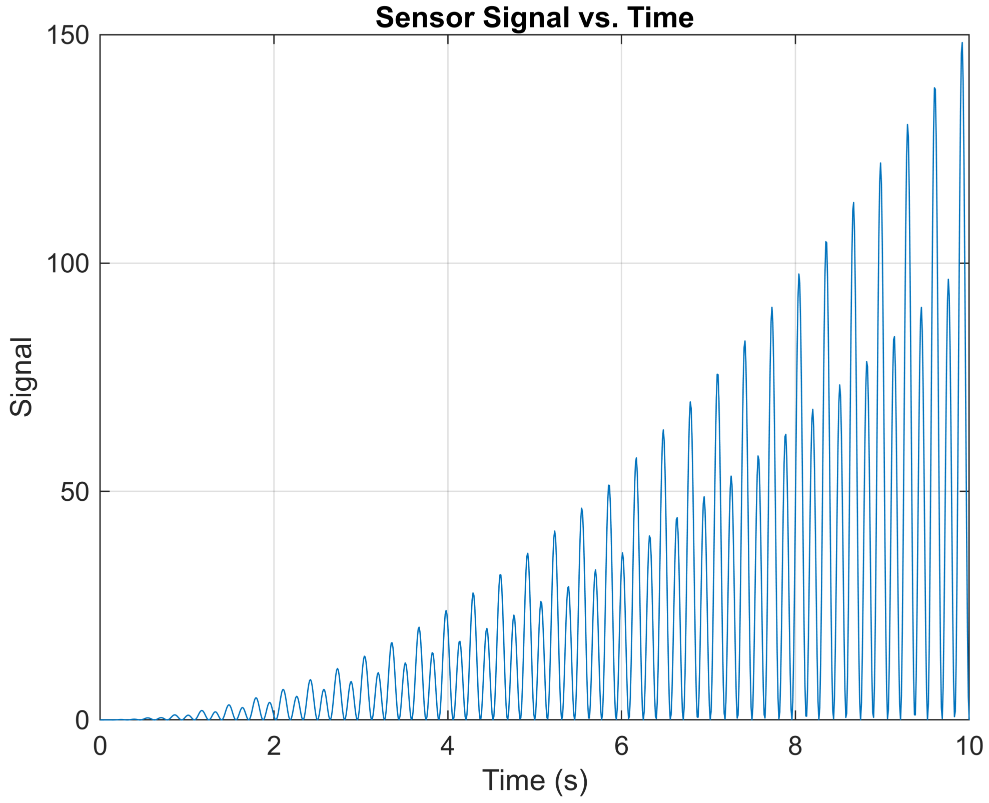
Question 1

```
%a
f = 1.6;
t = 0:0.01:10;

signal = 5*t.^2 .* cos(2*pi*f*t + 0.1).^2 .* sin(2*pi*f*t).^2;

figure;
plot(t, signal);
xlabel('Time (s)');
ylabel('Signal');
title('Sensor Signal vs. Time');
grid on;
```



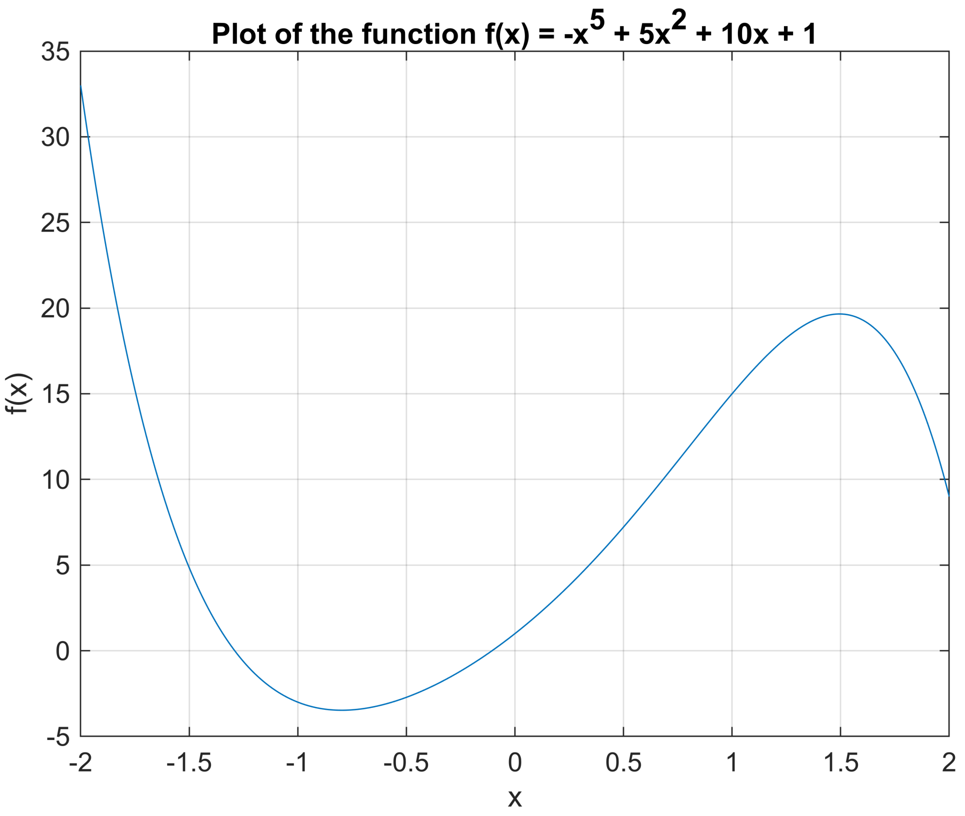
```


%b
a = 6.5;
b = 6.9;
epsilon = 1e-5;

phi = (1 + sqrt(5)) / 2;

func = @(t) 5*t.^2 .* cos(2*pi*f*t + 0.1).^2 .* sin(2*pi*f*t).^2;

while (b - a) > epsilon
```

```
    c = b - (b - a) / phi;
    d = a + (b - a) / phi;

    if func(c) < func(d)
        b = d;
    else
        a = c;
    end
end


t_opt = (a + b) / 2;
min_val = func(t_opt);

fprintf('The minimum of the function within the given range occurs at t = %.5f seconds, with a
```

```
The minimum of the function within the given range occurs at t = 6.70880 seconds, with a value of 0.00000.
```

Question 2

```
%a
f = @(x) -x.^5 + 5*x.^2 + 10*x + 1;

x = linspace(-2, 2, 400);
