Marcus Domingo
Project 1
MATH-446-001

$$f(x) = (432x^4 + 72x^2 + 16x + 5)e - 8e^{6x}$$

1. $f'(x) = (1728x^3 + 144x + 16)e - 48e^{6x}$ therefore, $x_{i+1} = x_i - \frac{f(x_i)}{f'(x_i)}$ for 5 steps gives a root $r = 0.473815838069242$. To check the accuracy of root I repeated with 6 steps and 7 steps getting a root of $r = 0.473815838069241$ and $r = 0.473815838069242$ respectively. The root continues to switch between 1 and 2 for the last decimal places so I believe the root is correct up until that point $r = 0.47381583806924$.
2. $f'(r) = -95.327948195875706 \neq 0$ therefore, Newton's Method converges to the root quadratically. $\lim_{i\to\infty} \frac{e_{i+1}}{e_i^2} = 7.278903995234184$, theoretical value: $M = \frac{f''(r)}{2f'(r)}$

   $f''(r) = (5184x^2 + 144)e - 288e^{6x} \rightarrow M = 7.283386597094728$. If rounded they match couple of decimal places ≈ 7.28.
3. $f_{new}(x) = (432x^4 + 72x^2 + 16x + 3)e - 8e^{6x}$

   $f'_{new}(x) = f'(x) = (1728x^3 + 144x + 16)e - 48e^{6x}$ therefore, $x_{i+1} = x_i - \frac{f(x_i)}{f'(x_i)}$ for 5 steps gives a root $r = 0.283196592326605$. To check the accuracy of the root I repeated with 15 steps and 30 steps getting a root of $r = 0.179524666382757$ and $r = 0.167127502576928$ respectively. Knowing that the root is exactly $\frac{1}{6}$ then the root is correct up until the second decimal place…the third if rounded, $r = 0.16 \; or \; 0.167$.

$$f'(r) = 0, f''(r) = 0, f'''(r) = 0, f''''(r) = 0$$

$f'''''(r) = -1.690988759847803 * 10^5$ therefore, Newton's Method converges to the root linearly with a multiplicity of 5. $\lim_{i\to\infty} \frac{e_{i+1}}{e_i} \approx 0.799841624652284$, theoretical value: $\frac{m-1}{m} = \frac{4}{5} = 0.8$. If rounded they match a decimal place ≈ 0.8.

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newt.m (for finding root)

```
function newt(f, fp, k)
g=@(x) x-f(x)/fp(x);
steps=k;
x=zeros(steps+1,1);
x(1)=0.5;
for i=1:steps
  x(i+1)=g(x(i))
end
r=x(steps+1)
```

newt.m (for finding quadratic convergence)

```
function newt(f, fp, k)
g=@(x) x-f(x)/fp(x);
steps=k;
x=zeros(steps+1,1);
x(1)=0.5;
for i=1:steps
  x(i+1)=g(x(i))
end
r=x(steps+1)
e=abs(x-r);
rat=zeros(steps+1,1);
for i=1:steps
  rat(i)=e(i+1)/e(i)^2;
end
rat(steps+1)=0;
[x e rat]
```

newt.m (for finding linear convergence)

```
function newt(f, fp, k)
g=@(x) x-f(x)/fp(x);
steps=k;
x=zeros(steps+1,1);
x(1)=0.5;
for i=1:steps
  x(i+1)=g(x(i))
end
r=x(steps+1)
e=abs(x-r);
rat=zeros(steps+1,1);
for i=1:steps
  rat(i)=e(i+1)/e(i);
end
```

rat(steps+1)=0;
[x e rat]

