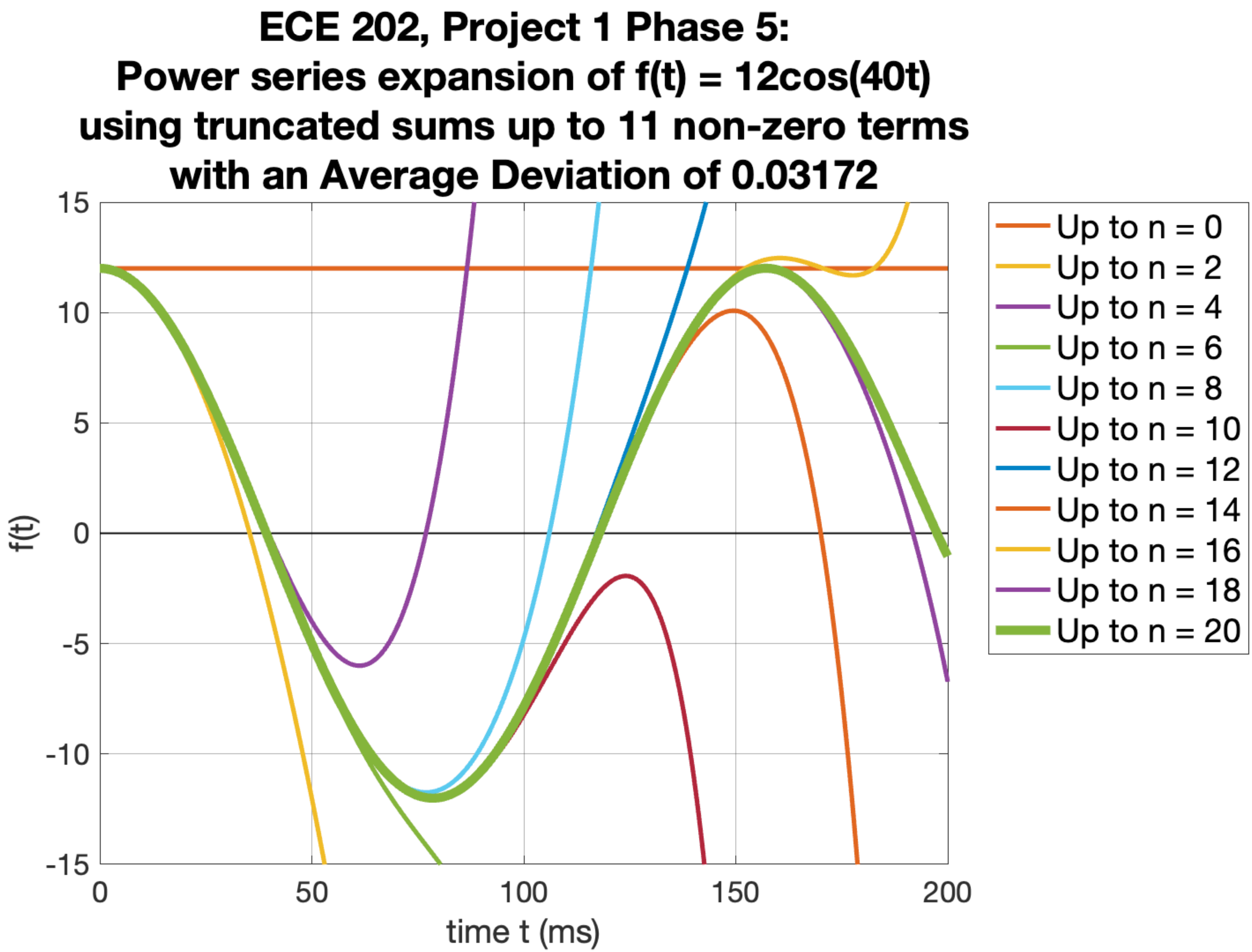
```
% Kavya Manchanda
% 11/1/2022
% ECE 202: Project 1 - Power Expansion Series of function of the form
% Acos(wt)
% Phase 6 : Understanding the Taylor series

clear; clf;
format shortG;

A = 12;           % amplitude
w = 40;           % angular frequency in rad/s
nz = input("Enter number of non zero terms: ");  % Number of non-zero terms

tmin = input("Enter starting time in ms: ");     % in ms
tmax = input("Enter ending time in ms: ");       % in ms
N = input("Enter number of intervals: ");        % intervals

tms = linspace(tmin, tmax, N);  % time array in ms
t = tms/1000;                     % time array in s
n = 0:2:2*nz - 2;          % first "nz" number of non zero term
% indices in series (only even values)


% The angular frequency in rad/s
an = A*(-1).^(n./2).*w.^n./factorial(n);

coefTable = table(n.',an.','VariableNames',{'n', 'aₙ'})

%----Adding the for loop and plotting-----
f = zeros(1,N);
p = zeros(nz,1);
plot([tmin,tmax],[0,0],"k","LineWidth",1)
hold on
for i = 1:nz
    f = f + an(i)*t.^n(i);
    if i~= nz                          % if not the last sum
        p(i) = plot(tms,f,"LineWidth",2.5);
    else                     % if it is the last sum, make the graph thicker
        p(nz) = plot(tms,f,"LineWidth",5);
    end
end
hold off

%---- Check from the previous phase ----
