PLTW Engineering

Student:_____

Activity 2.1.6 Step-by-Step Truss System

Introduction

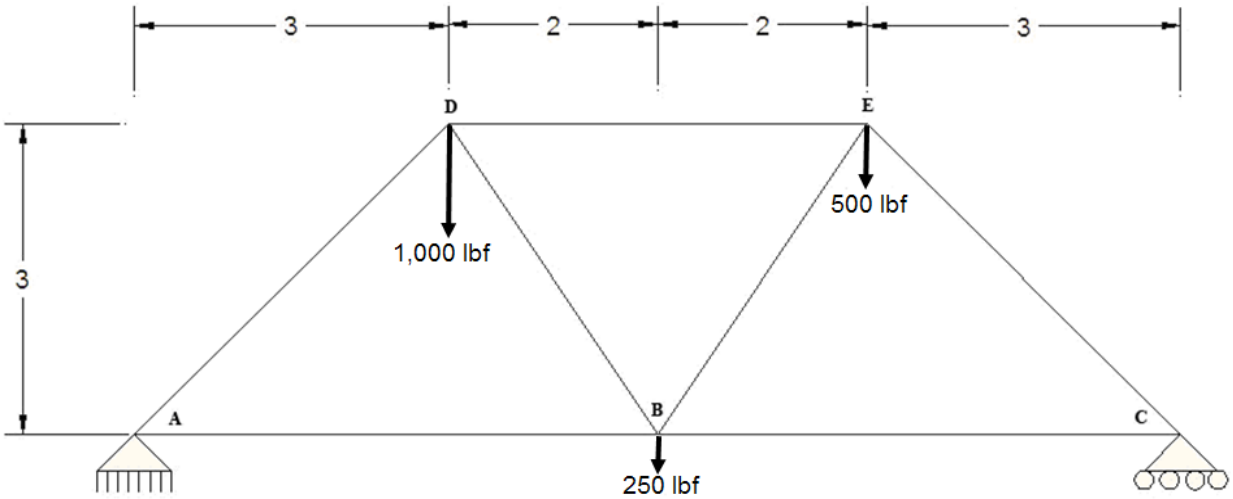
Truss systems are essential components within structural systems ranging from residential construction to large scale civil engineering projects such as bridges. Regardless of the system application, trusses are designed to utilize material strength, reduce costs, and support a determined load. Engineers must be able to understand how loads act on a truss structure and within the structure to ensure design feasibility and safety. Activity 2.1.6 will guide you through the step-by-step process of calculating reaction forces and member forces within a truss system.

Equipment

- Straight edge
- Calculator
- Pencil

Procedure

In this activity you will calculate reaction and member forces for the truss system illustrated below. To ensure proper calculations and free body diagrams, it is essential that you follow each step in the procedure.



Is this problem statically determinate: Equation is:

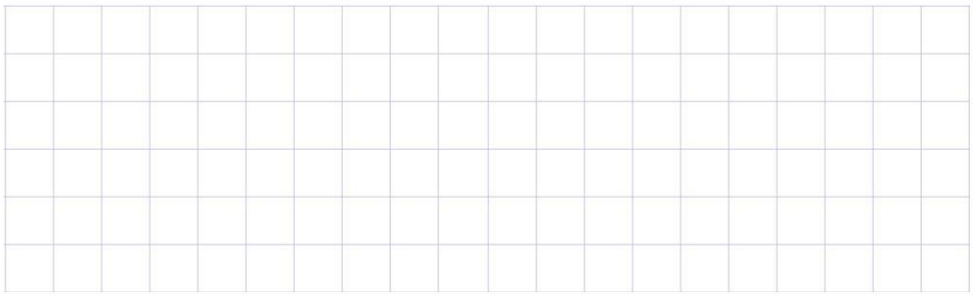
Result:

Calculate External Reaction Forces

x and y Reaction Force at Pin A and Y Reaction Force at Roller C

1. Draw a free body diagram for the **entire truss structure** illustrated above. *Make sure to include all known and unknown angles, forces, and distances. Calculate and determine all angles using trigonometry and geometry.*

(1 Box = .5 Units)



Algebra hints:

$\sin \theta = O/H$
$\cos \theta = A/H$
$\tan \theta = O/A$

$a^2 + b^2 = c^2$

2. Calculate reaction forces at the roller and pin connections.
   a. List static equilibrium equations. **Hint: Σ (They all involve summations)**
   b. List all known and unknown forces acting and reacting on the truss structure. *Label direction of force with an arrow.*
      i. Forces in the **x direction**
      ii. Forces in the **y direction**
      iii. **Moment** Forces – Determined from **Pin A**

Formula review:

M = Fd

c. Use the moment static equilibrium equation acting upon **pin A** to solve for $\mathbf{R_{Cy}}$.

