1. Charge Q is evenly distributed on the surface of a sphere with radius R. Charge density $\rho = f(r)$ outside of the sphere causes constant absolute value of the electric field. Calculate $f(r)$.

   (Hint: in spherical coordinates $\nabla \cdot \overline{E} = \frac{1}{r^2}\frac{d}{dr}(r^2 E)$, when $\overline{E} = E\,\overline{u}_r$.)

2. Calculate relative permittivity K of silicon at angular velocity $\omega = 3{,}8\text{x}10^{15}$ s^{-1} (equal to wavelength 500 nm) using harmonic oscillator model. The atoms in silicon are assumed as dipoles with charges $+e$ and $-e$. The density and molar mass of silicon are $2{,}3\text{x}10^3$ kgm^{-3} and 28,1 g, respectively

3. Electromagnetic radiation having angular velocity ω strikes perpendicularly to the surface of copper (conductivity $\sigma \gg \varepsilon\omega$). Show using Maxwell's equations that the electric field in the conductor is given by $\overline{E}(x,t) = \overline{E}_0 e^{-\alpha x}\sin(kx - \omega t)$ and determine α when $\alpha \approx k$.

   Hint: $\nabla \times \overline{B} = \mu\overline{j} + \mu\varepsilon\frac{\partial \overline{E}}{\partial t}$, where $\overline{j} = \sigma\overline{E}$

4. a) Calculate the modal density of 3-dimensional standing transversal electromagnetic waves.

   b) Sheet has an aperture with radius 1 mm. The sheet is illuminated with plane waves having wavelength 500 nm. Calculate using Fresnel diffraction whether the area in the screen 2 m directly behind the aperture is illuminated or dark and find its intensity.

Constants: $\varepsilon_0 = 8{,}85 \cdot 10^{-12}$ F/m, $\mu_0 = 4\pi \cdot 10^{-7}$ H/m, $c = 3{,}00 \cdot 10^8$ m/s, $e = 1{,}60 \cdot 10^{-19}\,C$,
$m_e = 9{,}11 \cdot 10^{-31} kg$, $N_A = 6{,}02 \cdot 10^{23}\,/\,mol$

Name, study number, study programme, course code and exam date in each paper.