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# 202a problem set, part II

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## Setup

```
function part_ii()

close all;

f = 100:.01:200; %Hz
omega = 2*pi*f; %rad/s
c = 1500; %m/s
d = 50; %m
```

## Math

```
% Find the highest mode number that has a cutoff frequency below 100Hz
m_max_100 = floor(100/c * (2*d));
m_max_200 = floor(200/c * (2*d));

for m = 1:m_max_200
    % Equation 8.39
    k_rm(m,:) = sqrt((omega/c).^2 - (m.*pi./d).^2); % rad/m

    k_zm(m,:) = sqrt((omega/c).^2 - k_rm(m,:).^2);

    v(m, :) = omega ./ k_rm(m,:);
    % Cutoff frequency (real wavenumber only above cutoff)
    f0m(m) = m*c/(2*d);
    f_real{m} = f(f>f0m(m));
    v_real{m} = v(m, (f>f0m(m)));

    % Find group velocity u
    u_temp = diff(omega)./diff(k_rm(m,:));
    u_temp = [0 u_temp]; % shift it over so that the dimensions match
    u_real{m} = u_temp(f>f0m(m));
end
```

## A: Number of modes

```
fprintf('Number of modes propagating at 100Hz = %d\n', m_max_100);
```

```
fprintf('Number of modes propgating at 200Hz = %d\n', m_max_200);
```

*Number of modes propgating at 100Hz = 6*

*Number of modes propgating at 200Hz = 13*

## B: Cut-off frequencies

```
fprintf('Cut off frequencies for each mode:\n');
for m=1:m_max_200
    fprintf('\t%d: %d Hz\n', m, f0m(m));
end
```

*Cut off frequencies for each mode:*

*1: 15 Hz*

*2: 30 Hz*

*3: 45 Hz*

*4: 60 Hz*

*5: 75 Hz*

*6: 90 Hz*

*7: 105 Hz*

*8: 120 Hz*

*9: 135 Hz*

*10: 150 Hz*

*11: 165 Hz*

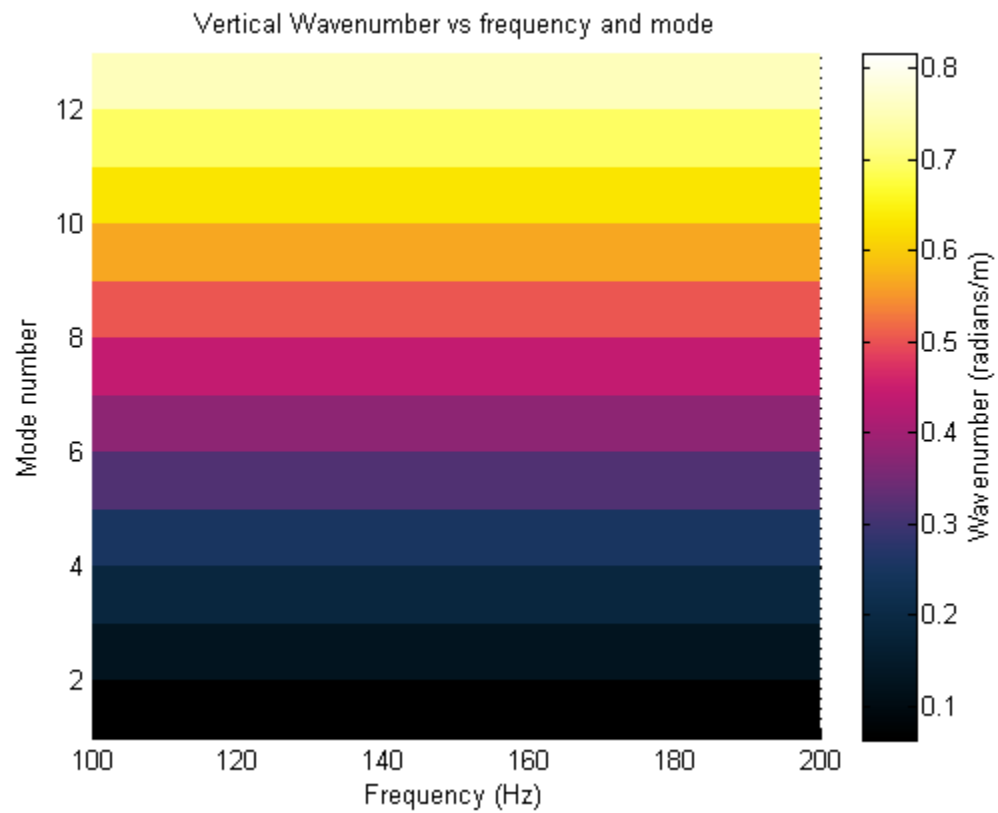
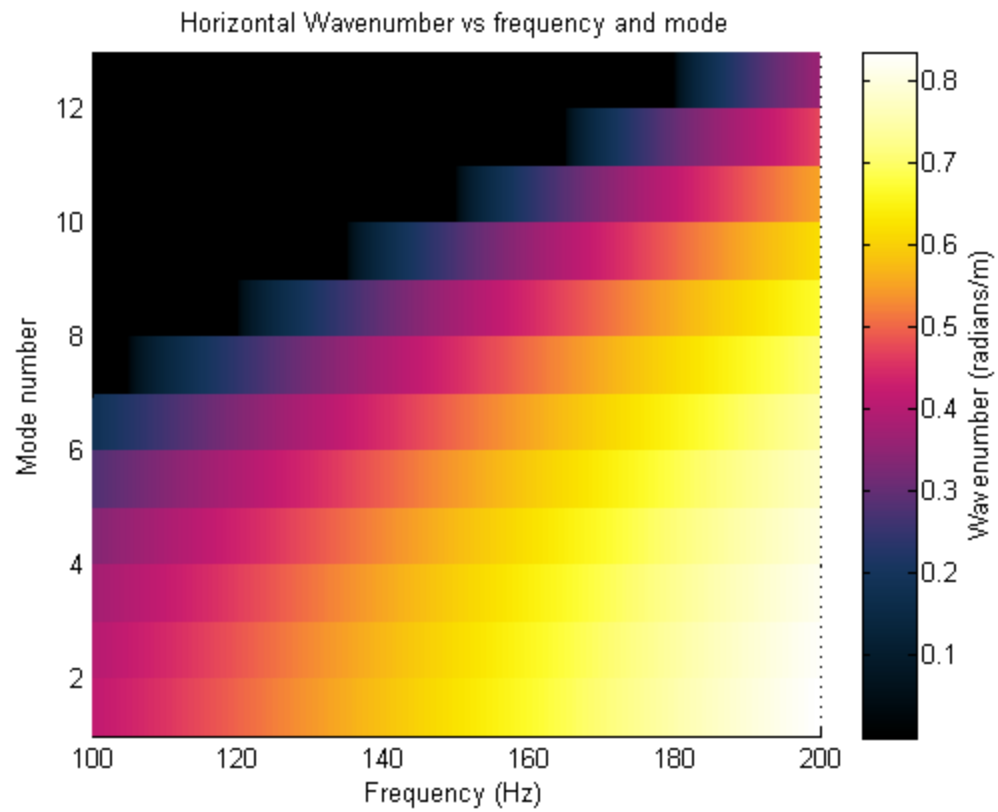
*12: 180 Hz*

