PHY102A Electricity – May 2018
Comments on examination performance

Qu. 1 Short answers. (Average mark 10.9/20 from 130 attempts.)

(a) Take care finding the directions (signs) of the *x* and *y* components of the force. It is the force *on* the charge at the origin which is requested, not the forces *due to* that charge on the others. Some people did not treat the forces as vectors, and simply added the magnitudes (rather than taking the square root of the sum of the squares). You should also have given the angle made by the resultant, measured, e.g., with respect to the *x*-axis.

(b) This should have been a very easy question, but was done badly! Many students failed to analyse the network correctly in terms of which components were in series and which in parallel. Some even re-drew it with a different and invalid topology!

(c) Most people did this well, though some used the formula for charging, rather than discharging, a capacitor. For the energy dissipated, it is *possible* to find the power in the resistor and integrate, but much easier to simply take the difference between the initial and final energies stored on the capacitor. It is important, however, to note that $V_0^2 - V_f^2$ is not the same as $(V_0 - V_f)^2$!

(d) Many people used invalid formulae for the change of resistance with temperature. The coefficient gives the *fractional* change per degree. You should have used 23°C as the standard temperature, with respect to which changes were calculated. (Since the coefficient in the question is positive, resistance rises with temperature. Therefore you should have found a higher resistance at 100°C, and a lower temperature for 5.50 Ω.)

(e) Most students did not explain the Drude model at all. You should have started from the force on a charge carrier in an electric field, and worked through to the formula for conductivity, defining the time τ on the way. The last part was basically substituting in numbers, remembering that resistivity is the reciprocal of conductivity.

Qu. 2 Gauss's law, *V* from *E*: (Average mark 8.0/20 from 128 attempts.) (This question was done very poorly, despite it being very similar to the first question covered in the revision lecture before the exam, except that the revision question referred to a cylinder rather than a sphere.)

(a) Most people wrote the formula for Gauss's law correctly, but not all explained what it meant. Though *Q* was often defined as "the enclosed charge", it was not stated what the charge was enclosed by! Very few explained *how* the law was used – this should have included the method used to choose a suitable surface.

(b)(i) Many people said that the total charge was charge density times volume. This cannot be valid (or even meaningful) for a non-uniform density! An integral of charge density over volume is required, and since the density is spherically symmetric, a spherical shell of volume element $4\pi r^2\, dr$ is appropriate. (Some people realised they should integrate, but did a 1-dimensional integral of ρ with respect to *r*.) Some people did not substitute in appropriate limits – it should be obvious that the *total* charge cannot be a function of *r*!

(ii) Almost no-one justified the choice of Gaussian surface, very few even stating what surface they were using. Most people did divide the charge calculated above by $4\pi r^2 \varepsilon_0$ to get the electric field. (Students were not penalised a second time for having the wrong charge from part (i).)

(iii) Again an integral was required to find the enclosed charge, and this time the result obviously *should* depend on *r*.

(c)(i) The answer should have started with an explanation in words. As well as an appropriate formula, $V = -\int \mathbf{E}.\mathrm{d}\mathbf{r}$, it was necessary to explain how the integration limits relate to the two points in question.

(ii) For $r > R$, you should have integrated the field calculated in (b)(ii) from infinity to r. Many integrated from 0 to r, which apart from not making sense should have provided a value of infinity from the lower limit!

(iii) For $r < R$, you should first have found the potential difference from the value at the surface to that at the point of interest by integrating the field calculated in (b)(iii) from R to r. Then you should have added on $V(R)$ by using the expression found in (c)(ii) evaluated at $r = R$. (This part was worth 4 marks because it was more involved!)

For the whole of part (c), many people got the limits wrong, sometimes by getting them in the wrong order (which gave a sign error) but often by integrating from 0 rather than the appropriate point. The question did point out that the zero of potential is defined as being at infinity. (Again, people were not penalised once more for using incorrect expressions from part (b), insofar as they could be integrated and give finite results.)

Dr. Chris Booth – 29th May 2018