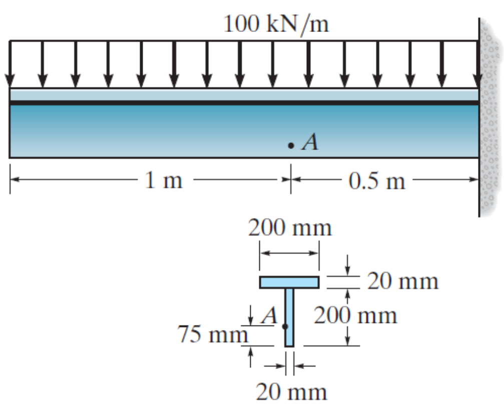
problem 9-22

9–22. The T-beam is subjected to the distributed loading that is applied along its centerline. Determine the principal stress at point *A* and show the results on an element located at this point.



Prob. 9–22

beam

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

old_assum = assumptions;
clearassum;

b = beam;
b = b.add('reaction', 'force', 'R', 1.5*u.m);
b = b.add('reaction', 'moment', 'M', 1.5*u.m);
b = b.add('distributed', 'force', -100*u.kN/u.m, [0 1.5]*u.m);
b.L = 1.5*u.m;
```

section properties

```
yc = [75/2; 75+(200-75)/2; 200+20/2]*u.mm;
Ac = [20*75; 20*(200-75); 200*20]*u.mm^2;
Ic = [20*75^3; 20*(200-75)^3; 200*20^3]*u.mm^4/12;

[yn Qn In] = beam.neutral_axis(yc, Ac, Ic); %#ok
```

```
b.I = rewrite(sum(In), u.m);
```

elastic curve

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

y(x, E) =

$$-\frac{781250\ (2\,x-3\,\mathrm{m})^2\ (4\,x^2+12\,x\,\mathrm{m}+27\,\mathrm{m}^2)}{113\,E}\ \frac{\mathrm{kN}}{\mathrm{m}^5}$$

```
dy
```

dy(x, E) =

$$-\frac{6250000\ (2\,x-3\,\mathrm{m})\ (4\,x^2+6\,x\,\mathrm{m}+9\,\mathrm{m}^2)}{113\,E}\ \frac{\mathrm{kN}}{\mathrm{m}^5}$$

```
m
```

m(x) =

$$-50\,x^2\ \frac{\mathrm{kN}}{\mathrm{m}}$$

```
v
```

v(x) =

$$-100\,x\ \frac{\mathrm{kN}}{\mathrm{m}}$$

```
w
```

w(x) =

$$-100\ \frac{\mathrm{kN}}{\mathrm{m}}$$

reactions

```
R = r.R %#ok
```

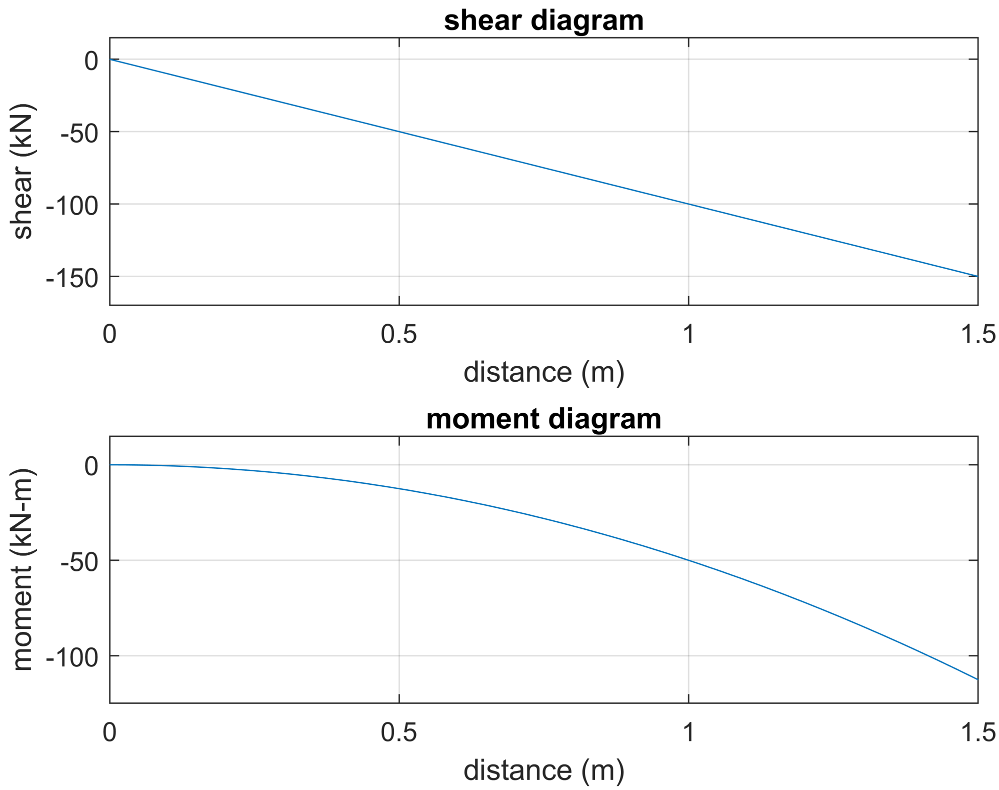
R = $150\ \mathrm{kN}$

