Time: 1 hour

Answer **ALL** Questions

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1. Define the terms "electric field strength" and "electric potential" in an electric field. Write down the relationship between the electric field and the potential gradient.

   A thin circular ring of radius a carries a uniform positive charge Q.

   (a) Show that the electric potential at point P at a distance x from the center of the ring is given by

   $$V(x) = \frac{Q}{4\pi\varepsilon_0} \frac{1}{\sqrt{a^2 + x^2}}.$$

   Hence, show that the electric field at point P is

   $$E(x) = \frac{Qx}{4\pi\varepsilon_0} \frac{1}{\sqrt[3]{a^2 + x^2}}.$$

   (b) Show that the maximum field strength $E_{max}(x) = \frac{Q}{6\sqrt{3\pi\varepsilon_0 a^2}}$ attains at $x = \frac{a}{\sqrt{2}}$ along the axis of the ring.

2. Define the term "capacitance" of a conductor. Draw a diagram of capacitors connected in series and find the expression for the equivalent capacitance for the assembly.

   Obtain an expression for the capacitance of a parallel plate capacitor, has plate area A and plate separation d.

   If the parallel plate capacitor containing a dielectric slab of thickness t between the parallel plates, show that the capacitance of the capacitor is given by

   $$C = \frac{A\varepsilon_0 \varepsilon_r}{t + \varepsilon_r(d - t)}$$

   where the symbols have their usual meaning.