Exam EE1510AM part I

Electricity and Magnetism

Wednesday, March 11, 2020, 9:00-11:00 a.m.

- This exam consists of 2 pages with 3 assignments.
- The total number of credits is 90.
- The number of credits rated for each assignment is listed to the left of each assignment.
- Start every assignment on a new sheet and write on every sheet of each worked out assignment your name and student number.

30 punten

Opgave 1

Consider 3 charges where the first charge $q_1 = Q$ is positioned at $< 0, 4R, 0 >$, the second charge $q_2 = -Q$ is positioned at $< -2R, 0, 0 >$, and the third charge $q_3 = 2Q$ is located at $< 0, 0, 3R >$.

a.) Determine the total electric field $\mathbf{E}$ in the point $< 4R, 0, 0 >$.

In the configuration with the three charges we add a sphere with radius $r = R$ with it's center located in the origin. The volume charge density in the sphere expressed in spherical coordinates is $\rho(r) = Q\sqrt{r}$.

b.) Determine the total charge Q_{tot} of the sphere.

c.) Assume that $\mathbf{E}_{\text{sphere}}$ is the electric field generated by the volume charge density ρ in the sphere. Determine the electric field $\mathbf{E}_{\text{sphere}}$ inside $(r < R)$ and outside $(r > R)$ the sphere with radius R.

d.) Determine the total force $\mathbf{F}$ on a charge Q located at the point $< 4R, 0, 0 >$ due to the electric field $\mathbf{E}$ excited by the three charges and the sphere.

35 punten

Opgave 2

Consider three concentric spheres, where the inner sphere has radius $r = R$, the middle sphere is a very thin perfectly conducting sphere with radius $r = 2R$, and the outer sphere is also a very thin perfectly conducting sphere with radius $r = 3R$. The inner sphere with radius $r = R$ is a solid perfectly conducting sphere. The space between the inner sphere with radius $r = R$ and the middle sphere with radius $r = 2R$ contains a volume charge density $\rho = k_0/r^2$. The outer sphere with radius $r = 3R$ contains a surface charge density $\sigma = k_1$ on the outside of the sphere, such that the whole configuration is neutral.

a.) Determine the surface charge $\sigma = k_1$ expressed in terms of k_0 and R.

b.) Determine the electric field $\mathbf{E}$ for all r, with $0 < r < \infty$.

We assume that the potential $V(r) = 0$, when $r \to \infty$.

c.) Determine the potential $V(r)$ outside the sphere with radius $r = 2R$.

d.) Determine the potential $V(0)$ at $r = 0$.

e.) Give an expression for the capacitance C formed by the perfectly conducting spheres with radius $r = 2R$ and $r = 3R$.

25 punten

Opgave 3

Consider a very long cylinder with radius $s = R$ that contains a volume charge density $\rho(s) = k_0 s/R$. The axis of the cylinder points in the z-direction and is positioned at $< 6R, 0, z >$. Apart from the cylinder we also have two point charges with each a charge Q, located at the position $< 0, 0, R >$ and one at the position $< 0, 0, -R >$.

a.) Determine the potential $V(x, 0, 0)$ due to the point charges, when $V = 0$ for $x \to \infty$.

b.) Determine the electric field $\mathbf{E}_{\text{cylinder}}(x, 0, z)$ that is generated by the volume charge density ρ inside the cylinder, when $0 < x < 5R$ and when $5R < x < 6R$.

c.) Find an expression for the charge Q, such that the total electric field $\mathbf{E}_{\text{total}}(3R, 0, 0) = \mathbf{0}$.

End of Exam