

**Lab Manual**

**for**

**THEORY OF MACHINE**

**AND**

**MEASUREMENT LAB**

**4<sup>th</sup> Semester, Mechanical Engg.**

**Prepared by**

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# Experiment – 01

## Determination of Centrifugal Force of a Governor (Hartnell / Watt/Porter)

### AIM

To Determine the centrifugal force of Governor (Hartnell/Watt/Porter).

### APPARATUS/TOOLS/EQUIPMENTS/MACHINARIES REQUIRED

Hartnell/Watt/Porter Governor.

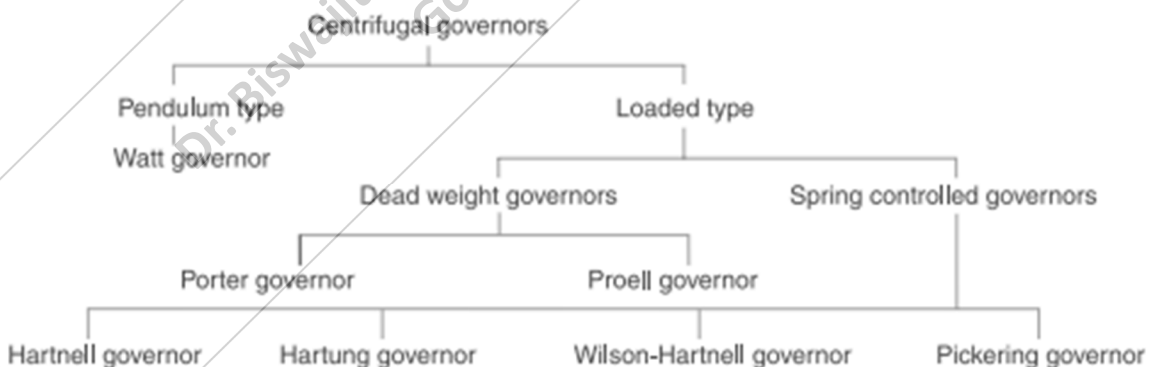
### THEORY

The function of a governor is to regulate the mean speed of an engine, when there are variations in the load e.g. when the load on an engine increases, its speed decreases, therefore it becomes necessary to increase the supply of working fluid. On the other hand, when the load on the engine decreases, its speed increases and thus less working fluid is required. The governor automatically controls the supply of working fluid to the engine with the varying load conditions and keeps the mean speed within certain limits.

### Types of Governors

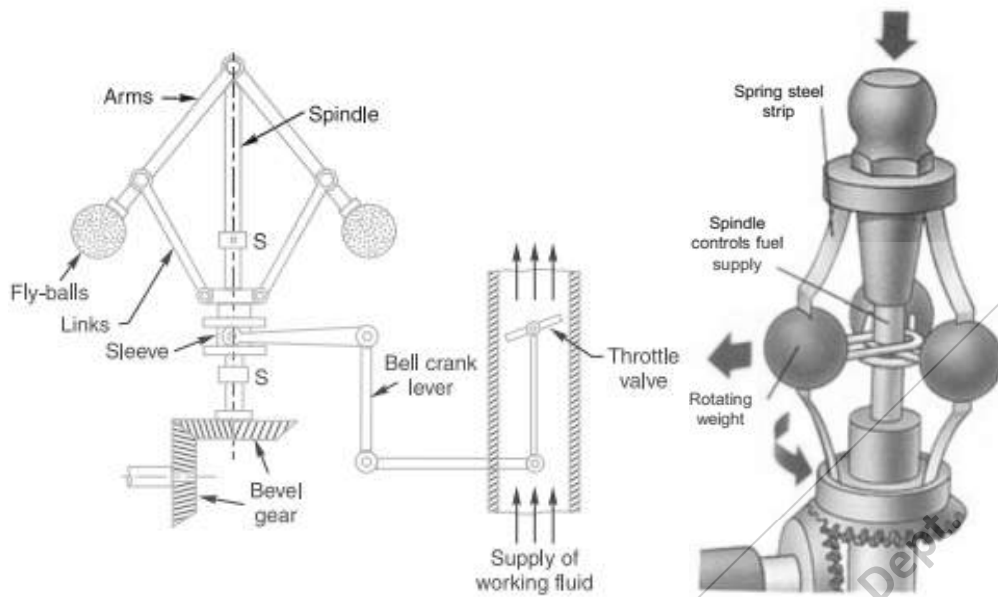
The governors may, broadly, be classified as

1. Centrifugal governors, and 2. Inertia governors



### Centrifugal Governors

The centrifugal governors are based on the balancing of centrifugal force on the rotating balls by an equal and opposite radial force, known as the controlling force\*. It consists of two balls of equal mass, which are attached to the arms as shown in Fig. 18.1. These balls are known as governor balls or fly balls.