*13: 195 Hz*

## C: Horizontal and vertical wavenumbers

```
m=1:m_max_200;
figure('name', 'Horizontal Wavenumber vs frequency and mode');
surf(f, m, real(k_rm), 'EdgeColor', 'none');
colormap(morgenstemning());
view([0 90]);
axis tight;
xlabel('Frequency (Hz)');
ylabel('Mode number');
cbar = colorbar();
ylabel(cbar, 'Wavenumber (radians/m)');
title(get(gcf(), 'name'));
```

```
figure('name', 'Vertical Wavenumber vs frequency and mode');
surf(f, m, real(k_zm), 'EdgeColor', 'none');
colormap(morgenstemning());
view([0 90]);
axis tight;
xlabel('Frequency (Hz)');
ylabel('Mode number');
cbar = colorbar();
ylabel(cbar, 'Wavenumber (radians/m)');
title(get(gcf(), 'name'));
```



## D: Group speed dispersion curves

```
figure();

for i = 1:length(f_real)
    plot(f_real{i}, u_real{i});
    hold on;
end

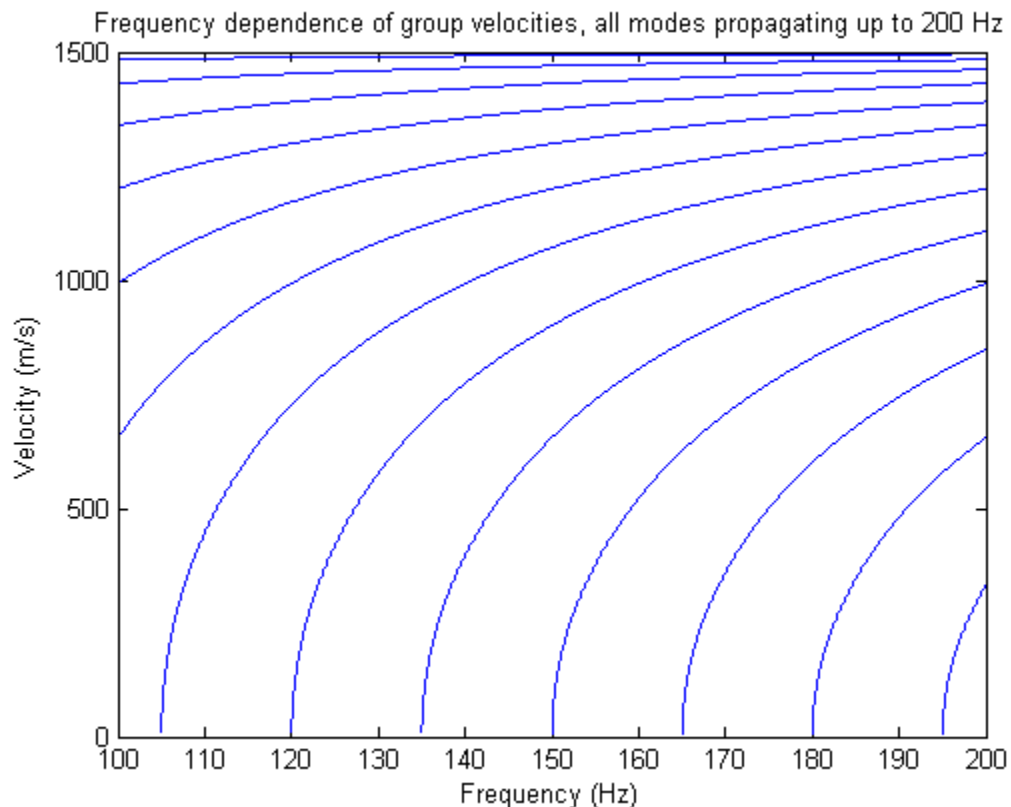
% plot(f_real{1}, u_real{1}, 'r--');
% hold on;
% plot(f_real{2}, u_real{2}, 'g--');
% plot(f_real{3}, u_real{3}, 'b--');

% plot(f_real{1}, v_real{1}, 'r');
% plot(f_real{2}, v_real{2}, 'g');
% plot(f_real{3}, v_real{3}, 'b');

%ylim([1300 1500]);
%legend('u1', 'u2', 'u3', 'Location', 'SouthEast');%, 'v1', 'v2', 'v3')
xlabel('Frequency (Hz)');
ylabel('Velocity (m/s)');
title('Frequency dependence of group velocities, all modes propagating up to 200 H
```

*Warning: Imaginary parts of complex X and/or Y arguments ignored*

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## E: Shape of the modes

```

z = 0:0.1:50;

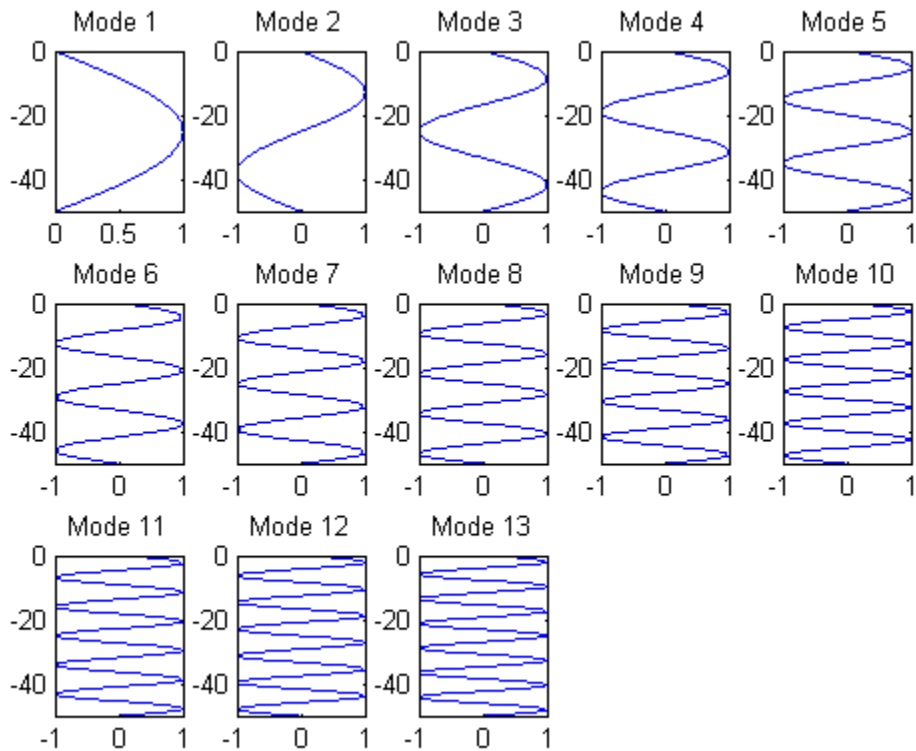
figure('name', 'Shape of modes in depth');

for m = 1:m_max_200
    shape = sin(k_zm(m,end)*z);
    subplot(3,5,m);
    plot(shape, -z);
    title(['Mode ' num2str(m)]);
end

disp('done');

done

```



```
end
```

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