Ministry of high Education and Scientific Research
Al-Fourat Al-Awsat Technical University
Technical Institute / Najaf
Civil Techniques Department

ENGINEERING MECHANICS

First class

Branch of Engineering Drawing

References

1-Singer , Ferdinand L. ,1975

Engineering Mechanics ,3rd edition ,New York ,Harper and Row publisher

2-Higdon Archie and William B. 1968

Engineering Mechanics 3rd edition , United States , prentice - Hall

First Modular Unit

Deifination of mechanics, forece and trigonometric ratios

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Mechanics is very important subject to be studied in order to have a full knowledge about the portions of mechanics classifications of forces and trigonometric ratios of angles, for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1 -Definition of mechanics

2 -The portions of mechanics

3 -Definition of force

4 -Classification of forces

5 -Trigonometric ratios of angles

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying second modular unit .
- get less than 9 , go back and study the first modular unit ; or any part of it ; again and then do the post test again .

2/ Performance objectives

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

1-Define the mechanics and its portions.

2-Define the force and its classifications.

3-Determine the trigonometric ratios for angles .

3/ Pre test

1-Define the force .

2-Write the values of (Sin 30º,Sin 45º,Cos 60º) .

4/ The text

Mechanics: is that branch of physical sciences which describes the motion of bodies with rest being considered a special case of motion .

Mechanics of rigid bodies: is divided into tow portions:

1-Statics:deals with bodies at rest

2-Dynamics:deals with bodies in motion

Physical Quantities :is classified to:

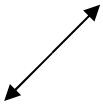
1-Scalar quantities :have only magnitude(mass ,volume)

2-Vector quantities :have both magnitude and direction(couple ,force)

FORCE :any action which change or try to change the shape ,volume or the motion of a body .

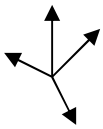
Classification of forces :

1-Collinear

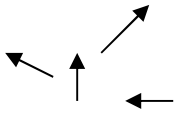


2-Parallelforces

3-Concurrent forces



4-Non parallel ,non concurrent forces



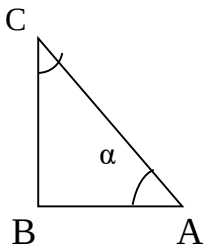
Right angle triangle:

Sin α=BC/AC → BC=AC Sin α

Cos α=AB/AC → AB=AC Cos α

Tan α=BC/AB

$(AC)^2=(AB)^2 + (BC)^2$



5/ Post test

1-Define the vector quantities

2-Classify the physical quantities .

6/ Key answer

1- Pre test :-

1- As in text

2- Sin 30=0.5 ,Sin 45=0.707 ,Cos 60=0.5

2- Post test :-

1- As in text

2- As in text

Second Modular Unit

Analysis of Forces

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Analysis of forces is very important subject to be studied in order to have a full knowledge about the principles of determination of components for the forces, for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1 -Determination of the horizontal and vertical components of forces

2 -Examples

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying third modular unit .
- get less than 9 , go back and study the second modular unit ; or any part of it ; again and then do the post test again .

2/ Performance Objectives

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

1.Determine horizontal and vertical components of forces

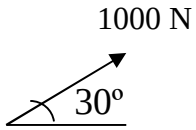
3/ Pre test

1-Define mechanics .

2-what are the types of forces .

4/ The text

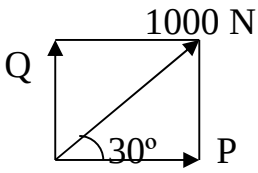
Example: Resolve the (1000N) force shown in figure into two Perpendicular components .



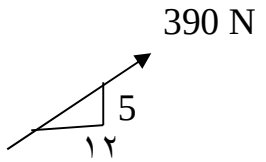
Solution:

Sin 30=Q / 1000 → Q=500 N

Cos 30=P / 1000 → P=866 N



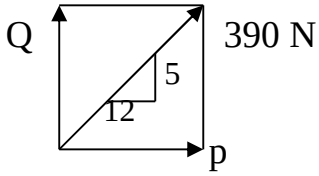
Example: Resolve the (390 N) force shown in figure into two Perpendicular components .



Solution:

5/13=Q/390 → Q=150N

12/13=P/390 → P=360 N



Example: Resolve the (600N)force shown in figure into two components one of them perpendicular on the inclined surface and the another parallel to it .

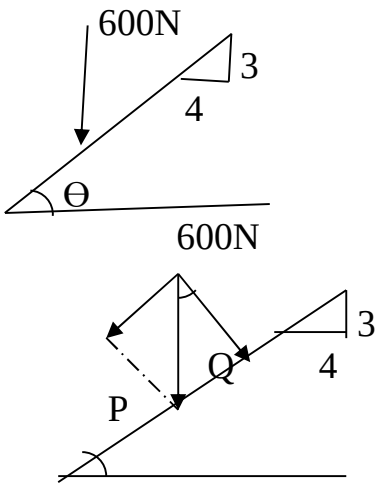
Solution:

Sin Θ=P/600

3/5=P/600 → P=360 N

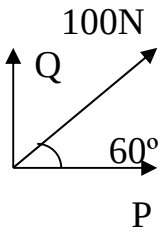
Cos Θ=Q/600

4/5=Q/600 → Q=480N



5/ Post test

1-Resolve the (100N) into two perpendicular components as shown in figure .



6/ Key answer

1- Pre test :-

1- As in text

2- As in text

2- Post test :-

1- P=50N , Q=86.6N

Third Modular Unit

Triangle force and parallogram laws

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Parallelogram laws are very important subject to be studied in order to have a full knowledge about the principles of determination of non perpendicular components for the forces, for this reason I have designed this modular unit for this knowledge to be understood

1 / C –Central Idea :-

1-Determination of non perpendicular components of forces

2-Examples on Sin and Cos laws

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying fourth modular unit .
- get less than 9 , go back and study the third modular unit ; or any part of it ; again and then do the post test again .

2/ Performance Objectives

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

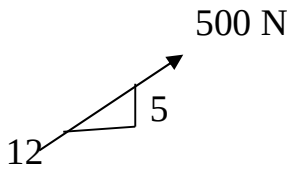
1.Determine the non perpendicular components of forces

2.Use the Sin and Cos laws

3/ Pre test

1-Resolve the (390 N) force shown in figure into two

Perpendicular components .

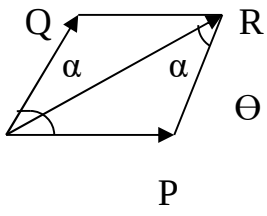


4/ The text

Parallelogram :

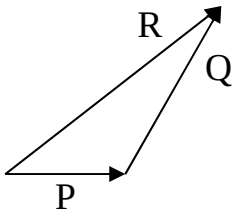
Cos. Law:

$$R^2=P^2 + Q^2 - 2PQ \cos(180-\Theta-\alpha)$$



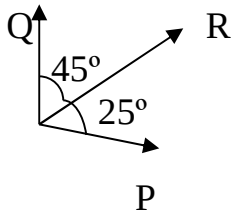
Sin. Law:

$$R / \sin(180-\Theta-\alpha)=Q / \sin\Theta=P / \sin\alpha$$



Example :Resolve the (300N) force into two components as shown in figure .

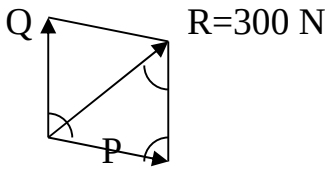
Solution :



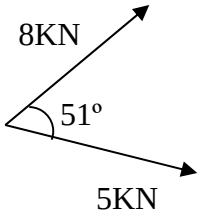
180-45-25=110º

300 / Sin 110 = P / Sin 45 → P=225.7 N

300/ Sin 110 =Q / Sin 25 → Q=134.69 N



Example: Determine the magnitude of resultant for the two forces shown in figure .



Solution:

$R^2=P^2 + Q^2 - 2PQ \cos(180-\Theta-\alpha)$

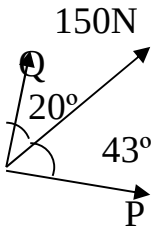
$=(8)^2+(5)^2-2*8*5*\cos(129)$

$=139.34$

R=11.8N

5/ Post test

1-Resolve the (150N)force into two components as shown in figure .



6/ Key answer

1- Pre test :-

1- Fx=461.53N ,Fy=192.3N

2- Post test :-

1- P=57.57N , Q=114.81N

Forth Modular Unit

Moment of force

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Moment of forces is very important subject to be studied in order to have a full knowledge about determination of the moments for the forces about any point or axis, for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1-Determination of moments when the perpendicular distance is known

2-Determination of moments by using Varignan's theory .

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying fifth modular unit.
- get less than 9 , go back and study the fourth modular unit ; or any part of it ; again and then do the post test again .

2/ Performance Objectives

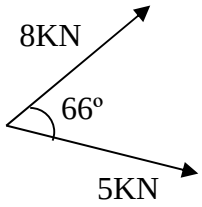
After studying the fourth modular unit , the student will be able to:-

1.Determine the moments of forces

2.Use Varignan's theory .

3/ Pre test

1-Determine the magnitude of resultant for the two forces shown in figure .

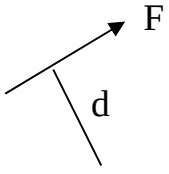


4/ The text

Moment Of Forces: is a measure to its tendency to turn a force about a point or axis

Mathematical expression of moment:

Ma=F.d



F=the magnitude of force.

d=moment arm=the perpendicular distance between the force and the point.

Direction of Moment:

Clock wise ↻ -

Counter clockwise ↺ +

Units of Moment: N.cm , N.m , Kn.m , Ib.in .

Varignan's Theory: the moment of a force about any point or axis is equal to the vector sum the moments of its components about the same point or axis .

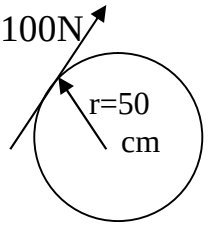
Example: Determine the moment of the (100N) force shown in figure about the axis through Point A .

Solution:

+ ↺ Ma=F . d

=- 100 × 50=-5000N.cm

=5000N.cm ↻



Example: Determine the moment of the (130N) force shown in figure about the axis through Point A .

Solution:

Fx=130× 12/13=120N

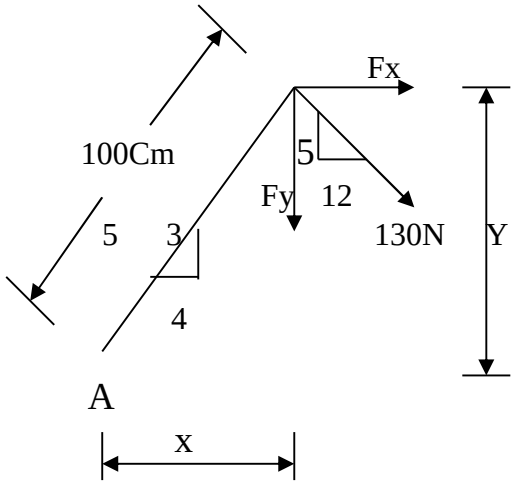
Fy=130× 5/13 =50N

X=100× 4/5=80Cm

Y=100× 3/5=60Cm

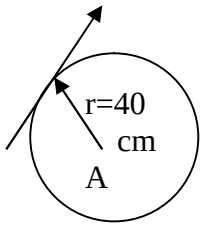
+↺ MA=-120× 60-50× 80=-11200N.Cm

=11200N.Cm ↻



5/ Post test

1-Determine the moment of the (150N) force shown in figure about the axis through Point A .



6/ Key answer

1- Pre test :-

1-R=11.02N

2- Post test :-

1- M=6000N.cm

Fifth Modular Unit

Couples

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Couples are very important subject to be studied in order to have a full knowledge about determination of the moments for the forces which have parallel line of action and opposite senses for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1-Determination of moments the forces which have parallel line of action and opposite senses .

2-Resolution of a force into a force and a couple .

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying sixth modular unit .
- get less than 9 , go back and study the fifth modular unit ; or any part of it ; again and then do the post test again .

2/ Performance Objectives

1.Determine the moments of forces which have parallel line of action and opposite senses

2.Resolution of a force into a force and a couple

3/ Pre test

1-Define the moment

2-What are the units of moment

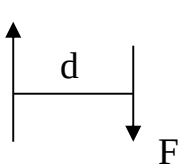
4/ The text

Coupls:

A couple cosists of two equal forces which have parallel line of actions and apposite Senses and work on turn the body .

Moment of a couple: Mc

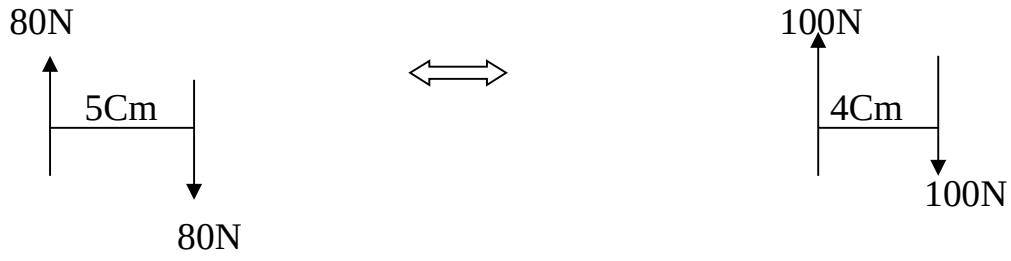
$$Mc = F \cdot d$$



Mc:the sum of the moments of the forces .

d : the perpendicular distance between the forces .

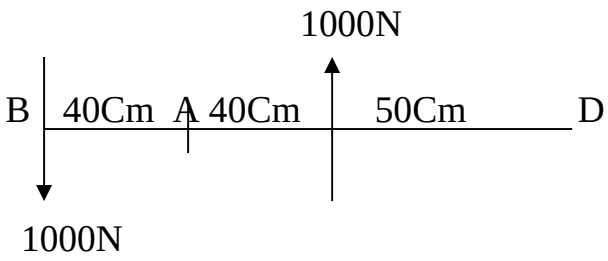
Transformation of a couple:



+ ⟲ Mc=-80× 5=-400N.Cm + ⟲ Mc=-100× 4=-400N.Cm

NOTE: the moment of a couple about any point is equal .

Example: Determine the moment of the couple shown in figure about the axis through Points A,B,D .



Solution:

+ ⟲ Mc(A)=1000× 40+1000× 40=80000N.Cm

+ ⟲ Mc(B)=1000× (40+40)=80000N.Cm

+ ⟲ Mc(D)=1000× (40+40+50)-1000× 50=80000N.Cm

NOTE: two or more couples may be replaced by a single couple have the same magnitude and direction of moment results by the summation of moments of the original couples .

Example: Replace the following couples shown in figure by a single couple its forces effects horizontally at points B,D .

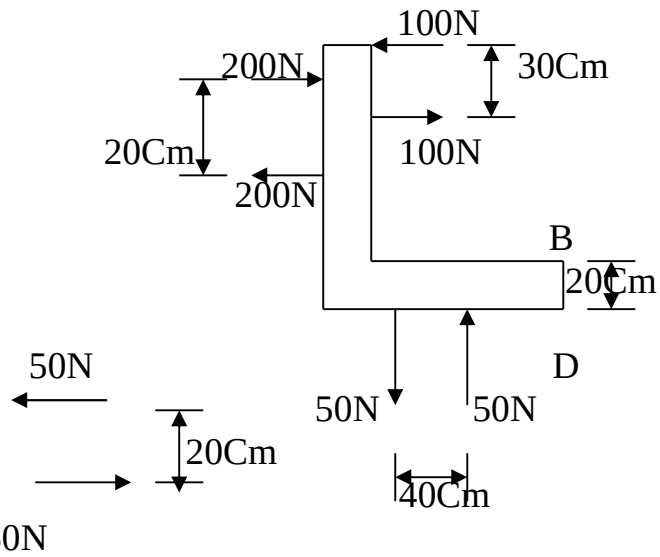
Solution:

+ ⟲ Mc=-200× 20+100× 30+50× 40
=1000N.Cm

Mc=F . d

1000=F × 20
20Cm

F=50N



Resolution of a force into a force and a couple:

A force can be replaced by a parallel force at any different point and a couple by addition of two equal collinear forces of opposite senses to the force system.

Example: Replace the(70N)force shown in figure by a force which acts at point A and a couple whose forces act vertically at points B,D .

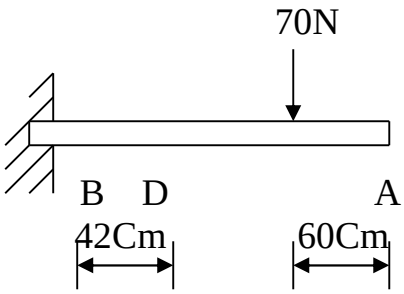
Solution:

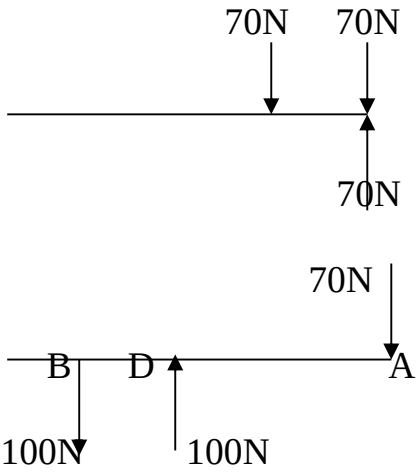
+⟲ Mc=70× 60=4200N.Cm

Mc=F . d

4200=F × 42

F=100N





5/ Post test

1-Determine the moment of a couple consists of tow equal forces have parallel line of action and opposite senses the magnitude of each one is (75N) and the distance between them is (35cm) .

6/ Key answer

1- Pre test:-

1-As in text

2-As in text

2- Post test :-

1- M=2625N.cm

Sixth Modular Unit

Resultant of concurrent forces

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Resultant is very important subject to be studied in order to have a full knowledge about determination of the resultant for the concurrent forces for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1-Determination of resultant of concurrent forces

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying seventh modular unit .
- get less than 9 , go back and study the sixth modular unit ; or any part of it ; again and then do the post test again .

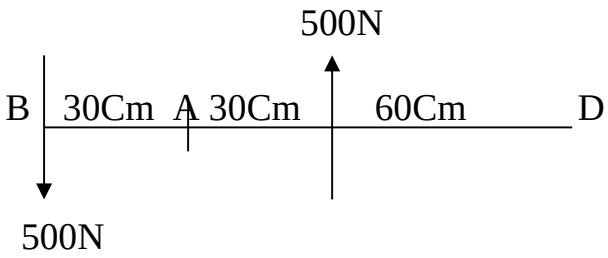
2/ Performance Objectives

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

1.Determine the resultant of concurrent forces

3/ Pre test

1- Determine the moment of the couple shown in figure about the axis through Points A,B,D .



