

EMAT20920: Numerical Methods in MATLAB

COURSEWORK ASSESSMENT

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All figures in this report have been saved using `saveFigPDF` function as it automatically resizes the paper to the correct size.

```
function saveFigPDF(fileName)
    % saveFigPDF saves open figure as a PDF file
    %
    % Inputs:
    %   fileName = File name to save figure as
    % Usage:
    %   saveFigPDF("polynomial") -> Saves current figure as polynomial.pdf

    % Get current figure handle
    figureHandle = gcf;
    % Resize paper
    set(figureHandle, 'PaperPosition', 3*[0 0 6 4]);
    set(figureHandle, 'PaperSize', 3*[6 4]);
    set(figureHandle, 'PaperUnits', 'centimeters');

    print(fileName, '-dpdf');
end
```

Question 1: Root-finding

- (a) To find how many solutions each equation has in the given domain I will rearrange all the equations to be equal to zero and then look for the zeros of the rearranged equations. As a corollary to the intermediate value theorem, if a function is continuous and changes sign in a bracket then that bracket must contain a zero. So I will plot each of the rearranged equation and I look for appropriate brackets. I will use the `pltFunc` function to plot the functions as it removes values outside a defined limit which prevents MATLAB plotting discontinuous functions as continuous. The limits can then be changed using the property explorer to give a more useful plot.

```
function pltFunc(f, xLimits, discountLim)
    %pltFunc plots function f between values of xLim removing any values
    % that are greater than discountLim to prevent MATLAB plotting
    % discontinuous functions as continuous and plots a line of x = 0 to
    % help make any zeros clear
    %
    % Input:
    %   f = function handle to plot
    %   xLimits = domain of function to plot
    %   discountLim = absolute values of the function greater than this are
    %   changed to NaN. Setting to inf will plot all values of the function
    %
    % Usage:
    %   pltFunc(@(x) 1./x, [-10 10], 5) -> Plots 1/x between -10 and 10
    %   changing the values where |1/x|>5 to Nan
```

```

% Check xLim is the correct dimensions
assert(isequal(size(xLimits), [1 2]), "xLim must be a 1x2 array")

%% Generate values to plot
x = linspace(xLimits(1), xLimits(2));
y = f(x);

% Remove large values of y to prevent MATLAB plotting discontinuous
% functions as continuous
y(abs(y)>discontLim) = NaN;

%% Plot function and line x = 0
plot(x, y, [min(x) max(x)], [0 0], "g-", "LineWidth", 2);
xlabel("x");
ylabel("f(x)");
xlim(xLimits);
title("Plot of f(x)");
grid on;
end

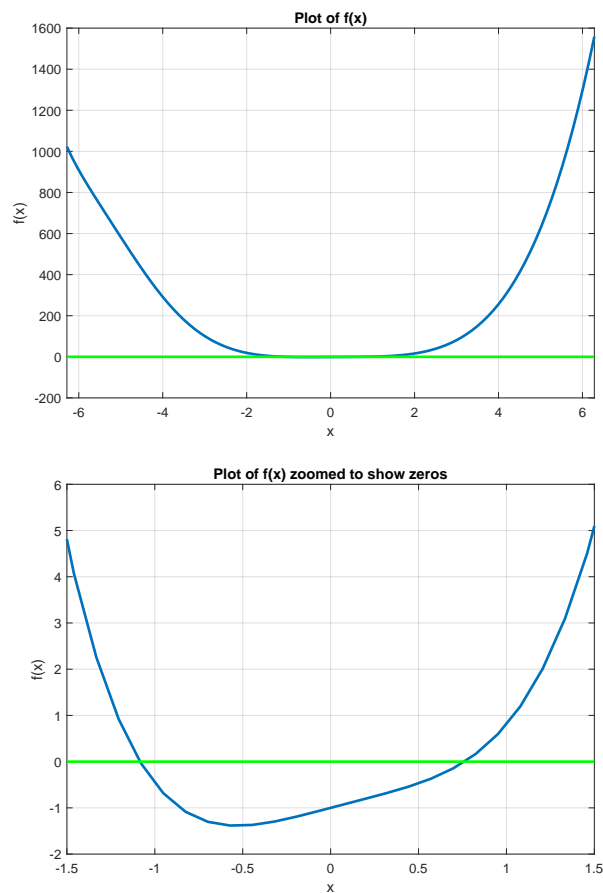
```

(i) Rearranging $x^4 = e^{-x} \cos(x)$ gives $f(x) = x^4 - e^{-x} \cos(x)$.

```

f = @(x) x.^4 - exp(-x).*cos(x);
pltFunc(f, [-2*pi 2*pi], inf);

```

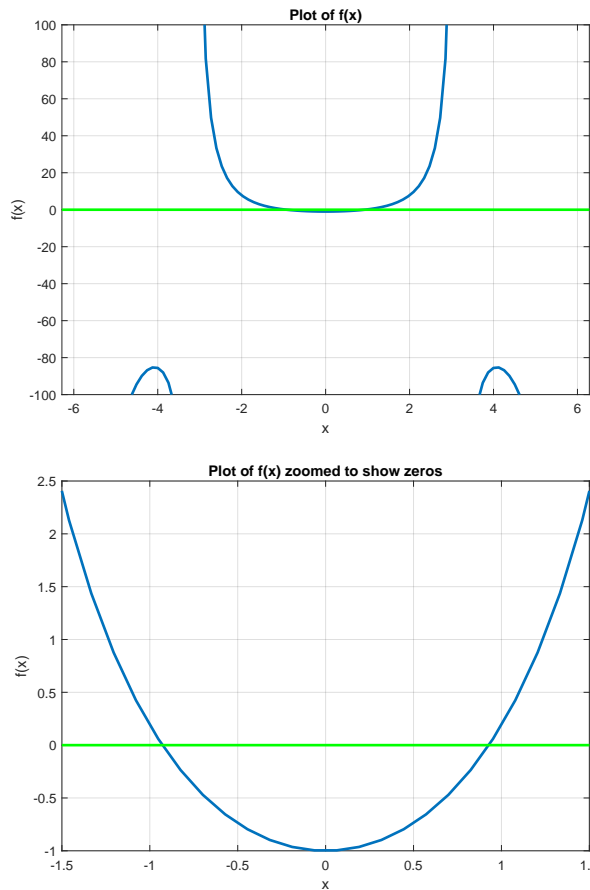


The second zoomed in plot shows there are two zeros in the given domain. The first zero can be bracketed by $[-1.5, -1]$ as $f(-1.5) = 4.7455$ and $f(-1) = -0.4687$ so since the function

is continuous and there is a change of sign this bracket must contain a zero. Likewise the second root can be bracketed by $[0.5, 1]$ as $f(0.5) = -0.4698$ and $f(1) = 0.8012$.

(ii) Setting $f(x) = \frac{x^3}{\sin(x)} - 1$.

```
f = @(x) (x.^3)./sin(x) - 1;
pltFunc(f, [-2*pi 2*pi], 500);
```



The first root can be bracketed by $[-1, -0.5]$ as $f(-1) = 0.1884$ and $f(-0.5) = -0.7393$ and $f(x)$ is continuous in this bracket. Likewise, the second root can be bracketed by $[0.5, 1]$ as $f(0.5) = -0.7393$ and $f(1) = 0.1884$.

(iii) Rearranging $\cot(x)$