MatLab Session

```
f=@(x) (432*x.^4+72*x.^2+16*x+5)*exp(1)-8*exp(6*x);
fp=@(x) (1728*x.^3+144*x+16)*exp(1)-48*exp(6*x);
newt(f, fp, 5);
```

```
x =

  0.500000000000000
  0.478047251377279
                  0
                  0
                  0
                  0


x =

  0.500000000000000
  0.478047251377279
  0.473942618700500
                  0
                  0
                  0


x =

  0.500000000000000
  0.478047251377279
  0.473942618700500
  0.473815955037586
                  0
                  0


x =

  0.500000000000000
  0.478047251377279
  0.473942618700500
  0.473815955037586
  0.473815838069341
                  0


x =

  0.500000000000000
  0.478047251377279
  0.473942618700500
```

```
   0.473815955037586
   0.473815838069341
   0.473815838069242


r =

   0.473815838069242

newt(f, fp, 6);

x =

   0.500000000000000
   0.478047251377279
                   0
                   0
                   0
                   0
                   0


x =

   0.500000000000000
   0.478047251377279
   0.473942618700500
                   0
                   0
                   0
                   0


x =

   0.500000000000000
   0.478047251377279
   0.473942618700500
   0.473815955037586
                   0
                   0
                   0


x =

   0.500000000000000
   0.478047251377279
   0.473942618700500
   0.473815955037586
   0.473815838069341
                   0
                   0
```

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```
x =

   0.500000000000000
   0.478047251377279
   0.473942618700500
   0.473815955037586
   0.473815838069341
   0.473815838069242
                   0


x =

   0.500000000000000
   0.478047251377279
   0.473942618700500
   0.473815955037586
   0.473815838069341
   0.473815838069242
   0.473815838069241


r =

   0.473815838069241

newt(f, fp, 7);

x =

   0.500000000000000
   0.478047251377279
                   0
                   0
                   0
                   0
                   0
                   0


x =

   0.500000000000000
   0.478047251377279
   0.473942618700500
                   0
                   0
                   0
                   0
                   0


x =
```

```
   0.500000000000000
   0.478047251377279
   0.473942618700500
   0.473815955037586
                   0
                   0
                   0
                   0

x =

   0.500000000000000
   0.478047251377279
   0.473942618700500
   0.473815955037586
   0.473815838069341
                   0
                   0
                   0

x =

   0.500000000000000
   0.478047251377279
   0.473942618700500
   0.473815955037586
   0.473815838069341
   0.473815838069242
                   0
                   0

x =

   0.500000000000000
   0.478047251377279
   0.473942618700500
   0.473815955037586
   0.473815838069341
   0.473815838069242
   0.473815838069241
                   0

x =

   0.500000000000000
   0.478047251377279
   0.473942618700500
   0.473815955037586
   0.473815838069341
```

```
   0.473815838069242
   0.473815838069241
   0.473815838069242


r =

   0.473815838069242

newt(f, fp, 5);

x =

   0.500000000000000
   0.478047251377279
                   0
                   0
                   0
                   0


x =

   0.500000000000000
   0.478047251377279
   0.473942618700500
                   0
                   0
                   0


x =

   0.500000000000000
   0.478047251377279
   0.473942618700500
   0.473815955037586
                   0
                   0


x =

   0.500000000000000
   0.478047251377279
   0.473942618700500
   0.473815955037586
   0.473815838069341
                   0


x =

   0.500000000000000
```

```
   0.478047251377279
   0.473942618700500
   0.473815955037586
   0.473815838069341
   0.473815838069242


r =

   0.473815838069242


ans =

   0.500000000000000   0.026184161930758   6.171746669725795
   0.478047251377279   0.004231413308037   7.080794895271423
   0.473942618700500   0.000126780631258   7.277170009868958
   0.473815955037586   0.000000116968344   7.278903995234184
   0.473815838069341   0.000000000000100                   0
   0.473815838069242                   0                   0

fpp=@(x) (5184*x.^2+144)*exp(1)-288*exp(6*x);
fpp(0.47381583806924)/(2*fp(0.47381583806924))

ans =

   7.283386597094728

f=@(x) (432*x.^4+72*x.^2+16*x+3)*exp(1)-8*exp(6*x);
newt(f, fp, 5);