4/ The text

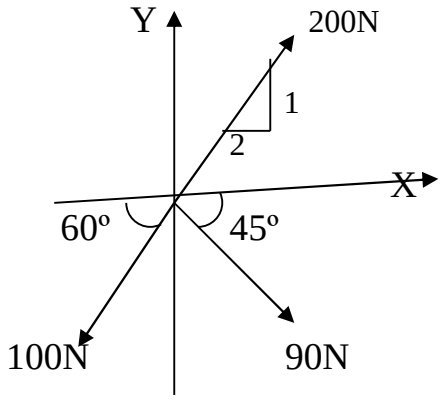
Resultant: the resultant is the simplest force which can replace the original force system without changing its external effect on the body .

if R=0 the body is in equilibrium .

if R≠0 the body will be accelerated .

1:Resultant of concurrent forces : expected resultant is a force .

Example: Determine the magnitude and direction of the resultant for the force system shown in figure .



Solution:

$+\rightarrow$ $Rx=200\times 2/\sqrt{5}+90\cos 45-100\cos 60$

$=192.5N \rightarrow$

$+\uparrow$ $Ry=200\times 1/\sqrt{5}-90\sin 45-100\cos 60$

$=-60.78N=60.78N \leftarrow$

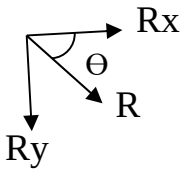
$R=\sqrt{(Rx)^2+(Ry)^2}$

$R=\sqrt{(192.5)^2+(60.78)^2}$

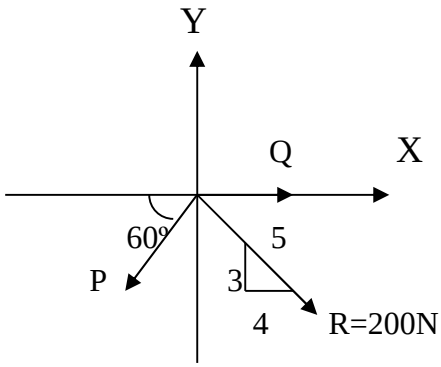
$=201.86\ N$

$\Theta=Tan^{-1}\ Ry/Rx$

$=17.5^{o}$



Example; Determine the magnitude of forces (P)and(Q),if the resultant is (200N)as shown in figure .



+ Solution:

$\rightarrow$ $Rx=200\times 4/5=160N \rightarrow$

$+\uparrow$ $Ry=-200\times 3/5=-120N=120N \downarrow$

$Rx=Q-P\cos 60$

$160=Q-0.5P$ ------ 1

$Ry=-P\sin 60$

$-120=-P\sin 60$

$P=138.56N$

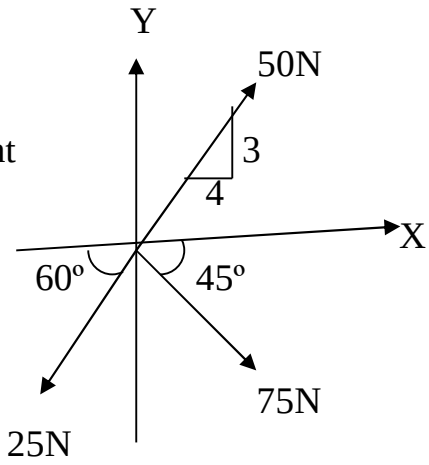
Substitute in equation 1

$160=Q-0.5\times 138.56$

$Q=229.28N$

5/ Post test

1-Determine the magnitude and direction of the resultant for the force system shown in figure .



6/ Key answer

1- Pre test :-

1-MA=MB=MD 30000N.Cm

2- Post test :-

1- R=83.49N , Θ=32.35º

Seventh Modular Unit

Resultant of nonconcorrent forces

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Resultant is very important subject to be studied in order to have a full knowledge about determination of the resultant for the non concurrent forces for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1 -Determination of resultant of non concurrent forces

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying eighth modular unit.
- get less than 9 , go back and study the seventh modular unit ; or any part of it ; again and then do the post test again .

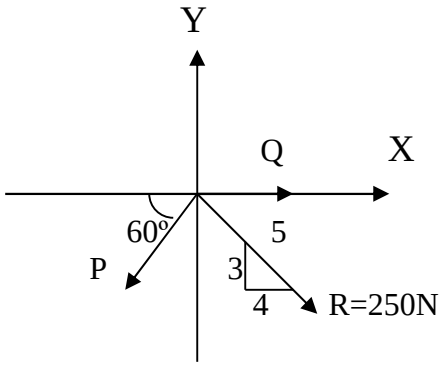
2/ Performance Objectives

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

1.Determine the resultant of non concurrent forces

3/ Pre test

1- Determine the magnitude of forces (P)and(Q),if the resultant is (250N)as shown in figure .



4/ The text

text

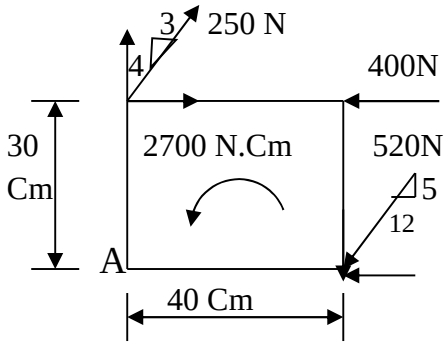
2-Resultant of non concurrent ,non parallel forces:

if $R \neq 0$ the resultant is a force

if $R = 0$ the resultant is a couple and $Mc = \sum Mo$

Example: Determine the resultant of the forces and the couple shown in figure and locate it with respect to point (A) .

Solution:



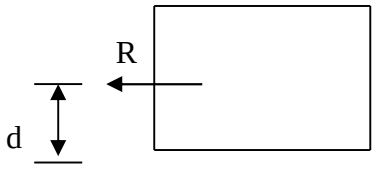
+→ Rx =250× 3/5-520× 12/13-400
=-730 N=730N ←

Ry=250× 4/5-520× 5/13= 0

R=730 N ←

R× d= ∑Ma

730× d=-250× 3/5× 30+400 × 30
-520× 5/13× 40+2700
d =3 Cm



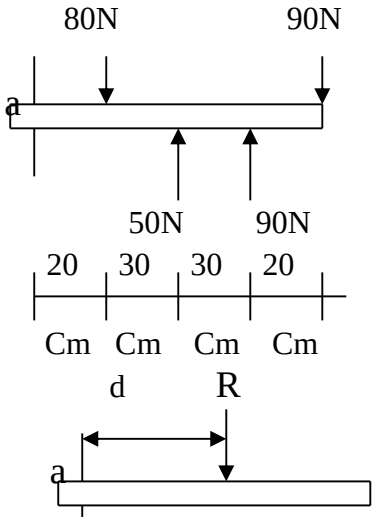
3:Resultant of parallel force system:

If $R \neq 0$ then the resultant is a force

If $R = 0$ then the resultant is a couple and Mc = ∑ Ma

Example: Determine the resultant of the parallel forces shown in figure, and its Location from point (a) .

Solution:



+↑ R=∑Fy

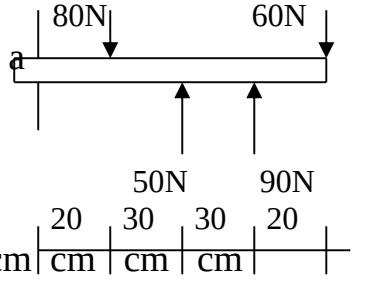
=50+90-80-90=-30N=30N ↓

+↻ R× d=∑Ma

-30× d=-800× 20+50× 50+90× 80-90× 100
d=30 Cm

Example: Determine the resultant of the parallel forces shown in figure, and its Location from point (a) .

Solution:



+↑ R=∑Fy

=50+90-80-60=0

The resultant may be a couple

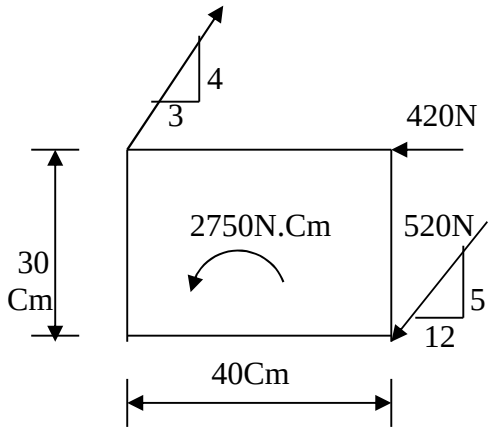
↺ Mc=∑M

=-80×20+50×50+90× 80-60× 100=2100N.Cm

5/ The test

test

1- Determine the resultant of the forces and the couple shown in figure and locate it with respect to point (A) .



6/ Key answer

1- Pre test :-

1-P=173.2N , Q=286.6N

2- Post test :-

1- R=750N , d=3.8cm

Eighth Modular Unit

Distributed Loads

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Distributed loads is very important subject to be studied in order to have a full knowledge about determination of the resultant for the distributed load and its location for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1-Determination of resultant of distributed loads .

2- Determination of location of resultant of distributed loads .

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying ninth modular unit .
- get less than 9 , go back and study the eighth modular unit ; or any part of it ; again and then do the post test again .

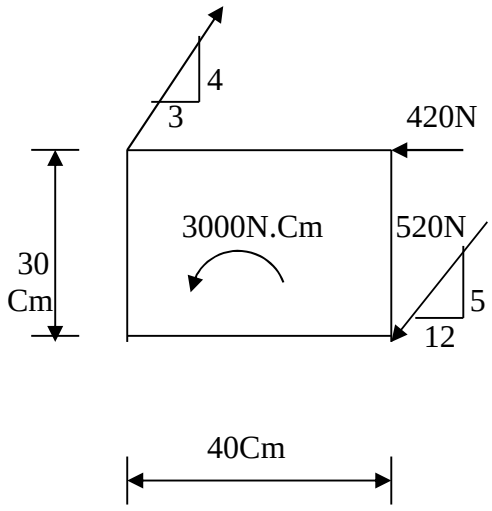
2/ Performance Objectives

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

1.Determine the resultant of distributed loads .
2.Determine the location of resultant of distributed loads .

3/ Pre test

1-Determine the resultant of the forces and the couple shown in figure and locate it with respect to point (A) .

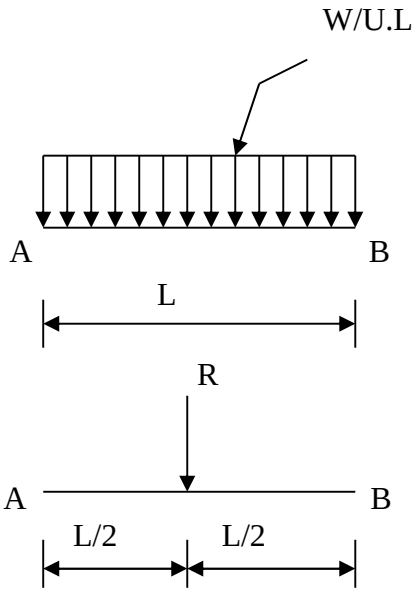


4/ The text

DISTRIBUTED LOADS :

1:Uniformly Distributed Loads or rectangular loads U. D. L

R=W/U.L * L

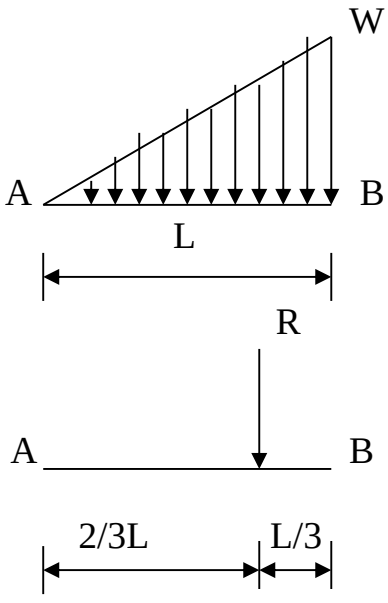


R: resultant of the total weight of construction
W/U.L: the weight for unit length
L: the length of construction

NOTE: the location of (R) is in the middle
i.e L/2 from A and B

2:Varying Loads or triangular loads

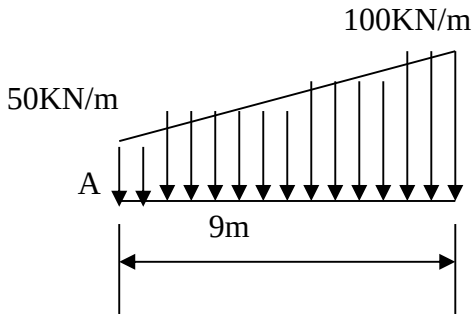
R=1/2 * W * L



NOTE :the location of (R) is:

L /3 from point B and
2L /3 from point A

Example: Determine the resultant of the distributed loads shown in figure and indicate its location from point (A) .



Solution:

R1=50× 9=450N ↓

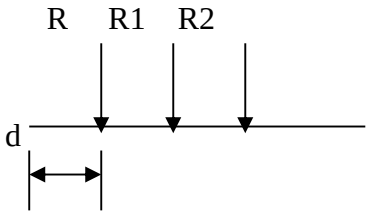
R2=1/2× 50× 9=225N ↓

R=R1+R=450+225=675N ↓

R*d=R1*4.5+R2*6

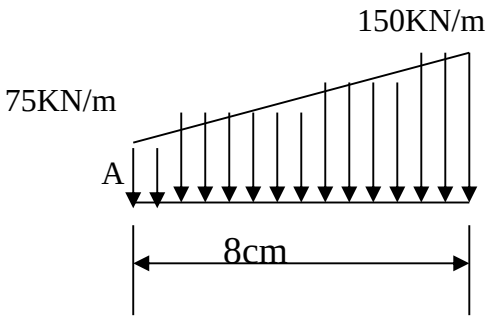
675*d=450*4.5+225*6

d=5m



5/ Post test

1- Determine the resultant of the distributed loads shown in figure and indicate its location from point (A) .



6/ Key answer

1- Pre test :-

1-R=750N , d=4.13cm

2- Post test :-

1- R=3600N , d=1.1cm

Ninth Modular Unit

Equilibrum in concorrent forces

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Equilibrium is very important subject to be studied in order to have a full knowledge about determination of the forces effect on bodies and drawing the free body diagram for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1-Determination of the forces effect on bodies .

2-Drawing the free body diagram .

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying tenth modular unit .
- get less than 9 , go back and study the ninth modular unit ; or any part of it ; again and then do the post test again .

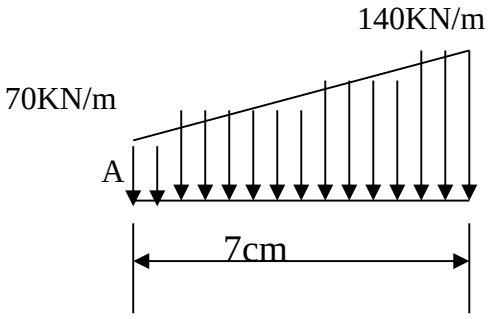
2/ Performance Objectives

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

1.Determine the forces effect on bodies .
2.Draw the free body diagram .

3/ Pre test

1-Determine the resultant of the distributed loads shown in figure and indicate its location from point (A) .

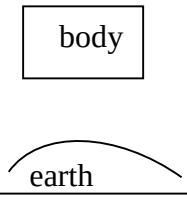
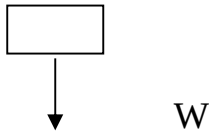
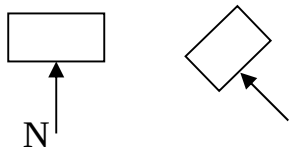
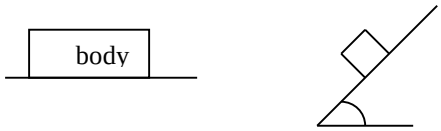
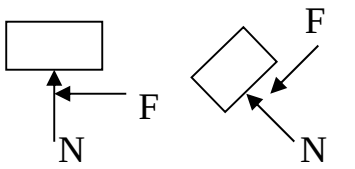
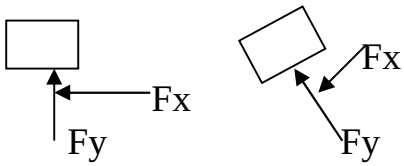
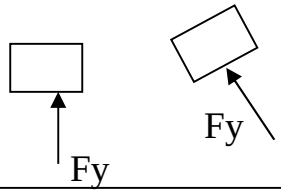
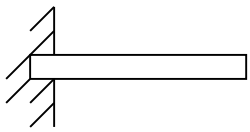
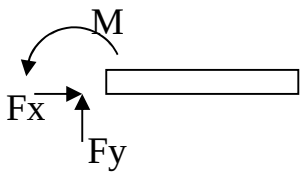
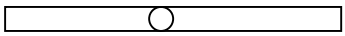
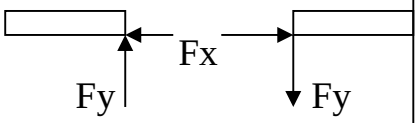
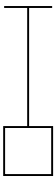
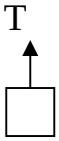


4/ The text

EQUILIBRIUM:
Is the condition of the body when the resultant of forces acting on it is equal to(ZERO)

Free Body Diagram: F.B.D
Is a diagram shown all the forces acting on the body.

Types of supports:

Type of support	Body diagram	F.B.D
1- Earth		
2- Smooth surface		
3- Rough surface		
4- Hinge		
5- Roller		
6- Fixed		
7- Internal hinge		
8- Cable		

1:Equilibrium of concurrent forces:

The resultant of this system is a force can be calculated by $R= \sqrt{Rx^2 + Ry^2}$

In equilibrium condition R=0 then:

$Rx=\sum Fx=0$ --------(1)

$Ry=\sum Fy=0$ -------(2)

Example: Find all forces which effects on the cylinder (A) shown in figure if all concurrent surfaces are smooth ,and the weight of cylinder(A)is(500N),and cylinder (B) is (300N) .

