Force, Analysis of forces, Resultant of concurrent forces

1- Over view

1-A-Target population:-

For students of first class

Institute of Technology / Baghdad

Department of Water Resources 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, analysis of forces, resultant of concurrent forces, for this reason I have designed this 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 - Analysis of forces

6- Resultant of concurrent forces

1-D-Instructions:-

1- Study over view unit thoroughly.

2- Identify the goal of this 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 unit well.

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

*Get 9 or more, so go on studying second unit.

*Get less than 9, go back and study the first unit; or any part of it; again and

then do the post test again.

2-Performance Objectives:-

After studying the first 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.

4- Analysis of forces and resultant of concurrent forces

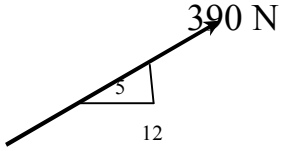
3-Pre test:-

1-Define mechanics.

2-Define the force.

3-what are the types of forces.

4-Resolve the (390 N) force has shown in figure into two Perpendicular components.



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:

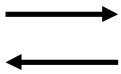
1-Scalar quantities: have only magnitude (mass, volume)

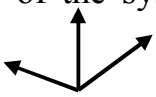
2-Vector quantities: have both magnitude and direction (couple, force)

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

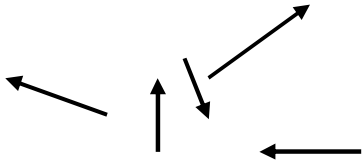
Classification of forces:

1-Collinear: All forces of the system have common line of action 

2-Parallel, coplanar: the action lines of all forces of the system are parallel and line in the same plane. 

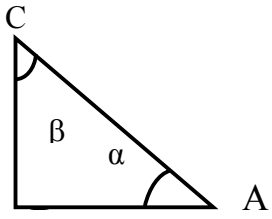
3-Concurrent, coplanar: the action lines of all forces of the system are in the same plane and intersect at a common point. 

4-Non parallel, non concurrent forces: the action lines of all forces of the system are in the same plane but they are not all parallel and not all intersect at a common point.



Trigonometry:-

1-In a Right angle triangle ABC:



$\text{Sin } \alpha = BC / AC \quad \rightarrow BC = AC \text{ Sin } \alpha$

$\text{Cos } \alpha \; AB / AC \quad \rightarrow AB = AC \text{ Cos } \alpha$

$\text{Tan } \alpha = BC / AB$

Or

$\text{Sin } \beta = AB / AC \quad \rightarrow AB = AC \text{ Sin } \beta$

$\text{Cos } \beta = BC / AC \quad \rightarrow BC = AC \text{ Cos } \beta$

$\text{Tan } \beta = AB / BC$

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

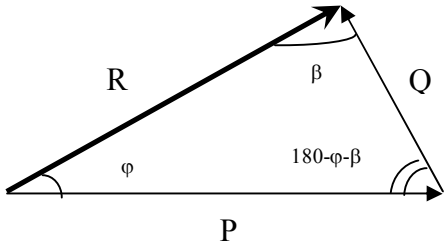
2- Cos Law:

$R^2 = P^2 + Q^2 - 2PQ \text{ Cos } (180-\varphi-\beta)$

If $(180-\varphi-\beta) = 90$

$\text{Cos } 90 = 0$

$R^2 = P^2 + Q^2$

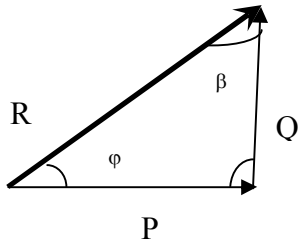


3- Sin Law:

$$\frac{R}{\text{Sin } (180-\varphi-\beta)} = \frac{Q}{\text{Sin } \varphi} = \frac{P}{\text{Sin } \beta}$$

If $(180-\varphi-\beta) = 90$

$\text{Sin } 90 = 1$



$$\frac{R}{\text{Sin } 90} = \frac{Q}{\text{Sin } \varphi} = \frac{P}{\text{Sin } \beta}$$

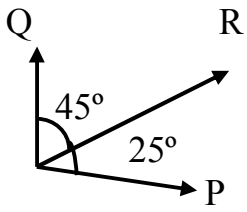
$$R = \frac{Q}{\text{Sin } \varphi}$$

Or

$$R = \frac{P}{\text{Sin } \beta}$$

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

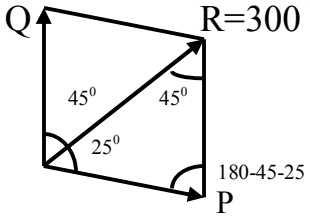
Solution:



180-45-25=110º

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

300/ Sin 110 =Q / Sin 25 ⟶ Q=134.68 N



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

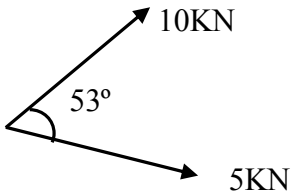
Solution:

$R^2=P^2 + Q^2 - 2PQ \text{ Cos}(180-\Theta-\alpha)$

$=(10)^2+(5)^2-2*10*5*\text{Cos}(127)$

$=185.18$

$R=13.6N$

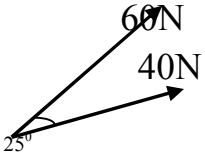


5-Post test:-

1- the two forces 60N and 40N act on a bolt, determine their resultant

a) Using parallelogram law.

b) use Sin law to determine the angle of resultant.



6-key answer:-

1- Pre test:-

1- As in text

2- As in text

3- As in text

4- Fx=360 N, Fy=150N

2- Post test:-

1- a) R=98 N

b) The angle of resultant= 35^0

7-Sources:-

1-Higdon Archie and William B., (1968), "***Engineering Mechanics***", 3rd, edition, United States, prentice -Hall

2-Singer, Ferdinand L., (1975),"***Engineering Mechanics***", 3rd edition, New York, Harper and Row publisher

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Moment of forces, Couple

1- Over view

1 -A-Target population:-

For students of first class

Institute of Technology / Baghdad

Department of Water Resources Techniques

1-B -Rationale:-

Moment and couples of forces is very important subjects to be studied in order to have a full knowledge about determination of the moments for the forces about any point or axis and the moments for the forces which have parallel line of action and opposite senses, for this reason I have designed this 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 when have been using Varignan's theory.

3-Determination of moments the forces which have parallel line of action and

1-D-Instructions:-

1-Study over view is 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 unit well .

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

*get 9 or more , so go on studying third unit.

*get less than 9 , go back and study the second unit ; or any part of it ; again and then do the post test again .

2-Performance Objectives:-

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

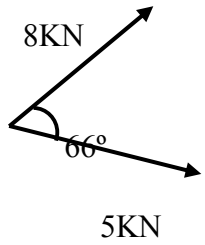
1- Determine the moments of forces

2-Use is Varignan's theory.

3-Determine of couple.

3-Pre test:-

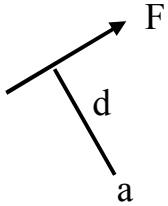
1-Determine the magnitude of resultant for the two forces shown in figure .



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:

Clockwise ⟳ _

Counter clockwise ⟲ +

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

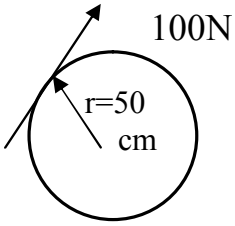
Varignan's Theory: the moment of a force about any point or axis is equal to the vector sum the moments of its components about the same point or axis.

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

Solution:

+ ⟲ Ma=F . d

A



=- 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

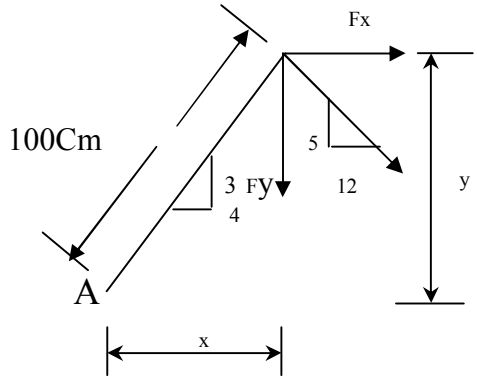
Fy=130× 5/13 =50

X=100× 4/5=80Cm

Y=100× 3/5=60Cm

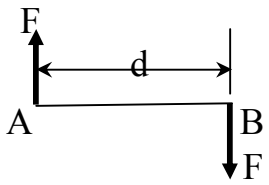
+⟲ MA=-120× 60-50× 80=-11200N.Cm

=11200N.Cm ⟳



Couples: A couple consists of two forces which have been equal magnitude, apposite senses, parallel line of actions and work on turn the body.

Moment of a couple: **Mc**

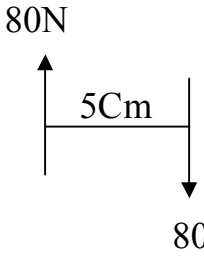


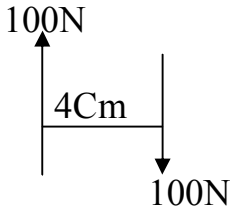
Mc= F * d

Mc: the sum of the moments of the forces.

d: the perpendicular distance between the forces .

