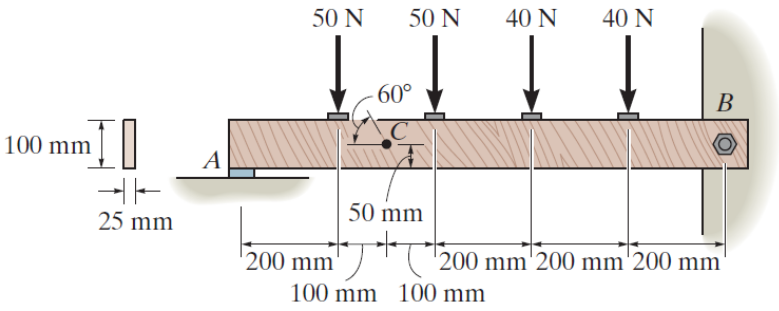
problem 9-105

•9–105. The wooden strut is subjected to the loading shown. Determine the principal stresses that act at point C and specify the orientation of the element at this point. The strut is supported by a bolt (pin) at B and smooth support at A.



beam

```
u = symunit;
x = sym('x');
E = sym('E');

old_assum = assumptions;
clearassum;

b = beam; %(N,mm)
b = b.add('reaction', 'force', 'Ra', 0);
b = b.add('reaction', 'force', 'Rb', 1000*u.mm);
b = b.add('applied', 'force', -50*u.N, 200*u.mm);
b = b.add('applied', 'force', -50*u.N, 400*u.mm);
b = b.add('applied', 'force', -40*u.N, 600*u.mm);
b = b.add('applied', 'force', -40*u.N, 800*u.mm);
b.L = 1000*u.mm;
```

section properties

```
B = 25*u.mm;
H = 100*u.mm;
b.I = B*H^3/12;
A = B*H;
```

elastic curve

```
[y(x,E) dy(x,E) m v w r] = b.elastic_curve(x, 'factor'); %#ok
y
```

y(x, E) =

$$\begin{cases} -\dfrac{x\ (27360000\ \text{mm}^2 - 47\ x^2)}{6250000\ \text{E}}\ \dfrac{\text{N}}{\text{mm}^4} & \text{if } x \le 200\ \text{mm} \\ \dfrac{11\ x^3 + 7500\ x^2\ \text{mm} - 15180000\ x\ \text{mm}^2 + 100000000\ \text{mm}^3}{3125000\ \text{E}}\ \dfrac{\text{N}}{\text{mm}^4} & \text{if } x \in (200\ \text{mm}, 400\ \text{mm}] \\ -\dfrac{3\ (x^3 - 15000\ x^2\ \text{mm} + 14120000\ x\ \text{mm}^2 - 600000000\ \text{mm}^3)}{6250000\ \text{E}}\ \dfrac{\text{N}}{\text{mm}^4} & \text{if } x \in (400\ \text{mm}, 600\ \text{mm}] \\ -\dfrac{23\ x^3 - 81000\ x^2\ \text{mm} + 63960000\ x\ \text{mm}^2 - 6120000000\ \text{mm}^3}{6250000\ \text{E}}\ \dfrac{\text{N}}{\text{mm}^4} & \text{if } x \in (600\ \text{mm}, 800\ \text{mm}] \\ -\dfrac{(x - 1000\ \text{mm})\ (43\ x^2 - 86000\ x\ \text{mm} + 16360000\ \text{mm}^2)}{6250000\ \text{E}}\ \dfrac{\text{N}}{\text{mm}^4} & \text{if } 800\ \text{mm} < x \end{cases}$$

```
dy
```

dy(x, E) =

$$\begin{cases} -\dfrac{3\ (9120000\ \text{mm}^2 - 47\ x^2)}{6250000\ \text{E}}\ \dfrac{\text{N}}{\text{mm}^4} & \text{if } x \le 200\ \text{mm} \\ \dfrac{3\ (11\ x^2 + 5000\ x\ \text{mm} - 5060000\ \text{mm}^2)}{3125000\ \text{E}}\ \dfrac{\text{N}}{\text{mm}^4} & \text{if } x \in (200\ \text{mm}, 400\ \text{mm}] \\ -\dfrac{3\ (3\ x^2 - 30000\ x\ \text{mm} + 14120000\ \text{mm}^2)}{6250000\ \text{E}}\ \dfrac{\text{N}}{\text{mm}^4} & \text{if } x \in (400\ \text{mm}, 600\ \text{mm}] \\ -\dfrac{3\ (23\ x^2 - 54000\ x\ \text{mm} + 21320000\ \text{mm}^2)}{6250000\ \text{E}}\ \dfrac{\text{N}}{\text{mm}^4} & \text{if } x \in (600\ \text{mm}, 800\ \text{mm}] \\ -\dfrac{3\ (43\ x^2 - 86000\ x\ \text{mm} + 34120000\ \text{mm}^2)}{6250000\ \text{E}}\ \dfrac{\text{N}}{\text{mm}^4} & \text{if } 800\ \text{mm} < x \end{cases}$$

```
m
```

