C:\Users\osteb\OneDrive - Aarhus universitet\Kandidat\10 semester\Control and sensor tech\Homeworks\SensorHW\HW7\HW7

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Group number
3

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[1]:
```python
import numpy as np
from scipy.optimize import minimize
import scipy.signal as si
import sympy as sp
import control as ct
from typing import List
from sympy.plotting import plot
import matplotlib.pyplot as plt
from IPython.display import display, Latex, Math, Image
%matplotlib inline

def eq_disp(varstring, expr, unit=""):
    display(Latex(f"${varstring}={sp.latex(expr)} \: {unit}$"))

def reduce_feedback(G_fwd, G_bwd):
    """Assumes feedback is deducted from signal, if not
    change sign of feedback"""
    return sp.simplify(G_fwd/(1+G_fwd*G_bwd))
```

0.1 Problem 1

[2]:
```python
P, L, h, E, I, X, Vi, F=sp.symbols('P, L, h, E, I, X, V_i, F')
eps1 = P*(L+X)*h/(2*E*I)
eps2 = P*L*h/(2*E*I)
eps3 = P*(L+X)*-h/(2*E*I)
eps4 = P*L*-h/(2*E*I)
```

```
Vo = (1/4*F*(eps3-eps4+eps2-eps1)*Vi).simplify()
eq_disp("V_o", Vo)
```

$V_o = -\frac{0.25FPV_iXh}{EI}$

L doesnt have an influence on the measured strain. This setup measures strain at the clamp as if P was applied at distance X instead of L. the advantage of the system is that it doesnt matter where the load is applied - (the value of L doesnt matter)

0.2 Problem 2

[3]:
```
d = 0.25
A = d**2/4*np.pi
R = 120
dR = 0.01
F = 500
E = 30*10**6
```

We can calulate the axial stress. The stress is proportional to the strain through the youngs modulus so we can find strain

[4]:
```
sigma = F/A
axial_strain = sigma/E
```

Now by the definition of the Gauge factor we calculate it

[16]:
```
GF = dR/R/axial_strain
eq_disp("GF", GF)
```

$GF = 0.0445110441696305$

0.3 Problem 3

[6]:
```
E = 200
d = 10
F = 50
A = d**2/4*np.pi
GF = 2.115
R = 120
```

Stress in the bar is:

[7]:
```
sigma = F/A
eq_disp('\sigma',round(sigma,5), "GPa")
```

$\sigma = 0.63662\,GPa$

Strain is:

[8]:
```
strain = sigma/E
```

From the definition of gauge factor we find ΔR

[9]:
```
dR = GF*strain*R
eq_disp("\Delta R", round(dR,5))
```

$\Delta R = 0.80787$

For a One-Gauge bridge measurement the ouput voltage is

[10]:
```
Vo = 1/4*dR/R*Vi
eq_disp("V_{out}",sp.N(Vo,5))
```

$V_{out} = 0.0016831V_i$

0.4 Problem 4

[11]:
```
GF = 3
R = 1000
L = 100   #mm
t = 20   #mm
w = 40   #mm
A = t*w
E = 73.1
```

0.4.1 1)

[12]:
```
F = 1*9.82/1000 #kN
I = w*t**3/12
```

Assuming the strain gauge is mounted at the fixed end and assuming the load is applied as a transverse load the strain will be

[13]:
```
strain = F*(L)*t/(2*E*I)
```

The additional resistance can now be calculated from the gauge factor

[14]:
```
dR = GF*strain*R
eq_disp("R", round(dR+R,5))
```

$R = 1000.01511$

0.4.2 2)

The voltage between the terminals is calculated from the strain

[15]:
```
Vin = 5
Vout = 1/4*GF*strain*Vin
eq_disp("V_{out}", round(Vout,10), "V")
```

$V_{out} = 1.88911 \cdot 10^{-5}\ V$