The Zero-Force Member (ZFM) Analysis Tool

A learning tool for identifying zero-force members
in truss structures

https://www.zeroforce.page

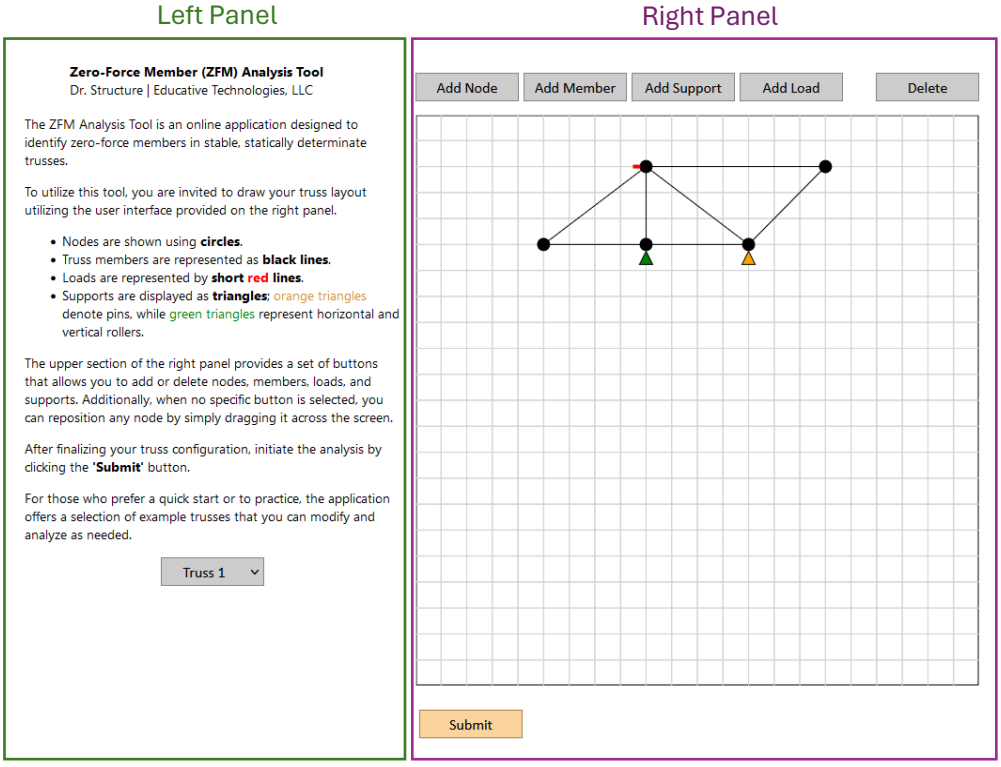
1. Introduction

The ZFM Analysis Tool is a web-based program designed to assist students in learning how to identify zero-force members in stable, statically determinate truss structures. The tool employs a specific set of rules to facilitate the identification and annotation of zero-force members in the truss. Appendix A describes these rules and their underlying principles.

2. System Overview

Upon opening the application, you will see two main panels:

- **Left Panel**: Provides instructions, definitions, and an overview of the symbols used within the application. Also, the left panel displays the result of the analysis.
- **Right Panel**: This is the space for drawing and modifying trusses interactively. The panel embodies a grid-based canvas for constructing trusses.



3. Getting Started with the Truss Canvas

The canvas on the right is where you can build your truss. It is a grid-based area allowing for precise placement of nodes, members, supports, and loads.

4. Using the Construction Tools

At the top of the canvas, you will find a toolbar with the following buttons:

- **Add Node**: Click to create a new node on the canvas.
- **Add Member**: Use this to connect two nodes and create a member.
- **Add Support**: This button adds support to your truss. There are three defined types of supports: pin support (), horizontal roller (), and vertical roller (). Use the dropdown menu to select the support type.
- **Add Load**: Places point loads at one or more nodes. Short red lines represent loads. You can place the load horizontally () or vertically () at the node. Use the dropdown menu to select the load direction.
- **Delete**: Removes selected nodes, members, supports, or loads from the structure.