Transformation of a couple:



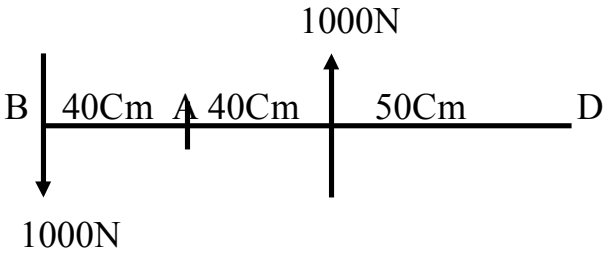


+ ⟲ Mc=-80× 5=-400N.Cm

+ ⟲ 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

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

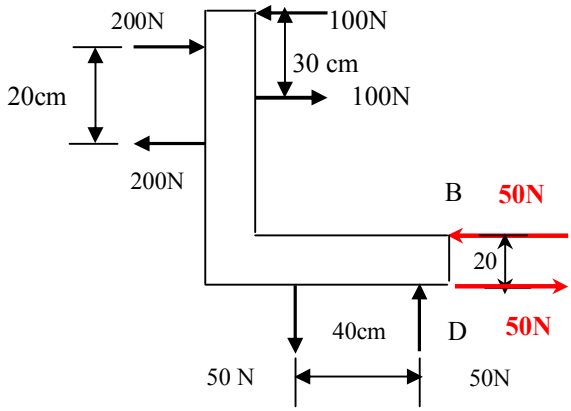
Solution:

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

Mc=F . d

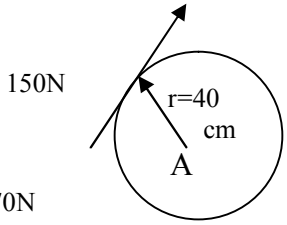
1000=F × 20

F=50N

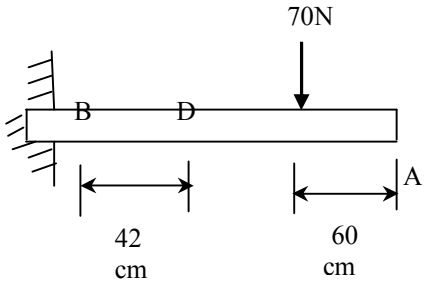


5-Post test:-

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



2-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 .



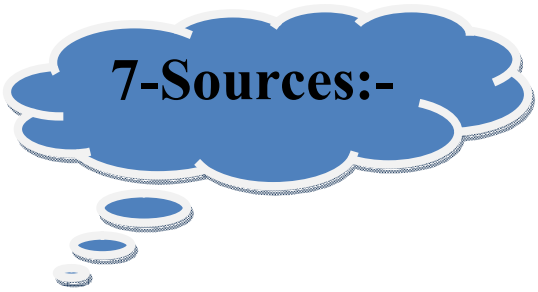
6-key answer:-

1- Pre test:-

1-R=11.02N

2- Post test :-

1- M=6000N.cm



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Equilibrium, Equilibrium in concurrent and non concurrent forces

1-Over view

1 -A-Target population:-

For students of first class

Institute of Technology / Baghdad

Department of Water Resources Techniques

1-B -Rationale:-

Equilibrium 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 unit for this knowledge to be understood.

1-C-Central Idea:-

1-Determine of the forces effect on bodies.

2- Draw the free body diagram.

1-D-Instructions:-

1-Study over view is thoroughly.

2-Identify the goal of this 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 unit well.

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

∗Get 9 or more, so go on studying fourth unit.

∗Get less than 9, go back and study the thired unit; or any part of it; again and then do the post test again.

2-Performance Objectives:-

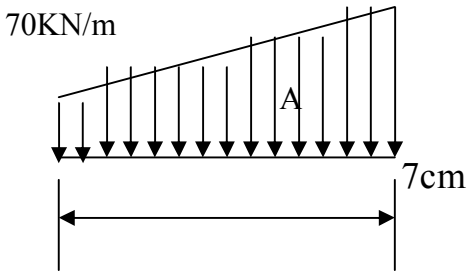
After studying the fourth unit, the student will be able to:-

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) .

140KN/m

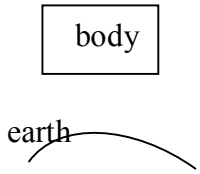
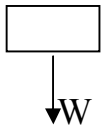
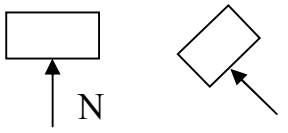
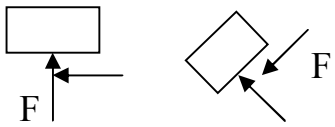
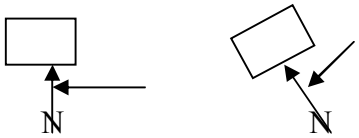
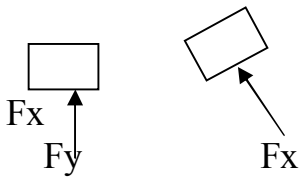
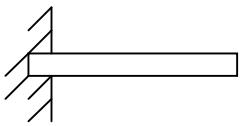
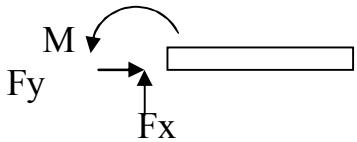
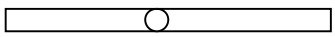
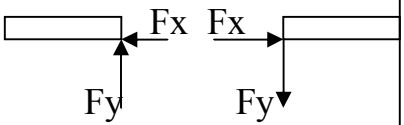
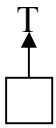


4-the text:-

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	 Plane Inclined	
3- Rough surface	 Plane Inclined	
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) :

$\sum Fy=0$

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

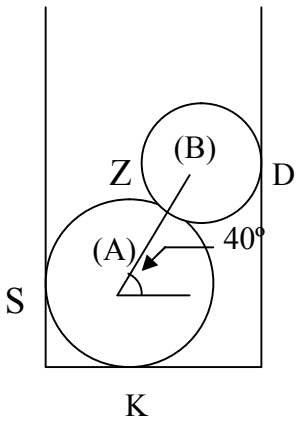
From F.B.D of cylinder (A):

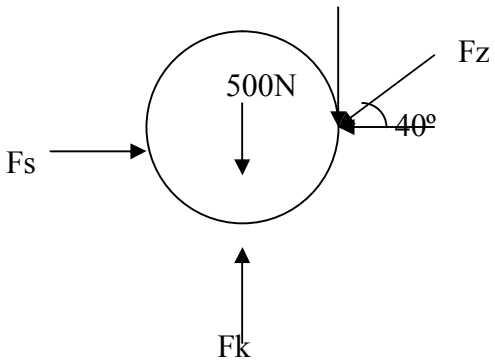
$\sum Fx=0$

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

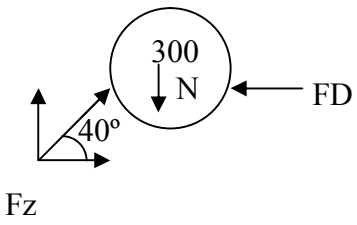
$\sum Fy=0$

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





F.B.D of cylinder (A)



F.B.D of cylinder (B)

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=∑M when R= 0

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

Rx=∑Fx=0 ----------(1)

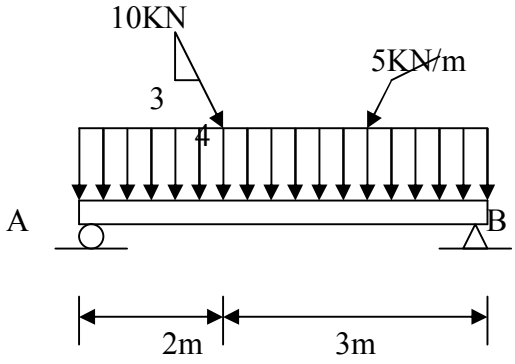
Ry=∑Fy=0 ----------(2)

Mc=∑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

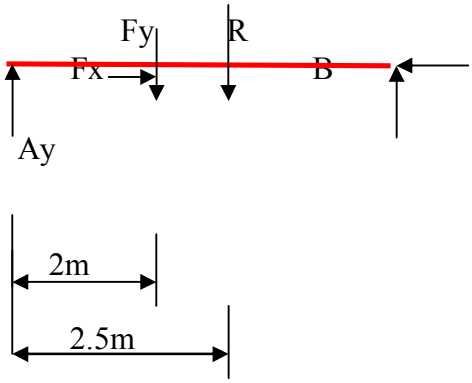
8-Bx=0 ⟶ Bx=8K

∑MA=0

By× 5-6× 2-25× 2.5=0 ⟶ By=14.9KN

∑Fy=0

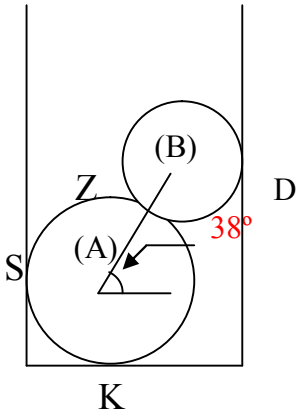
Ay+14.9-25-6=0 ⟶ Ay=16.1KN



(F.B.D)

5-Post test:-

1-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-R=750N , d=4.13cm

2-Post test:-

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

7-Sources:-

1-Higdon Archie and William B., (1968), "***Engineering Mechanics***", 3rd, edition, United States, prentice -Hall

2-Singer, Ferdinand L., (1975),"***Engineering Mechanics***", 3rd edition, New York, Harper and Row publisher

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Types of friction, Laws of friction, Angle of friction, Coefficient of friction

1 -A-Target population:-

For students of first class

Institute of Technology / Baghdad

Department of Water Resources Techniques

1-B-Rationale:-

Types of friction, Laws of friction, Angle of friction, Coefficient 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 unit for this knowledge to be understood .

