Definitions

Q/ what is strength of Materials?

Bodies: are solid objects, like steel cable, gear teeth, beams, and axle shaft. (No liquid, No gases).

Rigid Bodies: means the bodies do not stretch, bend, or twist.

Equilibrium: means the rigid bodies are not accelerating (Not dynamic). Only 3 Equations

Statics: is the study of forces acting in equilibrium on rigid bodies.

Engineering Mechanics: the field of mechanics covers the relations between forces on rigid bodies in statics (equilibrium).

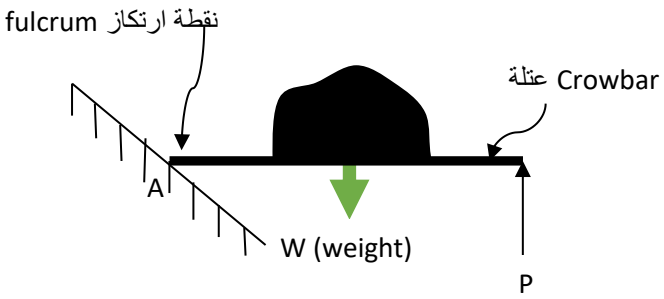
Strength of Materials: study the behavior of materials under loads.

(Investigate the internal resistance and deformations of solid bodies subjected to loads).

Q/ What is the difference between Engineering Mechanics and Strength of Materials?

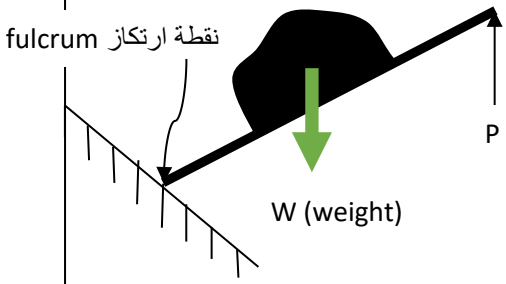
A/

Engineering Mechanics	Strength of Materials
The body in Equilibrium	The body in Equilibrium
The body is **Rigid**	The body is **Not Rigid**



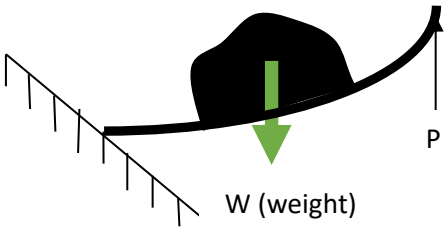
In Mechanics the crowbar must be rigid to lift the weight making a moment around point A.

Rigid member



In strength of materials the crowbar not rigid, therefore we must investigate the bar itself that it will neither break nor bends without lifting the load.

Not Rigid member



The bar bent before lift the weight

The bar broken before lift the weight

Q/ Which is the real assumption, Engineering Mechanics or Strength of Materials?

A/ Strength of Materials.

In Strength of Materials we keep the assumptions of bodies in equilibrium, but we drop the "Rigid" assumption. Because:

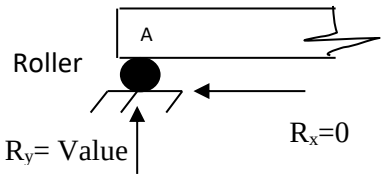
- Real cables stretch under tension.
- Real floor joists bend when you walk across a wood floor.
- Real axle shafts twist under torsion load.

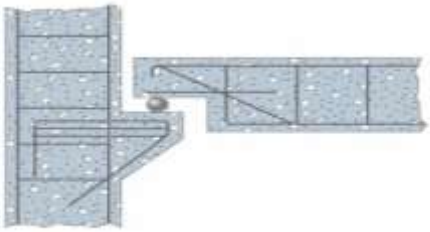
Types of Support:

1- Roller :

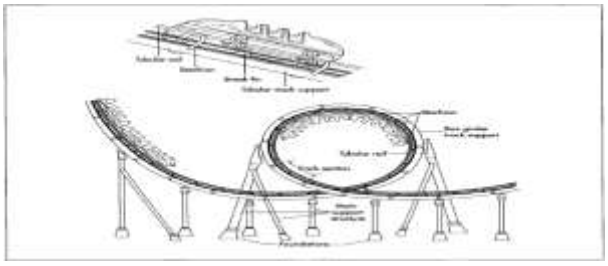
- You can rotate a member at point A, therefore No resistance moment at point A.
- You can move the member horizontally, therefore No resistance force R_x at point A.
- You can Not move the member vertically, there is a force R_y at point A.

∴ 1 unknown force





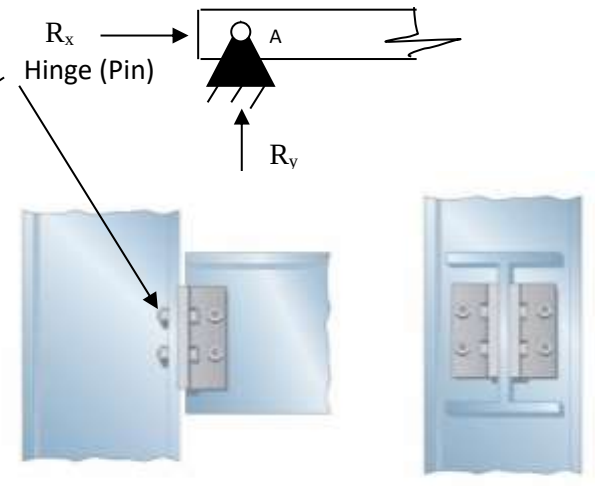
typical "roller-supported" connection (concrete)



2- Hinge (Pin):

- You can rotate a member at point A, therefore No resistance moment at point A.
- You can Not move the member horizontally, there is a force R_x at point A.
- You can Not move the member vertically, there is a force R_y at point A.

