Exercise 2

a)

Found out that spline interpolation gives the best graph.

```
close all
clear all
clc

motor = [0, 400, 800, 1200, 1600, 1763;
         8, 8.5, 9.0, 9.90, 7.15, 0];

fan   = [0, 400, 800, 1200;
         2, 3.8, 7.5, 14];

interpolation_type = 'spline';

graphSpeed = linspace(0,1800,1801);

MotorTorque = interp1(motor(1,:),motor(2,:),graphSpeed,interpolation_type);
FanTorque   = interp1(fan(1,:),fan(2,:),graphSpeed,interpolation_type);
```

The speed (in RPM) that gives the maximum allowed power, is the speed that gives

$T_{motor} = 4.0\ [in \cdot lb]$

We find interception between the motor torque curve and the straight line $T(v) = 4$.

```
[MaxAllowedMotorSpeed, MaxAllowedMotorTorque] = interception(graphSpeed,MotorTorque,graphSpeed,
```

```
MaxAllowedMotorSpeed = 1.6870e+03
MaxAllowedMotorTorque = 4.0000
```

This gives max allowed Power [lb in rpm]

```
MaxAllowedPower = MaxAllowedMotorSpeed*MaxAllowedMotorTorque
```

```
MaxAllowedPower = 6.7479e+03
```

b)

Power is conserved in the system, so we need to find a set of torque and speed for the fan that matches the power output from the motor

```
PowerFan = FanTorque .* graphSpeed;
[MaxAllowedFanSpeed,~] = interception(graphSpeed,PowerFan,[0 1800],[MaxAllowedPower MaxAllowedP
```

```
MaxAllowedFanSpeed = 841.0620
```

```
[~,MaxAllowedFanTorque] = interception(graphSpeed, FanTorque,[MaxAllowedFanSpeed MaxAllowedFanS
```

```
MaxAllowedFanTorque = 8.0231
```

Ratio for the motor and fan can be found by

$$i = \frac{D_m}{D_f} = \frac{\omega_f}{\omega_m} = \frac{P\,T_m}{P\,T_f} = \frac{T_m}{T_f}$$

```
beltRatio = MaxAllowedMotorTorque/MaxAllowedFanTorque
```

```
beltRatio = 0.4986
```

c)

Newtons second law of

$$\sum T = \frac{d}{dt}\left(I \cdot \omega\right)$$

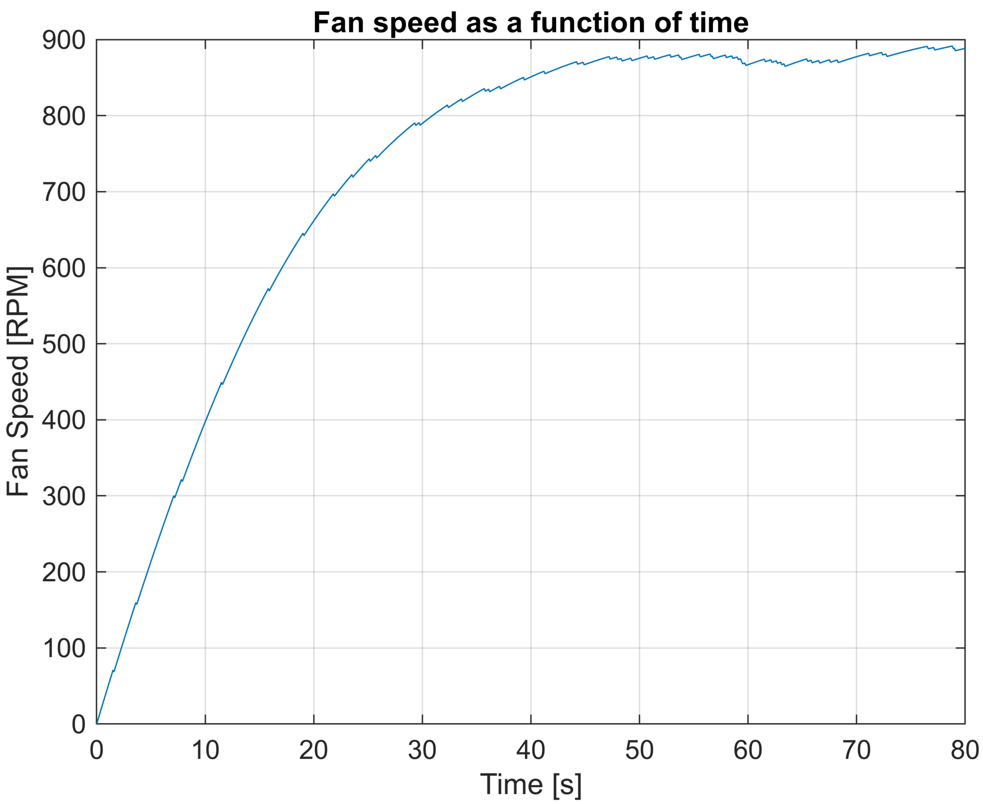
$$T_m - T_f = \frac{d}{dt}\left(I \cdot \omega\right)$$

