1st year Electricity and Magnetism, Tony Bell

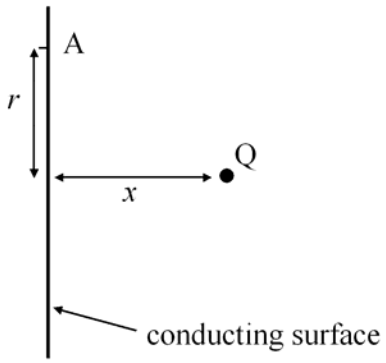
Classwork 2 - 17th February 2005

1(i) A uniform charge density resides on the surface of an infinitely long cylinder. The radius of the cylinder is R and the charge per unit length of the cylinder is ρ. Find the electric field $\mathbf{E}(r)$ both outside the cylinder ($r>R$) and inside the cylinder ($r<R$), where r is the distance from the axis.

(ii) A second infinitely long cylinder, also of radius R, also has a charge ρ per unit length, but in this case the charge is spread uniformly throughout the interior of the cylinder (the charge density is constant inside the cylinder). Again, derive expressions for the electric field both inside and outside the cylinder. Hint: The difference between this derivation and that in (i) is analogous to the difference between sections C.3 and C.2 in the lectures.

2. We showed in the lectures that the magnitude of the electric field on the surface of a conductor is $E=\sigma/\varepsilon_0$. What does the symbol σ stand for? What is the direction of the electric field? We also showed in the lectures that the electric field on each side of a thin charge sheet is $E=\sigma/2\varepsilon_0$. Why is there an extra factor of 2 in this expression?

3. A single charge Q is placed a distance x from a conducting plane.



Use the method of images to derive an expression for the magnitude of the electric field on the surface of the conductor at point A. What is the direction of the electric field?

Use the relationship $E=\sigma/\varepsilon_0$ (see question 2) to calculate the charge density σ on the surface of the conductor at the point A.

An optional extra (if you have time and inclination): Calculate the total charge on the conductor by integrating over the surface.