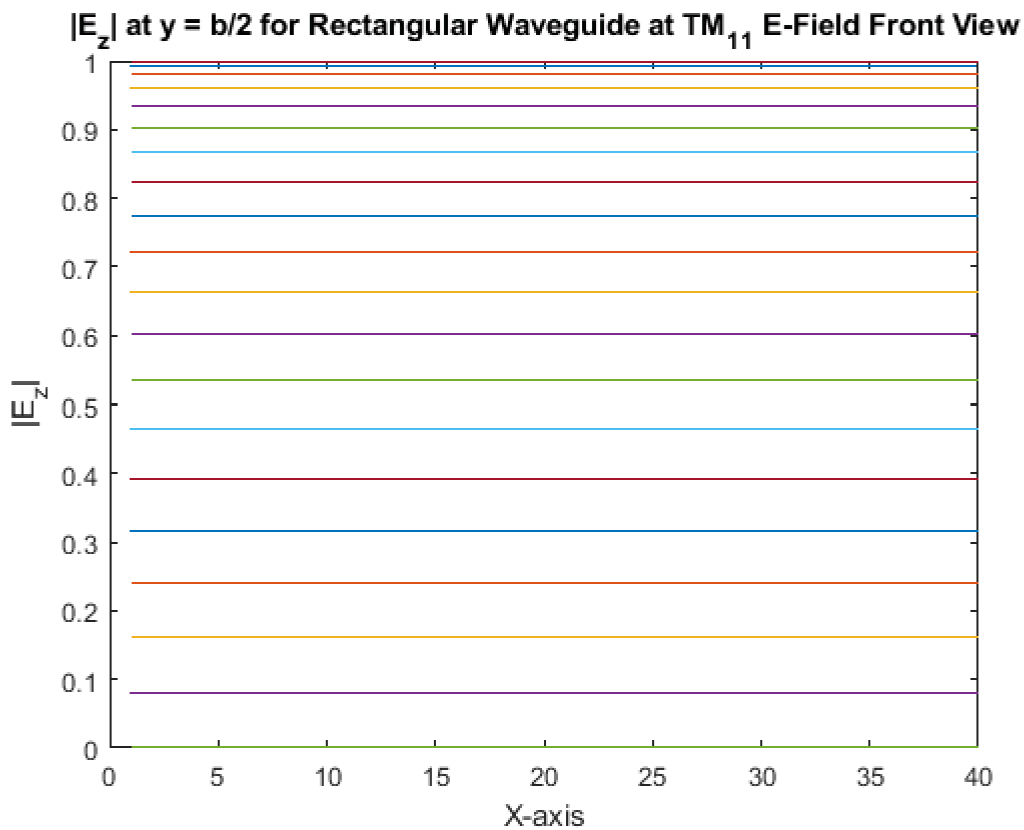
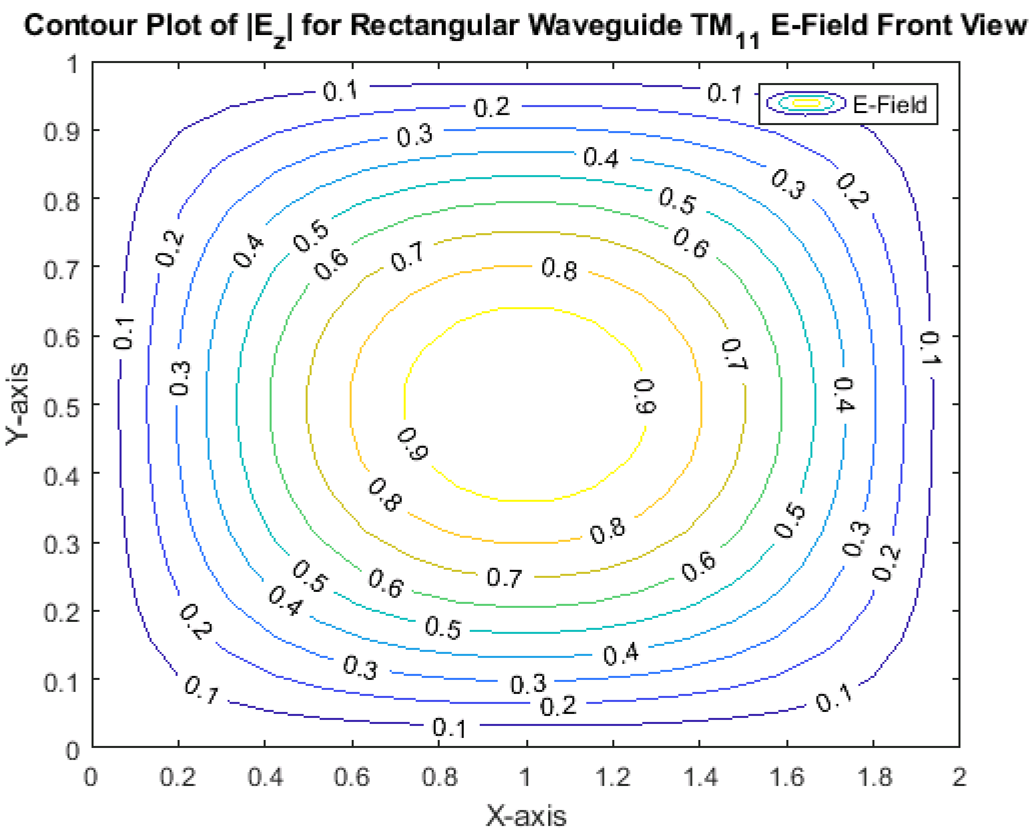
```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Ryan Nand
% 05/02/2020
% |E_z| at y = b/2
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Constants
m = 1;              % TM11 mode
n = 1;              % TM11 mode
u_po = 3*10^8;      % Phase velocity will be speed of light
omega = 4*pi*10^8;  % Chosen angular frequency
a = 2;              % Chosen length of rectangular waveguide
b = a/2;            % Chosen height of rectangular waveguide
E_o = 1;            % Chosen intial E field
j = sqrt(-1);       % Imaginary j

% Equations for waveguides
k = omega/u_po;                             % Unbounded wavenumber
k_c = (pi/a)^2+(pi/b)^2;                    % Cutoff wavenumber
f_mn = (u_po/2)*sqrt((m/a)^2+(n/b)^2);      % Cutoff frequency
beta = sqrt(k^2-k_c^2);                     % Propagation constant

% Plot data
M = 40; % Number of data points
x = linspace(0,a,M);    % Creating evenly spaced points
y = linspace(0,b,M);    % Creating evenly spaced points
[x,y] = meshgrid(x,y);  % Creating grid of points

% Equation for E_z field
z = 0;
y = b/2;
E_z = E_o.*sin((m.*pi.*x)./a).*sin((n.*pi.*y)./b).*exp(-j.*beta.*z);
% Magnitude
magE_z = abs(E_z);

% Plot 1-d |E_z| at y = b/2
figure();
plot(magE_z)
title('|E_z| at y = b/2 for Rectangular Waveguide at TM_{11} E-Field Front View');
xlabel('X-axis');
ylabel('|E_z|');
```