When the load on the engine increases, the engine and the governor speed decreases. This results in the decrease of centrifugal force on the balls. Hence the balls move inwards and the sleeve moves downwards. The downward movement of the sleeve operates a throttle valve at the other end of the bell crank lever to increase the supply of working fluid and thus the engine speed is increased. In this case, the extra power output is provided to balance the increased load. When the load on the engine decreases, the engine and the governor speed increases, which results in the increase of centrifugal force on the balls. Thus the balls move outwards and the sleeve rises upwards. This upward movement of the sleeve reduces the supply of the working fluid and hence the speed is decreased. In this case, the power output is reduced.

### PROCEDURE:

Mount the required governor assembly over the spindle.

1. Tighten the necessary bolts.
2. Start the motor and gradually increase the speed.
3. The flyweight will fly outward due to which the sleeve will rise.
4. Note down the speed and sleeve rise or calculate by theoretical method.
5. Repeat the experiment at different speeds till the balls fly to maximum position.
6. Bring back the sleeve down by reducing the speed gradually and stop.

### SPECIFICATIONS

Watt & Porter Governor

Initial height  $h_0$  = -----mm

Weight of Balls = -----Kg

Length of the link  $L$  = -----mm

Hartnell Governor

Length of the link L=-----mm

Initial height  $h_0$ =-----mm

**CALCULATION**

Sl. No.	Sleeve lift in cm	RPM (N)	Radius of Rotation	Centrifugal Force

x= raise of sleeve in cm

$$\omega = 2\pi N / 60$$

$h_0$  = initial height

N=Speed in rpm

w = weight of balls

Initial radius of rotation =  $r_1$

L= length of the link

1. Height of balls where link centre lines intersect  $h = m$

$$h = \frac{h_0 + X}{2}$$

2. Initial radius of rotation =  $r_1$

$$r_1 = \sqrt{L^2 - h^2}$$

3.  $r = r_1 + 0.16$

4. Angular speed

$$\omega = \frac{2\pi N}{60}$$

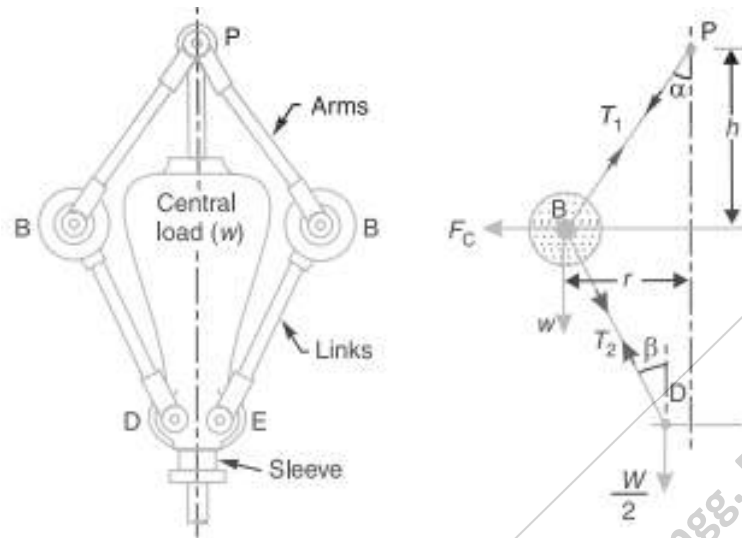
5. Centrifugal force

$$F = \frac{W}{g} \times \omega^2 \times r$$

**Porter Governor (With Weight)**

The Porter governor is a modification of a Watt's governor, with central load attached to the sleeve as shown in Fig 2. The load moves up and down the central spindle. This additional downward.

force increases the speed of revolution required to enable the balls to rise to any predetermined level.

