EE254 P5 - Romberg Integration, Connor McGarty, cmcgarty

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In this project, we examine the error of different levels of Romberg Integration. For different functions, the different levels of R.I. and the decrease of the error as the number of integration segment increases. With the higher order of Romberg Integration, the error decreases much more quickly as number of segments increase as well.

Solution

```
close all; clear; clc;
syms x;
```

Define Functions

```
y1 = 0.2 + 25*x - 200*x^2 + 675*x^3 - 900*x^4 + 400*x^5;
y2 = x + (1/(x+1));
y3 = -0.055*x^4 + 0.86*x^3 - 4.2*x^2 + 6.3*x + 2;
y4 = 5*cos(x-(pi/2));


% for each function
    % increase n
    % for each xdelta, do romberg up to 3 levels
for i = [1:4]

    switch i
        case 1
            f = y1;
            t = '0.2 + 25*x - 200*x^2 + 675*x^3 - 900*x^4 + 400*x^5';
        case 2
            f = y2;
            t = 'x + (1/x)';
        case 3
            f = y3;
            t = '-0.055*x^4 + 0.86*x^3 - 4.2*x^2 + 6.3*x + 2';
        case 4
            f = y4;
            t = '5*cos(x-(pi/2))';
    end

    xmin = 0;
    xmax = 2;
    stop = 5;
    for n = [0:stop]
```

```matlab