Solution:

From F.B.D of cylinder (B) :

$\sum Fy=0$

$Fz \sin 40 - 300 = 0 \Rightarrow Fz = 466.71N$

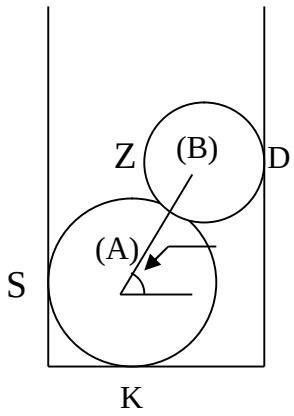
From F.B.D of cylinder (A) :

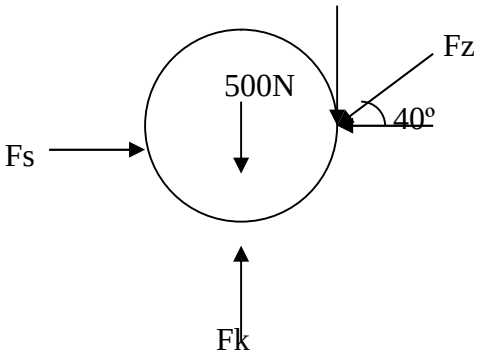
$\sum Fx=0$

$Fs - 466.71 \cos 40 = 0 \Rightarrow Fs = 357.52N$

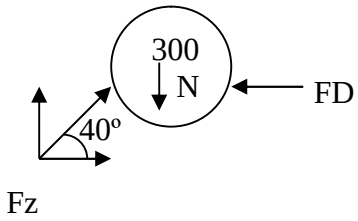
$\sum Fy=0$

$Fk - 500 - 466.71 \sin 40 = 0 \Rightarrow Fk = 800N$





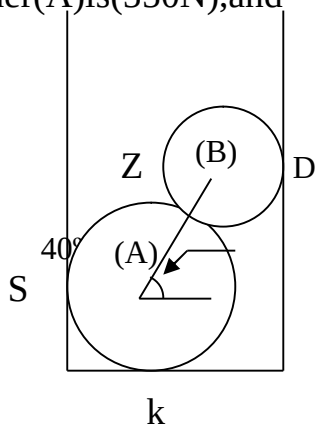
F.B.D of cylinder (A)



F.B.D of cylinder (B)

5/ Post test

1-Find all forces which effects on the cylinder (A) shown in figure if all concurrent surfaces are smooth ,and the weight of cylinder(A)is(550N),and cylinder (B) is (350N) .



6/ Key answer

1- Pre test :-

1-R=750N , d=4.13cm

2- Post test :-

1-Fz=568.49N , Fs=447.97N , Fk=900N

Tenth Modular Unit

Equilibrium in nonconcorrent forces

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Equilibrium in non concurrent forces is very important subject to be studied in order to have a full knowledge about determination of reactions at supports and drawing the free body diagram for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1-Determination of reactions at supports .

2- Drawing the free body diagram .

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying eleventh modular unit .
- get less than 9 , go back and study the tenth modular unit ; or any part of it ; again and then do the post test again .

2/ Performance Objectives

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

1.Determine the reactions at supports .
2.Draw the free body diagram .

3/ Pre test

1-Define :(equilibrium , free body diagram)

4/ The text

2:Equilibrium of non concurrent forces :

The resultant of this system is:

A force can be calculated by $R=\sqrt{Rx^2+Ry^2}$ when $R\neq 0$ OR

A couple can be calculated by $Mc=\sum M$ when $R= 0$

In equilibrium condition $R=0$ and $Mc=0$ then:

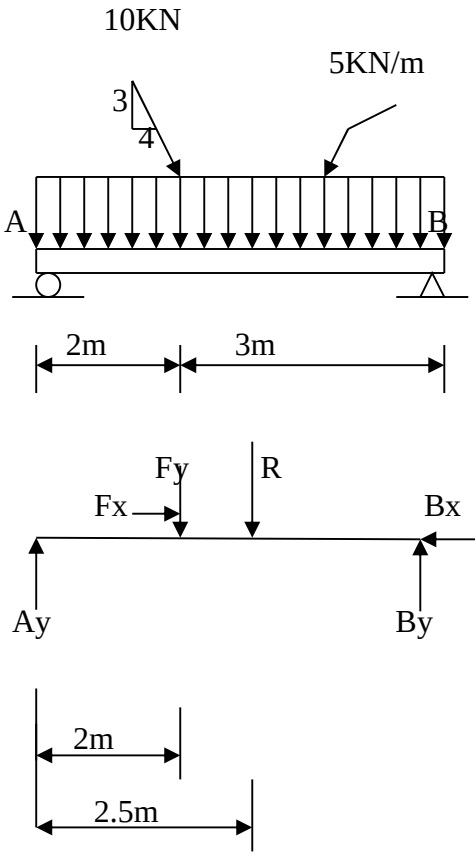
$Rx=\sum Fx=0$ ----------(1)

$Ry=\sum Fy=0$ ----------(2)

$Mc=\sum M=0$ ----------(3)

Example: Determine the reactions at supports (A) and (B) for the beam loaded as shown In figure .

Solution:



R=5×5=25KN

Fx=10× 4/5=8KN

Fy=10× 3/5=6KN

∑Fx=0

8-Bx=0 ⇨ Bx=8KN

∑MA=0

By× 5-6× 2-25× 2.5=0 ⇨ By=14.9KN

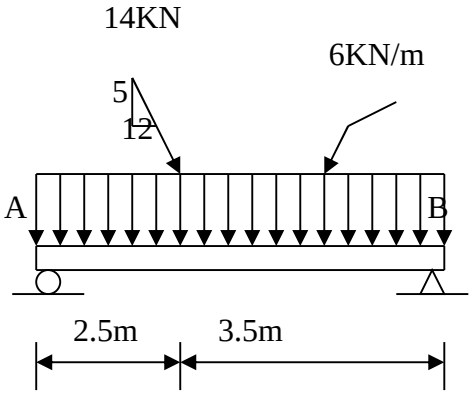
∑Fy=0

Ay+14.9-25-6=0 ⇨ Ay=16.1KN

(F.B.D)

5/ Post test

1-Determine the reactions at supports (A) and (B) for the beam loaded as shown In figure .



6/ Key answer

1- Pre test :-

1-As in text

2- Post test :-

1-Ay=21.14 N, Bx=12.92 N, By=20,24N

Eleventh Modular Unit

Types of beams and supports

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Types of beams and supports is very important subject to be studied in order to have a full knowledge about drawing the free body diagram for different beams ,for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1-types of beams .

2- types of supports .

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying twelfth modular unit .
- get less than 9 , go back and study the eleventh modular unit ; or any part of it ; again and then do the post test again .

2/ Performance Objectives

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

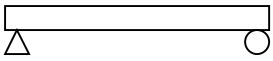
1.Draw the free body diagram for different beams .

3/ Pre test

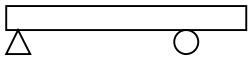
1-Draw the F.B.D for five type of supports .

4/ The text

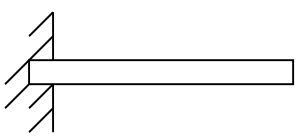
Types of beams & supports:



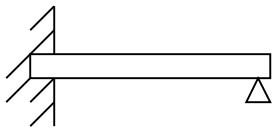
Simply supported beam



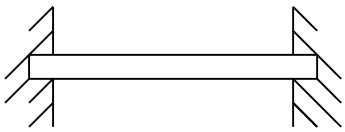
Over hanging beam



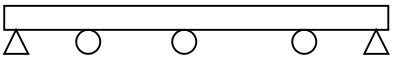
Cantilever beam



Propped beam



Fixed beam



Continuous beam

5/ Post test

1-Draw three types of beams .

6/ Key answer

1- Pre test :-

1-As in text

2- Post test :-

1-As in text

Twelth Modular Unit

Analysis of Trusses by joint method

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Trusses is very important subject to be studied in order to have a full knowledge about the definition of truss and the analysis of trusses by using the method of joints ,for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1-Definition of truss .

2-Analysis of trusses by using the method of joints .

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying thirteenth modular unit .
- get less than 9 , go back and study the twelfth modular unit ; or any part of it ; again and then do the post test again .

2/ Performance Objectives

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

1-Define of truss .
2-analysis of trusses by using the method of joints .

3/ Pre test

1-Draw the F.B.D of overhanging beam .

4/ The text

TRUSSES: A truss is a structure composed of a number of members joined together at their ends to form a rigid body .

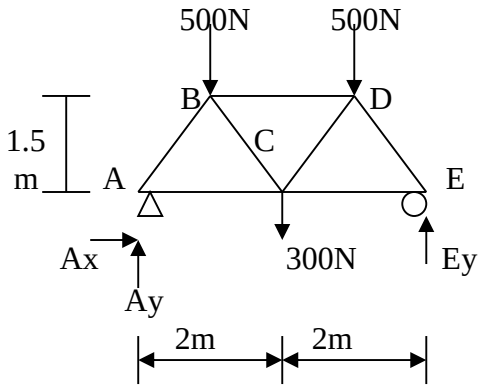
Analysis of trusses : is how to determine the forces in each member of the truss .

1:- Method of joints : In this method a single joint is isolated as a free body diagram and applying the equations of concurrent forces $\sum Fx=0, \sum Fy=0$.

Example: Determine the forces in each member of the truss shown in figure and Indicate wether the member is in tension or compression .

Solution:

$\sum Fx=0 \Rightarrow Ax=0$



$\sum MA=0$

$Ey\times 4-500\times 1-500\times 3-300\times 2=0$

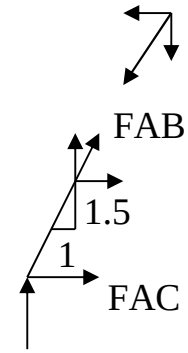
$Ey=650N$

$\sum Fy=0$

$Ay+300+650-500-500=0$

$Ay=650N$

Joint (A) :



$\sum Fy=0$

$650+FAB\times 1.5/1.8=0$

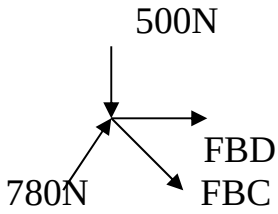
$FAB=-780N=780N$ (C)

$\sum Fx=0$

$FAC-780\times 1/1.8=0$

$FAC=433.3N$ (T)

Joint (B) :



$\sum Fy=0$

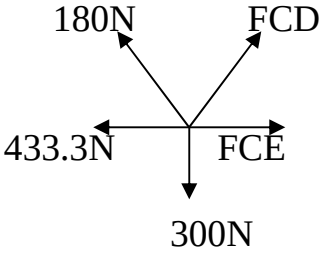
$780\times 1.5/1.8-500-FBC\times 1.5/1.8=0$

$FBC=180N$ (T)

$\sum Fx=0$

$780\times 1/1.8+FBD+180\times 1/1.8=0 \Rightarrow FBD=-533.3N=533.3N$ (C)

Joint (C) :



$\sum Fy=0$

$180\times 1.5/1.8+FCD\times 1.5/1.8-300=0$

$FCD=180N$ (T)

$\sum Fx=0$

$FCE-180\times 1/1.8+180\times \ 1/1.8-433.3=0$

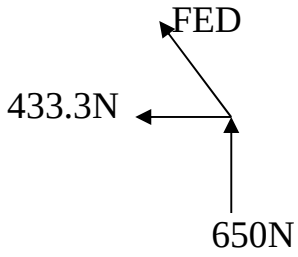
FCE=433.3N (T)

Joint (E) :

∑Fy=0

650+FED× 1.5/1.8=0

FED=-780N=780N (C)



5/ Post test

1-Define : truss , method of joints

6/ Key answer

1- Pre test :-

1-As in text

2- Post test :-

1-As in text

Thirteen Modular Unit

Analysis of trusses by method of sections

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Analysis of trusses by method of sections is very important subject to be studied in order to have a full knowledge about the definition of method of sections and the analysis of trusses by using the method of sections ,for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1-Definition of method of sections.

2-Analysis of trusses by using the method of sections .

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying fourteenth modular unit .
- get less than 9 , go back and study the thirteenth modular unit ; or any part of it ; again and then do the post test again .

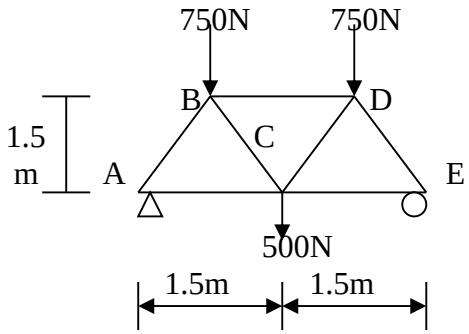
2/ Performance Objectives

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

1-Define of method of sections.
2-Analysis of trusses by using the method of sections.

3/ Pre test

1-Determine the forces in members (DE,CE) of the truss shown in figure and Indicate wether the member is in tension or compression .

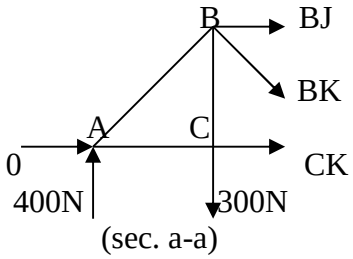


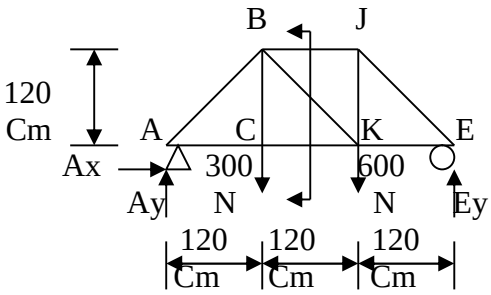
4/ The text

2:-Method Of Sections : When two or more joints are isolated and applying the equations of non concurrent forces ∑Fx=0, ∑Fy=0 ,∑M=0 .

Example: Determine the forces in members (CK,BK,BJ) for the truss shown in figure and indicate wether the members are in tension or compression .

Solution:





∑Fx=0

Ax=0

∑ME=0

600× 120+300× 240-Ay× 360=0

Ay=400N

∑Fy=0

400+Ey-300-600=0

Ey=500N

From Section (a-a) :

∑MB=0

CK× 120-400× 120=0

CK=400N (T)

∑Fy=0

400-300-BK× $1/\sqrt{2}$ =0

BK=141.4N (T)

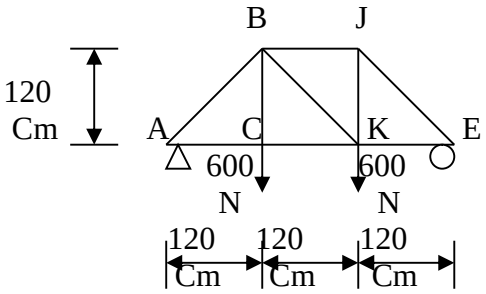
∑Fx=0

400+BJ+141.4× $1/\sqrt{2}$ =0

BJ=-500N=500N (C)

5/ Post test

1:Determine the forces in members (CK,BK,BJ) for the truss shown in figure and indicate wether the members are in tension or compression .



6/ Key answer

1- Pre test :-

1-FED=1414.21N(C) ,FCE=1000N(T)

2- Post test :-

1-BK=0 , CK=600N(T) , BJ=600N©

Fourteenth Modular Unit

Friction

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Friction is very important subject to be studied in order to have a full knowledge about the definition of friction and friction theory ,for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1-Definition friction.

2-Explanation of friction theory .

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying fifteenth modular unit .
- get less than 9 , go back and study the fourteenth modular unit ; or any part of it ; again and then do the post test again .

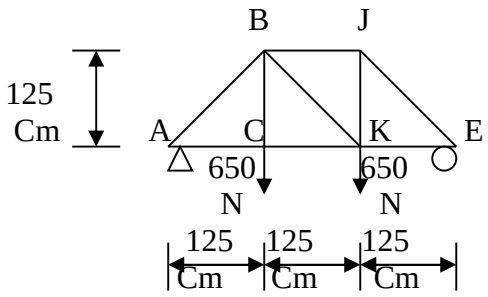
2/ Performance Objectives

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

1-Define the friction.
2-Explane the theory of friction.

3/ Pre test

1-Determine the forces in members (CK,BK,BJ) for the truss shown in figure and indicate wether the members are in tension or compression .



4/ The text

FRICTION: Is the force tangent to the contact surface which resists the motion when a body slides or tends to slides on another body .

Friction Theory : Let a block of weight (W) rests on a horizontal plane as shown in (Figure 1) ,and a horizontal force (P) is applied on it as shown in (Figure 2) :

1:-When (P=0) the frictional force (F=0) and the block is in equilibrium .

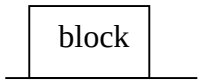


Figure 1

2:-When (P) increased the frictional force (F) is also increased in the same value to prevent motion .

3:-When (F) reach its maximum value (Fmax.) any increase in (P) will cause motion .

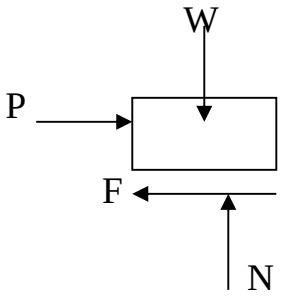


Figure 2

5/ Post test

1-Define the friction .
2-Explane the theory of friction .

6/ Key answer

1- Pre test :-

1- BK=0 , CK=650N(T) , BJ=650N(C)

2- Post test :-

1-As in text

Fifteenth Modular Unit

Laws of Friction, Types of Friction, applications

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Laws of friction is very important subject to be studied in order to have a full knowledge about the determination of maximum frictional force and the types of friction ,for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1-Determination of maximum frictional force.

2-Types of friction .

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying sixteenth modular unit .
- get less than 9 , go back and study the fifteenth modular unit ; or any part of it ; again and then do the post test again .

2/ Performance Objectives

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

1-Define the maximum frictional force.
2-Explane the types of friction .

3/ Pre test

1- When the body will be move .
2-IF the external force (P) is zero .What is the magnitude of the frictional force .

4/ The text

Laws of friction:

The maximum frictional force (Fmax.)is proportional with the normal force (N) between the contact surfaces .

$$F_{max.} \alpha N$$

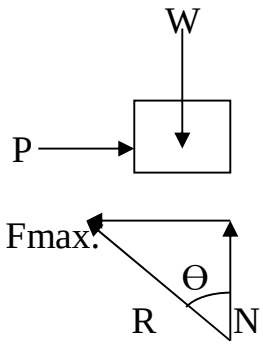
$$F_{max.}=\mu * N \quad \Longrightarrow \quad \mu=F_{max.}/N$$

Angle of friction :

Tan Θ=Fmax./ N

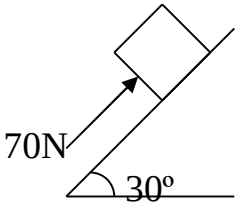
μ=Fmax./ N

Tan Θ = μ



Example: Determine the frictional force exerted on the (200N) block weight by the Inclined surface shown in figure if the block is subjected to (70N) force (μ=0.2) .

Solution:



Wx=200× Sin30=100N

Wy=200× Cos30=173.2N

Assume the block will move upward

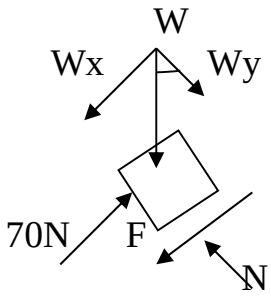
∑Fx=0

70-100-F=0

F=-30N

That means the block is try to move downward

(F) must be equal or less than(Fmax.)



