Sec.14

EGM 3520 Mechanics of Materials (MoM)

Beer et al. 2012, Mechanics of Materials, McGraw-Hill.

P4.18, p.239

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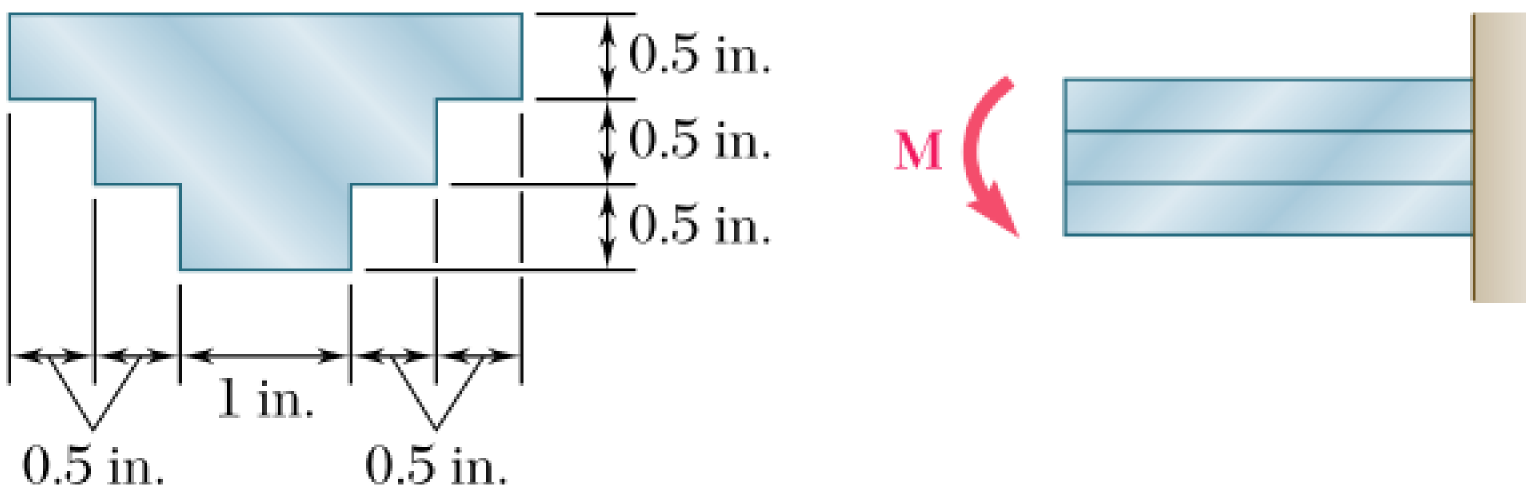


Fig. P4.18

Knowing that for the casting shown the allowable stress is 5 ksi in tension and 18 ksi in compression, determine the largest couple **M** that can be applied.

Pause video NOW !