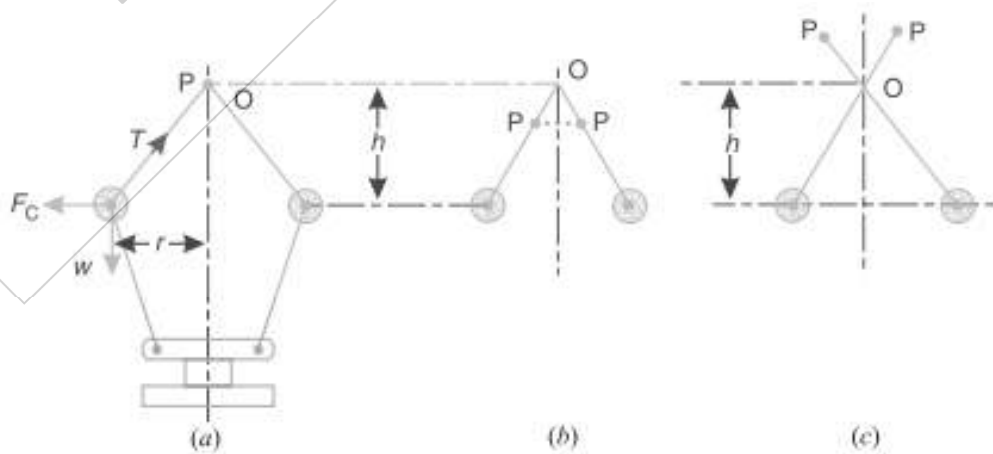


**TABULATION**

SI No	LIFT X in mm	Speed in Rpm	h in m	r <sub>1</sub> in mm	r in mm	ω in rad/sec	Centrifugal force in Kgf

**Watt Governor (Without Weight)**

The simplest form of a centrifugal governor is watt governor (Fig3). It is basically a conical pendulum with links attached to a sleeve of negligible mass. The arms of the governor may be connected to the spindle in the following three ways:



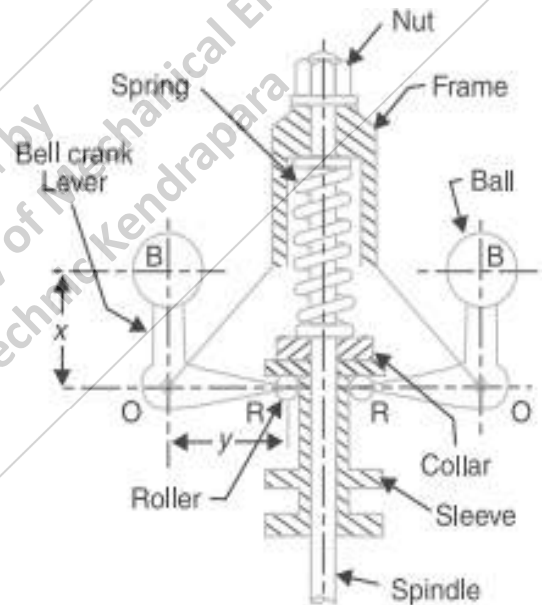
1. The pivot P may be on the spindle axis.
2. The pivot P may be offset from spindle axis and arms when produced intersect at O.
3. The pivot P may be offset but the arms cross the axis at O.

**TABULATION**

No	LIFT X in mm	Speed in Rpm	H in m	r <sub>1</sub> in mm	r in mm	$\phi$ in rad/sec	Centrifugal force in Kgf

**Hartnell Governor**

A Hartnell governor is a spring-loaded governor as shown in Fig. It consists of two bell crank levers pivoted at the points O, O to the frame. The frame is attached to the governor spindle and therefore rotates with it. Each lever carries a ball at the end of the vertical arm OB and a roller at the end of the horizontal arm OR. A helical spring in compression provides equal downward forces on the two rollers through a collar on the sleeve. The spring force may be adjusted by screwing a nut up or down on the sleeve.



**TABULATION**

Sl No	Lift X In m	Speed In Rpm	h In m	r <sub>1</sub> In m	$\phi$ In Rad/Sec	Centrifugal Force(Kgf)

## **PRECAUTIONS:**

- DO NOT KEEP THE MAINS ON when trial is complete increase the speed gradually.
- Take the sleeve displacement reading when the pointer remains steady.
- See that at higher speed the load on sleeve does not hit the upper sleeve of the governor.
- while closing the test bring the dimmer to zero position and then switch OFF

## **CONCLUSION**

The centrifugal force of different Governors (Hartnell/Watt/Porter) have been calculated successfully.

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# Experiment – 02

## Study & Demonstration of Static Balancing Apparatus

### AIM

To study the working of a Static Balancing Apparatus.

### APPARATUS/TOOLS/EQUIPMENTS/MACHINARIES REQUIRED

Static Balancing Machine.

### THEORY

A system of rotating masses is said to be in static balance if the combined mass centre of the system lies on the axis of rotation.

