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```
%Logan McBride
%September 8, 2023
%Project 1 Truncation vs Rounding Error
%EML 3034C Modeling Methods in MAE

% Clear command window, close all graphs, clear workspace
clc, close all, clear

% ========================================================================
fprintf("=============================================================\n")
fprintf("Project 1 - Round-off vs Truncation Error\n")
fprintf("Logan McBride\n")
display(datetime("today"))
fprintf("=============================================================\n\n")
% ========================================================================

format short e

% Define the function f(x)
f = @(x) 2.5 - 1.25 * cos(3.8 * x); % Insert Function f(x)
df = @(x) 1.25 * 3.8 * sin(3.8 * x); % Insert Exact First Derivative df(x)
% Select x value to evaluate derivative
x = 5.25;
```

```
=============================================================
Project 1 - Round-off vs Truncation Error
Logan McBride
  datetime

   01-Sep-2023

=============================================================
```

Double-Precision

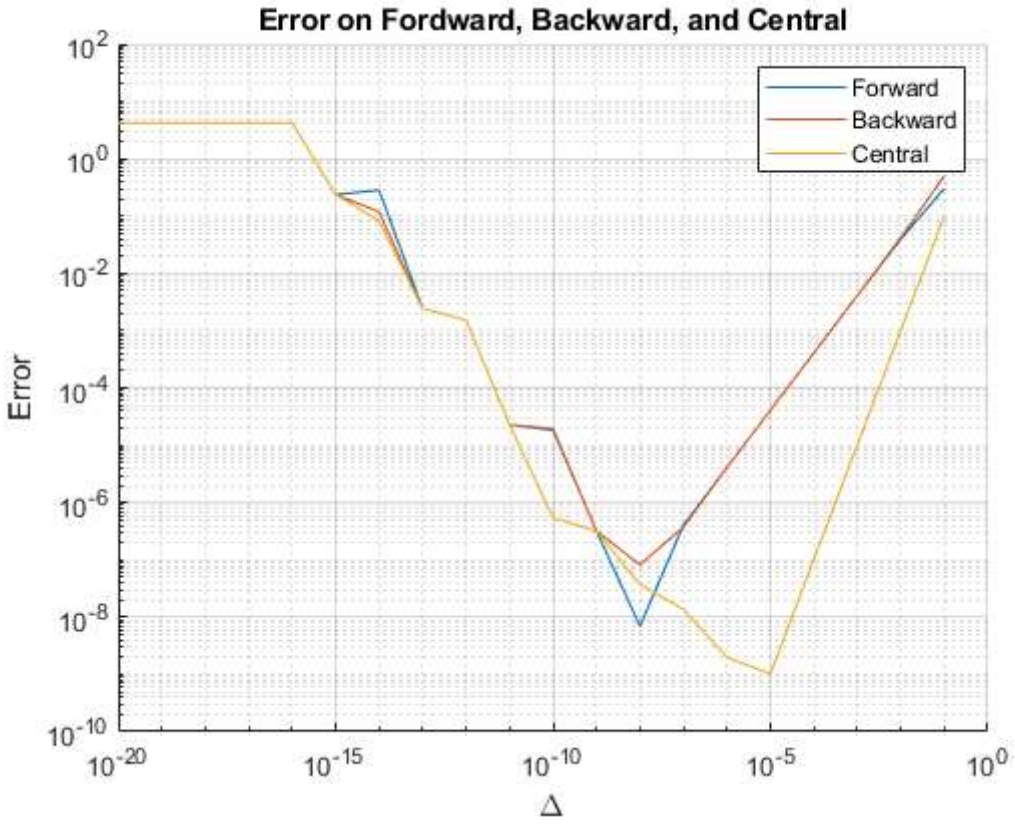
loop through the exponents for each delta x value and evaluate the derivative

```
for i = 1:20
% calculate the delta x
del(i,1) = 10^(-i);
```

```
% Backward Finite Difference
backward(i,1) = (f(x) - f(x-del(i,1))) / (del(i,1));

