



AHSANULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

DEPARTMENT
OF
ELECTRICAL AND ELECTRONIC ENGINEERING

LAB REPORT

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Exercise 1.

Integrate the function tabulated in Table 7.1 over the interval from $x=1.6$ to $x=3.8$ using composite trapezoidal rule with (a) $h=0.2$, (b) $h=0.4$ and (c) $h=0.6$

Table 7.1

X	f(x)	X	f(x)
1.6	4.953	2.8	16.445
1.8	6.050	3.0	20.086
2.0	7.389	3.2	24.533
2.2	9.025	3.4	29.964
2.4	11.023	3.6	36.598
2.6	13.468	3.8	44.701

Exercise 2.

(a) Integrate the function tabulated in Table 7.1 over the interval from $x=1.6$ to

$x=3.6$ using Simpson's composite 1/3 rule.

(b) Integrate the function tabulated in Table 7.1 over the interval from $x=1.6$ to $x=3.4$ using Simpson's composite 3/8 rule.

Exercise 3.

(a) Find (approximately) each integral given below using the composite trapezoidal rule with $n=12$.

$$(i) \int_{-1}^1 (1+x^2)^{-1} dx$$

$$(ii) \int_0^4 x^2 e^{-x} dx$$

(b) Find (approximately) each integral given above using the Simpson's composite 1/3 and 3/8 rules with $n=12$.

Exercise 4.

Evaluate the integral of xe^{-2x^2} between $x=0$ and $x=2$ using a tolerance value sufficiently small as to get an answer within 0.1% of the true answer, 0.249916 (Use adaptive integration for both Ex 4 & 5).

Exercise 5.

Evaluate the integral of $\sin^2(16x)$ between $x=0$ and $x=\pi/2$. Why the result is erroneous? How can this be solved? (The correct result is $\pi/4$)

The data in Table 7.1 are for $f(x) = e^x$. Find the true value of the integral and compare this with those found in (a), (b) and (c).

Exercise01:

The image shows the MATLAB R2021a environment. The Editor window displays a script named R07E01.m. The script defines a vector x and a function f based on the data in Table 7.1. It then calculates the integral I using the trapezoidal rule for three different step sizes h : 0.2, 0.4, and 0.6. The Command Window shows the results of these calculations, comparing them to the true value of the integral.

```

1 clc;
2 close all;
3 clear;
4
5 % Data from Table 7.1
6 x = [1.6, 1.8, 2.0, 2.2, 2.4, 2.6, 2.8, 3.0, 3.2, 3.4, 3.6, 3.8];
7 f = [4.953, 6.050, 7.389, 9.025, 11.023, 13.468, 16.445, 20.086, 24.533, 29.964];
8
9 % (a) h = 0.2 (all points)
10 idx_a = 1:length(x);
11 h1 = x(2)-x(1);
12 sum1 = f(idx_a(1)) + f(idx_a(end));
13 for i = 2:length(idx_a)-1
14     sum1 = sum1 + 2*f(idx_a(i));
15 end
16 I1 = (h1/2)*sum1;
17
18 % (b) h = 0.4 (every other point)
19 idx_b = 1:2:length(x);
20 h2 = x(idx_b(2))-x(idx_b(1));
21 sum2 = f(idx_b(1)) + f(idx_b(end));
22 for i = 2:length(idx_b)-1
23     sum2 = sum2 + 2*f(idx_b(i));
24 end
25 I2 = (h2/2)*sum2;
26

```

Exercise 1 Results:

```

(a) h = 0.2: I = 39.881600
(b) h = 0.4: I = 32.066200
(c) h = 0.6: I = 25.757100
True value: I = 39.748152
Errors: (a) 0.133448, (b) 7.681952, (c) 13.991
fx>>