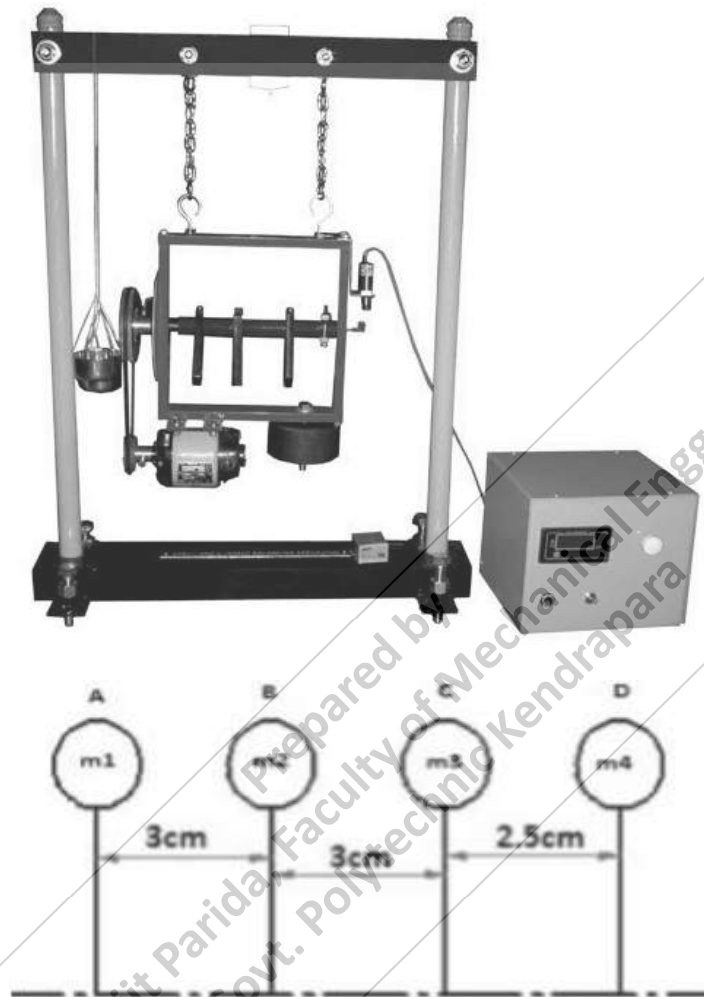
Whenever a certain mass is attached to a rotating shaft, it exerts some centrifugal force, whose effect is to bend the shaft and to produce vibrations in it. In order to prevent the effect of centrifugal force, another mass is attached to the opposite side of the shaft. The process of providing the second mass in order to counteract the effect of the centrifugal force of the first mass is called balancing of rotating masses.

### PROCEDURE

Remove the belt, the value of weight for each block is determined by clamping each block in turn on the shaft and with the cord and container system suspended over the protractor disc, the number of steel balls, which are of equal weight are placed into one of the containers to exactly balance the blocks on the shaft. When the block becomes horizontal, the number of balls  $N$  will give the value of wt. for the block. For finding out  $W_r$  during static balancing proceed as follow:

1. Remove the belt.
2. Screw the combined hook to the pulley with groove. This pulley is different than the belt pulley.
3. Attached the cord end of the pans to above combined hook.
4. Attached the block no.-1 to the shaft at any convenient position and in vertical downward direction.
5. Put steel balls in one of the pans till the blocks starts moving up. (upto horizontal position).

6. Number of balls gives the  $W_r$  value of block-1. repeat this for 2-3 times and find the average no. of balls.
7. Repeat the procedure for other blocks.



- a) Consider one of the planes, say "A" as the reference plane. The distance of all the other planes to the left of the reference plane may be regarded as negative, and those to the right as positive
- b) Tabulate the data in the table shown below. The planes are tabulated in the same order in which they occur, reading from left to right. Since the magnitude of the centrifugal forces are proportional to the product of the mass and its radius, the product " $mr$ " can be calculated and tabulated.
- c) Now draw the couple polygon considering the value of couple for each plane. Since the angular distance between masses is not given, consider position of mass 2 as horizontal, i.e. angle is zero. The value of couple for reference plane is zero. By drawing the couple polygon angular position of mass 3 and mass 4 with respect to mass 2 can be found out.

- d) Now draw the force polygon considering the value of centrifugal force and angular positions of masses 2, 3 & 4. From the force polygon weight of mass 1 and its angular position can be found out
- e) Considering the values of angular positions of masses, fix them on the shaft of the apparatus and check for static balance.

**TABULATION**

Sl.no	Plane	Radius(r) In m	Centrifugal force $\omega^2$ mr (kgm)	Distance from plane X (L in m)	Couple $\omega^2$ mrl (kg m <sup>2</sup> )

**CONCLUSION**

The working of a Static Balancing Apparatus has been studied successfully.