% Forward Finite Difference
forward(i,1) = (f(x+del(i,1)) - f(x)) / (del(i,1));

% Central Finite Difference
central(i,1) = (f(x+del(i,1)) - f(x-del(i,1))) / (2*del(i,1));

% calculate the errors compared to exact (analytical) derivative
backward_error(i,1) = abs(backward(i,1) - df(x));
forward_error(i,1) = abs(forward(i,1) - df(x));
central_error(i,1) = abs(central(i,1) - df(x));
end

% Plot the error vs del x for each method on the log scale
figure
hold on
% Scale of log for axis
set(gca, 'XScale', 'log', 'YScale', 'log')
% the loglog() function is the same as plot() but on log scale for both axes
loglog(del, forward_error)
loglog(del, backward_error)
loglog(del, central_error)
xlabel('\Delta'), ylabel('Error')
title('Error on Fordward, Backward, and Central')
legend('Forward','Backward','Central')
grid on, hold off
% assemble the results into a table (actually a matrix)
Table = [del, forward_error, backward_error, central_error];
% print to screen
fprintf("=========== Double Precision Results ===========\n")
fprintf("     Delta x     Forward     Backward     Central\n")
disp(Table)

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
=========== Double Precision Results ===========
     Delta x     Forward     Backward     Central
   1.0000e-01   3.0295e-01   5.0528e-01   1.0117e-01
   1.0000e-02   3.9877e-02   4.1915e-02   1.0190e-03
   1.0000e-03   4.0799e-03   4.1003e-03   1.0190e-05
   1.0000e-04   4.0891e-04   4.0912e-04   1.0190e-07
   1.0000e-05   4.0900e-05   4.0902e-05   1.0243e-09
   1.0000e-06   4.0921e-06   4.0882e-06   1.9733e-09
   1.0000e-07   4.0221e-07   3.7495e-07   1.3631e-08
   1.0000e-08   6.9693e-09   8.1849e-08   3.7440e-08
   1.0000e-09   3.1783e-07   3.1783e-07   3.1783e-07
   1.0000e-10   1.8334e-05   1.9414e-05   5.3988e-07
   1.0000e-11   2.2775e-05   2.2775e-05   2.2775e-05
   1.0000e-12   1.5315e-03   1.5315e-03   1.5315e-03
   1.0000e-13   2.4197e-03   2.4197e-03   2.4197e-03
   1.0000e-14   2.8180e-01   1.1788e-01   8.1957e-02
   1.0000e-15   2.3739e-01   2.3739e-01   2.3739e-01
```