x =

   0.500000000000000
   0.438579819183476
                   0
                   0
                   0
                   0


x =

   0.500000000000000
   0.438579819183476
   0.387587511880733
                   0
                   0
                   0


x =

   0.500000000000000
```

```
   0.438579819183476
   0.387587511880733
   0.345586289965882
                   0
                   0


x =

   0.500000000000000
   0.438579819183476
   0.387587511880733
   0.345586289965882
   0.311204672896067
                   0


x =

   0.500000000000000
   0.438579819183476
   0.387587511880733
   0.345586289965882
   0.311204672896067
   0.283196592326605


r =

   0.283196592326605

newt(f, fp, 15);

x =

   0.500000000000000
   0.438579819183476
                   0
                   0
                   0
                   0
                   0
                   0
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                   0
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x =
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0.500000000000000
0.438579819183476
0.387587511880733
0
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x =

0.500000000000000
0.438579819183476
0.387587511880733
0.345586289965882
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x =

0.500000000000000
0.438579819183476
0.387587511880733
0.345586289965882
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x =

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x =

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0.438579819183476
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x =

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0.438579819183476
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0.242076245291962
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x =

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x =

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x =

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x =

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x =

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   0.197911843682273
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   0.182726164066434
   0.179524666382757


r =

   0.179524666382757

newt(f, fp, 30);

x =

   0.500000000000000
   0.438579819183476
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x =

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x =

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0.345586289965882
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0.283196592326605
0.260467086689482
0.242076245291962
0.227230752530793
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x =

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0.438579819183476
0.387587511880733
0.345586289965882
0.311204672896067
0.283196592326605
0.260467086689482
0.242076245291962
0.227230752530793
0.215269283335350
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x =

0.500000000000000
0.438579819183476
0.387587511880733
0.345586289965882
0.311204672896067
0.283196592326605
0.260467086689482
0.242076245291962
0.227230752530793
0.215269283335350
0.205645634503915
0.197911843682273
0.191702490389894
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0.182726164066434
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x =

0.500000000000000
0.438579819183476
0.387587511880733
0.345586289965882
0.311204672896067
0.283196592326605
0.260467086689482
0.242076245291962
0.227230752530793
0.215269283335350
0.205645634503915
0.197911843682273
0.191702490389894
0.186720721881015
0.182726164066434
0.179524666382757
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MATH-446-001

x =

0.500000000000000
0.438579819183476
0.387587511880733
0.345586289965882
0.311204672896067
0.283196592326605
0.260467086689482
0.242076245291962
0.227230752530793
0.215269283335350
0.205645634503915
0.197911843682273
0.191702490389894
0.186720721881015
0.182726164066434
0.179524666382757
0.176959723446675
0
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0

x =

0.500000000000000
0.438579819183476
0.387587511880733
0.345586289965882
0.311204672896067
0.283196592326605
0.260467086689482
0.242076245291962
0.227230752530793
0.215269283335350
0.205645634503915
0.197911843682273
0.191702490389894
0.186720721881015
0.182726164066434
0.179524666382757
0.176959723446675

0.174905372494976
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x =

0.500000000000000
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   0.167552708766568
   0.167376182797637
   0.167237022214275
   0.167127502576928


r =

   0.167127502576928

fp(1/6)

ans =

     0

fpp(1/6)

ans =

     0
```

Marcus Domingo
Project 1
MATH-446-001

```
fppp=@(x) 10368*x*exp(1)-1728*exp(6*x);
fppp(1/6)

ans =

     0

fpppp=@(x) 10368*exp(1)-10368*exp(6*x);
fpppp(1/6)

ans =

     0

fppppp=@(x) -62208*exp(6*x);
fppppp(1/6)

ans =

    -1.690988759847803e+05

newt(f, fp, 30);

x =

   0.500000000000000
   0.438579819183476
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Marcus Domingo
Project 1
MATH-446-001

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Marcus Domingo
Project 1
MATH-446-001

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x =

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ans =

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