PHYS 101: General Physics 2 **KOÇ UNIVERSITY** Spring Semester 2016

College of Sciences

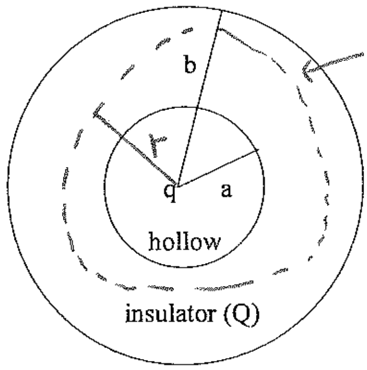
Section 1 **Quiz 2** **18 February 2016**

Closed book. No calculators are to be used for this quiz.

Quiz duration: 10 minutes

Name: **Student ID:** **Signature:**

Consider the insulating solid sphere with a hollow cavity shown in the figure. The total charge **Q** is uniformly distributed over the insulating material, and there is a point charge **q** at the center of the cavity. First identify the volume/surface/line charge density within the insulator and use the Gauss law to calculate the electric field for **a < r < b**.



Gaussian surface

The volume of the insulating spherical shell is

$$V = \frac{4}{3}\pi (b^3 - a^3)$$

The charge density ρ is

$$\rho = \frac{Q}{V} = \frac{Q}{\frac{4}{3}\pi (b^3 - a^3)}$$

by applying Gauss's law, we calculate the electric field in the region $a < r < b$

$$\oint \vec{E} \cdot d\vec{a} = \frac{Q_{enc}}{\epsilon_0}$$

$$E \cdot 4\pi r^2 = \frac{q + Q_{ins.}}{\epsilon_0}$$

charge in the insulator

$$E = \frac{q + Q_{ins.}}{4\pi r^2 \epsilon_0}$$

$$Q_{ins.} = \rho V = \rho \cdot \frac{4\pi (r^3 - a^3)}{3} = \frac{Q}{\frac{4}{3}\pi (b^3 - a^3)} \cdot \frac{4\pi (r^3 - a^3)}{3} = \frac{Q (r^3 - a^3)}{(b^3 - a^3)}$$

$$\boxed{\vec{E} = \frac{1}{4\pi \epsilon_0 r^2} \left(q + \frac{Q (r^3 - a^3)}{(b^3 - a^3)} \right) \hat{r}}$$

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Section 2 **Quiz 2** **18 February 2016**

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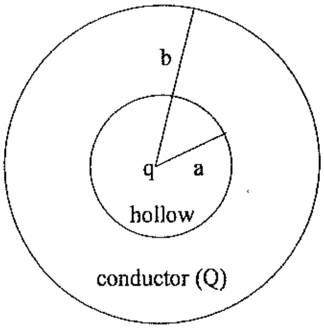
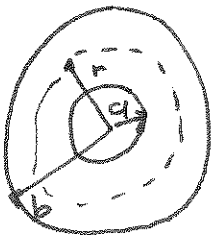
Quiz duration: 10 minutes

Name: **Student ID:** **Signature:**

Consider the conducting solid sphere with a hollow cavity shown in the figure. The total charge on the conductor is **Q,** and there is a point charge **q** at the center of the cavity. First identify the volume/surface/line charge density within the conductor and use the Gauss law to calculate the electric field for **r > b**.

surface density at the inner surface of the conductor. (charges are on the surfaces of the conductor)





$E=0 \Rightarrow$ inside conductor

$$\oint \vec{E}\cdot d\vec{a} = 0 = \frac{Q_{enc}}{\epsilon_0} \Rightarrow Q_{enc} = 0$$

from conservation of charges

$$Q_{enc} = q + Q_{in} = 0 \Rightarrow \boxed{Q_{in} = -q}$$

charge surface density

$$\boxed{\sigma_{in} = \frac{Q_{in}}{A_{in}} = \frac{-q}{4\pi a^2}}$$

• outer surface: $Q = Q_{in} + Q_{out}$ (from charge conservation)

$$Q = -q + Q_{out} \Rightarrow \boxed{Q_{out} = Q + q}$$

The surface charge density

$$\boxed{\sigma_{out} = \frac{Q_{out}}{A_{out}} = \frac{Q+q}{4\pi\ b^2}}$$

when $r > b$: using Gauss's law, we find

$$\oint \vec{E} \cdot d\vec{a} = \frac{Q_{enc}}{\epsilon_0}$$

$$E \cdot 4\pi r^2 = \frac{q+Q}{\epsilon_0}$$

$$\boxed{\vec{E} = \frac{q+Q}{4\pi r^2 \epsilon_0}\ \hat{r}}$$

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Section 3 **Quiz 2** **18 February 2016**