```
1.0000e-16    4.2342e+00    4.2342e+00    4.2342e+00
1.0000e-17    4.2342e+00    4.2342e+00    4.2342e+00
1.0000e-18    4.2342e+00    4.2342e+00    4.2342e+00
1.0000e-19    4.2342e+00    4.2342e+00    4.2342e+00
1.0000e-20    4.2342e+00    4.2342e+00    4.2342e+00
```



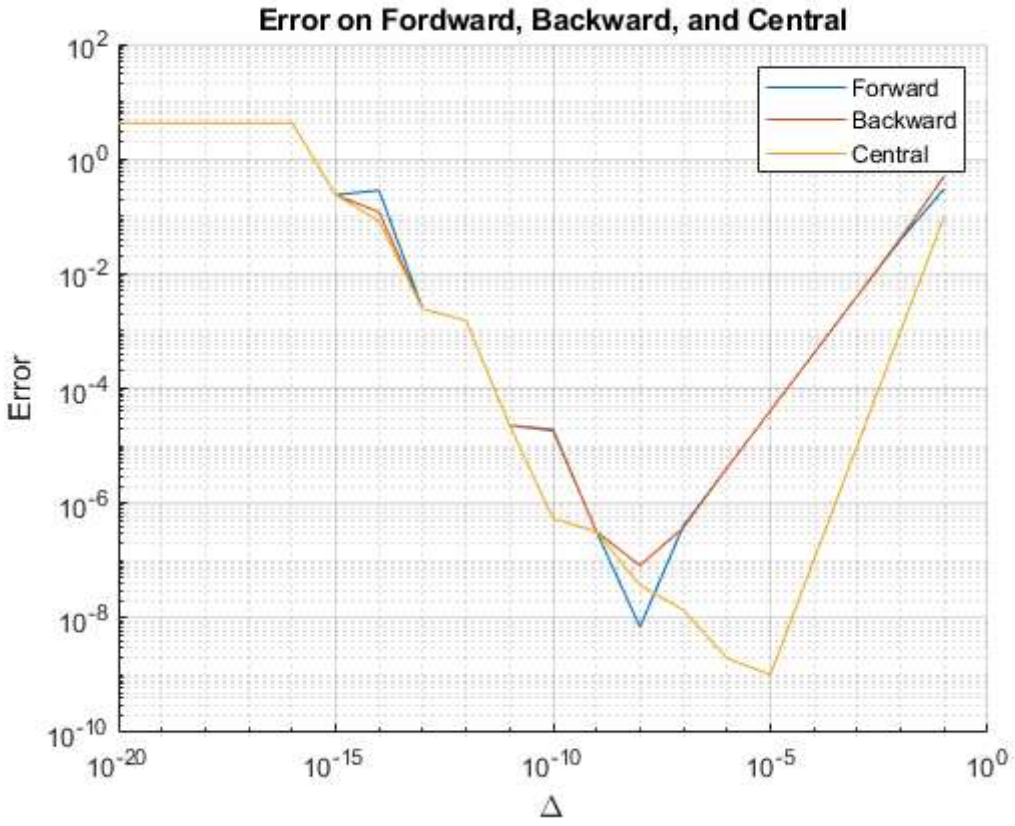
Repeat everything, but in single precision

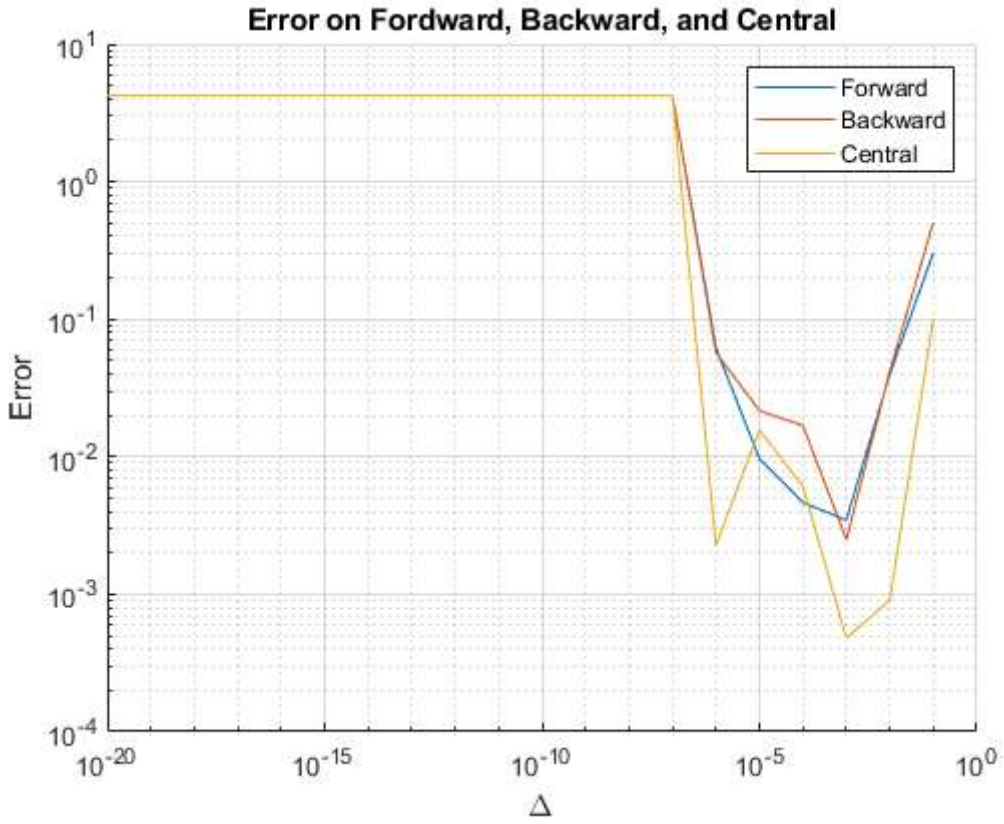
Select x value to evaluate derivative

