight line charge at a distance of r from the wire. The charge per unit length is λ.

2. An alpha particle (consists of two protons and two neutrons) having a kinetic energy of 5 MeV collides directly into the nucleus of a gold atom. Calculate how close to the nucleus the alpha particle is able to approach. The ordinal number of gold is 79.

3. The potential difference between the plates of a planar capacitor is 120 V. Both plates have an area of 0.200 m^2 and the distance between the plates is 1.00 mm. a) Calculate the charge of the capacitor. b) Dielectric material with a dielectric constant of 4.5 is inserted between the plates. What is the voltage between the plates, if the charge of the plates is kept constant? c) Calculate the energy density of the electric field in the dielectric.

4. The average emitting power of a radio station is $1.2 \cdot 10^5$ W. Assume that the power is distributed evenly to the half-space above ground. a) Calculate the average absolute value of the Poynting vector $\overline{S} = \mu_0^{-1}\overline{E} \times \overline{B}$ at the distance of 10 km from the station. b) Calculate the amplitude of the electric field strength by assuming that the wave is harmonic at the observation point.

5. Surfaces of a thin double-convex lens (as shown in the figure) have a radius of 20.0 cm and 12.0 cm. The refractive index of the lens is 1.47.
   a) Calculate the focal length of the lens.
   b) A 3.0 cm high object is placed at 25.0 cm from the lens. Calculate the position and height of an image.



6. An electron is in a one-dimensional box of width $L = 3.0$ nm.
   a) Calculate the energy of the lowest three states in the box.
   b) Calculate the wavelength of the emitted photon when the electron makes a transition from the third state ($n = 3$) to the ground state ($n = 1$).

Constants: mass $m_e = 9.11 \cdot 10^{-31}$ kg and charge $e = 1.60 \cdot 10^{-19}$ C of an electron, mass of proton $m_p = 1.67 \cdot 10^{-27} kg$, $c = 3.00 \cdot 10^8$ m/s, $\mu_0 = 4\pi \cdot 10^{-7}$ Tm/A, $\varepsilon_0 = 8{,}85 \cdot 10^{-12}$ F/m, $h = 6.635 \cdot 10^{-34}$ Js

Name, student number, degree programme (EST, TLT, AUT, BIO, ...), course code and the date on each examination paper.