        [area(n+1), error(n+1)] = ...
            trapezoidal_with_error(matlabFunction(f),
matlabFunction(diff(f)), ...
            xmin, xmax, 2^n);
    end

    figure;
    area_actual = integral(matlabFunction(f), xmin, xmax);
    e_t = abs(area - area_actual);
    subplot(2,2,1);
    sgtitle(strcat('Trapezoidal Romberg Iteration:', ' ', t));
    plot(1:length(e_t), e_t);
    title('Num Segments vs Error, O(h^2)');

    subplot(2,2,2);

    order_2 = (4/3)*area(2:end) - (1/3)*area(1:end-1);
    e_t_order2 = abs(order_2 - area_actual);
    plot(1:length(order_2), e_t_order2);
    title('Romberg Iteration Error, O(h^4)');
    subplot(2,2,3);

    order_3 = (16/15)*order_2(2:end) - (1/15)*order_2(1:end-1);
    e_t_order3 = abs(order_3 - area_actual);
    plot(1:length(order_3), e_t_order3);
    title('Romberg Iteration Error, O(h^6)');
    subplot(2,2,4);

    order_4 = (64/63)*order_3(2:end) - (1/63)*order_3(1:end-1);
    e_t_order4 = abs(order_4 - area_actual);
    plot(1:length(order_4), e_t_order4);
    title('Romberg Iteration Error, O(h^8)');

end
```
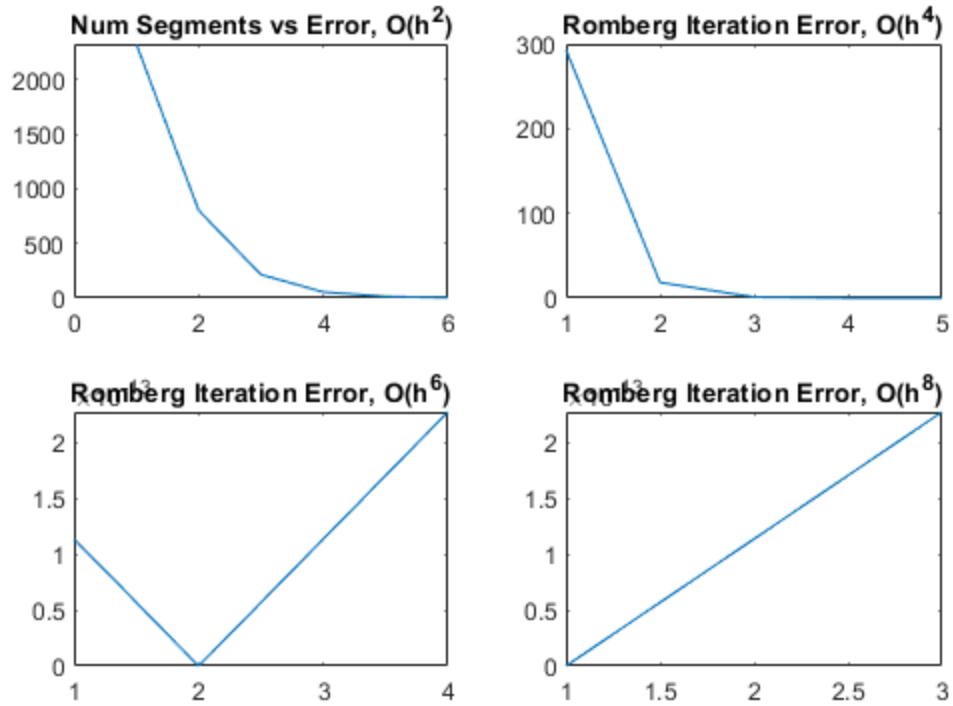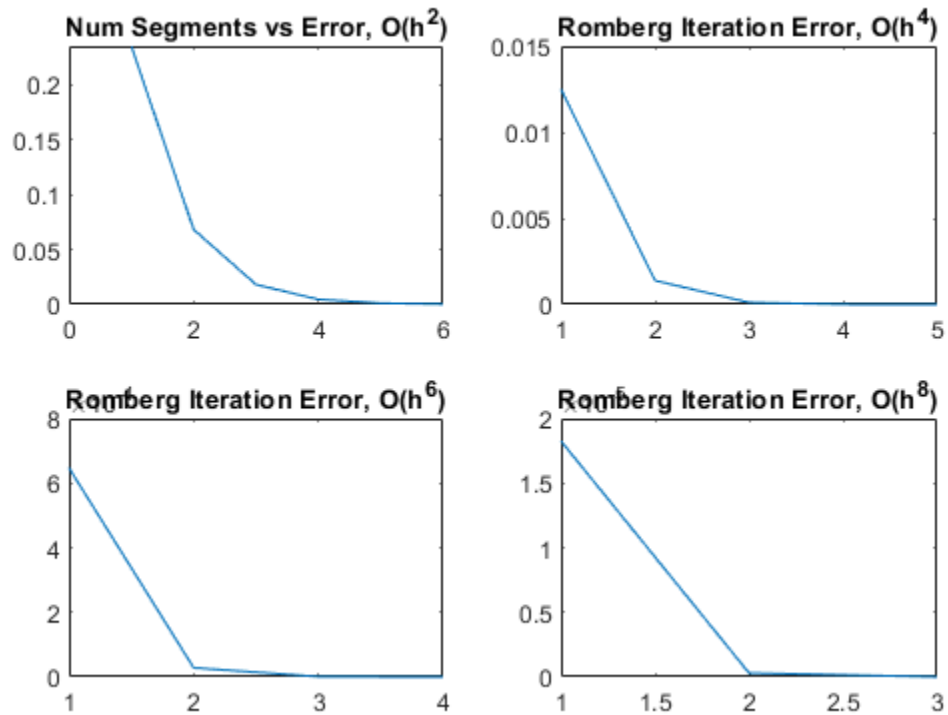
apezoidal Romberg Iteration:$0.2 + 25*x - 200*x^2 + 675*x^3 - 900*x^4 + 400*$

