This is the Title PhL 3.26.05

This has the field continuity conditions in perp and parallel notation. First part is incorporated into Ch 1 of lines doc. I decided on a t and n notation instead.

If the two media are conducting dielectrics with Ohm's law $\mathbf{J_c} = \sigma\mathbf{E}$, we can apply continuity (**) to our tiny box to find that

$$\text{div}\,\mathbf{J_c} = -\partial_t\rho_{free} \quad \Leftrightarrow \quad -\partial_t\left[\int_V \rho_{free}\, dV\right] = \int_S \mathbf{J_c} \bullet d\mathbf{A} \qquad (1.1.16)$$

so that

$$-\partial_t n_{free} = [J_{n1} - J_{n2}] = \sigma_1 E_{n1} - \sigma_2 E_{n2}$$

or for monochrome time dependence

$$-j\omega\, n_{free} = \sigma_1 E_{n1} - \sigma_2 E_{n2}\ .$$

Recall now from *** that

$$n_{free} = \varepsilon_1 E_{n1} - \varepsilon_2 E_{n2}$$

Adding the last equation to $1/j\omega$ times the previous equation gives

$$0 = [\varepsilon_1 + \sigma_1/j\omega]\, E_{n1} - [\varepsilon_2 + \sigma_2/j\omega] E_{n2}$$

In terms of the complex dielectric constants ξ_i this says that $0 = \xi_1 E_{n1} - \xi_2 E_{n2}$ so that

$$\xi_1 E_{n1} = \xi_2 E_{n2}$$

In the limit that say medium 2 becomes a perfect conductor, $\xi_2 \approx \sigma_2/j\omega \to \infty$ and $E_{n2} \to 0$, but the product is maintained equal to $\xi_1 E_{n1}$.

But there is no free charge in such dielectrics, nor any at the boundary between them unless supplied by a very contrived apparatus, because any such free charge would leak away into the dielectrics. If one of the dielectrics is a "conductor",

There will be polarization charge n_{pol} at the boundary due to "differential displacement" of the two dielectrics there.

********** saving things here **********

$E_{||}^{(1)} = E_{||}^{(2)}$ or $(1/\varepsilon_1)D_{||}^{(1)} = (1/\varepsilon_2)D_{||}^{(2)}$ (1.1.20)

$H_{||}^{(1)} = H_{||}^{(2)}$ or $(1/\mu_1)B_{||}^{(1)} = (1/\mu_2)B_{||}^{(2)}$ (1.1.21)

$[D_{\perp}^{(1)} - D_{\perp}^{(2)}] = n_{free}$ or $[\varepsilon_1 E_{\perp}^{(1)} - \varepsilon_2 E_{\perp}^{(2)}] = n_{free}$ (1.1.22)

$B_{\perp}^{(1)} = B_{\perp}^{(2)}$ or $\mu_1 H_{\perp}^{(1)} = \mu_2 H_{\perp}^{(2)}$ (1.1.23)

Rules for continuity of parallel and normal fields at a boundary: (1.2.24)

$E_{||}^{(1)} = E_{||}^{(2)}$ or $(1/\varepsilon_1)D_{||}^{(1)} = (1/\varepsilon_2)D_{||}^{(2)}$ *(1.1.20)*

$H_{||}^{(1)} = H_{||}^{(2)}$ or $(1/\mu_1)B_{||}^{(1)} = (1/\mu_2)B_{||}^{(2)}$ *(1.1.21)*

$[D_{\perp}^{(1)} - D_{\perp}^{(2)}] = n$ or $[\varepsilon_1 E_{\perp}^{(1)} - \varepsilon_2 E_{\perp}^{(2)}] = n$ *(1.1.22)*

$\mu_1 H_{\perp}^{(1)} = \mu_2 H_{\perp}^{(2)}$ or $B_{\perp}^{(1)} = B_{\perp}^{(2)}$ *(1.1.23)*