5. Constructing Your Truss

To build a truss:

1. **Create Nodes**: Click the “Add Node” button. Then, click on the canvas where you want to place the node.
2. **Add Members**: Select “Add Member.” Click on a starting node and drag it to another node to create a member.
3. **Set Supports and Loads**: Choose “Add Support” or “Add Load.” Then, click on a node to place these elements.
4. **Delete Elements**: If you need to remove an element, click “Delete,” then click on the item you wish to remove. If you remove the node, you will also remove all the elements attached to the node.

6. Analyzing Your Truss

Once you construct your truss to identify its zero-force members, click the “Submit” button. The system will analyze the truss, identify its zero-force members step by step, as explained in the left panel, and highlight them on the canvas.

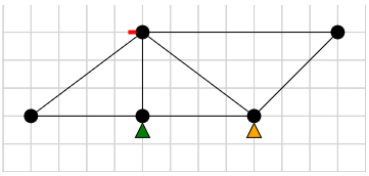
To identify a truss's zero-force members, ensure the structure is stable. The “Submit” button is active only if the truss is stable.

7. Example Trusses

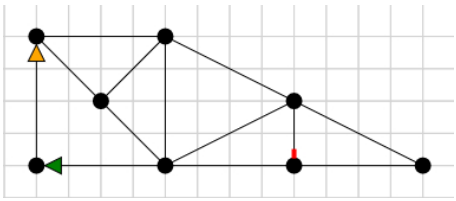
The application provides example trusses that you can modify and analyze for practice. Select an example truss from the dropdown menu in the left panel. Then click the “Submit” button to identify the selected truss's zero-force members.

The following table shows example trusses labeled Truss 1 through Truss 15.

