# Quiz 4B

PHYSICS 208, WINTER 2016

SECTION: NAME:

**The Cylindrical Capacitor:** Two long, coaxial cylindrical conductors are separated by vacuum. The inner cylinder has radius $r_a$ and linear charge density $+\lambda$. The outer cylinder has inner radius $r_b$ and linear charge density $-\lambda$.

(10 pts) **Problem 1:** Find the capacitance for the cylindrical capacitor.

Electric Field

(1 pt) (i) By considering a cylindrical Gaussian surface, you can obtain the electric field for the region between the two cylindrical shells. What is $Q_{enc}$ for the constructed surface?

(3 pts) (ii) Integrate $\oint \vec{E} \cdot d\vec{a}$, which runs over the entire Gaussian surface.
*Note: $\vec{E}$ is uniform, $\oint da$ is the total area of the Gaussian surface when $\vec{E}$ is parallel to the surface normal $\hat{n}$.*

(1 pt) (iii) What is $\vec{E}$ (with direction $\hat{r}$)?

Potential Difference

(3 pts)(i) Using $V_{ab} = \int_{r_a}^{r_b} E(r)\, dr$, find the potential difference between the concentric cylinders by integrating the electric field previously found.

Capacitance

(1 pt)(i) What is the equation for the capacitance in terms of the potential difference $V_{ab}$ and charge $Q$?

(1 pt)(ii) Using the value of $V_{ab}$ you obtained, write the capacitance of the cylindrical capacitor.

(5 pts) **Problem 2:** Find the energy stored in the cylindrical capacitor.

*The work $dW$ needed to put a charge of $dq$ on the capacitor is given by $dW = V dq$.*

(1 pt)(i) Write the potential $V$ in terms of $Q$ and $C$.

(2 pt)(ii) The total work is given by $W = \int_0^W dW$. Integrate this expression to find $W$.

(1pt)(iii) What is the electrical potential energy $U$ stored for the cylindrical capacitor?

(1pt)(iv) Using the value obtained for the capacitance in problem 1, write the potential energy stored for the cylindrical capacitor.

[BONUS (2 pts)]**Conceptual Question** : **Circle the correct choices to complete the statement.**
The capacitance of a cylindrical capacitor *INCREASES/DECREASES* if a dielectric material is inserted into the space between the cylinders and *INCREASES/DECREASES* if the ratio $\frac{r_b}{r_a}$ increases.