Work out the next step

→ on your own first

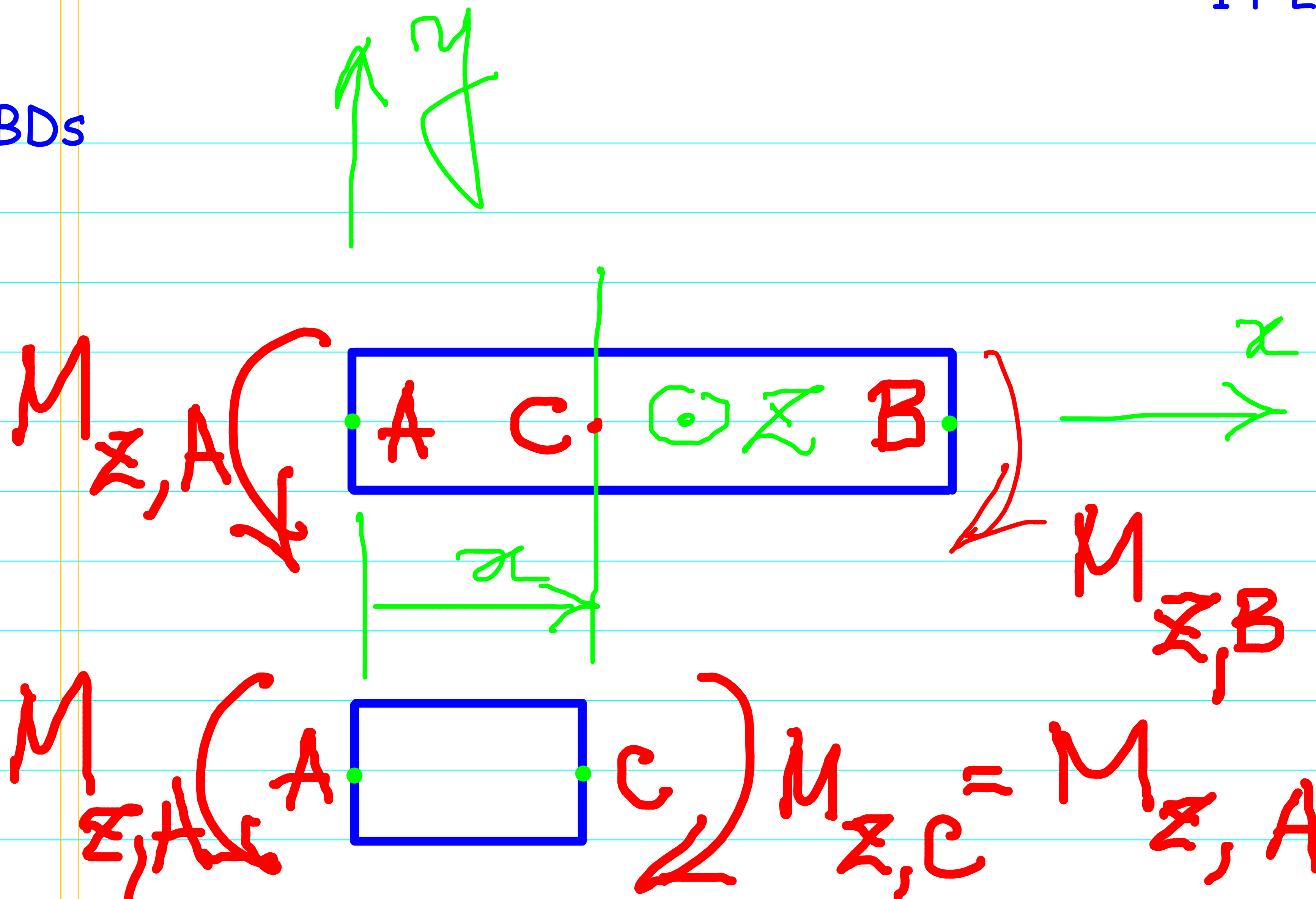
→ discuss with teammates

if you get stuck

then continue to watch the video

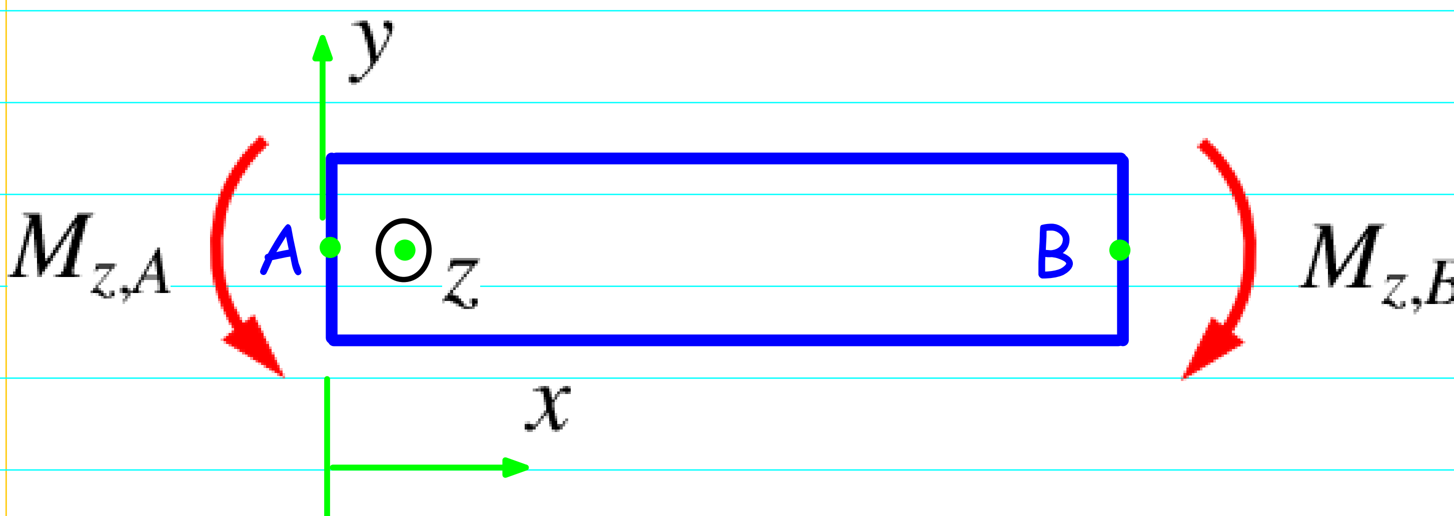
> “Intelligence consists of this; that we recognize the similarity between different things, and the difference between similar things.”
>
> Baron de la Brède et de Montesquieu (1689-1755)
>
> quoted in [Quantum field theory, E. Zeidler, 2008, p.175]