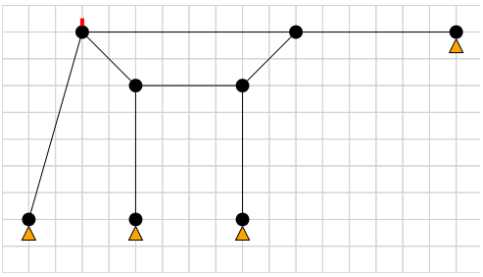
Truss 1



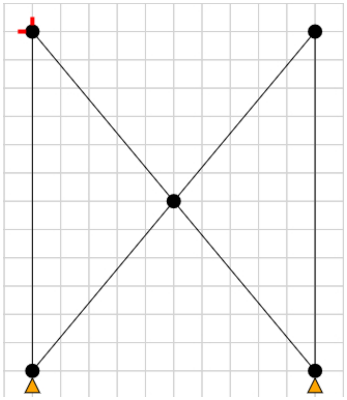
Truss 2



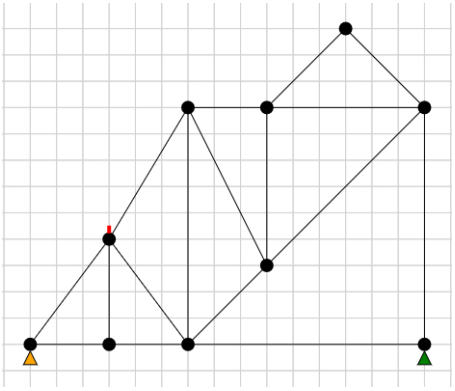
Truss 3



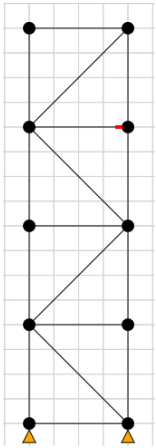
Truss 4



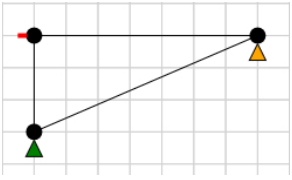
Truss 5



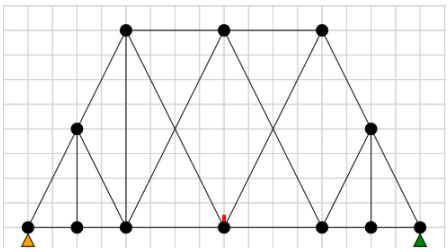
Truss 6



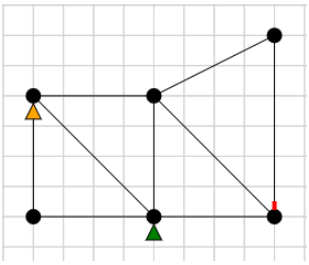
Truss 7



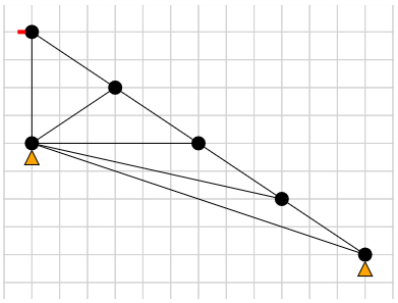
Truss 8



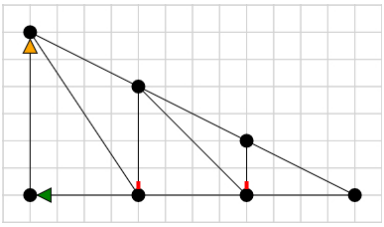
Truss 9



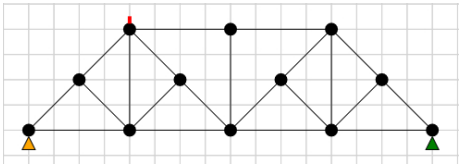
Truss 10



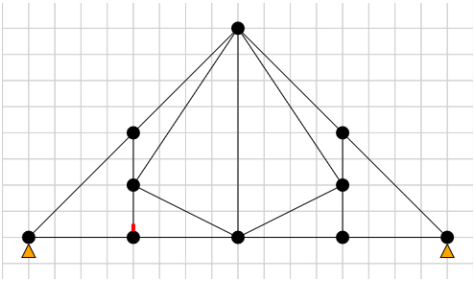
Truss 11



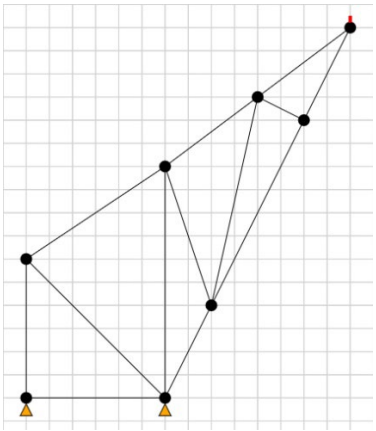
Truss 12



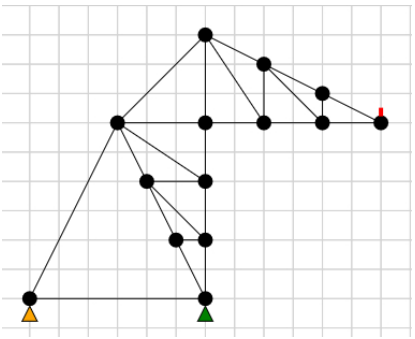
Truss 13



Truss 14



Truss 15



8. Questions and Suggestions

Email your questions or suggestions to Dr.Structure@EducativeTechnologies.net.

Appendix A

We use twelve (12) rules for identifying zero-force members in trusses. These rules and their explanations regarding the equilibrium conditions at the truss joints are as follows.

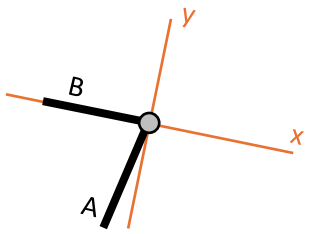
Rule 1

Condition:	An unsupported and unloaded node connecting only two truss members.
Conclusion:	Neither member carries any force.

Explanation:

Since the sum of the forces acting in the y-direction must be zero, the force in member A is zero.

Given that the sum of the forces in the x-direction must be zero, and the force in member A is zero, the force in member B also comes out to be zero.

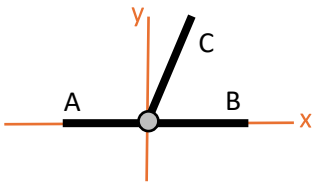


Rule 2

Condition:	An unsupported and unloaded node connecting only three members, two of which are collinear.
Conclusion:	The other (third) member carries no force.

Explanation:

Since the sum of the forces acting in the y-direction must be zero, and the force in member C is the only force in the y-direction, it follows that C is a zero-force member.

