CS-215: Experiment 2B

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1. Shifting and Scaling Functions

Aim

Plot shifted and scaled versions of

$$f[n] = \begin{cases} -2 & n < -4 \\ n & -4 \leq n < 1 \\ \frac{4}{n} & 1 \leq n \end{cases}$$

Theoretical Background

Shifting and scaling a function is a normal part of signal processing. Both continuous and discrete signals can undergo the transformations. Note that, these two are not commutative.

Methodology

- Multiply the continuous parts with their conditions, so that they are zero elsewhere. Add all the 3 such continuous signals to obtain the desired one.
- Generate the integer points on x-axis and the corresponding y values.
- The discrete (x, t) pairs are plotted using stem plot.

Code

```
clear all
clc

f = @(n) (-2) .* (n < -4) + ...
         (n) .* (n < 1) .* (n >= -4) + ...
         (4 ./ n) .* (n >= 1);

Ts = [-10: 10];
fn = [f(Ts); f(2 - Ts); f(2 * Ts); f(Ts ./ 2)];

titles = [ 'f [n]     '   ; ...
```

```
            'f [2 - n]'   ; ...
            'f [2n]    '   ; ...
            'f [n / 2]'   ];

positions = [.025, .45, .45, .5 ; ...
             .525, .45, .45, .5 ; ...
             .025, .05, .45, .5 ; ...
             .525, .05, .45, .5 ];

for i = [1: 4]
    subplot(2, 2, i);
    hold on;

    stem(Ts, fn(i, :), 'filled' , ...
        'MarkerSize'    ,1.5    , ...
        'LineWidth'     ,0.7    );

    pbaspect([1.5, 1, 1]);
    set(gca, ...
        'Box'       ,'off'          , ...
        'TickDir'   ,'out'          , ...
        'YGrid'     ,'on'           , ...
        'XTick'     ,[-10: 2: 10]      , ...
        'YTick'     ,[-12: 2: 12]      , ...
        'FontSize'  ,6              , ...
        'YLim'      ,[-4, 4]        );

    axis([-10.5, 10.5, -4.5, 4.5]);
    title(titles(i, :), 'FontSize', 12, 'FontName', 'Times');
end

print(gcf, ['exp1abc', '.eps'], '-depsc');
```

Input Description

4 functions are to be plotted: $f[n]$, $f[2-n]$, $f[2n]$, $f\left[\frac{n}{2}\right]$.

The range to be taken is $[-10, 10]$.

Result

Conclusion

The 4 plots are thus generated. Note, the function value range remains between $[-4, 4]$.

