1) An infinite sheet with positive charge density $\sigma > 0$ is aligned with the y-z plane. A negative charge $-Q$ is located on the x-axis at $x = +a$. Define a Gaussian surface to be a cylinder intersecting the infinite plane, as shown by the dashed lines in the figure. Define Φ_b to be the flux through the <u>barrel</u> (*i.e.* the curved side only) of the cylinder. Which of the following relations is true? (Remember the sign convention: flux through closed surfaces, or portions thereof, is positive when it points *outwards*.) **[4]**

(a) $\Phi_b < 00$
(b) $\Phi_b = 00$
(c) $\Phi_b > 00$
(d) the sign of Φ_b is impossible to determine
   given this information
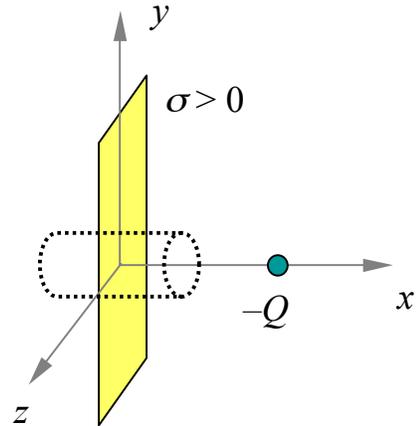
Consider a non-conducting sphere of radius a, which carries a total charge Q distributed *uniformly* throughout the volume. This sphere is surrounded by a conducting spherical shell of inner radius R_1 and outer radius R_2. The conducting shell is uncharged.
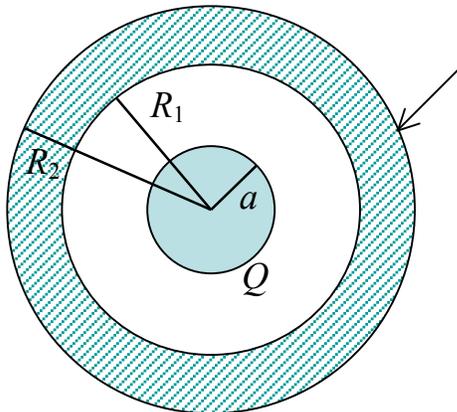
uncharged
metal shell

$a = 1.5$ mm
$R_1 = 4.5$ mm
$R_2 = 6.0$ mm
$Q = -8$ μC

2) What is the electric field at a radius of 5.0 mm from the center of the system? **[4]**

uncharged
metal shell
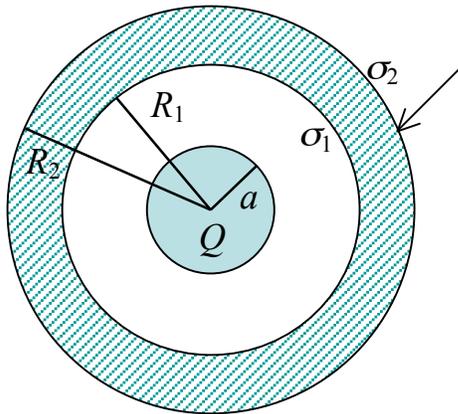
$a = 1.5$ mm
$R_1 = 4.5$ mm
$R_2 = 6.0$ mm
$Q = -8$ μC

3) What is the surface charge density σ_1 on the inner surface of the spherical shell? **[8]**

4) What is the volume charge density ρ of the non-conducting sphere? (Please leave your answer in symbolic form, no numbers required.) **[4]**