1 Problem 3

1.1 Part a

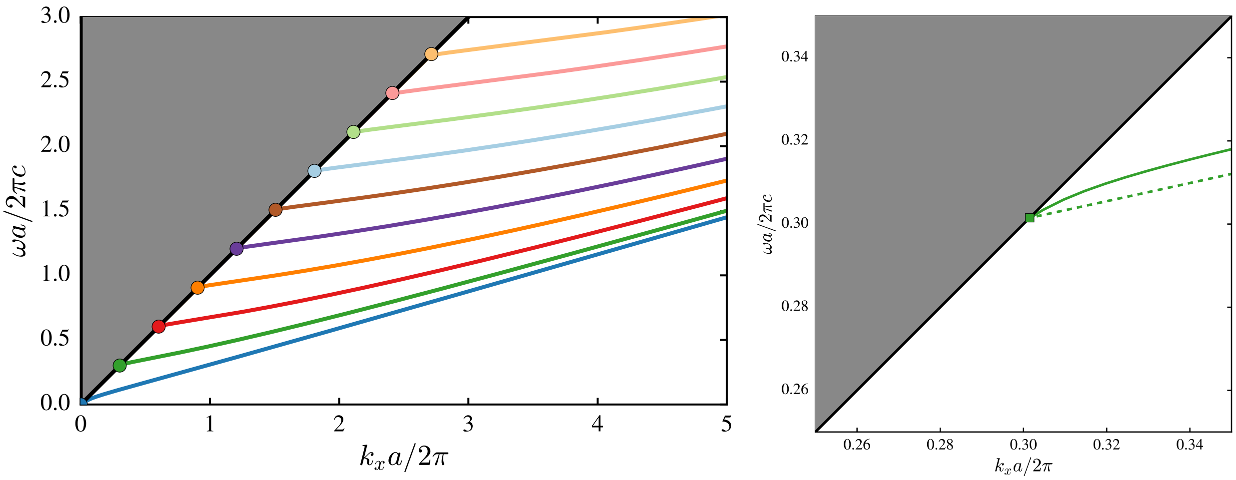

Figure 1: (left) Even mode frequency bands for the infinite waveguide. Solid markers on the light cone edge indicate the prediction for where new modes should appear. (right) Close-up of Mode 2 at low $k_x a/2\pi$. Dotted line indicates truncated computational cell (`Y=2`). As the computational cell size is increased, the the guided band $\omega(k)$ appears more tangent to the light cone.

1.2 Part b

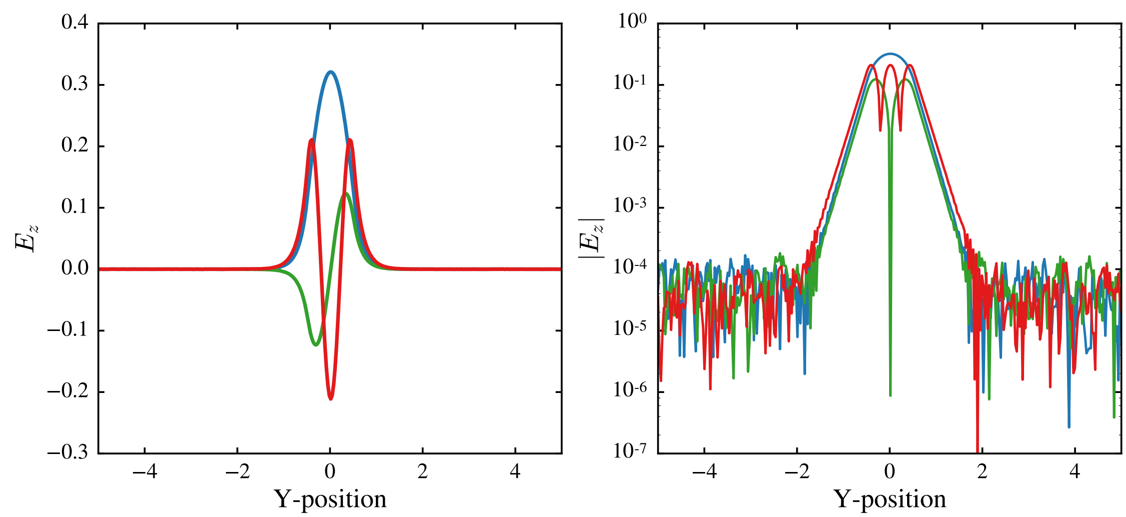

Figure 2: E-field of first 3 guided modes within the waveguide. On the right, the fields are plotted semi-log to reveal the exponential decay of the fields away from the waveguide (since it's linear on the log-scale). After decaying substantially, the field enters a noise floor around 10^{-6}, which persists to the boundary of the computational cell.

