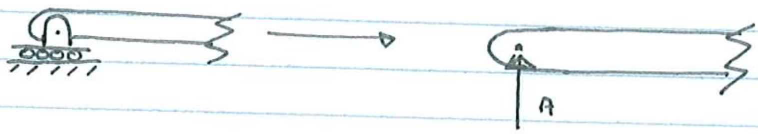
> MIDTERM: Oct. 19th/16
> - Covers all content to now.
> - 8:30 AM

2.2 Roller Support

The roller support is a pin support mounted on wheels. The roller support cannot exert a couple about the axis of the pin or a force in the direction to the surface on which it is free to roll.



2.3 The Built-in support

The Built-in Support or Fixed support can exert two components of force and a couple.

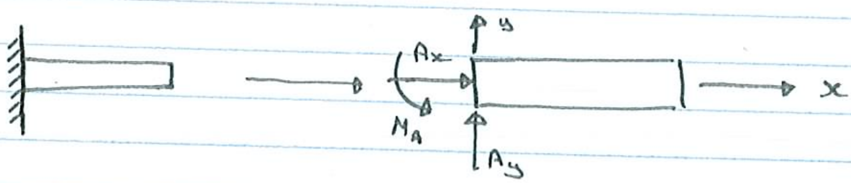
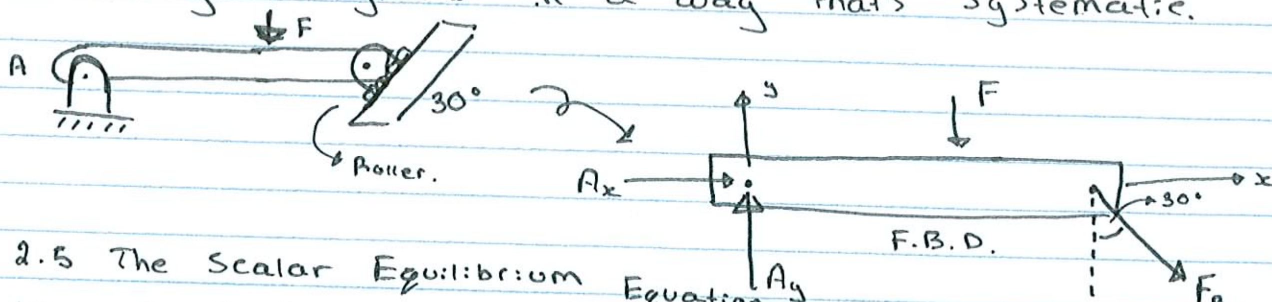


Table of supports used in two-dimensional applications in Figure 4.1 of the text.

2.4 Free-body diagrams

By using the support conventions, we can model more elaborate objects and construct their free-body diagrams in a way that's systematic.



2.5 The Scalar Equilibrium Equations.

When the loads and reactions on an object in equilibrium form a two-dimensional system of forces and moments, they are related by three scalar equilibrium equations:

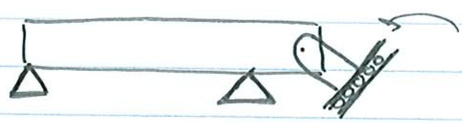
$$\Sigma F_x = 0 \quad , \quad \Sigma F_y = 0 \quad , \quad \Sigma M_{(\text{any point})} = 0$$

We can't obtain more than three independent equilibrium equations from a two-dimensional F.B.D., which means we can only solve for three unknown forces or couples at the most.

3. Statically Indeterminate Objects

Since we can write no more than three independent equilibrium equations for a given F.B.D. in a two-dimensional problem, when there are more than three unknowns we can't determine them from the equilibrium equations alone. This occurs when:

1 - An object has more supports than the minimum number necessary to maintain it in equilibrium

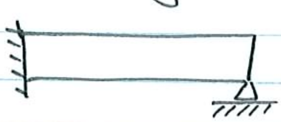


(For example, at least one is redundant)

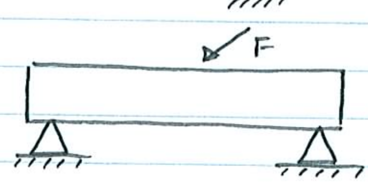
Such an object is said to have redundant supports.

2 - The supports of an object are improperly designed such that they cannot maintain equilibrium and the loads acting on it. This object is said to have improper support.

In either situation, the object is said to be statically indeterminate.



