LIST OF EXPERIMENTS

1. Vernier calliper , Screw gauge and Travelling Microscope.
2. Spring Constant.
3. Young’s Modulus- uniform bending.
4. Kater’s Pendulum.
5. Compound Pendulum.
6. Torsional Pendulum.

I. SCREW GAUGE

Aim

To determine the thickness of a given glass plate using screw gauge.

Apparatus required

Screw gauge and glass plate

Description

It is based upon the principle of a screw. It consists of a U-shaped metal frame. One end of which carries a fixed stud A whereas the other end B is attached to a cylindrical tube as shown in Fig. 1. A scale graduated in millimetres is marked on the cylindrical tube along its length. It is called Pitch scale.

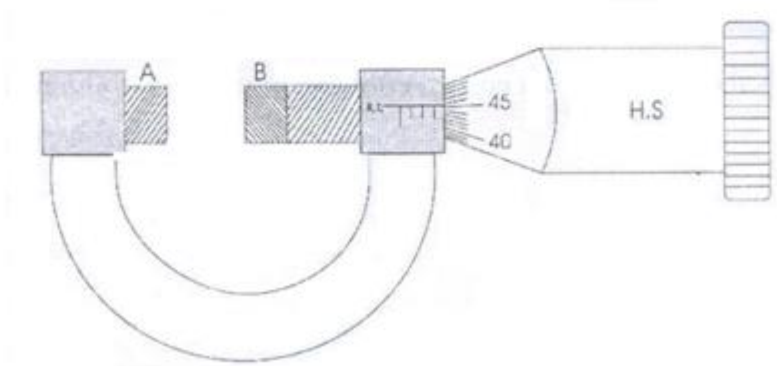


Fig.1 Screw Gauge

The screw carries a head H which has a beveled edge. The edge is divided into 100 equal divisions. It is called the Head scale H.S. When the head is rotated, the head scale moves on the pitch scale.

Procedure:

1. To find the least count (LC) of the screw gauge

Least count of a screw gauge is the distance through which the screw tip moves when the screw is rotated through one division on the head scale.

To find the pitch, the head or the screw is given say 5 rotations and the distance moved by the head scale on the pitch scale is noted. Then by using the above formula, the least count of the screw gauge is calculated.

Pitch = 5 mm / 5 = 1 mm

Least Count = 1 mm / 100 = 0.01 mm

The screw head is rotated until the two plane faces A and B are just in contact.

2. **To find the zero correction (ZC)**

i) **Nil error**

If the zero of the head scale coincides with the zero of the pitch scale and also lies on the base line (B.L), the instrument has no zero error and hence there is no zero correction.

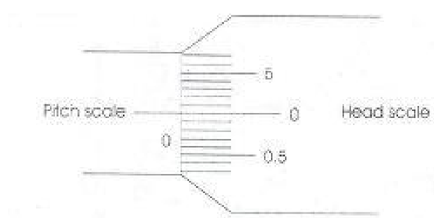


Fig. 2 Nil Error

ii) **Positive zero error**

If the zero of the head scale lies below the base line (B.L) of the pitch scale then the zero error is positive and zero correction is negative. The division on the head scale, which coincides with the base line of pitch scale, is noted. The division multiplied by the least count gives the value of the positive zero error. This error is to be subtracted from the observed reading i.e. the zero correction is negative (See Fig.3).

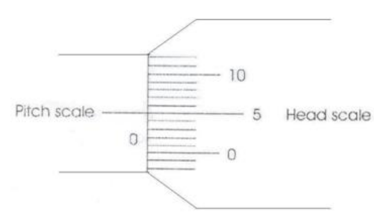


Fig. 3. Positive Zero Error

Example

If 5th division of the head scale coincides with the base line of the pitch scale then Zero error = +5 divisions

Zero correction = (Z.E x LC) = -(5 x 0.01) = - 0.05 mm.

iii) Negative zero error

If the zero of head scale lies above the base line (B.L) of the pitch scale, then the zero error is negative and zero correction is positive. The division on the head scale which coincides on the base line of pitch scale is noted. This value is subtracted from the total head scale divisions. This division multiplied by the least count gives the value of the negative error. This error is to be added to the observed reading i.e. zero correction is positive (See Fig. 4).

