A short course on

Equilibrium

This video:

Determinate Structures

Terje's Toolbox is freely available at terje.civil.ubc.ca
It is created and maintained by Professor Terje Haukaas, Ph.D., P.Eng.,
Department of Civil Engineering, The University of British Columbia (UBC), Vancouver, Canada

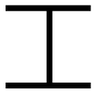
Analysis of Determinate Structures

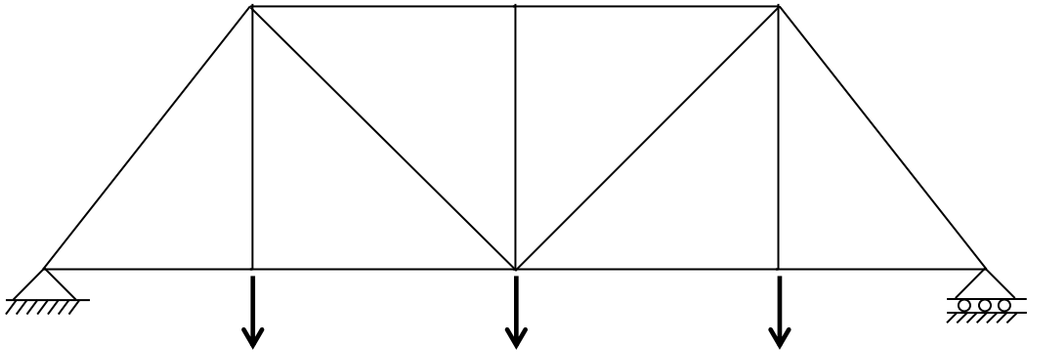
What is analysis?

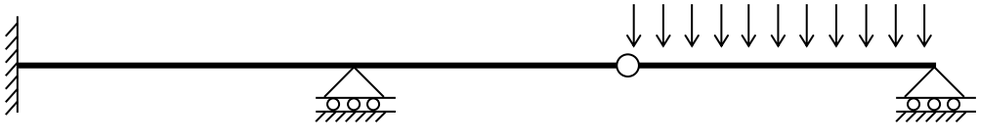
What is determinate?

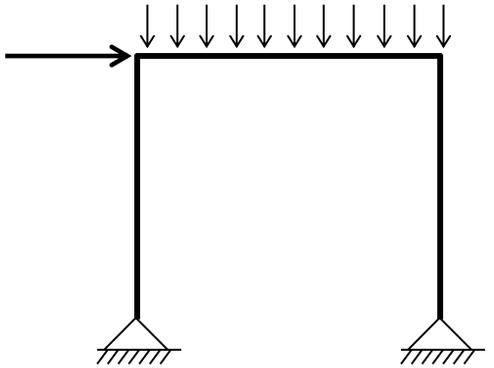
What is a structure?

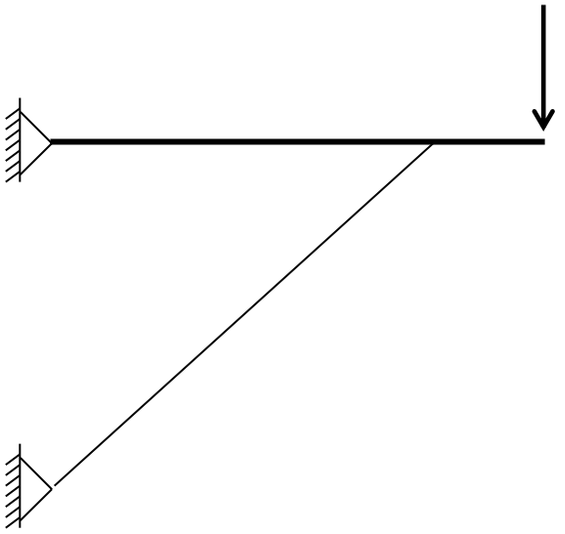
A Structure is…

- Comprised of “longitudinal” members
- With a cross-section 
- Truss?
- Beam?
- Frame?
- Mixed?