1-C-Central Idea:-

1- Types of friction.

2-Determine of maximum frictional force.

1-D-Instructions:-

1-Study over view is thoroughly.

2-Identify the goal of this 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 unit well .

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

*get 9 or more , so go on studying sixth unit .

*get less than 9 , go back and study the fifth unit ; or any part of it ; again and then do the post test again.

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

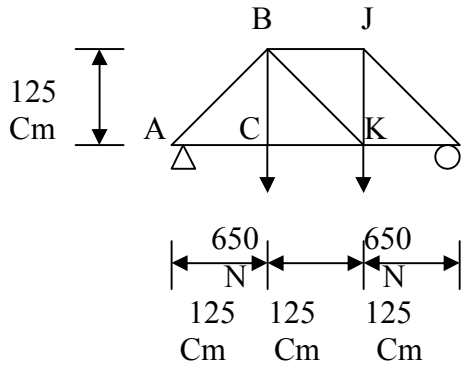
1- Knowingness types of friction.

2-Determine of maximum frictional force.

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 .

E



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) :

block

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

2:-When (P) increased the frictional force (F) is also increased in the same value to prevent motion . Figure 1

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

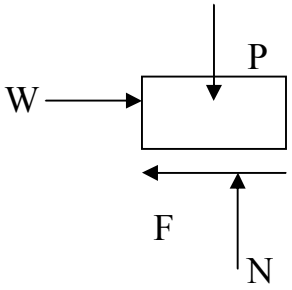


Figure 2

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

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

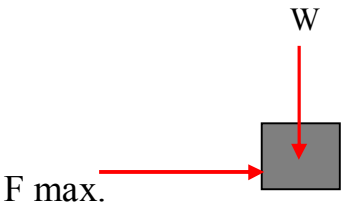
$$F_{max.} = \mu * N \longrightarrow \mu = F_{max.}/N$$

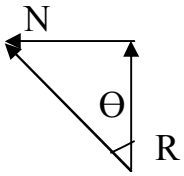
Angle of friction:

$$\tan \Theta = F_{max.}/N$$

$$\mu = F_{max.}/N$$

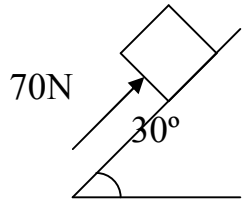
$$\boxed{\tan \Theta = \mu}$$





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) .

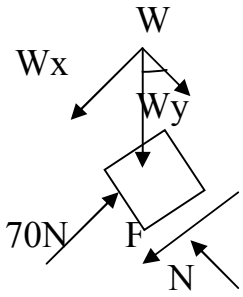
Solution:



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.)

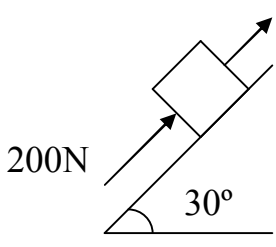


Fmax.=μ*N

∑Fy=0

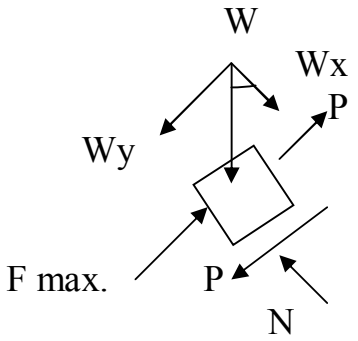
N-70=0 ⟶ N=70N
Fmax.=0.2× 173.2=34.64N > 30N
F=30N

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

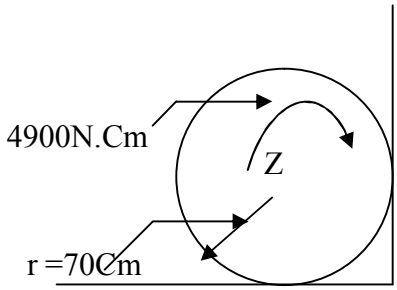


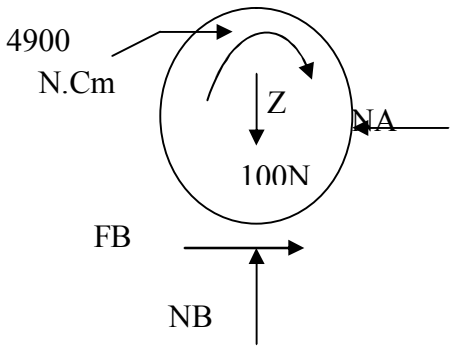
Example: A cylinder of (100N) weight is to entrust to a horizontal surface its coefficient of friction (μ=0.4) and a smooth vertical surface as shown in figure .Determine the frictional force .

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

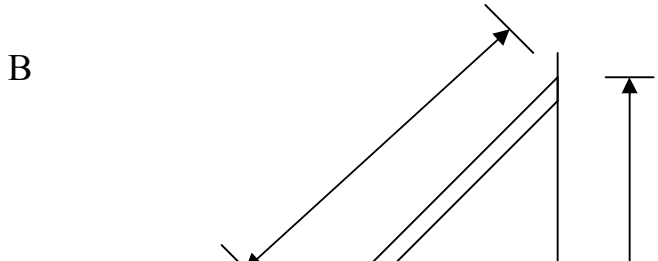




F.B.D of cylinder

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:

2.6m

∑Fy=0

2.4 cm

N-300-150=0

Θ

A

N=450N

Fmax.=μ*N

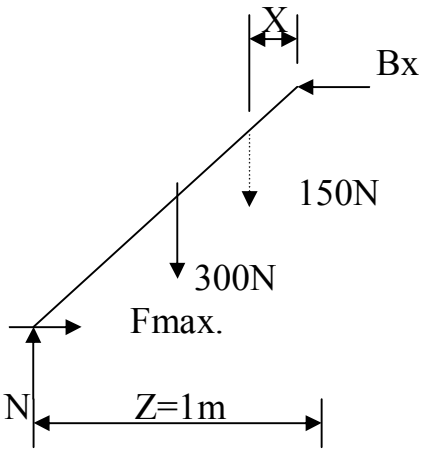
=0.2× 450=90N

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

∑MB=0

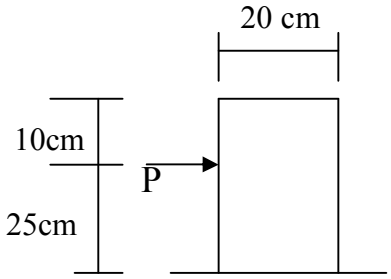
-450× 1+300× 0.5+67.5× 2.4+150× X=0

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)

∑ Fx = 0

P = Fmax.

∑ Fy = 0 ⟶ N=400N

Fmax.= μ*N=0.34× 400=136N

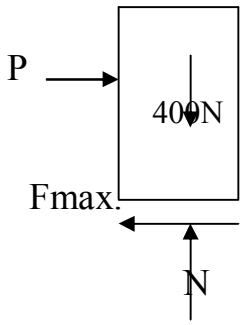
P=136N

2-the block is overturn
From (F.B.D 2)

∑ MA= 0

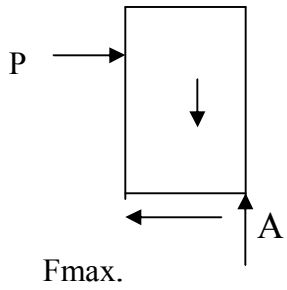
25 × p-400× 10= 0 F.B.D 1

P=160N



The block is slides and P= 136N

400N



F.B.D 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

7-Sources:-

1-Higdon Archie and William B., (1968), "***Engineering Mechanics***", 3rd, edition, United States, prentice -Hall

2-Singer, Ferdinand L., (1975),"***Engineering Mechanics***", 3rd edition, New York, Harper and Row publisher

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Centroids of regular and irregular area

1-Over view

1-A-Target population:-

For students of first class

Institute of Technology / Baghdad

Department of Water Resources 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 regular and irregular area, for this reason I have designed this unit for this knowledge to be understood.

1-C-Central Idea:-

1- Location of centroid of different regular and irregular shapes.

1-D Instructions:-

1- Study over view thoroughly.

2-Identify the goal of this 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 unit well.