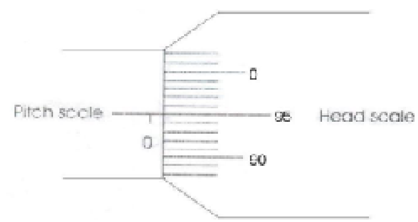


Fig. 4 Negative Zero Error

Example

If the 95th division of the head scale coincides with the base line of the pitch scale then, Zero error = -5 divisions Zero correction = + 0.05 mm

3. To find the thickness of the glass plate

The glass plate is gently gripped between the faces A and B. The pitch scale reading and the head scale coincidence are noted. The readings are tabulated.

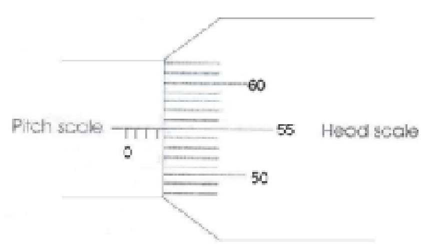


Fig. 5 Screw Gauge Readings

Pitch Scale Reading (P.S.R)

Number of pitch scale division just in front of the head scale fully completed is noted (see Fig. 5). It is measured in millimeter.

Head Scale Coincidence (H.S.C)

Coincidence of head scale division on the base line of the pitch scale is also noted.

Example:					
LC = 0:01 mm		Zero correction (Z.C.) = +0.03 mm			
S.No.	P.S.R mm	H.S.C div	H.S.R = (H.S. C x LC) mm	Total Reading = P.S.R+ H.S.R mm	Corrected Reading = T.R. ± Z.C. mm

Mean thickness of the glass plate =

II. VERNIER CALIPERS

Aim

To measure the dimensions of the given object.

Apparatus

Vernier Calipers and Wooden block

Description

The vernier calipers consist of a long rigid rectangular steel strip called the main scale (M.S) with a jaw (A) fixed at one end at right angles to its length as shown in Fig.l. The main scale is graduated both in centimeters and inches. The second jaw (B) carrying a vernier scale and capable of moving along the main scale can be fixed to any position by means of a screw cap S. The vernier scale is divided into 10 divisions, which is equivalent to 9 main scale divisions (M.S.D). So the value of 1 vernier scale division is equal to 9/10 M.S.D. The value of 1 M.S.D. is 1 mm.

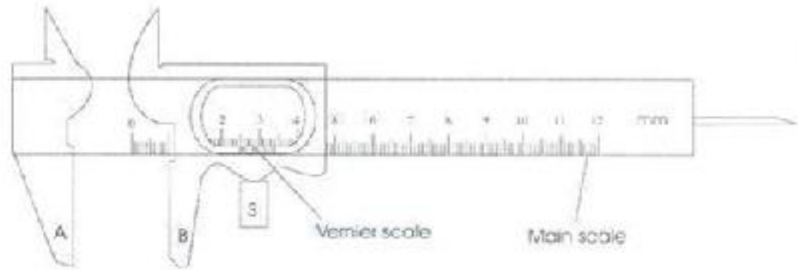


Fig.1. Vernier Calipers

Procedure:

1. To find the Least Count (LC) of the vernier calipers (see Fig. 2)

It is the smallest length that can be measured accurately by the vernier calipers and is measured as the difference between one main scale division and one vernier scale division.

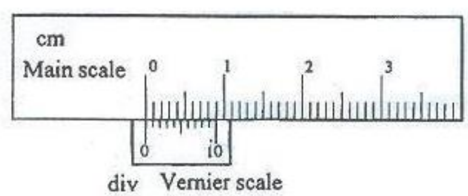


Fig. 2 Vernier scale and main scale

Least Count (LC) = 1 M.S.D — 1 V.S.D

Value of 1 M.S.D = 1 mm

No of divisions on the vernier scale = 10 divisions.

10 V.S.D =9 M.S.D

1 V.S.D =9/10 M.S.D = 9/10 x 1 mm = 9/10 mm L.C.=1 M.S.D —1 V.S.D

=1 mm - 9/10 mm

=0.1 mm = 0.01 cm L.C. = 0.01 cm.

To find the Zero Correction (ZC)

Before taking the readings with the vernier calipers, we must note the zero error of the vernier calipers. When the two jaws of the vernier calipers are pressed together, if the zero of the vernier scale coincides with the zero of the main scale the instrument has no error, otherwise there is a zero error. The zero error is positive if the vernier zero is after the main scale zero. The zero error is negative when the vernier zero is before the main scale zero. Ordinarily, the zero error is negligible in the case of vernier calipers and so zero error can be considered to be nil.