y = f(x);

figure;
plot(x, y)
xlabel('x')
ylabel('f(x)')
title('Plot of the function f(x) = -x^5 + 5x^2 + 10x + 1')
grid on
```



```
%b
df = @(x) -5*x.^4 + 10*x + 10;

x_eval = -1.5;
derivative_value = df(x_eval);
disp(['The derivative at x = -1.5 is: ', num2str(derivative_value)])
```

```
The derivative at x = -1.5 is: -30.3125
```

```
%c
x_start = -1.5;
h = 0.1;

if f(x_start + h) < f(x_start)
    direction = 1;
else
    direction = -1;
end

x1 = x_start + direction * h;
x2 = x_start + direction * 2 * h;
f1 = f(x1);
f2 = f(x2);
```

```
disp(['Point 1: x = ', num2str(x1), ', f(x) = ', num2str(f1)]);
```

```
Point 1: x = -1.4, f(x) = 2.1782
```

```
disp(['Point 2: x = ', num2str(x2), ', f(x) = ', num2str(f2)]);
```

```
Point 2: x = -1.3, f(x) = 0.16293
```

```


%d
x = -1.5;
h = 0.1;
f_current = f(x);

while true
    x_left = x - h;
    x_right = x + h;
    f_left = f(x_left);
    f_right = f(x_right);

