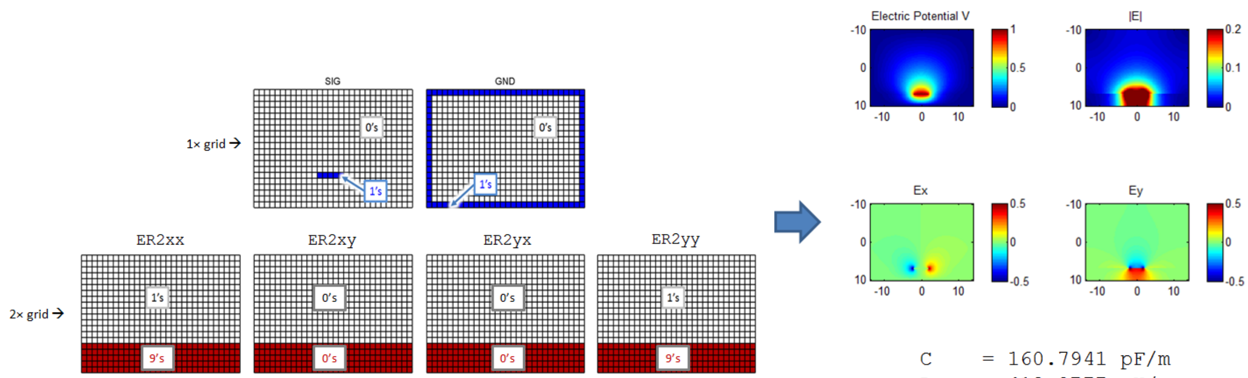
Problem #1: Generic Transmission Line Simulator

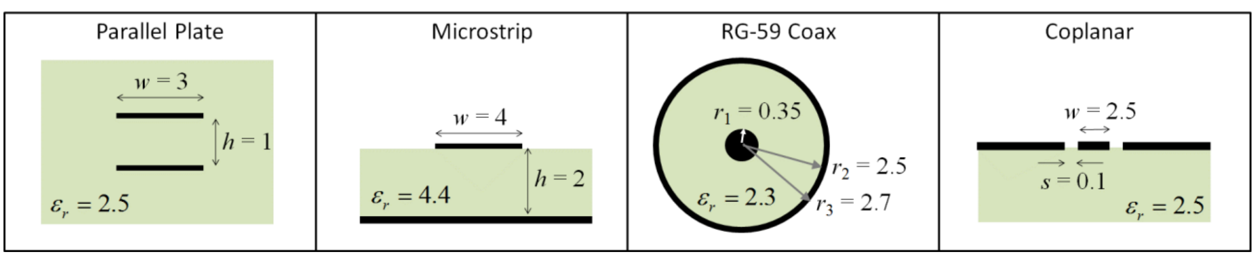
Write a generic MATLAB program to simulate an arbitrary transmission line embedded in a fully anisotropic medium. The program shall construct four arrays `ERxx`, `ERxy`, `ERyx`, and `ERyy` defining the elements of the permittivity tensor, as well as three arrays `SIG1`, `SIG2`, and `GND` describing the two conductors of the transmission line as well as the ground. The program should calculate the electric potential $V(x,y)$ (volts), electric field intensity $\vec{E}(x,y)$ (V/m), distributed capacitance C (F/m), distributed inductance L (H/m), characteristic impedance Z_c (ohms), and effective refractive index n_{eff}.




```
C    = 160.7941 pF/m
L    = 412.8777 nH/m
Z0   = 50.6729 ohms
neff = 2.4427
```

Problem #2: Benchmark Simulations

For each transmission line shown below, calculate the transmission line parameters (i.e. L, C, Z_0, and n_{eff}) and plot the electric potential $V(x,y)$ and electric field $\vec{E}(x,y)$. Use the `quiver()` command to superimpose the vector information onto the field magnitude.



Notes: The parallel plate and coplanar transmission lines incorporate ABS plastic which has a relative permittivity of 2.5. This is a commonly 3D printed material. The substrate of the microstrip antenna is FR-4 which has a relative permittivity of 4.4. The RG-59 coax is the standard coaxial cable for television prior to HDMI. The dielectric is Teflon which has a relative permittivity of 2.3.

Problem #3: Spatially Variant Anisotropic Media

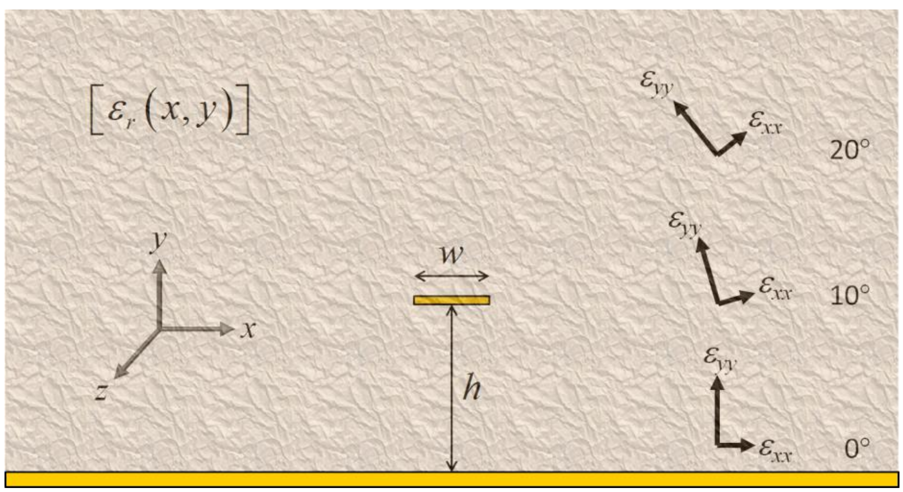
A microstrip transmission line with $w = 4$ and $h = 3$ is to be completely embedded within a spatially variant anisotropic medium (SVAM) with the following dielectric tensor. The material possesses negligible magnetic response so $\mu_r = 1.0$.

$$[\varepsilon_r] = \begin{bmatrix} 2 & 0 & 0 \\ 0 & 9 & 0 \\ 0 & 0 & 6 \end{bmatrix}$$

The orientation of the tensor is rotated about the z-axis by ϕ=10° for every distance h above the substrate. This is done in a smooth and continuous manner so that the tensor rotation as a function of height above the substrate is

$$\phi(y) = \frac{y}{h}(10°).$$

If you do this correctly, ϕ=0° at the ground plane, ϕ=5° at $h/2$ above the ground plane, ϕ=10° at the signal conductor, and ϕ=20° at a distance $2h$ above the ground the plane. This is illustrated in the figure below.



Plot the nine tensor functions, conductors, scalar potential, and the electric field.

Provide the transmission line parameters L, C, Z_0, and n_{eff}.

Discuss your results and make meaningful conclusions.