To find the length of the given object

The given object is firmly gripped between the jaws, taking care not to press it too hard. The main scale reading and the vernier coincidence are noted. The main scale reading is the reading on the main scale that is just before the vernier zero. The vernier scale coincidence is found by noting the vernier division that coincides with any one of the main scale. Then the vernier scale reading is found by multiplying the vernier coincidence with the least count. The observations are repeated for various positions of the object.

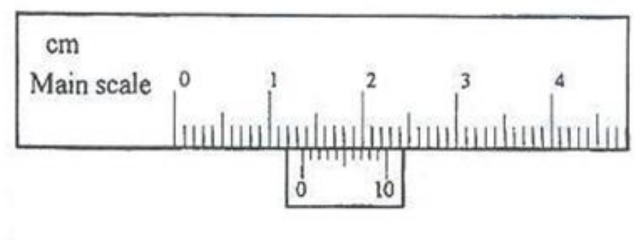


Fig. 3 Vernier Caliper readings

Example:

Vernier Calipers readings: (See Fig. 3)

LC = 0.01cm

S. No.	M.S.R cm	V.S.C.- div	V.S.R = (V.S.0 x LC) cm	Total Reading = M.S.R+ V.S.R cm	Corrected Reading = T.R. ± Z.C. cm
1	1.3	6	0.06	1.36	1.36

Mean length of the given object =

III. THE TRAVELLING MICROSCOPE

Aim:

To learn the parts of a Travelling Microcope and to read a reading.

Apparatus:

Reading lens and capillary tube

Description:

It is a compound microscope attached to a graduated vertical pillar, which is mounted on rigid platform (Fig. 1). The platform is provided with three levelling screws. The microscope can be set with its axis either in the vertical or the horizontal position. The microscope can be moved in the vertical or horizontal direction by means of a screw arrangement attached to it.

The distance through which the microscope is moved is read on the scale. There are two scales one for horizontal movement and the other for the vertical movement. Each scale has a main scale (M1, M2) and a vernier scale (V1, V2). The vernier moves with the microscope. As in the spectrometer, there is a set of main screw and fine adjustment screw, for the horizontal and the vertical movements. One set is fixed to the pillar for vertical movement and the other set is fixed to the platform for horizontal movement. The eyepiece of the microscope is provided with cross-wires. The image of an object is focussed by the microscope using a side screw (focusing screw) attached to the microscope.

Procedure:

1. To find the Least Count (LC) of the travelling microscope

The main scale is graduated in mm. There are 50 V.S.D equivalent to 49 M.S.D. The value of one M.S.D. is 0.5mm=0.05cm

LC	=	1 M.S.D –1 V.S.D.
1 M.S.D	=	0.05 cm
50 V.S.D	=	49 M.S.D
1 V.S.D	=	49/50 x 0.05 = 0.049 cm
LC	=	0.05 -- 0.049 cm
LC	**=**	**0.001cm**

Fig. 1 Travelling Microscope

2. **To read a reading**

When the microscope is clamped by the main screw or fine adjustment screw at any position, the reading is taken in the vertical scale or in the horizontal scale according to the requirement. M.S.R and V.S.R are taken as in the vernier calipers. For example see Fig. 2. And write the M.S.R and V.S.R.

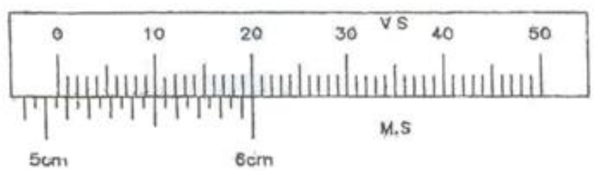


Fig. 2 Vernier and Main scale

Note:

In the Vernier calipers, travelling microscope and the spectrometer, the MS zero may coincide with the VS zero. In such cases, the MSD, which coincides with the VS zero is the MSR reading.

Example:

Travelling microscope readings:

LC = 0.001cm

S. No.	M.S.R cm	V.S.C div	V.S.R = (V.S.C x LC) Cm	T.R = M.S.R + V.S.R cm
1				

Result:

The parts and functions of the travelling microscope are studied and a few readings are taken.