if nz==6  % checking only when non-zero terms are 6
    f1 = an(1)*t.^n(1);      % first sum (ie. first term) in the power series
    f2 = f1 + an(2)*t.^n(2); % sum of first two terms
    f3 = f2 + an(3)*t.^n(3); % sum of first three terms
    f4 = f3 + an(4)*t.^n(4); % sum of first four terms
    f5 = f4 + an(5)*t.^n(5); % sum of first five terms
    f6 = f5 + an(6)*t.^n(6); % sum of first six terms

    check = sum(abs(f-f6))   % should be zero
end

%----- Attributes of the graph -----
diff = abs(A*cos(w*t) - f);  % difference between the two functions
aveDeviation = sum(diff)/length(diff)  % average standard deviation
```

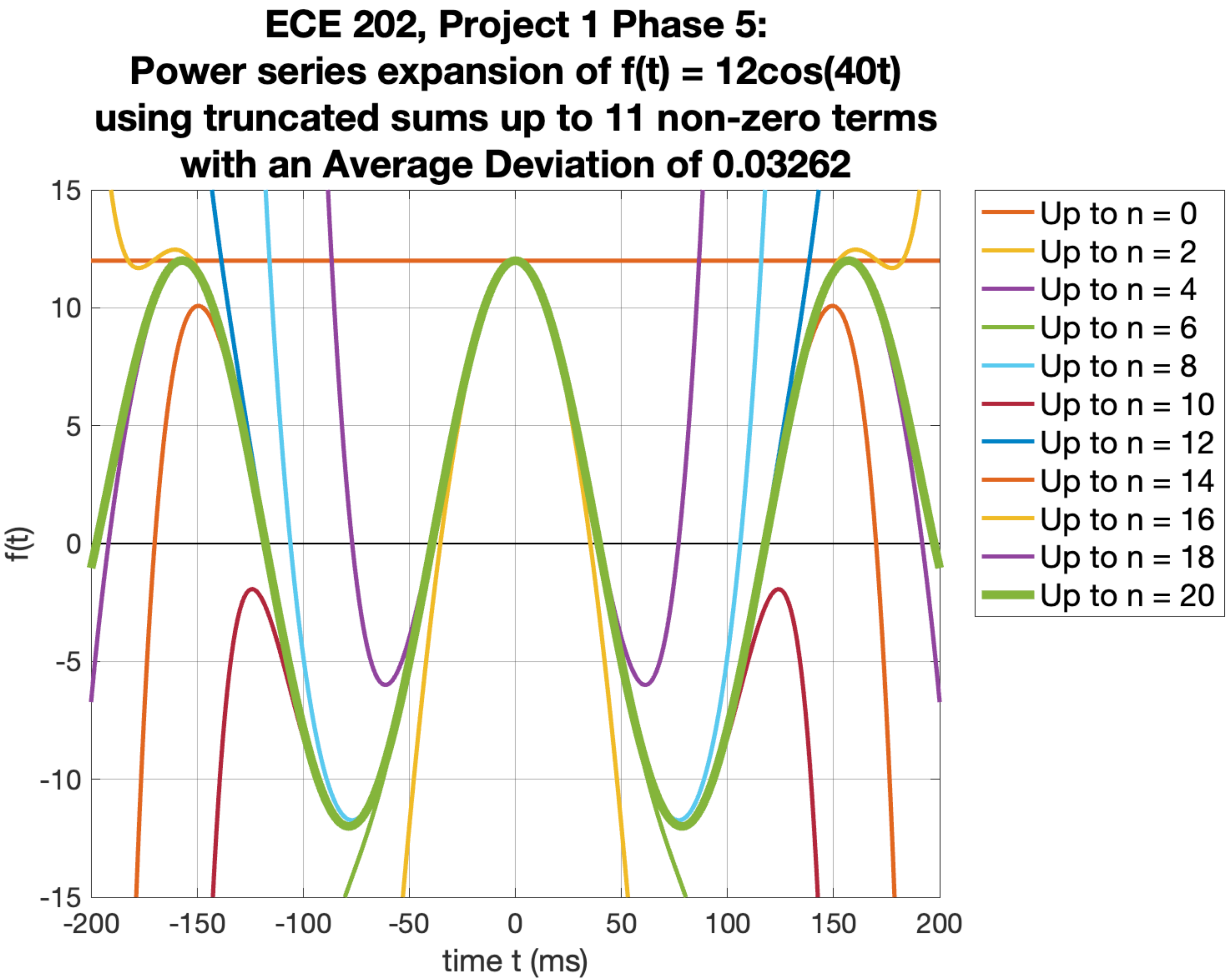
```matlab
ax = gca;
ax.GridAlpha = 0.4;
ax.FontSize = 16;
xlabel('time t (ms)','FontSize',18);
ylabel('f(t)','FontSize',18)
ylim([-1.25*A,1.25*A])
str1 = sprintf("Power series expansion of f(t) = %gcos(%gt)",A,w);
str2 = sprintf("using truncated sums up to %g non-zero terms",nz);
str3 = sprintf("with an Average Deviation of %0.4g",aveDeviation);
title(["ECE 202, Project 1 Phase 6:",str1,str2,str3],"FontSize",22)
legend(p,"Up to n = " + n,"FontSize",18,"Location","bestoutside")

grid on

% a) Through trial, the smallest number of non-zero terms with an average
% deviation less than 0.05 is 11 terms, with an average deviation of 0.032.
%
% b) When the intervals are doubled, the average deviation is still pretty
% close to the original value of 0.032. Now, it is equal to 0.03129.
%
% c) The deviation from -200ms to 200 ms will be the same as that of 0ms to
% 200ms as the function is a cosine function and as we already know that it
% is mirrored along the y-axis, hence the deviation will more or less be
% similar to the original value.
%
% d) The value for aveDeviation was close to the average deviation of the
% first graph with a value of 0.0326. This means that the hypothesis in
% part c) was correct.
%
% e) If we expand the Taylor series at t0 = 200ms, it will be very
% difficult to showcase the same in a graph, because of the huge
% exponents of the numbers. The average deviation from the original
% function would be way too high.
%
% f) During the second 200ms of the function, we cannot see the graphs as
% much. It seems as if the sums don't exist, while in reality, they are too
% high to be shown on the scales of our graphs. Hence, the siginificance of
% choosing t0 = 0ms is that we can get a good idea about the expanded
% Taylor series for the times which are feasible enough to be graphed. As
% we go farther, the sums get really huge and hard to visualise.
%
% g) With trial, I found that with 16 non-zero terms, we almost get a
% figure which looks like the given function.