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

∗Get 9 or more, so go on studying eighth unit.

∗Get less than 9, go back and study the seventh unit; or any part of it; again and then do the post test again.

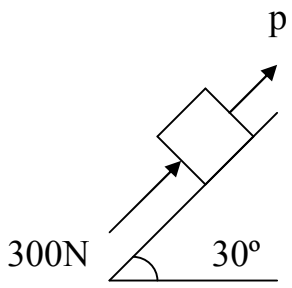
2-Performance Objectives:-

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

1-Locate the centroid of different simple shapes.
2- locate the position of the centroid of regular and irregular area.

3-Pre test:-

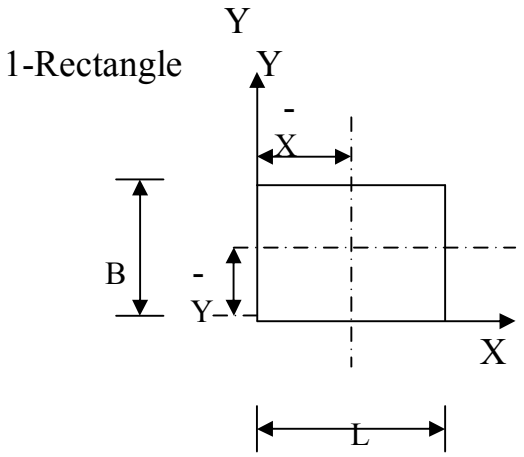
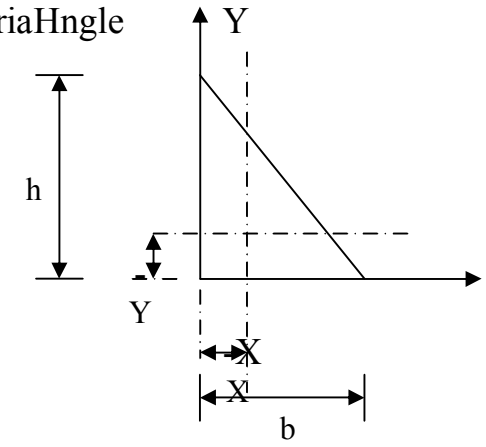
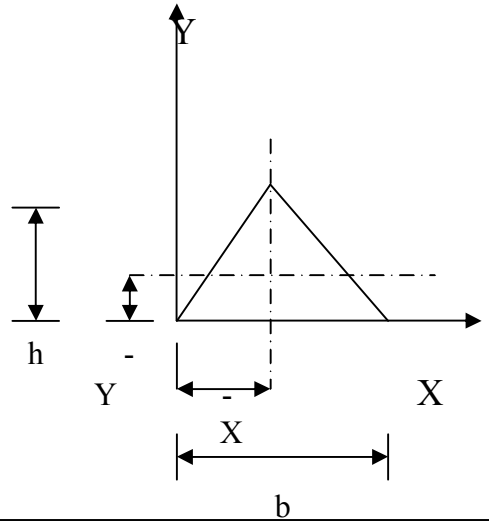
1- Calculate the force (P) required to move the (650N) block weight up the inclined surface shown in figure ,if the block is subjected to (300N)force assume (μ=0.5).

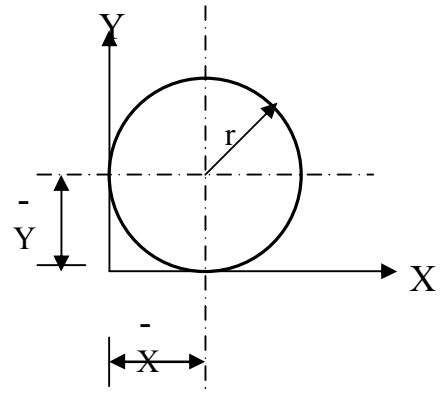
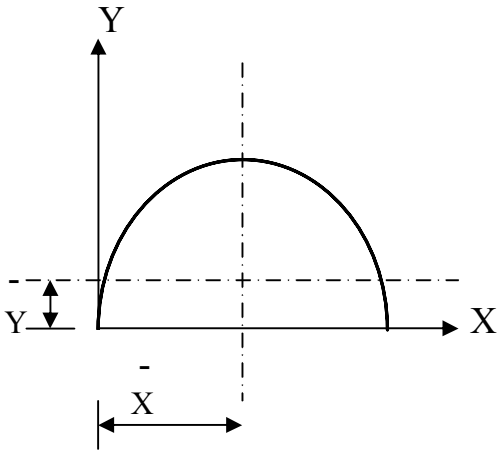
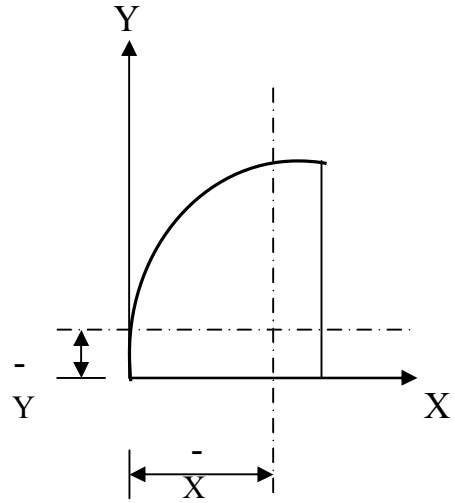


4-the text:-

CENTROID:

1:-Centroids of simple shapes:

Shape	Area (ai)	$\bar{X}$	$\bar{Y}$
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.

7-Sources:-

1-Higdon Archie and William B., (1968), "***Engineering Mechanics***", 3rd, edition, United States, prentice -Hall

2-Singer, Ferdinand L., (1975),"***Engineering Mechanics***", 3rd edition, New York, Harper and Row publisher

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Centroids of complex shapes

1-Over view

1-A-Target population:-

For students of first class

Institute of Technology / Baghdad

Department of Water Resources 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 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 is thoroughly.

2-Identify the goal of this 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 unit well.

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

∗Get 9 or more, so go on studying seventh unit.

∗Get less than 9, go back and study the sixth 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-thetext:-

2:- Centroids of complex shapes :

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

$$\bar{X} = \frac{\sum aixi}{\sum ai} \qquad \bar{Y} = \frac{\sum aiyi}{\sum ai}$$

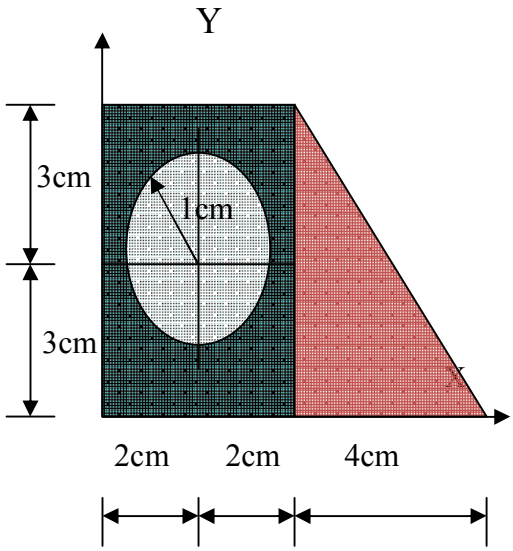
Example: Determine the centroid of the shaded area shown in figure with respect to (X) and (Y) axes .

Solution:

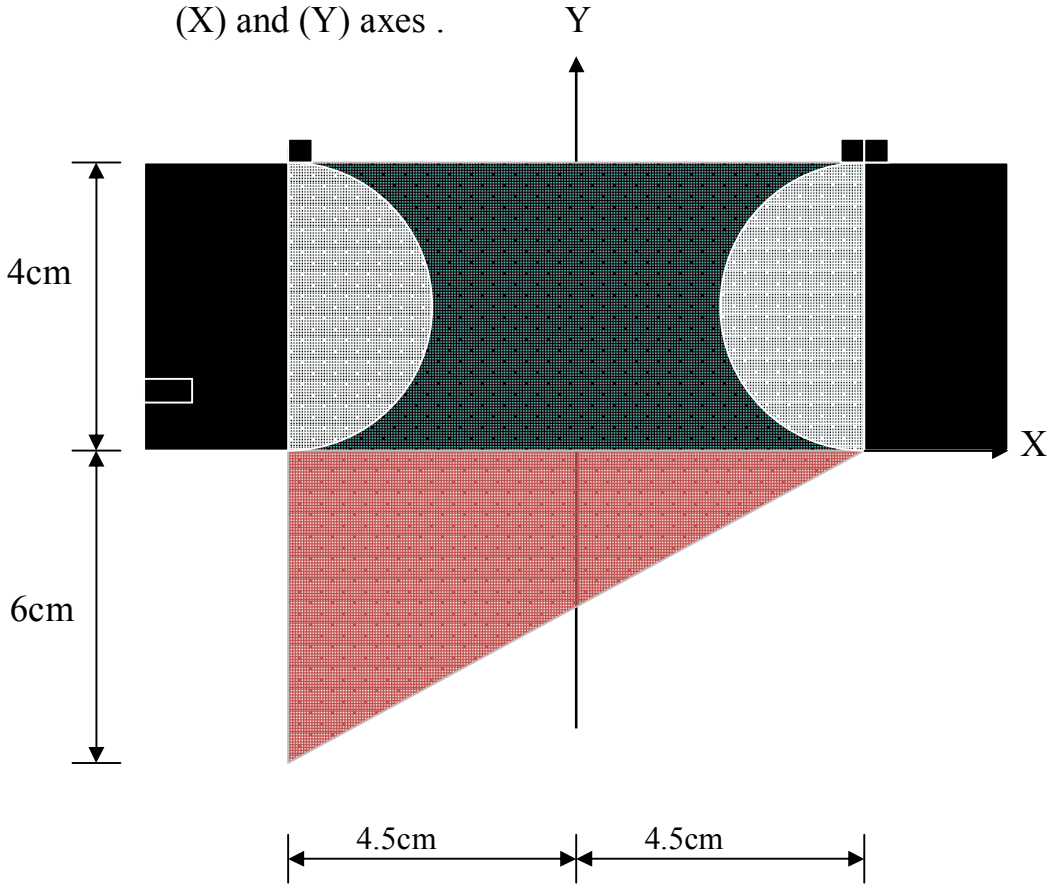
Fig.	ai	xi	yi	aixi	aiyi
	4× 6=24	2	3	48	72
	4× 6/2=12	5.33	2	64	24
	- π(1)²=-3.14	2	3	-6.28	-9.42
∑	32.86			105.72	86.58