∴ 2 unknown force

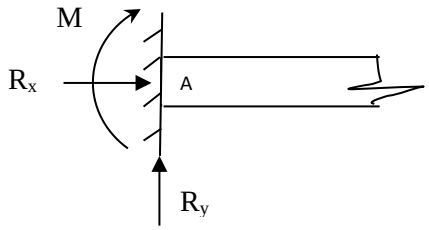


typical "pin-supported" connection (metal)

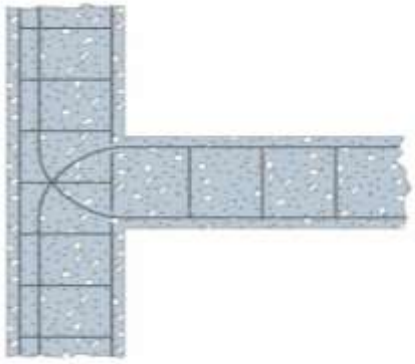
3- Fixed end:

- You can Not rotate a member at point A, there is a moment M at point A.
- You can Not move the member horizontally, there is a force R_x at point A.
- You can Not move the member vertically, there is a force R_y at point A.

∴ 3 unknown force



typical "fixed-supported" connection (metal)



typical "fixed-supported" connection (concrete)

Units

1- SI System of units and prefixes

SI = International System= Metric System

Quantity	Unit	Symbol	Definition
Length	Meter	m	-
Mass	Gram	g	-
Force or Weight	Newton	N	$kg.m/s^2$
Stress or Pressure	Pascal	Pa	N/m^2
Moment or Torque	Newton meter	N.m	-

1 MPa = 1 N/mm^2

1 Pa = 1 N/m^2

Prefix	Abbreviate		Multiplier
Nano-	n	=	10^{-9}
Micro-	μ	=	10^{-6}
Milli-	m	=	10^{-3}
Centi-	c	=	10^{-2}
Kilo-	k	=	10^{3}
Mega-	M	=	10^{6}
Giga-	G	=	10^{9}
Tera-	T	=	10^{12}

2- US System of units and prefixes

US = British Units =English Units

Quantity	Unit	Symbol	Definition
Length	Foot	ft.	-
Force or Weight	Pound	Ib.	-
Stress or Pressure	Pounds per square inch	psi	$Ib./in.^2$
Moment or Torque	Foot pound	ft.Ib.	-

Hint: US unit symbols are abbreviations with period:

write the unit foot “ft.” not “ft”

write the unit inch “in.” not “in”

except for “psi” and “ksi” write without period

Unit		Equivalent conversion factor
1 ft.	=	12 in.
1 yd.	=	3 ft.
1 kip	=	1,000 Ib.
1 ksi	=	1,000 psi
1 ton	=	2,000 Ib.

Prefixes of US System

US System does not use prefixes to indicate scale, except for "kips" for "kilo pounds"

1 kips=1,000 pounds (Ib.), instead of that we use equivalent conversion factor.

Conversion factors between SI and US units:

US unit		SI unit
1 in.	=	2.54 cm
1 ft.	=	30.48 cm
1 Ib.	=	4.448 N
1 psi	=	6895 Pa
1 psi	=	6.895 kPa
1 ksi	=	6.895 MPa

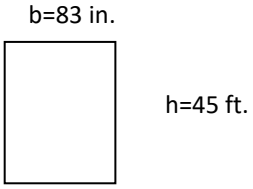
Example 1:

Find the area of triangle in square ft?

$A = b \times h$

$A = 83\ (\text{in.}) \times 45\ (\text{ft.})$

$A = \frac{83}{12}\ (\text{ft.}) * 45\ (\text{ft.}) = 311.25\ \text{ft}^2$



Example 2:

Calculate the stress in psi if $P = 7000\ \text{Ib.}$ and $A = 3\text{ft}^2$

$$\sigma = \frac{P}{A} = \frac{7000\ (\text{Ib.})}{3\ (\text{ft.})^2} = \frac{7000\ (\text{Ib.})}{3 \times (12\ \text{in.})^2} = 16.2\ \text{psi}$$

Example 3: convert 1 GPa to the unit of N/m^2 ?

$$1\ \text{GPa} = 1000 \times (\text{MPa}) = 1000 \times \left(\frac{\text{N}}{\text{mm}^2}\right) = 1000 \times \left(\frac{\text{N}}{(\frac{1}{1000})^2.\text{m}^2}\right) = 10^3 \times \frac{\text{N}}{\text{m}^2} \times 10^6 = 10^9 \frac{\text{N}}{\text{m}^2}$$

$$\text{or } 1\ \text{GPa} = 10^9\ \text{Pa} = 10^9\ \left(\frac{\text{N}}{\text{m}^2}\right)$$