Machine Design Homework 2

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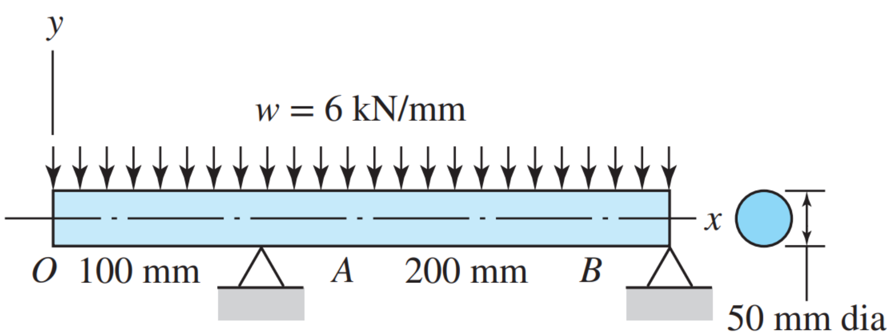
[1]:
```python
# Notebook Preamble
import sympy as sp
import numpy as np
import matplotlib.pyplot as plt
from IPython.display import display, Markdown

plt.style.use('maroon_ipynb.mplstyle')
```

Contents

1 Problem 3-39

1.1 Given

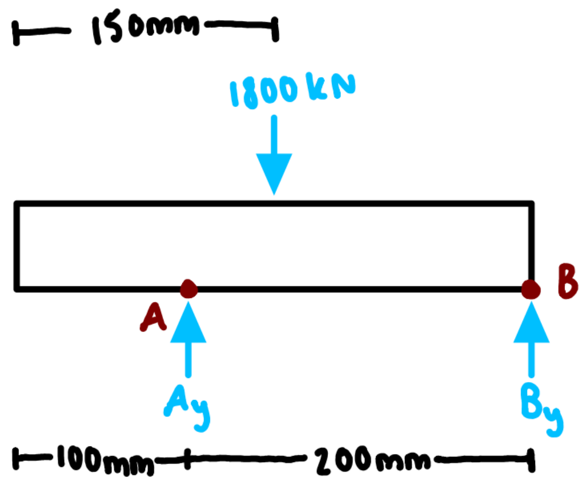


1.2 Find

For the beam above, find the maximum tensile stress due to M and the maximum shear stress due to V.

1.3 Solution

The free body diagram is,



[2]:
```
# Getting reaction forces
Ay, By = sp.symbols('A_y B_y')
eq1 = sp.Eq(Ay + By, 1800)
eq2 = sp.Eq(200*Ay, 150*1800)

sol = sp.solve([eq1, eq2], dict=True)[0]
[display(eq) for eq in [eq1, eq2]]
```

```python
display(Markdown('---'))

for key, value in sol.items():
    display(sp.Eq(key, value))
```