-
X= 105.72/32.86=3.2 Cm

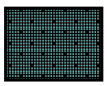
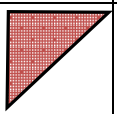
-
Y= 86.58/32.86 =2.6 Cm



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



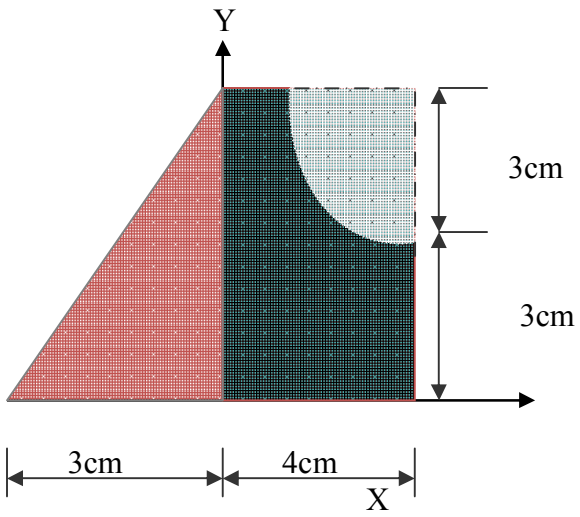
Solution:

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

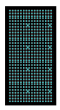
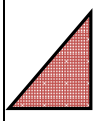
- X=-40.5/50.434=-0.803cm

- 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:

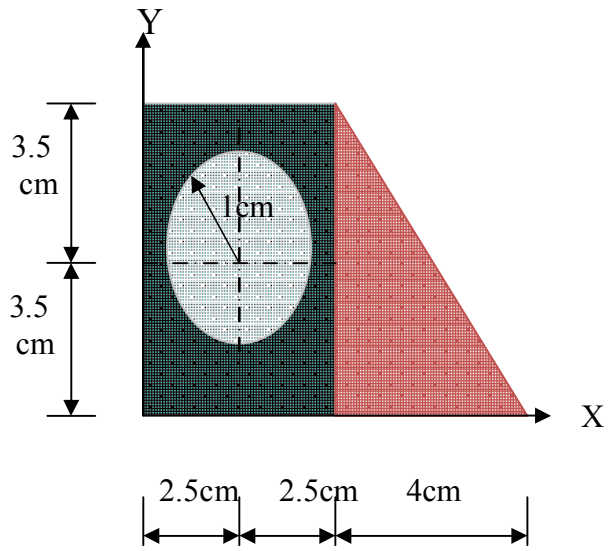
Fig.	ai	xi	yi	aixi	aiyi
	4× 6=24	2	3	48	72
	1/2× 3× 6=9	-1	2	-9	18
	-π(3)²/4=-7.069	4-(0.424×3) =2.728	6-(0.424× 3) =4.728	-19.27	-33.4
∑	25.931			19.73	56.6

- 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 .

7-Sources:-

1-Higdon Archie and William B., (1968), "***Engineering Mechanics***", 3rd, edition, United States, prentice -Hall

2-Singer, Ferdinand L., (1975),"***Engineering Mechanics***", 3rd edition, New York, Harper and Row publisher

٣-ج. ل. ميريامز، الميكانيكا الهندسية،الأستاتيكا، المجلد الأول، طبعة

Moment of inertia for the simple shapes

1-Over view:-

1-A-Target population:-

For students of first class

Institute of Technology / Baghdad

Department of Water Resources 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 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 is thoroughly.

2-Identify the goal of this 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 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 unit.

∗Get less than 9, go back and study the eighth unit; or any part of it ; again and then do the post test again .

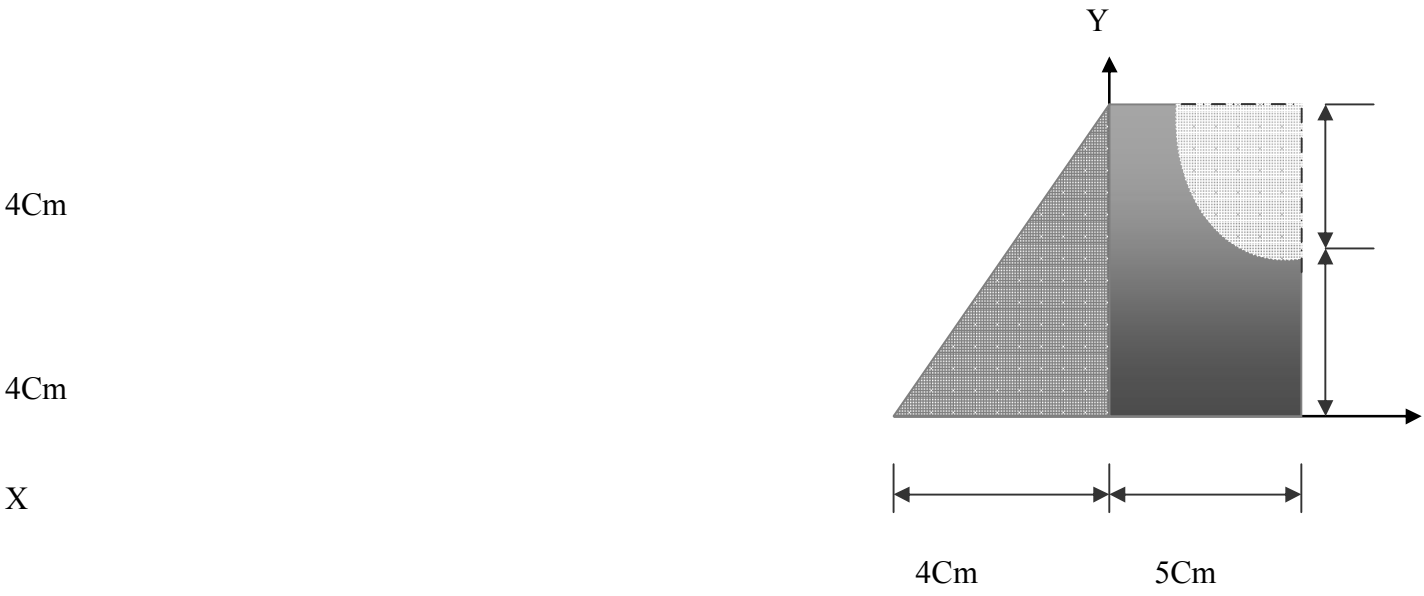
2-Performance Objectives:-

After studying the ninth 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 Inertia: (I)

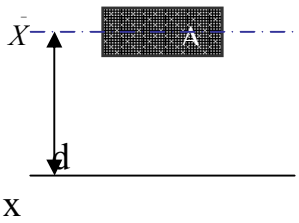
The moment of inertia of an area is equal to the product of this area by the square distance about the axis of rotation.