```
M = vpa(r.M) %#ok
```

M = $-112.5\ \mathrm{kN\ m}$

shear and moment diagram

```
beam.shear_moment(m, v, [0 1.5], {'kN' 'm'});
subplot(2,1,1);
axis([0 1.5 -170 15]);
subplot(2,1,2);
axis([0 1.5 -125 15]);
```



loads at point A

```
M_A = m(u.m)
```

M_A = $-50\ \mathrm{kN\ m}$

```
V_A = v(u.m)
```

V_A = $-100\ \mathrm{kN}$

stresses at point A

```
y_A = 75*u.mm-yn;
b.I = rewrite(b.I, u.m);
sigma_val = rewrite(-M_A*y_A/b.I, u.MPa);
```

```
sigma_A = vpa(sigma_val, 5) %#ok
```

sigma_A = -106.19 MPa

```
Q_A = abs(Qn(1));
t_A = 20*u.mm;
tau_val = rewrite(-V_A*Q_A/(b.I*t_A), u.MPa);
tau_A = vpa(tau_val, 4) %#ok
```

tau_A = 23.4 MPa

```
sigma_A = sigma_val;
tau_A = tau_val;
```

mohr stresses at point A

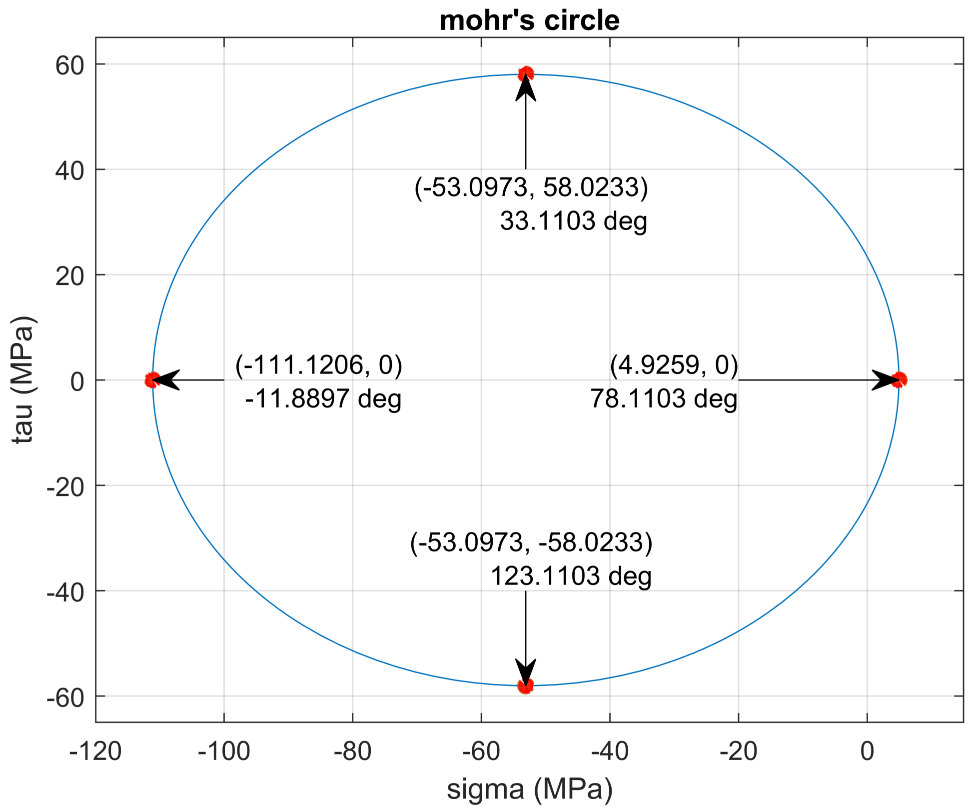
```
sigmax = sigma_A;
sigmay = sym(0);
tauxy = tau_A;

[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, {'MPa'});
axis([-120 15 -65 65]);
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 = -100;
      y1 = 0;
    case 2
      x1 = -20;
      y1 = 0;
    case 3
      x1 = xvals(3);
      y1 = 40;
    case 4
      x1 = xvals(4);
      y1 = -40;
  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 R M sigma_val tau_val;
clear xvals yvals thetavals k x1 y1 x2 y2 text_str;
```