Fmax.=μ*N

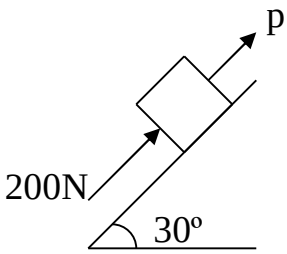
∑Fy=0

N-70=0 ⇨ N=70N

Fmax.=0.2× 173.2=34.64N > 30N

F=30N

Example: Calculate the force (P) required to move the (500N) block weight up the inclined surface shown in figure ,if the block is subjected to (200N)force assume (μ=0.5) .



Solution:

Wx=500× Sin30=250N

Wy=500× Cos30=433N

∑Fy=0

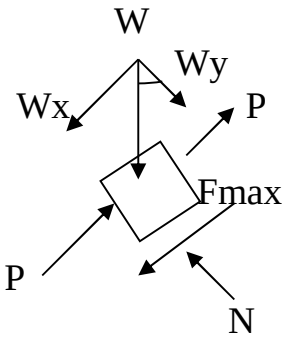
N-433=0 ⇨ N=433N

Fmax.=μ*N=0.5×433=216.5N

∑Fy=0

200+p-250-216.5=0

Fmax.=266.5N



Example: A cylinder of (100N) weight is to entrust to a horizontal surface its coefficient of friction (μ=0.4) and a smooth vertical surface as shown in figure .Determine the frictional force .

Solution:

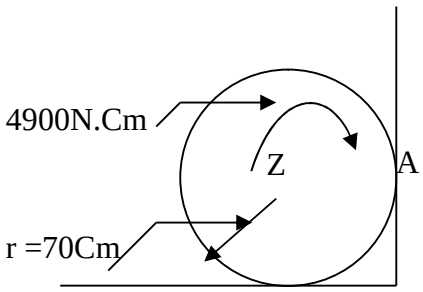
From F.B.D of cylinder

Assume FB to the right as shown

∑MZ=0

-4900+FB× 70=0

FB=70N



FB must be equal or less than Fmax.

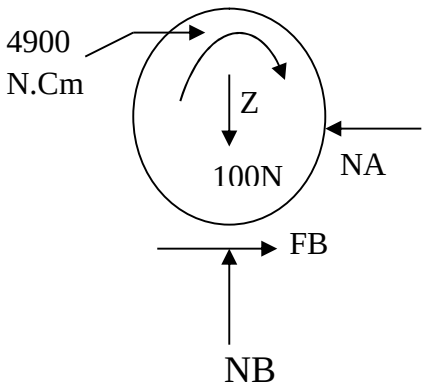
Fmax.=μ*N

∑Fy=0

NB-100=0 ⇨ NB=100N

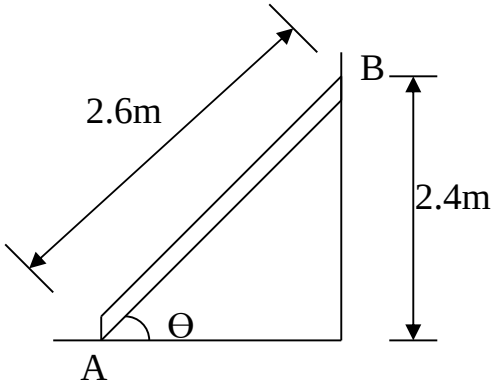
Fmax.=0.4× 100=40N< 70N

FB=40N



F.B.D of cylinder

Example: A ladder (300N) weight is rest as shown in figure ,if the vertical wall is smooth and the horizontal surface has (μ=0.2).Determine the distance from point(B) which make the ladder move when a boy of (150N)weight try to going up the ladder .



Solution:

From F.B.D of ladder:

∑Fy=0

N-300-150=0

N=450N

Fmax.=μ*N

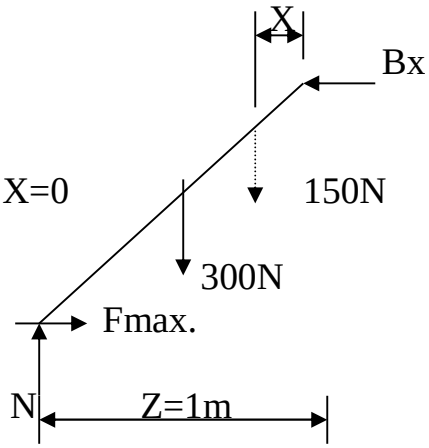
=0.2× 450=90N

$Z= \sqrt{(2.6)^2-(2.4)^2} =1m$

∑MB=0

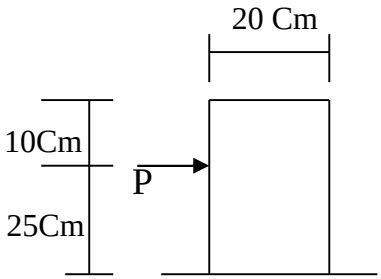
-450× 1+300× 0.5+67.5× 2.4+150× X=0

X=0.56m



F.B.D of ladder

Example: Determine the force (P) required to move the (400N) block weight shown in figure if the horizontal surface has (μ =0.34) .



Solution:

The block is either slides or overturn

1-the block is slides

From (F.B.D 1)

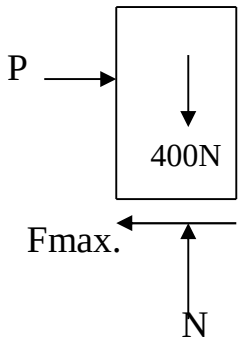
$\sum Fx = 0$

$P = Fmax.$

$\sum Fy = 0 \quad \Rightarrow \quad N=400N$

$Fmax.= \mu * N=0.34\times 400=136N$

$P=136N$



F.B.D 1

2-the block is overturn

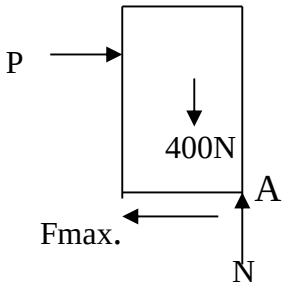
From (F.B.D 2)

$\sum MA= 0$

$25 \times p-400\times 10= 0$

$P=160N$

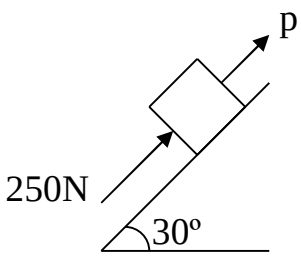
The block is slides and P= 136N



F.B.D 2

5/ Post test

1- Calculate the force (P) required to move the (600N) block weight up the inclined surface shown in figure ,if the block is subjected to (250N)force assume (μ=0.5) .



6/ Key answer

1- Pre test :-

1- As in text .

2- As in text .

2- Post test :-

1-P=309.8N .

Sixteenth Modular Unit

Centroids of simple shapes

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Centroid is very important subject to be studied in order to have a full knowledge about locate the position of the centroid of different simple shapes ,for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1 –location of centroid of different simple shapes.

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying seventeenth modular unit .
- get less than 9 , go back and study the sixteenth modular unit ; or any part of it ; again and then do the post test again .

2/ Performance Objectives

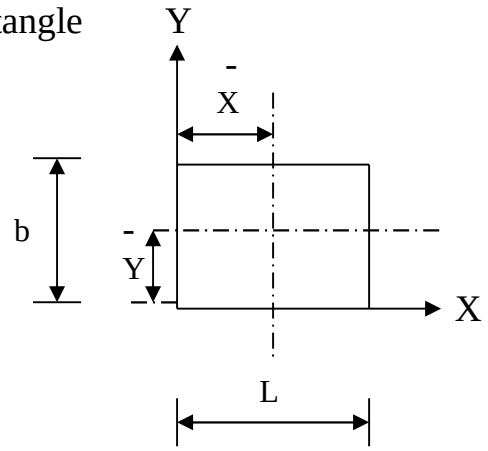
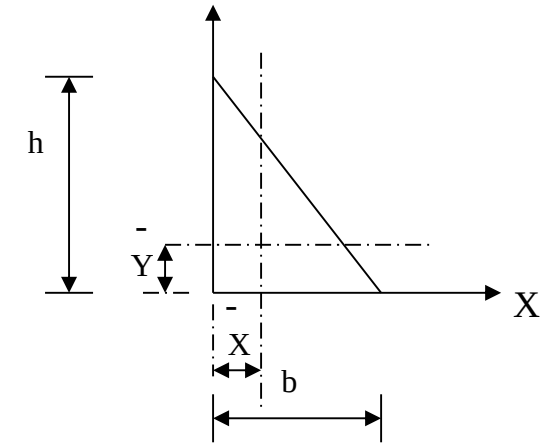
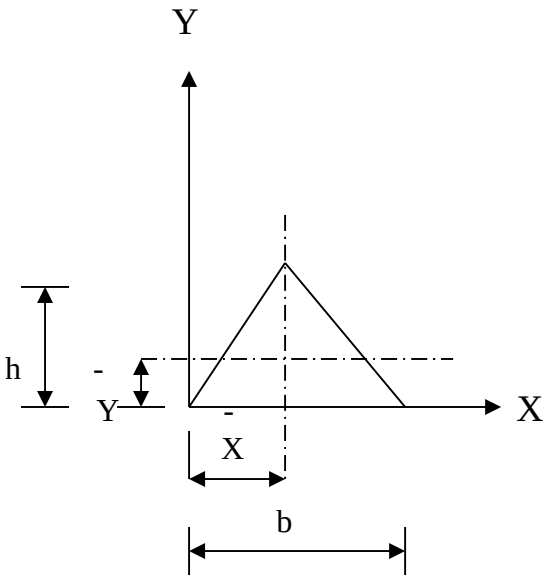
After studying the sixteenth modular unit , the student will be able to:-

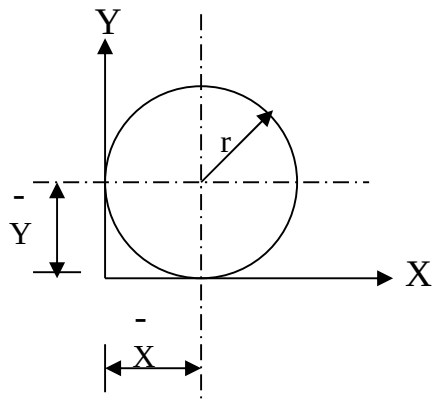
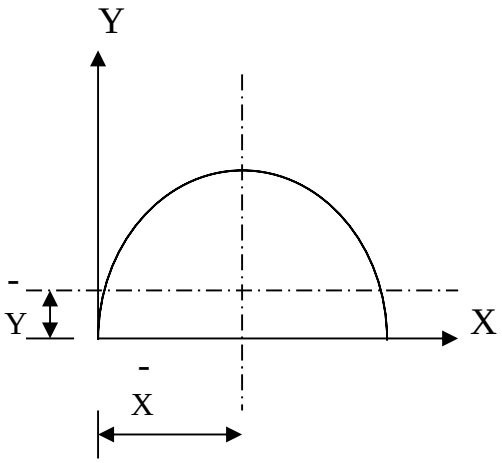
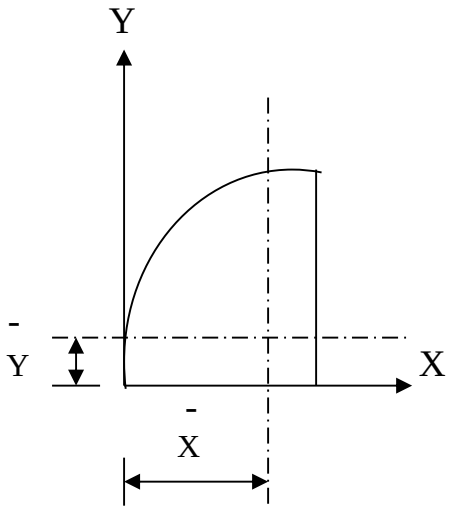
1-Locate the centroid of different simple shapes.

4/ The text

CENTROID :

1:-Centroids of simple shapes:

Shape	Area (ai)	- X	- Y
1-Rectangle 	L× b	L/2	b/2
2-TriaHngle 	1/2× b× h	b/3	h/3
	$\frac{b \times h}{2}$	b/2	h/3

Shape	Area (ai)	$\bar{X}$	$\bar{Y}$
3-Circle 	πr^2	r	r
4-Half circle 	$\frac{\pi r^2}{2}$	r	0.424r
5-Quarter circle 	$\frac{\pi r^2}{4}$	r-0.424r	0.424r

5/ Post test

1-Locate with drawing the centroid of rectangle .

2- Locate with drawing the centroid of a half circle .

6/ Key answer

1- Pre test :-

1- P=396.52N .

2- Post test :-

1-As in text .

2-As in text.

Seventeenth Modular Unit

Centroids of complex shapes

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Centroid of complex shapes is very important subject to be studied in order to have a full knowledge about the laws and determination of centroid of different complex shapes ,for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1 –Determination of centroid of different complex shapes .

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying eighteenth modular unit .
- get less than 9 , go back and study the seventeenth modular unit ; or any part of it ; again and then do the post test again .

2/ Performance Objectives

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

1-Determine the centroid of different complex shapes.

3/ Pre test

1- Locate with drawing the centroid of triangle.

2- Locate with drawing the centroid of a quarter circle .

4/ The text

2.- Centroids of complex shapes :

NOTE: the coordinates (x , y) of centroid of any non uniformly area about X and Y axes can be found by :

$$\bar{X} = \frac{\sum a_i x_i}{\sum a_i} \qquad \bar{Y} = \frac{\sum a_i y_i}{\sum a_i}$$

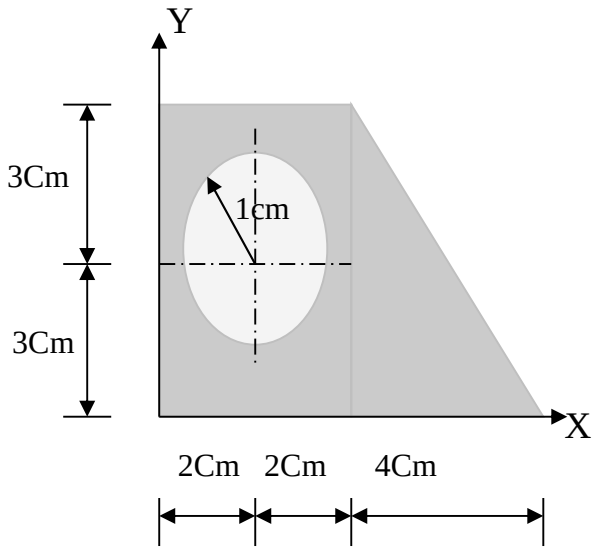
Example : Determine the centroid of the shaded area shown in figure with respect to (X) and (Y) axes .

Solution:

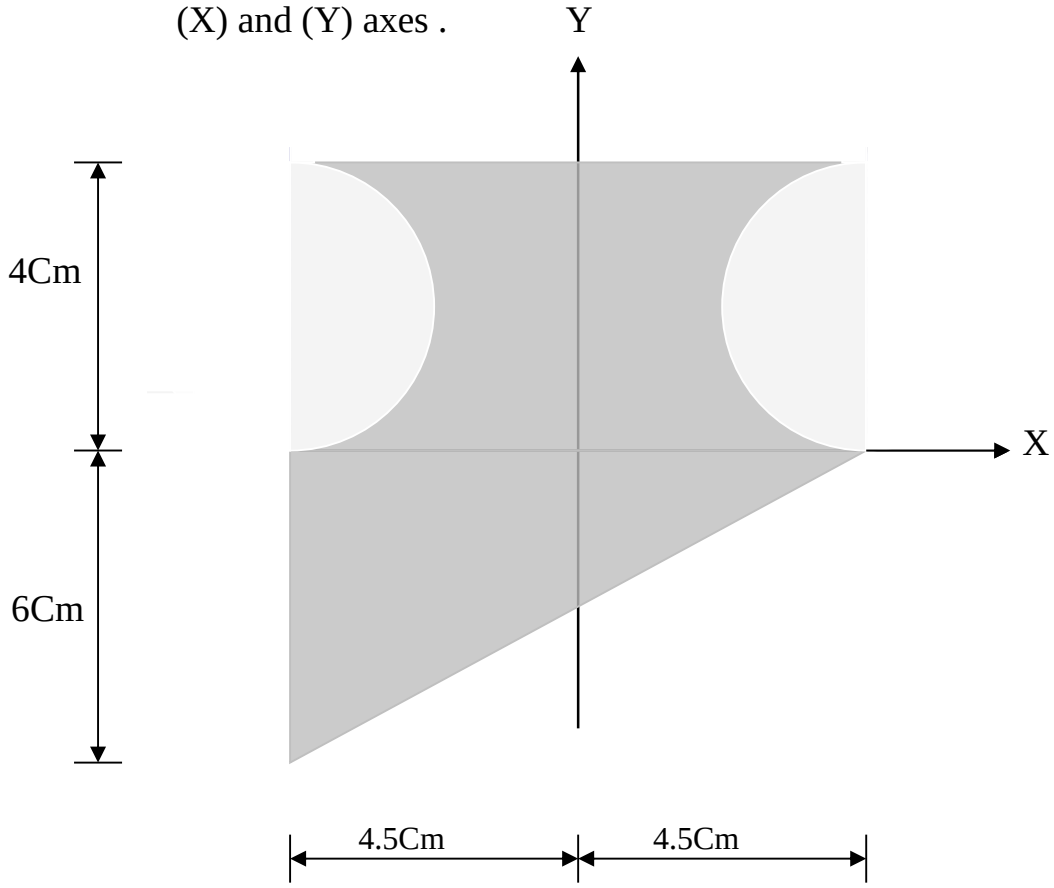
Fig.	ai	xi	yi	aixi	aiyi
	4× 6=24	2	3	48	72
	4× 6/2=12	5.33	2	64	24
	- π(1)²=-3.14	2	3	-6.28	-9.42
∑	32.86			105.72	86.58

-
X= 105.72/32.86=3.2 Cm

-
Y= 86.58/32.86 =2.6 Cm



Example : Determine the centroid of the shaded area shown in figure with respect to (X) and (Y) axes .