Not sure if the above plot was the intended result. However, when I tried other things with the magnitude of E_z nothing would show. This is the only result that appeared.

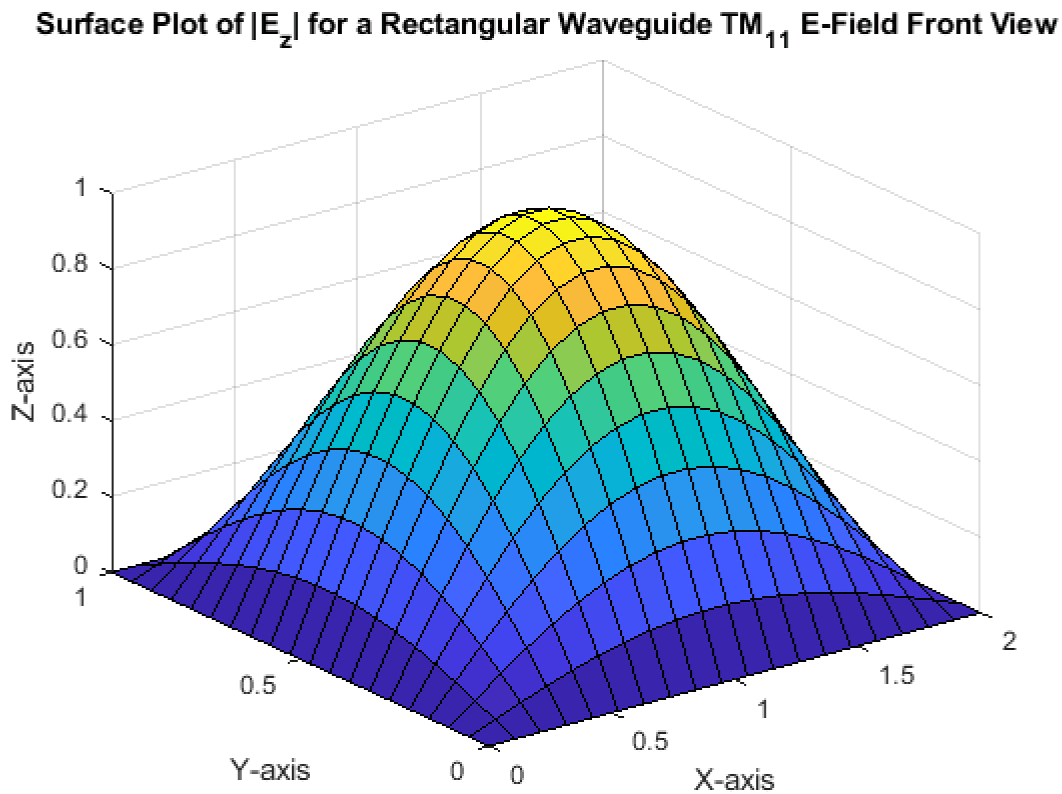
The above is wrong

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Ryan Nand
% 05/02/2020
% 2-d Contour Plot of |E_z|
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Constants
m = 1;              % TM11 mode
n = 1;              % TM11 mode
u_po = 3*10^8;      % Phase velocity will be speed of light
omega = 4*pi*10^8;  % Chosen angular frequency
a = 2;              % Chosen length of rectangular waveguide
b = a/2;            % Chosen height of rectangular waveguide
E_o = 1;            % Chosen intial E field
j = sqrt(-1);       % Imaginary j
% Equations for waveguides
k = omega/u_po;                         % Unbounded wavenumber
k_c = (pi/a)^2+(pi/b)^2;                % Cutoff wavenumber
f_mn = (u_po/2)*sqrt((m/a)^2+(n/b)^2);  % Cutoff frequency
beta = sqrt(k^2-k_c^2);                 % Propagation constant

% Plot data
M = 20; % Number of data points
x = linspace(0,a,M);    % Creating evenly spaced points
