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Examination

Electrodynamics, TFYY67, NFYD70
2007-08-22
Elektromagnetisk fältteori och vågutbredning

The examination consists of 4 problems. Each correctly solved problem gives 4 points. The points you have earned from solving the home-work problems will be added to the results of the examination. The grades will be set according to:

grade 3: total score of 8-11 points
grade 4: 12-15 points
grade 5: 16-20 points

grade G: 8-14 points
grade VG: 15-20 points

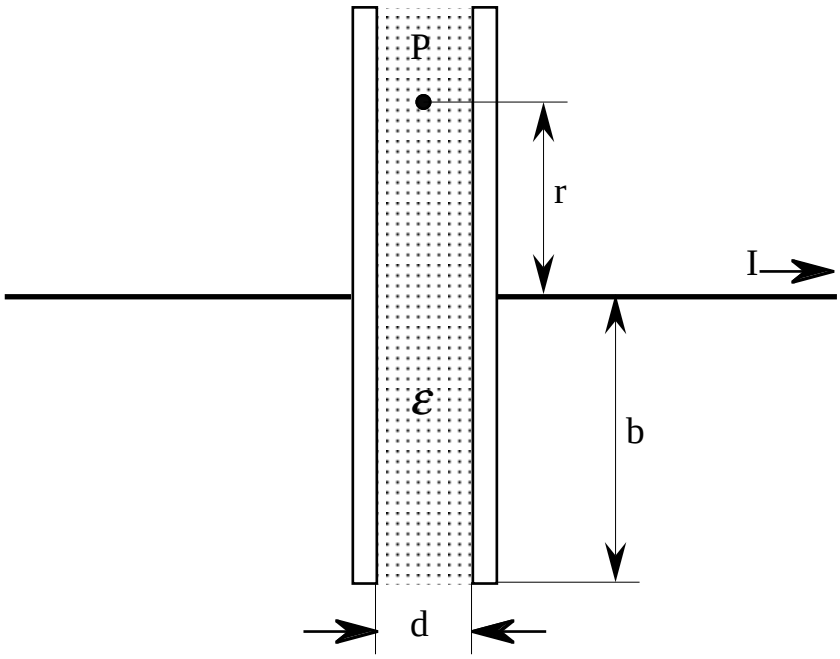
Allowed to bring to the examination: "Classical Electromagnetic Radiation" by Heald & Marion, Physics Handbook, English dictionary, electronic calculator.
Additional material might be distributed during the examination.

The solutions should be in either English or Swedish.

1. (4p) A spherical volume of radius a is filled with charge of uniform density. The total charge is Q.
   a) Determine the potential energy U of the sphere, i.e., the work done in assembling it.
   b) Apply this to the electron. Assume that the electron is spherical, that the charge is distributed uniformly throughout the volume of the electron and that the energy needed to assemble it equals the relativistic rest energy, $m_e c^2$. Determine the electron radius obtained from this model

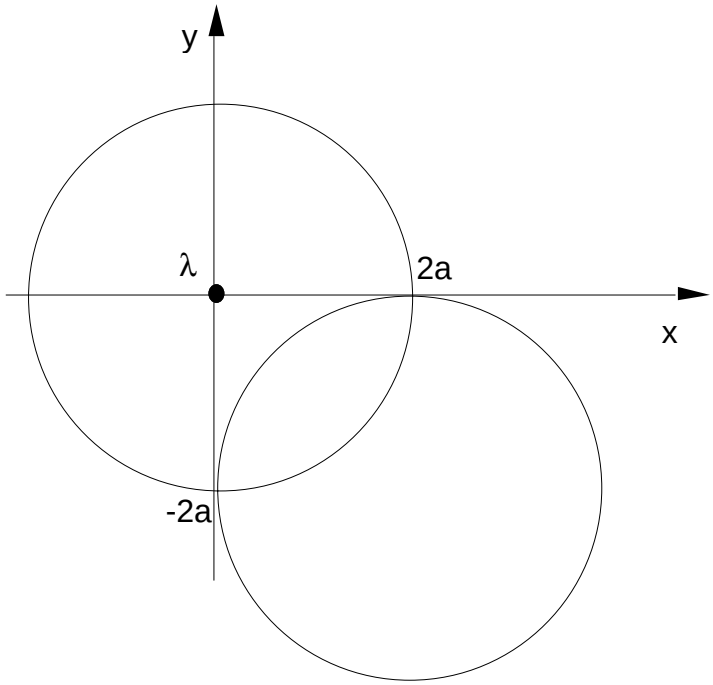
2. (4p) The charge q is distributed uniformly on the boundary of a square of side a. Calculate the electrostatic potential at large distances from the square using multipole expansion up to and including the quadrupole term. The result should be given in spherical coordinates. Let the origin be at the center of the square, the x- and y-axes be parallel to the sides of the square and the z-axis perpendicular to the plane of the square. Note that the charge distribution is one-dimensional, i.e., we have a line-charge-density in this problem.

3. (4p) Determine the magnetic field in a point P in the middle between the two circular plates of a discharging capacitor according to the figure. We assume symmetry about the axis and neglect any edge effects (stray fields). The region between the plates is filled with an ideal dielectric.



Hint: Use one of Maxwell's equations and use Stokes' theorem to get it on integral form.

4. (4p)Two grounded intersecting cylinders are positioned according to the figure. A line charge with charge density λ is placed as described in the figure [$\rho(x,y,z)=\lambda\delta(x)\delta(y)$]. Determine the potential in the region between the cylinders and line charge.



Hint: Use the following Möbius transformation: $\omega = u + iv = b(1-i)\dfrac{z+i2a}{z-2a}$; $z = x + iy$ to transform the geometry into a more familiar one. Then solve this new problem with help of mirror charges or further conformal mapping.

Finding the new, more familiar, geometry will give 1p.