m(x) =

$$\begin{cases} 94\ x\ \text{N} & \text{if } x \le 200\ \text{mm} \\ 4\ (11\ x + 2500\ \text{mm})\ \text{N} & \text{if } x \in (200\ \text{mm}, 400\ \text{mm}] \\ -6\ (x - 5000\ \text{mm})\ \text{N} & \text{if } x \in (400\ \text{mm}, 600\ \text{mm}] \\ -2\ (23\ x - 27000\ \text{mm})\ \text{N} & \text{if } x \in (600\ \text{mm}, 800\ \text{mm}] \\ -86\ (x - 1000\ \text{mm})\ \text{N} & \text{if } 800\ \text{mm} < x \end{cases}$$

```
v
```

v(x) =

$$\begin{cases} 94\,\mathrm{N} & \text{if } x \le 200\,\mathrm{mm} \\ 44\,\mathrm{N} & \text{if } x \in (200\,\mathrm{mm}, 400\,\mathrm{mm}] \\ -6\,\mathrm{N} & \text{if } x \in (400\,\mathrm{mm}, 600\,\mathrm{mm}] \\ -46\,\mathrm{N} & \text{if } x \in (600\,\mathrm{mm}, 800\,\mathrm{mm}] \\ -86\,\mathrm{N} & \text{if } 800\,\mathrm{mm} < x \end{cases}$$

```
w
```

$$w(x) = 0$$

reactions

```
Ra = r.Ra %#ok
```

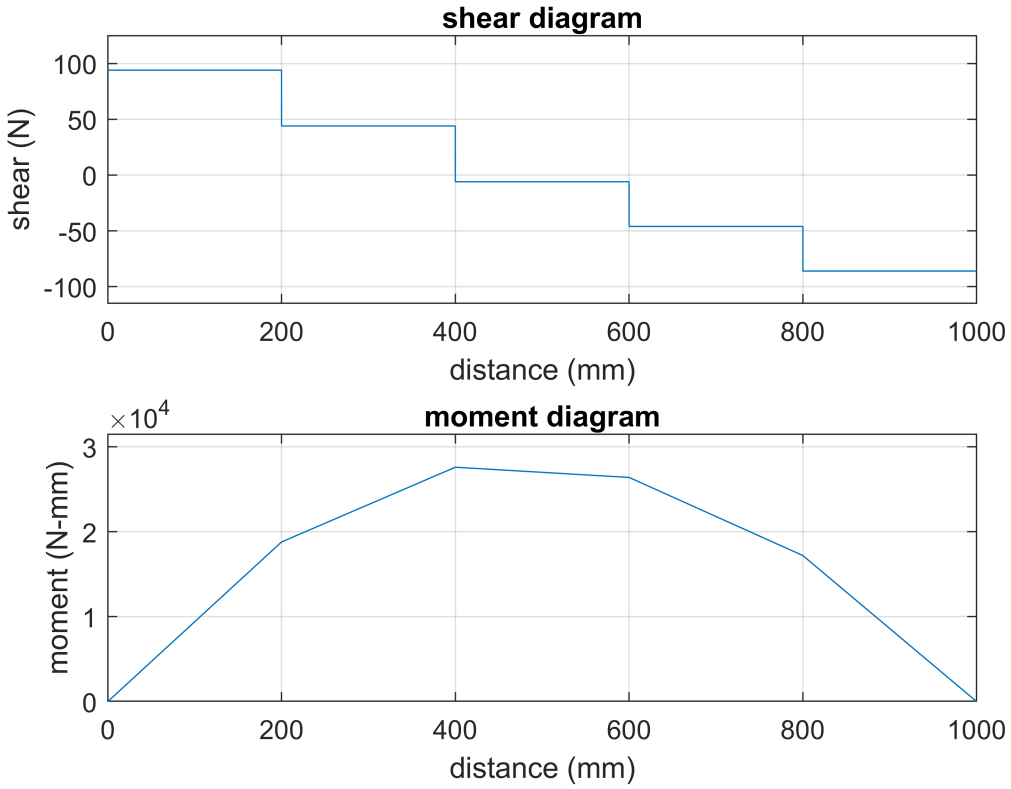
$$Ra = 94\,\mathrm{N}$$

```
Rb = r.Rb %#ok
```

$$Rb = 86\,\mathrm{N}$$

shear and moment diagram

```
beam.shear_moment(m, v, [0 1000], {'N' 'mm'});
subplot(2,1,1);
axis([0 1000 -115 125]);
subplot(2,1,2);
axis([0 1000 0 31500]);
```



loads at point C

```
M_C = m(300*u.mm)
```

$M\_C = 23200\ \mathrm{N\ mm}$

```
V_C = v(300*u.mm)
```

$V\_C = 44\ \mathrm{N}$

stresses at point C

```
sigma_C = sym(0)
```

$sigma\_C = 0$

```
tau_val = rewrite(-3*V_C/(2*A), u.kPa);
tau_C = vpa(tau_val) %#ok
```

