Sample examination type questions for material in EEE349 / EEE350 not previously covered in EEE345

Physical constants: $\varepsilon_0 = 8.85\times10^{-12}$ Fm^{-1}

1. **a.** Figure 1 shows a cross-section through an insulated cable which comprises a core conductor of radius R_c and a layer of insulation of thickness (R_i-R_c). ***The conductor has a uniform charge density q***. Derive expressions for the following:

i) The variation with radius of the electric field within the core conductor.

ii) The variation with radius of the electric field within the insulation layer.

Hence, sketch a representative plot of the variation of electric field from the centre of the core conductor to a distant point, taking to label any significant values or features. **(7)**

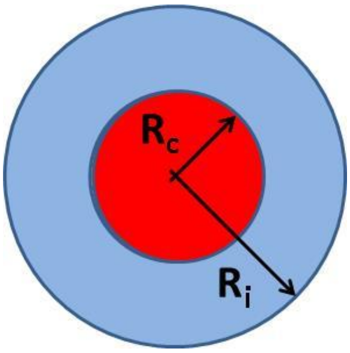


Figure 1 – Cross-section through an insulated cable

b. The insulated cable of Figure 1 is to be surrounded by a conducting metal sheath which is grounded (which can be regarded as 0V). Calculate the maximum voltage that can be applied to the conducting central core if R_c= 10mm, R_i=50mm, the relative permittivity of the insulation layer is 6 and the breakdown electric field strength of the insulation is 40×10^6 V/m. ***You may assume that the relative permittivity of the conductor is 1.0***. **(7)**

c. At another section of the transmission system, the same voltage as calculated in part (b) is applied to an uninsulated cable which is located in air 5m above a ground plane which is at 0V. Calculate the minimum radius of the core conductor of the non-insulated cable which would prevent breakdown of the surrounding air (you may assume that the breakdown electric field strength of the air is 3×10^6 V/m). ***You may assume that the radius to be calculated is << 5m distance from the ground plane.*** **(7)**

2. **a.** Figure 2 shows a single isolated transmission line which is a distance h above the ground. The radius of the transmission line is R_c and its length is L_c. The charge density of the transmission line is q. Stating any assumptions that you make, and starting from Gauss's Law, show that the capacitance <u>to ground</u> of the transmission line is given by:

$$C = \frac{2\pi\varepsilon_0 L_c}{log_e\left(\frac{2h}{R_c}\right)}$$ **(9)**

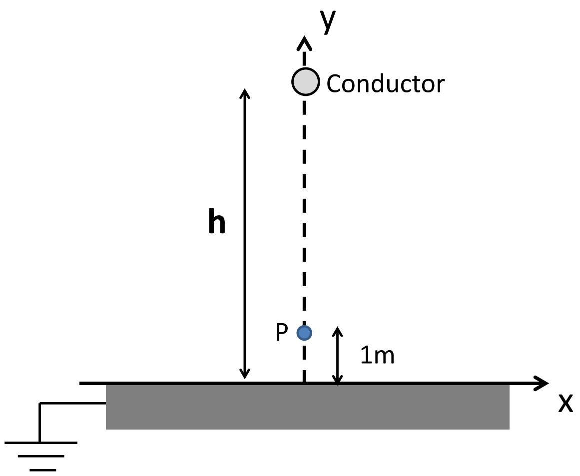


Figure 2

b. If the distance h is 10m, and the peak voltage on the conductor is 130kV. Calculate the following given that the transmission line cross-section has a radius of 40mm:

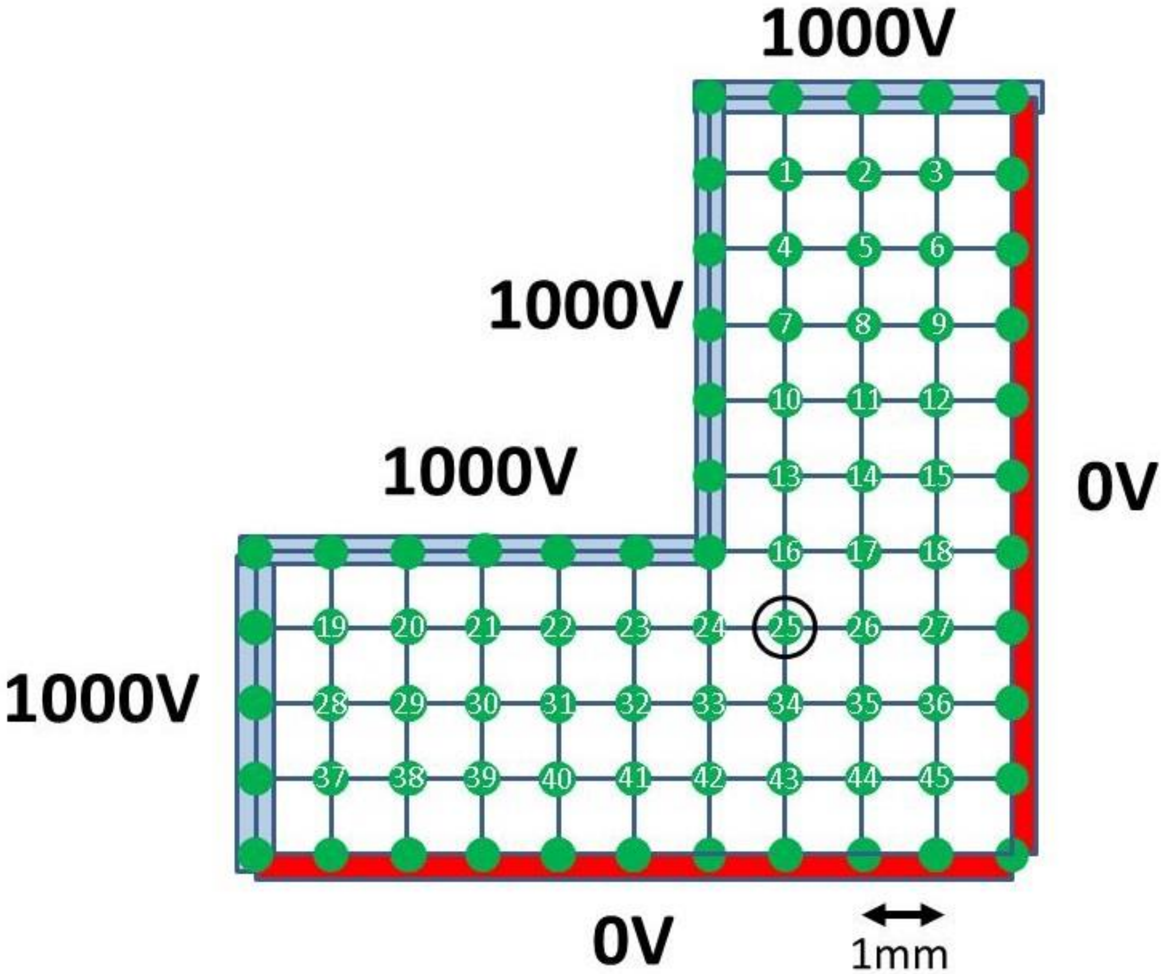
i) The static charge on 1km of the transmission line.

ii) The magnitude of the electric field strength on the surface of the conductor.

iii) The magnitude electric field strength at the point **P** in Figure 2 which is directly below the transmission line and 1m above the ground. **(8)**

c. During expansion of the transmission system, the local topography of the land results in the minimum value of h being only 7.5m. Re-calculate the magnitude electric field strength at the point **P** (which is still 1m above the ground) **(3)**

3. **a.** Figure 3 shows the region between two conducting plates, both of which have a sharp right angle corners. The region between the plates is overlaid with a uniform gird of points with horizontal and vertical spacing of 1mm. Taking care to exploit any symmetry in the region, perform two iterations **two** iterations to provide an estimate of the voltage at the point designated as 25 (no marks will be awarded for additional iterations even if convergence has not been achieved). **(10)**



b. i) Estimate of the **average** electric field between point 25 (circled for clarity) and the right angled corner of the 1000V plate. **(3)**

ii) Using this estimate of the average electric field, estimate the maximum voltage that can be applied to higher voltage plate before breakdown of the air is likely to occur (You may assume that the breakdown electric field strength of air is 3×10^6 V/m). **(4)**

iii) Briefly discuss why in practice is this value of voltage unlikely to be reached before breakdown occurs. **(3)**