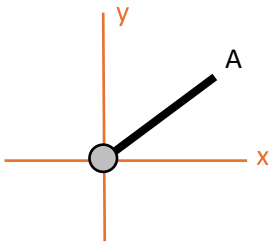


Rule 3

Condition:	An unsupported and unloaded node with a single member attached to it.
Conclusion:	The member carries no force.

Explanation:

Since the sum of the forces at the node must be zero and no members attached to the node other than A, the force in member A is zero.

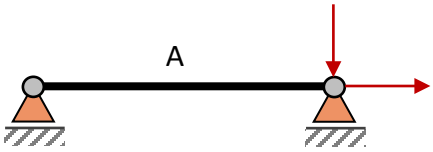


Rule 4

Condition:	A member supported by a pin at each end.
Conclusion:	The member carries no force.

Explanation:

The pin supports fully absorb the loads applied at the end nodes of the member. Therefore, member A carries no force.

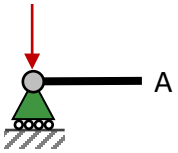


Rule 5

Condition:	A node with a horizontal roller support, not subjected to a horizontal load, having a single horizontal member attached to it.
Conclusion:	The member carries no force.

Explanation:

Since no horizontal forces are acting at the node other than the force in member A, the force equilibrium conditions can be maintained only if the force in member A is zero.

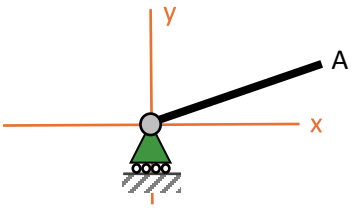


Rule 6

Condition:	An unloaded node having a horizontal roller support with a single member attached to it.
Conclusion:	The member carries no force.

Explanation:

Since the sum of forces in the x-direction must be zero, and the force in member A is the only force in that direction, then A is a zero-force member.

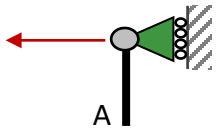


Rule 7

Condition:	A node with a vertical roller support, not subjected to a vertical load, having a single vertical member attached to it.
Conclusion:	The member carries no force.

Explanation:

Since the sum of forces in the y-direction must be zero, and the force in member A is the only force in that direction, then A is a zero-force member.

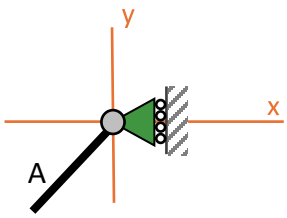


Rule 8

Condition:	An unloaded node having a vertical roller support with a single member attached to it.
Conclusion:	The member carries no force.

Explanation:

Since the sum of forces in the y-direction must be zero, and the force in member A is the only force in that direction, then A is a zero-force member.

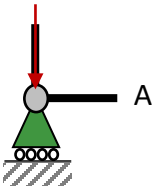


Rule 9

Condition:	A node with a horizontal roller support and no load in the horizontal direction connects a horizontal and a vertical member.
Conclusion:	The horizontal member carries no force.

Explanation:

Since the sum of forces in the x-direction must be zero, and the force in member A is the only force in that direction, then A is a zero-force member.

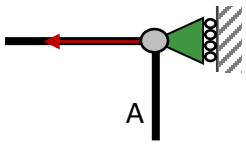


Rule 10

Condition:	A node with a vertical roller support and no load in the vertical direction connects a horizontal and a vertical member.
Conclusion:	The vertical member carries no force.

Explanation:

Since the sum of forces in the y-direction must be zero, and the force in member A is the only force in that direction, then A is a zero-force member.

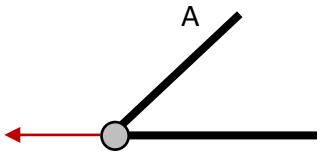


Rule 11

Condition:	An unsupported node, with a load in the horizontal direction, connects a horizontal and a non-horizontal member.
Conclusion:	The non-horizontal member carries no force.

Explanation:

Since the sum of forces in the y-direction must be zero, and the force in member A is the only force in that direction, then A is a zero-force member.



Rule 12

Condition:	An unsupported node with a load in the vertical direction connects a vertical and a non-vertical member.
Conclusion:	The non-vertical member carries no force.

Explanation:

Since the sum of forces in the x-direction must be zero, and the force in member A is the only force in that direction, then A is a zero-force member.