Ministry of high Education and Scientific Research
Southern Technical University
Technological institute of Basra
Department of Civil Techniques

Learning package

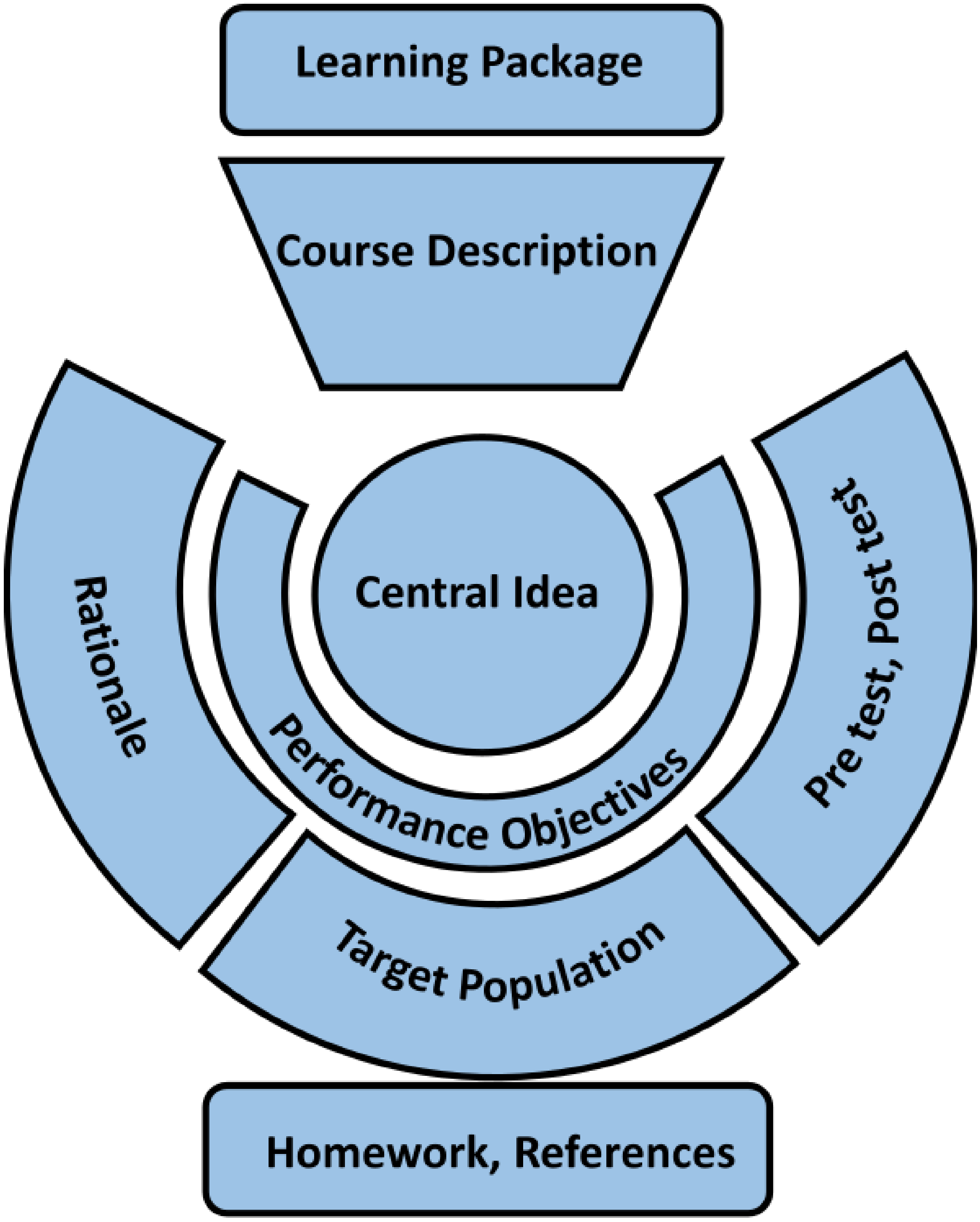
Engineering Mechanics

For

First year students

By

Ms. Aliaa Ghalib Salih
Dep. Of Civil Techniques
2025


Learning Package
Course Description
Central Idea
Rationale
Performance Objectives
Pre test, Post test
Target Population
Homework, References

Course Description

1. Course Name:	
ENGINEEING MECHANINCS	
2. Course Code:	
C1-2	
3. Semester / Year:	
Semester / 1st Year:	
4. Description Preparation Date:	
1/6/2025	
5. Available Attendance Forms:	
Attendance is in-person only.	
6. Number of Credit Hours (Total) / Number of Units (Total)	
90 hours per year (2 theoretical + 1 practicals over 30 weeks) / 6 units (3 units per semester)	
7. Course administrator's name (mention all, if more than one name)	
Name: Aliaa Ghalib Salih Email: aliaa.g.salih.u@stu.edu.iq	
8. Course Objectives	
Course Objectives	Teaching students how to analyze structures and find the resultant forces, stresses, and strains generated in their components as a result of applying external loads, and the relationship of this to the properties of the materials that make up the structural member, and designing engineering structures that meet safety and economic requirements.
9. Teaching and Learning Strategies	
Strategy	1. Cognitive strategies. 2. Active learning strategies. 3. Cooperative learning strategies. 4. Discussion strategies.
10. Course Structure	

Week	Hours	Required Learning Outcomes	Unit or subject name	Learning method	Evaluation method
1st semester					
1 **2** **3** **4** **5** **6** **7** **8** **9** **10** **11** **12** **13** **14** **15**	3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours	1-The student learns the basic principles of engineering mechanics. 2- Acquire basic skills in analyzi structural eleme and finding the resultant forces stresses to be the basis for design structural structures.	1- Definition of mechanics. 2- Analysis composition forces. 3- applications on subject of analysis force. 4- Moment of force 5- Couples. 6- Resultant of convergent, non-convergent and parallel forces. 7- Resultant of convergent, non-convergent and parallel forces. 8- Equilibrium, drawing a free b diagram, equilibrium equations, equilibrium in th case of converge non-convergent parallel forces. 9- Equilibrium, drawing a free b diagram, equilibrium equations, equilibrium in th case of convergent non-convergent, and parallel forces. 10- Distributed loads 11- Types of beams Supports. 12- Analysis of truss by method of joi	Theoretical and practical lectur	Exams and discussions reports.

			13- Analysis of truss by method of sections. 14- Friction, friction theory. 15- Laws of friction, types of friction, applications.		
2nd semester					
1 **2** **3** **4** **5** **6** **7** **8** **9** **10** **11** **12** **13** **14** **15**	3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours		1- Introduction about strength of materials, Centroi of simple shapes. 2- Centroids of complex shapes 3- Moment inertia For the simple Shapes. 4- Moment of inertia for the complex shap 5- Strength of materials, definite of stre types of stresses fac of safety. 6- Stresses applications. 7- hook 's law, relation betwe stress and stra 8- Lateral strain, poison 's ratio applications of relation betwee stress and strain. 9- Bending str for beams Shear forc and bending moment diagram. 10- applications o	Theoretical and practical lectures	Exams and discussions reports.

			bending stress for beams Shear force and bending moment diagrams 11- Bending moment for beams. 12- Applications of Bending moment beams. 13- Shear stress and applications. 14- Beams which making from two materials and their applications 15- Beams which making from two materials and their applications		

11. Course Evaluation

Distribution as follows:40 degree for striving (30 theoretical + 10 practical year).60 marks for final exam

12. Learning and Teaching Resources

Required textbooks (curricular books, if any)	
Main references (sources)	Engineering Mechanics - HKD Engineering Mechanics - Maryam Kraige Engineering Mechanics – Hibbeler Engineering Mechanics – Beer Vector
Recommended books and references (scientific journals, reports…)	Reviewing many scientific journals issued by various Iraqi universities in addition to visits to scientific libraries and the institute's library
Electronic References, Websites	

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Department of Civil Techniques

Learning package

In

General Principle

For

Students of First Year

By

Ms. Aliaa Ghalib Salih
Dep. Of Civil Techniques

2025

1/ Overview

1 / A –Target population :-

For students of First year
Technological institute of Basra
Dep. Of Civil Techniques

1 / B –Rationale :-

Understanding basic principles of engineering mechanics, which is why I have created this modular unit to facilitate learning about this subject.

1 / C –Central Idea :-

1- Definition of mechanics.
2- General review of physics topics related to material topics.
3- Trigonometric ratios of angles, vector and non-vector quantities.

1 / D – Performance Objectives

After studying the this unit, the student will be able to:-

1- Define the science of mechanics and examine its fundamental principles.
2- Discuss and compare the International System of Units and U.S. Customary Units.
3- Discuss how to approach the solution of mechanics problems, and introduce the SMART problem-solving methodology.
4- Examine factors that govern numerical accuracy in the solution of a mechanics problem.

2/ Introduction :

2.1 What is Mechanics?

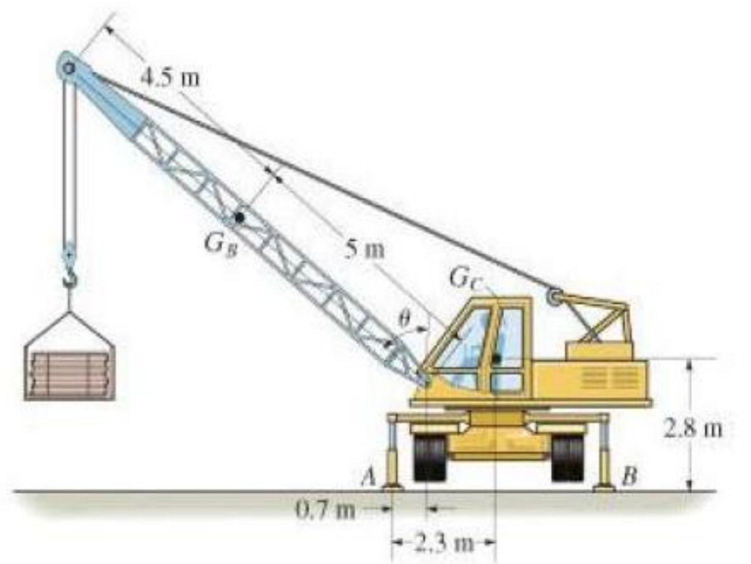
Mechanics is defined as the science that describes and predicts the conditions of rest or motion of bodies under the action of forces. It consists of the mechanics of rigid bodies, mechanics of deformable bodies, and mechanics of fluids.

2.2 Consists of Mechanics into :-

A- Rigid body mechanics

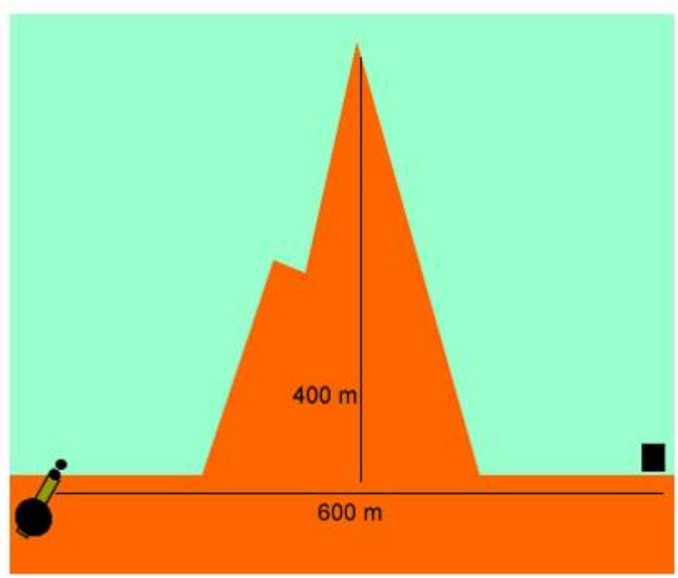
(1) Statics

deals with equilibrium of bodies under action of forces (bodies may be either at rest or move with a constant



(2) Dynamic

deals with motion of bodies (accelerated motion)



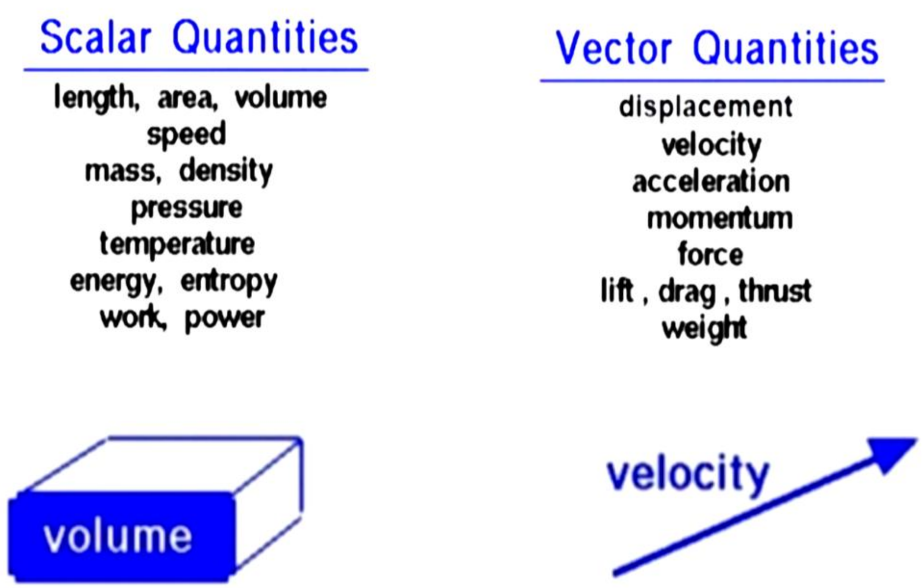
B- deformable body mechanics.

C- fluid mechanics.

3/ Basic Concepts :-

3-1 Scalar & Vector

A scalar quantity has only magnitude, a vector quantity has both magnitude & direction.



3-2 Newton 's Law of Gravitational Attraction

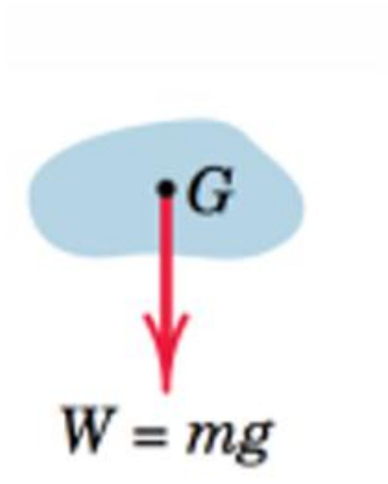
- **Weight of a body (gravitational force acting on a body)** is required to be computed in Statics as well as Dynamics.

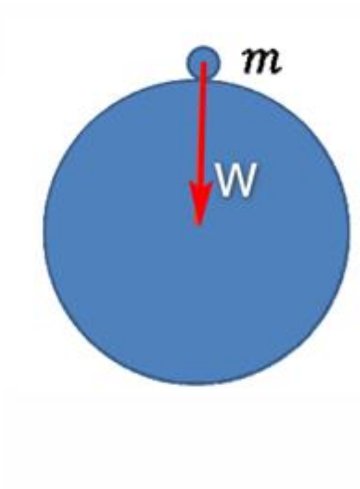
- **<u>Weight of a Body</u>**: If a particle is located at or near the surface of the earth, the only significant gravitational force is that between the earth and the particle

  W=m . g

  Where: m= mass of the body

  g= acceleration due to gravity



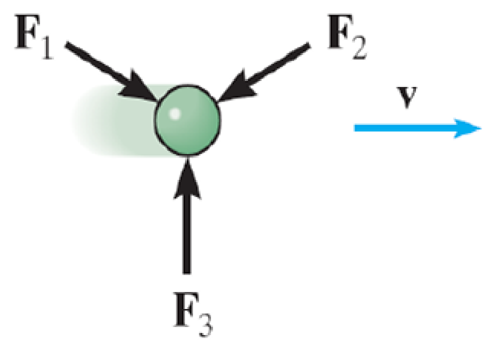


Newton’ s Three Laws of Motion

Basis of formulation of rigid body mechanics.

First Law: A particle originally at rest, or moving in a straight line with constant velocity, tends to remain in this state provided the particle is not subjected to an unbalanced force.

First law contains the principle of the equilibrium of forces → main topic of concern in Statics



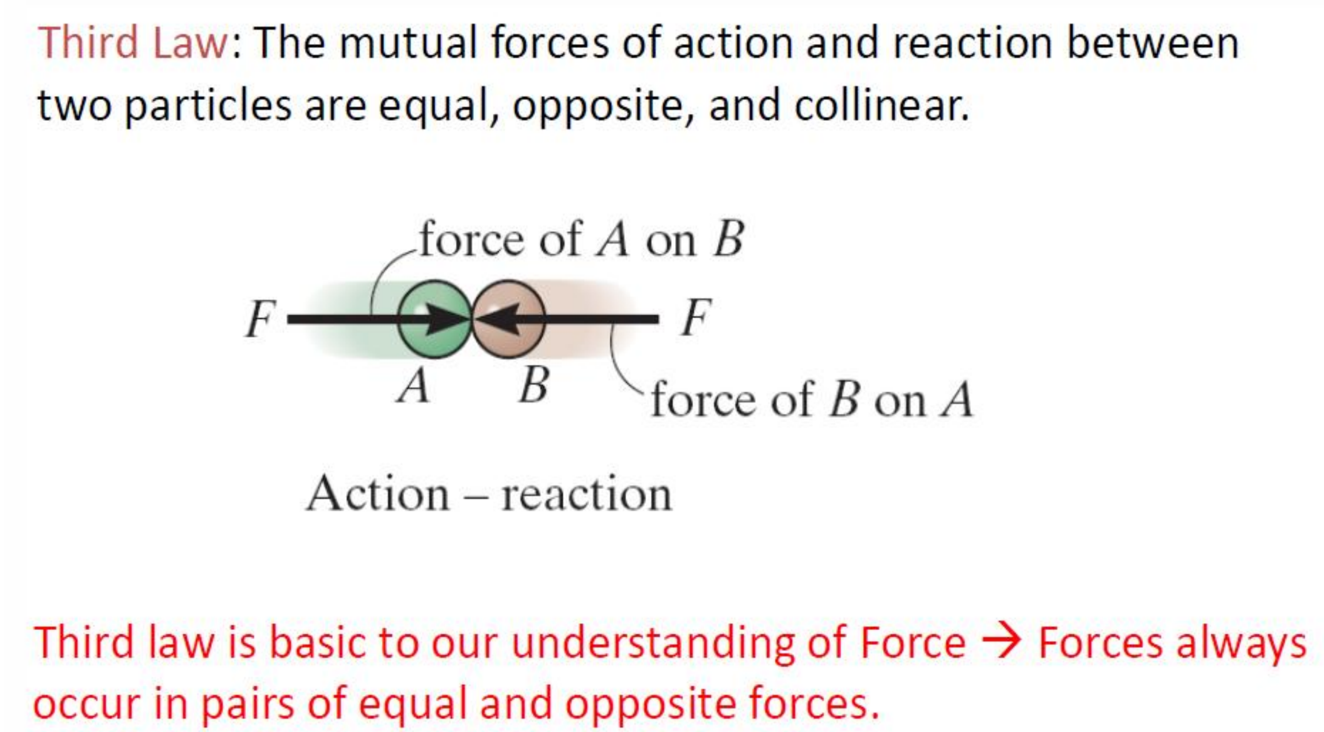
Equilibrium

Second Law: A particle of mass “m” acted upon by an unbalanced force “F” experiences an acceleration “a” that has the same direction as the force and a magnitude that is directly proportional to the force.

$F = ma$

Accelerated motion

Second Law forms the basis for most of the analysis in Dynamics



3-3Trigonometric Functions

The graphs of the sine and cosine functions are shown in following Figure.

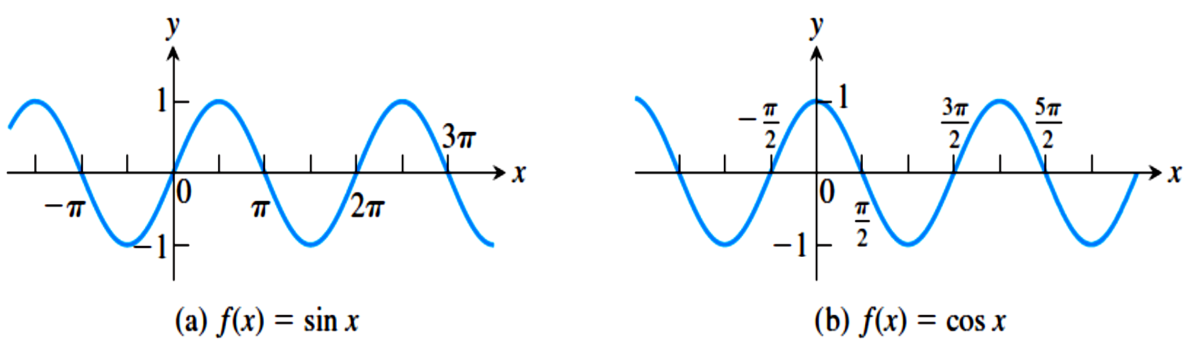
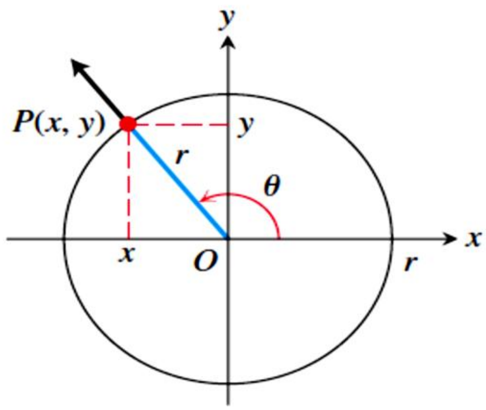


Fig. Graphs of the sine and cosine functions

Table: Angles measured in degrees and radians

Degrees	−180	−135	−90	−45	0	30	45	60	90	120	135	150	180	270	360
θ (radians)	$-\pi$	$\frac{-3\pi}{4}$	$\frac{-\pi}{2}$	$\frac{-\pi}{4}$	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{3\pi}{2}$	2π

3-4 The six basic trigonometric functions



The trigonometric functions of a general angle *θ* are defined in terms of *x*, *y*, and *r*.

sine:	$\sin\theta = \frac{y}{r}$	**cosecant:**	$\csc\theta = \frac{r}{y}$
cosine:	$\cos\theta = \frac{x}{r}$	**secant:**	$\sec\theta = \frac{r}{x}$
tangent:	$\tan\theta = \frac{y}{x}$	**cotangent:**	$\cot\theta = \frac{x}{y}$

$$\tan\theta = \frac{\sin\theta}{\cos\theta} \qquad \cot\theta = \frac{1}{\tan\theta}$$

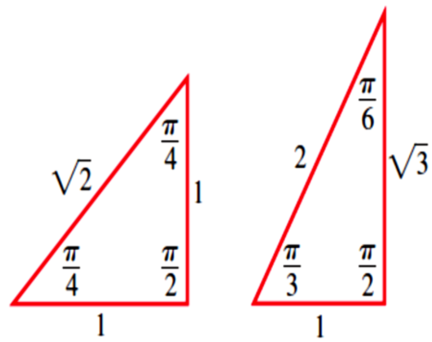
$$\sec\theta = \frac{1}{\cos\theta} \qquad \csc\theta = \frac{1}{\sin\theta}$$

Radian angles and side lengths of two common triangles (45 º, 90 º)

$$\sin\frac{\pi}{4} = \frac{1}{\sqrt{2}} \qquad \sin\frac{\pi}{6} = \frac{1}{2} \qquad \sin\frac{\pi}{3} = \frac{\sqrt{3}}{2}$$

$$\cos\frac{\pi}{4} = \frac{1}{\sqrt{2}} \qquad \cos\frac{\pi}{6} = \frac{\sqrt{3}}{2} \qquad \cos\frac{\pi}{3} = \frac{1}{2}$$

$$\tan\frac{\pi}{4} = 1 \qquad \tan\frac{\pi}{6} = \frac{1}{\sqrt{3}} \qquad \tan\frac{\pi}{3} = \sqrt{3}$$



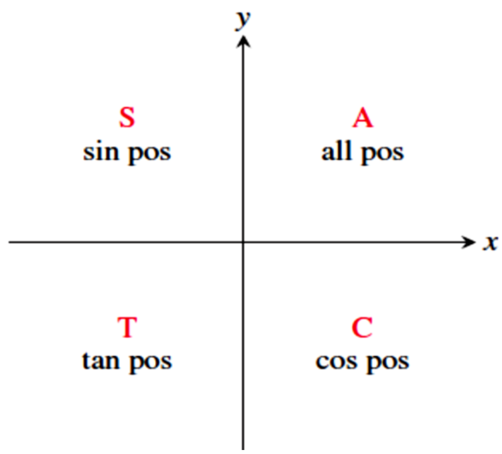


Table: Values of sin *θ*, cos *θ*, and tan *θ* for selected values of *θ*.