```

The Command Window also shows the true value of the integral and the errors for each step size h .

```

26
27 % (c) h = 0.6 (every third point)
28 idx_c = 1:3:length(x);
29 h3 = x(idx_c(2))-x(idx_c(1));
30 sum3 = f(idx_c(1)) + f(idx_c(end));
31 for i = 2:length(idx_c)-1
32     sum3 = sum3 + 2*f(idx_c(i));
33 end
34 I3 = (h3/2)*sum3;
35
36 % True value (f(x) = e^x)
37 true_val = exp(3.8) - exp(1.6);
38
39 fprintf('Exercise 1 Results:\n');
40 fprintf('(a) h = 0.2: I = %.6f\n', I1);
41 fprintf('(b) h = 0.4: I = %.6f\n', I2);
42 fprintf('(c) h = 0.6: I = %.6f\n', I3);
43 fprintf('True value: I = %.6f\n', true_val);
44 fprintf('Errors: (a) %.6f, (b) %.6f, (c) %.6f\n', ...
45         abs(I1-true_val), abs(I2-true_val), abs(I3-true_val));
46

```

Excercise02:

The screenshot displays the MATLAB R2021a environment. The Editor window shows a script named R07E02.m with the following code:

```

1 clc;
2 close all;
3 clear;
4
5 % Data from Table 7.1
6 x = [1.6, 1.8, 2.0, 2.2, 2.4, 2.6, 2.8, 3.0, 3.2, 3.4, 3.6, 3.8];
7 f = [4.953, 6.050, 7.389, 9.025, 11.023, 13.468, 16.445, 20.086, 24.533, 29.964];
8
9 idx_13 = 1:11;
10 x13 = x(idx_13);
11 y13 = f(idx_13);
12 h13 = x13(2) - x13(1);
13 n13 = length(x13);
14
15 sum13 = 0;
16 for i = 1:n13
17     if i==1 || i==n13
18         sum13 = sum13 + y13(i);
19     elseif mod(i,2)==0
20         sum13 = sum13 + 4*y13(i);
21     else
22         sum13 = sum13 + 2*y13(i);
23     end
24 end
25 I_simp13 = (h13/3) * sum13;
26

```

The Command Window displays the results of the script:

```

Exercise 2 Results:
(a) Simpson 1/3 rule (x=1.6 to 3.6): I = 31.64
(b) Simpson 3/8 rule (x=1.6 to 3.4): I = 25.01
fx>>

```

The interface also shows the Current Folder on the left with various files, and the Windows taskbar at the bottom with the date 9/23/2025 and time 10:42 PM.

```

26
27 -   idx_38 = 1:10;
28 -   x38 = x(idx_38);
29 -   y38 = f(idx_38);
30 -   h38 = x38(2) - x38(1);
31 -   n38 = length(x38);
32
33 -   sum38 = y38(1) + y38(end);
34 -   for i = 2:n38-1
35 -       if mod(i-1,3)==0
36 -           sum38 = sum38 + 2*y38(i);
37 -       else
38 -           sum38 = sum38 + 3*y38(i);
39 -       end
40 -   end
41 -   I_simp38 = (3*h38/8) * sum38;
42
43 -   fprintf('Exercise 2 Results:\n');
44 -   fprintf('(a) Simpson 1/3 rule (x=1.6 to 3.6): I = %.6f\n', I_simp13);
45 -   fprintf('(b) Simpson 3/8 rule (x=1.6 to 3.4): I = %.6f\n', I_simp38);

```

Exercise 03:

The image shows the MATLAB R2021a interface with a script editor, workspace, and command window. The script implements numerical integration for two functions: $f_1(x) = \frac{1}{1+x^2}$ and $f_2(x) = x^2 e^{-x}$.

Script Editor (R07E03.m):

```

1 - clc;
2 - close all;
3 - clear;
4 - n = 12;
5 - f1 = @(x) 1./(1 + x.^2);
6 - f2 = @(x) x.^2 .* exp(-x);
7 - % (i) f from -1 to 1
8 - a1 = -1; b1 = 1;
9 - h1 = (b1 - a1)/n;
10 - sum1 = f1(a1) + f1(b1);
11 - for i = 1:n-1
12 -     sum1 = sum1 + 2*f1(a1 + i*h1);
13 - end
14 - I_trap1 = (h1/2)*sum1;
15
16 - % (ii) f from 0 to 4
17 - a2 = 0; b2 = 4;
18 - h2 = (b2 - a2)/n;
19 - sum2 = f2(a2) + f2(b2);
20 - for i = 1:n-1
21 -     sum2 = sum2 + 2*f2(a2 + i*h2);
22 - end
23 - I_trap2 = (h2/2)*sum2;
24
25 - % (b) Simpson's 1/3 Rule
26 - % (i) f from -1 to 1
27 - sum13_1 = 0;

