

Script Reading Guide

- What to read: Read the non-bracket text verbatim.
- What to do: Blue bracket text (e.g., (instructor points to slide)) = actions/stage directions. Do not read them; perform them. Pause where it says (wait for replies/student interaction).

Instructor Script

(First slide: Today's objectives)

Hello everyone! Today, we're diving into an exciting topic: Bridge Design. After this class, you'll be able to define a simple truss, determine the forces in truss members, and identify zero-force members. (Use fingers to point to each objective, make eye contact across the room)

Remember, in this class, you'll need to take notes. You'll also have two minutes after each session to review your notes before taking the post-learning quiz. (hold up two fingers when mentioning "two minutes") Sounds good? Let's get started!

(Change to next slide: Demonstration: Paper Bridge)

Let's do a quick demonstration! (Pre-stage two books and paper) I want you to take a strip of paper and hold it between two books like a bridge. (Show the flat paper bridge from the side so students can see deflection) Now, press gently in the middle. What happens? (Wait for reply) It bends, right? Now, let's fold the paper like an accordion and place it back. (Fold the paper) Press again. It holds better, doesn't it? That's the power of a truss—by adding structure, we distribute the force more effectively!

(Change to next slide: Truss Applications)

We actually see a lot of truss structures every day, like on bridges and roofs. These frameworks, composed of interconnected triangles, provide strength and stability to many structures around us. Trusses are commonly used to support roofs, offering a lightweight yet sturdy solution that can span large distances without the need for internal supports. Beyond rooftops, trusses are integral components in cranes, aircraft frames, and even the International Space Station, showcasing their versatility in various engineering applications. Can you think of a truss example in your life? (Wait for reply)

(Change to next slide: The advantages of trusses)

OK, now let's talk about why trusses are a smart choice in construction. First off all, trusses are quick and easy to install. They can be assembled rapidly on-site, saving both time and labor costs. Next, trusses can span longer distances without the need for intermediate supports. This makes them ideal for creating large, open spaces like bridges and large buildings. Finally, trusses provide ideal load distribution. Their triangular configuration ensures that loads are evenly spread throughout the structure, enhancing stability and efficiency. (instructor makes pull/push motions along a sketched member to show axial action)

(Change to next slide: Introduction to truss system)

OK, now let's properly define what a truss is. A truss is a structure made entirely of straight members connected at their ends by pin joints. These joints allow rotation but not translation. Importantly, all external forces, including loads and reactions, are applied solely at the joints, not along the members themselves.

(Change to next slide: Truss analysis: force)

OK, now let's see how we analyze the force distribution in a truss. When analyzing trusses, we make two key assumptions to simplify the process: First, we assume that all loads are applied only at the joints, and the weight of the truss members is often neglected as the weight is usually small as compared to the forces supported by the members. Second, we assume that the members are joined together by smooth pins. This assumption is satisfied in most practical cases where the joints are formed by bolting the ends together. With these assumptions, each member becomes a two-force member, the internal forces in the members are either pulling (tension) or pushing (compression) along the axis of the member. (Instructor holds a thin tube and pulls to show tension, then pushes to show compression; adds axial arrows on two sample members using a drawing tool.) Can you use the arrow to point out the direction of the force? (wait for student interaction; if correct: "Great!", if not: instructor taps the correct arrow) Offtime, the compressive members are made thicker to prevent buckling (instructor gently bows a thin stick to show buckling, then contrasts with a thicker stick).

(Change to next slide: Truss analysis: stable)

OK, now let's see how we determine if a truss is stable. We use this formula: $M = 2J - 3$, where M is the number of members and J is the number of joints. If this equation holds, the truss is considered statically determinate and stable. This means the structure has just enough members to maintain its shape and support loads without collapsing. However, it's important to note that this is a necessary condition for stability, but not always sufficient; the actual geometry and support conditions also play crucial roles.

(Change to next slide: Zero force members)

Next, I'd like to talk about zero-force members—an important concept in truss analysis. Zero-force members are structural elements that, under certain loading conditions, carry no force. Identifying these members simplifies calculations during analysis, as they can be excluded from force computations. Moreover, they help in designing efficient truss structures by reducing unnecessary material usage. Finding zero-force members also ensures stability and rigidity in construction.

(Change to next slide: Rule 1)

There are two rules to identify zero-force members. The first rule is: If only two non-collinear members meet at a joint with no external load or support reaction, then both are zero-force members. For instance, in this example (instructor takes out Truss Model 1 and also shows the VR 3D model to students), for this model, can you guess which one is a zero-force member? Use the highlighter in your desk (wait for the student interaction)., we can see that members ED and CD met at point D, and only those two members are at point D (with hand pointing to the points). There's no loads on point D as well. Therefore, both ED and CD are zero force

members, and can be safely removed from the structure. Similarly, members FA and BA meet at point A, and there's no other load or reaction on point A, so they are zero-force members as well. After removing those two, we now have a much simpler truss structure that can also hold the same weight.

(Change to next slide: Rule 2)

The second rule for identifying zero-force members is: If three members meet at a joint and two of them are collinear—meaning they form a straight line—and there's no external load or support reaction at that joint, then the third, non-collinear member is a zero-force member. Let's look at this example. (Instructor shows Truss Model 2.) In this model, AD, ED, and CD meet at point D. And ED and CD form a straight line (with hand pointing to the points). No force is applied on point D, so the third member, the non-collinear member, AD, is the zero force member. Similarly we can find out that AC is also a zero force member.

We see that, after removing the zero-force members, the structure is simpler. Does that mean we need to remove all zero force members? Use the status to show me your answer. (Instructor looks up and says, "OK, I see your [status], thanks!").

(Change to next slide: Why keep zero force members?)

Actually, in the real world, engineers often choose to keep these members.

They enhance structural stability by preventing unwanted deformations and vibrations, especially under dynamic conditions. They act as a safeguard against unexpected loads, such as those from wind, earthquakes, or shifting weights, becoming active when needed. They provide redundancy, serving as backups if key members fail, thereby increasing the safety of the structure. They help prevent buckling in compression members by offering lateral support, maintaining the integrity of the structure. And they allow for future modifications or increased loads, offering flexibility in design and use. So, while zero-force members might seem unnecessary at first glance, they play crucial roles in ensuring the durability and adaptability of truss structures.

(Change to next slide: Types of trusses)

Just go over different types of trusses. Now, I will give you two minutes to review the notes.