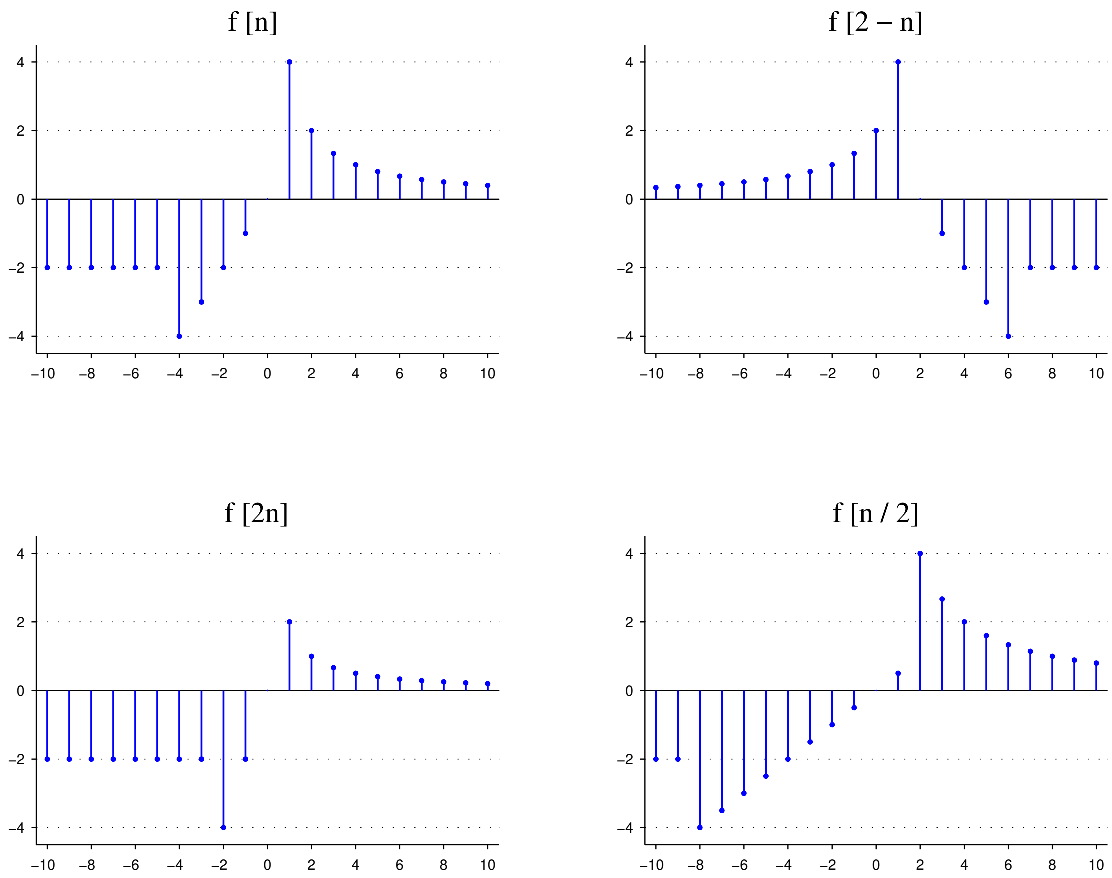

Figure 1.1: *Different transformations of* $f[n]$

2. Symbolic and Numeric Integration

Aim

To integrate $\sin x$ symbolically and numerically, consequently comparing them.

Theoretical Background

Here, 2 numerical integration techniques: Cumulative and Trapezoidal sum are used. Cumulative Sum merely adds the current index with all the previous indices and stores them at each index, while Trapezoidal Sum approximates the functions as trapezoids of fixed width.

Methodology

- Use built-in Matlab functions to find numerical sums with widths (dx) being 1.
- All the discrete and continuous functions are plotted simultaneously. Discrete sums are to be plotted using STAIRS.

Code

```
clear all
clc

xRange = [-10, 10];
xPoints = [-20: 20];
scale = .1;

syms t f(t) F(t);
f(t) = sin(t);
F(t) = int(f);

f_ = @(t) sin(t);
points = f_(xPoints);

hold on;

```

```
fplot(matlabFunction(f), xRange, '-r');
fplot(matlabFunction(F), xRange, '--k');
stairs(xPoints, cumsum(points), '-.b');
stairs(xPoints, cumtrapz(points), ':m');

hold off;

lgd = legend('f(t) = sin(t)', 'int(f) = - cos(t)', ...
       'Cumulative-Sum(f)', 'Trapezoid-Sum(f)');
set(lgd, 'FontName', 'Times', 'FontSize', 9);

set(gca, ...
        'Box'        ,'off'   , ...
        'TickDir'    ,'out'   , ...
        'FontSize'   ,8       );

axis([0, 2 * pi * (1+scale), -1.5, 1.5]);
pbaspect([2, 1, 1]);

print(gcf, ['symbolicInt', '.eps'], '-depsc');
```

Input Description

3 integration technique is to be used on $\sin x$: Symbolic, Cumulative and Trapezoidal. The range taken is $[0, 2\pi]$.

