1. a) $Q = 8a\lambda$, $\lim_{r\to\infty} \Phi = \dfrac{Q}{4\pi\epsilon_0 r}$, $E_r = \dfrac{Q}{4\pi\epsilon_0 r^2}$

b) $d\Phi = 4\dfrac{\lambda dx'}{4\pi\epsilon_0[x'^2+a^2+z^2]^{1/2}}$ $\quad -a \le x' \le a$

$$\Phi = \frac{\lambda}{\pi\epsilon_0}\int_{-a}^{a}\frac{dx'}{[x'^2+a^2+z^2]^{1/2}}$$

$$= \frac{\lambda}{\pi\epsilon_0}\ln\left[x'+\sqrt{a^2+z^2+x'^2}\right]\Big|_{-a}^{+a}$$

$$= \frac{\lambda}{\pi\epsilon_0}\left[\ln\left[a+\sqrt{2a^2+z^2}\right]-\ln\left[-a+\sqrt{2a^2+z^2}\right]\right]$$

2. a) $\nabla\cdot(\epsilon(x)\bar{E}) = \dfrac{d}{dx}\left(\epsilon(x)E_x(x)\right) = \rho_f = 0$

$$\epsilon(x)E_x(x) = C(t)$$

$$E_x(x) = \frac{C(t)}{\epsilon(x)} = \frac{C(t)}{\epsilon_0}e^{-\alpha x}$$

$$\int_0^d E_x(x)dx = v(t) = \frac{C(t)e^{-\alpha x}}{-\alpha\epsilon_0}\Big|_0^d = -\frac{C(t)}{\alpha\epsilon_0}(e^{-\alpha d}-1)$$

$$= \frac{C(t)}{\alpha\epsilon_0}(1-e^{-\alpha d})$$

$$C(t) = \frac{\alpha\epsilon_0 v(t)}{1-e^{-\alpha d}}$$

$$E_x(x) = \frac{\alpha\epsilon_0 v(t)}{(1-e^{-\alpha d})\epsilon_0 e^{\alpha x}} = \frac{\alpha v(t)e^{-\alpha x}}{(1-e^{-\alpha d})}$$

b) $\sigma_s(x=0,t) = \epsilon_0 E_x(x=0,t) = \dfrac{\alpha\epsilon_0 v(t)}{(1-e^{-\alpha d})}$

$\sigma_s(x=d,t) = -\epsilon_0 e^{\alpha d}E_x(x=d,t) = -\dfrac{\epsilon_0 e^{\alpha d}\alpha v(t)e^{-\alpha d}}{(1-e^{-\alpha d})} = -\dfrac{\epsilon_0\alpha v(t)}{(1-e^{-\alpha d})}$

c) $C = \dfrac{A\sigma_s(x=0,t)}{v(t)} = \dfrac{A\epsilon_0\alpha}{(1-e^{-\alpha d})}$