Timediscretizisation using an explicit forward euler scheme.

$$\omega^{n+1} = \omega^n + \frac{T_m - T_f}{I} \cdot \Delta t$$

```
I = 1.2;
tmax = 80;
dt = 0.1;
tol = 0.001;
omegaFan = 0;
PowerMotor = graphSpeed.*MotorTorque;

i = 0;
tVector = zeros(1,ceil(tmax/dt));
omegaVector = zeros(1,ceil(tmax/dt));

for t = 0:dt:tmax
    i = i + 1;
    [~, Tf] = interception(graphSpeed, FanTorque,[omegaFan omegaFan+0.001],[0 20]);
    ConstantPower = omegaFan*Tf;
    [omegaMotor, ~] = interception(graphSpeed, PowerMotor,[0 1800], [ConstantPower ConstantPowe
    [~, Tm] = interception(graphSpeed, MotorTorque,[omegaMotor omegaMotor+0.001], [0 20]);
    omegaFan_new = omegaFan+((Tm-Tf)/I*dt)*60/(2*pi); % converting the additve term to rpm fron
    %disp(" time[s] = "+num2str(t)+" omega_fan = "+num2str(omegaFan_new))
    tVector(i) = t;
    omegaVector(i) = omegaFan;
    omegaFan = omegaFan_new;
    switch i
        case {1,2,3,4,5,6}
        otherwise
            avg = 1/5*(omegaVector(i-5)+omegaVector(i-4)+omegaVector(i-3)+omegaVector(i-2)+omeg
            if abs(avg-omegaFan)<tol
```

```
                break
            end
    end
end

tVectorSliced = tVector(1:i);
omegaVectorSliced = omegaVector(1:i);

plot(tVectorSliced,omegaVectorSliced)
grid on
title('Fan speed as a function of time')
xlabel('Time [s]')
ylabel('Fan Speed [RPM]')
```



Ble litt vanskelig med stopping kriteriet når grafen ble veldig veldig ruglete

Functions

Interception(x1,y1,x2,y2)

Find the interception point of two graphs on vector form.

```
function [xcross,ycross] = interception(x1,y1,x2,y2)
% Find intersections between two arrays y1 and y2
```

```
xstart = max(x1(1),x2(1));
xstop  = min(x1(end),x2(end));
x      = linspace(xstart,xstop,(xstop-xstart)*1000 + 1);
y1_int = interp1(x1,y1,x,'linear');
y2_int = interp1(x2,y2,x,'linear');

diff_vec = abs(y2_int-y1_int);
minDiff  = min(diff_vec);
minIndex = find(diff_vec == minDiff);
xcross = x(minIndex);
ycross = y1_int(minIndex);
end
```