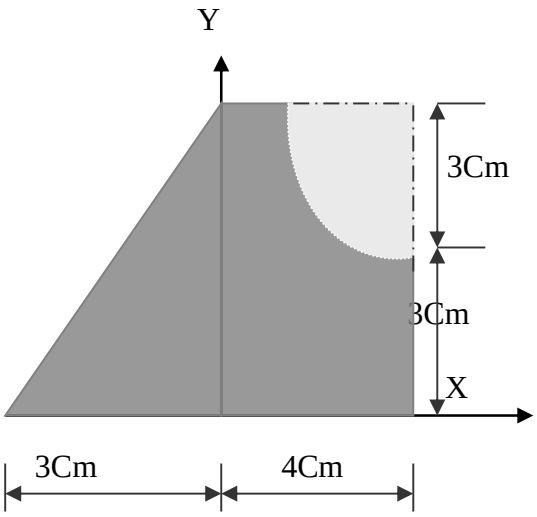


Solution:

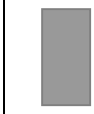
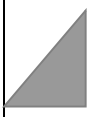
Fig.	ai	xi	yi	aixi	aiyi
	4× 9=36	0	2	0	72
	1/2× 6× 9=27	-1.5	-2	-40.5	-54
	$-\pi(2)^2/2=-6.283$	-(4.5-0.424×2) =-3.652	2	22.945	-12.566
	-6.283	3.652	2	-22.945	-12.566
∑	50.434			-40.5	-7.132

$\bar{X}=-40.5/50.434=-0.803Cm$ $\bar{Y}=-7.132/50.434=-0.141Cm$

Example: Determine the centroid of the shaded area shown in figure with respect to (X) and (Y) axes .



Solution:

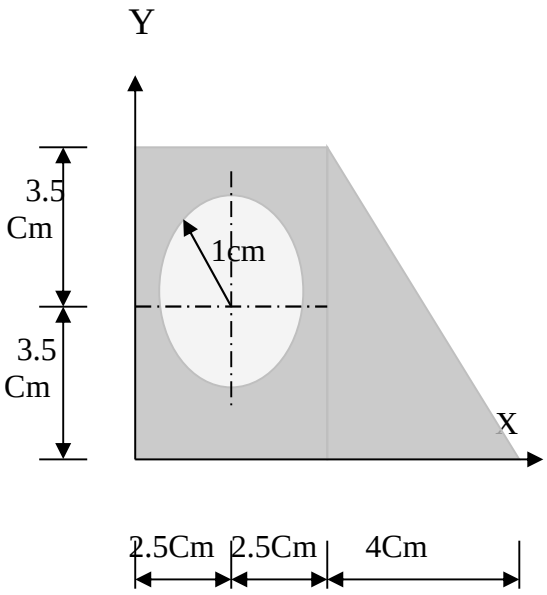
Fig.	ai	xi	yi	aixi	aiyi
	4× 6=24	2	3	48	72
	1/2× 3× 6=9	-1	2	-9	18
	-π(3)²/4=-7.069	4-(0.424×3) =2.728	6-(0.424× 3) =4.728	-19.27	-33.4
∑	25.931			19.73	56.6

- X=19.73/25.931=0.76Cm

- Y=56.6/25.931=2.18Cm

5/ Post test

1- Determine the centroid of the shaded area shown in figure with respect to (X) and (Y) axes .



6/ Key answer

1- Pre test :-

1-As in text .

2-As in text .

2- Post test :-

- -

1-X=3.67Cm , Y=3.14Cm .

Eighteenth Modular Unit

Moment of inertia of simple shapes

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Moment of inertia is very important subject to be studied in order to have a full knowledge about the definition and the laws of moment of inertia for different simple shapes ,for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1 –Definition of moment of inertia .

2-The laws of moment of inertia for different simple shapes .

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying nineteenth modular unit .
- get less than 9 , go back and study the eighteenth modular unit ; or any part of it ; again and then do the post test again .

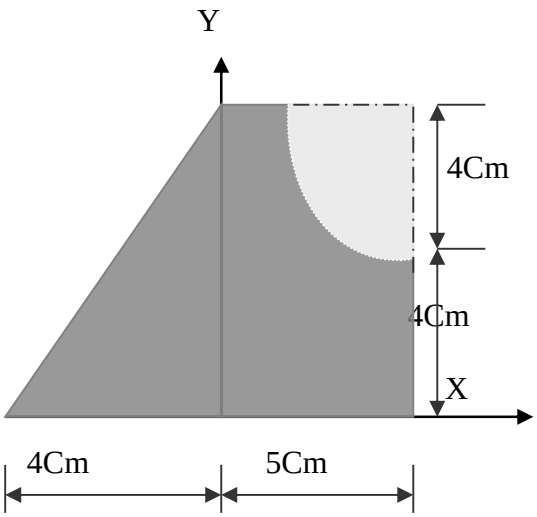
2/ Performance Objectives

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

1-Define the moment of inertia .
2-Write the laws of moment of inertia for different simple shapes.

3/ Pre test

1-Determine the centroid of the shaded area shown in figure with respect to (X) and (Y) axes .



4/ The text

Moment of Inèrtia : (I)

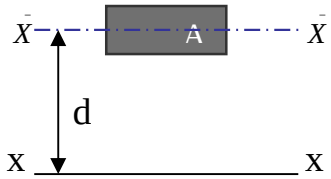
The moment of inertia of an area is equal to the product of this area by the square distance about the axis of rotation .

$$I=A*d^2$$

Transfer formula for moment of inertia :

-

$$Ix=Ix+ A*d^2$$



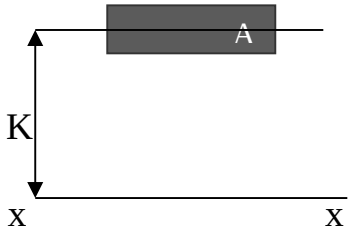
Units of moment of inertia : mm^4 , Cm^4

Polar moment of inertia : Ij_0

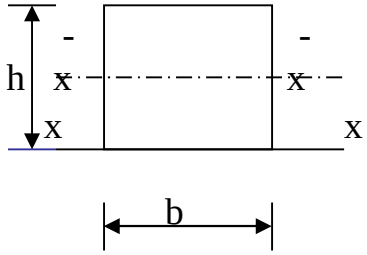
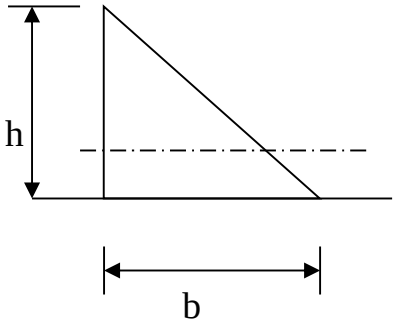
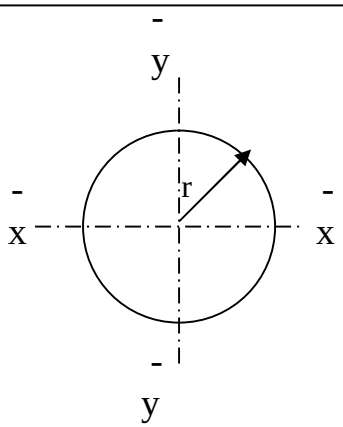
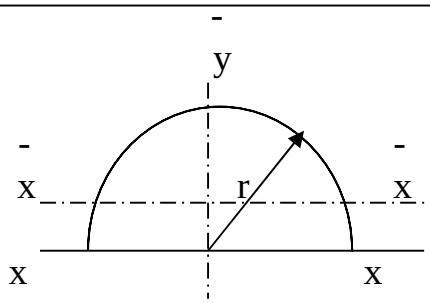
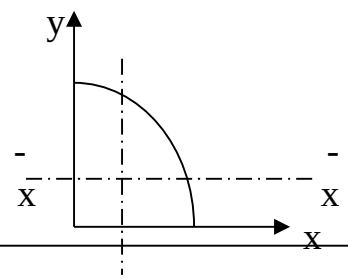
$$Ijo=Ix+Iy$$

Radius of gyration : Kx

$$Kx=\sqrt{I / A}$$



1:-Moment of inertia for the simple shapes :

Shape	Moment of inertia (I)	Radius of gyration (K)
	- $Ix = bh^3/12$ $Ix = bh^3/3$	- $Kx = h/\sqrt{12}$ $Kx = h/\sqrt{3}$
	- $Ix = bh^3/36$ $Ix = bh^3/12$	- $Kx = h/\sqrt{18}$ $Kx = h/\sqrt{6}$
	- - $Ix = Iy = \pi r^4/4$	- $Kx = r/2$
	- $Ix = 0.11r^4$ - $Ix = Iy = \pi r^4/8$	- $Kx = Ky = r/2$ - $Kx = 0.264r$
	$Ix = Iy = \pi r^4/16$ - - $Ix = Iy = 0.055r^4$	$Kx = Ky = r/2$ - - $Kx = Ky = 0.264r$

5/ Post test

1-Define the moment of inertia .
2-What is the unit of moment of inertia .

6/ Key answer

1- Pre test :-

1-X=0.85Cm , Y=2.84Cm .

2- Post test :-

1-As in text .

2-As in text .

Nineteenth Modular Unit
Moment of inertia for the complex shapes

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Moment of inertia for complex shapes is very important subject to be studied in order to have a full knowledge about the determination of moment of inertia for complex shapes about any axis ,for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1-Determination of moment of inertia for complex shapes about any axis .

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying twentieth modular unit .
- get less than 9 , go back and study the nineteenth modular unit ; or any part of it ; again and then do the post test again .

2/ Performance Objectives

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

1-Determine the moment of inertia for complex shapes about any axis .

3/ Pre test

1-A rectangle its dimensions (30*50)cm .Determine (Ix) .

4/ The text

Example: For the shaded area shown in figure .Determine the moment of inertia about (b-b)axis if the moment of inertia about (a-a)axis is (8 cm^4).

Solution:

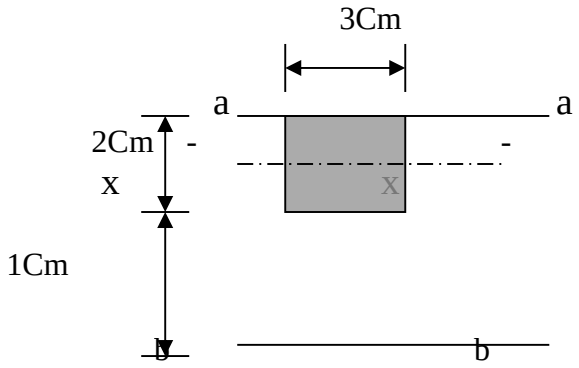
$Ia=Ix+ Ad^2$

$8 =Ix+(2*3)*(1)^2$

$Ix=2Cm$

$Ib =Ix+Ad^2$

$=2+ 6*(2)^2=26\,cm^4$



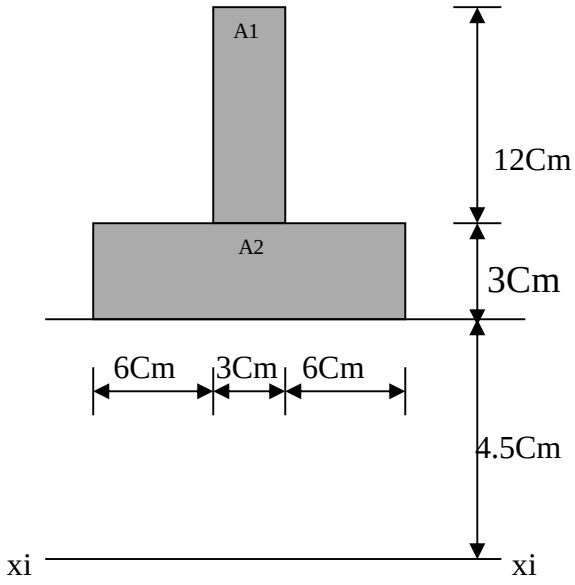
NOTE: when Ia is unknown in example :

$Ib = bh^3/12+Ad^2=3*(2)^3/12+6*(2)^2 =26\,cm^4$

Example: Determine the moment of inertia of the shaded area shown in figure with respect to (xi-xi) axis .

Solution:

A1=12× 3=36Cm²
A2=15× 3=45Cm²



For (A1):
-
$I_{xi}=I_x+Ad^2$
$=bh^3/12+Ad^2$

$=3*(12)^3/12+36*(13.5)^2$

$=6993\,cm^4$ (+)

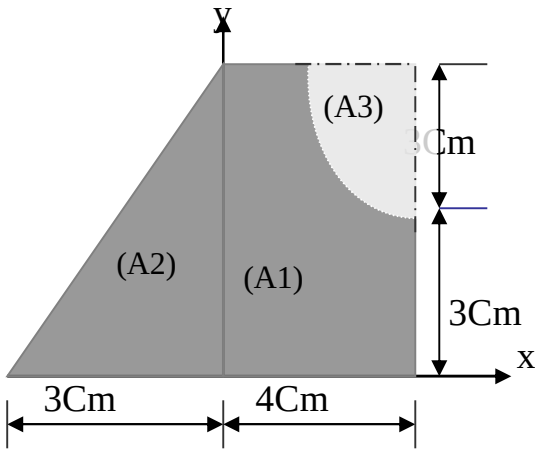
For (A2):
-
$I_{xi}=I_x+Ad^2$
$=bh^3/12+Ad^2$
$=15*(3)^3/12+45*(6)^2$
$=1653.75\,cm^4$ (+)

I_{xi} (total) $=6993+1653.75=8646.75\,cm^4$

Example: Determine the moment of inertia of the shaded area shown in figure with respect to(x) axis .

Solution:

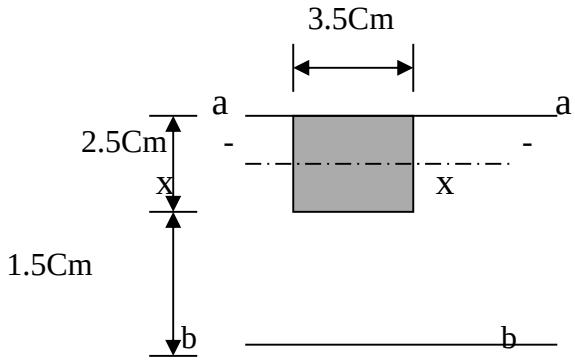
A1=4× 6=24Cm²
A2=1/2× 3× 6=9Cm²
A3=π(3)²/4=7.06Cm²



For(A1) :
$I_x=bh^3/12+Ad^2=4*(6)^3/12+24*(3)^2=288Cm^4$ (+)
For(A2) :
$I_x=bh^3/36+Ad^2=3*(6)^3/36+9*(2)^2=54Cm^4$ (+)
For(A3) :
$I_x=0.055(r)^4+Ad^2=0.055*(3)^4+7.06*(4.728)^2=162.27Cm^4$ (-)
I_x(total)=288+54-162.27=179.73Cm^4

5/ Post test

1- For the shaded area shown in figure .Determine the moment of inertia about (b-b)axis if the moment of inertia about (a-a)axis is (8 cm^4).



6/ Key answer

1- Pre test :- 1-Ix=0.31*10 ^{6} cm^4 .

2- Post test : 1-Ib=67.5 cm^4

Twentieth Modular Unit

Applications

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Solving more applications about moment of inertia for complex shapes is very important subject to be studied in order to have a full knowledge about the determination of moment of inertia for complex shapes about any axis ,for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1-Determination of moment of inertia for complex shapes about any axis .

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying twenty-first modular unit.
- get less than 9 , go back and study the twentieth modular unit ; or any part of it ; again and then do the post test again .

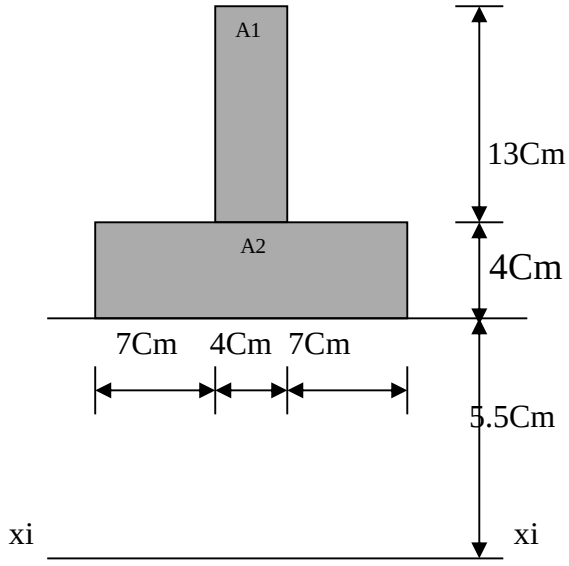
2/ Performance Objectives

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

1-Determine the moment of inertia for complex shapes about any axis .

3/ Pre test

1-Determine the moment of inertia of the shaded area shown in figure with respect to (xi-xi) axis .



4/ The text

Example: A column its dimensions (30× 60)cm and (2.5m)height as shown in figure Indicate the suitable case to resist a wind from east .

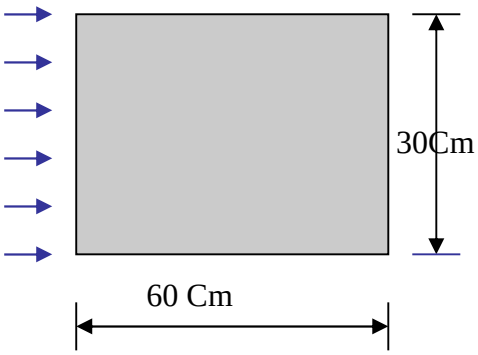
Solution:

CASE 1:

-

$Iy=hb^3/12$

$=30*(60)^3/12=540000\,cm^4$



CASE 2:

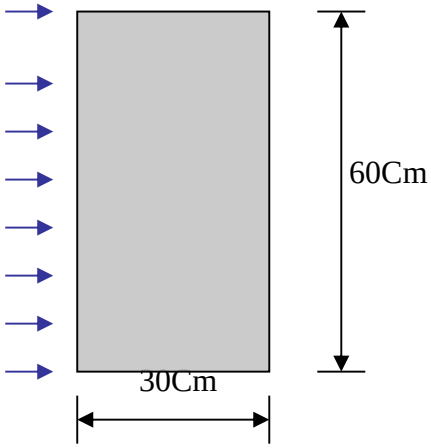
$Iy=60*(30)^3/12=135000\,cm^4$

We choose case1 because the resistance

is more than case 2 i.e

the smaller dimension put in the face of the wind

CASE 2



Example: Determine the polar moment of inertia(Ij_0)for the shaded area shown in figure. Assume (r1=30Cm , r2=40Cm) .

