1.(a) Applying Ampere's law using a rectangle with one side at r, the other side outside the selenoid, with length d, we get $dH = K = dNI/D$. So that $B = \mu(r)H = \mu(r)NI/D$.
(b) Magnetic flux through a circle of radius R:
$\Phi_B = \int_o^R B(r)2\pi r dr = \int_o^R \mu_o 2\pi r(1 + r/R)(NI/D)dr = 2\pi\mu_o(NI/D)(R^2/2 + R^2/3)$
$= 5\pi R^2\mu_o NI/(3D)$
(c) $L = 5\pi R^2\mu_o N^2/(3D)$

2.(a)For positive plate at the top and negative at the bottom, $\vec{E} = -\hat{z}\sigma/\epsilon_o = -\hat{z}(\sigma_o/\epsilon_o)\sin(\omega t)$
(b) The flux of E-field in the $-z$ direction through a circle of radius r will be
$\Phi_E = E\pi r^2 = (\sigma_o/\epsilon_o)\pi r^2 \sin(\omega t)$. This will result in a magnetic field $B{\cdot}2\pi r = \mu_o\epsilon_o\, \partial\Phi_E/\partial t$, so that $B = (\mu_o\sigma_o/2)r\omega\cos(\omega t)$ in the $-\hat{\phi}$ direction.

(c) A magnetic field in the $-\hat{\phi}$ direction generates a flux Φ_B in the positive direction for loop c with the given direction:
$\Phi_B = \int_a^b B(r)L\, dr = \int_a^b (\mu_o\sigma_o/2)r\omega\cos(\omega t)L\, dr = (\mu_o\sigma_o/4)\omega\cos(\omega t)L(b^2 - a^2)$
(d) Current density on the disk must satisfy $\partial\rho/\partial t = -\nabla\cdot\vec{J} \Longrightarrow -\partial\sigma/\partial t = \frac{1}{r}\frac{\partial}{\partial r}(rK_r)$
$\frac{1}{r}\frac{\partial}{\partial r}(rK_r) = -\sigma_o\omega\cos(\omega t) \Longrightarrow \frac{\partial}{\partial r}(rK_r) = -r\sigma_o\omega\cos(\omega t) \Longrightarrow rK_r = (R^2 - r^2)\sigma_o\omega\cos(\omega t)/2$
since the current must go to zero at the edge of the disk.
We then have $K_r = (R^2 - r^2)\sigma_o\omega\cos(\omega t)/2r$. So, the current is going radially outward as charge increases.
(e) Current at the center of the disk will be $I = K_r(2\pi r)|_{r=0} = \pi R^2\sigma_o\omega\cos(\omega t)$ which may also be determined from the change in the total charge on a disk:
$I = \frac{d}{dt}\sigma\pi R^2 = \pi R^2\sigma_o\omega\cos(\omega t)$.

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3. (a) $\rho_m = -\nabla\cdot\vec{M} = -2\alpha x$
(b) $\sigma_m = \vec{M}\cdot\hat{S} = \alpha x^2\hat{x}\cdot\hat{r} = \alpha x^2\cos\phi = \alpha R^2\cos^3\phi$
(c) $\cos^3\phi = \cos\phi\ \cos^2\phi = \cos\phi\,[\cos(2\phi) + 1]/2 = (1/4)\cos(3\phi) + (3/4)\cos\phi$
$V_{m\text{in}} = Ar\cos\phi + Cr^3\cos(3\phi)$
$V_{m\text{out}} = Dr^{-1}\cos\phi + Er^{-3}\cos(3\phi)$

$V_{m\text{in}}(R) = V_{m\text{out}}(R)$	$V'_{m\text{in}}(R) - V'_{m\text{out}}(R) = \sigma_m$	Solution	
$AR = D/R$	$A + D/R^2 = 3\alpha R^2/4$	$A = 3\alpha R^2/8$	$D = 3\alpha R^4/8$
$CR^3 = E/R^3$	$3CR^2 + 3E/R^4 = \alpha R^2/4$	$C = \alpha/24$	$E = \alpha R^6/24$