    if f_left > f_current && f_current < f_right
        break;
    else
        h = 2 * h;
        if f_left < f_current
            x = x_left;
        else
            x = x_right;
        end
        f_current = f(x);
    end
end

x1 = x - h;
x2 = x;
x3 = x + h;
disp(['Unimodal interval points and their function values:']);
```

```
Unimodal interval points and their function values:
```

```
disp(['x1 = ', num2str(x1), ', f(x1) = ', num2str(f(x1))]);
```

```
x1 = -1.6, f(x1) = 8.2858
```

```
disp(['x2 = ', num2str(x2), ', f(x2) = ', num2str(f(x2))]);
```

```
x2 = -0.8, f(x2) = -3.4723
```

```
disp(['x3 = ', num2str(x3), ', f(x3) = ', num2str(f(x3))]);
```

```
x3 = 1.1102e-16, f(x3) = 1
```

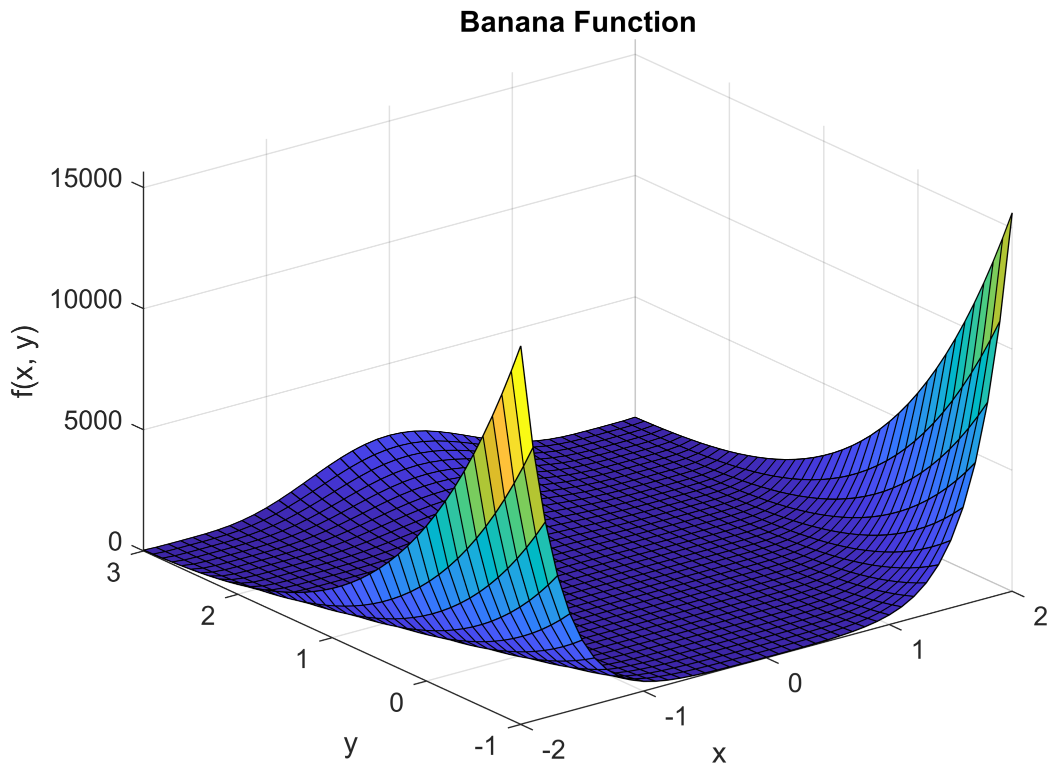
```


%BONUS
```

```
syms x_sym;

Lagrange_poly = ((x_sym - x2) * (x_sym - x3) / ((x1 - x2) * (x1 - x3))) * f(x1) + ...
                ((x_sym - x1) * (x_sym - x3) / ((x2 - x1) * (x2 - x3))) * f(x2) + ...