Solution:

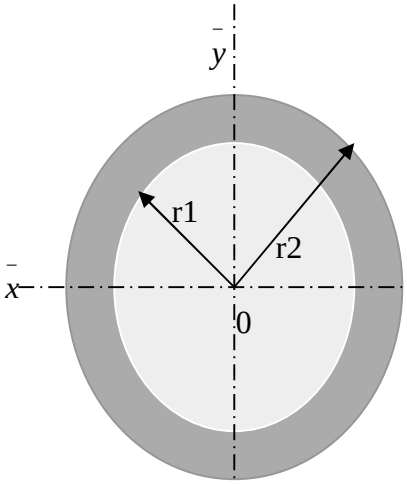
$(I\bar{x})1= (I\bar{y})1 = \pi r^4/4=\pi*(30)^4/4=0.63*10^6\ cm^4$ (-)

$(I\bar{x})2= (I\bar{y})2 = \pi r^4/4=\pi*(40)^4/4=2*10^6\ cm^4$ (+)

$(Ij_0)1 =(I\bar{x})1+(I\bar{y})1= 1.26*10^6\ cm^4$ (-)

$(Ij_0)2 = (I\bar{x})2+(I\bar{y})2= 4*10^6\ cm^4$ (+)

$(Ij_0)total=(Ij_0)1+(Ij_0)2=2.74*10^6\ cm^4$



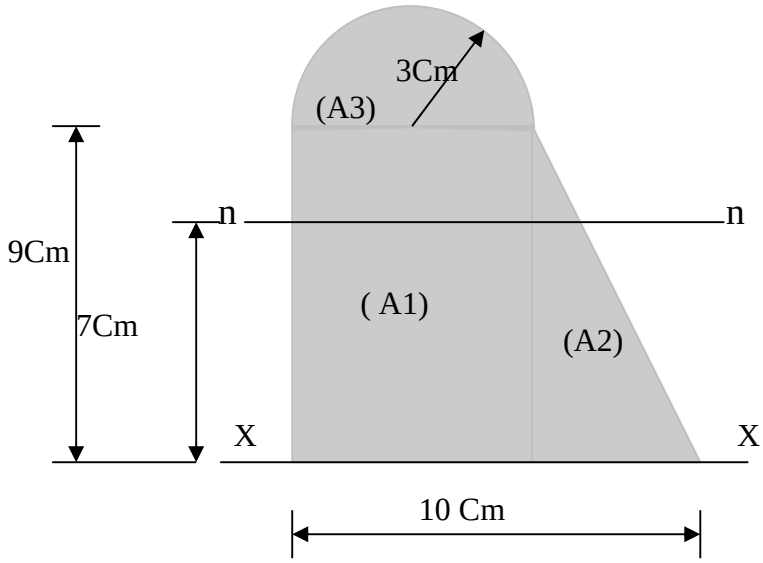
Example: Determine the moment of inertia of the shaded area shown in figure with respect to (n-n) axis .

Solution:

A1=6× 9=54Cm²

A2=1/2× 4× 9=18Cm²

A3=π(3)²/2=14.14Cm²



For(A1):

In=bh³/12+Ad²

=6*(9)³/12+54*(2.5)²=702 cm^4 (+)

For(A2):

In=bh³/36+Ad²

=4*(9)³/36+18*(4)²=369 cm^4 (+)

For(A3):

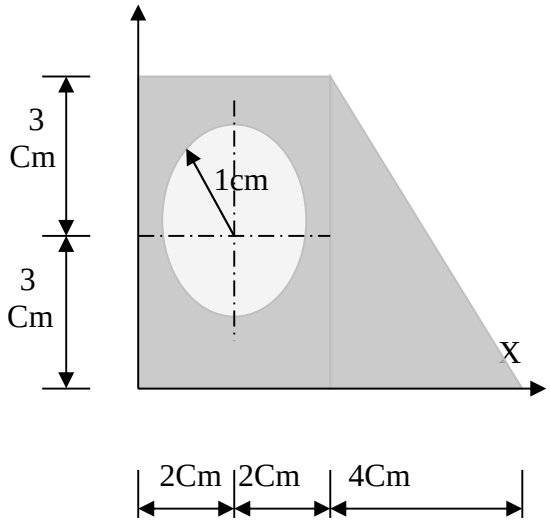
In=0.11 r^4 +Ad²

=0.11*(3) ^{4} +14.14*(3.272)²=160.29 cm^4 (+)

In(total)=702+369+160.29=1231.29 cm^4

5/ Post test

1-Determine the moment of inertia of the shaded area shown in figure with respect to (X) axis .



6/ Key answer

1- Pre test :- 1-Ixi=5186.33 cm^4 .

2- Post test : 1-Ix=330.96 cm^4

Twenty First Modular Unit

Strngth of material, define of stress, types of stress, factor of safty

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Strength of materials is very important subject to be studied in order to have a full knowledge about the definition of stress, types of stresses , factor of safety for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1- Definition of stress.

2-Types of stresses .

3-Definition of factor of safety .

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying twenty-second modular unit.
- get less than 9 , go back and study the twenty-first modular unit ; or any part of it ; again and then do the post test again .

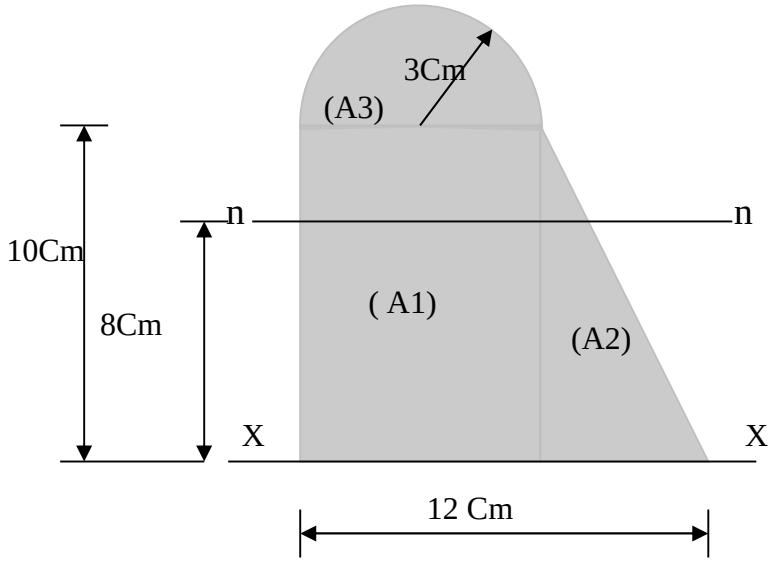
2/ Performance Objectives

After studying the twenty-first modular unit , the student will be able to:-

1-Define the stress , types of stresses .
2-Define the factor of safety .

3/ Pre test

1-Determine the moment of inertia of the shaded area shown in figure with respect to (N-N) axis .



4/ The text

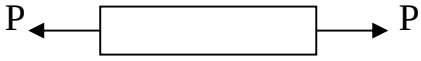
STRENGTH OF MATERIALS

Deals with relations between external loads and their internal effects on bodies .

STRESS : S

Is the unit strength of a material and can be calculated by :

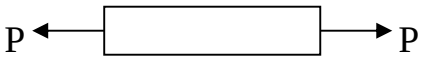
$$S = P/A$$



P : axial force
A: cross sectional area

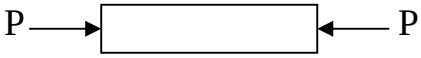
Units of stress : N/m^2= pa. (pascal)
Mpa.=mega pascal $=10^6$ pa. = N/mm^2

Types of stresses :



1:- Tensile stress

2:- Compressive stress



Example: An aluminum bar of (40mm) diameter carries an axial load of (12560N) . Determine the stress in the bar .

Solution:

$S = P/A$

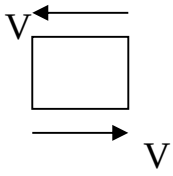
Cross sectional area (A)= $\pi * (20/1000)^2 = 1256 * 10^{-6}$ mm^2

$S = 12560/1256*10^{-6} = 10*10^6$ pa.=10 Mpa.

3:-Shearing stress : t

it is caused by a force acting parallel to area resisting the force.

$$t = V/A$$



V :shearing force

A :area of parallel cross section

4:-Bearing stress:

Is a contact pressure between separate bodies such as the soil pressure ,force on bearing plate .

Example :Determine the shearing stress in the rivet shown in figure due to the (30KN) applying load if the diameter of the rivet is (20mm) .

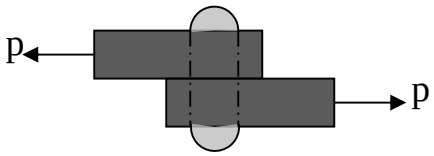
Solution:

d=20+1.5=21.5mm

$t = V/A$

$=30*1000/(21.5/2)^2*\pi$

=82.7 Mpa.



FACTOR OF SAFETY: F.S

F.S=Ultimate stress / Working stress (about 4 to 10)

Example :A(15*50)mm steel bar carries an axial load of (7.5ton) ,if the maximum tensile load which can be carries by a specimen of the same steel has cross sectional area of (1.6) Cm^2 is (6.4ton) .Find the factor of safety .

Solution:

Working stress=7.5*1000*9.8/ 15*50=98 Mpa.

Ultimate stress =6.4*1000*9.8/1.6*100=392 Mpa.

Factor of safety=392/98 =4

5/ Post test

1-An aluminum bar of (50mm) diameter carries an axial load of (13000N) . Determine the stress in the bar .

6/ Key answer

1- Pre test :-

1-In=2065.28 cm^4 .

2- Post test :

1-6.6Mpa.

Twenty Second Modular Unit

Strain, Hook's Law

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Strain is very important subject to be studied in order to have a full knowledge about the determination of deformation caused in bodies after loading, for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1- Definition of strain .

2-determination of deformation .

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying twenty-third modular unit .
- get less than 9 , go back and study the twenty- second modular unit ; or any part of it ; again and then do the post test again .

2/ Performance Objectives

After studying the twenty-second modular unit , the student will be able to:-

1-Define the strain .
2-Determine the deformation .

3/ Pre test

1-Determine the shearing stress in the rivet shown in figure due to the (40KN) applying load if the diameter of the rivet is (25mm) .

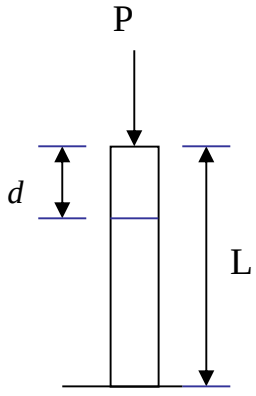
4/ The text

STRAIN: e

Is the unit deformation caused by stress

Strain= Change in length / Original length

$$e = d / L$$

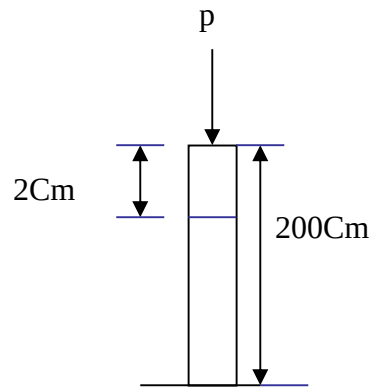


Example :Determine the strain of a body caused by the applied force (p) if the decrease in length is (2Cm) , and the length of the body is (200Cm) .

Solution:

$e = d / L$

=2/200=0.01



HOOK'S LAW : Axial deformation

The slope of stress-strain curve (straight line portion)=modulus of elasticity=E

$E = s / e \quad \Longrightarrow \quad s = E * e$

NOTE: the units of (E) is the same units 0f stress , for example:

E for steel =200*10^9 pa. =200Gpa.
E for aluminum=70*10^9 pa. =70 Gpa.
Gpa.=gega pascal= 10^9 pa.

$s = E * e$

$P/A = E * d / L$

$d = PL/AE$

5/ Post test

1-Determine the strain of a body caused by the applied force (p) if the decrease in length is (2.5Cm) , and the length of the body is (400Cm) .

6/ Key answer

1- Pre test :-

1- t =72.52Mpa.

2- Post test :

1- e =0.006

Twenty Third Modular Unit

Lateral strain, poison's ratio, application

1/ Over View

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Poison's ratio is very important subject to be studied in order to have a full knowledge about the relation between the lateral strain longitudinal strain caused in bodies after loading, for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1- Definition poison's ratio .

2-Solving application on stress , strain .

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying twenty-fourth modular unit .
- get less than 9 , go back and study the twenty-third modular unit ; or any part of it ; again and then do the post test again .

2/ Performance Objectives

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

1-Define poison's ratio .
2-Solve applications on stress , strain .

3/ Pre test

1- Determine the strain of a body caused by the applied force (p) if the decrease in length is (1.5Cm) , and the length of the body is (250Cm) .

4/ The text

POISSON'S RATIO: n

n = Lateral strain / Longitudinal strain

$$n = e_y / e_x$$

Example :A steel wire (8m) long hanging vertically support a tensile load of (4000N) Determine the required diameter and the elongation in the wire if the stress is not exceed (50Mpa.) .Assume Es=200Gpa.

Solution:

$s = P/A$

$50*10^6 = 4000/A$

$A = 80*10^{-6}\ m^2 = 80mm^2$

$A = \pi r^2$

$80 = \pi r^2 \Longrightarrow r = 5.04mm \Longrightarrow d = 10.1mm = 1Cm$

$E = s / e$

$200*10^9 = 50*10^6 / e$

$e = 0.25*10^{-3}$

$e = d / L$

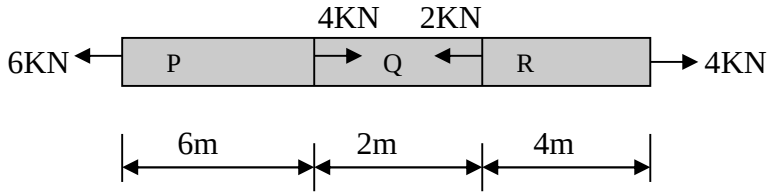
$0.25*10^{-3} = d / 8*10^3$

$d = 2mm$

Example :A uniformly bar of ($1Cm^2$) area .Axial loads are applied as shown in figure .Find the total deformation . Assume (E=200Gpa.) .

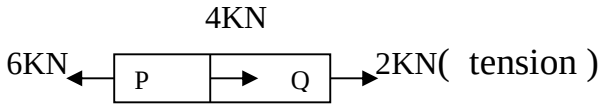
Solution:

$d = PL/AE$



$d_p = 6*1000*6/1*10^{-4}*200*10^9$ 6KN P 6KN (tension)

$= 0.0018m = 1.8mm$ (+)

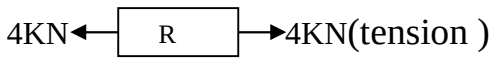


$d_Q = 2*1000*2/1*10^{-4}*200*10^9$

$= 0.0002m = 0.2mm$ (+)

$d_R = 4*1000*4/1*10^{-4}*200*10^9$

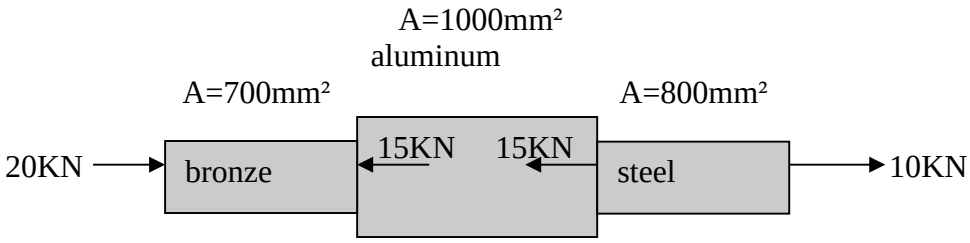
$= 0.0008m = 0.8mm$



d total $= 1.8+0.2+0.8$

$= 2.8mm$

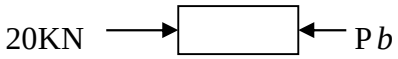
Example: An aluminum tube is rigidly fastened between a bronze bar and a steel bar .Axial loads are applied as shown in figure. Determine the stress in each material



Solution : $s = P/A$

$s_b = 20*1000/700* 10^{-6} = 28.6* 10^6$ pa

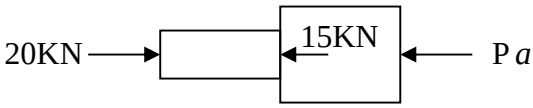
=28.6 Mpa. (C)



compression

$s_a = 5*1000/1000*10^{-6} = 5*10^6$ pa

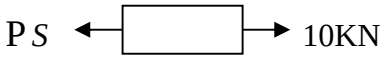
=5 Mpa. (C)



compression

$s_s = 10*1000/800*10^{-6} = 12.5* 10^6$ pa

=12.5 Mpa. (T)



tension

Example :Determine the maximum safe load (p) which may be applied on the steel plate shown in figure if the average tensile stress is (160 Mpa.) .

Solution:

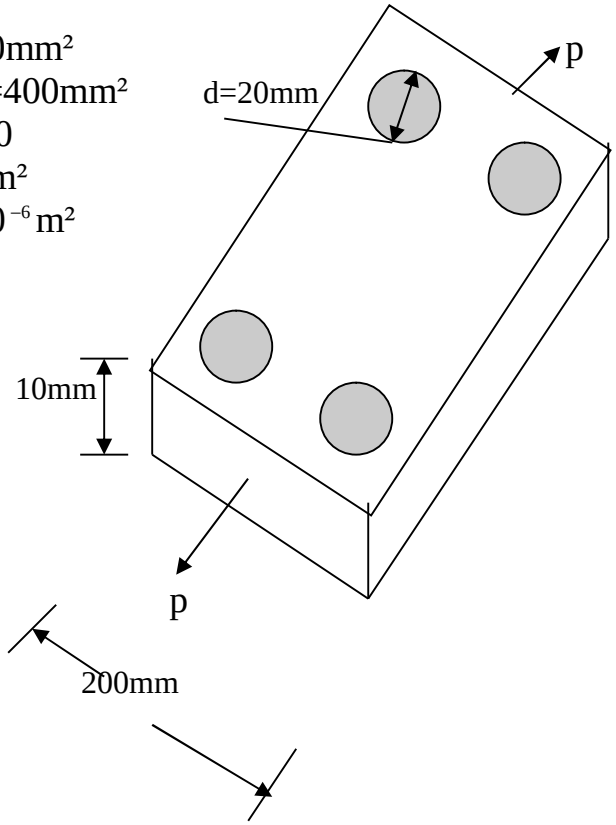
Area of section=200*10=2000mm²

Area of two holes=2*20*10=400mm²

Net area of section=2000-400

=1600 mm²

=1600*10^{-6} m²



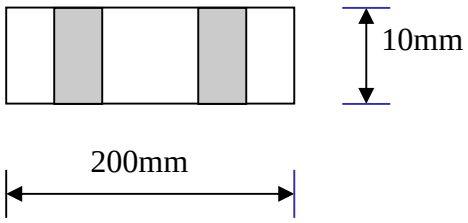
s =P/A

P=A* s

=1600*10^{-6}*160*10^{6}

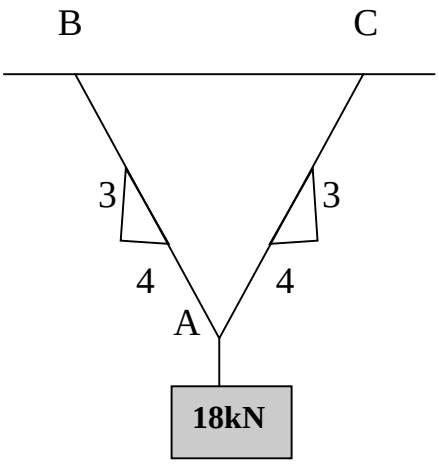
=256000N

=256KN



Example :A(18KN)weight is supported by two steel wires as shown in figure .Determine the cross sectional area of each wire if the tensile stresses in the wires are limited to (100 Mpa.) .