```

```
>> project1phase6
Enter number of non zero terms: 11
Enter starting time in ms: 0
Enter ending time in ms: 200
Enter number of intervals: 400

coefTable =

  11×2 table

    n        aₙ
    __    ___________

     0             12
     2          -9600
     4        1.28e+06
     6    -6.8267e+07
     8     1.9505e+09
    10    -3.4675e+10
    12      4.203e+11
    14     -3.695e+12
    16     2.4633e+13
    18     -1.288e+14
    20     5.4232e+14


aveDeviation =

     0.031717

>>
```

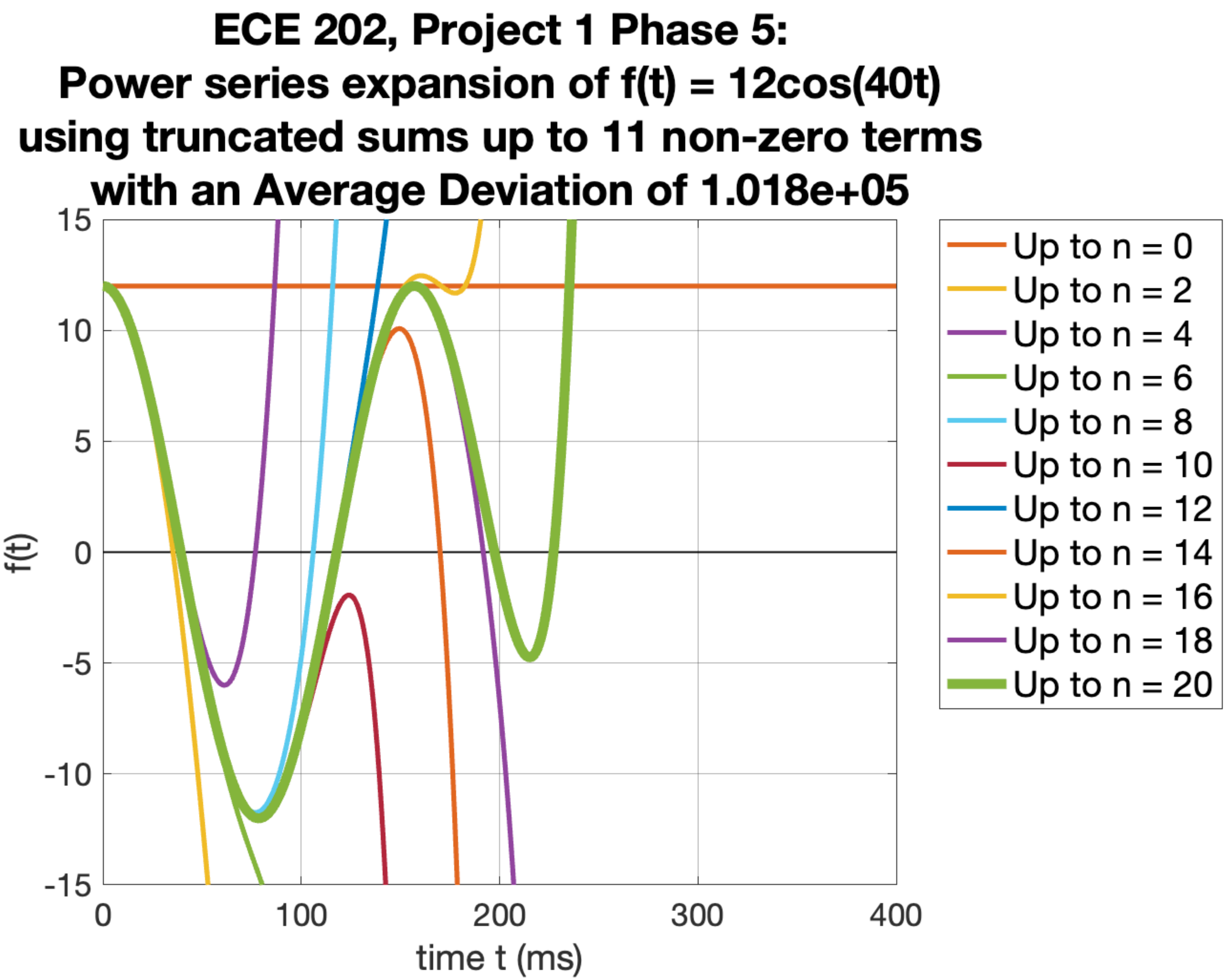

ECE 202, Project 1 Phase 5:
Power series expansion of f(t) = 12cos(40t)
using truncated sums up to 11 non-zero terms
with an Average Deviation of 0.03172
15
10
5
0
-5
-10
-15
f(t)
0
50
100
150
200
time t (ms)
Up to n = 0
Up to n = 2
Up to n = 4
Up to n = 6
Up to n = 8
Up to n = 10
Up to n = 12
Up to n = 14
Up to n = 16
Up to n = 18
Up to n = 20

```
>> project1phase6
Enter number of non zero terms: 11
Enter starting time in ms: 0
Enter ending time in ms: 200
Enter number of intervals: 800

coefTable =

  11×2 table

    n        aₙ
    __    ___________

     0             12
     2          -9600
     4        1.28e+06
     6     -6.8267e+07
     8      1.9505e+09
    10     -3.4675e+10
    12       4.203e+11
    14      -3.695e+12
    16      2.4633e+13
    18      -1.288e+14
    20      5.4232e+14


aveDeviation =

     0.031309

>>