y = linspace(0,b,M);    % Creating evenly spaced points
[x,y] = meshgrid(x,y);  % Creating grid of points
% Equation for E_z field
z = 0;
E_z = E_o.*sin((m.*pi.*x)./a).*sin((n.*pi.*y)./b).*exp(-j.*beta.*z);
% Magnitude
magE_z = abs(E_z);

% Plot the 2-d contour
figure();
contour(x,y,magE_z, 'ShowText','on');
title('Contour Plot of |E_z| for Rectangular Waveguide TM_{11} E-Field Front View');
legend('E-Field');
xlabel('X-axis');
ylabel('Y-axis');
```



Contour shows a magnitude strongest in the center and gets smaller whens the radius gets larger.

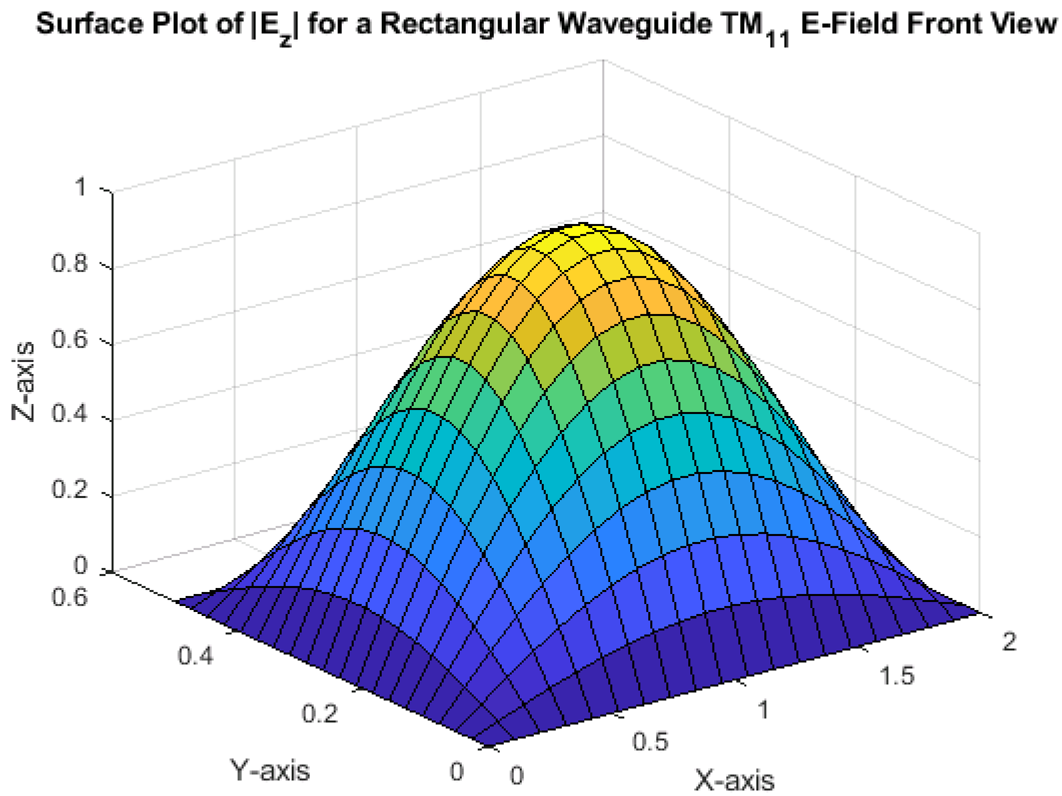
```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Ryan Nand
% 05/02/2020
% 3-d Surface Plot of |E_z|
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Constants
m = 1;              % TM11 mode
n = 1;              % TM11 mode
u_po = 3*10^8;      % Phase velocity will be speed of light
omega = 4*pi*10^8;  % Chosen angular frequency
a = 2;              % Chosen length of rectangular waveguide
b = a/2;            % Chosen height of rectangular waveguide
E_o = 1;            % Chosen intial E field
j = sqrt(-1);       % Imaginary j