2. COMPOUND (PHYSICAL) PENDULUM

AIM:

Use the compound pendulum to find:

The acceleration due to gravity g.

The moment of inertia of the rod.

THEORY:

Any object mounted on a horizontal axis so as to oscillate under the force of gravity is a compound pendulum. The one used in this experiment is a uniform rod suspended at different locations along its length. The period T of a compound pendulum is given by

$$T = 2\pi \sqrt{(l/Mgh)} \text{ ----------- } (1)$$

Where:

I is the rotational inertia of the pendulum about the axis of suspension

M is the pendulum mass

And h is the distance between the suspension point and the center of mass.

Using the parallel axis theorem

$$I=I_G + Mh^2 \qquad (2)$$

I_G is the rotational inertia of the body about its center of mass and it is given by

$$I_G = MK^2 \qquad (3)$$

Substituting equation 3 in equation 2

$I = M(h^2 + K^2)$ (4)

Where K is the radius of gyration .substituting equation 4 in equation 1

$$T = 2\pi \frac{h^2 + K^2}{gh} \qquad (5)$$

The period of the simple pendulum is given by

$$T = 2\pi \frac{L}{g} \qquad (6)$$

The period of a compound pendulum equals the period of a simple pendulum of a length

$$L = \frac{h^2 + K^2}{h} \qquad (7)$$

This equation can be solved to find L and K:

$L = h_1 + h_2$ (8)

$K = h_1 h_2$ (9)

PROCEDURE:

1- First hang the pendulum horizontally and move it until it reaches equilibrium so you can find the center of mass and mark it.

2- Secondly hang it vertically inserting the tip of the knife in the first hole from the center of mass. Then set it oscillating through a small angle.

3- Measure the time needed for 20 oscillations and the corresponding h.

4- Repeat steps 2 and 3 for the other holes.

5- Record your measurements in a table.

MEASURMENTS AND RESULTS:

M=

One Side from C.M			The other side of C.M		
h(m)	20T (s)	T(s)	h(m)	20T (s)	T(s)

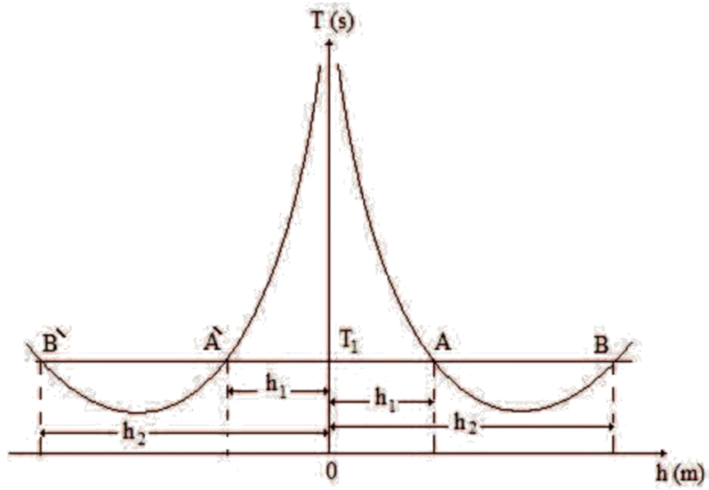
From the graph:

T	h_1 (average)	h_2 (average)	$L=h_1+h_2$	$K=\sqrt{h_1 h_2}$	$g=\frac{4\pi^2 L}{T^2}$	$I_G=MK^2$
(s)	(m)	(m)	(m)	(m)	(m/s^2)	Kg m^2

Finally calculate:

g (average) I_G = (average)

GRAPHS:



3. Rigidity Modulus - Torsional Pendulum

AIM

To find the moment of inertia of the disc and the rigidity modulus of the material of the suspension wire subjected to torsional oscillations.

