To do ...

- HW17 due **tonight**
- HW18 (Prairie Learn) due **Friday**

- WA7 due **Sunday March 13th**

- Engineering Open House – **March 11 & 12**
  “Engineering Open House is an annual student-led event featuring two days of exciting exhibits and captivating competitions that showcase the talent and ingenuity of engineering students at the University of Illinois. … come and experience the atmosphere of innovation and creativity.”

- No lecture on **Friday March 11**

- Quiz 4 (**Mon March 14** – **Fri March 18**)
Quiz 3

75.7 ± 20.6

great job!!
Rapid Refresh ...

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iQ>clicker

1. In mechanics, the force component acting tangent to, or along the face of, the section is called the ________.
   A) Axial force  B) Shear force
   C) Normal force  D) Bending moment
iQ>clicker

2. Determine the magnitude of the internal loads (normal, shear, and bending moment) at point C.

A) (100 N, 80 N, 80 N m)
B) (100 N, 80 N, 40 N m)
C) (80 N, 100 N, 40 N m)
D) (80 N, 100 N, 0 N m)

\[ \Sigma F_x: \quad -N - 100 = 0 \]
\[ \Sigma F_y: \quad -V - 80 = 0 \]
\[ \Sigma M_c = N_c + (0.5)(80) = 0 \]
Procedure for analysis:

1. Find support reactions (free-body diagram of entire structure)
2. Pass an imaginary section through the member
3. Draw a free-body diagram of the segment that has the least number of loads on it
4. Apply the equations of equilibrium

Find the internal forces and moments at B (just to the left of P) and at C (just to the right of P)

\[ \Sigma F_x = 0 \Rightarrow N \]  
\[ \Sigma F_y = 0 \Rightarrow V \]  
\[ \Sigma M = 0 \Rightarrow M \] 

Sign convention

Action-Reaction
Determine the normal force, shear force, and bending moment acting at point E of the frame.

**FBD of member AC**

**FBD of section EC.**

**FBD at C**

\[ \Sigma V: \ V_E + R \cos 45 = 0 \]
\[ V_E = -R \cos (45) \]

\[ \Sigma F_y: \ N_E - R \sin (45) = 0 \]
\[ N_E = R \sin (45) \]

\[ \Sigma M_E: \ y R \cos (45) - M_E = 0 \]
\[ M_E = y R \cos (45) \]

\[ R = \frac{600}{\sin(45)} \]
Q: Why is this poor design?
Consider replacing member AC

FBD of joint C

FBD of EC

no shear or bending moment in straight two force members!
Internal loadings developed in structural members

Concentrated vs. continuous loads.

Cantilevered beam.

Q: Variations of V and M at each point along beam?

Construct shear and bending moment diagrams as function of x.

Q: Are internal forces at each point along the beam the same?

* Provide graphical description of how internal shear and moment vary throughout beam.
Draw the shear and moment diagrams for the simply supported beam.

1. Determine reactive forces and couple moments.
2. Specify coordinate system—start from left.
3. Section beam, draw FBD w/ V and M in positive sense.
4. Apply 3 laws of equilibrium.
Draw the shear and moment diagrams for the simply supported beam.

Deform Eqs of \( M \)
\[ \Sigma F_x: \quad A_x = 0 \]
\[ \Sigma M_B: \quad A_y = \]
\[ \Sigma F_y: \quad B_y = P - A_y \]

\( A_x, A_y, \) \& \( B_y \) are boundary conditions.

1) \( \text{TBD of } A_x \)

2) \( \text{TBD of } A_x \)

**Sum forces in } y**
\[ \Sigma F_y: \quad A_y - F_{Rx} - V = 0 \]
\[ V = A_y - w x_1 \]
\[ V(\infty) = A_y - \text{const} \]
\[ @ x_1 = 0. \quad V(x) = A_y \]

3) \( \text{TBD of } A_x \)

**Sum forces in } y**
\[ \Sigma F_y: \quad A_y - F_R - V = 0 \]
\[ V(x) = A_y - aw - P = \text{const} \]

**Shear diagram**
Shear diagram

$V(y)$

$A_y$

$A_y-wa$

$A_y-wa-P$

$x$
Draw the shear and moment diagrams for the simply supported beam.

1) $Ax_1$

\[ \sum F_y = 0 \]
\[ A_y = \frac{P}{2} \]
\[ \sum M_{B_y} = 0 \]
\[ B_y = \frac{P}{2} \]

$A_y, A_1, B_y$ are boundary conditions.

2) \[ \text{FBD of } Ax_1 \]

\[ \sum M_{x_1} = M - x_1A_y + \left( \frac{1}{2} x_1 \right) (x_1a) \]
\[ M(x) = A_y x_1 - \frac{1}{2} w x_1^2 \]
\[ @ x_1 = 0, M = 0. \]

\[ \sum M_{x_2} = M - x_2A_y + \left( x_2 - \frac{9}{2} \right) aw = 0 \]
\[ M(x) = A_y x_2 - \left( x_2 - \frac{9}{2} \right) aw = 0 \]
\[ M(x) = x_2 (A_y - aw) + \frac{wa^2}{2} = 0 \]

\[ M - x_3A_y + \left( x_3 - \frac{9}{2} \right) Fe + \left( x_3 - b \right) P = 0 \]
\[ M(x) = A_y x_3 - \left( x_3 - \frac{9}{2} \right) Fe - \left( x_3 - b \right) P \]
\[ M(x) = x_3 (A_y - aw - P) + \frac{wa}{2} + bP < 0 \]

negative slope.

\[ \text{Shear diagram} \]

\[ V(x) \]
\[ A_y - wa \]
\[ \text{Dist. load} \]
\[ \text{Conc. force} \]
Bending-moment diagram.