% Equations for waveguides
k = omega/u_po;                     % Unbounded wavenumber
k_c = (pi/a)^2+(pi/b)^2;            % Cutoff wavenumber
f_mn = (u_po/2)*sqrt((m/a)^2+(n/b)^2);  % Cutoff frequency
beta = sqrt(k^2-k_c^2);             % Propagation constant

% Plot data
M = 20; % Number of data points
x = linspace(0,a,M);    % Creating evenly spaced points
y = linspace(0,b,M);    % Creating evenly spaced points
[x,y] = meshgrid(x,y);  % Creating grid of points

% Equation for E_z field
z = 0;
E_z = E_o.*sin((m.*pi.*x)./a).*sin((n.*pi.*y)./b).*exp(-j.*beta.*z);
% Magnitude
magE_z = abs(E_z);

% Plot the 3-d surface
figure();
surf(x,y,magE_z);
title('Surface Plot of |E_z| for a Rectangular Waveguide TM_{11} E-Field Front View');
xlabel('X-axis');
ylabel('Y-axis');
zlabel('Z-axis');
```



The above plot is the surface plot of the magnitude of the E field. Looks like the magnitude is the largest in the center of the rectangular waveguide in the positive z-direction. Just like the contour above this plot shows. The result should be the same, it is just two different plot types.

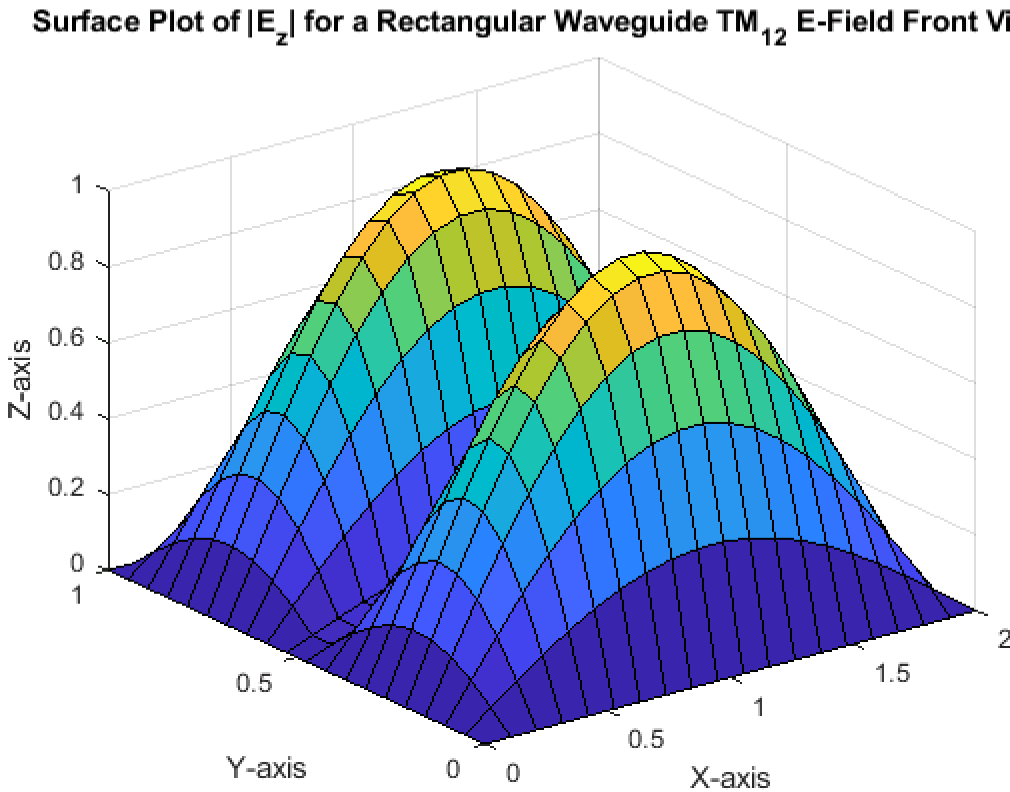
The following code and plots produced was to compare and contrast miniscule differences between the previous code and plots. To see how little the plots can change due to very minor changes in the dimension, mode, or field type. Also, surface plots were used because the visuals are better and surface plots are not often utilized.

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Ryan Nand
% 05/02/2020
% 3-d Surface Plot of |E_z| With Different Ratio
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Constants
m = 1;                % TM11 mode
n = 1;                % TM11 mode
u_po = 3*10^8;        % Phase velocity will be speed of light
omega = 4*pi*10^8;    % Chosen angular frequency
a = 2;                % Chosen length of rectangular waveguide
b = a/4;              % Chosen height of rectangular waveguide
E_o = 1;              % Chosen intial E field
j = sqrt(-1);         % Imaginary j

% Equations for waveguides
k = omega/u_po;                         % Unbounded wavenumber
k_c = (pi/a)^2+(pi/b)^2;                % Cutoff wavenumber
f_mn = (u_po/2)*sqrt((m/a)^2+(n/b)^2);  % Cutoff frequency
beta = sqrt(k^2-k_c^2);                 % Propagation constant

% Plot data
M = 20; % Number of data points
x = linspace(0,a,M);    % Creating evenly spaced points
y = linspace(0,b,M);    % Creating evenly spaced points
[x,y] = meshgrid(x,y);  % Creating grid of points

% Equation for E_z field
z = 0;
E_z = E_o.*sin((m.*pi.*x)./a).*sin((n.*pi.*y)./b).*exp(-j.*beta.*z);
% Magnitude
magE_z = abs(E_z);

% Plot the 3-d surface
figure();
surf(x, y, magE_z)
title('Surface Plot of |E_z| for a Rectangular Waveguide TM_{11} E-Field Front View');
xlabel('X-axis');
ylabel('Y-axis');
zlabel('Z-axis');
```



