Machine Design Homework 2

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```python
[1]:  # 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')
```
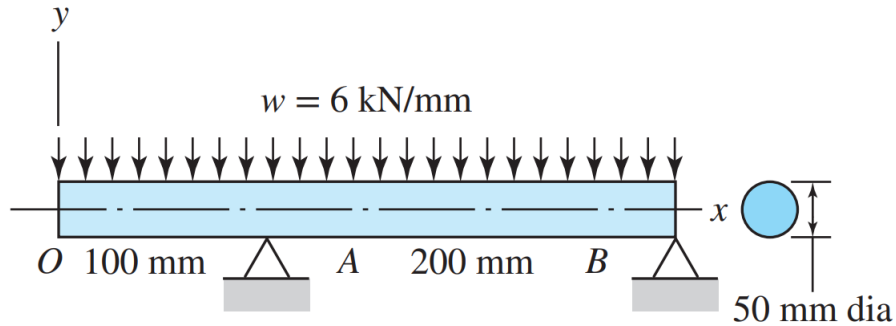
Contents

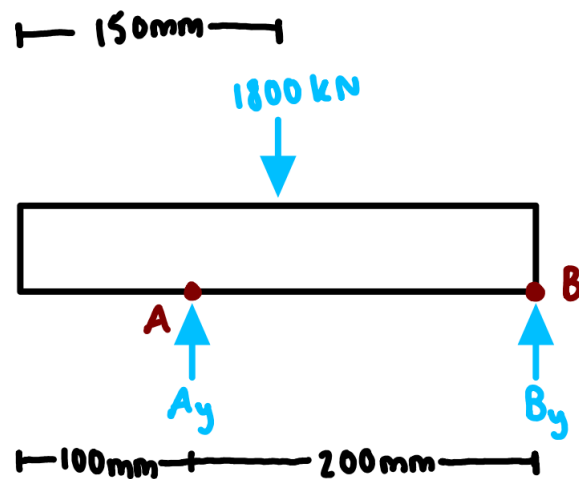# 1   Problem 3-39

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]]
```

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

for key, value in sol.items():
    display(sp.Eq(key, value))
```
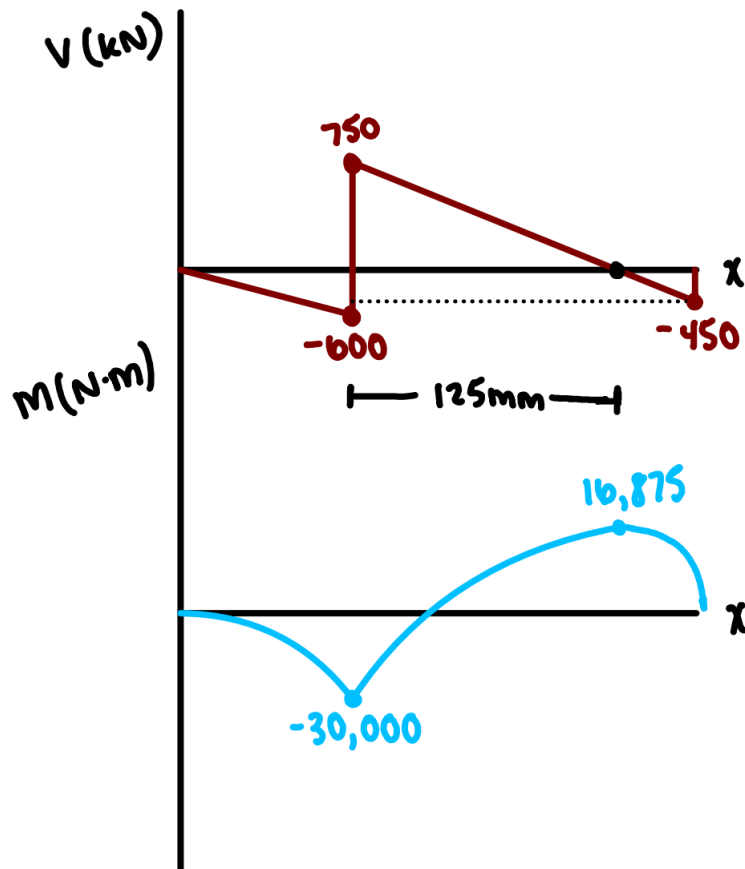
$A_y + B_y = 1800$

$200A_y = 270000$

$A_y = 1350$

$B_y = 450$

The shear and moment diagram is,

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

[3]:
```
# Calculating stress due to bending
M, c = 30_000, sp.S(0.025)
(M*c/(sp.pi/4*c**4)).n()   # in Pa
```
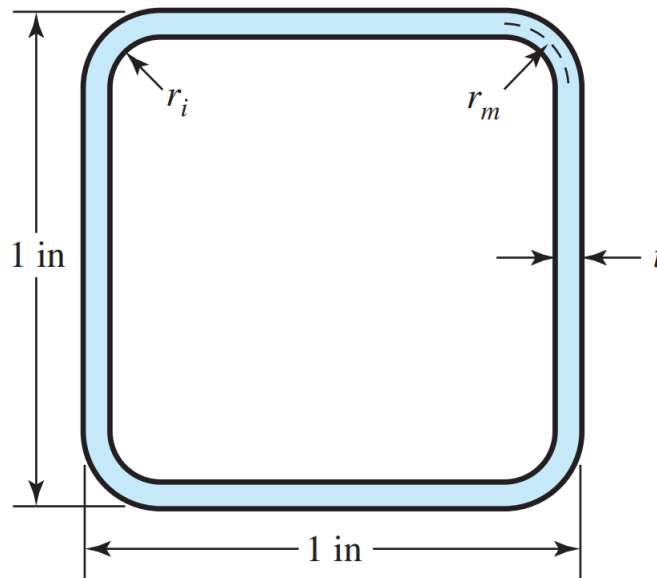
[3]: 2444619925.89151

```
[4]: # 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.

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,

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

$$\theta_1 = \frac{T L_m}{4 G A_m^2 t}$$

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

```
# 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.