Num Segments vs Error, O(h^2)

Romberg Iteration Error, O(h^4)

Romberg Iteration Error, O(h^6)

Romberg Iteration Error, O(h^8)

Trapezoidal Romberg Iteration:$x + (1/x)$

Num Segments vs Error, O(h^2)

Romberg Iteration Error, O(h^4)

Romberg Iteration Error, O(h^6)

Romberg Iteration Error, O(h^8)

Trapezoidal Romberg Iteration:$-0.055{*}x^4 + 0.86{*}x^3 - 4.2{*}x^2 + 6.3{*}x + 2$

Num Segments vs Error, O(h^2)

Romberg Iteration Error, O(h^4)

Romberg Iteration Error, O(h^6)

Romberg Iteration Error, O(h^8)

Trapezoidal Romberg Iteration:$5{*}cos(x-(pi/2))$

Num Segments vs Error, O(h^2)

Romberg Iteration Error, O(h^4)

Romberg Iteration Error, O(h^6)
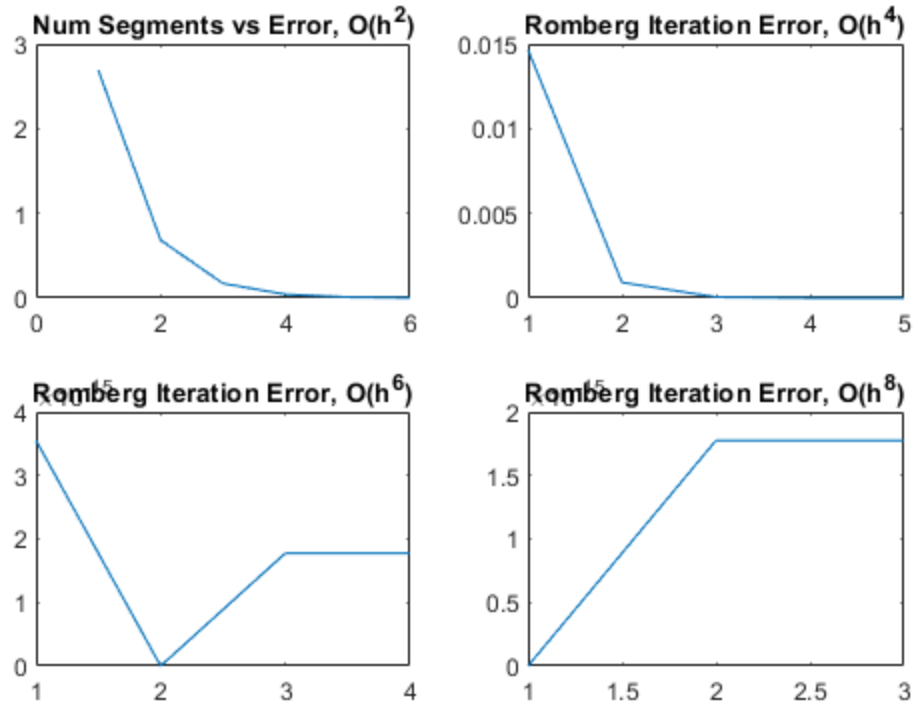
Romberg Iteration Error, O(h^8)
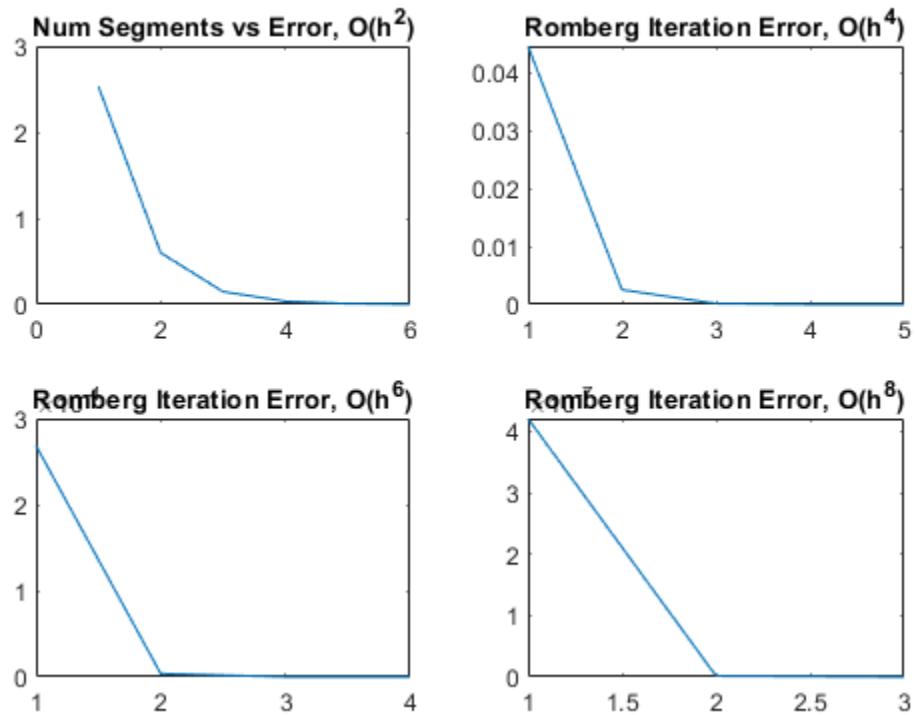
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