PHYS1022 Electricity and Magnetism

Problem Sheet 6 - workshop

1 A 100-pF capacitor and a 400-pF capacitor are charged to 1 kV and 2 kV respectively. They are then disconnected from the voltage source and are connected together, positive plate to positive plate, and negative plate to negative plate.

(a) Find the resulting potential difference across each capacitor.

(b) Find the energy lost when the connections are made.

2. A uniformly charged thin ring has radius 15.0 cm and has total charge +24.0 nC. An electron is placed on the ring's axis a distance 30.0 cm from the centre of the ring and is constrained to stay on the axis of the ring. The electron is then released from rest.

(a) Derive an expression for the potential along the axis due to the charged ring. Draw a sketch of this function, and a sketch of the potential energy of the electron.

(b) Describe the subsequent motion of the electron by sketching its position along the axis as a function of time.

(c) Find the speed of the electron when it reaches the centre of the ring.

3. Show that the electric field for an infinitely long, uniformly charged cylindrical shell of radius R carrying a surface charge density σ is given by

$E_r = 0$ for $r < R$

$$E_r = \frac{\sigma R}{\varepsilon_0 r} = \frac{\lambda}{2\pi\varepsilon_0 r} \quad \text{for } r > R$$

where $\lambda = 2\pi R\sigma$ is the charge per unit length on the shell.

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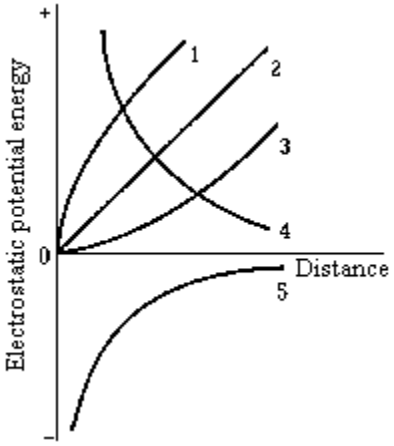
Problem Sheet 5 – for tutorials

1.



Which of the curves in the graph represents the electrostatic potential energy of a small negative charge plotted as a function of its distance from a positive point charge?
A) 1 B) 2 C) 3 D) 4 E) 5
Now draw a sketch of the electric field of the positive point charge, and add equipotential surfaces of equal separation in magnitude.

2. The potential (relative to a point at infinity) midway between two charges of equal magnitude and opposite sign is zero. Is it possible to bring a test charge from infinity to this midpoint in such a way that no work is done in any part of the displacement? If so, describe how it can be done. If it is not possible, explain why.

3. The capacitance of a parallel-plate capacitor (separation d and area A) is given by ε_0 A / d. If we solve this for ε_0, we find that its SI unit is the farad per metre. Show with explanatory steps that this is equivalent to that obtained earlier for ε_0, namely, $C^2/N.m^2$.

4. Three point charges are on the x-axis: q_1 at the origin, q_2 at x = 3 m, and q_3 at x = 6 m. Find the electrostatic potential energy for
   (a) $q_1 = q_2 = q_3 = 2$ μC
   (b) $q_1 = q_2 = 2$ μC, and $q_3 = -2$ μC
   (c) $q_1 = q_3 = 2$ μC, and $q_2 = -2$ μC.
   NB First derive a formula from the definition of electric potential energy which can be used for all parts.