```

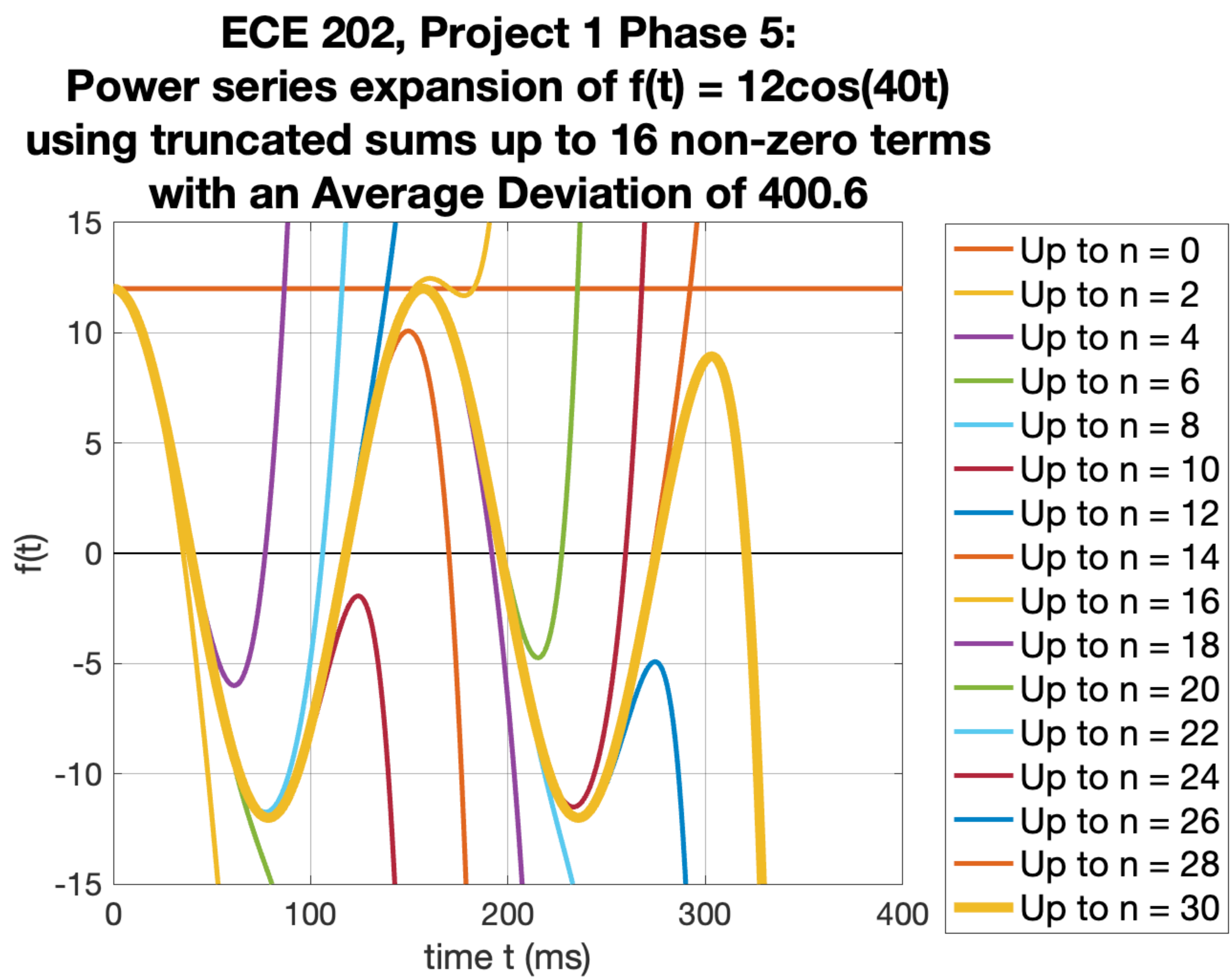
```
>> project1phase6
Enter number of non zero terms: 11
Enter starting time in ms: -200
Enter ending time in ms: 200
Enter number of intervals: 400

coefTable =

  11×2 table

    n         aₙ
    __    ___________

     0             12
     2          -9600
     4       1.28e+06
     6    -6.8267e+07
     8     1.9505e+09
    10    -3.4675e+10
    12      4.203e+11
    14     -3.695e+12
    16     2.4633e+13
    18     -1.288e+14
    20     5.4232e+14


aveDeviation =

     0.032622

>>
```


ECE 202, Project 1 Phase 5:
Power series expansion of f(t) = 12cos(40t)
using truncated sums up to 11 non-zero terms
with an Average Deviation of 0.03262
15
10
5
0
-5
-10
-15
f(t)
-200
-150
-100
-50
0
50
100
150
200
time t (ms)
Up to n = 0
Up to n = 2
Up to n = 4
Up to n = 6
Up to n = 8
Up to n = 10
Up to n = 12
Up to n = 14
Up to n = 16
Up to n = 18
Up to n = 20

```
>> project1phase6
Enter number of non zero terms: 11
Enter starting time in ms: 0
Enter ending time in ms: 400
Enter number of intervals: 400

coefTable =

  11×2 table

    n         aₙ
    __    ___________

     0             12
     2          -9600
     4        1.28e+06
     6    -6.8267e+07
     8     1.9505e+09
    10    -3.4675e+10
    12      4.203e+11
    14     -3.695e+12
    16     2.4633e+13
    18     -1.288e+14
    20     5.4232e+14


aveDeviation =