Solution:



$\sum Fx=0$

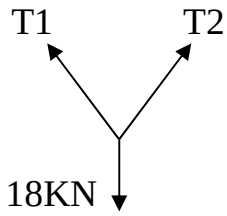
$T2*4/5-T1*4/5=0$

$T1=T2=T$

$\sum Fy=0$

$T*3/5+T*3/5-18=0$

$T=9*5/3=15KN$



$s = P/A$

$A=P/s$

$=15*1000/100*10^{6}$

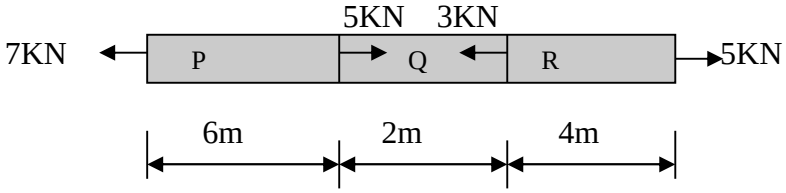
$=150*10^{-6}\ m^2$

$=150mm^2$

$d = PL/AE$

5/ Post test

1-A uniformly bar of ($1Cm^2$) area .Axial loads are applied as shown in figure . Find the total deformation . Assume (E=200Gpa.) .



6/ Key answer

1- Pre test :-

1- e =0.006.

2- Post test :

1- d total=3.3mm

Twenty Fourth Modular Unit

Shear force and bending moment daigrams

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Shear force and bending moment diagrams is very important subject to be studied in order to have a full knowledge about the relation between the shear force and bending moment with the distance of beams, for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1- Drawing the shear force diagram .

2- Drawing bending moment diagram .

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying twenty-fifth modular unit .
- get less than 9 , go back and study the twenty-fourth modular unit ; or any part of it ; again and then do the post test again .

2/ Performance Objectives

After studying the twenty-fourth modular unit , the student will be able to:-

1-Draw shear force diagram .
2-Draw bending moment diagram .

3/ Pre test

1- A steel wire (18m) long hanging vertically support a tensile load of (5000N) . Determine the required diameter and the elongation in the wire if the stress is not exceed (50Mpa.) .Assume Es=200Gpa.

4/ The text

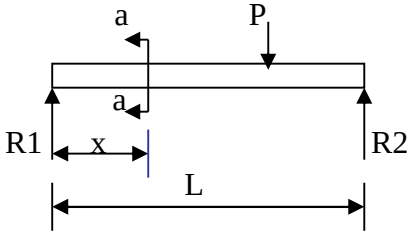
SHEAR FORCE AND BENDING MOMENT DIAGRAMS

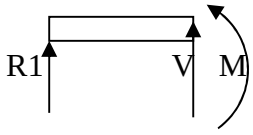
Shear force : is the summation of vertical external loads acting on the left side of the selected section .

Bending moment: is the summation of moments of all the loads acting to the left of the selected section .

$V=(\sum Fy)_L$

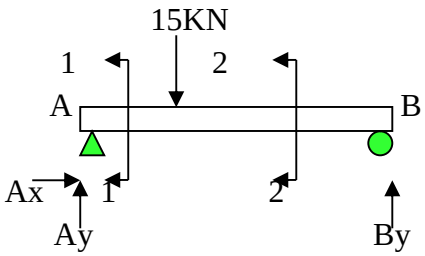
$M=(\sum M)_L$





Example :Draw shear force and bending moment diagrams for the beam loaded as shown in figure .

Solution:



1-determination of reactions

$\sum Fx=0 \Rightarrow Ax=0$

$\sum MA=0$

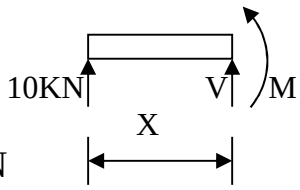
$By*1.5-1580.5=0 \Rightarrow By=5KN$

$\sum Fy=0$

$Ay+5-15=0 \Rightarrow Ay=10KN$

2-Drawing of S.F.D and B.M.D by written the equations at section (1-1) and (2-2) .

section (1-1)

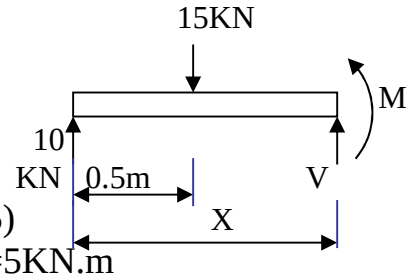


$V1=\sum Fy=10KN$

$M1=\sum M=10X$ When x=0 M1=0

When x=0.5 M1=5KN.m

section (2-2)

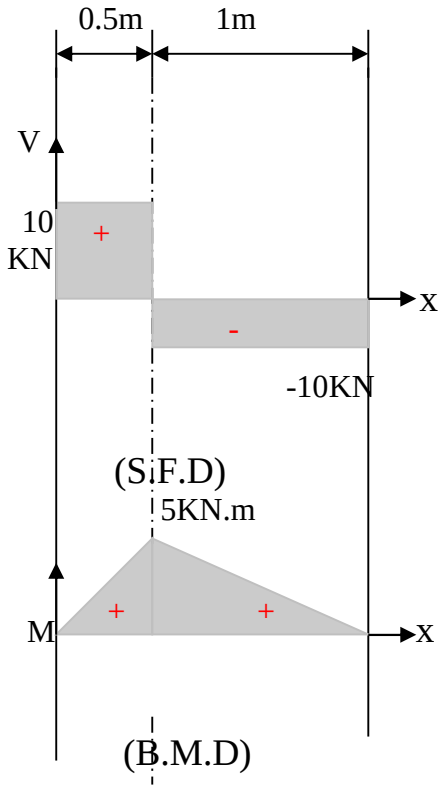


$V2=10-15=-5KN$

$M2=10X-15(X-0.5)$

When x=0.5 M2=5KN.m

When x=1.5 M2=0



5/ Post test

1-Define with drawing shear force and bending moment in beams .

6/ Key answer

1- Pre test :-

1-d=11.28mm , d =4.5mm.

2- Post test :

1- As in text .

Twenty Fifth Modular Unit

Applications on shear force and bending moment daigram

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Solving applications on shear force and bending moment diagrams is very important subject to be studied in order to have a full knowledge about the relation between the shear force and bending moment with the distance of beams for different types of loading , for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1-Drawing the shear force diagram for different types of loading.

2-Drawing bending moment diagram for different types of loading .

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying twenty-sixth modular unit .
- get less than 9 , go back and study the twenty-fifth modular unit ; or any part of it ; again and then do the post test again .

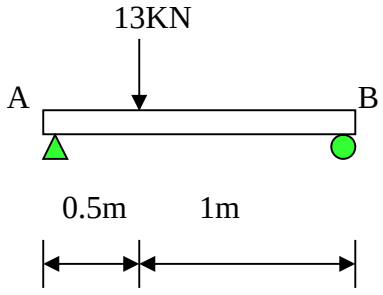
2/ Performance Objectives

After studying the twenty-fifth modular unit , the student will be able to:-

1-Draw shear force diagram for different types of loading.
2-Draw bending moment diagram for different types of loading .

3/ Pre test

1-Draw shear force and bending moment diagrams for the beam loaded as shown in figure .

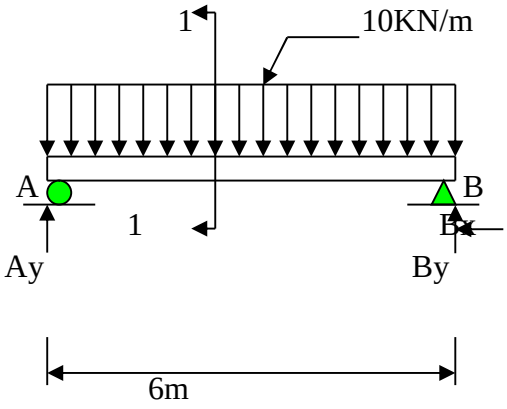


4/ The text

Example :Draw shear force and bending moment diagrams for the beam loaded as shown in figure .

Solution:

1-determination of reactions



$\sum Fx=0 \Rightarrow Bx=0$

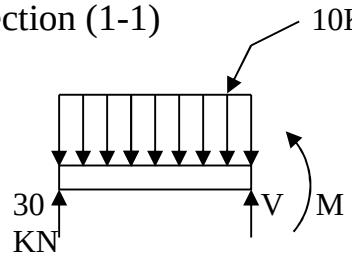
$\sum MA=0$

$By*6-10*6*3=0 \Rightarrow By=30KN$

$\sum Fy=0$

$Ay+30-6*10=0 \Rightarrow Ay=30KN$

2-Drawing of S.F.D and B.M.D by written the equations at section (1-1)



$V=30-10X$ when $x=0$ $v=30KN$

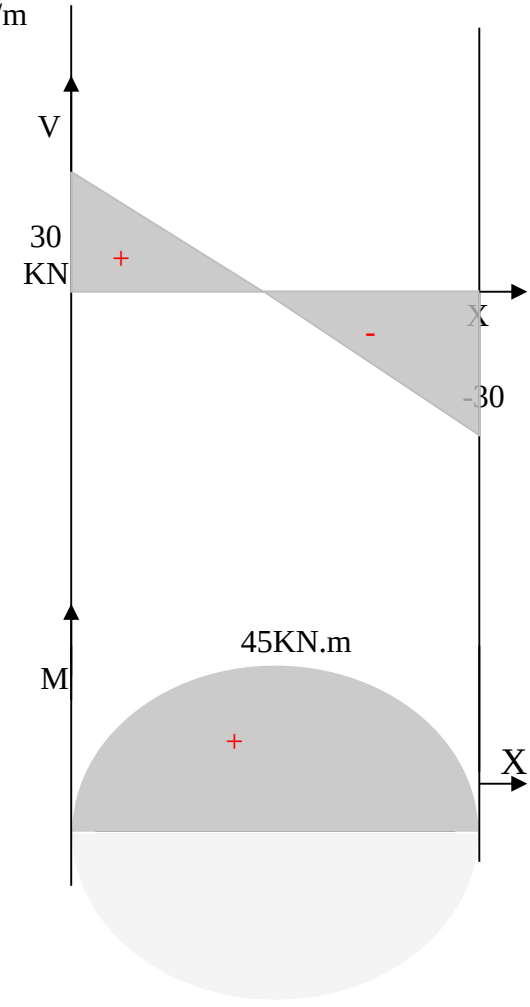
when $x=6$ $v=-30KN$

$M=30X-10X(X/2)$

$=30X-5X^2$

when $x=0$ $M=0$

when $x=6$ $M=0$



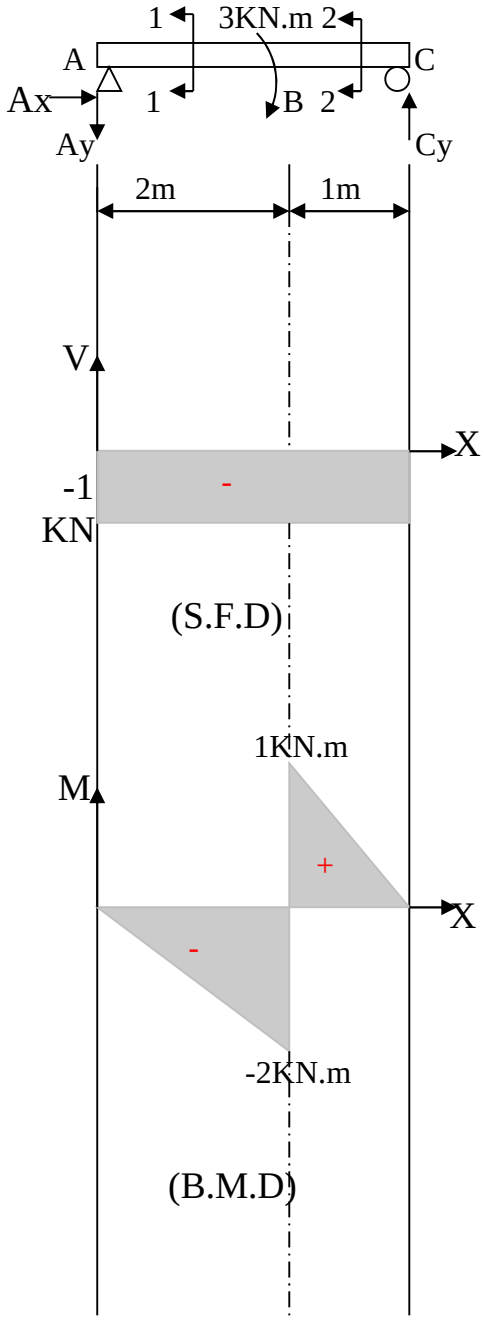
Note :the maximum bending moment caused when v=0 therefore :

when $x=3$ $Mmax.=45KN.m$

Example :Draw shear force and bending moment diagrams for the beam loaded as shown in figure .

Solution:

1-determination of reactions



$\sum Fx=0 \Rightarrow Ax=0$

$\sum MA=0$

$-3+Cy*3=0 \Rightarrow Cy=1KN$

$\sum Fy=0$

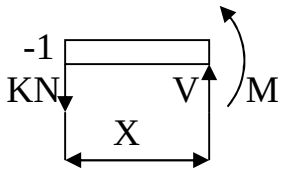
$Ay+1=0 \Rightarrow Ay=-1KN=1KN\downarrow$

2-Drawing of S.F.D and B.M.D by written the equations at section (1-1) and (2-2) .

section (1-1)

V=-1KN

M=-X



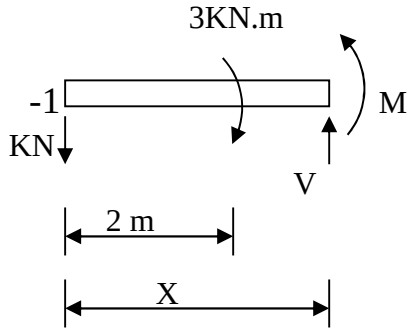
when x=0 M=0

when x=2 M=-2KN.m

section (2-2)

V=-1KN

M=-X +3

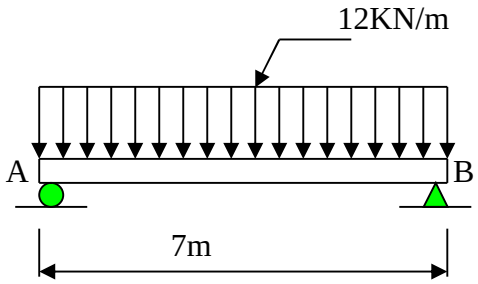


when x=2 M=1KN.m

when x=3 M=0

5/ Post test

1-Draw shear force and bending moment diagrams for the beam loaded as shown in figure .



6/ Key answer

1- Pre test : 1-Ay=8.67KN , By=4.33KN , Mmax.=4.33KN.m .

2- Post test : 1- Ay=By=42KN , Mmax.=147KN.m .

Twenty Sixth Modular Unit

Bending stress for beam

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Bending stress in beams is very important subject to be studied in order to have a full knowledge about the relation between the bending moment and the bending stress for different types of beams , for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1-Determination of bending stress in beams.

2-Determination of the maximum bending stress in beams .

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying twenty-seventh modular unit .
- get less than 9 , go back and study the twenty-sixth modular unit ; or any part of it ; again and then do the post test again .

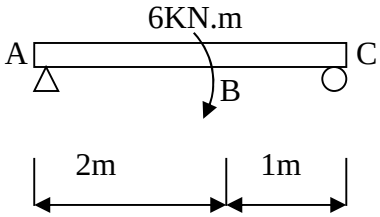
2/ Performance Objectives

After studying the twenty-sixth modular unit , the student will be able to:-

1-Determine the bending stress in beams.
2-Determinethe maximum bending stress in beams .

3/ Per test

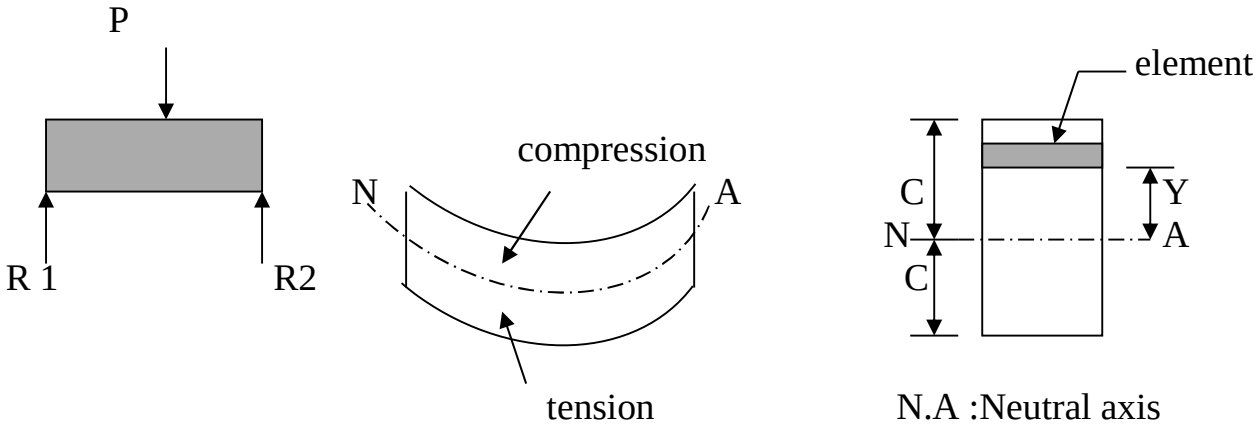
1-Draw shear force and bending moment diagrams for the beam loaded as shown in figure .



4/ The text

STRESSES IN BEAMS : (Rectangular sections)

1:-Bending stress : (Flexure stress)
Is the stress caused by the bending moment .
Flexure formula :is the relation between bending stress and the bending moment .