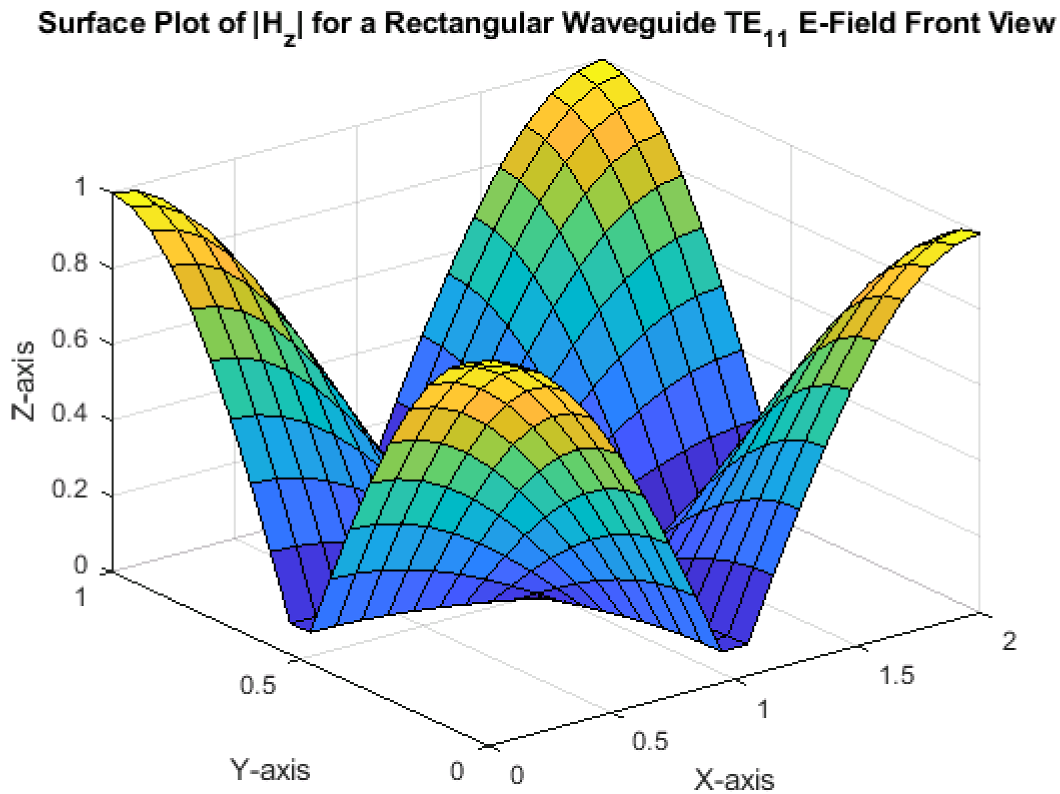
Here you can see the surface become more narrow due to changing the dimensions or ratio of the rectangular waveguide. Makes sense if you make the area of the rectangular waveguide smaller.

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Ryan Nand
% 05/02/2020
% 3-d Surface Plot of |E_z| With Different Mode
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Constants
m = 1;              % TM11 mode
n = 2;              % TM11 mode
u_po = 3*10^8;      % Phase velocity will be speed of light
omega = 4*pi*10^8;  % Chosen angular frequency
a = 2;              % Chosen length of rectangular waveguide
b = a/2;            % Chosen height of rectangular waveguide
E_o = 1;            % Chosen intial E field
j = sqrt(-1);       % Imaginary j

% Equations for waveguides
k = omega/u_po;                         % Unbounded wavenumber
k_c = (pi/a)^2+(pi/b)^2;                % Cutoff wavenumber
f_mn = (u_po/2)*sqrt((m/a)^2+(n/b)^2);  % Cutoff frequency
beta = sqrt(k^2-k_c^2);                 % Propagation constant

% Plot data
M = 20; % Number of data points
x = linspace(0,a,M);     % Creating evenly spaced points
y = linspace(0,b,M);     % Creating evenly spaced points
[x,y] = meshgrid(x,y);  % Creating grid of points

% Equation for E_z field
z = 0;
E_z = E_o.*sin((m.*pi.*x)./a).*sin((n.*pi.*y)./b).*exp(-j.*beta.*z);
% Magnitude
magE_z = abs(E_z);

% Plot the 3-d surface
figure();
surf(x, y, magE_z)
title('Surface Plot of |E_z| for a Rectangular Waveguide TM_{11} E-Field Front View');
xlabel('X-axis');
ylabel('Y-axis');
zlabel('Z-axis');
```



I noticed that varying m and n creates the number of peaks in the surface plot. Also, the directions of the peaks (where the sides of the peaks are) depend on m or n. For instance, if it was backwards where m = 2 and n = 1, the above plot would be the same but the valley of the two peaks would be facing the x-axis instead.

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Ryan Nand
% 05/02/2020
% 3-d Surface Plot of |H_z| in TE Mode
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Constants
m = 1;               % TE11 mode
n = 1;               % TE11 mode
u_po = 3*10^8;       % Phase velocity will be speed of light
omega = 4*pi*10^8;   % Chosen angular frequency
a = 2;               % Chosen length of rectangular waveguide
b = a/2;             % Chosen height of rectangular waveguide
H_o = 1;             % Chosen intial H field
j = sqrt(-1);        % Imaginary j

% Equations for waveguides
k = omega/u_po;                       % Unbounded wavenumber
k_c = (pi/a)^2+(pi/b)^2;              % Cutoff wavenumber
f_mn = (u_po/2)*sqrt((m/a)^2+(n/b)^2); % Cutoff frequency
beta = sqrt(k^2-k_c^2);               % Propagation constant

% Plot data
M = 20; % Number of data points
x = linspace(0,a,M);    % Creating evenly spaced points
y = linspace(0,b,M);    % Creating evenly spaced points
[x,y] = meshgrid(x,y);  % Creating grid of points

% Equation for E_z field
z = 0;
H_z = H_o.*cos((pi.*x)./a).*cos((pi.*y)./b).*exp(-j.*beta.*z);
% Magnitude
magH_z = abs(H_z);

% Plot the 3-d surface
figure();
surf(x, y, magH_z)
title('Surface Plot of |H_z| for a Rectangular Waveguide TE_{11} E-Field Front View');
xlabel('X-axis');
ylabel('Y-axis');
zlabel('Z-axis');
```