$I=A*d^2$

Transfer formula for moment of inertia :

-

$Ix=Ix+A*d^2$



$\bar{X}$

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

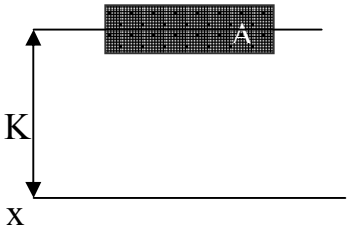
x

Polar moment of inertia: Ij_0

$Ijo=Ix+Iy$

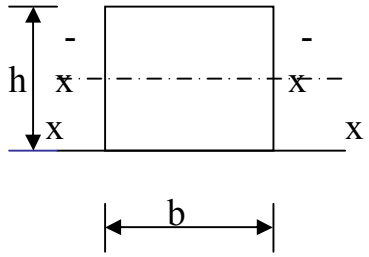
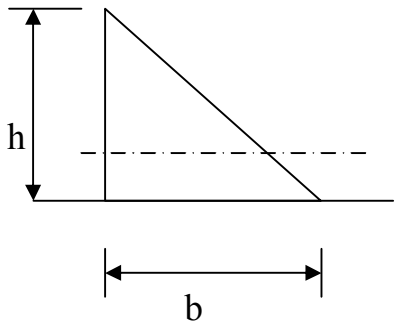
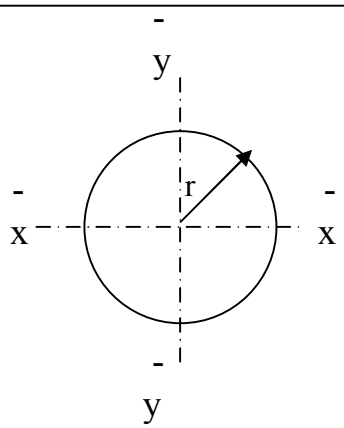
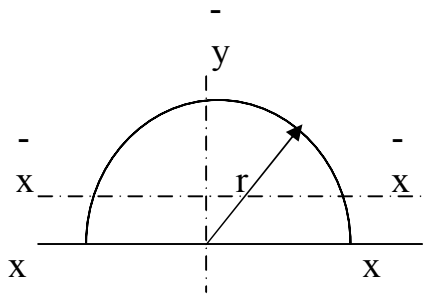
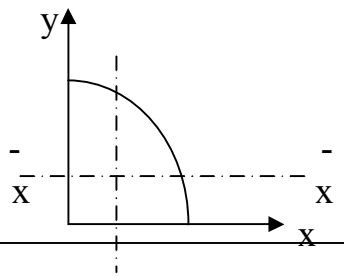
Radius of gyration: Kx

$Kx=\sqrt{I / A}$



x

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 .

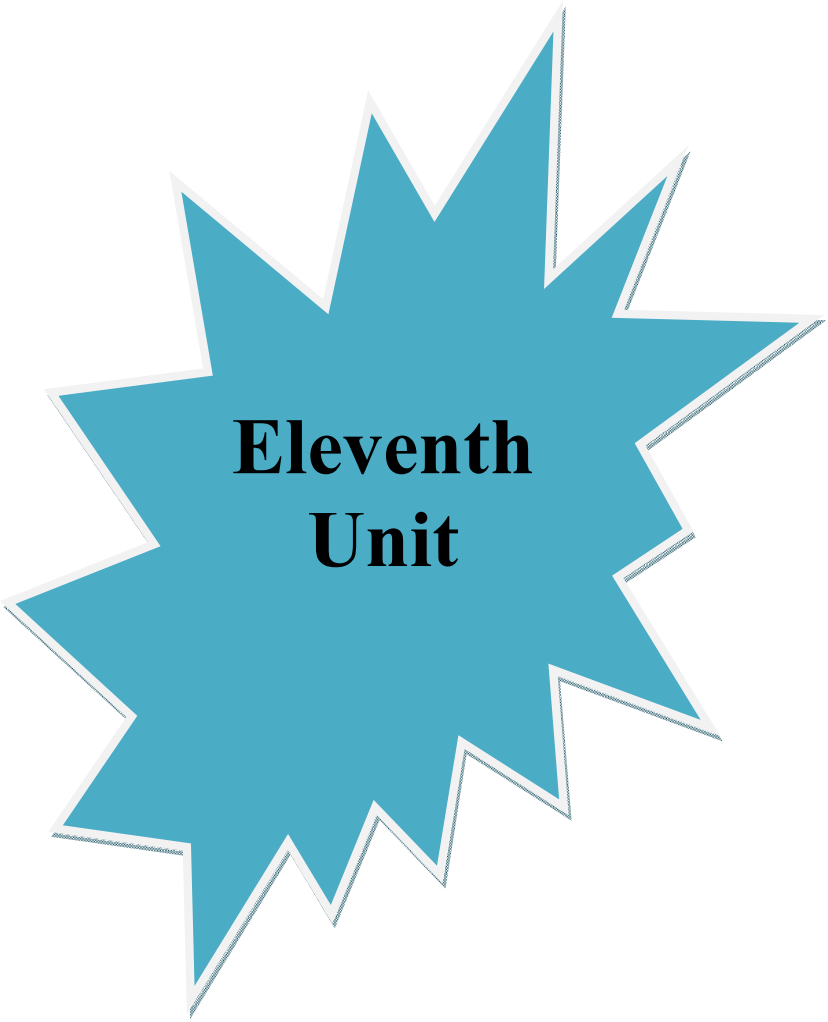
7-Sources:-

1-Higdon Archie and William B., (1968), "***Engineering Mechanics***", 3rd, edition, United States, prentice -Hall

2-Singer, Ferdinand L., (1975),"***Engineering Mechanics***", 3rd edition, New York, Harper and Row publisher

٣-ج. ل. ميريامز، الميكانيكا الهندسية،الأستاتيكا، المجلد الأول، طبعة

Moment of inertia for the complex shapes



1-Over view:-

1-A-Target population:-

For students of first class

Institute of Technology / Baghdad

Department of Water Resources 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 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 is 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 unit well.

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

∗Get 9 or more, so go on studying eleventh unit.

∗Get less than 9, go back and study the tenth unit; or any part of it; again and then do the post test again.

2-Performance Objectives:-

After studying the eleventh 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:

-

$Ia=Ix+ Ad^2$

a

-

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

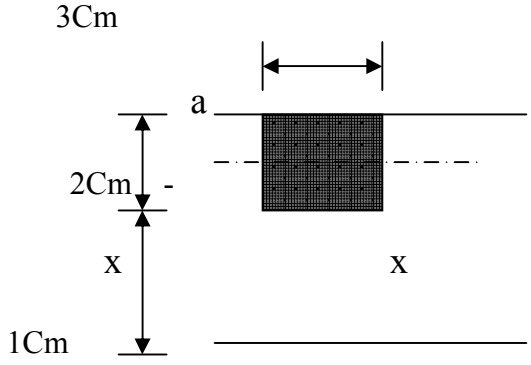
-

$Ix=2Cm$

-

$Ib =Ix+Ad^2$

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



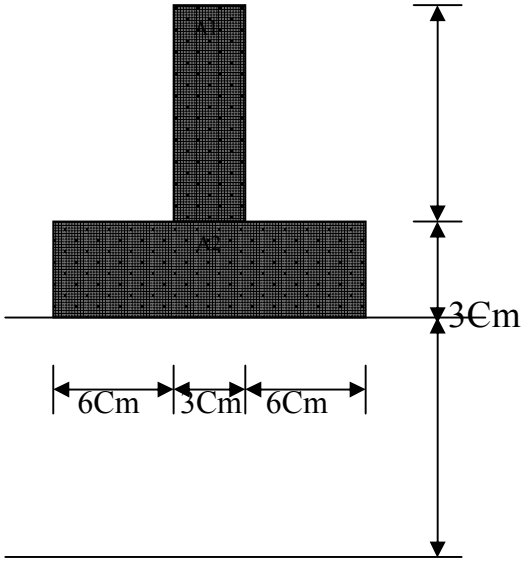
NOTE: when Ia is unknown in example :

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

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



12Cm

For (A1):

-

Ixi=Ix+Ad²

=bh³/12+Ad²

=3*(12)³/12+36*(13.5)²

4.5Cm

=6993 cm^4 (+)

xi

xi

For (A2):

-

Ixi=Ix+Ad²

=bh³/12+Ad²

=15*(3)³/12+45*(6)²

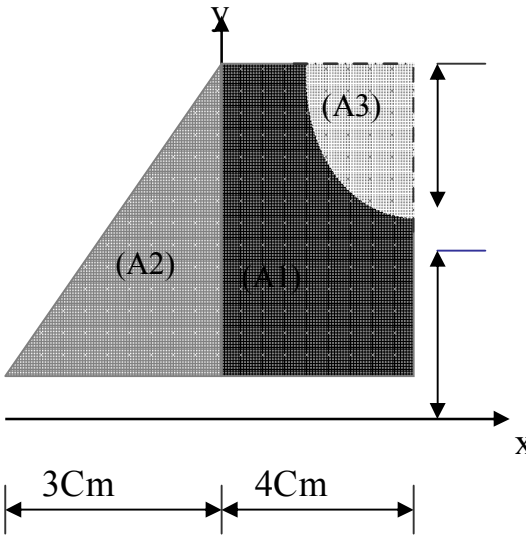
=1653.75 cm^4 (+)

Ixi (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



3Cm

3Cm

For(A1) :

$Ix=bh^3/12+Ad^2=4*(6)^3/12+24*(3)^2=288Cm^4$ (+)

For(A2) :

$Ix=bh^3/36+Ad^2=3*(6)^3/36+9*(2)^2=54Cm^4$ (+)

For(A3) :

$Ix=0.055(r)^4+Ad^2=0.055*(3)^4+7.06*(4.728)^2=162.27Cm^4$ (-)

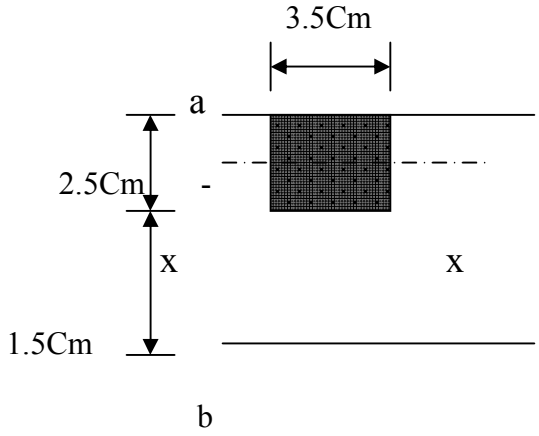
$Ix(total)=288+54-162.27=179.73Cm^4$

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).

a

-



b

6-key answer:-

-

1- Pre test:- 1-$Ix=0.31*10^6\ cm^4$.