FBDs



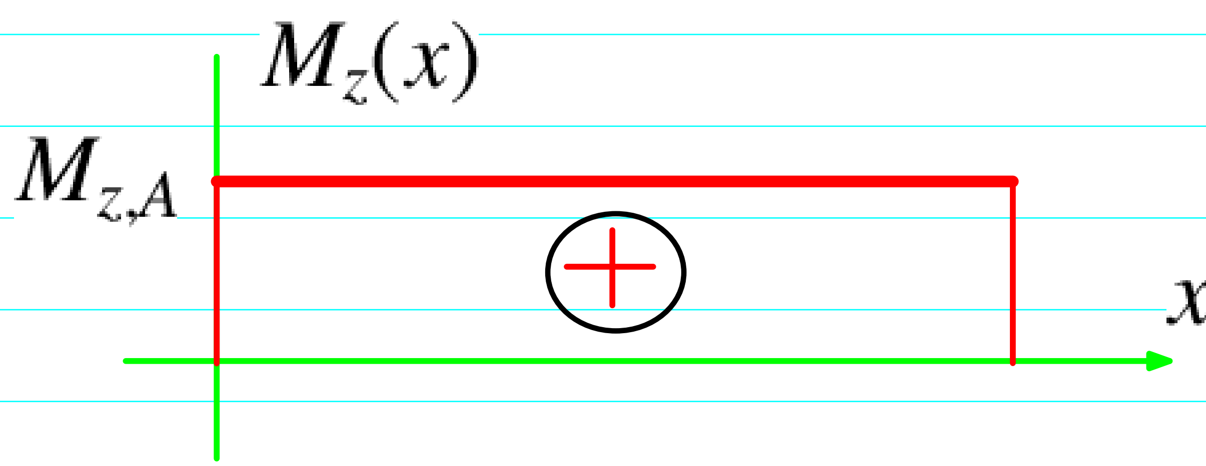
Method

FBD and bending moment diagram



M_{z,A}

Use negative curvature ("down") convention



Normal stress on beam cross section

$$\sigma_x = {\color{red} +} \frac{M_z \, y}{I_z} \quad (1)$$

\sigma_x = {\color{red} +} \frac{M_z \, y}{I_z}

due to "down" convention

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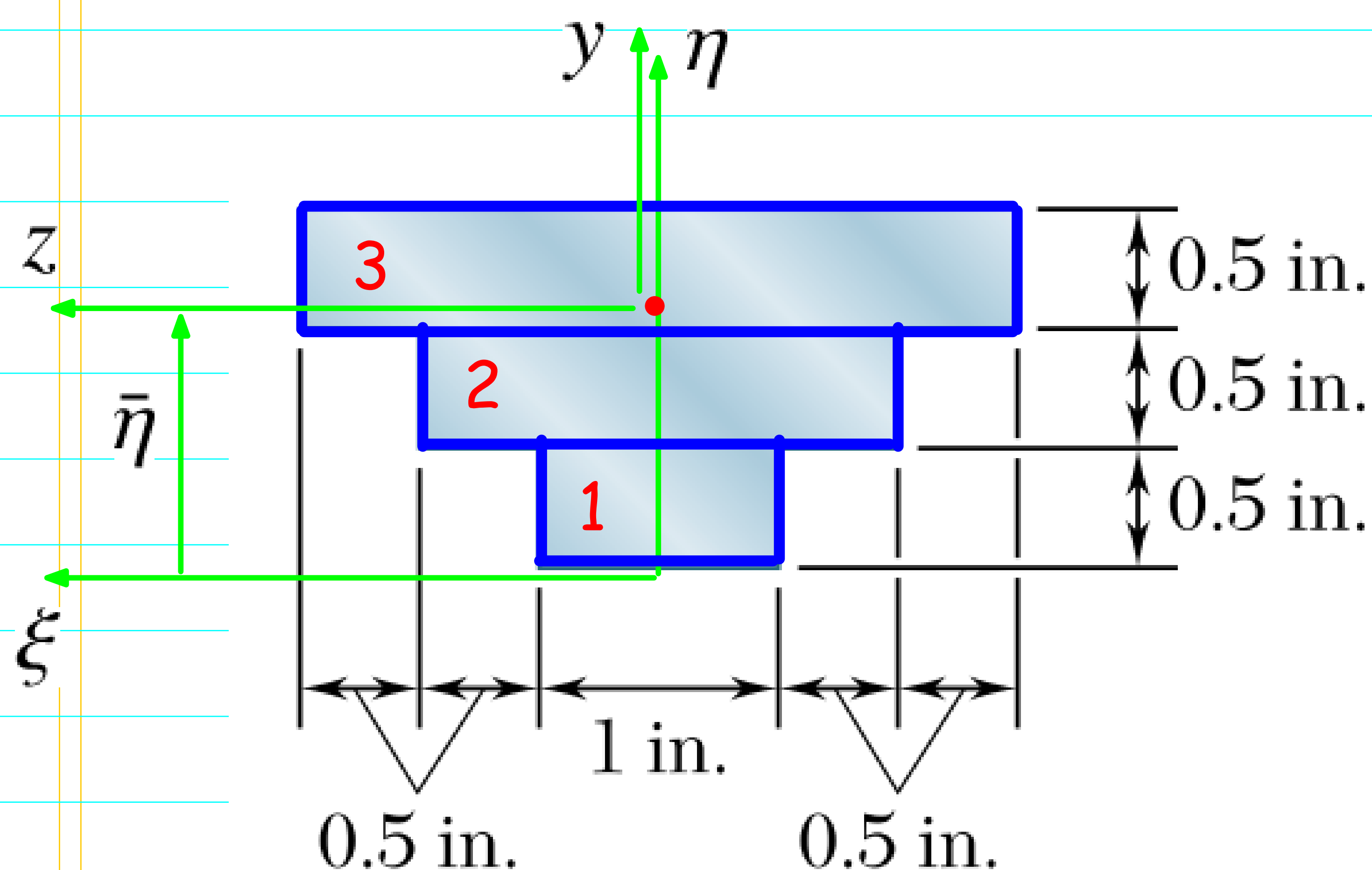
Computation