Analysis is…

Structural engineering = Design + Analysis

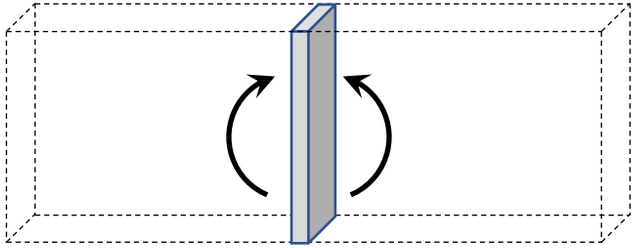
Design = Establish trial dimensions

Analysis = Determine deformations and internal forces due to external loads

BMD = Bending moment diagram
SFD = Shear force diagram
AFD = Axial force diagram

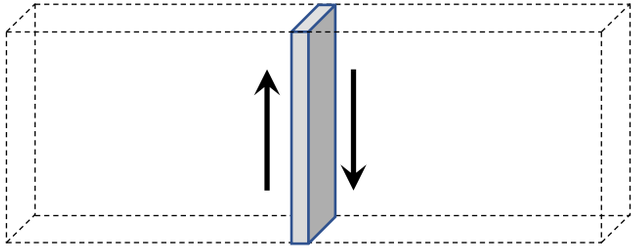
Internal Forces

Bending moment, M



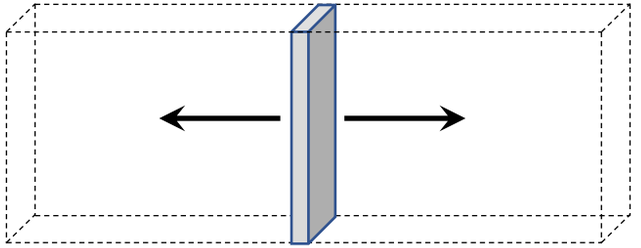
Bending moment diagram, BMD

Shear force, V



Shear force diagram, SFD

Axial force, N



Axial force diagram, AFD

Determinacy is…

Degree of static indeterminacy (DSI)

DSI = number of unknown forces in the structure – number of equilibrium equations

DSI=0 means determinate

DSI=0 means equilibrium is sufficient to determine BMD, SFD, AFD

We consider only determinate structures in this video

Compute DSI in the course on indeterminate structures

Determinacy also means…

Equilibrium is sufficient

No need to know material behaviour to find forces

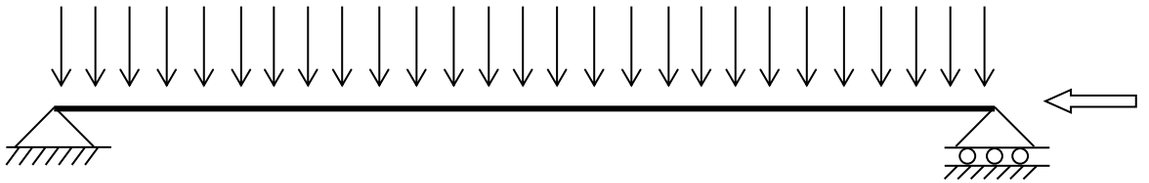
Stiffness of the structure does not influence the distribution of forces in the structure

Will NOT have additional forces due to support settlements or temperature changes

Does not possess redundancy

Structure will collapse if one member or one support fails

Conventions



BMD, SFD, AFD

Diagrams drawn along members, showing what occurs inside the member

AFD in truss or frame members

Tension is positive or negative?

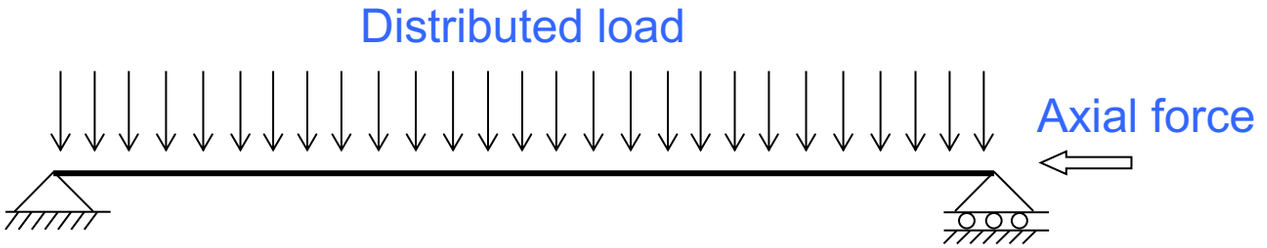
BMD in beam and frame members

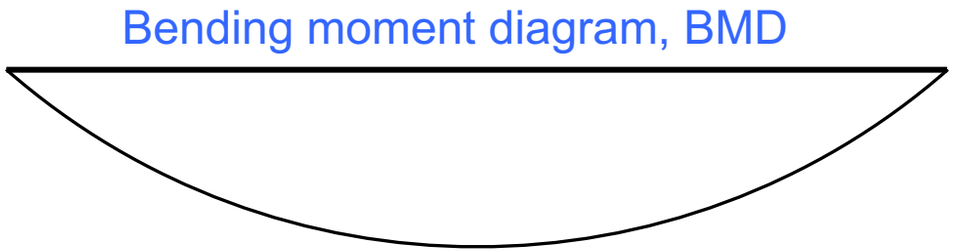
Use signs, or draw the diagram on a specified side of the member?