1.3 Part c

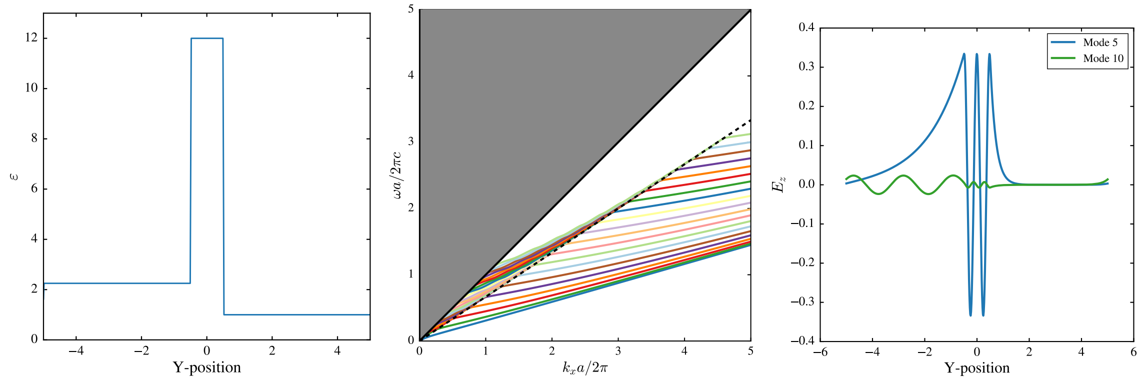

Figure 3: (Panel 1) Dielectric constant ε within the computational cell. (Panel 2) The first 20 guided modes. All collapse to a new low-frequency bound below the light line. This new low-ω cutoff lies at $\omega/c = 2k_x/3$ (Panel 3) Two of the higher modes within the computational cell. The lack of symmetry in ε is reflected in the asymmetric field structures that appear more clearly in higher-order modes.

1.4 Part d

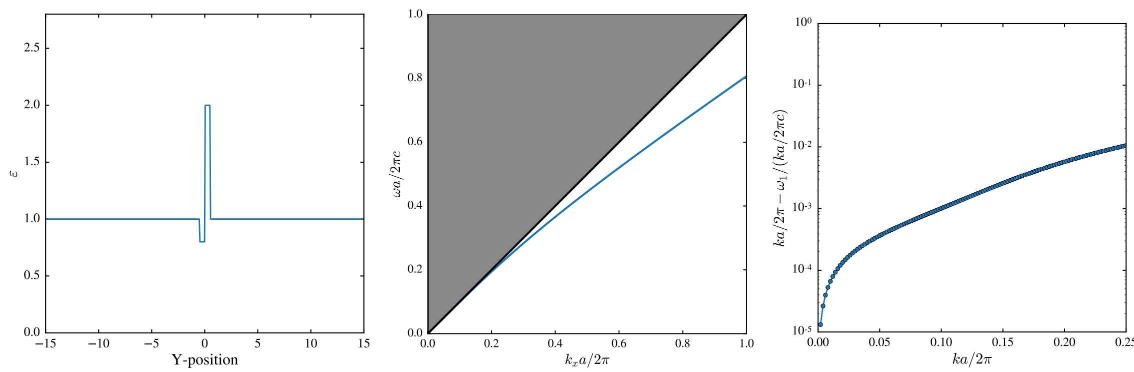

Figure 4: (Panel 1) Dielectric constant ε within the computational cell. (Panel 2) First guided mode for low-k. This guided mode should persist to very low $k \ll a$ because as k decreases, the wavelength increases and the field "sees" an effective medium of average dielectric constant $\varepsilon = 1.4$, which would support a guided mode. (Panel 3) Verification of this prediction - distance of the guided mode frequency from the light line. Notice how the distance is always positive, indicating that the mode persists beneath the light line (i.e. as a guided mode).

2 Problem 4

2.1 Part a

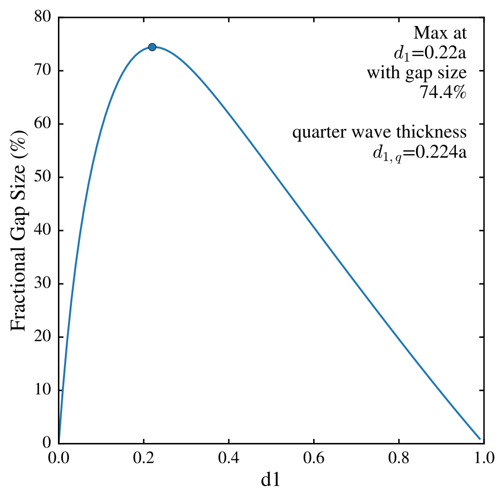

Figure 5: Fractional gap size as a function of layer 1 thickness, d_1. The gap size is maximized for a thickness equal to the quarter-wave thickness $d_1 = d_{1,q}$.

2.2 Part c

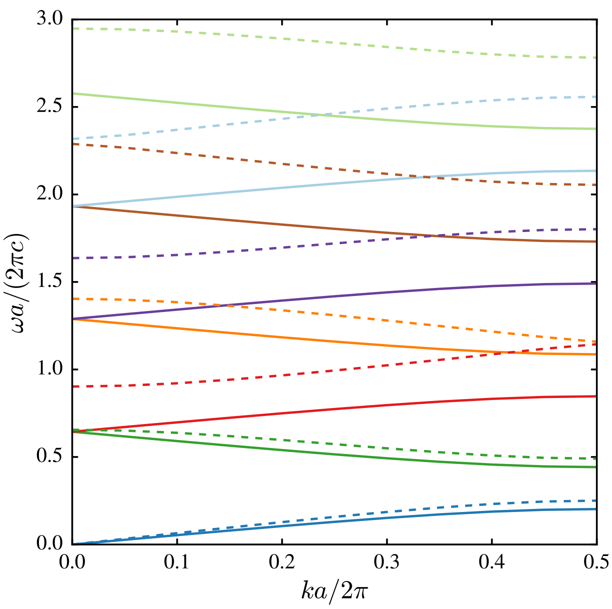

Figure 6: Band structure for $d_1 = d_{1,q}$ (solid lines) and for an arbitrary $d_1 = 0.12345$. Unlike the arbitrary d_1, when d_1 is the quarter-wave thickness, there are no gaps at $ka/2\pi = 0$.