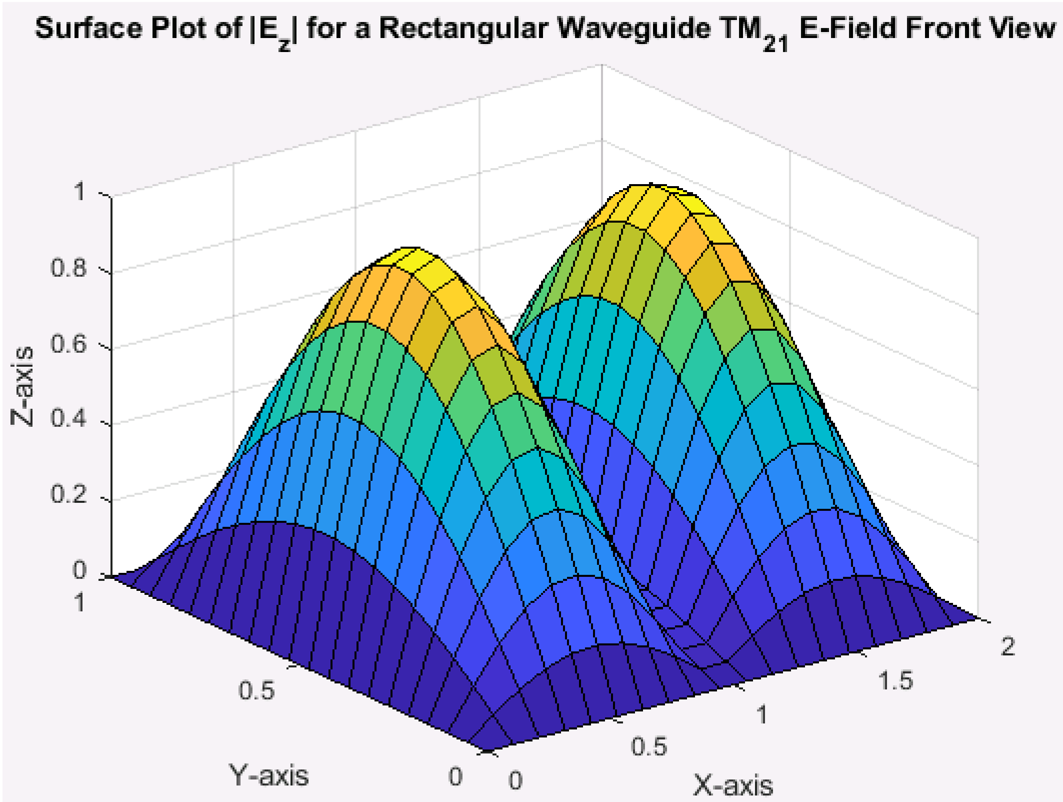


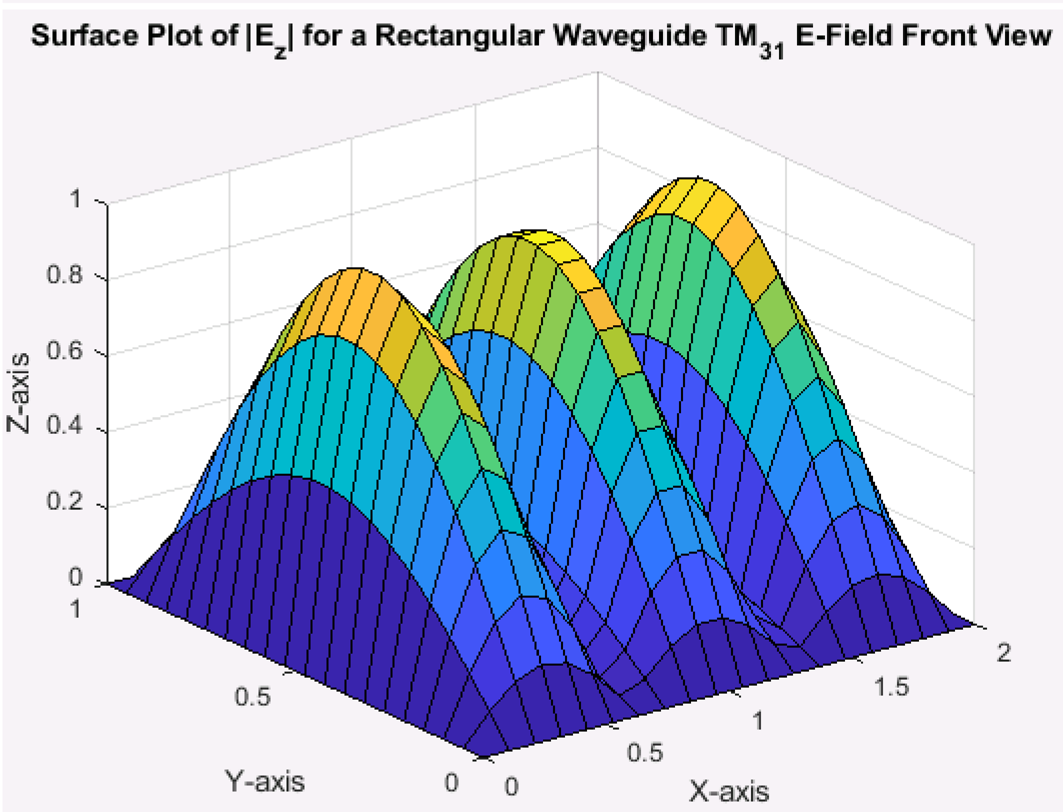
This plot above is the |H_z| of the TE mode because it is zero for transverse magnetic. Looks like the magnitudes are larges towards the outer corners in the +z-direction.

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Ryan Nand
% 05/02/2020
% 3-d Surface Plot of |E_z| With Choice
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
m = input('Enter mode value m:');
n = input('Enter mode value n:');
if m == 0 && n == 0
        fprintf(['TM_',num2str(m),num2str(n), ' mode doesnot exist']);
end
% Constants
u_po = 3*10^8;      % Phase velocity will be speed of light
omega = 4*pi*10^8;  % Chosen angular frequency
a = 2;              % Chosen length of rectangular waveguide
b = a/2;            % Chosen height of rectangular waveguide
E_o = 1;            % Chosen intial E field
j = sqrt(-1);       % Imaginary j
% Equations for waveguides
k = omega/u_po;                       % Unbounded wavenumber
k_c = (pi/a)^2+(pi/b)^2;              % Cutoff wavenumber
f_mn = (u_po/2)*sqrt((m/a)^2+(n/b)^2); % Cutoff frequency
beta = sqrt(k^2-k_c^2);               % Propagation constant

% Plot data
M = 20; % Number of data points
x = linspace(0,a,M);    % Creating evenly spaced points