                ((x_sym - x1) * (x_sym - x2) / ((x3 - x1) * (x3 - x2))) * f(x3);

min_Lagrange = min(Lagrange_poly);
min_x_Lagrange = vpasolve(diff(Lagrange_poly) == 0, x_sym);

disp(['x value at the minimum: ', char(min_x_Lagrange)]);
```

```
x value at the minimum: -0.62044164037854884380809852421695
```

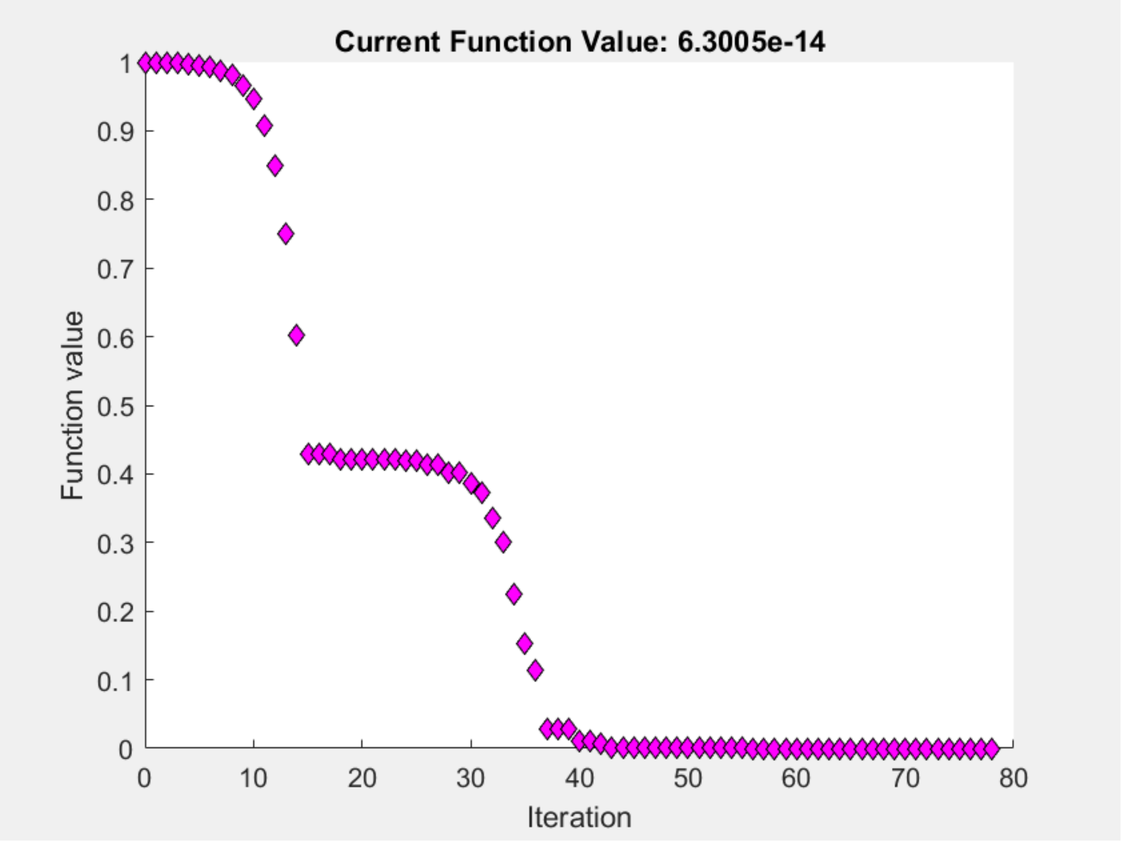
Question 3

```
%a
bananaFunc = @(x) 25*(x(2) - x(1)^2)^4 + (1 - x(1))^2;
[X, Y] = meshgrid(-2:0.1:2, -1:0.1:3);
Z = 25*(Y - X.^2).^4 + (1 - X).^2;

surf(X, Y, Z)
xlabel('x')
ylabel('y')
zlabel('f(x, y)')
title('Banana Function')
```



```
options = optimset('Display', 'iter', 'PlotFcns', @optimplotfval);
[xMin, fValMin, exitflag, output] = fminsearch(bananaFunc, [0, 0], options);
```

```
 Iteration   Func-count     min f(x)         Procedure
     0            1                1         
     1            3           0.9995         initial simplex
     2            4           0.9995         reflect
     3            6         0.998501         expand
     4            8         0.998001         expand
     5           10         0.995755         expand
     6           12         0.993635         expand
     7           14         0.988098         expand
     8           16         0.981121         expand
     9           18         0.966673         expand
    10           20         0.945764         expand
    11           22          0.90729         expand
    12           24         0.848504         expand
    13           26         0.749123         expand
    14           28         0.601775         expand
    15           30         0.428136         expand
    16           31         0.428136         reflect
    17           33         0.428136         contract inside
    18           35         0.421275         contract inside
    19           37         0.421275         contract inside
    20           39         0.421275         contract outside
    21           41         0.421275         contract inside
    22           43         0.421275         contract inside
    23           45         0.420845         reflect
    24           47         0.419062         expand
    25           49         0.418383         expand
    26           51         0.413072         expand
    27           52         0.413072         reflect
    28           54         0.402566         expand
    29           55         0.402566         reflect
    30           57         0.385237         expand
    31           59         0.373301         expand
    32           61         0.335074         expand
    33           63         0.300331         expand
    34           65         0.225436         expand
    35           67          0.15207         expand
    36           69         0.113666         reflect
    37           71        0.0278181         expand
    38           72        0.0278181         reflect
    39           74        0.0278181         contract outside
    40           76        0.0105912         reflect
    41           78        0.0105912         contract inside
    42           80        0.0071003         reflect