SFD in beam and frame members

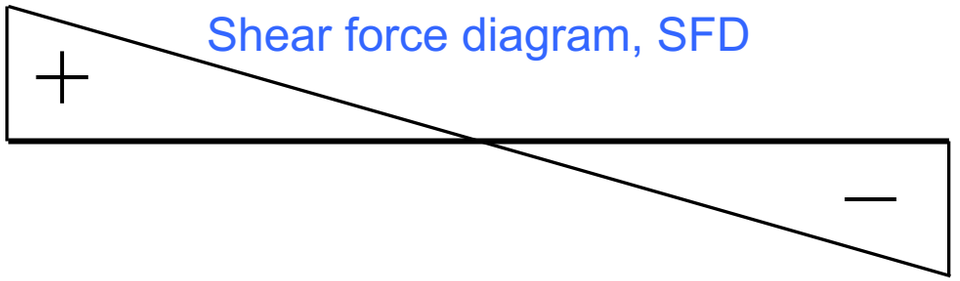
Use signs, or draw the diagram on a specified side of the member?

Choices Made

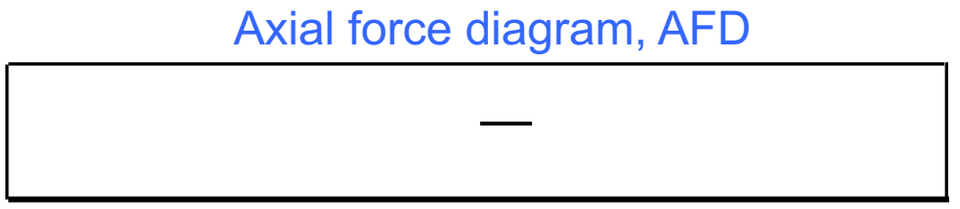




BMDs are drawn on the tension side without signs

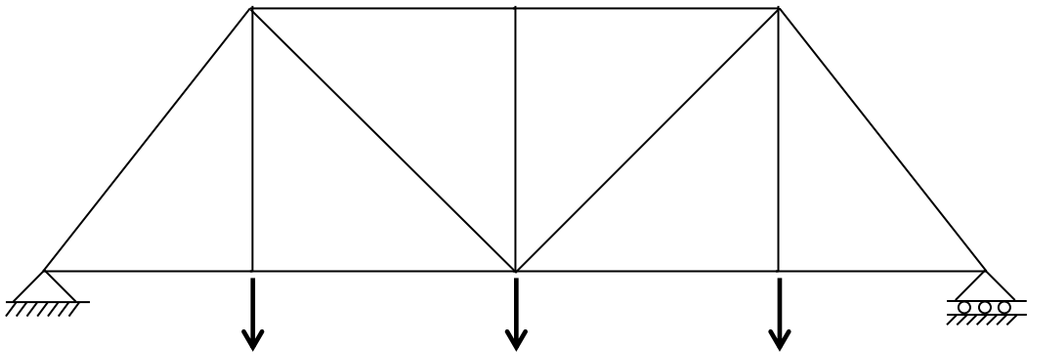


SFDs are drawn on either side of the member, but marked with a sign that indicates clockwise (+) or counter-clockwise (–) shear force



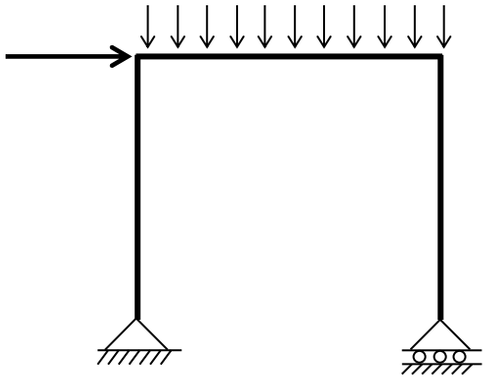
AFDs are drawn on either side of the member, but marked with a sign that indicates tension (+) or compression (–)