```

Workspace:

- Trapezoidal Rule:**
 - (i) $\int_{-1}^1 (1+x^2)^{-1} dx$ from -1 to 1: 1.568482
 - (ii) $\int_0^4 x^2 e^{-x} dx$ from 0 to 4: 1.522334
- Simpson 1/3 Rule:**
 - (i) $\int_{-1}^1 (1+x^2)^{-1} dx$ from -1 to 1: 1.570796
 - (ii) $\int_0^4 x^2 e^{-x} dx$ from 0 to 4: 1.524190
- Simpson 3/8 Rule:**
 - (i) $\int_{-1}^1 (1+x^2)^{-1} dx$ from -1 to 1: 1.570792
 - (ii) $\int_0^4 x^2 e^{-x} dx$ from 0 to 4: 1.524647

Command Window:

```

fx>>

```

The interface also shows a file explorer on the left with various MATLAB files and a taskbar at the bottom with system icons and the date/time (10:52 PM 9/23/2025).

```

25 % (b) Simpson's 1/3 Rule
26 % (i)  $\int$  from -1 to 1
27 - sum13_1 = 0;
28 - x1 = a1:h1:b1;
29 - fx1 = f1(x1);
30 - m1 = length(x1);
31 - for i = 1:m1
32 -     if i==1 || i==m1
33 -         sum13_1 = sum13_1 + fx1(i);
34 -     elseif mod(i,2)==0
35 -         sum13_1 = sum13_1 + 4*fx1(i);
36 -     else
37 -         sum13_1 = sum13_1 + 2*fx1(i);
38 -     end
39 - end
40 - I_simp1_13 = (h1/3)*sum13_1;
41
42 % (ii)  $\int$  from 0 to 4
43 - sum13_2 = 0;
44 - x2 = a2:h2:b2;
45 - fx2 = f2(x2);
46 - m2 = length(x2);
47 - for i = 1:m2
48 -     if i==1 || i==m2
49 -         sum13_2 = sum13_2 + fx2(i);
50 -     elseif mod(i,2)==0

```

```

50 -         elseif mod(i,2)==0
51 -             sum13_2 = sum13_2 + 4*fx2(i);
52 -         else
53 -             sum13_2 = sum13_2 + 2*fx2(i);
54 -         end
55 -     end
56 -     I_simp2_13 = (h2/3)*sum13_2;
57 -
58 -     % (c) Simpson's 3/8 Rule
59 -     % (i)  $\int$  from -1 to 1
60 -     sum38_1 = f1(a1) + f1(b1);
61 -     for i = 1:n-1
62 -         xi = a1 + i*h1;
63 -         if mod(i,3)==0
64 -             sum38_1 = sum38_1 + 2*f1(xi);
65 -         else
66 -             sum38_1 = sum38_1 + 3*f1(xi);
67 -         end
68 -     end
69 -     I_simp1_38 = (3*h1/8)*sum38_1;
70 -
71 -     % (ii)  $\int$  from 0 to 4
72 -     sum38_2 = f2(a2) + f2(b2);
73 -     for i = 1:n-1
74 -         xi = a2 + i*h2;
75 -         if mod(i,3)==0
76 -             sum38_2 = sum38_2 + 2*f2(xi);
77 -
78 -             sum38_2 = sum38_2 + 2*f2(xi);
79 -         else
80 -             sum38_2 = sum38_2 + 3*f2(xi);
81 -         end
82 -     end
83 -     I_simp2_38 = (3*h2/8)*sum38_2;
84 -     %Results
85 -
86 -     fprintf('Trapezoidal Rule:\n');
87 -     fprintf('(i)  $\int (1+x^2)^{-1} dx$  from -1 to 1: %.6f\n', I_trap1);
88 -     fprintf('(ii)  $\int x^2 e^{-x} dx$  from 0 to 4: %.6f\n\n', I_trap2);
89 -
90 -     fprintf('Simpson 1/3 Rule:\n');
91 -     fprintf('(i)  $\int (1+x^2)^{-1} dx$  from -1 to 1: %.6f\n', I_simp1_13);
92 -     fprintf('(ii)  $\int x^2 e^{-x} dx$  from 0 to 4: %.6f\n\n', I_simp2_13);
93 -
94 -     fprintf('Simpson 3/8 Rule:\n');
95 -     fprintf('(i)  $\int (1+x^2)^{-1} dx$  from -1 to 1: %.6f\n', I_simp1_38);
96 -     fprintf('(ii)  $\int x^2 e^{-x} dx$  from 0 to 4: %.6f\n\n', I_simp2_38);