   1.0177e+05

>>
```


ECE 202, Project 1 Phase 5:
Power series expansion of f(t) = 12cos(40t)
using truncated sums up to 11 non-zero terms
with an Average Deviation of 1.018e+05
15
10
5
0
-5
-10
-15
f(t)
0
100
200
300
400
time t (ms)
Up to n = 0
Up to n = 2
Up to n = 4
Up to n = 6
Up to n = 8
Up to n = 10
Up to n = 12
Up to n = 14
Up to n = 16
Up to n = 18
Up to n = 20

```
>> project1phase6
Enter number of non zero terms: 16
Enter starting time in ms: 0
Enter ending time in ms: 400
Enter number of intervals: 400

coefTable =

  16×2 table

    n         aₙ
    __    ___________

     0             12
     2          -9600
     4        1.28e+06
     6    -6.8267e+07
     8     1.9505e+09
    10    -3.4675e+10
    12      4.203e+11
    14     -3.695e+12
    16     2.4633e+13
    18     -1.288e+14
    20     5.4232e+14
    22    -1.8782e+15
    24      5.444e+15
    26    -1.3401e+16
    28     2.8361e+16
    30    -5.2158e+16


aveDeviation =

       400.61

>>
```


ECE 202, Project 1 Phase 5:
Power series expansion of f(t) = 12cos(40t)
using truncated sums up to 16 non-zero terms
with an Average Deviation of 400.6
f(t)
time t (ms)
15
10
5
0
-5
-10
-15
0
100
200
300
400
Up to n = 0
Up to n = 2
Up to n = 4
Up to n = 6
Up to n = 8
Up to n = 10
Up to n = 12
Up to n = 14
Up to n = 16
Up to n = 18
Up to n = 20
Up to n = 22
Up to n = 24
Up to n = 26
Up to n = 28
Up to n = 30