Redundant



Improper

4 - Three-dimensional Applications

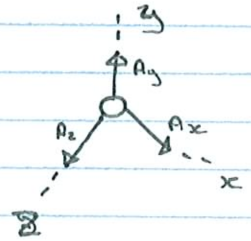
4.1 - The scalar equilibrium equations

The loads and reactions on an object in equilibrium satisfy the six scalar equilibrium equations:

$$\Sigma F_x = 0 \qquad \Sigma F_y = 0 \qquad \Sigma F_z = 0$$
$$\Sigma M_x = 0 \qquad \Sigma M_y = 0 \qquad \Sigma M_z = 0$$

4.2 - The ball-and-socket support

The ball-and-socket support can't exert a couple but can exert three components of force.



4.3 - The roller support

The roller support is a ball and socket support that can roll freely on a supporting surface. A roller support can exert only a force normal to the supporting surface.

4.5 - The bearing support

The bearing supports a circular shaft while permitting it to rotate about it's axis. The reactions are identical to those exerted by a hinge.

4.6 - The built-in support

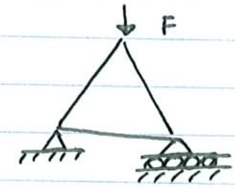
The built-in support or fixed support is capable of exerting forces in the A_x, A_y, and A_z - in each coordinate direction, and couples M_x, M_y, and M_z about each of the axes.

Supports used in three-dimensions are listed in Fig 4.10 of the texts.

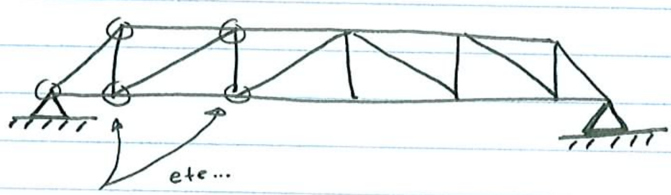
Structures in Equilibrium

1.- Trusses

Suppose we pin three bars together at their ends to form a triangle. If we add supports, we obtain a structure that will support a load F.



We can construct more elaborate structures by adding more triangles. The bars are the members of these structures, and the places where the bars are pinned together are called the joints. If these ~~joints~~ structures are supported and loaded at their joints, and we neglect the weight of the bars, each bar is a two-force member. Such a structure is called a truss.



Method of Joints - Analyzing each individual joint sequentially.
(Solve for unknown by $\Sigma F_y = 0$, etc.)

2 - The method of Joints

The method of joints involves drawing F.B.D. of the joints of a truss one by one and using the equilibrium equations to determine the axial forces in the members.

Before we begin, we usually need to draw a free-body diagram of the entire structure (truss) and determine reactions at the supports.

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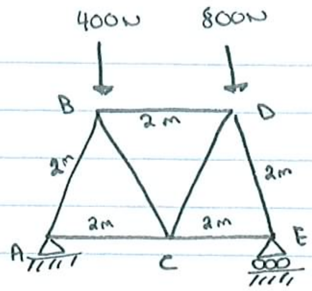
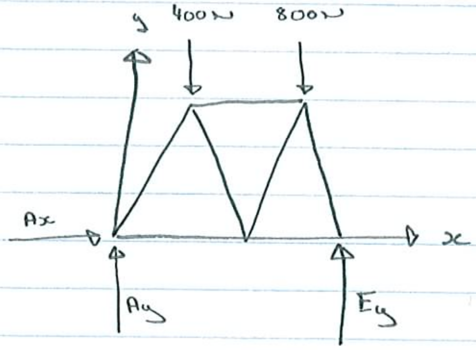




$\overset{+}{\rightarrow} \sum F_x = 0$

$\therefore A_x = 0$

$+\uparrow \sum F_y = 0$

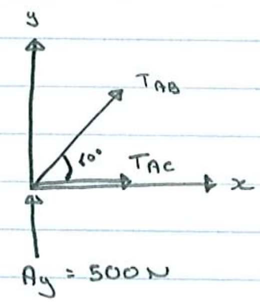
$A_y + E_y - 400 - 800 = 0$

$(A_y = 500\,N)$

$+\circlearrowleft \sum M_A = 0$

$(4m)E_y - 400N(1m) - 800N(3m) = 0$

$E_y = 700\,N$



Joint A:

$\sum F_x = 0$

$\overset{+}{\rightarrow} \sum F_x = T_{AC} + T_{AB} \cos 60°$

$(T_{AC} = 289\,N$ (tension)$)$

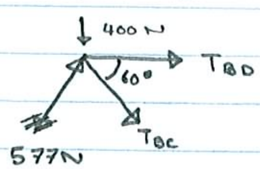
$+\uparrow \sum F_y = 0$

$\sum F_y = A_y + T_{AB} \sin 60°$

$T_{AB} = -577\,N$ (change direction of vector)

$T_{AB} = 577$ (compression)

Joint B:



$\overset{+}{\rightarrow} \sum F_x = 0$

$\sum F_x = T_{BD} + \cos 60° (T_{BC}) + 577N(\cos 60°) = 0$

$\uparrow + \sum F_y = 0$

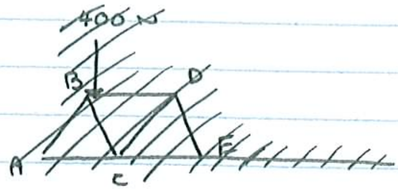
$577N(\sin 60°) - 400\,N - \sin 60° (T_{BC}) = 0$

$T_{BC} = 115\,N$ (Tension)

$T_{BD} = -346\,N$ (change direction)

$T_{BD} = 346\,N$ (compress) (this is what he wrote, but it's tension.)