Degrees	−180	−135	−90	−45	0	30	45	60	90	120	135	150	180	270	360
θ (radians)	$-\pi$	$\frac{-3\pi}{4}$	$\frac{-\pi}{2}$	$\frac{-\pi}{4}$	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{3\pi}{2}$	2π
$\sin\theta$	0	$\frac{-\sqrt{2}}{2}$	−1	$\frac{-\sqrt{2}}{2}$	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	−1	0
$\cos\theta$	−1	$\frac{-\sqrt{2}}{2}$	0	$\frac{\sqrt{2}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$\frac{-\sqrt{2}}{2}$	$\frac{-\sqrt{3}}{2}$	−1	0	1
$\tan\theta$	0	1		−1	0	$\frac{\sqrt{3}}{3}$	1	$\sqrt{3}$		$-\sqrt{3}$	−1	$\frac{-\sqrt{3}}{3}$	0		0

- **note**

Even
$\cos(-x) = \cos x$
$\sec(-x) = \sec x$

Odd
$\sin(-x) = -\sin x$
$\tan(-x) = -\tan x$
$\csc(-x) = -\csc x$
$\cot(-x) = -\cot x$

3-5 SI units (International system of units)

The **International System of Units,** known by the international abbreviation **SI** in all languages. and sometimes as the **SI system**, is the modern form of the metric system.

Table 1.1 The common prefixes used in SI units and the multiples they represent.

Prefix	Abbreviation	Multiple
nano-	n	10^{-9}
micro-	μ	10^{-6}
milli-	m	10^{-3}
kilo-	k	10^{3}
mega-	M	10^{6}
giga-	G	10^{9}

Table1-2 Si units

Length	الطول	m
Area	المساحه	.m2
Volume	الحجم	.m3
Mass	الكتله	-g
Weight	الوزن	N
Density	الكثافه	.g/m3
Unit weight	وحدة الوزن	N/m3
Specific gravity	الوزن النوعي	No units
Stress		KN/m2

Table 1.3 Unit conversions.

Time	1 minute	=	60 seconds
	1 hour	=	60 minutes
	1 day	=	24 hours
Mass	1 slug	=	14.59 kilograms
Force	1 pound	=	4.448 newtons

Length	1 foot	=	12 inches
	1 mile	=	5280 feet
	1 inch	=	25.4 millimeters
	1 foot	=	0.3048 meters
Angle	2π radians	=	360 degrees

4/ Post test :-

1- What is the weight in newtons of an object that has a mass of (a) 8 kg, (b) 0.04 kg, and (c) 760 Mg?

2- Represent each of the following combinations of units in the correct SI form: (a) /KN/μs, (b) Mg/mN, and (c) MN/(kg · ms).

key answer :-

post test:-

1-

(a) $W = 9.81(8) = 78.5\text{ N}$

(b) $W = 9.81(0.04)(10^{-3}) = 3.92(10^{-4})\text{ N} = 0.392\text{ mN}$

(c) $W = 9.81(760)(10^{3}) = 7.46(10^{6})\text{ N} = 7.46\text{ MN}$

2-

(a) $\text{kN}/\mu\text{s} = 10^{3}\text{N}/(10^{-6})\text{s} = \text{GN/s}$

(b) $\text{Mg/mN} = 10^{6}\text{g}/10^{-3}\text{N} = \text{Gg/N}$

(c) $\text{MN}/(\text{kg}\cdot\text{ms}) = 10^{6}\text{N}/\text{kg}(10^{-3}\text{s}) = \text{GN}/(\text{kg}\cdot\text{s})$

5/ HomeWorks: -

1- Determine the weight in newtons of a car whose mass is 1400 kg. Convert the mass of the car to slugs and then determine its weight in pounds?

2- What is the mass in both slugs and kilograms of a 3000-lb car?

6/References :-

1- Engineering Mechanics - Maryam Kraige
2- Engineering Mechanics – Hibbeler
3- Engineering Mechanics – Beer Vector

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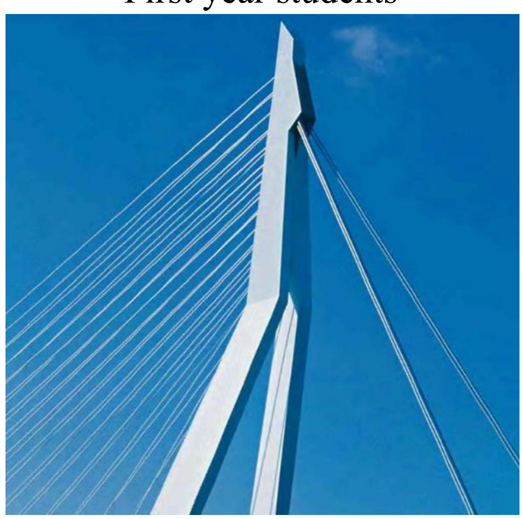
Learning package

In

Resultant of forces system

For

First year students



By

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Dep. Of Civil Techniques

2025

1/ Overview

1 / A –Target population :-

For students of First year
Technological institute of Basra
Dep. Of Civil Techniques

1 / B –Rationale :-

To understand the effects of forces which act on engineering structures and mechanisms.

1 / C –Central Idea :-

Analysis and composition of forces, force triangle law and force polygon

1 / D – Performance Objectives

After studying this unit, the student will be able to:-

1- Describe force as a vector quantity.
2- Examine vector operations useful for the analysis of forces.

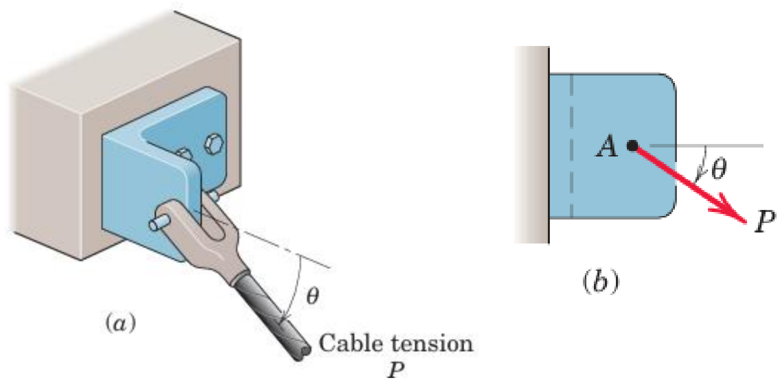
3- Determine the resultant of multiple forces acting on a particle.
4- Resolve forces into components.
5- Add forces that have been resolved into rectangular components.
6- Introduce the concept of the free-body diagram.
7- Use free-body diagrams to assist in the analysis of planar and spatial particle equilibrium problems.

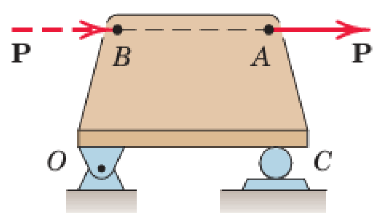
2/ Pretest :

3/ Resultant of forces system :-

3-1 Define force

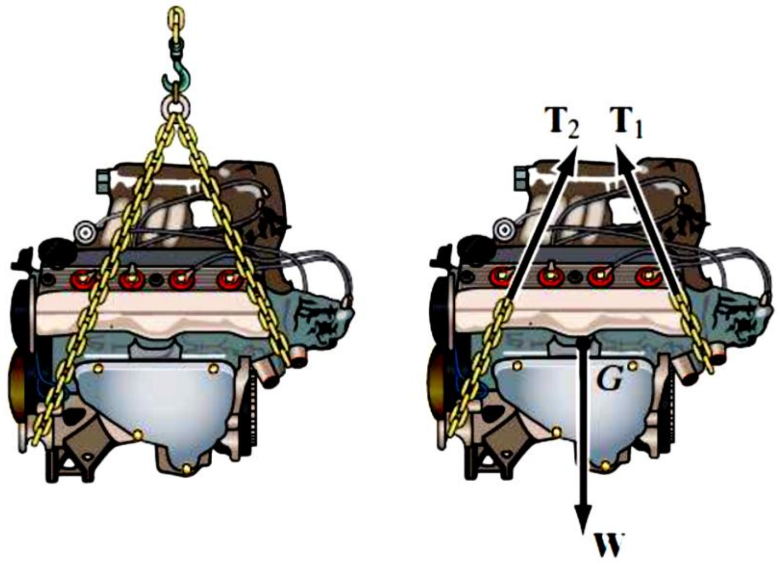
A force is the action of one body on another. A force tends to move a body in the direction of its action. The action of a force is characterized by its magnitude, by the direction of its action, and by its point of application. Thus, force is a vector quantity, because its effect depends on the direction as well as on the magnitude of the action. Thus, forces may be combined according to the parallelogram law of vector addition.

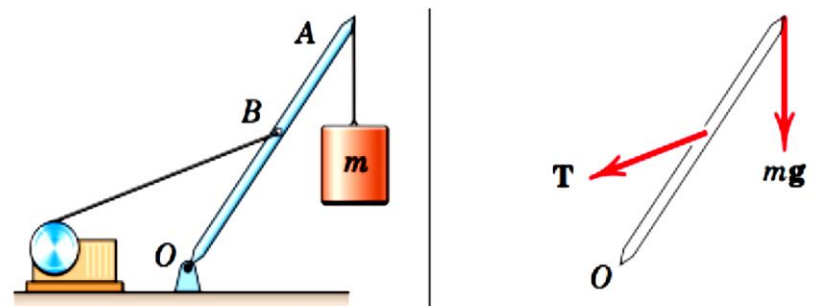


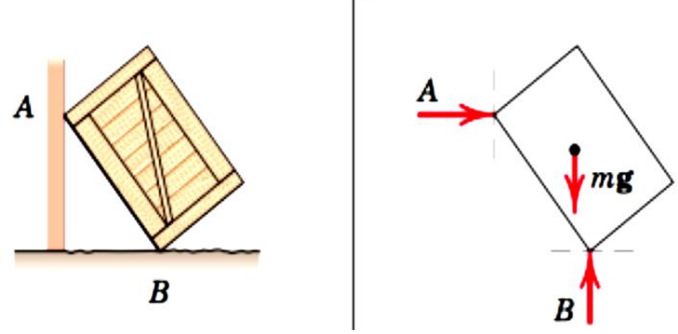


3-2 Free body diagram (FBD)

This diagram is a sketch of the outlined shape of the body, which represents it as being isolated or “free” from its surroundings, i.e., “free body”. On this sketch it is necessary to show all the forces and couple moments that the surroundings exert on the body so that these effects can be accounted for when the equations of equilibrium are applied.


T2 T1
G
W


A
B
m
O
T
mg
O

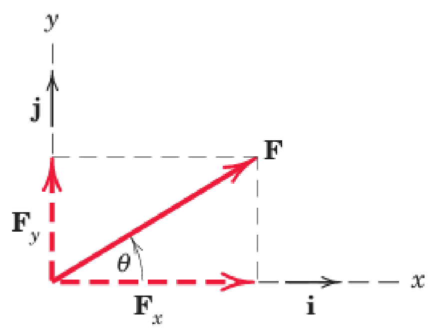

A
B
A
mg
B

3-3 TWO-DIMENSIONAL FORCE SYSTEMS: -

3-3-1 Rectangular Components: -

The most common two-dimensional resolution of a force vector is into rectangular components. It follows from the parallelogram rule that the vector F, may be written as,

$$F_R = F_x + F_y$$

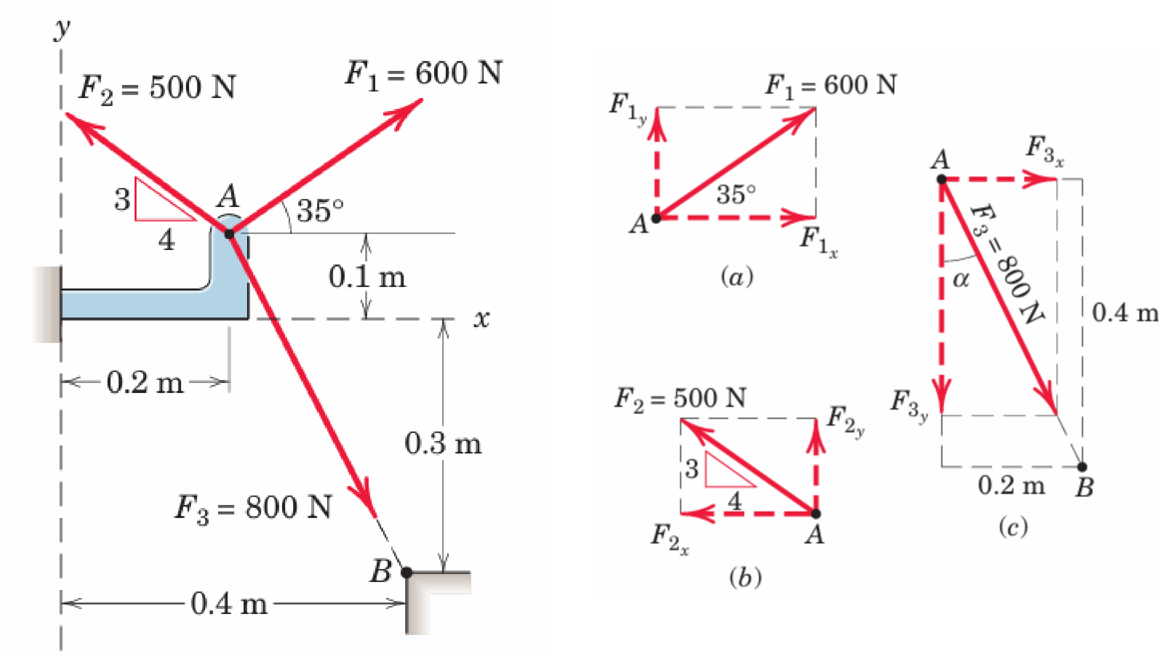


where F_x and F_y are vector components of F in the x- and y-directions. Each of the two vector components may be written as a scalar time the appropriate unit vector.

$$F_x = F\cos\theta \qquad F = \sqrt{F_x^2 + F_y^2}$$

$$F_y = F\sin\theta \qquad \theta = \tan^{-1}\frac{F_y}{F_x}$$

Exmple1/ The forces F1, F2, and F3, all of which act on point A of the bracket, are specified in three different ways. Determine the x-and y-scalar components of each of the three forces.



Solution. The scalar components of F1, are:

$$F_{1_x} = 600 \cos 35° = 491 \text{ N}$$

$$F_{1_y} = 600 \sin 35° = 344 \text{ N}$$

The scalar components of $\mathbf{F}_2$, from Fig. *b*, are

$$F_{2_x} = -500(\tfrac{4}{5}) = -400 \text{ N}$$

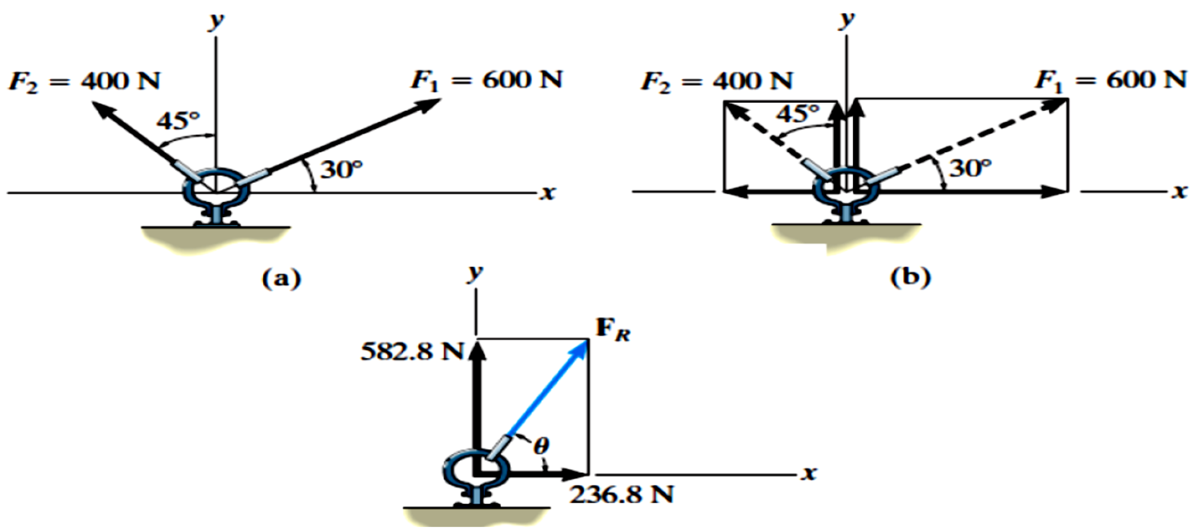
$$F_{2_y} = 500(\tfrac{3}{5}) = 300 \text{ N}$$

$$\alpha = \tan^{-1}\left[\frac{0.2}{0.4}\right] = 26.6^\circ$$

$$F_{3_x} = F_3 \sin\alpha = 800 \sin 26.6^\circ = 358 \text{ N}$$

$$F_{3_y} = -F_3 \cos\alpha = -800 \cos 26.6^\circ = -716 \text{ N}$$

Example 2/



The link in Fig. 2–19*a* is subjected to two forces $\mathbf{F}_1$ and $\mathbf{F}_2$. Determine the magnitude and direction of the resultant force .

SOLUTION I

Scalar Notation. First we resolve each force into its x and y components, Fig. 2–19*b*, then we sum these components algebraically.

$$\xrightarrow{+} (F_R)_x = \Sigma F_x; \qquad (F_R)_x = 600 \cos 30^\circ \text{ N} - 400 \sin 45^\circ \text{ N}$$
$$= 236.8 \text{ N} \rightarrow$$

$$+\uparrow (F_R)_y = \Sigma F_y; \qquad (F_R)_y = 600 \sin 30^\circ \text{ N} + 400 \cos 45^\circ \text{ N}$$
$$= 582.8 \text{ N} \uparrow$$

The resultant force, shown in Fig. 2–19*c*, has a *magnitude* of

$$F_R = \sqrt{(236.8 \text{ N})^2 + (582.8 \text{ N})^2}$$
$$= 629 \text{ N} \qquad \textit{Ans.}$$

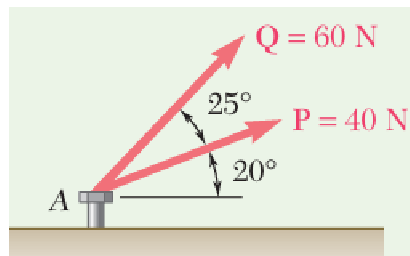
From the vector addition,

$$\theta = \tan^{-1}\left(\frac{582.8 \text{ N}}{236.8 \text{ N}}\right) = 67.9^\circ \qquad \textit{Ans.}$$

will show that Cartesian vector analysis is very beneficial for solving three-dimensional problems.

4/ Post test :-

Two forces P and Q act on a bolt A. Determine their resultant?



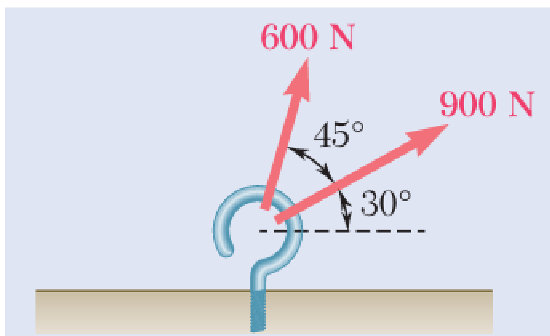
key answer :-

1- post test :-

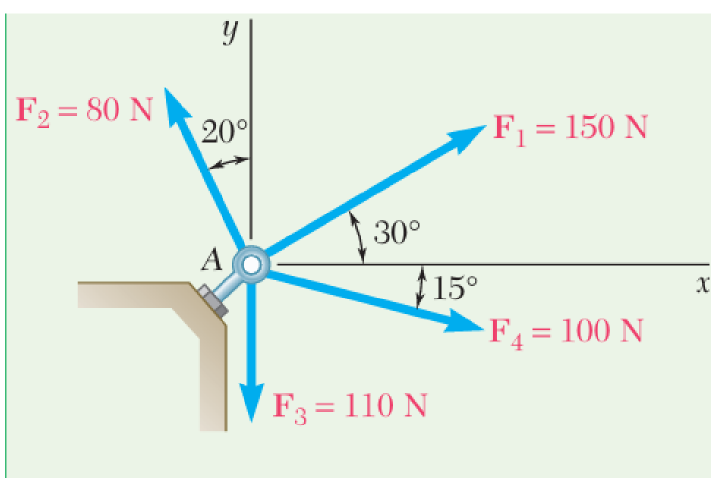
R=97.73 N

5/ HomeWorks: -

a. Two forces are applied as shown to a hook. Determine graphically the magnitude and direction of their resultant using the triangle rule.



b. Four forces act on bolt A as shown. Determine the resultant of the forces on the bolt.