y = linspace(0,b,M);    % Creating evenly spaced points
[x,y] = meshgrid(x,y);  % Creating grid of points
% Equation for E_z field
z = 0;
E_z = E_o.*sin((m.*pi.*x)./a).*sin((n.*pi.*y)./b).*exp(-j.*beta.*z);
% Magnitude
magE_z = abs(E_z);

% Plot the 3-d surface
figure();
surf(x, y, magE_z)
title(['Surface Plot of |E_z| for a Rectangular Waveguide TM_',num2str(m),'_',num2str(n),' E-Field Front View']);
xlabel('X-axis');
ylabel('Y-axis');
zlabel('Z-axis');
```

I couldn't get the publish to work where input arguments could be predetermined through the publish configuration editor. It would not execute for some reason.

I chose to vary the mode, since this variation made the biggest difference right after changing between transverse electric and transverse magnetic. These plots made the most sense because I know the vector pattern of the electric field. Therefore, when I see these plots I know where the magnitudes are the largest.


Surface Plot of |E_z| for a Rectangular Waveguide TM_21 E-Field Front View
Z-axis
1
0.8
0.6
0.4
0.2
0
Y-axis
1
0.5
0
X-axis
0
0.5
1
1.5
2


Surface Plot of |E_z| for a Rectangular Waveguide TM_31 E-Field Front View
Z-axis
1
0.8
0.6
0.4
0.2
0
Y-axis
1
0.5
0
X-axis
0
0.5
1
1.5
2