Equation | Substitution

Simplification | $\mathbf{R_{Cy}}$ = Solution

d. Solve for unknown reaction force in the x direction ($\mathbf{R_{Ax}}$).
*Use the sum of forces in the **x** direction equilibrium equation.*

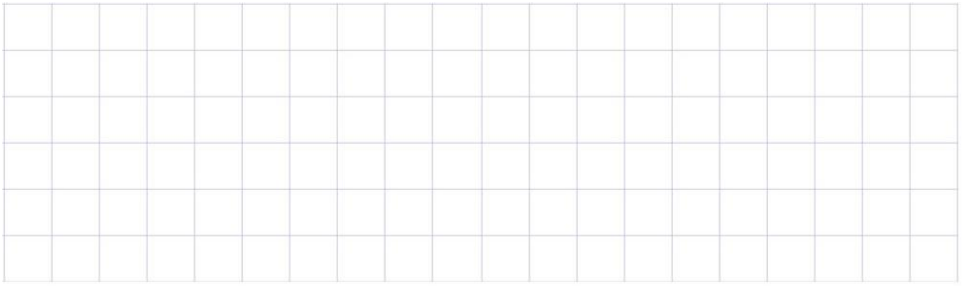
Equation | Substitution | $\mathbf{R_{Ax}}$ = Solution

e. Solve for unknown reaction forces in the y direction.
*Use the sum of forces in the **y** direction equilibrium equation.*

Equation | Substitution

$\mathbf{R_{Ay}}$ = Solution

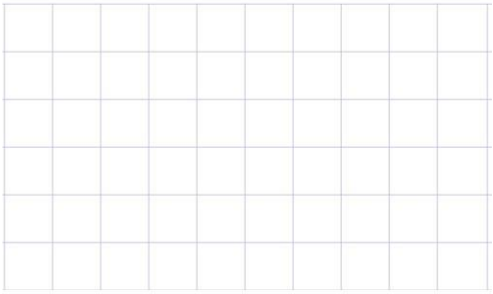
f. Draw a free body diagram for the entire truss system illustrated on page 1. *Make sure to include your calculated support reactions (1 Box = .5 units).*



Calculate Individual Truss Member Forces

3. Calculate member forces **AD** and **AB**.
   a. Draw the free body diagram for joint A.

      *Make sure to include all **known** and **unknown angles** and **forces (including x and y vector components)**. **Do not include lengths**.*



   b. Use SOH CAH TOA to express $\mathbf{AD_x}$ and $\mathbf{AD_y}$ in terms of **AD**.
      i. Calculate $\mathbf{AD_x}$

		$\mathbf{AD_x}$ =
Equation	Substitution	Solution

ii. Calculate $\mathbf{AD_y}$

		$\mathbf{AD_y}$ =
Equation	Substitution	Solution

c. List all known and unknown forces.
Label direction of force with an arrow.

i. Forces in the **x** direction

ii. Forces in the **y** direction

d. Use static equilibrium equations to solve for **AD** and **AB**.

i. Solve for **AD** by calculating **y** direction static equilibrium.

Equation	Substitution	Simplification

	AD =
Simplification	Solution

ii. Solve for **AB** by calculating **x** direction static equilibrium.

Equation	Substitution	Simplification

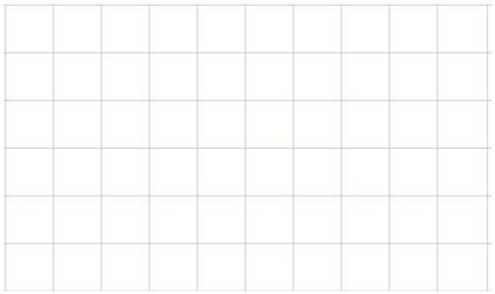
	AB =
Substitution – Insert calculated AD value	Solution

e. Update the joint **A free body diagram** with calculated forces for **AD** and **AB**.

4. Calculate **CB** and **CE.**

   a. Draw the free body diagram for **joint C**.

