$\vec{P}(\vec{r}) = k\vec{r}$

$\boxed{\text{Griffiths } 4.10}$

$\sigma_b = \vec{P} \cdot \hat{n}$

$\rho = -\vec{\nabla} \cdot \vec{P}$

(a) * $\vec{P} \cdot \hat{n} = kr = \sigma_b$

* $\rho = -\vec{\nabla} \cdot \vec{P} = -\vec{\nabla}\left[r\sin\theta\cos\phi\,\hat{x} + r\sin\theta\sin\phi\,\hat{y} + r\cos\theta\,\hat{z} \right]$

$$= -r\left[\sin\theta\cos\phi + \sin\theta\sin\phi + \cos\theta \right].$$

(b) Inside: we don't need to consider bound charge.

$$\int k \frac{-r[\sin\theta\cos\phi + \sin\theta\sin\phi + \cos\theta]}{r^2}\, d\phi$$

$=$

use gaussian surface: $\int k$ $\quad \vec{\nabla} \cdot \vec{E} = \frac{\rho}{\varepsilon_0}$.

$\sigma_b =$

$$\oint \vec{E} \cdot \hat{n}\, da = \int (\vec{\nabla} \cdot \vec{E})\, d\tau$$

$$4\pi r^2 E_\perp = \frac{Q_{enc}}{\varepsilon_0}$$

$$Q_{enc} = \int -\frac{k}{r} 2\pi \cos\theta$$