Result

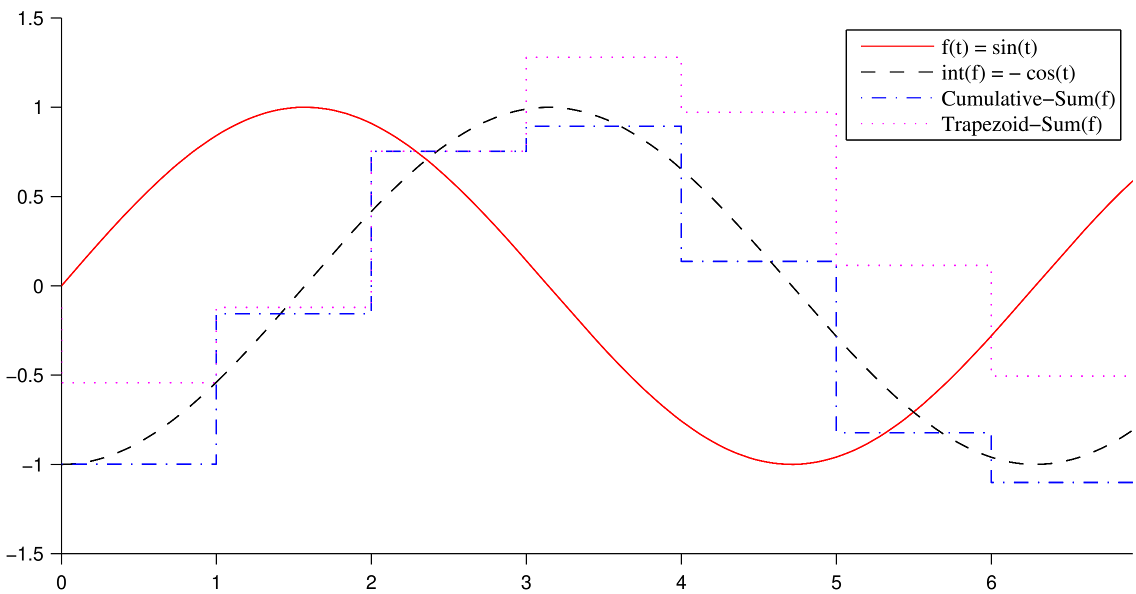

Figure 2.1: *Comparison of Symbolic and Numerical Intgration*

Discussion

Note that, if the step size is not 1, then the numerical methods will differ significantly. Here, Cumulative Sum seems to approximate the Integral the best.

3. Sampling of Analog and Discrete Signals

Aim

To plot even and odd parts of

a. $f(t) = t(t^2 + 3)$

b. $g(t) = t(2 - t^2)(1 + 4t^2)$

Theoretical Background

Functions such as $f(-x) = f(x)$ are called even functions, while $f(-x) = -f(x)$ are called odd functions. Essentially every function can be decomposed into an even function and odd function.

$$f(x) = f_e(x) + f_o(x)$$
$$f_e(x) = \frac{f(x) + f(-x)}{2}$$
$$f_o(x) = \frac{f(x) - f(-x)}{2}$$

Methodology

- The odd and even parts of function are obtained from above equations.
- They are plotted in subplots to compare.

Code

```
clear all
clc

xRange = [-5, 5];
aspect = [2, 1, 1];
syms t f(t) fe(t) fo(t) g(t) ge(t) go(t);
```

```
f(t) = t * (t^2 + 3);
fe(t) = (f(t) + f(-t)) / 2;
fo(t) = (f(t) - f(-t)) / 2;

subplot(3, 1, 1);
fplot( matlabFunction(f), xRange, '-r');
title('f(t)', 'FontSize', 10, 'FontName', 'Times');
pbaspect(aspect);

subplot(3, 1, 2);
fplot( matlabFunction(fe), xRange, '-r');
title('Even part of f(t)', 'FontSize', 10, 'FontName', 'Times');
pbaspect(aspect);

subplot(3, 1, 3);
fplot( matlabFunction(fo), xRange, '-r');
title('Odd part of f(t)', 'FontSize', 10, 'FontName', 'Times');
pbaspect(aspect);

set(findobj(gcf, 'type', 'axes'), ...
    'Box'       ,'off'          , ...
    'TickDir'   ,'out'          , ...
    'FontSize'  ,8              , ...
    'FontName'  ,'Times'        , ...
    'XTick'     ,[-10: 10]      , ...
    'YTick'     ,[-200: 50: 200], ...
    'ylim'      ,[-150, 150]    );

print(gcf, ['3a_f(t)', '.eps'], '-depsc');


g(t) = t * (2 - t^2) * (1 + 4*t^2);
ge(t) = (g(t) + g(-t)) / 2;
go(t) = (g(t) - g(-t)) / 2;

subplot(3, 1, 1);
fplot( matlabFunction(g), xRange, '-r');
title('g(t)', 'FontSize', 10, 'FontName', 'Times');
pbaspect(aspect);

subplot(3, 1, 2);
fplot( matlabFunction(ge), xRange, '-r');
title('Even part of g(t)', 'FontSize', 10, 'FontName', 'Times');
pbaspect(aspect);

```

```
subplot(3, 1, 3);
fplot( matlabFunction(go), xRange, '-r');
title('Odd part of g(t)', 'FontSize', 10, 'FontName', 'Times');
pbaspect(aspect);

set(findobj(gcf, 'type', 'axes'), ...
    'Box'        ,'off'          , ...
    'TickDir'    ,'out'          , ...
    'FontSize'   ,8              , ...
    'FontName'   ,'Times'        , ...
    'XTick'      ,[-10: 10]      , ...
    'YTick'      ,[-200: 50: 200], ...
    'ylim'       ,[-150, 150]    );

print(gcf, ['3b_g(t)', '.eps'], '-depsc');
```

Input Description

The 2 functions are:

$$f(t) = t(t^2 + 3)$$

$$g(t) = t(2 - t^2)(1 + 4t^2)$$

The given range is $[-5, 5]$.