<u>**6 / References**</u>

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In

Concept of moment

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1/ Overview

1 / A –Target population :-

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1 / B –Rationale :-

To understand the ability to move an object in the direction of its application, force can also lead to rotating an object around an axis, this is called moment.

1 / C –Central Idea :-

The magnitude moment of this tendency depends on both the magnitude F of the force and the effective length d of the wrench handle.

1 / D – Performance Objectives

After studying the third unit, the student will be able to:-

1. Define the moment of a force about a point.
2. Examine vector and scalar products, useful in analysis involving moments.
3. Define the moment of a couple, and consider the particular properties of couples.

2/ Introduction :

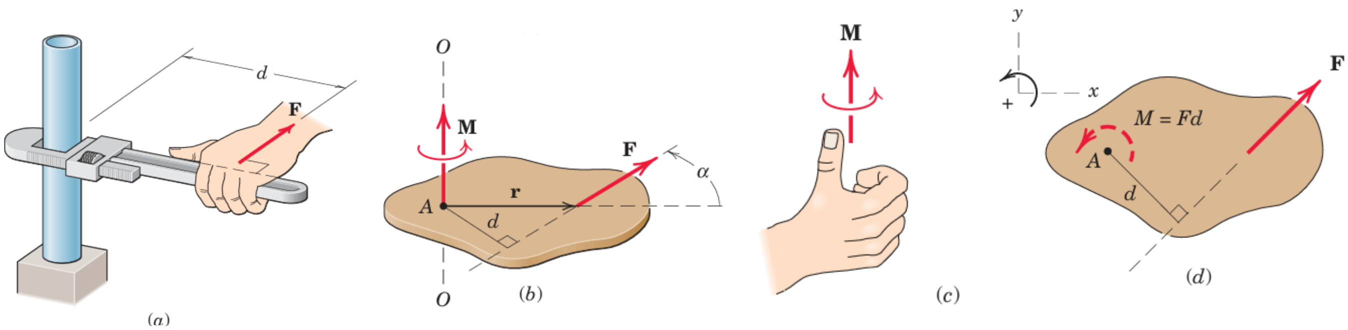
2.1 Moment of a Force about a Point

Figure 3-1 shows a two-dimensional body acted on by a force F in its plane. The magnitude of the moment or tendency of the force to rotate the body about the axis O-O perpendicular to the plane of the body is proportional both to the magnitude of the force and to the moment arm d, which is the perpendicular distance from the axis to the line of action of the force. Therefore, the magnitude of the moment is defined as

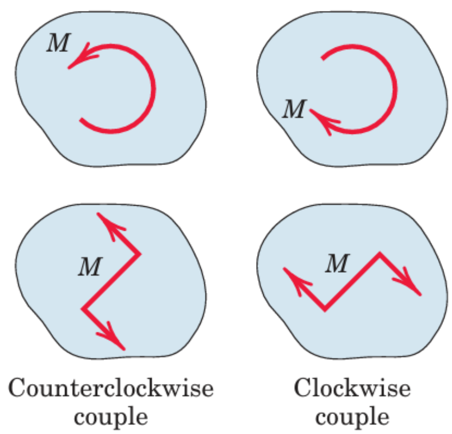
$$M = Fd$$

F: the magnitude of the force,

d: the perpendicular distance from the axis to the line of action of the force.

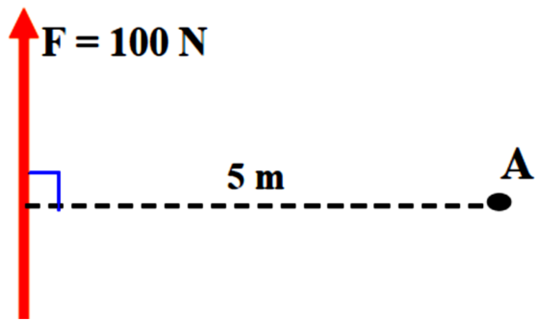


Direction. The direction of M_O is defined by its moment axis, which is perpendicular to the plane that contains the force *F* and its moment arm *d*. A direction of force moment about any point either in clockwise or counterclockwise.



- The unit of the moment is ***N.m.***

Example 1/ Calculate the magnitude of the moment of the force F about point A.



Solution:

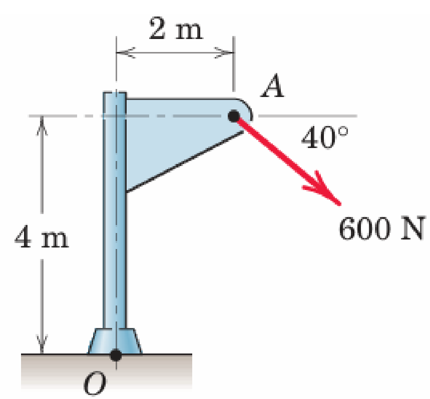
$$M_{F/o} = +\ 100 \times 5 = +\ 1000\ N.m$$

Example2/ Calculate the magnitude of the moment about the base point Oof the 600-N force in five different ways?

Solution/

$$d = 4 \cos 40° + 2 \sin 40° = 4.35\ m$$

$$M_O = 600(4.35) = 2610\ N \cdot m$$



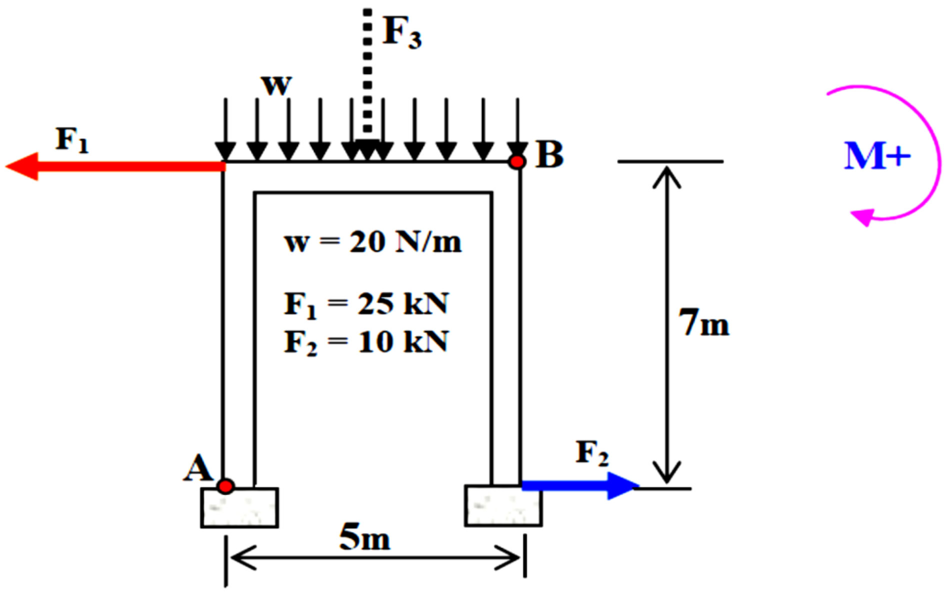
Example 3/ The frame below is subjected to some forces:

a- Calculate moment of force F_1 about point A, $M_{F1/A}$.

b- Calculate moment of force F_2 about point A, $M_{F2/A}$.

c- Calculate moment of force F_2 about point B, $M_{F2/B}$.

d- Calculate moment of force W about point B, M $_{w/A}$.



Solution:

a-

$$M_{F1/A} = -F_1 \times 7 = -25 \times 7 = -175 \text{ kN.m}$$

b-

$$M_{F2/A} = F_2 \times 0 = 0$$

c-

$$M_{F2/B} = -F_2 \times 7 = -10 \times 7 = -70 \text{ kN.m}$$

d-

$$F_3 = 20 \times 5 = 100 \text{ N}$$

$$M_{w/B} = M_{F3/B} = -100 \times 5/2 = -250 \text{ N.m}$$

3/Varignon's Theorem:-

One of the most useful principles of mechanics is Varignon's theorem, which states that the moment of a force about any point is equal to the sum of the moments of the components of the force about the same point.

To prove this theorem, consider the force R acting in the plane of the body shown in Fig. 2/9a. The forces P and Q represent any two non-rectangular components of R. The moment of R about point O is

$$\mathbf{M_O = r \times R}$$

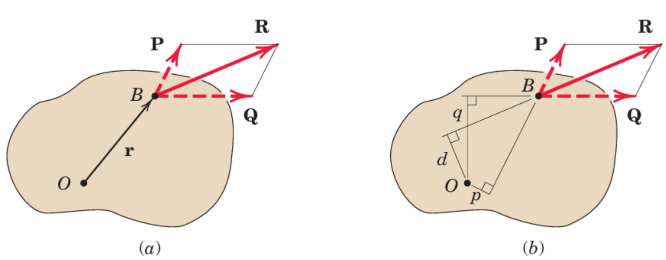
Because R=P + Q, we may write

$$\mathbf{r \times R = r \times (P + Q)}$$

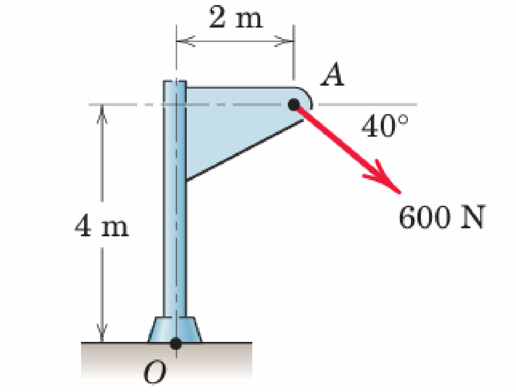
Using the distributive law for cross products, we have

$$\mathbf{M_O = r \times R = r \times P + r \times Q}$$

$$\mathbf{Mo = M_x + M_y = r \times F_x + r \times F_y}$$



Example/ Calculate the magnitude of the moment about the base point Oof the 600-N force in five different ways.



$$F_1 = 600 \cos 40° = 460 \text{ N}, \qquad F_2 = 600 \sin 40° = 386 \text{ N}$$

By Varignon's theorem, the moment becomes

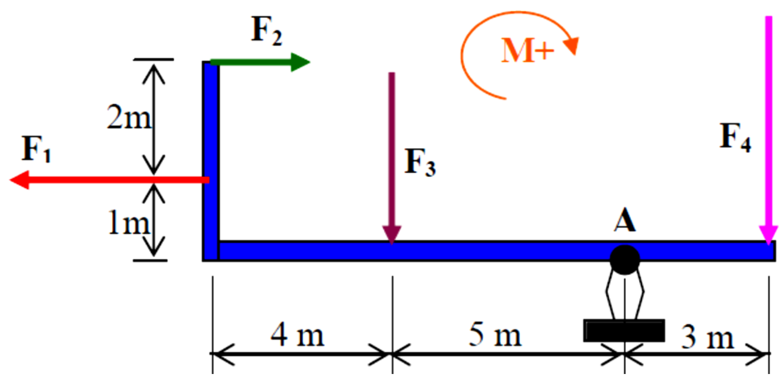
$$M_O = 460(4) + 386(2) = 2610 \text{ N}\cdot\text{m}$$

4/Moment of forces :-

If the body is subjected to forces (F_1, F_2, F_3,……), the moment of forces about point o, (M_o) equal to sum. of moment of single force about the same point;

$$\Sigma M_O = M_O = MF_{1/O} + MF_{2/O} + MF_{3/O} + \ldots$$

Example 1/ Calculate the moment of all the forces about point A.



$F_1 = 70$ KN
$F_2 = 20$ KN
$F_3 = 50$ KN
$F_4 = 100$KN

Soultion:

$$\Sigma M_A = M_A = MF_{1/A} + MF_{2/A} + MF_{3/A} + MF_{4/A}$$
$$= -F_1 \times 1 + F_2 \times 3 - F_3 \times 5 + F_4 \times 3$$
$$= -70 + 60 - 250 + 300$$
$$\Sigma M_A = M_A = +\,40 \text{ kN.m}$$

5/Moment of a couple :-

The moment produced by two equals, opposite, and noncollinear forces is called a couple. Couples have certain unique properties and have important applications in mechanics.

Two forces F_1 and F_2, having the same magnitude, parallel lines of action, and opposite sense, are said to form a couple. Clearly, the sum of the components of the two forces in any direction is zero. The sum of the moments of the two forces about a given point, however, is not zero. The two forces do not cause the body on which they act to move along a line (translation), but they do tend to make it rotate.

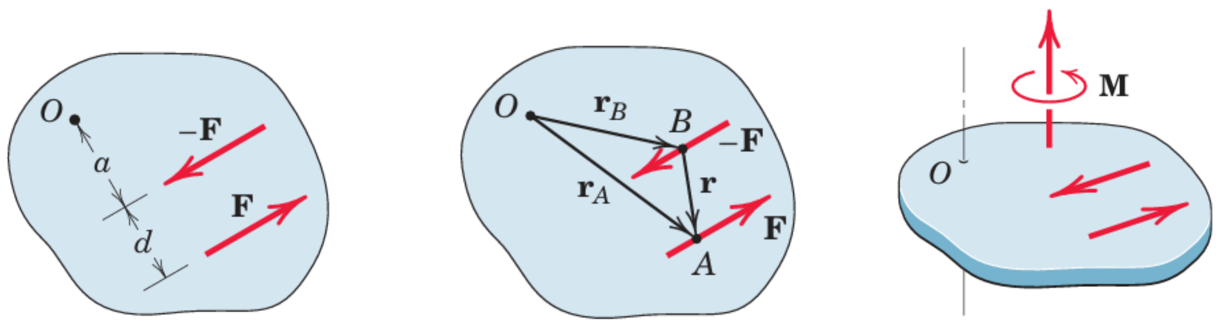


Photo 3.1
The parallel upward and downward forces of equal magnitude exerted on the arms of the lug nut wrench are an example of a couple.

Example1/

Determine the resultant couple moment of the three couples acting on the plate in Fig. 4–30.

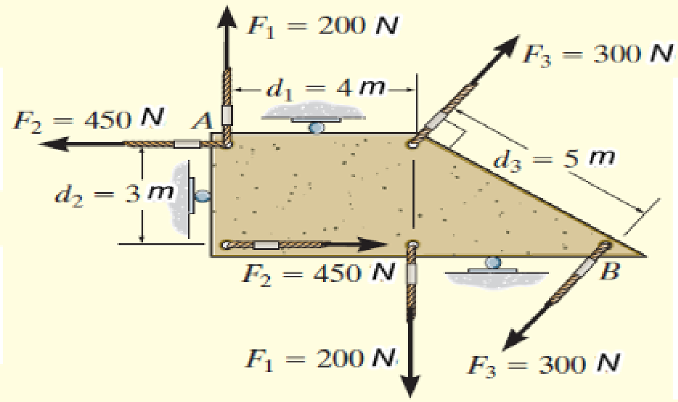


Fig. 4–30

SOLUTION

As shown the perpendicular distances between each pair of couple forces are $d_1 = 4$ m, $d_2 = 3$ m, and $d_3 = 5$ m. Considering counterclockwise couple moments as positive, we have

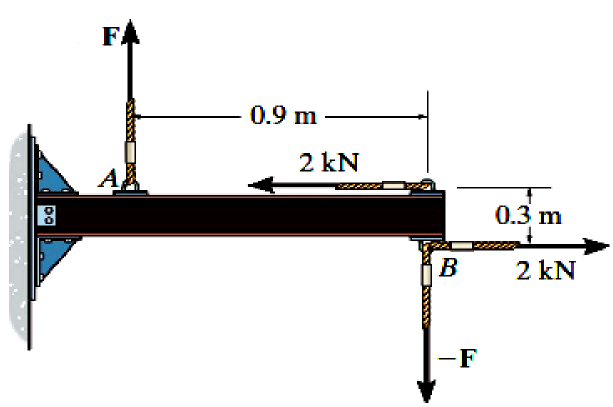
$$\circlearrowleft + M_R = \Sigma M; \quad M_R = -F_1 d_1 + F_2 d_2 - F_3 d_3$$

$$= -(200 \text{ N})(4 \text{ m}) + (450 \text{ N})(3 \text{ m}) - (300 \text{ N})(5 \text{ m})$$

$$= -950 \text{ lb} \cdot \text{ft} = 950 \text{ N} \cdot \text{m} \circlearrowright \qquad \textit{Ans.}$$

The negative sign indicates that $\mathbf{M}_R$ has a clockwise rotational sense.

Example2/ Determine the magnitude of F so that the resultant couple moment acting on the beam is 1.5 KN.m clockwise.



Solution:

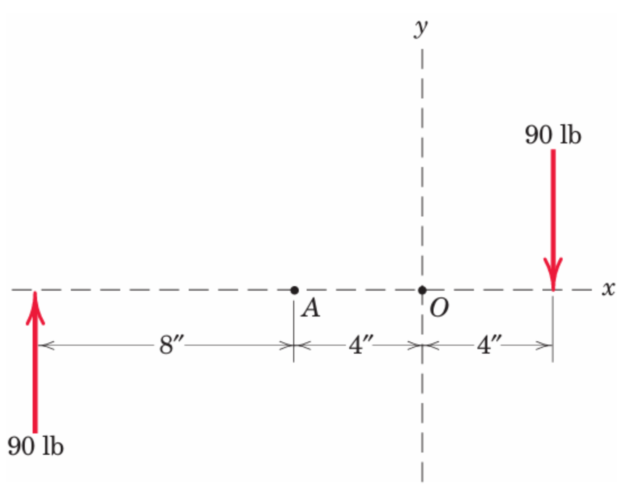
M = F*(0.9) - (2)*(0.3)

1.5 = 0.9 F- 0.6

F = 2.33 kN

6/ Post Test :-

Compute the combined moment of the two 90-lb forces about point O.



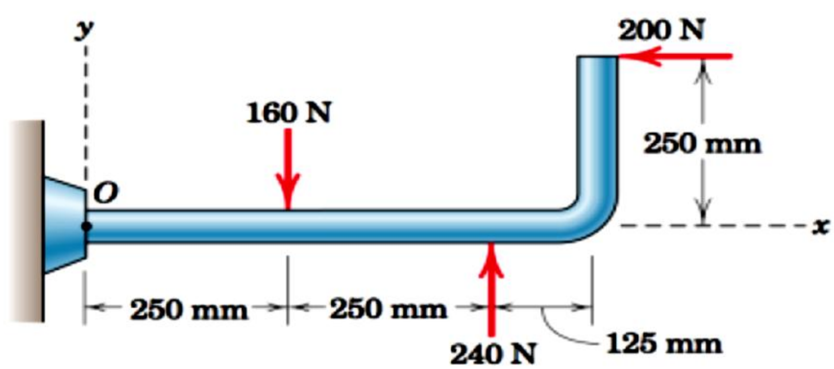
key answer :-

post test:-

M_O = 720 KN.m

7/ HomeWorks: -

Q/ Calculate the moment of all the forces about point O.



8/References :-

4- Engineering Mechanics - Maryam Kraige
5- Engineering Mechanics – Hibbeler
6- Engineering Mechanics – Beer Vector

Ministry of high Education and Scientific Research
Southern Technical University
Technological institute of Basra
Department of Civil Techniques

Learning package

In

Equilibrium

For

First year students

By

Ms. Aliaa Ghalib Salih
Dep. of Civil Techniques

2025

1/ Overview

1 / A –Target population :-

For students of First year
Technological institute of Basra
Dep. Of Civil Techniques

1 / B –Rationale :-

To understand the make continual use of the concepts developed in involving forces, moments, couples, and resultants as we apply the principles of equilibrium.

2 / C –Central Idea :-

When a body is in equilibrium, the resultant of all forces acting on it is zero.

1 / D – Performance Objectives

After studying this unit, the student will be able to:-

1- Analyze the static equilibrium of rigid bodies in two and three dimensions.
2- Consider the attributes of a properly drawn free-body diagram, an essential tool for the equilibrium analysis of rigid bodies.
3- Examine rigid bodies supported by statically indeterminate reactions and partial constraints.
4- Study two cases of particular interest: the equilibrium of two-force and three-force bodies.

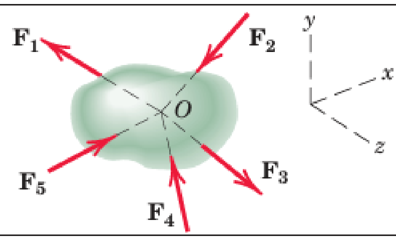
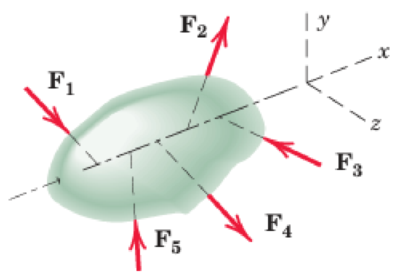
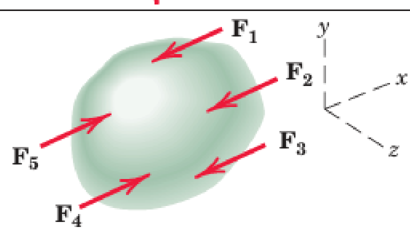
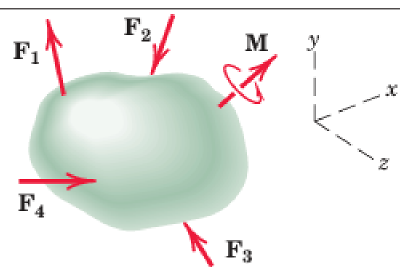
2/ Pretest :

3/ Equilibrium :-

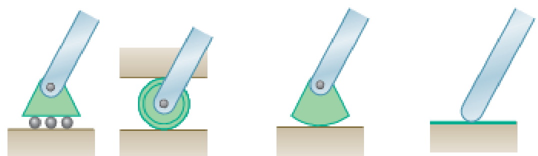
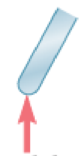
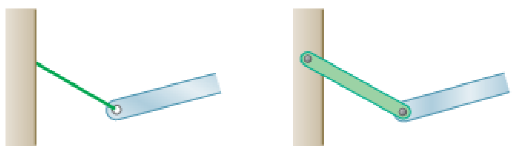
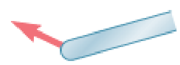
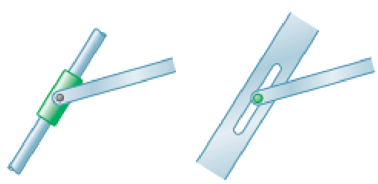
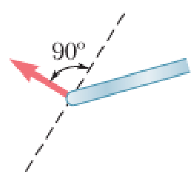
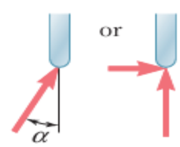
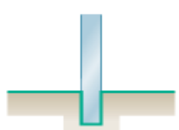
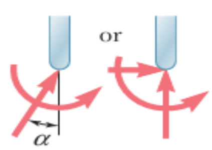
3-1 Define equilibrium:-

The external forces acting on a rigid body to a force-couple system at some arbitrary point O. When the force and the couple are both equal to zero, the external forces form a system equivalent to zero, and the rigid body is said to be in **equilibrium**.