Find the centroid of cross section



Area of cross section

$$A = A_1 + A_2 + A_3 \quad (1)$$

A = A_1 + A_2 + A_3

$(\bar{\xi}, \bar{\eta})$ coordinates of centroid

(\bar \xi , \bar \eta)

$$\bar{\xi} = 0 \quad (2)$$

\bar \xi = 0

$$\bar{\eta} = \frac{A_1\bar{\eta}_1 + A_2\bar{\eta}_2 + A_3\bar{\eta}_3}{A} \quad (3)$$

\bar \eta = \frac{A_1 \bar \eta_1 + A_2 \bar \eta_2 + A_3 \bar \eta_3}{A}

$$A_1 = 0.5 \, in^2 \, , \, A_2 = 1 \, in^2 \, , \, A_3 = 1.5 \, in^2 \quad (1)$$

A_1 = 0.5 \, in^2 \ , \ A_2 = 1 \, in^2 \ , \ A_3 = 1.5 \, in^2

$$\bar \eta_1 = 0.25 \, in \, , \, \bar \eta_2 = 0.75 \, in \, , \, \bar \eta_3 = 1.25 \, in \quad (2)$$

\bar \eta_1 = 0.25 \, in \ , \ \bar \eta_2 = 0.75 \, in \ , \ \bar \eta_3 = 1.25 \, in

$$y = \eta - \bar \eta \quad (3)$$

y = \eta - \bar \eta

Ordinate of top surface from centroid

$$y_{top} = \eta_{top} - \bar \eta \quad (4)$$

y_{top} = \eta_{top} - \bar \eta

$$\eta_{top} = 1.5 \, in \quad (5)$$

\eta_{top} = 1.5 \, in

Ordinate of bottom surface from centroid

$$y_{bot} = \eta_{bot} - \bar \eta = 0 - \bar \eta = - \bar \eta \quad (6)$$

y_{bot} = \eta_{bot} - \bar \eta = 0 - \bar \eta = - \bar \eta

Normal stress at top surface (tension)

$$\sigma_{x, top} = {\color{red} +} \frac{M_{z,A} \, y_{top}}{I_z} \le \sigma_{U, \, tension} \quad (7)$$

\sigma_{x, top} = {\color{red} +} \frac{M_{z,A} \, y_{top}}{I_z} \le \sigma_{U, \, tension}

$$M_{z,A, 1} = \frac{I_z \, \sigma_{U, \, tension}}{y_{top}} \quad (8)$$

M_{z,A, 1} = \frac{I_z \, \sigma_{U, \, tension}}{y_{top}}

Normal stress at bottom surface (compression)

$$|\sigma_{x,bot}| = {\color{red}+} \frac{M_{z,A} \, |y_{bot}|}{I_z} \le \sigma_{U, \, comp} \quad (1)$$

| \sigma_{x, bot} | = {\color{red} +} \frac{M_{z,A} \, | y_{bot} |}{I_z}
\le \sigma_{U, \, comp}

$$M_{z,A,2} = \frac{I_z \, \sigma_{U, \, comp}}{|y_{bot}|} \quad (2)$$

M_{z,A, 2} = \frac{I_z \, \sigma_{U, \, comp}}{| y_{bot} |}

Maximum allowable bending moment

$$M_{allow} = \min(M_{z,A,1}, M_{z,A,2}) \quad (3)$$

M_{allow} = \min (M_{z,A, 1} , M_{z,A, 2})

Find 2nd area moment of inertia

$$I_\xi = I_{\xi,1} + I_{\xi,2} + I_{\xi,3} \quad (4)$$

I_\xi = I_{\xi , 1} + I_{\xi , 2} + I_{\xi , 3}

$$I_{\xi,i} = \frac{b_i \, (h_i)^3}{12} + A_i \, (\bar\eta_i)^2 \text{ for } i = 1, 2, 3 \quad (5)$$

I_{\xi , i} = \frac{b_i \, (h_i)^3}{12} + A_i \, (\bar \eta_i)^2 \text{ for } i=1,2,3

$$I_z = I_\xi - A \, (\bar\eta)^2 \quad (6)$$

I_z = I_{\xi} - A \, (\bar \eta)^2