Truss

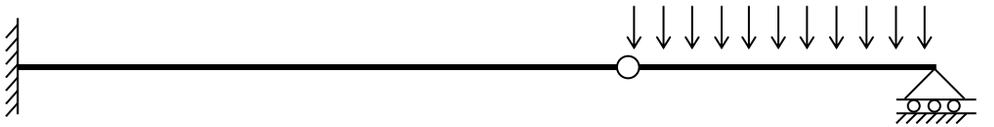


- Determine reaction forces
- Select an arbitrary joint with maximum two unknown forces
- Use ”equilibrium of forces at a point” to determine the unknown forces there
- Go to the next joint…

Beam/Frame



- Determine reactions



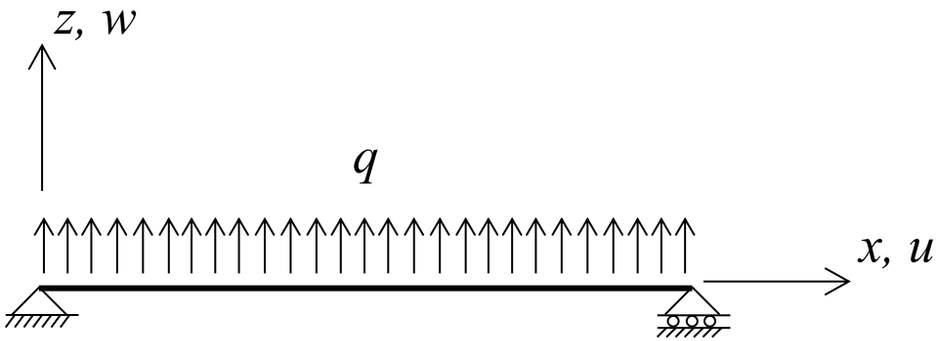
- Determine bending moment at key locations
- Draw the BMD between those locations:

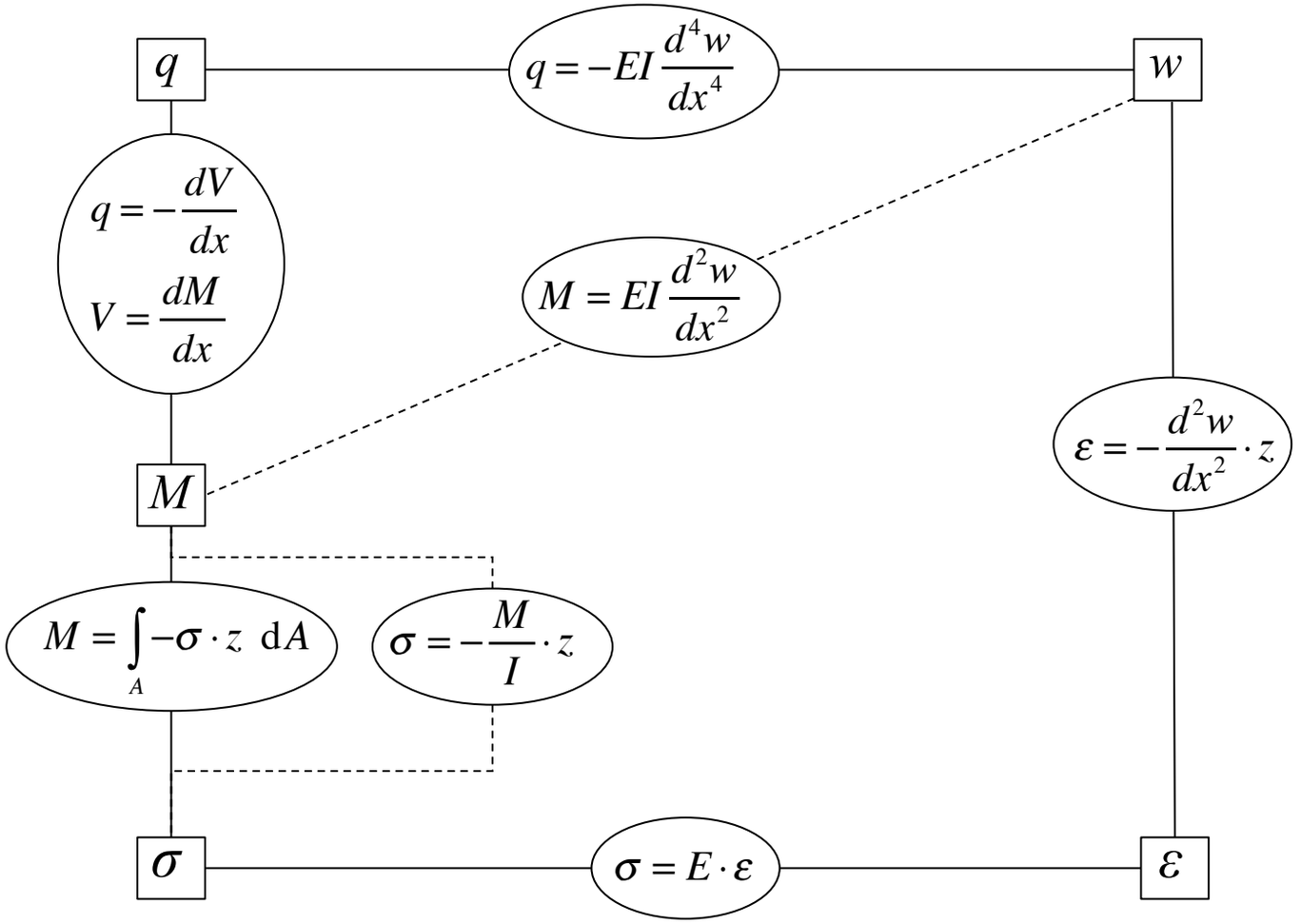
Load:	None	Uniform	Linear	etc.
Bending moment:	Linear	Parabola	3rd order	etc.