GENERAL OBJECTIVE

To assess the shear elastic behavior of a given material using torsional pendulum

SPECIFIC OBJECTIVES

1) To measure the time period of the torsional pendulum
2) To calculate the moment of inertia of the disc
3) To measure the radius of the wire using screw gauge
4) To determine the rigidity modulus of the wire using the formula

APPARATUS REQUIRED

- Metallic disc
- Brass/steel wire
- Symmetrical masses
- Stop clock

- Metre scale
- Screw gauge
- Stand

FORMULA

Moment of inertia of the disc

$$I = \frac{2m(d_2^2 \quad d_1^2)T_0^2}{T_2^2 \quad T_1^2} \ kg.m^2$$

Rigidity modulus of the material of the wire

$$n = \frac{8 I l}{T_0^2 r^4} \ N/m^2$$

Explanation

m	Mass of one of the cylinder in Kg
d_1	Closest distance between suspension wire and the centre of mass of the cylinder in metre
d2	Farthest distance between suspension wire and the centre of mass of the cylinder in metre
T_0	Time period without any mass placed on the disc in second
T1	Time period when equal masses are placed at a distance d_1 in seconds
T2	Time period when equal masses are placed at a distance d_2 in seconds
l	Length of the suspension wire in metre

r Radius of the wire in metre

1.To find the time period of the disc

Length of the suspension wire (l): --------------- X10^{-2} m.

Position of the equal masses	**Time for the 10 oscillations**			**Time period**	**Square of the time period**
	Trail 1	**Trail 2**	**Mean**		
Unit	**Sec**	**Sec**	**Sec**	**Sec**	**Sec**
With out any Masses				T_0 =	T_0^2 =
With masses at closest distance d_1=……..x10^{-2} m				T_1 =	T_1^2 =
With masses at farthe distance d_2=……….X10^{-2}m				T_2 =	T_2^2 =

2. T find the radius of the wire.

Zero error = …………div.

Zero correction =…………mm.

S.No	Pitch Scale Reading (PSR) Mm	Head Scale Coincidence (HSC) div.	Head scale reading (HSR) (HSC x LC) mm.	Observed reading (PSR+HSR) mm.	Correct reading (OR ZC) mm.
1					

Mean diameter of the wire (2r) =------------------------------- X10^{-3}m

Mean radius of the wire (r) =------------------------------- X10^{-3}m

Procedure

A torsion pendulum is constructed as shown in Figure.

Measure carefully the length of the suspension wire between the two chucks. Standing in front of the pendulum, gently set it in torsional oscillation without any lateral movement. Note the time for 10 oscillations. T0,the period of oscillation of the pendulum without any masses in it calculated. Take two readings. Find the mean.

Two equal cylindrical masses(m) are placed on the disc symmetrically on either side, close to the suspension wire. The closest distance 'd_1' from the centre of the mass of the cylinder and the centre of the suspension wire is found. Set the pendulum to oscillate and note the time for 10 oscillations. From that the period of oscillation T_1 is calculated. Take two readings find the mean.

Two equal masses are now moved to the extreme ends so that the edges of masses coincide with the edge of the disc and the centers are equal-distant. The distance 'd_2' from the centre of the mass of the cylinder and the centre of the suspension wire is noted. Set the pendulum to oscillate and note the time for 10 oscillations. Take two readings. Calculate the mean period of oscillation T_2.

Measure carefully, the diameter(2r) of the wire at various places, with a screw gauge. Find the mean of the diameter and calculate the radius. Note the mass(m) of the one cylindrical mass. The moment of inertia of the disc and rigidity modulus of the wire are calculated using the formula

Calculation

Time period of oscillations (without masses) T_0 = ……………..seconds.

Time period when masses are at distance 'd_1' T_1 = …………….seconds.

Closest distance between suspension wire and the centre of mass of the cylinder d_1=……………..x10^{-2} m.

Farthest distance between suspension wire and the centre of mass of the cylinder d_2=…………….X10^{-2} m

Result:

1. The moment of inertia of the disc (I) =------------------Kg-m^2.
2. Rigidity modulus of the material of given wire (n) = ------------------N/m^2

4. Young's Modulus - Uniform Bending

AIM

To find the Young's modulus of the given material of the beam by uniform bending. **GENERAL OBJECTIVE**

To evaluate the elastic behavior of the given wooden beam by pin and microscope experimental method and to find its Young's modulus

SPECIFIC OBJECTIVES

1) To measure the thickness and breadth of the given wooden beam using screw gauge and vernier caliper, respectively
2) To determine the elevation of the given wooden beam loaded on both ends by uniform bending method
3) To find the slope from the graph drawn between the load versus elevation

4) To calculate the Young's modulus of the wooden beam from the mean elevation and slope obtained from table and graph, respectively
5) To analyze the elastic behavior of the given wooden beam from the results obtained

APPARATUS REQUIRED

- Wooden beam
- Weight hanger with slotted weights
- Knife edges
- Travelling microscope
- Vernier caliper
- Screw gauge
- Metre scale

