Exercise 5

Problem 1

a)

```
clc
close all
clear all

% a)
options = optimset('Display', 'off');
A = [];
b = [];
Aeq = [];
beq = [];
nonlcon = [];
lb = [0,0];
ub = [1,1];

fun = @(x)-(sin(4*pi*x(1))^4)*(sin(5*pi*x(2))^2)*(2-x(1))*(2-x(2));
% Iterates to give give different starting points
maxAltitude = 0;
for x1 = 0:0.1:1
    for x2 = 0:0.1:1
        x0 = [x1; x2];
        %x = fmincon(fun,x0,A,b,Aeq,beq,lb,ub);
        [X,Z,exitflag] = fmincon(fun,x0,A,b,Aeq,beq,lb,ub,nonlcon,options);
        if exitflag == 1 && (-Z > maxAltitude)
            maxAltitude = -Z;
            Xopt_quadratic = X;
        end
    end
end
```

Then the optimal for a rectangular constraint is:

```
Xopt_quadratic
```

```
Xopt_quadratic = 2×1
    0.3740
    0.2988
```

b)

```
clc
close all
clear all

options = optimset('Display', 'off');
```

```
A = [];
b = [];
Aeq = [];
beq = [];
nonlcon = @circlecon;
lb = [];
ub = [];

fun = @(x)-(sin(4*pi*x(1))^4)*(sin(5*pi*x(2))^2)*(2-x(1))*(2-x(2));
% Iterates to give give different starting points
maxAltitude = 0;
for x1 = 0:0.1:1
    for x2 = 0:0.1:1
        x0 = [x1; x2];
        %x = fmincon(fun,x0,A,b,Aeq,beq,lb,ub);
        [X,Z,exitflag] = fmincon(fun,x0,A,b,Aeq,beq,lb,ub,nonlcon,options);
        if exitflag == 1 && (-Z > maxAltitude)
            maxAltitude = -Z;
            Xopt_circular = X;
        end
    end
end
```

Then the optimal for a circular constraint is:

```
Xopt_circular
```

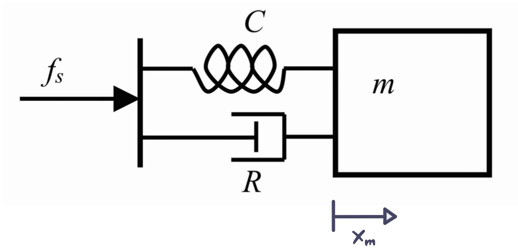
```
Xopt_circular = 2×1
    0.1242
    0.2988
```

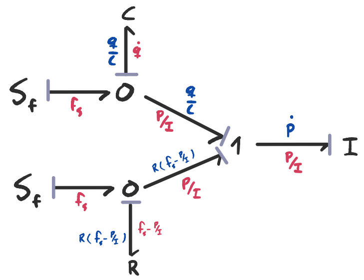
Additional functions

@cirlecon

```
function [c,ceq] = circlecon(x)
c = (x(1)-0.5)^2 + (x(2)-0.5)^2 - (0.5)^2;
ceq = [];
end
```

Problem 2





$$\Rightarrow \begin{bmatrix} \dot{p} \\ \dot{q} \end{bmatrix} = \begin{bmatrix} R(f_s - \frac{p}{I}) + \frac{q}{C} \\ f_s - \frac{p}{I} \end{bmatrix}$$

We need the mass position X_M:

$$\dot{X}_m = P/I$$

$$\Rightarrow \begin{bmatrix} \dot{X}_m \\ \dot{p} \\ \dot{q} \end{bmatrix} = \begin{bmatrix} P/I \\ R(f_s - \frac{p}{I}) + \frac{q}{C} \\ f_s - \frac{p}{I} \end{bmatrix}$$

Functions

@odefun

```
function dydt = odefun(t, y, R, C)
    % Extract variables from the y vector
    xm = y(1);
    p = y(2);
    q = y(3);

    T = 0:pi/30:12*pi;
    fs = interp1(T,cos(T),t,'nearest');

    m = 0.3;
    I = m;

    % Define the system of ODEs
    xmdot = p/I;
    pdot  = R*(fs-p/I)+q/C;
    qdot  = fs-p/I;

    % Pack the derivatives into a column vector
    dydt = [xmdot; pdot; qdot];
end
```

@costfunction

```
function cost= costfunction(x)
R = x(1);
```

```
C = x(2);
[~,y] =ode45(@(t, y) odefun(t, y, R, C),[0 10*pi],[0 0 1]);
[t,y] =ode45(@(t, y) odefun(t, y, R, C),[10*pi:0.1:12*pi],y(end,:));
cost = sum(abs(y(:,1)-cos(t)));
end
```

Then the simultion goes as follows

```
clc
close all
clear all

costFunc = @(x)costfunction(x);

A = [];
b = [];
Aeq = [];
beq = [];
nonlcon = [];
lb = [0,0];
ub = [500,1];
x0 = (lb + ub)/2;

[Xopt,cost,exitflag] = fmincon(costFunc,x0,A,b,Aeq,beq,lb,ub);
```

```
Local minimum possible. Constraints satisfied.

fmincon stopped because the size of the current step is less than
the value of the step size tolerance and constraints are
satisfied to within the value of the constraint tolerance.

<stopping criteria details>
```

```
R_opt = Xopt(1);
C_opt = Xopt(2);

%Plot
[t1,y1] =ode45(@(t, y) odefun(t, y, R_opt, C_opt),[0 10*pi],[0 0 1]);
[t2,y2] =ode45(@(t, y) odefun(t, y, R_opt, C_opt),[10*pi:0.1:12*pi],y1(end,:));


t12 = vertcat(t1,t2);
y12 = vertcat(y1(:,1),y2(:,1));

T = 0:0.1:12*pi;
cosinus = cos(T);
```

Where the optimal results for R and C are

```
R_opt
```

```
R_opt = 249.7842
```

```
C_opt
```

```
C_opt = 0.8794
```

Plot with the respective variables

```
plot(t12,y12,T,cosinus)
grid on
legend('Mass','Cosinus curve')
title(['Mass position as a function of time for R =' ...
    num2str(R_opt),', C = ' num2str(C_opt)])
xlabel('Time [s]')
ylabel('Position [m]')
```