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

7-Sources:-

1-Higdon Archie and William B., (1968), "***Engineering Mechanics***", 3rd, edition, United States, prentice -Hall

2-Singer, Ferdinand L., (1975),"***Engineering Mechanics***", 3rd edition, New York, Harper and Row publisher

٣-ج. ل. ميريامز، الميكانيكا الهندسية،الأستاتيكا، المجلد الأول، طبعة

Strength of materials, Types of stresses

1-Over view

1-A-Target population:-

For students of first class

Institute of Technology / Baghdad

Department of Water Resources Techniques

1-B-Rationale:-

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

1 / C –Central Idea:-

1- Definition strength of materials.

2- Types of stresses.

1 / D –Instructions:-

1-Study over view is thoroughly.

2-Identify the goal of this 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 unit well .

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

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

2-Performance Objectives:-

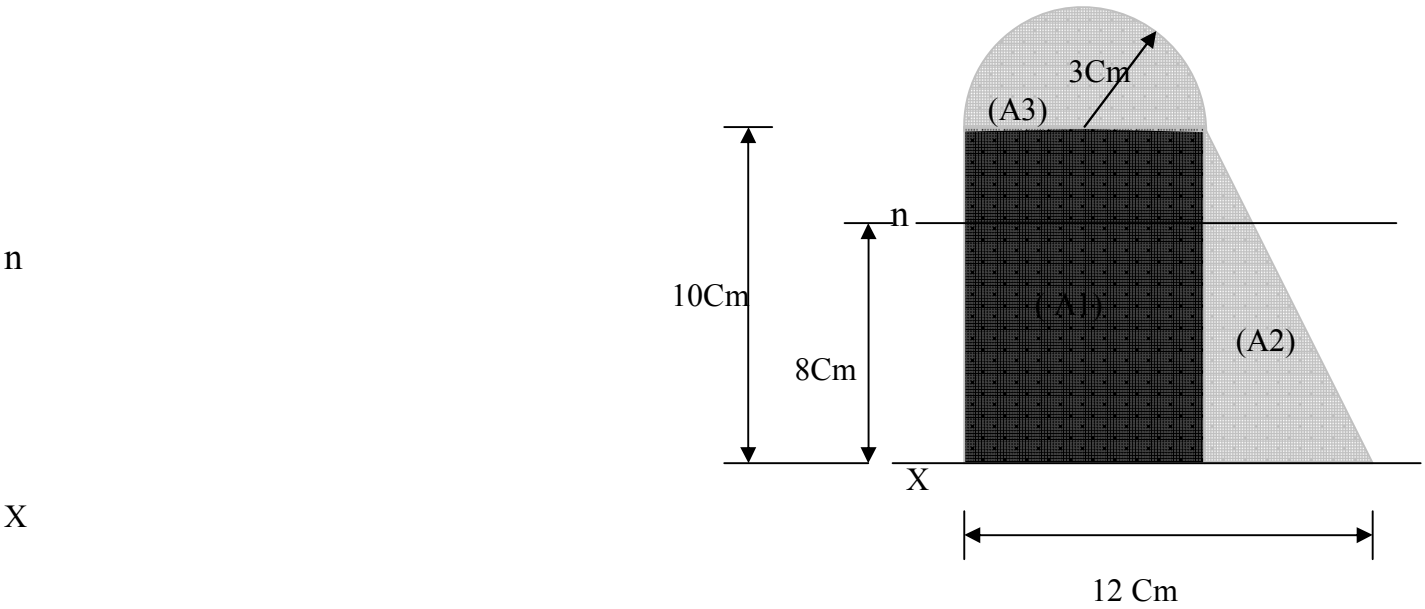
After studying the fifteenth unit, the student will be able to:-

1-Define the strength of materials

2-Define types of stresses.

3-Pre test:-

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



n

X

4-the text:-

STRENGTH OF MATERIALS: Deals with relations between external loads and their internal effects on bodies.

STRESS: σ

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

$\sigma = P/A$

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:

$\sigma = P/A$

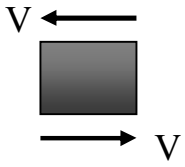
Cross sectional area (A)= π *$(20/1000)^2$ =1256*10^{-6} mm^2

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

3:-Shearing stress: τ

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

$$\tau = V/A$$



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.

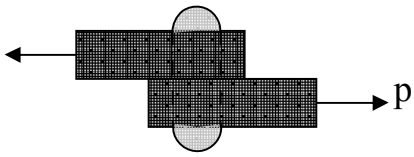
Example: Determine the shearing stress in the rivet shown in figure due to the (30KN) applying load if the diameter of the rivet is (20mm) .

Solution:

d=20+1.5=21.5mm

$\tau = V/A$ p

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



=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.

7-Sources:-

1 -وليم أفاش

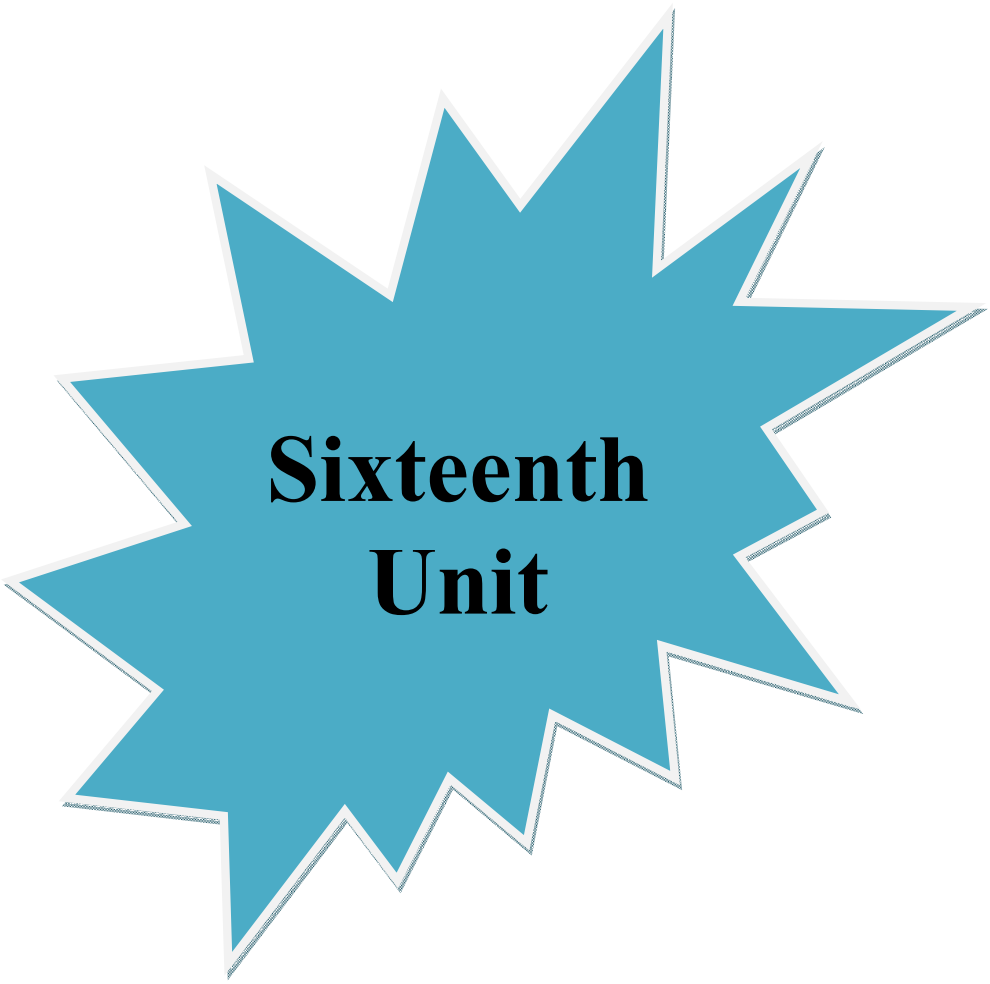
سلسلة شوم ، مقاومة المواد

دار ماكجروهيل

٢- بيتر ستيوبين
مقاومة المواد ، الطبعة الرابعة

٣- سنكر
مقاومة المواد ، النسخة العربية ، ترجمة خزعل ياسين محمود
جامعة صلاح الدين

Type of Strain and application



1- Over view

1-A-Target population:-

For students of first class

Institute of Technology / Baghdad
Department of Water Resources 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 unit for this knowledge to be understood .