$tau\_C = -26.4\ \mathrm{kPa}$

```
tau_C = tau_val;
```

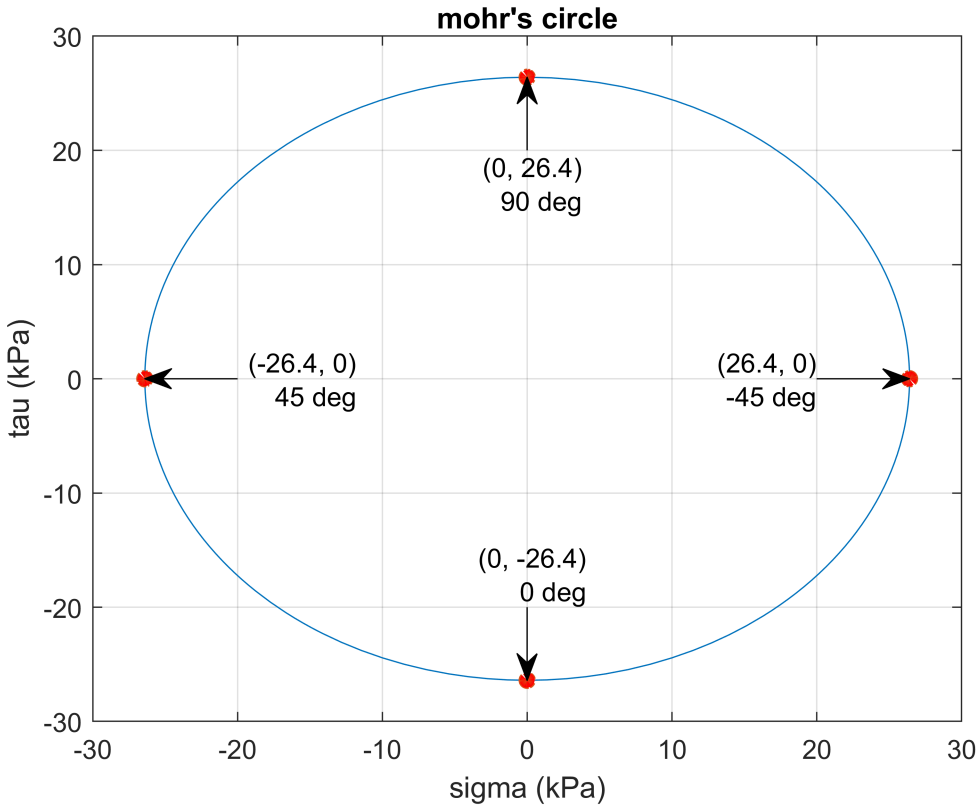
mohr stresses at point C

```
sigmax = sigma_C;
sigmay = sym(0);
tauxy = tau_C;

[sigmaxp sigmayp tauxyp thetap] = beam.principal(sigmax, sigmay, tauxy); %#ok
[sigmaxs sigmays tauxys thetas] = beam.max_shear(sigmax, sigmay, tauxy); %#ok
```

mohr's circle

```
beam.mohr_plot(sigmax, sigmay, tauxy, {'kPa'});
axis([-30 30 -30 30]);
xvals = double(separateUnits([sigmaxp sigmaxs]));
yvals = double(separateUnits([tauxyp tauxys]));
thetavals = double(separateUnits([thetap thetas]));
hold on;
plot(xvals, yvals, 'o', 'MarkerFaceColor', 'r');
for k = 1:4
  switch k
    case 1
      x1 = 20;
      y1 = 0;
    case 2
      x1 = -20;
      y1 = 0;
    case 3
      x1 = xvals(3);
      y1 = -20;
    case 4
      x1 = xvals(4);
      y1 = 20;
  end
  [x1 y1] = ds2nfu(x1, y1); %#ok
  [x2 y2] = ds2nfu(xvals(k), yvals(k)); %#ok
  text_str = {['(' num2str(xvals(k)) ', ' num2str(yvals(k)) ')']
              [num2str(thetavals(k)) ' deg']};
  annotation('textarrow', [x1 x2], [y1 y2], 'String', text_str);
end
```



clean up

```
setassum(old_assum);
clear old_assum Ra Rb tau_val;
clear xvals yvals thetavals k x1 y1 x2 y2 text_str;
```