By continuing to draw F.B.D. of the joints, we can determine the axial forces in all of the members.



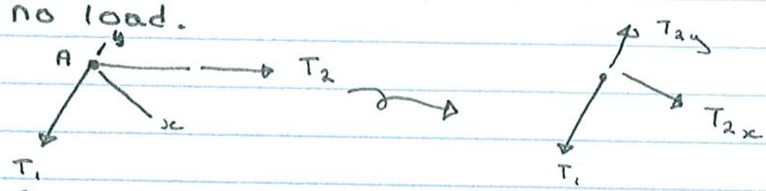
~~cssme@lakeheadu.ca~~

When we determine the axial forces in the members of a truss, our task will often be simple if we are familiar with the following three particular types of joints:

1 - Truss joints with two colinear members and no load.

The sum of the forces most equal zero, $\therefore T_1 = T_2$ the axial forces are equal.

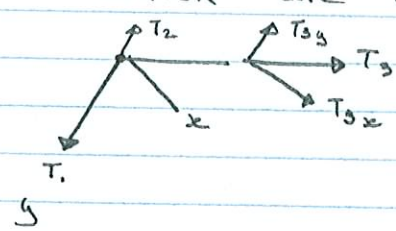
2 - Truss joints with two non colinear members and no load.



Because the sum of the forces in the x-direction must equal zero, $T_{2x} = 0 \quad \therefore T_2 = 0$

Therefore T_1 must also equal zero. The axial forces are zero.

3 - Truss joints with three members, two of which are colinear, and no load.



$T_1 = T_2$

$T_3 = 0$

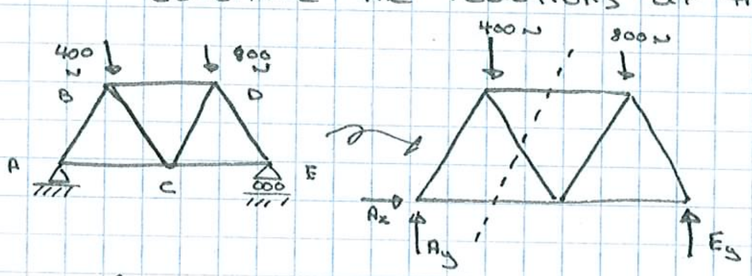
Using the method of joints to determine the axial forces in the members of a Truss, typically involves three steps.

1 - Determine the reactions at the supports. We usually need to draw the F.B.D. of the entire truss and determine the reactions at the supports.

2 - Identify special joints - Examine the truss to see if it has any of the types of joints discussed earlier. Although it is not essential, this step can simplify the resolution.

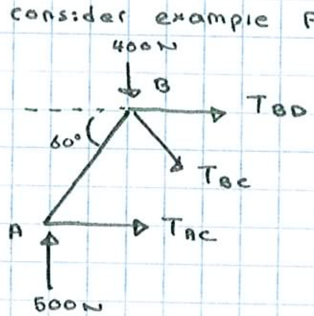
3 - Analyze the Joints - Draw F.B.D of joints and apply the equilibrium equations to determine the axial forces in the members. Choose joints that require you to solve for no more than two unknown forces.

3 (?) - Method of Sections
When we only need to know the axial forces in certain members in a truss, we often can determine them more quickly using the method of sections than using the method of joints. Just as in the method of joints, we begin by drawing a FBD of the entire truss, and determine the reactions at the supports.



Suppose that we only need to determine the axial force in members BC. Our next step is to cut the members AC, BC, BD to obtain a F.B.D. of a part / section of the truss.

(consider example from earlier)



Summing moments about point B, the equilibrium equations for the section are:

$$\overset{+}{\rightarrow} \sum F_x = T_{AC} + T_{BD} + T_{BC} \cos 60° = 0$$

$$+\uparrow \sum F_y = 500\,N - 400\,N - T_{BC} \sin 60° = 0$$

$$+\circlearrowleft \sum M_B = T_{AC} (2 \sin 60°) - 500 (2 \cos 60°) = 0$$

Solving the equations we obtain

T_{AC} = 289 N (T)
T_{BC} = 115 N (T)
T_{BD} = 346 N (C)