PC1143 PHYSICS III
AY2005/2006 Semester 2
Part I

1. By considering an appropriate Gaussian surface, it can be found that, for a charged plate, $E_+ = \frac{\sigma}{2\epsilon_0}$, assuming negligible fringe effect. In the region between the two parallel plates, $E = E_+ + E_- = \frac{\sigma}{\epsilon_0}$. Therefore, $C = \frac{Q}{V} = \frac{\epsilon_0 A}{d}$.

2. $\Phi = (E_{out} - E_{in})A = 0.56$ Nm^2 C^{-1}. Since Gauss's Law states: $\Phi = \oint E\, dA = \frac{Q}{\epsilon_0}$, we have $Q = 5.0 \times 10^{-12}$ C.

3. Consider a Gaussian sphere of radius r. For $r \leq R$, integrating 0 to r gives $Q = 2\pi a r^2$. Applying Gauss's Law will result in $E = \frac{a}{2\epsilon_0}$. For $r > R$, $Q = 2\pi a R^2$, so $E = \frac{aR^2}{2\epsilon_0 r^2}$.

4a. $X_L = 79\,\Omega$.
4b. $X_C = 1.6 \times 10^3\,\Omega$.
4c. $Z = 1.5 \times 10^3\,\Omega$.
4d. $I_{max} = 0.14$ A.
4e. $\phi = -84°$.

5. Listeners at the radio will receive the news first as it takes $t = 2.9 \times 10^{-3}$ s to reach them, as compared to the people in the newsroom, which hears it after $t = 8.8 \times 10^{-3}$ s.

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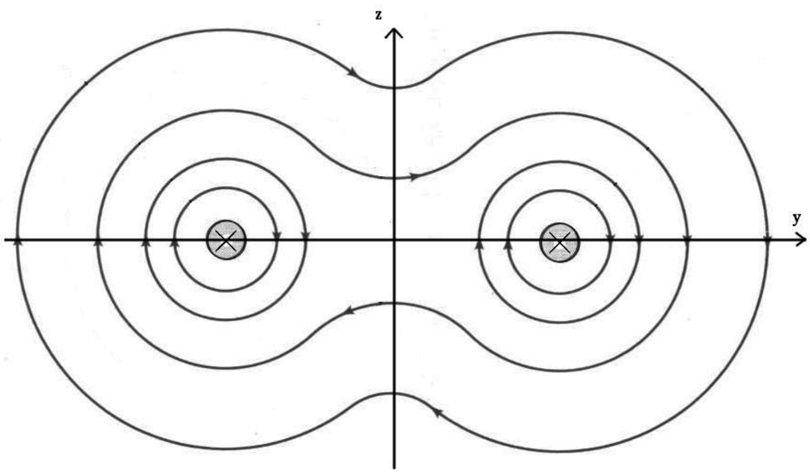
Part II

6a. Resolving forces on one of the bead parallel to the surface, one finds $q = \sqrt{\frac{4}{\sqrt{3}}\pi\epsilon_0 mgR^2}$.

6b. By symmetry, $E = 0$ in the x-direction. By consider a small element $dr = R\,d\theta$ of the wire with charge dQ, one can integrate over the whole wire and find $\lambda_0 = \frac{Q}{2R}$. Then, by considering the force due to that element and integrating over the whole wire, one discovers that $F = 0.707$ N.

7a. (i)



7a. (ii) Given that, for a wire of infinite length, $B = \frac{\mu_0 I}{2\pi r}$. Since, along the z-axis, B_{net} is the sum of the horizontal components, by taking $\frac{dB_{net}}{dz} = 0$, one finds that B_{net} is maximum when $z = \pm a$.

7b. (i) For a Gaussian surface of radius r, $I(r) = \frac{2}{3} b\pi r^3$. From this, one can find that $b = \frac{3I}{2\pi R^3}$ and thus $B = \frac{\mu_0 I}{2\pi R^3} r_1^2$.

7b. (ii) $B = \frac{\mu_0 I}{2\pi r_2}$.

8a. At a distance x from the wire, where $r \leq x \leq r + l$, the electromotive force due to an element dx is $|d\epsilon| = \frac{\mu_0 I}{2\pi x} v\, dx$.. Integrating over the length of the rod gives $|\epsilon| = \frac{\mu_0 I}{2\pi} v \ln\left(1 + \frac{l}{r}\right)$.

8b. By finding the kinematic expressions for speed v and distance r of the short wire, one can find that $|\epsilon| = Blv = \frac{1.18 \times 10^{-4} t}{0.800 - 4.9t^2}$. 0.30 seconds after the wire is released, $|\epsilon| = 9.9 \times 10^{-5}$ V.