Exercise sheet 8
Theoretical Physics 2: SS2016
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Exercise 1 (25 points): Polarized plane waves

Consider the following wave with the wave vector $\mathbf{k} = k\mathbf{e}_z$

$$\begin{aligned} E_x(t,\mathbf{r}) &= A\cos\left(kz-\omega t\right), \\ E_y(t,\mathbf{r}) &= B\cos\left(kz-\omega t+\phi\right). \end{aligned}$$

(a) (10 points)
Draw the path of the vector $\mathbf{E}(t,0)$ for arbitrary $A,\ B,\ \phi$.
(b) (15 points)
Express the wave for arbitrary $A,\ B,\ \phi$ as a superposition of two circularly polarized waves

$$\mathbf{E}_\pm = Re\left[A_\pm(\mathbf{e}_x \pm i\mathbf{e}_y)e^{i(kz-\omega t)}\right].$$

Express $A_\pm$ through $A,\ B,\ \phi$.

Exercise 2 (35 points): Electric field, magnetic field, and the Poynting vector

Write down the electric field, the magnetic field and the Poynting vector for a monochromatic wave in vacuum:

(a) (8 points)
plane wave travelling in the negative z-direction and polarized in the x-direction;
(b) (12 points)
circularly polarized wave travelling in the z-direction;
(c) (15 points)
plane wave travelling in the direction $(x, y, z) = (1, 1, 1)$ with polarization parallel to the xy-plane.

Exercise 3 (25 points): Wave parameters

For a given potential $\Phi = 0$ and $\mathbf{A} = -g(x - ct)\mathbf{e}_z$ find the electric field, the magnetic field, the Poynting vector $\mathbf{S}$ and the energy density u.

Exercise 4 (15 points): Spherical waves

Consider the wave equation

$$\frac{1}{c^2}\frac{\partial^2 f}{\partial t^2} - \nabla^2 f = 0.$$

Use the Ansatz for spherical waves

$$f(\mathbf{r}, t) = \frac{g(r, t)}{r},$$

and derive the equation for $g(r, t)$. Show that the general solution contains two free functions and write down the solution.