    43           82       0.00154907         expand
    44           83       0.00154907         reflect
    45           85       0.00040362         reflect
    46           87      0.000235605         contract inside
    47           89       0.00017051         contract inside
    48           91       4.7361e-05         contract inside
    49           93      3.48543e-05         contract inside
    50           95      1.24605e-05         contract inside
    51           96      1.24605e-05         reflect
    52           98      1.29998e-06         contract inside
    53           99      1.29998e-06         reflect
    54          101      1.29998e-06         contract inside
    55          103      5.99782e-07         contract outside
    56          105      2.07245e-07         contract inside
    57          107      8.84787e-08         contract inside
    58          109       4.49012e-08         contract outside
    59          111        1.0733e-08         contract inside
    60          113       6.37404e-09         contract outside
    61          115       4.31216e-09         contract inside
    62          117       2.64266e-09         contract inside
    63          119       1.66144e-09         contract outside
    64          121        9.2439e-10         contract inside
    65          123       8.21114e-11         contract inside
    66          124       8.21114e-11         reflect
    67          126       8.21114e-11         contract inside
    68          128       8.21114e-11         contract outside
    69          130       4.19939e-11         reflect
    70          132       9.17454e-12         contract inside
    71          134       7.97506e-12         reflect
    72          136       6.27893e-12         contract inside
    73          138       3.81396e-13         reflect
    74          140       3.81396e-13         contract inside
    75          142       3.81396e-13         contract outside
    76          144       3.55441e-13         contract inside
    77          146       1.33135e-13         contract outside
    78          148        6.3005e-14         contract inside
```



```
Optimization terminated:
 the current x satisfies the termination criteria using OPTIONS.TolX of 1.000000e-04
 and F(X) satisfies the convergence criteria using OPTIONS.TolFun of 1.000000e-04
```

```
%b
disp(['Minimum location: (', num2str(xMin(1)), ', ', num2str(xMin(2)), ')']);
```

```
Minimum location: (1, 1)
```

```
disp(['Function value at minimum: ', num2str(fValMin)]);
```

```
Function value at minimum: 6.3005e-14
```

```
%c
disp(['Total number of function evaluations: ', num2str(output.funcCount)]);
```

```
Total number of function evaluations: 148
```

```
disp(['Total number of iterations: ', num2str(output.iterations)]);
```

```
Total number of iterations: 78
```

```
%d
disp('Total number of each simplex maneuver (reflect, contract inside, contract outside, expand
```

```
Total number of each simplex maneuver (reflect, contract inside, contract outside, expand or shrink): 17,26,9,24,0
```