```
x = single(x);
for i = single(1:20)
% calculate the delta x
del(i,1) = single(10^(-i));

% Backward Finite Difference
backward(i,1) = single((f(x) - f(x-del(i,1))) / (del(i,1)));

% Forward Finite Difference
forward(i,1) = single((f(x+del(i,1)) - f(x)) / (del(i,1)));

% Central Finite Difference
central(i,1) = single(f(x+del(i,1)) - f(x-del(i,1))) / (2*del(i,1));

% calculate the errors compared to exact (analytical) derivative
```

```
backward_error(i,1) = single(abs(backward(i,1) - df(x)));
forward_error(i,1) = single(abs(forward(i,1) - df(x)));
central_error(i,1) = single(abs(central(i,1) - df(x)));
end
% Plot the error vs del x for each method on the log scale
figure
hold on
% Scale of log for axis
set(gca, 'XScale', 'log', 'YScale', 'log')
% the loglog() function is the same as plot() but on log scale for both axes
loglog(del, forward_error)
loglog(del, backward_error)
loglog(del, central_error)
xlabel('\Delta'), ylabel('Error')
title('Error on Fordward, Backward, and Central')
legend('Forward','Backward','Central')
grid on
% assemble the results into a table (actually a matrix)
fprintf("\n\n\n")
Table = [del, forward_error, backward_error, central_error];
% print to screen
fprintf("=========== Single Precision Results ===========\n")
fprintf("     Delta x     Forward    Backward     Central\n")
disp(Table);
```

```
=========== Single Precision Results ===========
     Delta x     Forward    Backward     Central
   1.0000e-01   3.0293e-01   5.0528e-01   1.0117e-01
   1.0000e-02   3.9889e-02   4.1698e-02   9.0408e-04
   1.0000e-03   3.4590e-03   2.5015e-03   4.7874e-04
   1.0000e-04   4.6473e-03   1.6810e-02   6.0816e-03
   1.0000e-05   9.6579e-03   2.1579e-02   1.5618e-02
   1.0000e-06   6.1868e-02   5.7342e-02   2.2631e-03
   1.0000e-07   4.2342e+00   4.2342e+00   4.2342e+00
   1.0000e-08   4.2342e+00   4.2342e+00   4.2342e+00
   1.0000e-09   4.2342e+00   4.2342e+00   4.2342e+00
   1.0000e-10   4.2342e+00   4.2342e+00   4.2342e+00
   1.0000e-11   4.2342e+00   4.2342e+00   4.2342e+00
   1.0000e-12   4.2342e+00   4.2342e+00   4.2342e+00
   1.0000e-13   4.2342e+00   4.2342e+00   4.2342e+00
   1.0000e-14   4.2342e+00   4.2342e+00   4.2342e+00
   1.0000e-15   4.2342e+00   4.2342e+00   4.2342e+00
   1.0000e-16   4.2342e+00   4.2342e+00   4.2342e+00
   1.0000e-17   4.2342e+00   4.2342e+00   4.2342e+00
   1.0000e-18   4.2342e+00   4.2342e+00   4.2342e+00
   1.0000e-19   4.2342e+00   4.2342e+00   4.2342e+00
   1.0000e-20   4.2342e+00   4.2342e+00   4.2342e+00
```


Error on Fordward, Backward, and Central
Forward
Backward
Central
Error
Δ


Error on Fordward, Backward, and Central
Forward
Backward
Central
Error
Δ

Machine epsilon

```
E_dbl = eps
E_sgl = eps("single")
```

```
E_dbl =

   2.2204e-16


E_sgl =

  single

  1.1921e-07
```

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