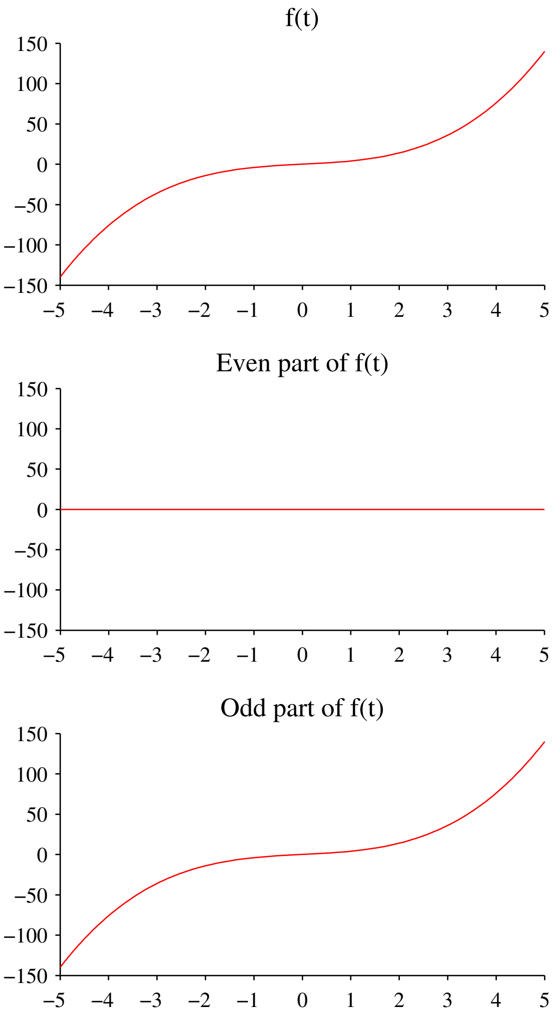

Figure 3.1: $f(t) = t \cdot (t^2 + 3)$

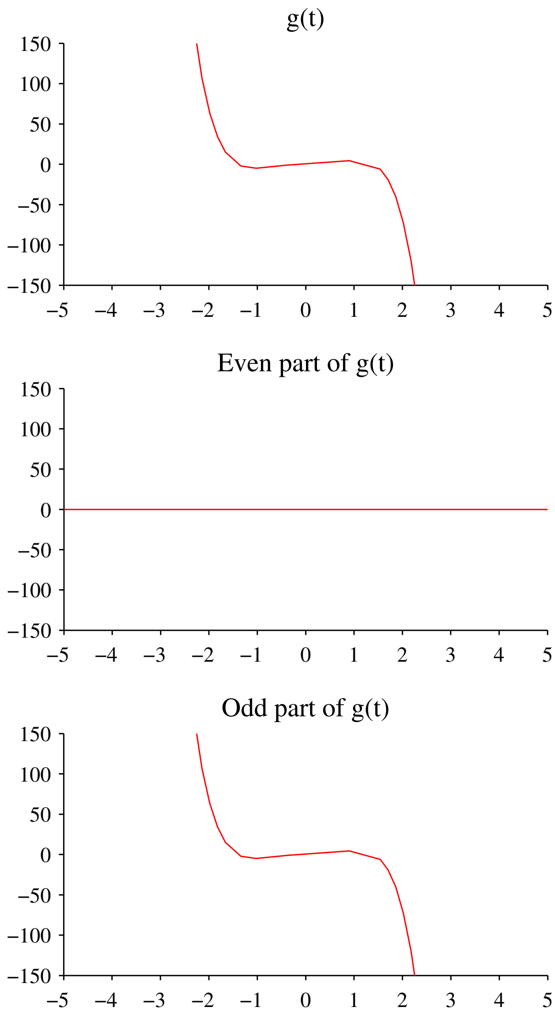

Figure 3.2: $g(t) = t \cdot (2 - t^2) \cdot (1 + 4t^2)$

Result

Discussion

Since, both f and g are pure odd functions, their even parts are 0.