- Obtain SFD from BMD (beam equations)
- Obtain AFD from SFD (equilibrium at a point)

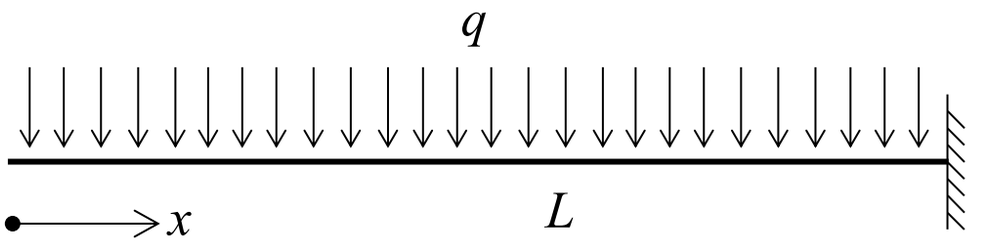
} Good to know because advanced methods give end moments

Beam Equations





Integration



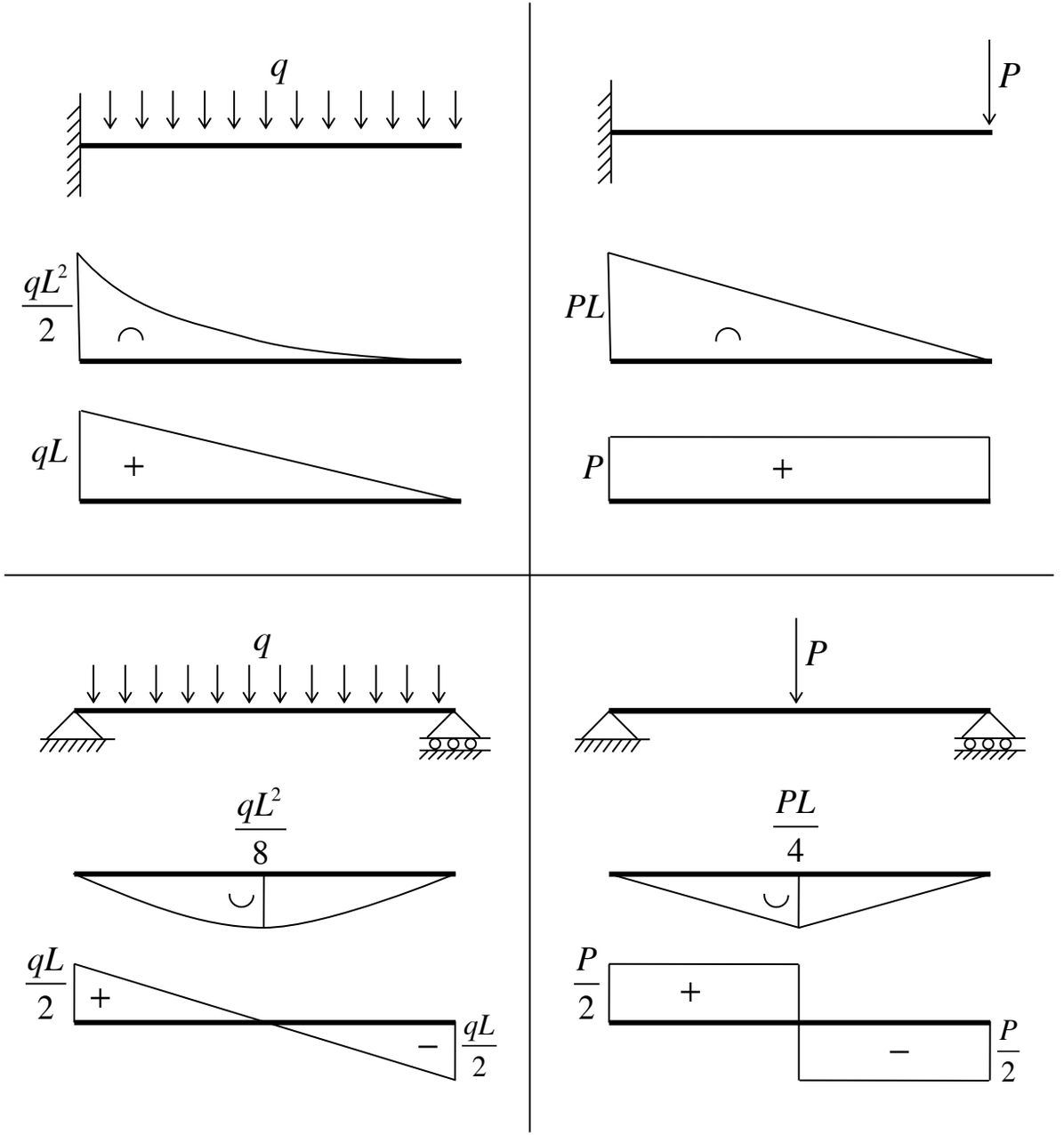
$$V = \int q\, dx = q \cdot x$$

Shear force at base (x=L): V=qL