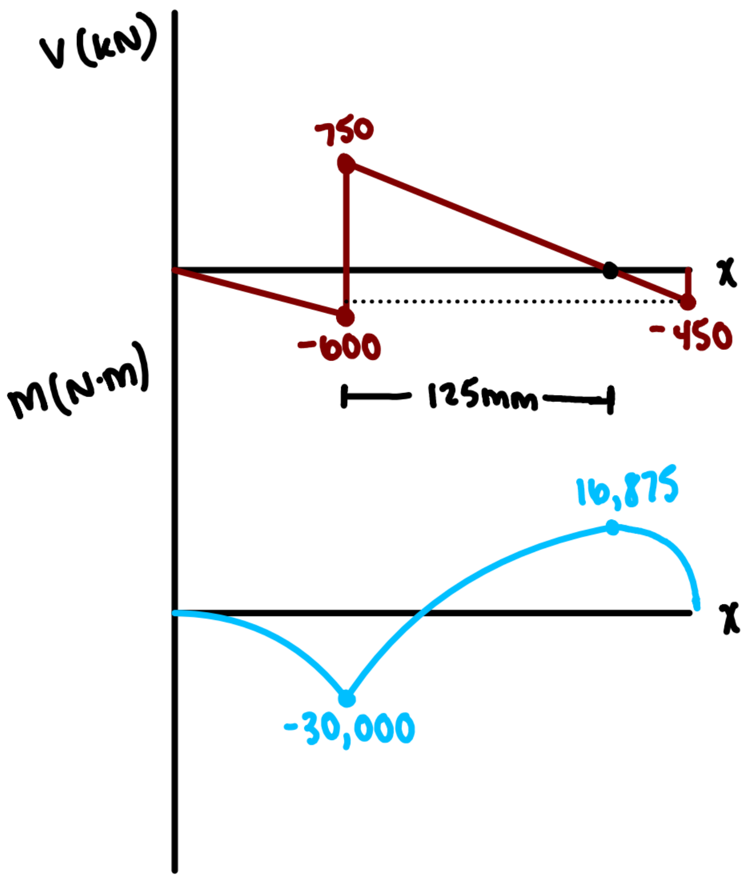
$A_y + B_y = 1800$

$200A_y = 270000$

$A_y = 1350$

$B_y = 450$

The shear and moment diagram is,



The maximum shear and tensile stress occur at $x = 100\ mm$.

[3]:
```python
# Calculating stress due to bending
M, c = 30_000, sp.S(0.025)
(M*c/(sp.pi/4*c**4)).n()  # in Pa
```

[3]: 2444619925.89151

[4]:

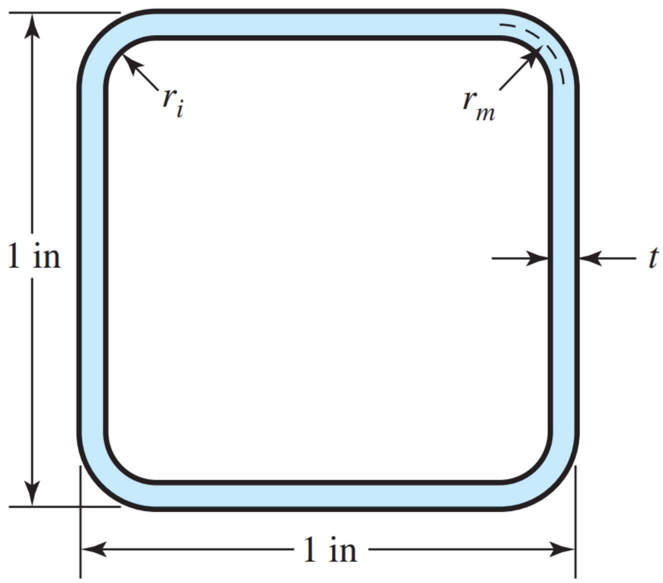
```python
# Calculating the maximum shear stress
V = 750_000
(sp.Rational(4, 3)*V/(sp.pi*c**2)).n()  # in Pa
```

[4]:

509295817.894065

2 Problem 62 Part A

2.1 Given



The tube is 36 *in* long and $r_i = r_m = 0$. The thickness t is $\frac{1}{16}$".

2.2 Find

The maximum torque that can be applied and the corresponding angle of twist of the tube.

2.3 Solution

For thin-walled tubes,

$$\tau = \frac{T}{2A_m t}$$

$$\theta_1 = \frac{TL_m}{4GA_m^2 t}$$

See p. 129 for additional details of the above formulas.

[5]:
```python
# Calculating the maximum torque
tau_max = 12_000  # lbf in
t = sp.Rational(1, 16)  # thickness in inches
Am = (1 - t)**2
T = tau_max*2*Am*t
T.n()  # lbf in
```

[5]:

1318.359375

From table A-5, the modulus of rigidity is 11.5 $Mpsi$.

[6]:

```
G = 11.5e6
Lm = (1 - t)*4  # total length
L = 36  # inches
phi_1 = T*Lm/(4*G*Am**2*t)*L
(phi_1*180/sp.pi).n()  # in degrees
```

[6]:

4.59163394776145

The expression gets multiplied by L because θ_1 is the angle of twist per unit length.