N.A :Neutral axis

$$s = MY / I$$

s =flexure stress (N/m²) at a distance Y from N.A
Y=distance from N.A to element
M=bending moment at the section
I =moment of inertia of the section

$$s_{max.} = MC / I$$

$s_{max.}$ =maximum flexure stress
C =the distance from N.A to the top or bottom of the section

5/ Post test

1-How can we determine the bending stress and the maximum bending stress in beams ?

6/ Key answer

1- Pre test : 1-Ay=-2KN , Cy=2KN , Mmax.=-4KN.m .

2- Post test : 1- As in text .

Twenty seventh Modular Unit

Shear stress for beams, applications

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Shear stress in beams is very important subject to be studied in order to have a full knowledge about the relation between the shear force and the shear stress for different types of beams , for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1-Determination of shear stress in beams.

2-Determination of the maximum shear stress in beams .

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying twenty-eighth modular unit .
- get less than 9 , go back and study the twenty-seventh modular unit ; or any part of it ; again and then do the post test again .

2/ Performance Objectives

After studying the twenty-seventh modular unit , the student will be able to:-

1-Determine the shear stress in beams.
2-Determinethe maximum shear stress in beams .

3/ Pre test

1-Draw a section in abeam shown the tension and compression and N.A location

4/ The text

2:-Shearing stress : t

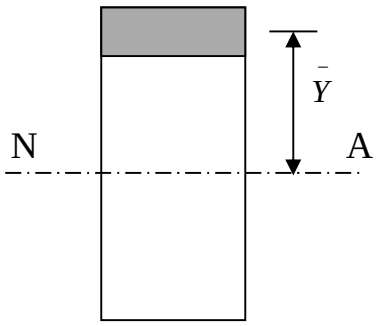
$$t = VA\bar{Y}/Ib$$

$t_{max} = 3V/2A$

A =shaded area

$\bar{Y}$ =distance from centroid of A to the N.A

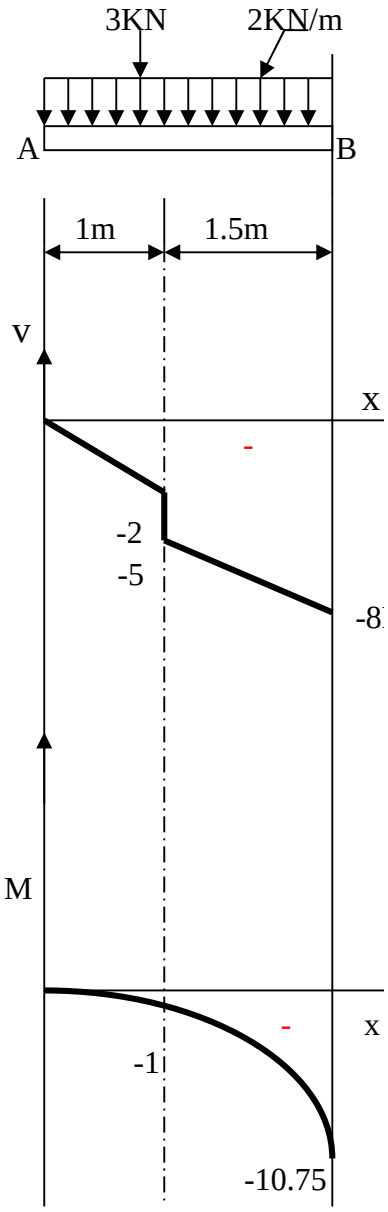
V =vertical shearing force



Example :A cantilever beam (110mm) wide by (220mm) height carries the loading Shown in figure .Determine :-

1-the maximum flexure stress

2- the maximum shear stress



KN.m

Solution:

1-we draw S.F.D and B.M.D as previous examples Then we find :

M_{max}=-10.75KN.m

V_{max}=-8KN

$s_{max.}$ =MC/ I

C=0.11m

$I=bh^3/12=0.11*(0.22)^3/12=97.6*10^{-6}\ m^4$

$s_{max.}=10.75*10^3*0.11/\ 97.6*10^{-6}=12.11*10^6$ pa.

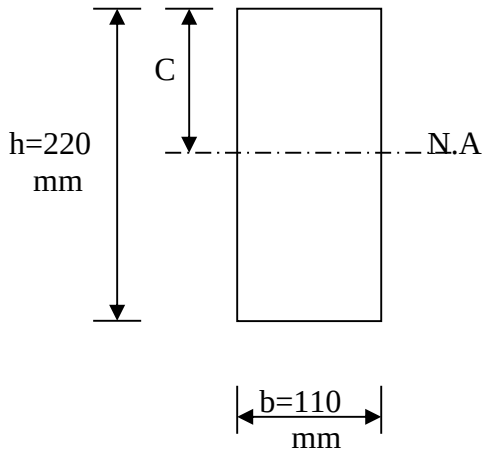
=12.11 Mpa.

t_{max} =3V/2A

=3*8*10³/2*0.11*0.22

$=0.49*\ 10^6$ pa.

=0.49 Mpa.



5/ Post test

1-A cantilever beam (115mm) wide by (230mm) height ,if (Vmax.=7.5KN) , Mmax.=11KN.m . Determine :

1-the maximum flexure stress

2-the maximum shear stress

6/ Key answer

1- Pre test : 1-As in text .

2- Post test : 1- $\sigma_{max.}$=10.8Mpa. , $\tau_{max.}$=0.42Mpa.

Twenty Eighth Modular Unit

Beams which making from two materials

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Beams which making from two materials is very important subject to be studied in order to have a full knowledge about the definition most common method of dealing with a non homogeneous beams and the determination of transform it into an equivalent homogeneous beam , for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1-definition of the method dealing with a non homogeneous beams.

2-Determination of transform the non homogeneous beams to an equivalent homogeneous beam .

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying twenty-ninth modular unit .
- get less than 9 , go back and study the twenty-eighth modular unit ; or any part of it ; again and then do the post test again .

2/ Performance Objectives

After studying the twenty-eighth modular unit , the student will be able to:-

1-Define the method of dealing with non homogeneous beams.
2-Determine the equivalent homogeneous beam .

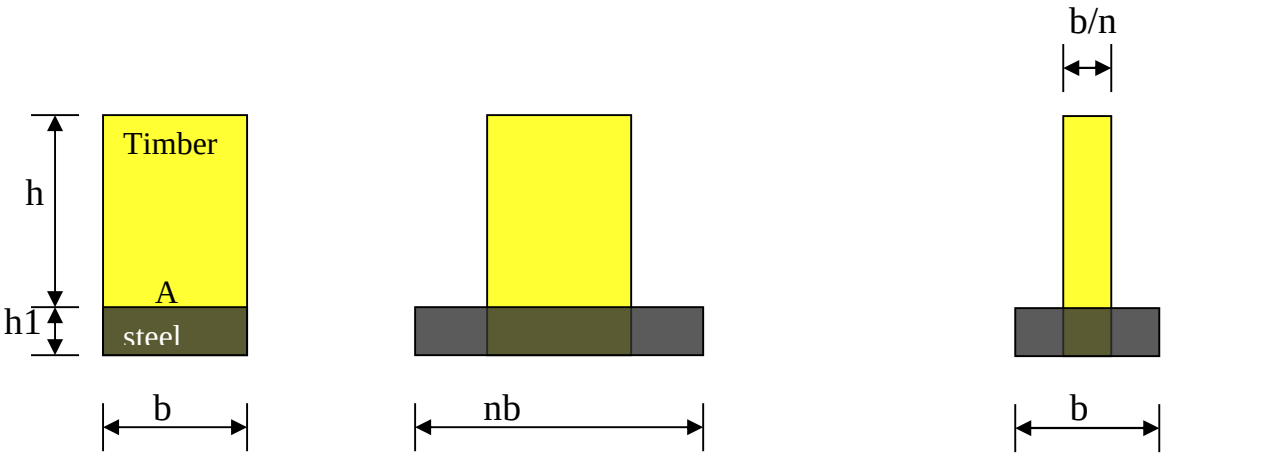
3/ Pre test

1-Determine the minimum width (b) of abeam if the bending stress is not exceed (10Mpa.) and the maximum bending moment is (5000N.m) and the depth of the beam is (200mm) .

4/ The text

COMPOSITE BEAMS : (Beams of different materials)

The most common method of dealing with a non homogenous beams is to transform it into an equivalent homogenous beam .



a)timber and steel section

b)equivalent wood section

c)equivalent steel section

strain of steel = strain of wood (at point A)

$$e_S = e_W$$

$$s_s / E_S = s_W / E_W \quad \text{----------(1)}$$

$$P_S = P_W$$

$$A_S s_S = A_W s_W \quad \text{---------(2)}$$

From eq.(1) and eq.(2)

$$A_S (E_S / E_W) s_W = A_W s_W$$

$$A_W = n A_S \quad , \quad n = E_S / E_W$$

5/ Post test

1-Draw a section of a beam making from two materials (steel and timber) and the equivalent steel section .

6/ Key answer

1- Pre test : 1-b=75mm .

2- Post test : As In text .

Twenty Ninth Modular Unit

Reinforced Concrete Beams

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Reinforced concrete beams is very important subject to be studied in order to have a full knowledge about drawing the equivalent section and determination of location of neutral axis and the maximum bending moment that may be applied , for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1- Drawing the equivalent section of reinforced concrete beams.

2- Determination of location of neutral axis .

3- Determination of the maximum bending moment that may be applied .

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying thirtieth modular unit .
- get less than 9 , go back and study the twenty-ninth modular unit ; or any part of it ; again and then do the post test again .

2/ Performance Objectives

After studying the twenty-ninth modular unit , the student will be able to:-

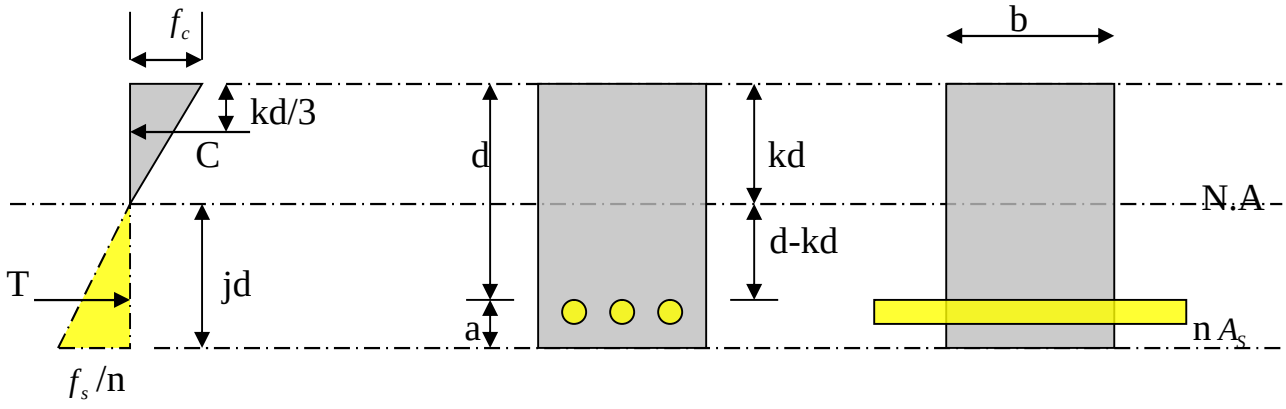
1-Draw the equivalent section of reinforced concrete beams .
2-Determine the location of neutral axis
3-Determine the maximum bending moment that may be applied .

3/ Pre test

1-Define the method of dealing with a non homogeneous beams .

4/ The text

REINFORCED CONCRETE BEAMS



d :the distance from the top of the beam to the center of the reinforcing steel (effective depth)
Kd : the distance from the top of the beam to N.A
NOTE :the N.A is located by applying the principles that the moment of area above the N.A is equal the moment of the area below this axis .

(b*kd)(kd/2)=n A_s (d-kd)

the resultant compressive force (C) in concrete acts at distance (kd/3) from the top of the beam .

$M_C = 1/2 * f_c (bkd)(jd)$

$M_S = f_s A_S (jd)$

C :compressive force in concrete

T :tensile force in steel

f_c :maximum compressive stress in concrete

f_s :the tensile stress in steel

Average stress in concrete = f_c /2

5/ Post test

1-Draw a section of reinforced concrete beam and its equivalent section .

6/ Key answer

1- Pre test : 1-As in text .

2- Post test : 1- As In text .

Thirtieth Modular Unit

Applications on beams making from two materials and reinforced concrete beams

1/ Over view

1 / A –Target population :-

For students of first class

Technical institute

Department of Civil Techniques

1 / B –Rationale :-

Solving applications on beams making from two materials and reinforced concrete beams is very important subject to be studied in order to have a full knowledge about the determination of equivalent section and location of neutral axis and the bending moment that may be applied , for this reason I have designed this modular unit for this knowledge to be understood .

1 / C –Central Idea :-

1-Determination of equivalent section.

2-Determination of location of neutral axis .

3-Determination of bending moment that may be applied .

1 / D –Instructions:-

1-Study over view thoroughly.

2-Identify the goal of this modular unit .

3-Do the pre test and if you :-

- get 9 or more you do not need to proceed .
- get less than 9 you have to study this modular unit well .

4-After studying the text of this modular unit ,do the post test , and if you :-

- get 9 or more , so go on studying next modular unit .
- get less than 9 , go back and study the thirtieth modular unit ; or any part of it ; again and then do the post test again .

2/ Performance Objectives

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

1-Draw and determine the equivalent section.
2-Determine the location of neutral axis
3-Determine the bending moment that may be applied .

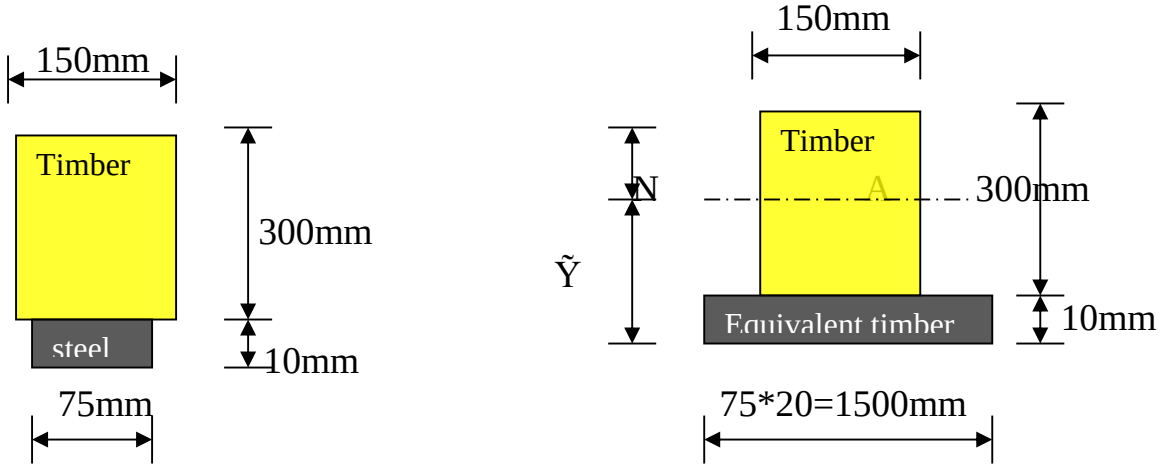
3/ Pre test

1-Draw a reinforced concrete beam and the equivalent section .

4/ The text

Example :A timber beam (150mm) by (300mm) is reinforced on the bottom only with a steel strip (75mm) wide by (10mm) thick .Determine the maximum resisting moment if the allowable stresses are $s_s \leq 120$Mpa. And $s_w \leq 8$Mpa. .Assume (n=20) .

Solution :



A_{w1}=150*300=45000mm²

A_s =75*10= 750 mm²

(A_W)equivalent for steel =n A_s=20*750=15000 mm²

Total equivalent wood area of section =60000 mm²

Location of N.A from the base of section :

60000* $\tilde{Y}$=45000*160+15000*5

$\tilde{Y}$=121mm

$I_{N.A}$=150*(300)³/12+45000*(39)²+1500*(10)³/12+15000*(116)²

=611*10^{-6} mm^4

M= s I/Y

M_w =8*10^6*611*10^{-6}/189*10^{-3}=25.9KN.m

In wood equivalent of the steel :

$s_W = s_S$/n=120/20=6Mpa.

M_S =6*10^6*611*10^{-6}/121*10^{-3}=30.39KN.m

The smaller resisting moment M_w =25.9KN.m is the safe resisting moment .

Example :In a reinforced concrete beam ,b=250mm,d=400mm, A_S =1000mm² and n=8 if the allowable stresses are $f_c \leq$12Mpa. and $f_s \leq$140Mpa. determine the maximum bending moment that may be applied ,is the beam over or under reinforced .

Solution :

Computing the factors kd,jd

250*(kd)²/2=8000*(400-kd)

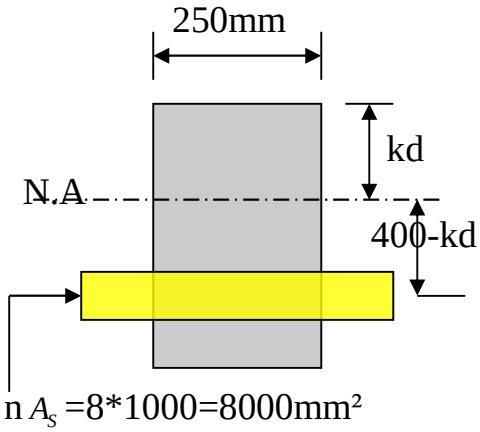
(kd)² +8000kd-3200000=0

(kd)²+64kd-25600=0

(kd-131)(kd+195)=0

Kd=131mm

Jd=400-(131/3)=356mm



M_C =1/2* f_c (bkd)(jd)

=1/2*(12*10^6)(0.25*0.131)(0.356)=70KN.m

M_S = f_s A_S (jd)

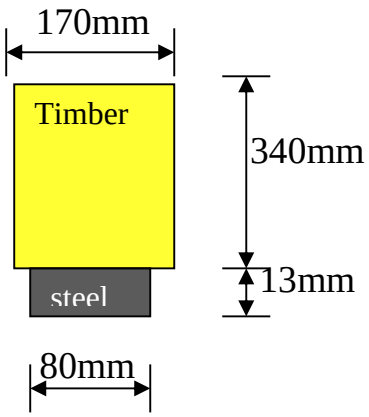
=140*10^6*1000*10^{-6}*0.356=49.8 KN.m

Maximum bending moment=49.8 KN.m

The beam is under reinforced

5/ Post test

1-A timber beam (175mm) by (340mm) is reinforced on the bottom only with a steel strip (80mm) wide by (13mm) thick .Determine the maximum resisting moment if the allowable stresses are $s_s \leq 130$Mpa. And $s_w \leq 9$Mpa. .Assume (n=20) .



6/ Key answer

1- Pre test : 1-As in text .

2- Post test :1- M=42.9KN.m **.**