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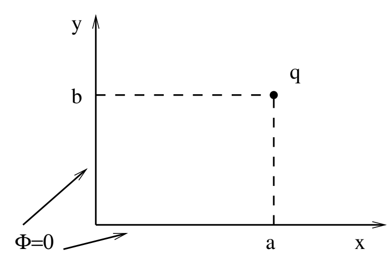
Elektrodynamik, Frühjahrsemester 2019

Blatt 3

Abgabe: 19.3.19, 12:00H (Treppenhaus 4. Stock)
Tutor: Niels Lörch, Gastzimmer Treppenhaus 4. Stock

(1) **Conducting planes at right angles** (4 Punkte)
Two semi-infinite grounded metallic planes meet at right angles. In the region between them, there is a point charge q situated as shown in the figure.



(a) Determine the potential $\phi(\mathbf{x})$. Hint: introduce image charges such that the potential vanishes on the metallic planes.

(b) What is the force on q?

(c) Calculate the induced charge density on the metallic planes.

(d) Suppose the planes meet at some other angle than $\pi/2$, say Θ; would you still be able to solve the problem by the method of images? If not, can you find a condition for Θ such that the method of images is applicable?

(e) Repeat (a) for non-metallic plates and Neumann boundary conditions $\partial\phi/\partial n = 0$.

(2) **Rectangular metallic pipe** (3 Punkte)
A rectangular pipe, running parallel to the z-axis (from $-\infty$ to ∞), has three grounded metal sides, at $y = 0$, $y = a$, and $x = 0$. The fourth side, at $x = b$, is maintained at a specified potential $V(y)$.

(a) Develop a general formula for the potential within the pipe.

(b) Find the potential explicitly, for the case $V(y) = V_0$ (a constant).

(c) Evaluate the above potential $\phi(x, y)$ numerically and plot the result as a function of x for several fixed values of y.

(3) **Potential of a charged spherical surface** (3 Punkte)

Consider a sphere with radius R that carries the surface charge $\sigma(\theta,\varphi) = \sigma_0[1+\cos\theta - \sin^2\theta]$, where $0 \le \theta \le \pi$ and $0 \le \varphi < 2\pi$.

Determine and discuss the potential inside and outside of the sphere.

Hint: The general solution of the Laplace equation in spherical coordinates for azimuthally symmetric (i.e., φ-independent) problems can be expressed as $\phi(r,\theta) = \sum_{j=0}^{\infty}(A_j r^j + B_j r^{-(j+1)})P_j(\cos\theta)$;
Recall that $P_0(\cos\theta) = 1,\ P_1(\cos\theta) = \cos\theta,\ P_2(\cos\theta) = \frac{1}{2}(3\cos^2\theta - 1)$.

(4) **Induction in a conducting loop** (just for fun!)

Consider a planar loop containing the resistors R_1, R_2, see Figure. A long solenoid perpendicular to the loop produces a time-dependent magnetic flux $\Phi(t)$. What are the voltages measured by the two voltmeters? Discuss the result.
Remark: Assume that the voltmeters are ideal, and that a voltmeter shows $-\int_a^b \mathbf{E}\cdot d\mathbf{l}$ if a, b are its terminals.