When a body is in equilibrium, the resultant of all forces acting on it is zero.

CATEGORIES OF EQUILIBRIUM IN THREE DIMENSIONS		
Force System	Free-Body Diagram	Independent Equations
1. Concurrent at a point		$\Sigma F_x = 0$ $\Sigma F_y = 0$ $\Sigma F_z = 0$
2. Concurrent with a line		$\Sigma F_x = 0$ $\Sigma M_y = 0$ $\Sigma F_y = 0$ $\Sigma M_z = 0$ $\Sigma F_z = 0$
3. Parallel		$\Sigma F_x = 0$ $\Sigma M_y = 0$ $\Sigma M_z = 0$
4. General		$\Sigma F_x = 0$ $\Sigma M_x = 0$ $\Sigma F_y = 0$ $\Sigma M_y = 0$ $\Sigma F_z = 0$ $\Sigma M_z = 0$

3-2 Reactions for a Two-Dimensional Structure:-

Support or Connection	Reaction	Number of Unknowns
 Rollers; Rocker; Frictionless surface	 Force with known line of action perpendicular to surface	1
 Short cable; Short link	 Force with known line of action along cable or link	1
 Collar on frictionless rod; Frictionless pin in slot	 Force with known line of action perpendicular to rod or slot	1
 Frictionless pin or hinge; Rough surface	 Force of unknown direction	2
 Fixed support	 Force and couple	3

This rocker bearing supports the weight of a bridge. The convex surface of the rocker allows the bridge to move slightly horizontally.

Links are often used to support suspended spans of highway bridges.

Force applied to the slider exerts a normal force on the rod, causing the window to open.

Pin supports are common on bridges and overpasses.

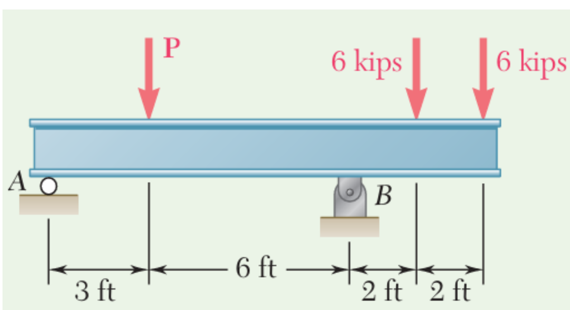
This cantilever support is fixed at one end and extends out into space at the other end.

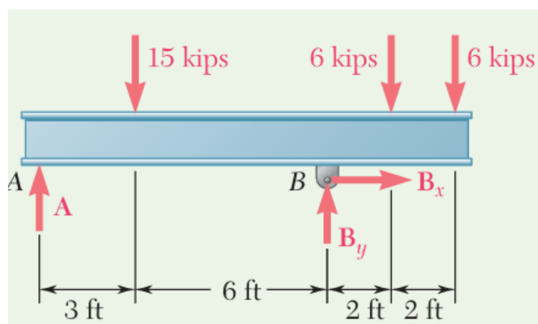
3-3 Equilibrium Conditions

we defined equilibrium as the condition in which the resultant of all forces and moments acting on a body is zero. Stated in another way, a body is in equilibrium if all forces and moments applied to it are in balance.

$$\Sigma F_x = 0 \qquad \Sigma F_y = 0 \qquad \Sigma M_A = 0$$

Example1/ Three loads are applied to a beam as shown. The beam is supported by a roller at A and by a pin at B. Neglecting the weight of the beam, determine the reactions at A and B when P=15 kips.





Solution/

$\xrightarrow{+} \Sigma F_x = 0: \qquad B_x = 0 \qquad \mathbf{B}_x = 0$ ◀

$+\circlearrowleft \Sigma M_A = 0:$

$$-(15 \text{ kips})(3 \text{ ft}) + B_y(9 \text{ ft}) - (6 \text{ kips})(11 \text{ ft}) - (6 \text{ kips})(13 \text{ ft}) = 0$$

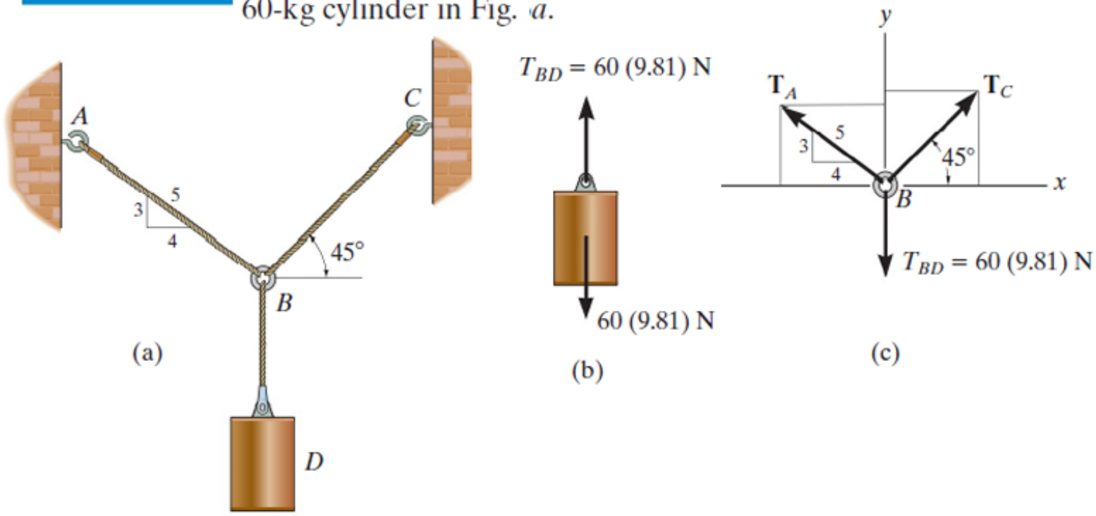
$B_y = +21.0 \text{ kips} \qquad \mathbf{B}_y = 21.0 \text{ kips} \uparrow$ ◀

$+\circlearrowleft \Sigma M_B = 0:$

$$-A(9 \text{ ft}) + (15 \text{ kips})(6 \text{ ft}) - (6 \text{ kips})(2 \text{ ft}) - (6 \text{ kips})(4 \text{ ft}) = 0$$

$A = +6.00 \text{ kips} \qquad \mathbf{A} = 6.00 \text{ kips} \uparrow$ ◀

EXAMPLE Determine the tension in cables BA and BC necessary to support the 60-kg cylinder in Fig. a.



SOLUTION

$$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad T_C \cos 45° - \left(\tfrac{4}{5}\right)T_A = 0 \qquad (1)$$

$$+\uparrow \Sigma F_y = 0; \qquad T_C \sin 45° + \left(\tfrac{3}{5}\right)T_A - 60(9.81)\text{ N} = 0 \qquad (2)$$

Equation (1) can be written as $T_A = 0.8839T_C$. Substituting this into Eq. (2) yields

$$T_C \sin 45° + \left(\tfrac{3}{5}\right)(0.8839T_C) - 60(9.81)\text{ N} = 0$$

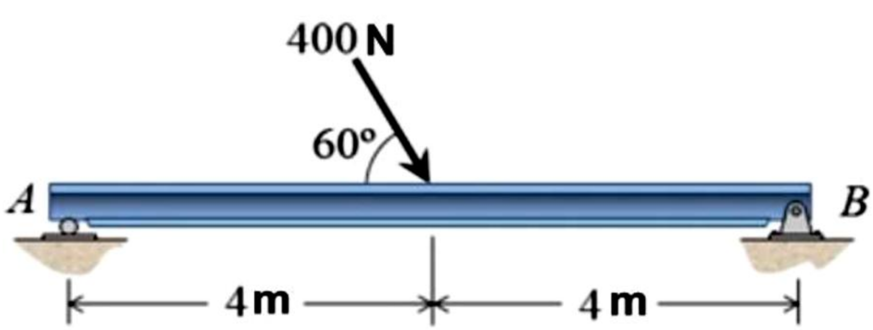
so that

$$T_C = 475.66\text{ N} = 476\text{ N} \qquad \textit{Ans.}$$

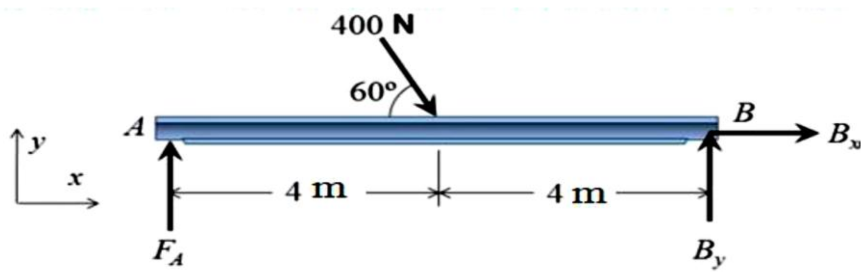
Substituting this result into either Eq. (1) or Eq. (2), we get

$$T_A = 420\text{ N} \qquad \textit{Ans.}$$

Example 3 / Determine the support reactions at the roller at A and the pin at B. Neglect the weight and size of the beam.

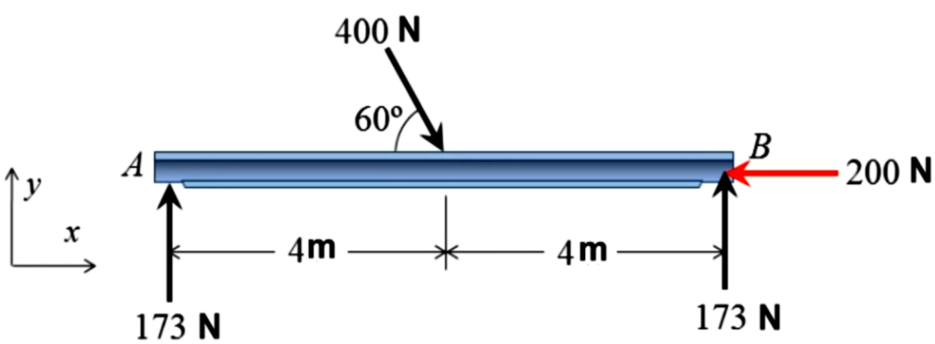


Solution:



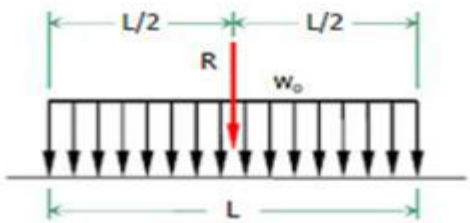
$$\sum F_x = 400 \cdot \cos 60^\circ + B_x = 0$$
$$\sum F_y = F_A - 400 \cdot \sin 60^\circ + B_y = 0$$
$$\sum M_B = -F_A \cdot 8 + 400 \cdot \sin 60^\circ \cdot 4 = 0$$

$$\therefore \begin{cases} F_A = 173\ \mathrm{N} \\ B_x = -200\ \mathrm{N} \\ B_y = 173\ \mathrm{N} \end{cases}$$



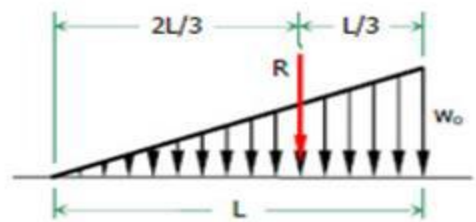
3-4 Resultant of Distributed Loads

The resultant of a distributed load is equal to the area of the load diagram. It is acting at the centroid of that area as indicated. The figure below shows the three common distributed loads namely; rectangular load, triangular load, and trapezoidal load.



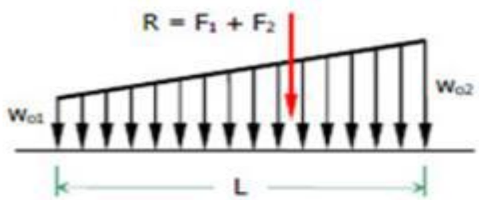
Rectangular Load

$R = w_o L$



Triangular Load

$R = \frac{1}{2} w_o L$



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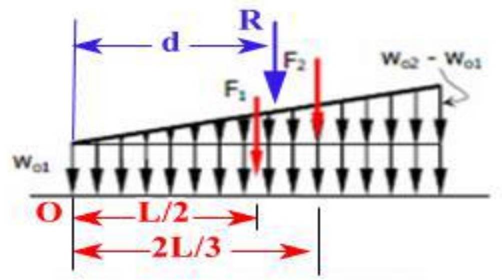
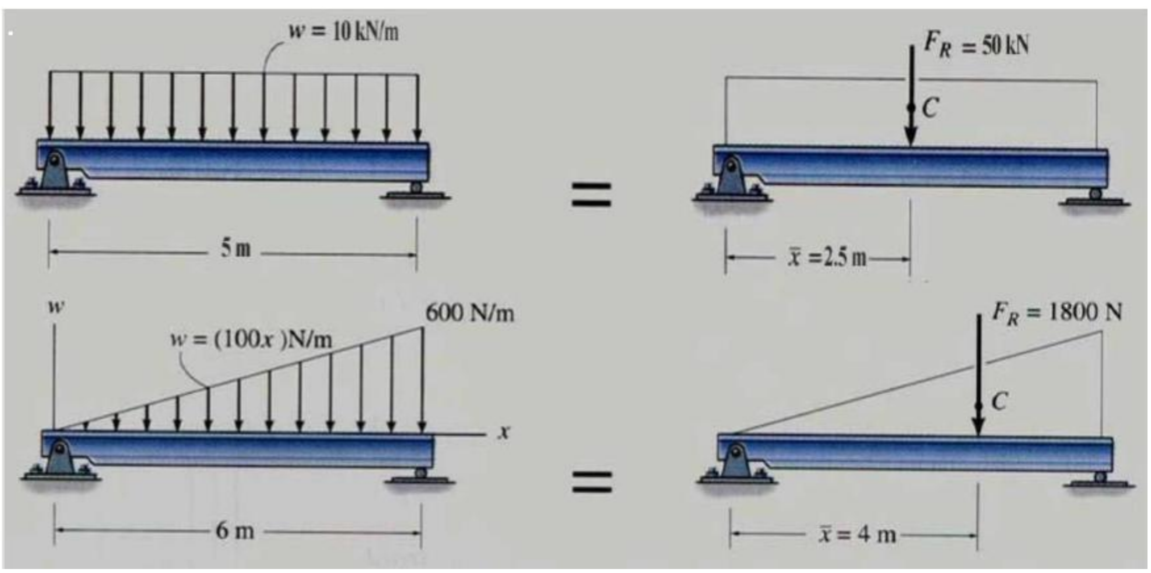


Trapezoidal Load

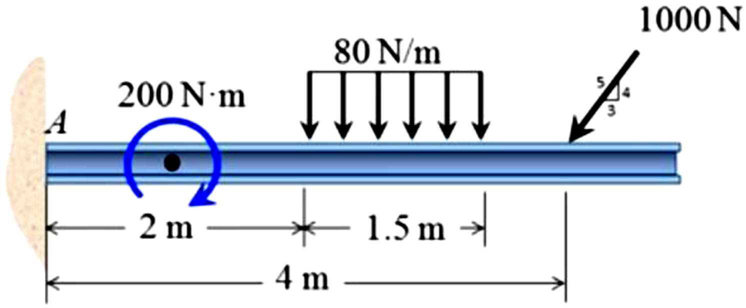
$R = w_{o1} L + \frac{1}{2}(w_{o2} - w_{o1}) L$

R.d= F1* L/2+F2* 2L/3



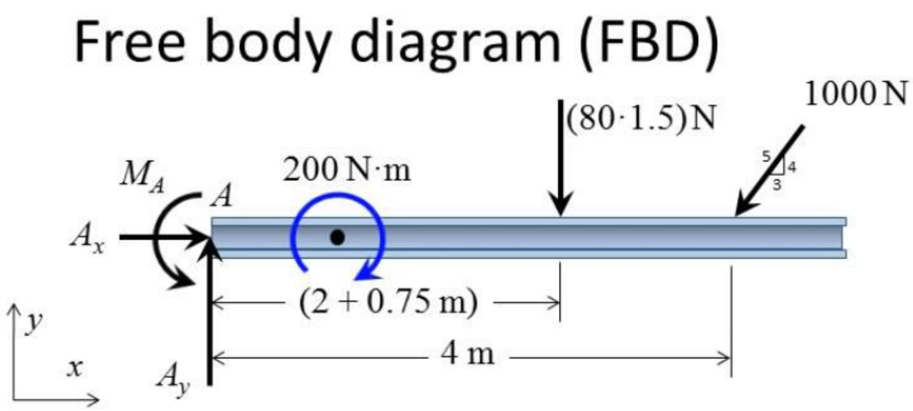
Example1:

Determine the support reactions at the fixed support, A. Neglect the weight and size of the beam.



Solution

There are 3 unknowns & 3 equilibrium Eqs. Therefore, the problem can be solved.



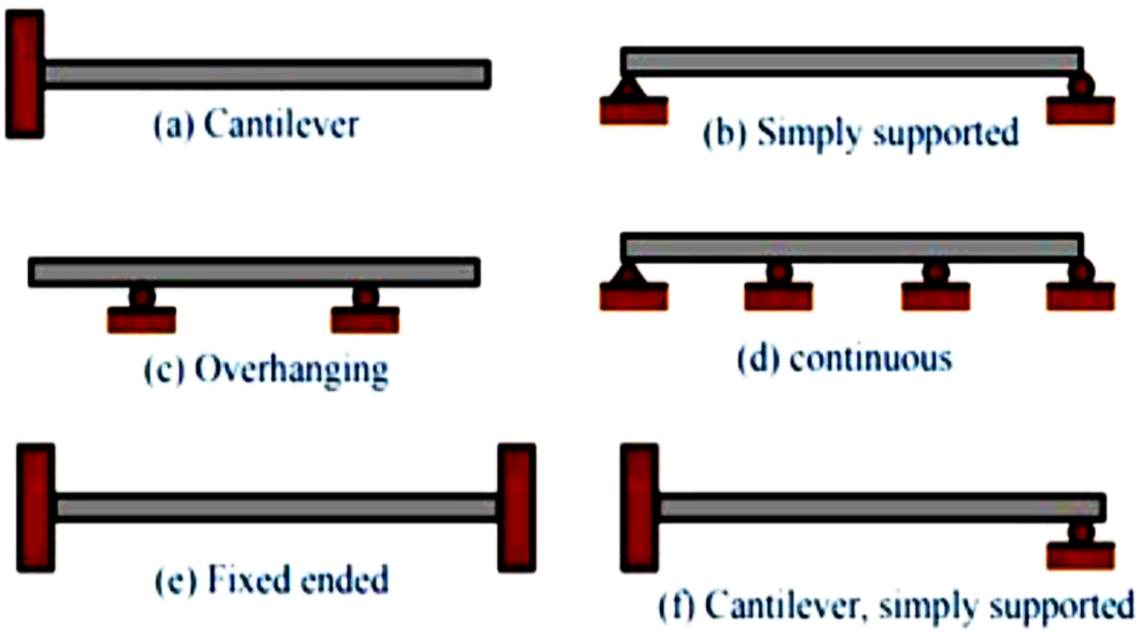
$$\sum F_x = A_x - \frac{3}{5}\cdot 1000\text{N} = 0$$

$$\sum F_y = A_y - 80\cdot 1.5\text{N} - \frac{4}{5}\cdot 1000\text{N} = 0$$

$$\sum M_A = M_A - 200\text{N}\cdot\text{m} - 80\cdot 1.5\text{N}\cdot 2.75\text{m} - \frac{4}{5}\cdot 1000\text{N}\cdot 4\text{m} = 0$$

$$\therefore \begin{cases} A_x = 600\ \text{N} \\ A_y = 920\ \text{N} \\ M_A = 3730\ \text{N}\cdot\text{m} \end{cases}$$

3-5 Types of Beams

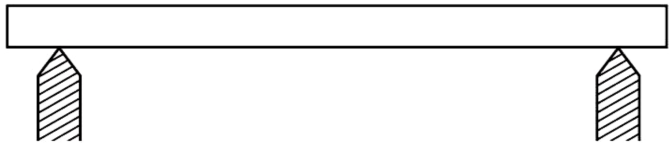


a- Cantilever beam

A beam which is fixed at one end and free at the other end, is known as cantilever beam. Such beam is shown in Fig.

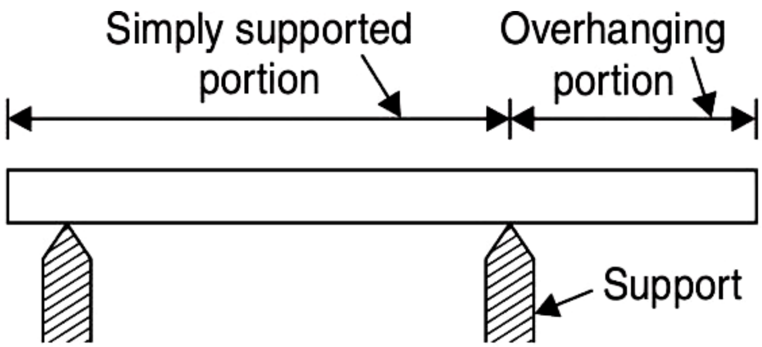
b- Simply Supported beam

A beam supported or resting freely on the supports at its both ends, is known as simply supported beam. Such beam is shown in Fig.



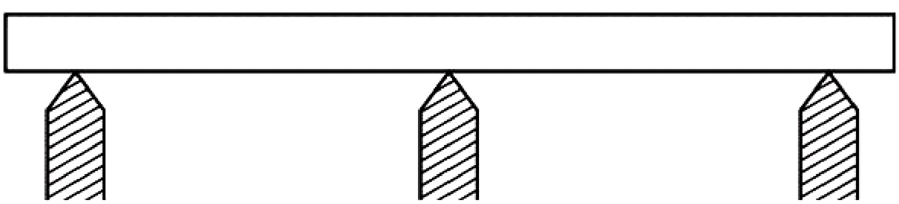
c- Overhanging Beam

If the end portion of a beam is extended beyond the support, such beam is known as overhanging beam. Overhanging beam is shown in Fig.