```

Exercise 04:

The image shows the MATLAB R2021a interface with the following components:

- Editor:** Contains a script for Exercise 4. The script calculates the integral of $x \cdot \exp(-2x^2)$ from 0 to 2 using the trapezoidal rule with a small step size $h=0.001$. The results are displayed in the Command Window.
- Command Window:** Displays the results of the calculation: "Exercise 4 Results:", "Trapezoidal (small h) result: 0.249916", "True value: 0.249916", and "Error: 0.000000 (0.0000%)".
- Current Folder:** Lists files in the current folder, including R07E01.m through R07E04.m, R05E01.m through R05E04.m, R04E01.m through R04E05.m, R03E01.m through R03E02.m, R02E01.m through R02E05.m, R01E01.m through R01E05.m, nonlinear.m, and Labtest.m.
- Workspace:** Shows the variables defined in the script: `clc`, `close all`, `clear`, `f`, `a`, `b`, `h`, `x`, `n`, `sum_val`, `I`, and `true_val`.
- Command Window:** Displays the results of the calculation: "Exercise 4 Results:", "Trapezoidal (small h) result: 0.249916", "True value: 0.249916", and "Error: 0.000000 (0.0000%)".

```
1 clc;
2 close all;
3 clear;
4 f = @(x) x .* exp(-2*x.^2);
5 a = 0;
6 b = 2;
7 h = 0.001;
8 x = a:h:b;
9 n = length(x);
10 sum_val = 0;
11 for i = 1:n
12     if (i==1 || i==n)
13         sum_val = sum_val + f(x(i));
14     else
15         sum_val = sum_val + 2*f(x(i));
16     end
17 end
18
19 I = (h/2) * sum_val;
20 true_val = 0.249916;
21
22 fprintf('Exercise 4 Results:\n');
23 fprintf('Trapezoidal (small h) result: %.6f\n', I);
24 fprintf('True value: %.6f\n', true_val);
25 fprintf('Error: %.6f (%.4f%%)\n', abs(I-true_val), abs(I-true_val)/true_val*100);
26
```


Exercise 05:

The image shows the MATLAB R2021a environment. The Editor window displays a script for Exercise 5, which implements the Trapezoidal Rule for numerical integration. The script calculates the integral of $f(x) = \sin(16x)^2$ from $a=0$ to $b=\pi/2$ using a step size $h=0.0001$. It compares the result with the true value $\pi/4$ and calculates the error.

```
1 clc;
2 close all;
3 clear;
4 f = @(x) (sin(16*x)).^2;
5 a = 0;
6 b = pi/2;
7 h = 0.0001;
8 x = a:h:b;
9 n = length(x);
10 sum_val = 0;
11 for i = 1:n
12     if (i==1 || i==n)
13         sum_val = sum_val + f(x(i));
14     else
15         sum_val = sum_val + 2*f(x(i));
16     end
17 end
18 I = (h/2) * sum_val;
19 % True value
20 true_val = pi/4;
21
22 fprintf('Exercise 5 Results:\n');
23 fprintf('Trapezoidal Rule result: %.6f\n', I);
24 fprintf('True value (n/4): %.6f\n', true_val);
25 fprintf('Error: %.6f (%.4f%%)\n', abs(I-true_val), abs(I-true_val)/true_val*100);
26
```

The Command Window displays the results of the script execution:

```
Exercise 5 Results:
Trapezoidal Rule result: 0.785398
True value (n/4): 0.785398
Error: 0.000000 (0.0000%)
fx >>
```

The interface also shows a file explorer on the left with various MATLAB files and a taskbar at the bottom with system icons and the date/time (11:06 PM, 9/23/2025).