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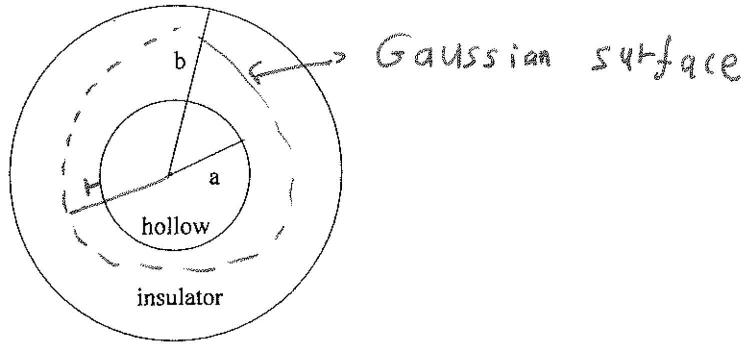
Quiz duration: 10 minutes

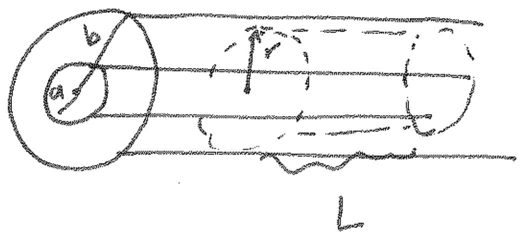
Name: **Student ID:** **Signature:**

Consider the infinitely long solid cylinder with a hollow cavity shown in the figure. The cylinder is made of an insulating material and it is uniformly charged with a volume charge density ρ. Use the Gauss law to calculate the electric field for **a < r < b**.

$a < r < b$



(top view of the cylinder)



using Gauss's law we find the electric field

$$\oint \vec{E} \cdot d\vec{a} = \frac{Q_{enc}}{\epsilon_0} = \frac{\rho V}{\epsilon_0}$$

$$E \cdot 2\pi r L = \frac{\rho}{\epsilon_0} \pi (r^2 - a^2) L$$

$$\boxed{\vec{E} = \frac{\rho (r^2 - a^2)}{2 r \epsilon_0} \hat{r}}$$

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Section 4 **Quiz 2** **18 February 2016**

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Quiz duration: 10 minutes

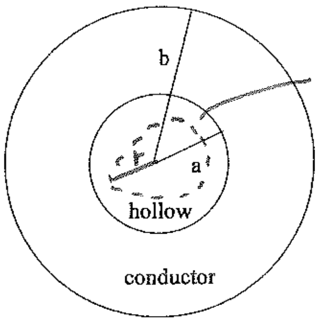
Name: **Student ID:** **Signature:**

Consider the infinitely long solid cylinder with a hollow cavity shown in the figure. The cylinder is made of a conducting material and its charge per unit length **C** is a constant. Use the Gauss law to calculate the electric field **everywhere** in space.

when $r < a$:

$$\oint \vec{E} \cdot d\vec{a} = \frac{Q_{enc}}{\epsilon_0} = 0$$

$$\Rightarrow \boxed{E = 0}$$

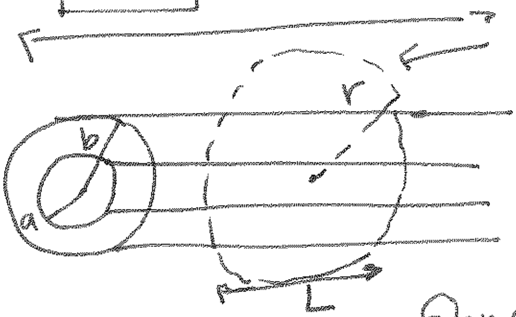


Gaussian surface

(top view of the cylinder)

$a < r < b$: $\boxed{E = 0}$ inside conductor $\vec{E}$ is always zero

$r > b$:



Gaussian surface

$$\oint \vec{E} \cdot d\vec{a} = \frac{Q_{enc}}{\epsilon_0}$$

$$E \cdot 2\pi r L = \frac{CL}{\epsilon_0}$$

$$\boxed{\vec{E} = \frac{C}{2\pi r \epsilon_0} \hat{r}}$$