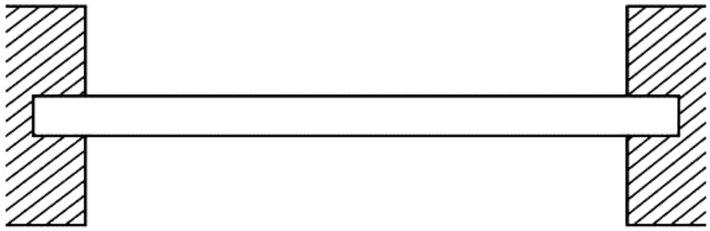
d- Continuous Beam

A beam which is provided more than two supports as shown in Fig. is known as continuous beam.



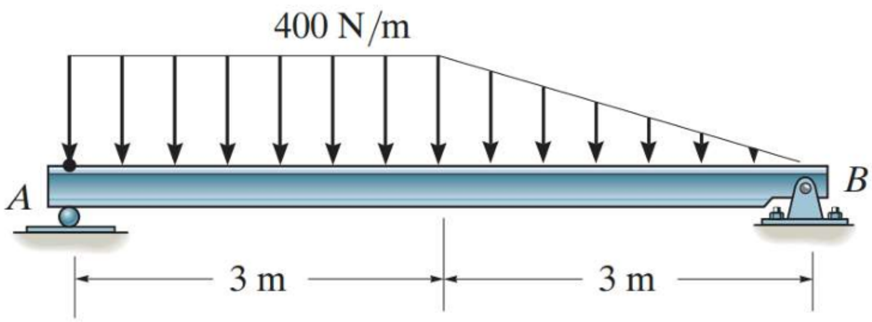
e- Fixed Beam

A beam whose both ends are fixed or built-in walls, is known as fixed beam. Such beam is shown in Fig. A fixed beam is also known as a built-in or encased beam.

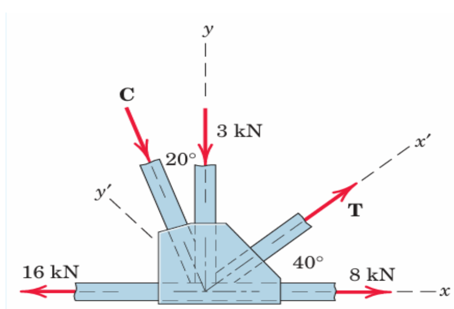


4/ Post test :-

1. Replace the loading by an equivalent resultant force and couple moment acting at point A.



2. Determine the magnitudes of the forces CandT, which, along with the other three forces shown, act on the bridge-truss joint.



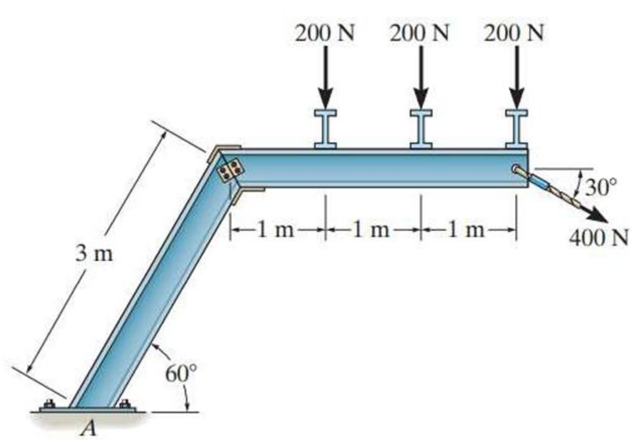
key answer :-

post test :-

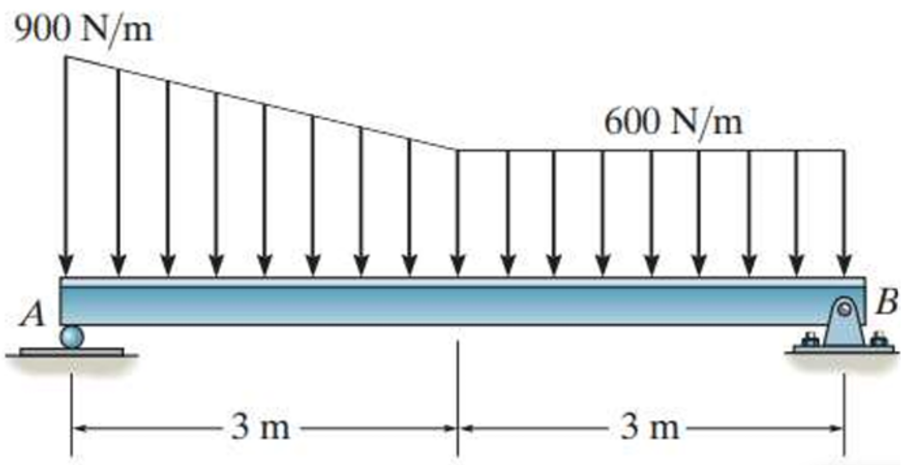
1. FR = -180 N, Moment about point A = - 4200 N. m (clockwise).
2. T 9.09 kN, C 3.03 kN

5/ HomeWorks: -

1. Determine the components of reaction at the fixed support A. Neglect the thickness of the beam.



2. Determine the reactions at the supports.



6 / References

1-Engineering Mechanics - Maryam Kraige
2-Engineering Mechanics – Hibbeler
3-Engineering Mechanics – Beer Vector

Ministry of high Education and Scientific Research
Southern Technical University
Technological institute of Basra
Department of Civil Techniques

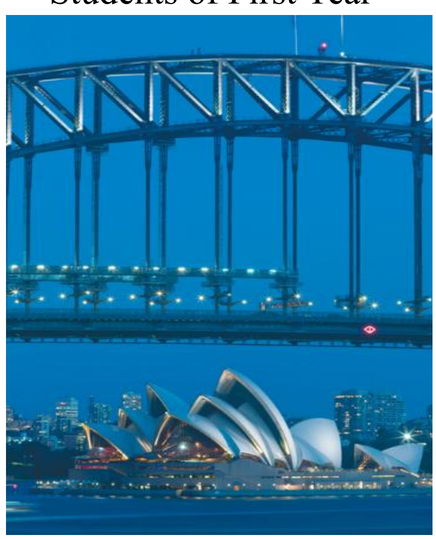
Learning package

In

Truss

For

Students of First Year



By

Ms. Aliaa Ghalib Salih
Dep. Of Civil Techniques

2025

1/ Overview

1 / A –Target population :-

For students of First year
Technological institute of Basra
Dep. Of Civil Techniques

1 / B –Rationale :-

To understand the analysis of trusses, frames and machines, and beams under concentrated loads constitutes a straightforward application of the material developed.

1 / C –Central Idea :-

A framework composed of members joined at their ends to form a rigid structure is called a truss.

1 / D – Performance Objectives

After studying the this unit, the student will be able to:-

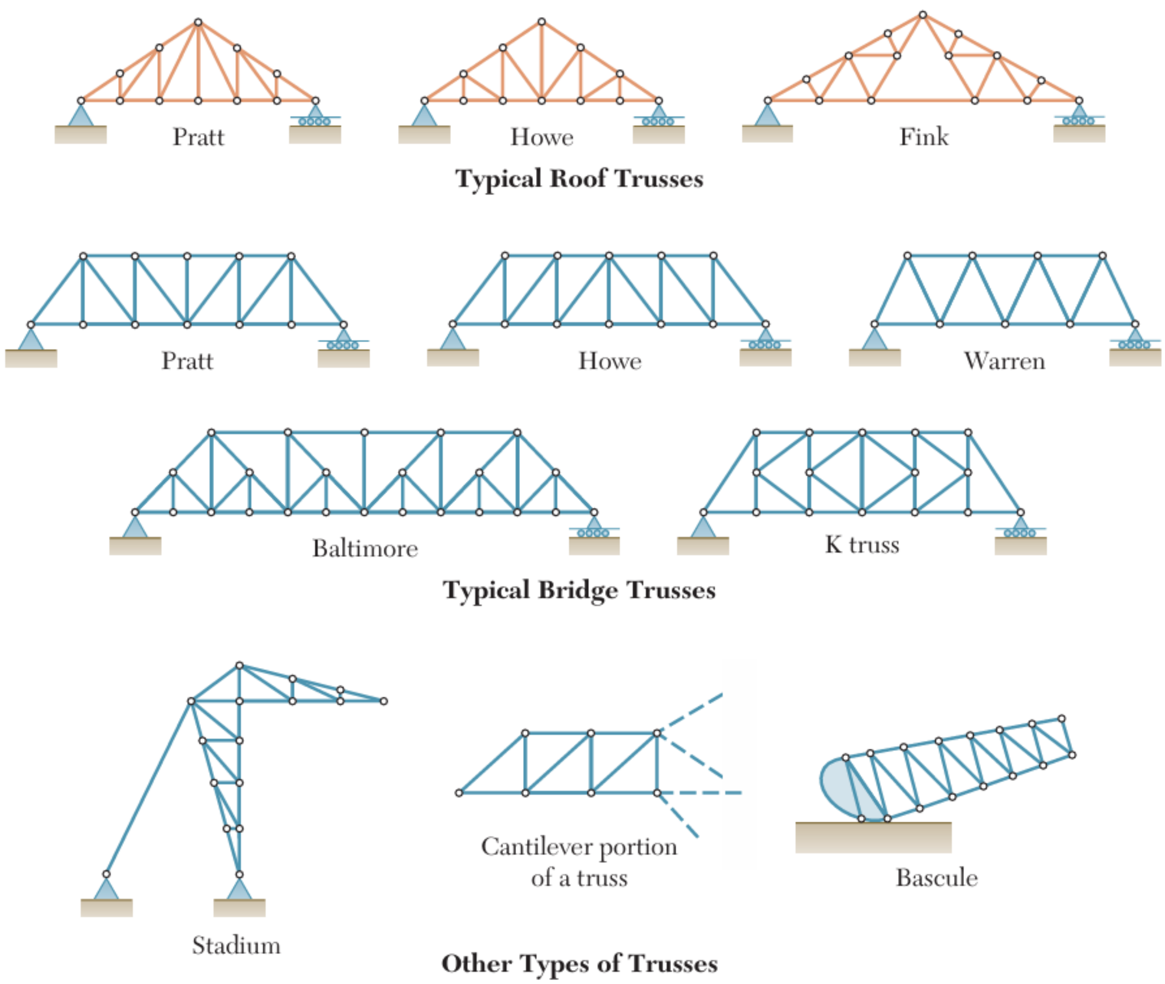
1. Define an ideal truss, and consider the attributes of simple trusses.
2. Analyze plane and space trusses by the method of joints.
3. Simplify certain truss analyses by recognizing special loading and geometry conditions.
4. Analyze trusses by the method of sections.
5. Consider the characteristics of compound trusses.
6. Analyze structures containing multi-force members, such as frames and machines.

2/ Truss :-

2-1 What is truss?

Trusses, which are designed to support loads and are usually stationary, fully constrained structures. Trusses consist exclusively of straight members connected at joints located at the ends of each member. Members of a truss, therefore, are two-force members, i.e., members acted upon by two equal and opposite forces directed along the member.

Figure1-1 A truss bridge



2-2 Analysis methods of trusses

There are two methods to analysis the trusses:

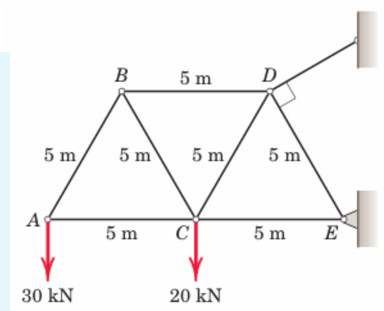
1- Joint method.
2- Section method.

2-3 The Method of Joints

This method for finding the forces in the members of a truss consists of satisfying the conditions of equilibrium for the forces acting on the connecting pin of each joint. The method therefore deals with the equilibrium of concurrent forces, and only two independent equilibrium equations are involved.

Therefore, if the free-body diagram of each joint is drawn, the force equilibrium equations can then be used to obtain the member forces acting on each joint. Since the members of a plane truss are straight two-force members lying in a single plane, each joint is subjected to a force system that is coplanar and concurrent. As a result, only $\Sigma F_x = 0$ and $\Sigma F_y = 0$ need to be satisfied for equilibrium.

Example 1/ Compute the force in each member of the loaded cantilever truss by the method of joints.

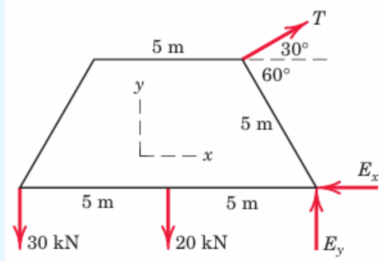


Solution. If it were not desired to calculate the external reactions at D and E, the analysis for a cantilever truss could begin with the joint at the loaded end. However, this truss will be analyzed completely, so the first step will be to compute the external forces at D and E from the free-body diagram of the truss as a whole. The equations of equilibrium give

$[\Sigma M_E = 0]$ $\quad 5T - 20(5) - 30(10) = 0 \quad T = 80 \text{ kN}$

$[\Sigma F_x = 0]$ $\quad 80 \cos 30° - E_x = 0 \quad E_x = 69.3 \text{ kN}$

$[\Sigma F_y = 0]$ $\quad 80 \sin 30° + E_y - 20 - 30 = 0 \quad E_y = 10 \text{ kN}$



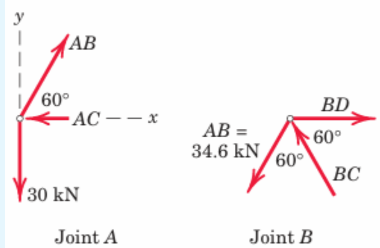
Next we draw free-body diagrams showing the forces acting on each of the connecting pins. The correctness of the assigned directions of the forces is verified when each joint is considered in sequence. There should be no question about the correct direction of the forces on joint A. Equilibrium requires

$[\Sigma F_y = 0]$ $\quad 0.866AB - 30 = 0 \quad AB = 34.6 \text{ kN } T$ *Ans.*

$[\Sigma F_x = 0]$ $\quad AC - 0.5(34.6) = 0 \quad AC = 17.32 \text{ kN } C$ *Ans.*

1 where T stands for tension and C stands for compression.

Joint B must be analyzed next, since there are more than two unknown forces on joint C. The force BC must provide an upward component, in which case BD must balance the force to the left. Again the forces are obtained from



$[\Sigma F_y = 0]$ $\quad 0.866BC - 0.866(34.6) = 0 \quad BC = 34.6 \text{ kN } C$ *Ans.*

$[\Sigma F_x = 0]$ $\quad BD - 2(0.5)(34.6) = 0 \quad BD = 34.6 \text{ kN } T$ *Ans.*

Joint C now contains only two unknowns, and these are found in the same way as before:

$[\Sigma F_y = 0]$ $\quad 0.866CD - 0.866(34.6) - 20 = 0$

$CD = 57.7 \text{ kN } T$ *Ans.*

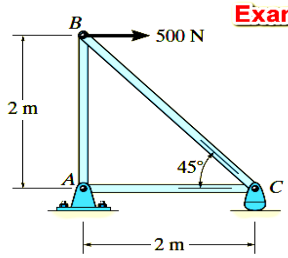
$[\Sigma F_x = 0]$ $\quad CE - 17.32 - 0.5(34.6) - 0.5(57.7) = 0$

$CE = 63.5 \text{ kN } C$ *Ans.*

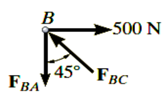
Finally, from joint E there results

$[\Sigma F_y = 0]$ $\quad 0.866DE = 10 \quad DE = 11.55 \text{ kN } C$ *Ans.*

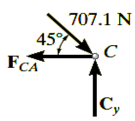
Example Determine the force in each member of the truss shown in Fig. and indicate whether the members are in tension or compression.



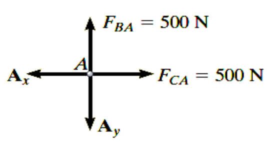
(a)



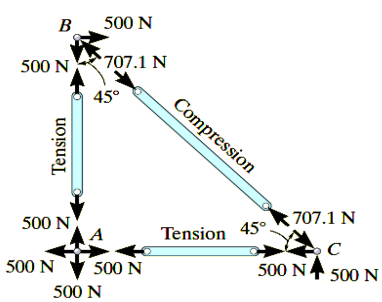
(b)



(c)



(d)



(e)

SOLUTION

Since we should have no more than two unknown forces at the joint and at least one known force acting there, we will begin our analysis at joint *B*.

Joint B. The free-body diagram of the joint at *B* is shown in Fig. 6–8*b*. Applying the equations of equilibrium, we have

$$\xrightarrow{+} \Sigma F_x = 0; \qquad 500\text{ N} - F_{BC}\sin 45° = 0 \qquad F_{BC} = 707.1\text{ N (C)} \qquad \textit{Ans.}$$

$$+\uparrow \Sigma F_y = 0; \qquad F_{BC}\cos 45° - F_{BA} = 0 \qquad F_{BA} = 500\text{ N (T)} \qquad \textit{Ans.}$$

Since the force in member *BC* has been calculated, we can proceed to analyze joint *C* to determine the force in member *CA* and the support reaction at the rocker.

Joint C. From the free-body diagram of joint *C*, Fig. 6–8*c*, we have

$$\xrightarrow{+} \Sigma F_x = 0; \quad -F_{CA} + 707.1\cos 45°\text{ N} = 0 \qquad F_{CA} = 500\text{ N (T)} \qquad \textit{Ans.}$$

$$+\uparrow \Sigma F_y = 0; \qquad C_y - 707.1\sin 45°\text{ N} = 0 \qquad C_y = 500\text{ N} \qquad \textit{Ans.}$$

Joint A. Although it is not necessary, we can determine the components of the support reactions at joint *A* using the results of F_{CA} and F_{BA}. From the free-body diagram, Fig. 6–8*d*, we have

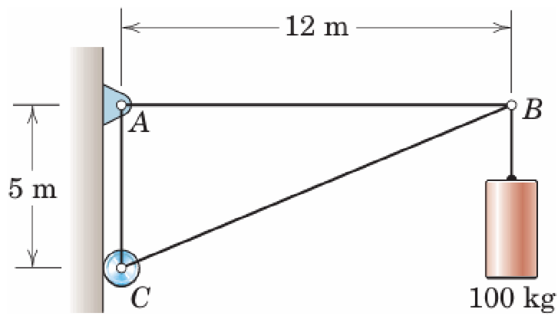
$$\xrightarrow{+} \Sigma F_x = 0; \qquad 500\text{ N} - A_x = 0 \qquad A_x = 500\text{ N}$$

$$+\uparrow \Sigma F_y = 0; \qquad 500\text{ N} - A_y = 0 \qquad A_y = 500\text{ N}$$

NOTE: The results of the analysis are summarized in Fig. 6–8*e*. Note that the free-body diagram of each joint (or pin) shows the effects of all the connected members and external forces applied to the joint, whereas the free-body diagram of each member shows only the effects of the end joints on the member.

6/ Post Test :-

Determine the force in each member of the loaded truss.



key answer :-

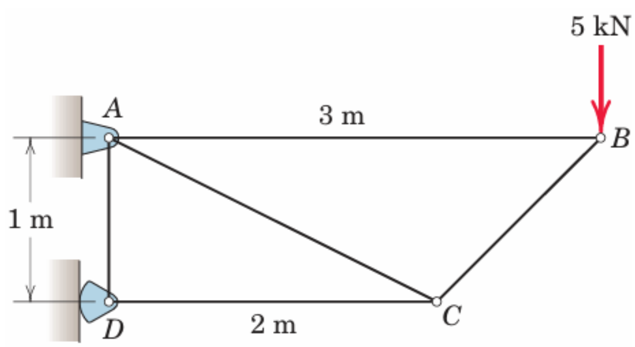
post test:-

BC= 3460 Ib C

AC= 1732 Ib T

7/ HomeWorks: -

Determine the force in each member of the truss. Note the presence of any zero-force members.



6/References :-

7- Engineering Mechanics - Maryam Kraige
8- Engineering Mechanics – Hibbeler
9- Engineering Mechanics – Beer Vector

Ministry of high Education and Scientific Research
Southern Technical University
Technological institute of Basra
Department of Civil Techniques

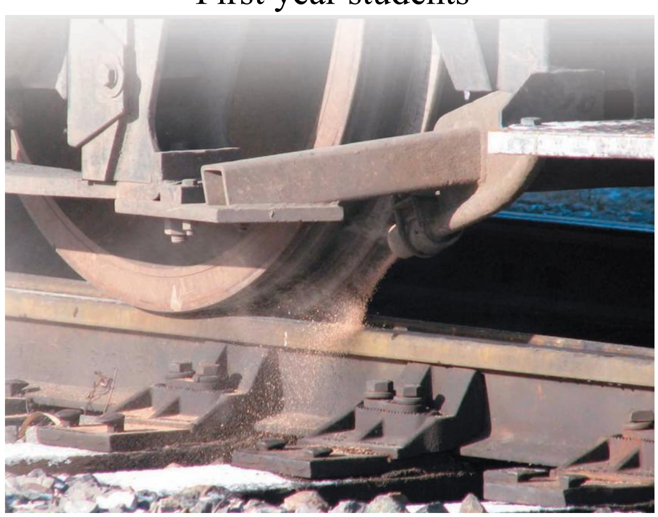
Learning package

In

Friction

For

First year students



By

Ms. Aliaa Ghalib Salih
Dep. of Civil Techniques

2025

1/ Overview

1 / A –Target population :-

For students of First year
Technological institute of Basra
Dep. Of Civil Techniques

1 / B –Rationale :-

To understand If they are frictionless, the force each surface exerts on the other is normal to the surfaces, and the two surfaces can move freely with respect to each other.

3 / C –Central Idea :-

Friction is a force that resists the movement of two contacting surfaces that slide relative to one another.

1 / D – Performance Objectives

After studying this unit, the student will be able to:-

1. Examine the laws of dry friction and the associated coefficients and angles of friction.
2. Consider the equilibrium of rigid bodies where dry friction at contact surfaces is modeled.
3. Apply the laws of friction to analyze problems involving wedges and square-threaded screws.
4. Study engineering applications of the laws of friction, such as in modeling axle, disk, wheel, and belt friction.

2/ Pretest :

3/ Friction :-

3-1 Define friction:-

This view is a simplified one. Actually, no perfectly frictionless sur face exists. When two surfaces are in contact, tangential forces, called friction forces, always develop if you attempt to move one surface with respect to the other. However, these friction forces are limited in magnitude and do not prevent motion if you apply sufficiently large forces. Thus, the distinction between frictionless and rough surfaces is a matter of degree.