LEAST COUNT FOR SCREW GAUGE

$$\text{Least Count (LC)} = \frac{\text{Pitch}}{\text{Number of head scale divisions}}$$

$$\text{Pitch} = \frac{\text{Distance moved}}{\text{Number of rotations given}} = \frac{5\text{ mm}}{5} = 1\text{mm}$$

$$\text{LC} = \frac{1\text{ mm}}{100} = 0.01\text{mm}$$

TABLE – I

To determine the thickness (d) of the beam using screw gauge

Zero Error (ZE) : **……….** divisions Zero Correction (ZC) : **……….**mm

S. No.	Pitch Scale Reading PSR 10^{-3} m	Head Scale Coincidence HSC divisions	Observed Reading OR = PSR + (HSC ×LC) (10^{-3} m)	Correct Reading CR = OR ±ZC (10^{-3} m)
1				
2				
3				
4				
5				

Mean (d) = **………. x10^{-3} m**

FORMULA

Young's modulus of the material of the beam

$$Y = \frac{3MgaL^2}{2sbd^3} \quad (N/m^2)$$

Symbol	Explanation	Unit
Y	Young's modulus of the material of the beam	N/m^2
M	Load applied	kg
L	Distance between the knife edges	m
a	Distance between the load and the nearest knife edge	m
g	Acceleration due to gravity	m/s^2
b	Breadth of the beam	m
d	Thickness of the beam	m
s	Elevation produced for 'M' kg load	m

Unit	Equivalent Units	
N/m^2	$kg\ m^{-1}\ s^{-2}$	1 Pa

LEAST COUNT FOR VERNIER CALIPER

Least Count (LC) = Value of 1 Main Scale Division (MSD)/ Number of divisions in the vernier

10 MSD= 1 cm

Value of 1 MSD = 1/10 cm = 0.1 cm

Number of divisions in the vernier = 0.1/ 10 = 0.01 cm

LC = 0.1/ 10 = 0.01 cm

TABLE - II

To determine the breadth (b) of the beam using vernier caliper

LC = **0.01** cm Zero Error (ZE): **……….** Zero Correction (ZC): **……….**

S. No.	**Main Scale Reading MSR (10^{-2} m)**	**Vernier Scale Coincidence VSC (divisions)**	**Observed Reading OR = MSR + (VSC × LC) (10^{-2} m)**	**Correct Reading CR = OR ± ZC (10^{-2} m)**
1				
2				
3				
4				
5				

Mean (b) = **………. x 10^{-2} m**

PROCEDURE

- The given beam is supported on two knife edges separated by a distance 'L'. A pin is fixed vertically at the mid-point.
- Two weight hangers are suspended, one each on either side of the knife edges so that their distances from the nearer knife edge are equal. The beam is brought to the elastic mood by loading and unloading it several times.
- With the dead load 'W', the pin is focused through microscope. The microscope is adjusted so that the horizontal crosswire coincides with the tip of the pin. The microscope reading is taken.
- The load is changed in steps of 0.05 kg and in each case the microscope reading is taken during loading and unloading. The readings are tabulated. The elevation at the mid-point for 'M' kg is calculated.
- The distance between the knife edges (L) is measured using a metre scale. The breadth (b) and thickness (d) of the beam are found using vernier caliper and screw gauge, respectively.

LEAST COUNT FOR TRAVELLING MICROSCOPE

Least Count (LC) = Value of 1 Main Scale Division (MSD)/ Number of divisions in the vernier

20 MSD = 1 cm

Value of 1 MSD= 1/20cm = 0.05 cm

Number of divisions in the vernier = 50

LC = 0.05/50= 0.001 cm

TABLE -III

***To find elevation'* s'**

LC = **0.001 cm** *TR= MSR + (VSC × LC)

Load M (10^{-3} kg)	Microscope reading							Elevation 's' for M kg (10^{-2} m)
	Loading			Unloading			Mean (10^{-2} m)	
	MSR (10^{-2} m)	VSC (div)	TR (10^{-2} m)	MSR (10^{-2} m)	VSC (div)	TR (10^{-2} m)		
W								
W + 50								
W + 100								
W + 150								
W+ 200								

Mean (s) = **………. × 10^{-2} m**

RESULT

The Young's modulus of the material of the given beam **Y = ………. × 10^{10} N/m^2**