      *Make sure to include all **known** and **unknown angles** and **forces (including x and y vector components)**. **Do not include lengths**.*



   b. Use SOH CAH TOA to express $\mathbf{CE_x}$ and $\mathbf{CE_y}$ in terms of **CE**.

      i. Calculate $\mathbf{CE_x}$

		$\mathbf{CE_x}$ =
Equation	Substitution	Solution

      ii. Calculate $\mathbf{CE_y}$

		$\mathbf{CE_y}$ =
Equation	Substitution	Solution

   c. List all known and unknown forces.
      Label direction of force with an arrow.

      i. Forces in the **x** direction

      ii. Forces in the **y** direction

d. Use static equilibrium equations to solve for **AD** and **AB**.

i. Solve for **CE** by calculating **y** direction static equilibrium.

Equation	Substitution	Simplification

CE =

Solution

ii. Solve for **CB** by calculating **x** direction static equilibrium.

Equation	Substitution	Simplification

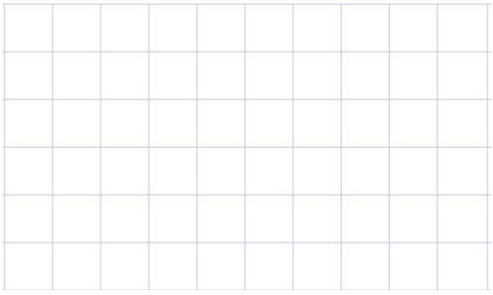
Substitution – Insert calculated CE value	**CB** = Solution

e. Update joint **C free-body diagram** with calculated forces for **CE** and **CB**.

5. Calculate **EB** and **ED**

a. Draw the free-body diagram for **joint E**.

*Make sure to include all **known** and **unknown angles** and **forces (including x and y vector components)**. **Do not include lengths**.*



b. Use SOH CAH TOA to express $\mathbf{EB_x}$ and $\mathbf{EB_y}$ in terms of **EB**.

i. Calculate $\mathbf{EB_y}$

		$\mathbf{EB_y}$ =
Equation	Substitution	Solution

ii. Calculate $\mathbf{EB_x}$

		$\mathbf{EB_x}$ =
Equation	Substitution	Solution

c. List all known and unknown forces.
Label direction of force with an arrow.

i. Forces in the **x** direction

ii. Forces in the **y** direction

d. Use static equilibrium equations to solve for **EB**.

i. Calculate **y** direction static equilibrium.

Equation	Substitution	Simplification

		EB =
Substitution	Simplification	Solution

ii. Calculate **x** direction static equilibrium.

Equation	Substitution	Simplification

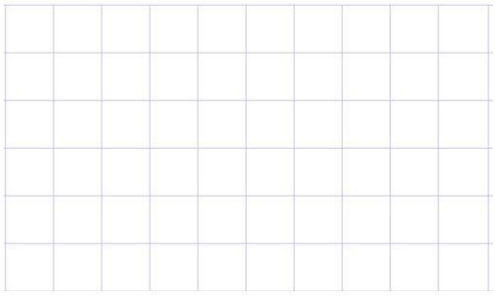
Substitution	Simplification	**ED** = Solution

e. Update joint **E free body diagram** with calculated forces for **EB** and **ED**.

6. Calculate **DB**

a. Draw the free body diagram for **joint D**.

*Make sure to include all **known** and **unknown angles** and **forces (including x and y vector components)**. **Do not include lengths**.*



b. Use SOH CAH TOA to express $\mathbf{DB_x}$ and $\mathbf{DB_y}$ in terms of **DB**.

i. Calculate $\mathbf{DB_y}$

Equation	Substitution	$\mathbf{DB_y}$ = Solution

ii. Calculate $\mathbf{DB_x}$

Equation	Substitution	$\mathbf{DB_x}$ = Solution

c. List all known and unknown forces.
Label direction of force with an arrow.

i. Forces in the **x** direction

ii. Forces in the **y** direction

d. Use static equilibrium equations to solve for **DB**.

i. Solve for **DB** by calculating **y**-direction static equilibrium.

Equation | Substitution | Simplification

Simplification | **DB** = Solution

e. Update joint **D free body diagram** with calculated forces for **DB** and **DE**.

Draw Completed Free Body Diagram

7. Draw a completed free body diagram for the entire truss structure using all calculated reaction and member forces.