3-2 Types of Friction:-

(a) **Dry Friction.** Dry friction occurs when the unlubricated surfaces of two solids are in contact under a condition of sliding or a tendency to slide.

(b) **Fluid Friction.** Fluid friction occurs when adjacent layers in a fluid (liquid or gas) are moving at different velocities. This motion causes frictional forces between fluid elements, and these forces depend on the relative velocity between layers.

(c) **Internal Friction.** Internal friction occurs in all solid materials which are subjected to cyclical loading. For highly elastic materials the recovery from deformation occurs with very little loss of energy due to internal friction.

3-3 The static and kinetic friction forces:-

The static and kinetic friction forces It was found that, as the magnitude F of the friction force increases from 0 to Fm, the point of application A of the resultant N of the normal forces of contact moves to the right. In this way, the couples formed by P and F and by W and N, respectively, remain balanced. If N reaches B before

F reaches its maximum value Fm, the block starts to tip about B before it can start sliding.

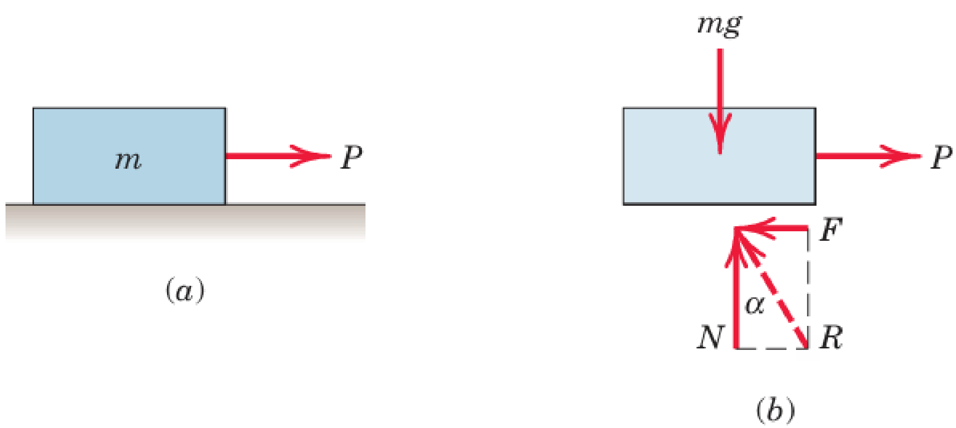


Figure 1-1: (a) Block on a horizontal plane, friction force is zero; (b) a horizontally applied force P produces an opposing friction force F.

1. Static Friction

The region up to the point of slippage or impending motion is called the range of static friction, and in this range the value of the friction force is determined by the equations of equilibrium. This friction force may have any value from zero up to and including the maximum value.

$$F_{\max} = \mu_s N$$

Where, Fmax is maximum value of static friction is proportional to the normal force N, μ_s is the proportionality constant, called the coefficient of static friction.

2. Kinetic Friction

After slippage occurs, a condition of kinetic friction accompanies the ensuing motion. Kinetic friction force is usually somewhat less than the maximum static friction force. The kinetic friction force F_k is also proportional to the normal force. Thus,

$$F_k = \mu_k N$$

Where μ_k is the coefficient of kinetic friction.

3-4 Friction Angles

The direction of the resultant R measured from the direction of N is specified by tan α= F/N. When the friction force reaches its limiting static value Fmax, the angle α reaches a maximum value ϕ_s. Thus,

$$\tan \phi_s = \mu_s$$

KEY CONCEPTS

Types of Friction Problems

We can now recognize the following three types of problems encountered in applications involving dry friction. The first step in solving a friction problem is to identify its type.

1. In the *first* type of problem, the condition of impending motion is known to exist. Here a body which is in equilibrium is on the verge of slipping, and the friction force equals the limiting static friction $F_{\text{max}} = \mu_s N$. The equations of equilibrium will, of course, also hold.
2. In the *second* type of problem, neither the condition of impending motion nor the condition of motion is known to exist. To determine the actual friction conditions, we first assume static equilibrium and then solve for the friction force F necessary for equilibrium. Three outcomes are possible:
   (*a*) $F < (F_{\text{max}} = \mu_s N)$: Here the friction force necessary for equilibrium can be supported, and therefore the body is in static equilibrium as assumed. We emphasize that the *actual* friction force F is *less than* the limiting value F_{max} given by Eq. 6/1 and that F is determined *solely* by the equations of equilibrium.
   (*b*) $F = (F_{\text{max}} = \mu_s N)$: Since the friction force F is at its maximum value F_{max}, motion impends, as discussed in problem type (1). The assumption of static equilibrium is valid.
   (*c*) $F > (F_{\text{max}} = \mu_s N)$: Clearly this condition is impossible, because the surfaces cannot support more force than the maximum $\mu_s N$. The assumption of equilibrium is therefore invalid, and motion occurs. The friction force F is equal to $\mu_k N$ from Eq. 6/2.
3. In the *third* type of problem, relative motion is known to exist between the contacting surfaces, and thus the kinetic coefficient of friction clearly applies. For this problem type, Eq. 6/2 always gives the kinetic friction force directly.

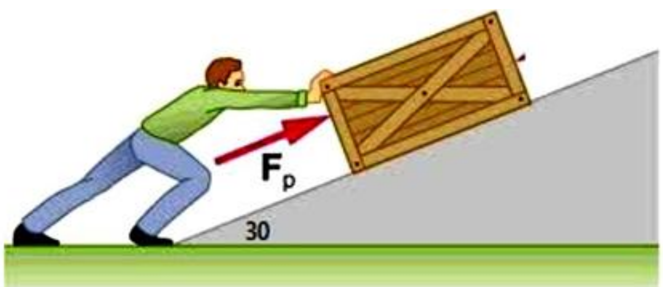
3-5 Procedure for Analysis

Equilibrium problems involving dry friction can be solved using the following procedure:

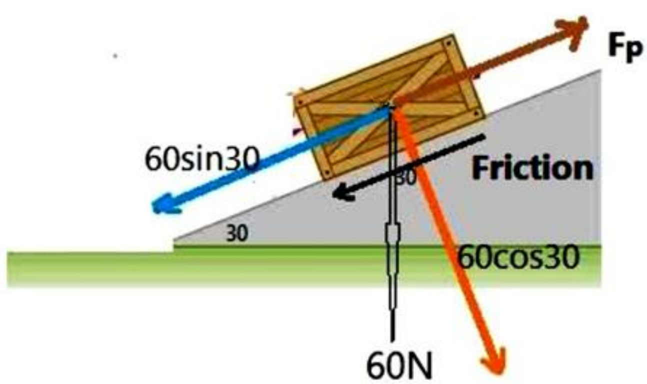
1-Free-Body Diagrams.

2-Equations of Equilibrium and Friction.

Example (2): Find the force needed to make balance and stop the movement of 60N load if the coefficient of friction between the surfaces 0.85.



Solution:

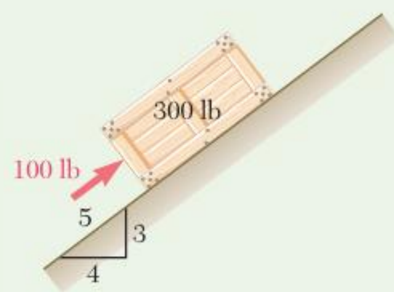


$Friction = \mu N = 0.85x60cos30 = 44.166N$

$\Sigma Fx = 0 = Fp - friction - 60sin30$

$Fp = 44.166 + 60x0.5 = 74.166N$

Example 2/ A 100-lb force acts as shown on a 300-lb crate placed on an inclined plane. The coefficients of friction between the crate and the plane are $\mu_s = 0.25$ and $\mu_k = 0.20$. Determine whether the crate is in equilibrium, and find the value of the friction force.



$+\nearrow \Sigma F_x = 0$: $\quad 100 \text{ lb} - \frac{3}{5}(300 \text{ lb}) - F = 0$

$F = -80 \text{ lb} \qquad \mathbf{F} = 80 \text{ lb} \nearrow$

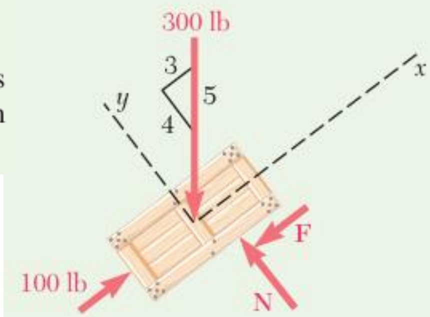
$+\nwarrow \Sigma F_y = 0$: $\quad N - \frac{4}{5}(300 \text{ lb}) = 0$

$N = +240 \text{ lb} \qquad \mathbf{N} = 240 \text{ lb} \nwarrow$

Maximum Friction Force. The magnitude of the maximum friction force that may be developed between the crate and the plane is

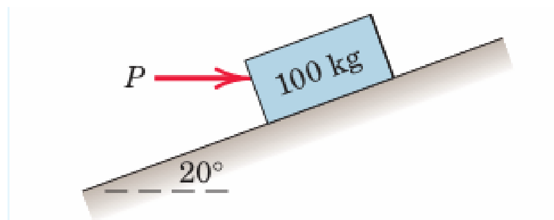
$$F_m = \mu_s N \qquad F_m = 0.25(240 \text{ lb}) = 60 \text{ lb}$$

Since the value of the force required to maintain equilibrium (80 lb) is larger than the maximum value that may be obtained (60 lb), equilibrium is not maintained and *the crate will slide down the plane*.



4/ Post test :-

Determine the magnitude and direction of the friction force acting on the 100-kg if, first, P= 500 N. The coefficient of static friction is 0.20, The forces are applied with the block initially at rest.



key answer:-

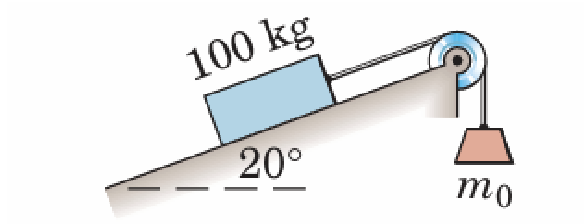
posttest:-

F = -134.3 N

Fmax= 219 N

5/ HomeWorks: -

Determine the range of values which the mass m0may have so that the 100-kg block shown in the figure will neither start moving up the plane nor slip down the plane. The coefficient of static friction for the contact surfaces is 0.30.



6 / References

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2-Engineering Mechanics – Hibbeler
3-Engineering Mechanics – Beer Vector

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Technological institute of Basra
Department of Civil Techniques

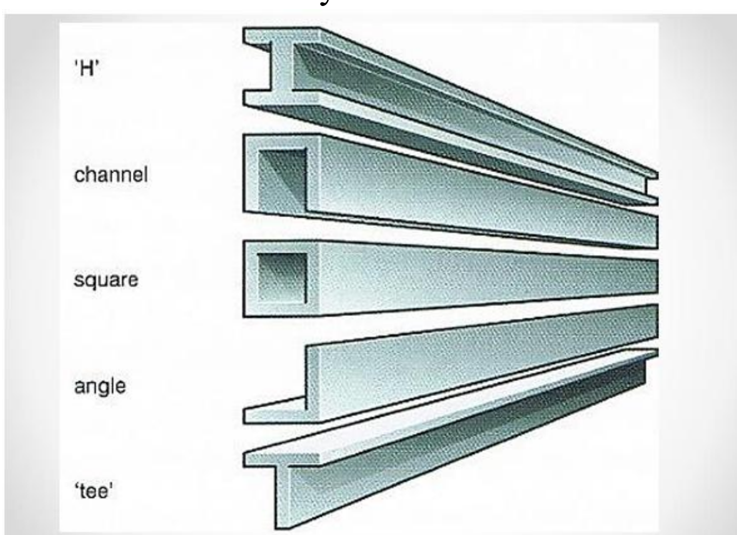
Learning package

In

Center of Gravity (Centroid)

For

First year students



By

Ms. Aliaa Ghalib Salih
Dep. of Civil Techniques

2025

1/ Overview

1 / A –Target population :-

For students of First year
Technological institute of Basra
Dep. Of Civil Techniques

1 / B –Rationale :-

To understand the earth exerts a force on each of the particles forming the body, so we should represent the attraction of the earth on a rigid body by a large number of small forces distributed over the entire body.

1 / C –Central Idea :-

We have assumed so far that we could represent the attraction exerted by the earth on a rigid body by a single force W. This force, called the force due to gravity or the weight of the body, is applied at the center of gravity of the body

1 / D – Performance Objectives

After studying this unit, the student will be able to:-

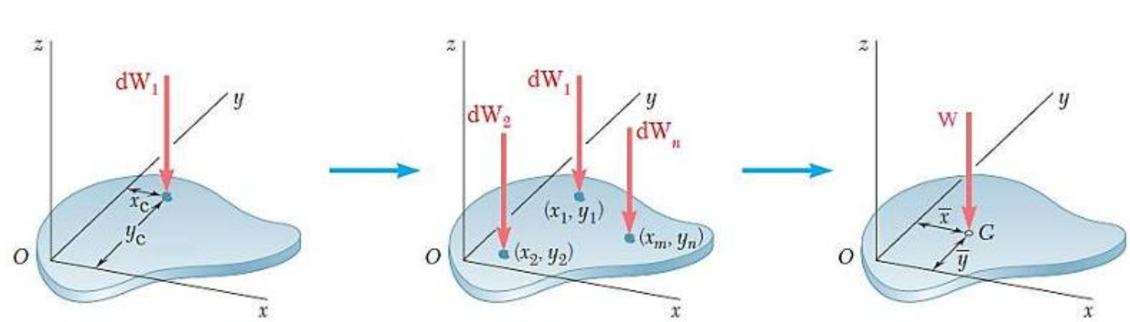
1. Describe the centers of gravity of two and three-dimensional bodies.
2. Define the centroids of lines, areas, and volumes.
3. Consider the fi rst moments of lines and areas, and examine their properties.
4. Determine centroids of composite lines, areas, and volumes by summation methods.
5. Determine centroids of composite lines, areas, and volumes by integration.
6. Apply the theorems of Pappus-Guldens to analyze surfaces and bodies of revolution.
7. Analyze distributed loads on beams and forces on submerged surfaces.

2/ Pretest :

3/ Centroid :-

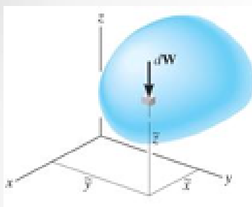
3-1 Define center of gravity:-

Center of gravity: of a body is the point at which the whole weight of the body may be assumed to be concentrated. A body is having only one center of gravity for all positions of the body. It is represented by CG. or simply G or C. A body is composed of an infinite number of particles, and so if the body is located within a gravitational field, then each of these particles will have a weight dw.

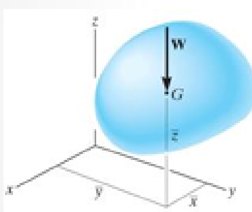


(a) Single element of the plate (b) Multiple elements of the plate (c) Center of gravity

CONCEPT OF CENTER OF GRAVITY (CG)



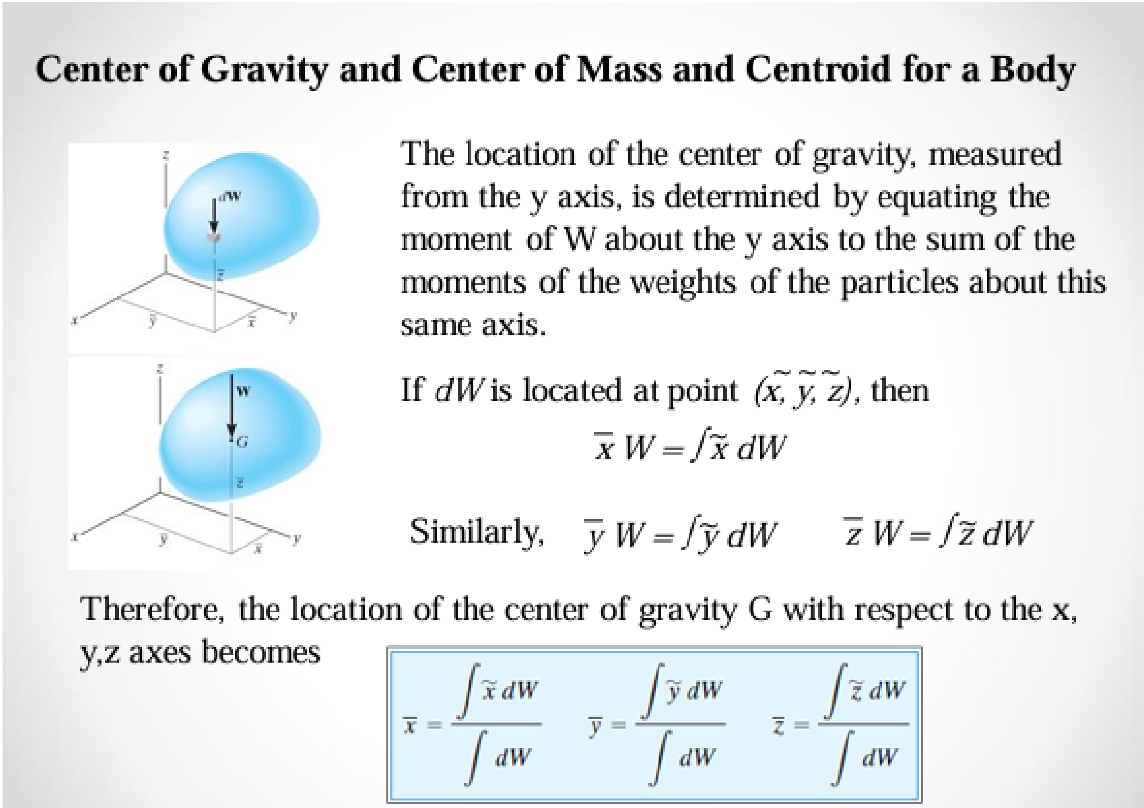
A body is composed of an infinite number of particles, and so if the body is located within a gravitational field, then each of these particles will have a weight *dW*.



The center of gravity (CG) is a point, often shown as G, which locates the resultant weight of a system of particles or a solid body.

From the definition of a resultant force, the sum of moments due to individual particle weighst about any point is the same as the moment due to the resultant weight located at G.

Also, note that the sum of moments due to the individual particle's weights about point G is equal to zero.



3-2 Composite Bodies

Consists of a series of connected “simpler” shaped bodies, which may be rectangular, triangular or semicircular. • A body can be sectioned or divided into its composite parts. • Provided the weight and location of the center of gravity of each of these parts are known, the need for integration to determine the center of gravity for the entire body can be neglected.

$$\bar{x} = \frac{\int_A x\,dA}{\int_A dA} \qquad \bar{y} = \frac{\int_A y\,dA}{\int_A dA}$$

Or

$$\bar{x} = \frac{\Sigma \tilde{x} A}{\Sigma A} \qquad \bar{y} = \frac{\Sigma \tilde{y} A}{\Sigma A}$$

Here $\bar{x}$ and $\bar{y}$ represent the algebraic distances or x, y coordinates for the centroid of each composite part, and ∑A represents the sum of the areas of the composite parts or simply the total area.

3-3 STEPS FOR ANALYSIS

1. Divide the body into pieces that are known shapes. Holes are considered as pieces with negative weight or size.

2. Make a table with the first column for segment number, the second column for weight, mass, or size (depending on the problem), the next set of columns for the moment arms, and, finally, several columns for recording results of simple intermediate calculations.

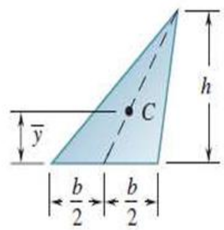
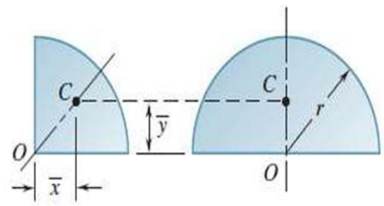
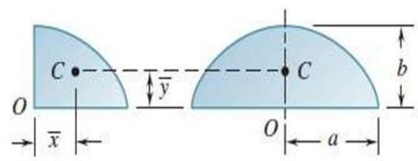
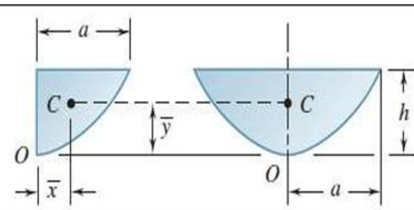
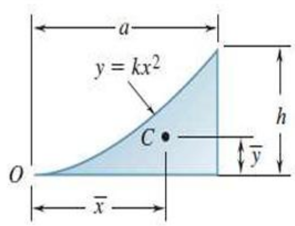
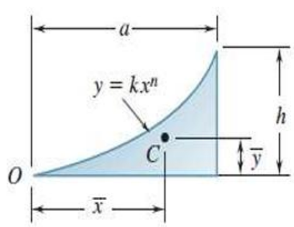
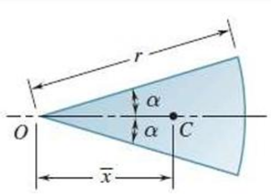
3. Fix the coordinate axes, determine the coordinates of the center of gravity of centroid of each piece, and then fill in the table.

4. Sum the columns to get x, y, and z. Use formulas like

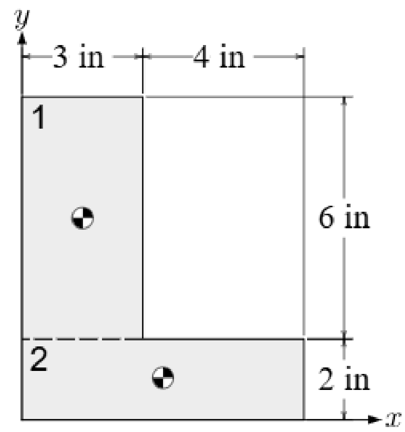
$$\bar{x} = \frac{\Sigma \tilde{x} A}{\Sigma A} \qquad \bar{y} = \frac{\Sigma \tilde{y} A}{\Sigma A}$$

- This approach will become clear by doing examples

Centroids of common shapes of areas.