1-C-Central Idea:-

1- Type of strain and its application.

1-D-Instructions:-

1-Study over view is thoroughly.

2-Identify the goal of this 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 unit well.

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

∗Get 9 or more, so go on studying seventeenth unit.

∗Get less than 9, go back and study the sixteenth unit; or any part of it; again and then do the post test again.

2-Performance Objectives:-

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

1- Type of strain and its application.

3-Pre test:-

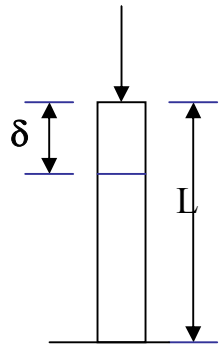
1-Determine the shearing stress in the rivet shown in figure due to the (40KN) applying load if the diameter of the rivet is (25mm) .

4-the text:-

STRAIN (ε):Is the unit deformation caused by stress

Strain= Change in length / Original length

$$\varepsilon = \delta / L$$



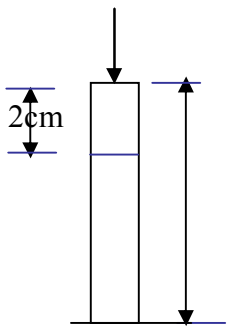
Example: Determine the strain of a body caused by the applied force (p) if the decrease in length is (2Cm) , and the length of the body is (200Cm).

Solution:

$$\varepsilon = \delta / L$$

$$=2/200=0.01$$

200Cm



HOOK'S LAW : Axial deformation

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

$$E = \sigma / \varepsilon \quad \Longrightarrow \quad \sigma = E * \varepsilon$$

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.

$$\sigma = E * \varepsilon$$
$$P/A = E * \delta / L$$

$$\delta = PL/AE$$

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- τ =72.52Mpa.

2- Post test :

1- ε =0.006

7-Sources:-

1 - وليم أفاش

سلسلة شوم ، مقاومة المواد

دار ماكجروهيل

٢- بيتر ستيوبين
مقاومة المواد ، الطبعة الرابعة

٣- سنكر
مقاومة المواد ، النسخة العربية ، ترجمة خزعل ياسين محمود
جامعة صلاح الدين

Shear force and bending moment diagrams

1- Over view

1-A-Target population:-

For students of first class

Institute of Technology / Baghdad

Department of Water Resources 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 is thoroughly.

2-Identify the goal of this 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 unit well.

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

∗Get 9 or more, so go on studying twenty-fourth unit.

∗Get less than 9, go back and study the twenty-third unit; or any part of it; again and then do the post test again.

2-Performance Objectives:-

After studying the twenty-third 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

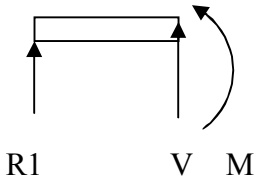
Shear force: is the summation of vertical external loads acting on the left side of the selected section .

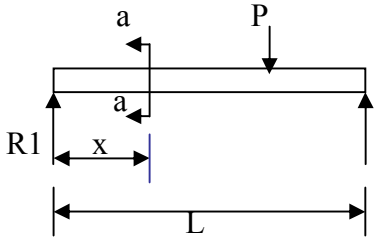
Bending moment: is the summation of moments of all the loads acting to the left of the selected section .

$V=(\sum Fy)_L$

$M=(\sum M)_L$

R2





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

Solution:

15KN

1-determination of reactions

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

B

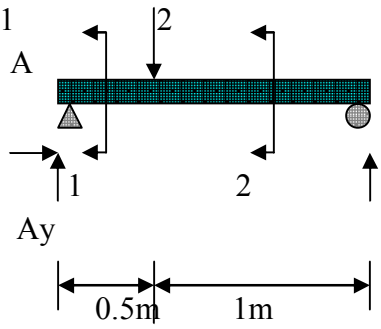
$\sum MA=0$

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

$\sum Fy=0$

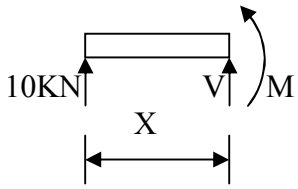
By

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



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

section (1-1)

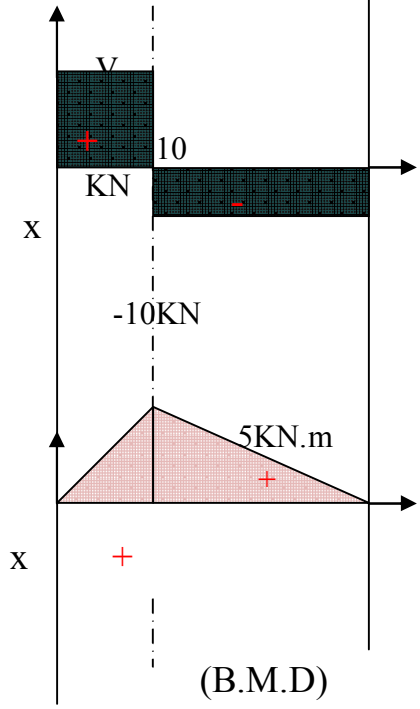


$V1=\sum Fy=10KN$

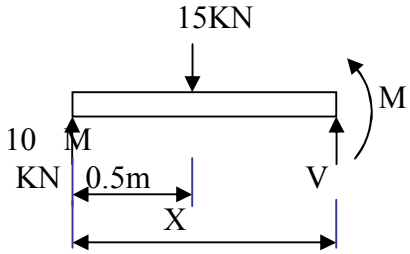
$M1=\sum M=10X$ When x=0 M1=0

When x=0.5 M1=5KN.m

(S.F.D)



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

(B.M.D)

5-Post test:-

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

6-key answer:-

-

1- Pre test :-

1-d=11.28mm , δ =4.5mm.

2- Post test :

1- As in text .

7-Sources:-

1 - وليم أفاش

سلسلة شوم ، مقاومة المواد

دار ماكجروهيل

٢- بيتر ستيوبين
مقاومة المواد ، الطبعة الرابعة

٣- سنكر
مقاومة المواد ، النسخة العربية ، ترجمة خزعل ياسين محمود
جامعة صلاح الدين

Shear stress-its law-application on bolts-connection of area and rivet

1- Over view

1-A-Target population:-

For students of first class

Institute of Technology / Baghdad

Department of Water Resources 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 .

Beams which making from two materials

Twenty –sventh Unit

1- Over view

1-A-Target population:-

For students of first class

Institute of Technology / Baghdad

Department of Water Resources 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:-

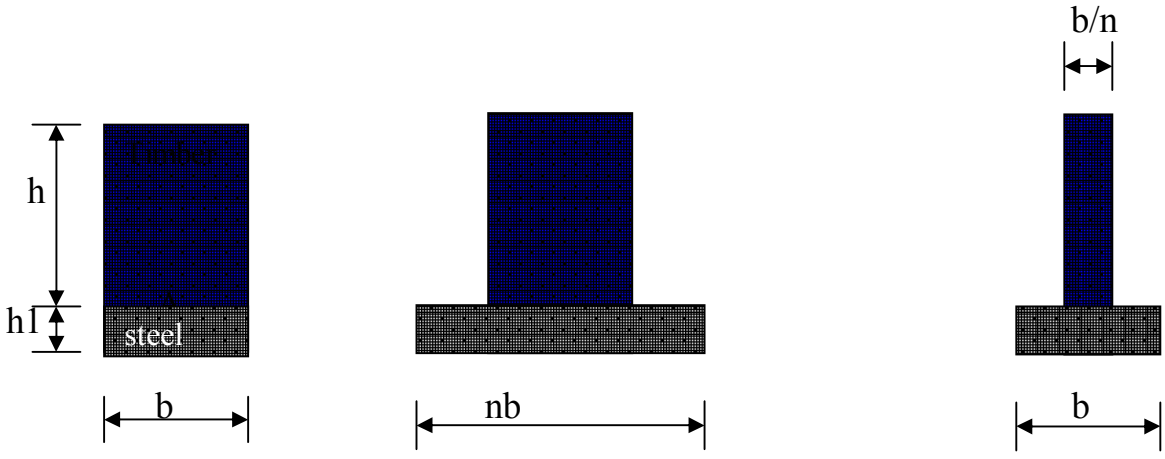
1-Define the method of dealing with non homogeneous beams.
2-Determine the equivalent homogeneous beam .

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)

$$\varepsilon_S = \varepsilon_W$$

$$\sigma_s / E_S = \sigma_W / E_W \quad \text{----------(1)}$$

$$P_S = P_W$$

$$A_S \sigma_S = A_W \sigma_W \quad \text{---------(2)}$$

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

$$A_S (E_S / E_W)\ \sigma_W = A_W \sigma_W$$

A_W=n A_S , 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 .

7-Sources:-

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