$$M = \int V\, dx = \int q \cdot x\, dx = \frac{qx^2}{2}$$

Bending moment at base (x=L): $M=qL^2/2$

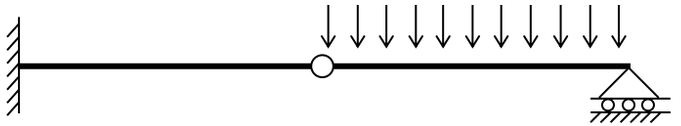
Formulas to Remember

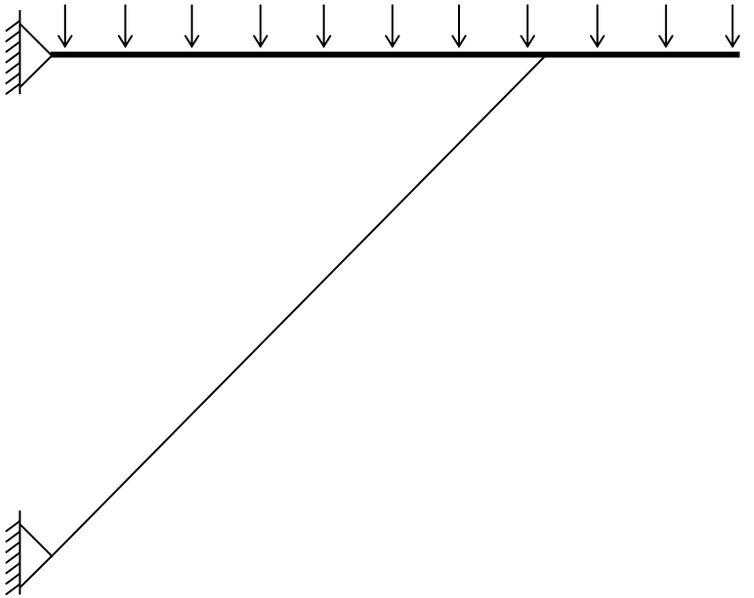


Reactions First?

To be safe, yes…

but sometimes life is easier…





More lectures:

Terje's Toobox:

terje.civil.ubc.ca