Shape		$\bar{x}$	$\bar{y}$	Area
Triangular area			$\frac{h}{3}$	$\frac{bh}{2}$
Quarter-circular area		$\frac{4r}{3\pi}$	$\frac{4r}{3\pi}$	$\frac{\pi r^2}{4}$
Semicircular area		0	$\frac{4r}{3\pi}$	$\frac{\pi r^2}{2}$
Quarter-elliptical area		$\frac{4a}{3\pi}$	$\frac{4b}{3\pi}$	$\frac{\pi ab}{4}$
Semielliptical area		0	$\frac{4b}{3\pi}$	$\frac{\pi ab}{2}$
Semiparabolic area		$\frac{3a}{8}$	$\frac{3h}{5}$	$\frac{2ah}{3}$
Parabolic area		0	$\frac{3h}{5}$	$\frac{4ah}{3}$
Parabolic spandrel		$\frac{3a}{4}$	$\frac{3h}{10}$	$\frac{ah}{3}$
General spandrel		$\frac{n+1}{n+2}a$	$\frac{n+1}{4n+2}h$	$\frac{ah}{n+1}$
Circular sector		$\frac{2r \sin \alpha}{3\alpha}$	0	αr^2

Example1/ Locate the centroid of the plate area?



$$A_1 = 18\,\text{in}^2,\ A_2 = 14\,\text{in}^2$$

$$\bar{x}_1 = 1.5\text{ in}, \bar{y}_1 = 5\text{ in}, \qquad \bar{x}_2 = 3.5\text{ in}, \bar{y}_2 = 1\text{ in}$$

$$\bar{x} = \frac{\sum \bar{x}_i A_i}{\sum A_i} \qquad \bar{y} = \frac{\sum \bar{y}_i A_i}{\sum A_i}$$

$$\bar{x} = \frac{(1.5)(18) + (3.5)(14)}{18 + 14} \qquad \bar{y} = \frac{\sum(5)(18) + (1)(14)}{18 + 14}$$

$$\bar{x} = 2.375\text{ in} \qquad \bar{y} = 3.25\text{ in}$$

Example 2/ Locate the centroid of the shaded area?

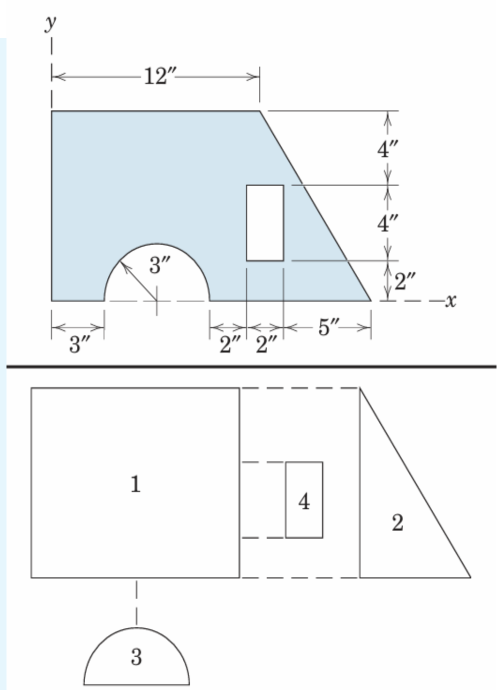
Solution. The composite area is divided into the four elementary shapes shown in the lower figure. The centroid locations of all these shapes may be obtained from Table D/3. Note that the areas of the "holes" (parts 3 and 4) are taken as negative in the following table:

PART	A in.^{2}	$\bar{x}$ in.	$\bar{y}$ in.	$\bar{x}A$ in.^{3}	$\bar{y}A$ in.^{3}
1	120	6	5	720	600
2	30	14	10/3	420	100
3	−14.14	6	1.273	−84.8	−18
4	−8	12	4	−96	−32
TOTALS	127.9			959	650

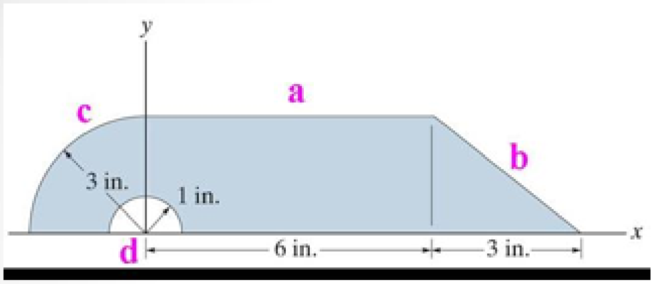
The area counterparts to Eqs. 5/7 are now applied and yield

$$\left[\bar{X} = \frac{\Sigma A\bar{x}}{\Sigma A}\right] \qquad \bar{X} = \frac{959}{127.9} = 7.50\text{ in.} \qquad \textit{Ans.}$$

$$\left[\bar{Y} = \frac{\Sigma A\bar{y}}{\Sigma A}\right] \qquad \bar{Y} = \frac{650}{127.9} = 5.08\text{ in.} \qquad \textit{Ans.}$$



Example -3-



Given: The part shown.

Find: The centroid of the part.

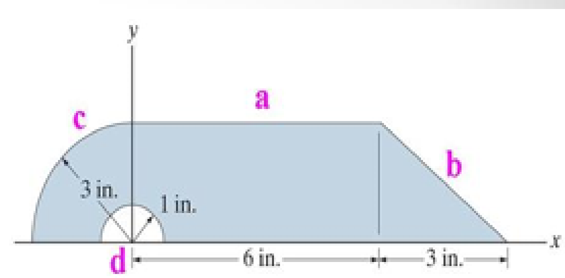
Plan: Follow the steps for analysis.

Solution:

1. This body can be divided into the following pieces: rectangle (a) + triangle (b) + quarter circular (c) – semicircular area (d). Note the negative sign on the hole!

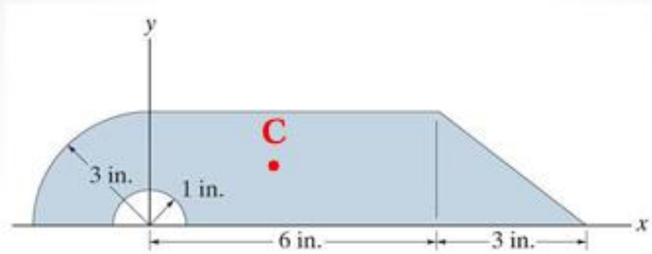
EXAMPLE (continued)

Steps 2 & 3: Make up and fill the table using parts a, b, c, and d.



Segment	Area A (in^2)	$\tilde{x}$ (in)	$\tilde{y}$ (in)	$\tilde{x}$ A (in^3)	$\tilde{y}$ A (in^3)
Rectangle	18	3	1.5	54	27
Triangle	4.5	7	1	31.5	4.5
Q. Circle	$9\pi / 4$	$-4(3) / (3\pi)$	$4(3) / (3\pi)$	– 9	9
Semi-Circle	$-\pi / 2$	0	$4(1) / (3\pi)$	0	- 2/3
Σ	28.0			76.5	39.83

EXAMPLE (continued)



4. Now use the table data results and the formulas to find the coordinates of the centroid.

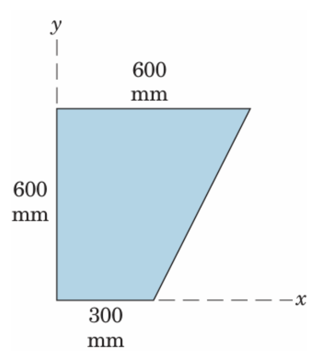
Area A	$\tilde{x}$ A	$\tilde{y}$ A
28.0	76.5	39.83

$\bar{x} = (\Sigma\, \tilde{x} A) / (\Sigma A) = 76.5\ in^3 / 28.0\ in^2 = $ **2.73 in**

$\bar{y} = (\Sigma\, \tilde{y} A) / (\Sigma A) = 39.83\ in^3 / 28.0\ in^2 = $ **1.42 in**

4/ Post test :-

Determine the coordinates of the centroid of the trapezoidal area shown.



key answer:-

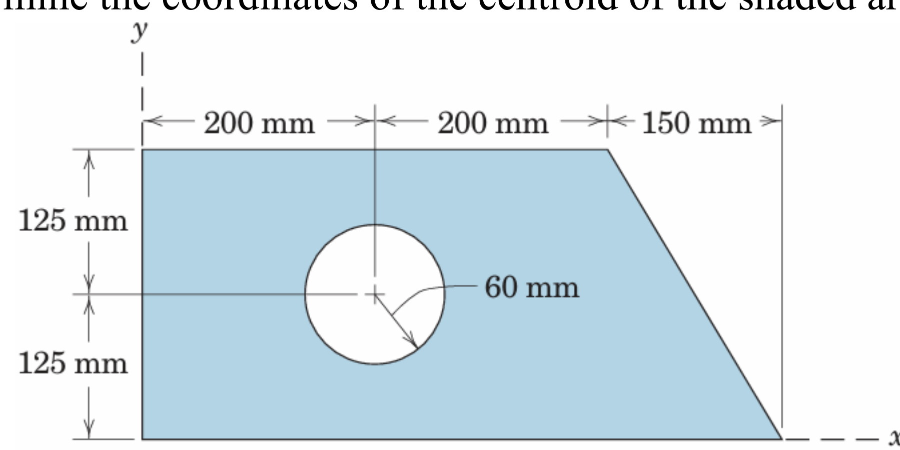
posttest:-

$\overline{X}$ =23.3 in

$\overline{Y}$ = 28 in

5/ HomeWorks: -

Determine the coordinates of the centroid of the shaded area.



6 / References

1-Engineering Mechanics - Maryam Kraige
2-Engineering Mechanics – Hibbeler
3-Engineering Mechanics – Beer Vector

Ministry of high Education and Scientific Research
Southern Technical University
Technological institute of Basra
Department of Civil Techniques

Learning package

In

MOMENT OF INERTIA

For

First year students

By

Ms. Aliaa Ghalib Salih
Dep. of Civil Techniques
2025

1/ Overview

1 / A –Target population :-

For students of First year
Technological institute of Basra
Dep. Of Civil Techniques

1 / B –Rationale :-

To understand the forces are distributed continuously over an area on which they act, it is often necessary to calculate the moment of these forces about some axis either in or perpendicular to the plane of the area. Frequently, the intensity of the force (pressure or stress) is proportional to the distance of the line of action of the force from the moment axis.

1 / C –Central Idea :-

The strength of structural members used in the construction of buildings depends to a large extent on the properties of their cross sections. This includes the second moments of area, or moments of inertia, of these cross sections.

1 / D – Performance Objectives

After studying this unit, the student will be able to:-

1. Describe the second moment, or moment of inertia, of an area.
2. Determine the rectangular and polar moments of inertia of areas and their corresponding radii of gyration by integration.
3. Develop the parallel-axis theorem and apply it to determine the moments of inertia of composite areas.
4. Introduce the product of inertia and apply it to analyze the transformation of moments of inertia when coordinate axes are rotated.
5. Describe the moment of inertia of a mass with respect to an axis.
6. Apply the parallel-axis theorem to facilitate mass moment of inertia computations.
7. Analyze the transformation of mass moments of inertia when coordinate axes are rotated.

2/ Pretest :

3/ Moment of inertia:-

3-1 What is moment of inertia:-

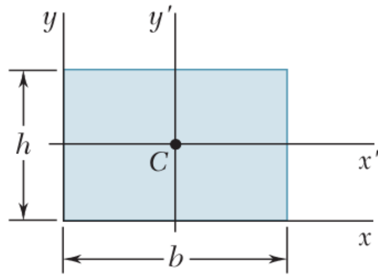
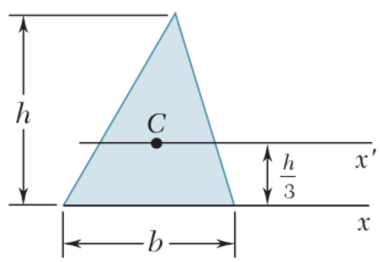
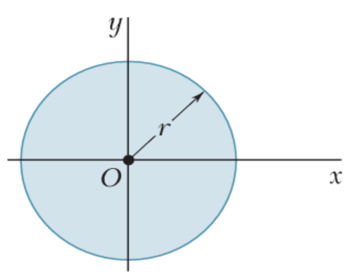
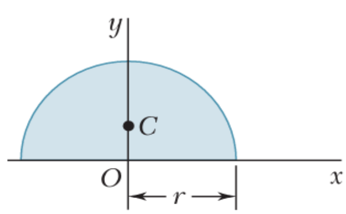
It is frequently necessary to calculate the moment of inertia of an area composed of a number of distinct parts of simple and calculable geometric shape. The moment of inertia of a composite area about a particular axis is therefore simply the sum of the moments of inertia of its component parts about the same axis. It is often convenient to regard a composite area as being composed of positive and negative parts.

Part	Area, A	d_x	d_y	$Ad_x^{\,2}$	$Ad_y^{\,2}$	$\bar{I}_x$	$\bar{I}_y$
Sums	ΣA			$\Sigma Ad_x^{\,2}$	$\Sigma Ad_y^{\,2}$	$\Sigma\bar{I}_x$	$\Sigma\bar{I}_y$

From the sums of the four columns, then, the moments of inertia for the composite area about the x- and y-axes become:

$$I_x = \Sigma \bar{I}_x + \Sigma A {d_x}^2$$

$$I_y = \Sigma \bar{I}_y + \Sigma A {d_y}^2$$

<table>
<tr><td>Rectangle</td><td>
</td><td>$\bar{I}_{x'} = \frac{1}{12}bh^3$
$\bar{I}_{y'} = \frac{1}{12}b^3h$
$I_x = \frac{1}{3}bh^3$
$I_y = \frac{1}{3}b^3h$
$J_C = \frac{1}{12}bh(b^2 + h^2)$</td></tr>
<tr><td>Triangle</td><td>
</td><td>$\bar{I}_{x'} = \frac{1}{36}bh^3$
$I_x = \frac{1}{12}bh^3$</td></tr>
<tr><td>Circle</td><td>
</td><td>$\bar{I}_x = \bar{I}_y = \frac{1}{4}\pi r^4$
$J_O = \frac{1}{2}\pi r^4$</td></tr>
<tr><td>Semicircle</td><td>
</td><td>$I_x = I_y = \frac{1}{8}\pi r^4$
$J_O = \frac{1}{4}\pi r^4$</td></tr>
</table>

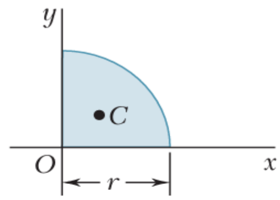
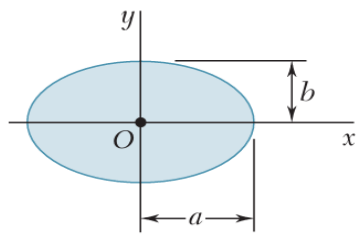
Quarter circle		$I_x = I_y = \frac{1}{16}\pi r^4$ $J_O = \frac{1}{8}\pi r^4$
Ellipse		$\bar{I}_x = \frac{1}{4}\pi a b^3$ $\bar{I}_y = \frac{1}{4}\pi a^3 b$ $J_O = \frac{1}{4}\pi a b(a^2 + b^2)$

Figure 3-1 Moments of inertia of common geometric shapes.

EXAMPLE 10.4

Determine the moment of inertia of the area shown in Fig. 10–8*a* about the *x* axis.

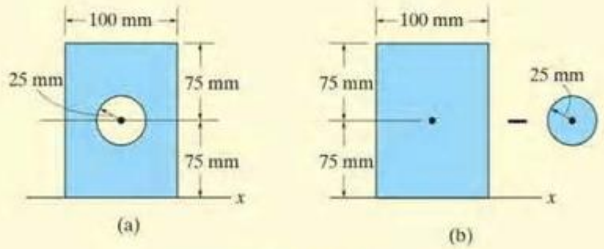


Fig. 10–8

SOLUTION

Composite Parts. The area can be obtained by *subtracting* the circle from the rectangle shown in Fig. 10–8*b*. The centroid of each area is located in the figure.

Parallel-Axis Theorem. The moments of inertia about the *x* axis are determined using the parallel-axis theorem and the data in the table on the inside back cover.

Circle

$$I_x = \bar{I}_{x'} + Ad_y^2$$
$$= \frac{1}{4}\pi(25)^4 + \pi(25)^2(75)^2 = 11.4(10^6)\text{ mm}^4$$

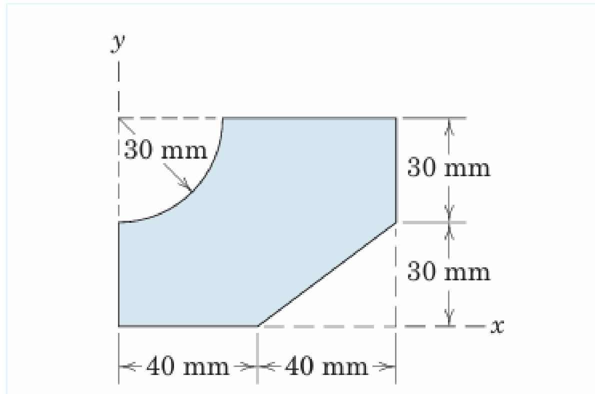
Rectangle

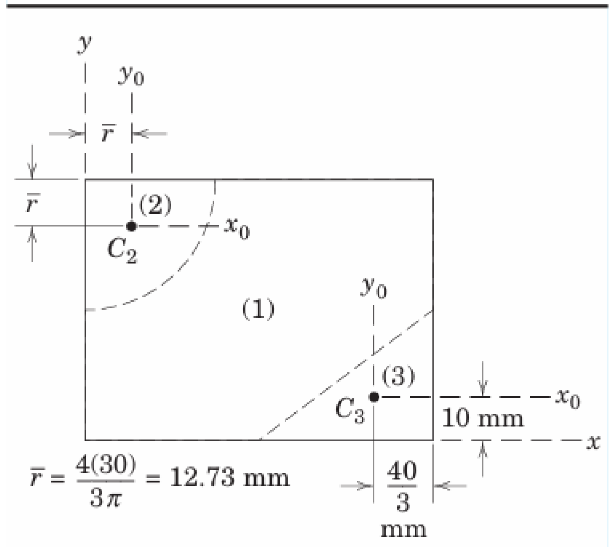
$$I_x = \bar{I}_{x'} + Ad_y^2$$
$$= \frac{1}{12}(100)(150)^3 + (100)(150)(75)^2 = 112.5(10^6)\text{ mm}^4$$

Summation. The moment of inertia for the area is therefore

$$I_x = -11.4(10^6) + 112.5(10^6)$$
$$= 101(10^6)\text{ mm}^4 \qquad \textit{Ans.}$$

Example 2/ Determine the moments of inertia about the x-and y-axes for the shaded area.





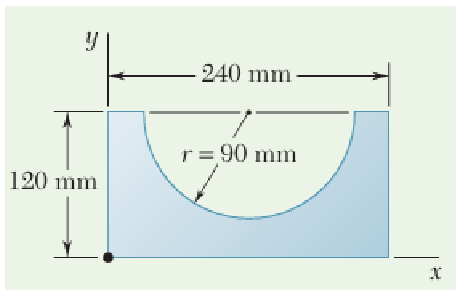
PART	A mm^2	d_x mm	d_y mm	Ad_x^2 mm^3	Ad_y^2 mm^3	$\bar{I}_x$ mm^4	$\bar{I}_y$ mm^4
1	80(60)	30	40	$4.32(10^6)$	$7.68(10^6)$	$\frac{1}{12}(80)(60)^3$	$\frac{1}{12}(60)(80)^3$
2	$-\frac{1}{4}\pi(30)^2$	(60 – 12.73)	12.73	$-1.579(10^6)$	$-0.1146(10^6)$	$-\left(\frac{\pi}{16} - \frac{4}{9\pi}\right)30^4$	$-\left(\frac{\pi}{16} - \frac{4}{9\pi}\right)30^4$
3	$-\frac{1}{2}(40)(30)$	$\frac{30}{3}$	$\left(80 - \frac{40}{3}\right)$	$-0.06(10^6)$	$-2.67(10^6)$	$-\frac{1}{36}40(30)^3$	$-\frac{1}{36}(30)(40)^3$
TOTALS	3490			$2.68(10^6)$	$4.90(10^6)$	$1.366(10^6)$	$2.46(10^6)$

$[I_x = \Sigma \bar{I}_x + \Sigma A d_x^2]$ $\quad I_x = 1.366(10^6) + 2.68(10^6) = 4.05(10^6)$ mm^4 *Ans.*

$[I_y = \Sigma \bar{I}_y + \Sigma A d_y^2]$ $\quad I_y = 2.46(10^6) + 4.90(10^6) = 7.36(10^6)$ mm^4 *Ans.*

4/ Post test :-

Determine the moment of inertia of the shaded area with respect to the x axis.



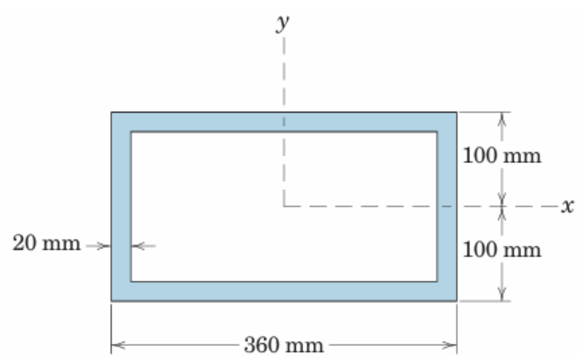
key answer:-

posttest:-

$I_x = 45.9 * 10^6 \ mm^4$

5/ HomeWorks: -

Determine the moment of inertia of the shaded area about the x-axis in two ways. The wall thickness is 20 mm on all four sides of the rectangle?



6 / References

1-Engineering Mechanics - Maryam Kraige
2-Engineering Mechanics – Hibbeler
3-Engineering Mechanics – Beer Vector

Ministry of high Education and Scientific Research
Southern Technical University
Technological institute of Basra
Department of Civil Techniques

Learning package

In

Strength of Materials

For

First year students

By

Ms. Aliaa Ghalib Salih
Dep. Of Civil Techniques

2025

1/ Overview

1 / A –Target population :-

For students of First year
Technological institute of Basra
Dep. Of Civil Techniques

1 / B –Rationale :-

To understand the concept of stress and strain.

1/ C –Central Idea :-

" Strength of Materials" or "Mechanics of Materials" deals with, Concept of stress, Stresses and strains, Axial loading and axial deformation.

1 / D – Performance Objectives

After studying this unit, the student will be able to:-

1. Be aware of the mathematical background for the different topics of strength of materials introduced in this course.

2. Understanding of stress concept and types of stresses.

3. Understanding of stress strain relationship and solving problems.

4. Understanding of internal forces in beams, how to draw shear force and bending moment diagrams.

5. Understanding of beam analysis, stresses in beams, beam theory and shear stresses.

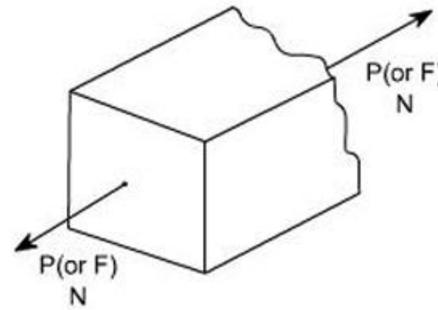
2/ Pretest :

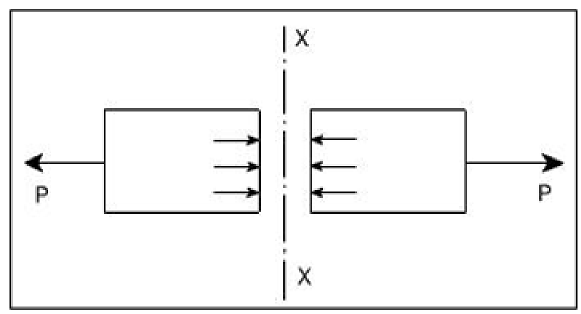
3/ Stress :-

3-1 Stress:-

Concept of Stress: Let us introduce the concept of stress, as we know that the main problem of engineering mechanics of material is the investigation of the internal resistance of the body, i.e. the nature of forces set up within a body to balance the effect of the externally applied forces.

Let us consider a rectangular bar of some cross–sectional area and subjected to some load or force (in Newton). Let us imagine that the same rectangular bar is assumed to be cut into two halves at section. Each portion of this rectangular bar is in equilibrium under the action of load P and the internal forces acting at the section has been shown.





3-2 Simple Stress

Simple stress is expressed as the ratio of the applied force divided by the resisting area or :

$$\sigma = \textbf{Force / Area}$$

It is the expression of force per unit area to structural members that are subjected to external forces and/or induced forces. Here we are using an assumption that the total force or total load carried by the bar is uniformly distributed over its cross-section.

Units:

The basic units of stress in S.I units i.e. (International System) are N / m2 (or Pa , Pascal) MPa = 106 Pa , GPa = 109 Pa , KPa = 103 Pa Sometimes N/mm2 units are also used, because this is an equivalent to MPa , while US customary unit is pound per square inch , psi. (lb/in^2).

Simple stress can be classified as **normal stress**, **shear stress**, and **bearing stress**. **Normal stress** develops when a force is applied perpendicular to the cross-sectional area of the material. If the force is going to pull the material, the stress is said to be tensile stress and compressive stress develops when the material is being compressed by two opposing forces. **Shear stress** is developed if the applied force is parallel to the resisting area. Example is the bolt that holds the tension rod in its anchor. Another condition of shearing is when we twist a bar along its longitudinal axis. This type of shearing is called torsion.

Another type of simple stress is the **bearing stress**, it is the contact pressure between two bodies. (It is in fact a compressive stress).

Example 101: A hollow steel tube with an inside diameter of 100 mm must carry a tensile load of 400 kN. Determine the outside diameter of the tube if the stress is limited to 120 MN/m^2.

Solution 101:

$$P = \sigma A$$

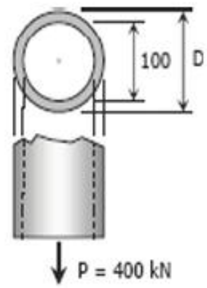
where:

$$P = 400 \text{ kN} = 400\,000 \text{ N}$$

$$\sigma = 120 \text{ MPa}$$

$$A = \tfrac{1}{4}\pi D^2 - \tfrac{1}{4}\pi(100^2)$$

$$= \tfrac{1}{4}\pi(D^2 - 10\,000)$$



thus,

$$400\,000 = 120[\tfrac{1}{4}\pi(D^2 - 10\,000)]$$

$$400\,000 = 30\pi D^2 - 300\,000\pi$$

$$D^2 = \frac{400\,000 + 300\,000\pi}{30\pi}$$

$$D = 119.35 \text{ mm}$$

3-2 Strin: -

The change in length ΔL per unit of the original length L of the line element. The normal strain is positive if the material fibers are stretched and negative if they are compressed.

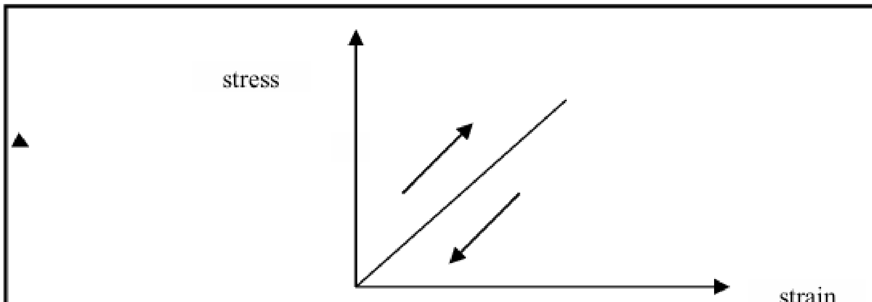
$$\textbf{Strain}(\varepsilon) = \frac{\Delta L}{L} = \frac{L - L_o}{L}$$

a- Tensile strain

b- compression strain

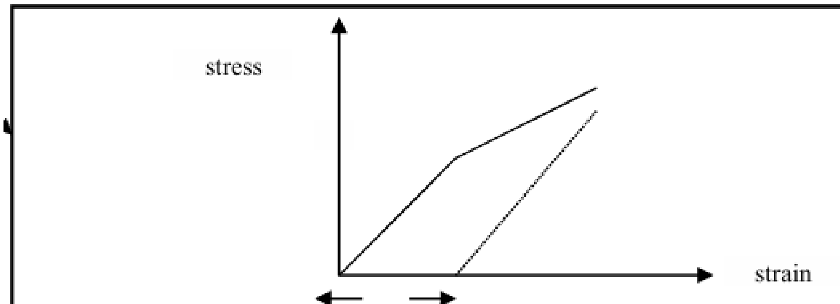
Strain Types

1- Elastic Strain stress



Stress -strain relation for elastic body

2- Plastic Strain



Stress- strain relation for plastic body

$\boldsymbol{Modulus of Elasticity}$ or $\boldsymbol{Young'Modulus}$: The ratio of tensile stress (σ) to tensile strain (ε).

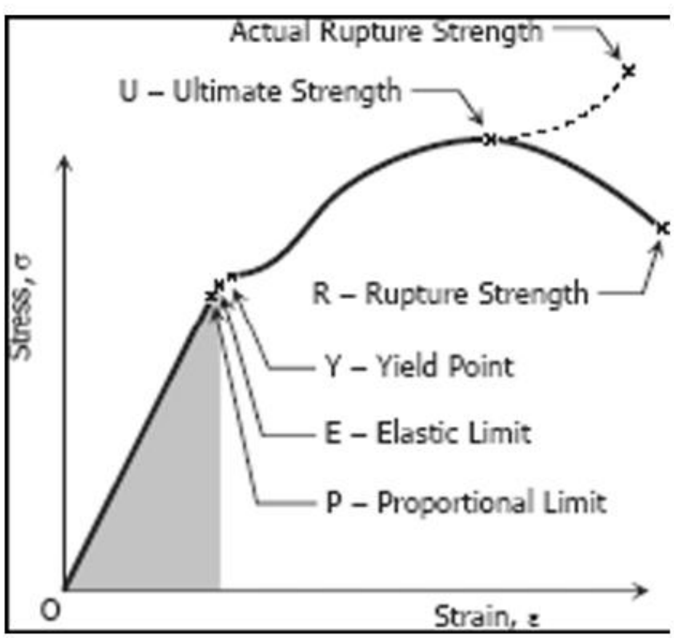
$$\boldsymbol{Modulus of Elasticity} = \frac{\boldsymbol{Stress}}{\boldsymbol{Strain}}$$

$$\boldsymbol{Young'Modulus(Y)} = \frac{\frac{\vec{F}}{A}}{\frac{\Delta L}{L}}$$

$$\boldsymbol{Young'Modulus(Y)} = \frac{\vec{F}}{A} \cdot \frac{L}{\Delta L} (N/m^2)$$

3-3 Stress-Strain Diagram

Suppose that a metal specimen be placed in tension-compression testing machine.



Example 1: The length of cable is **75 cm** and the diameter is **0.13 cm**, elongates by **0.0350 cm** when a weight **8 kg** is attached to its end, calculate:

1- Tensile stress?
2- Tensile strain?
3- Modulus of Elasticity?

Solution:

1- Tensile stress

$$A = \pi r^2 = (3.14)\left(\frac{\frac{0.130}{2}}{100}\right)^2 = (3.14)(0.4225x10^{-6})$$

$$\boxed{\Rightarrow A = 1.32665x10^{-6}\,m^2}$$

$$F = mg = (8)(9.8)\ \boxed{\Rightarrow F = 78.4N}$$

$$Stress(\delta) = \frac{\vec{F}}{A}\left(\frac{N}{m^2}\right)$$

$$Stress(\delta) = \frac{78.4}{1.32665x10^{-6}}\ \boxed{\Rightarrow Stress(\delta) = 5.91x10^{7}\,(N/m^2)}$$

2- Tensile strain

$$Strain(\varepsilon) = \frac{\Delta L}{L} = \frac{L - L_o}{L}$$

$$Strain\ (\varepsilon) = \frac{0.0350\ cm}{75\,cm} \qquad \boxed{\Rightarrow Strain\ (\varepsilon) = 4.67\,x10^{-4}}$$

3- Modulus of Elasticity

$$YoungModulus(Y) = \frac{\frac{\vec{F}}{A}}{\frac{\Delta L}{L}}$$

$$YoungModulus(Y) = \frac{5.91x10^{7}}{4.67x10^{-4}}$$

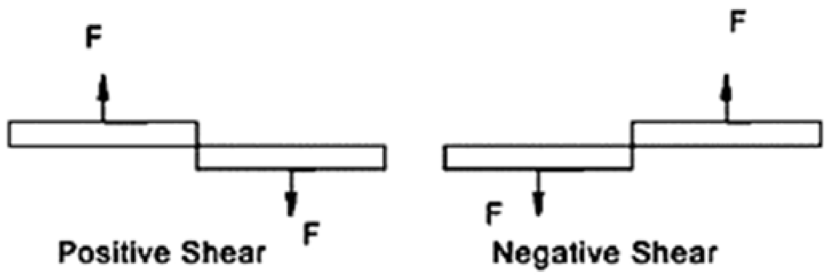
$$\Rightarrow Young'Modulus(Y) = 1.27x10^{11}(N/m^2)$$

3-4 Shear force Diagram & Bending Moment Diagram:-

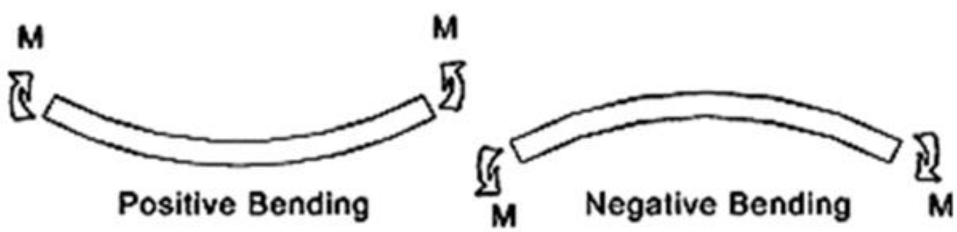
Shearing forces occur when a perpendicular force is applied to static material. bending moment is the reaction induced in a structural element when an external force or moment is applied to the element, causing the element to bend. The most common or simplest structural element subjected to bending moments is the beam. To draw S.F.D. & B.M.D, follow the next steps:

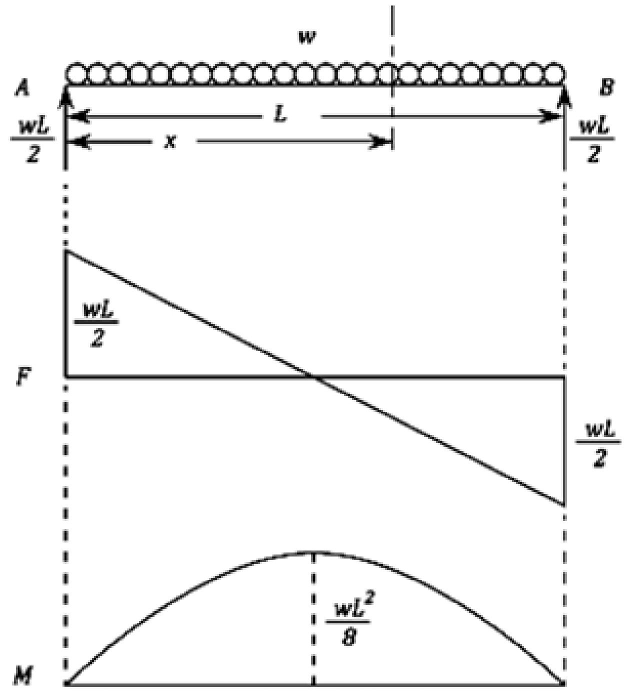
1- Calculate the reactions.

2- draw the S.F.D

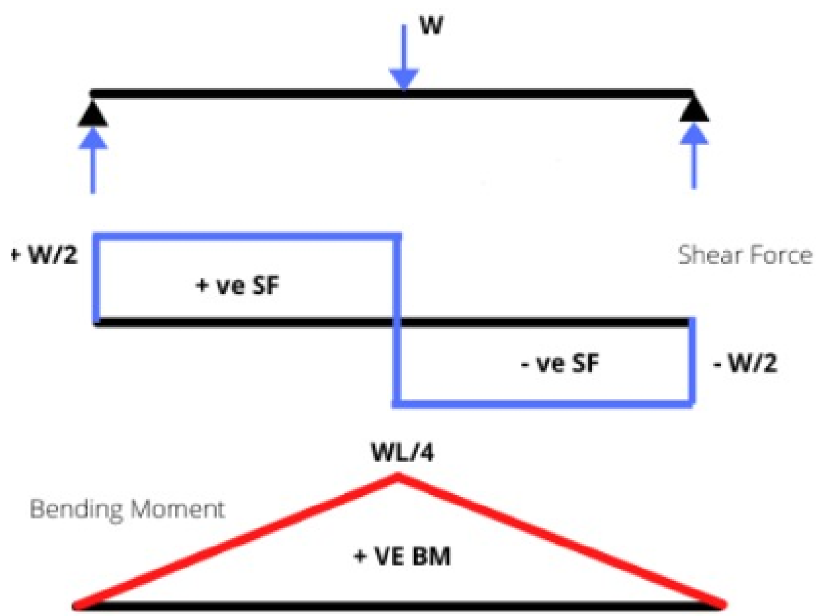


3- draw the B.M.D

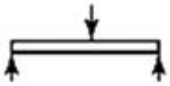
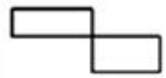
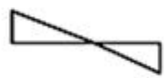




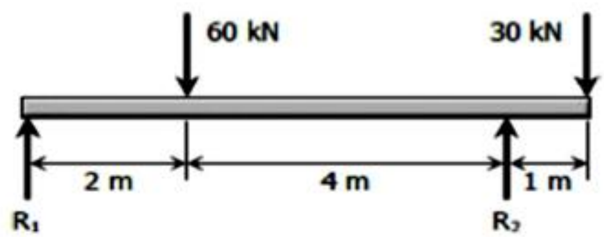
Simply supported beam with uniform distributed load



Simply supported beam with point load

Load	Slope for shear force	Slope for bending Moment
P 	Constant 	Linear 
Uniformly distributed load 	Linear 	Parabolic 
Uniformly varying load 	Parabolic 	Cubic 

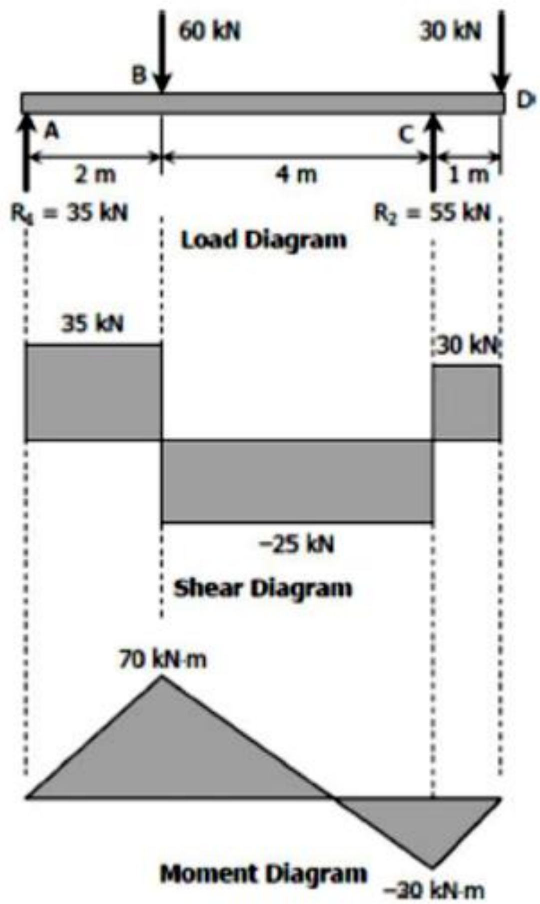
Ex 1: Draw the shear and moment diagrams for the following beam.



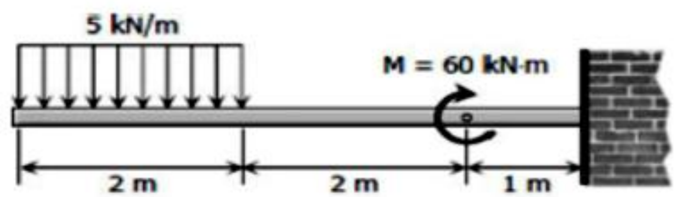
Solution:

$$\Sigma M_A = 0$$
$$6R_2 = 2(60) + 7(30)$$
$$R_2 = 55 \text{ kN}$$

$$\Sigma M_C = 0$$
$$6R_1 + 1(30) = 4(60)$$
$$R_1 = 35 \text{ kN}$$



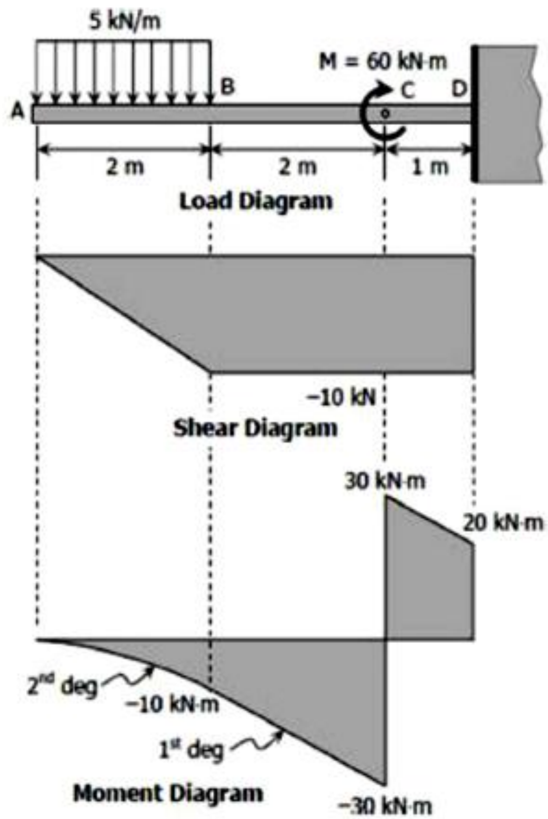
Ex 2: Draw the shear and moment diagrams for the following beam:



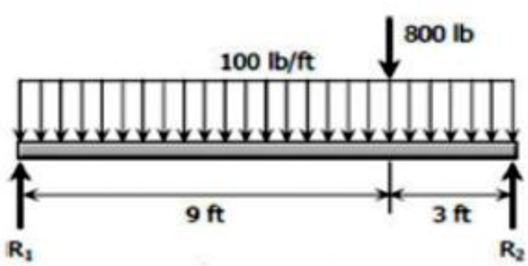
Solution:

$\Sigma Y=0$, R= 5(2) =10 kN

$\Sigma M=0$, $M-5(2)4+60=0$, $M= -20$ kN.m



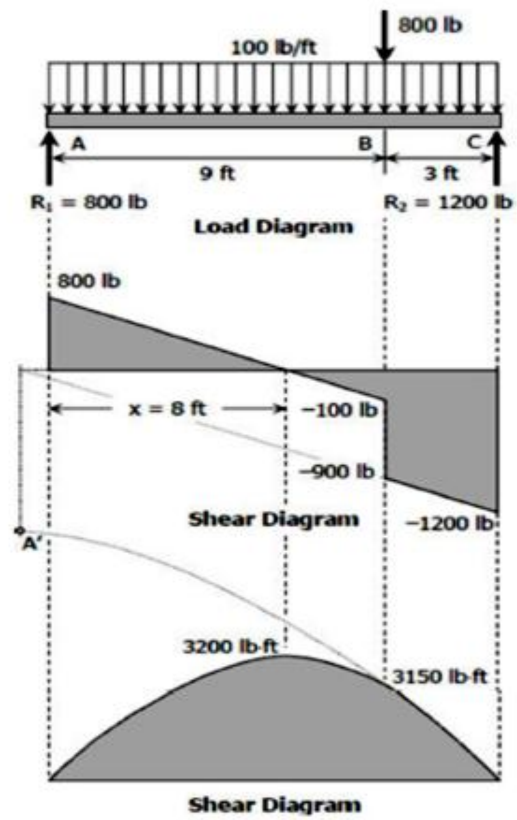
Ex 3: Draw the shear and moment diagrams for the following beam:



Solution:

$\Sigma M_C = 0$
$12R_1 = 100(12)(6) + 800(3)$
$R_1 = 800 \text{ lb}$

$\Sigma M_A = 0$
$12R_2 = 100(12)(6) + 800(9)$
$R_2 = 1200 \text{ lb}$



4/ Post test :-

The length of a cylindrical solid column 4m and the diameter 9 cm. what is the magnitude of the change in length when it carries a load 80000 kg, if the young's modulus of the column is equal to 1.9 x10^{11} N/m^2 ?

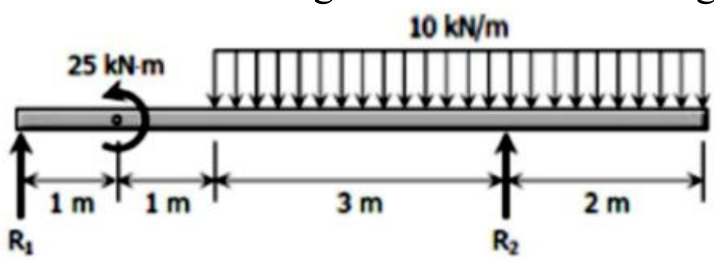
key answer :-

post test :-

$\Delta L = 2.6 \times 10^{-3}$ m

5/ HomeWorks: -

Draw the shear and moment diagrams for the following beam:



6 / References

1-Engineering Mechanics - Maryam Kraige
2-Engineering Mechanics – Hibbeler
3-Engineering Mechanics – Beer Vector