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## Experiment – 03

### Study & Demonstration of Journal Bearing Apparatus

#### AIM

To study the working of a Journal Bearing.

#### APPARATUS/TOOLS/EQUIPMENTS/MACHINARIES REQUIRED

A Journal Bearing Test Rig/Apparatus.

#### SPECIFICATIONS

- Diameter of Journal =  $2r = 52.5$  mm.
- Diameter of bearing =  $2R = 50$ mm (with 12 radial tapings and 2 axial tapings).
- Bearing width (L) = 90mm.
- Motor speed = 800 -1000rpm (variable speed – DC).
- Motor control. Electronic DC Controller for motor speed control.
- Manometer frame with 14 tubes of 240cm. Height with scales and adjustable oil supply tank.
- Recommended oil = Lubricating oil SAE 30.
- Supply required AC single phase 230v.50Hz stabilized.
- $r$  = Radius of Journal.
- $\delta$  = Radial clearance ( $R-r$ ) =  $(52.5-50) = 2.5$  mm.
- $e$  = Eccentricity between the center of the bearing & center of journal 2.5mm.
- Eccentricity ratio =  $e/\delta$  or  $e/n\delta = 2.5/2.5 = 1$
- $\mu$  = Viscosity of oil.
- $R$  = Radius of journal bearing.
- $\theta$  = Angle between the one of center and the position of which is to measured.
- $h$  = Film thickness =2.5 mm

#### THEORY

A bearing is a machine element that constrains relative motion to only the desired motion, and reduces friction between moving parts.

Journal Bearing Apparatus is designed on the bearing action used in practice. To formulate the bearing action accurately in mathematical terms is a more complex job. However,

one can visualize the pattern of bearing pressure distribution due to the hydrodynamic action with the help of experimental rig. This helps to understand the subject properly. The experimental rig consists of a small journal bearing as shown in Fig. This apparatus helps to demonstrate and study the effect of important variables such as speed, viscosity and load, on the pressure distribution in a Journal Bearing.

The mathematical analysis of the behavior of a journal in a bearing falls into two distinct categories:

1. Hydrodynamics of fluid flow between plates.
2. Journal bearing analysis where the motion of the journal in the oil films is considered.

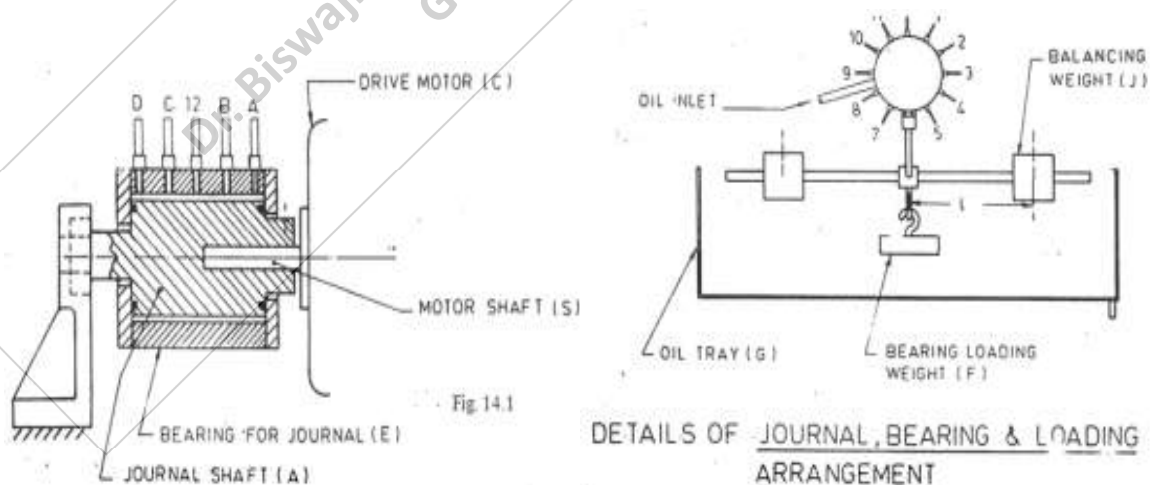
According to the equation the Sommerfield pressure function (when the velocity of the eccentricity and the whirl speed of the journal are both zero) is given by:

$$S_o = \left( \frac{r}{c} \right)^2 \left( \frac{\mu N}{P} \right) K_w \times 10^{-6}$$

when  $K_w$  correction factor for side leakage from graph.

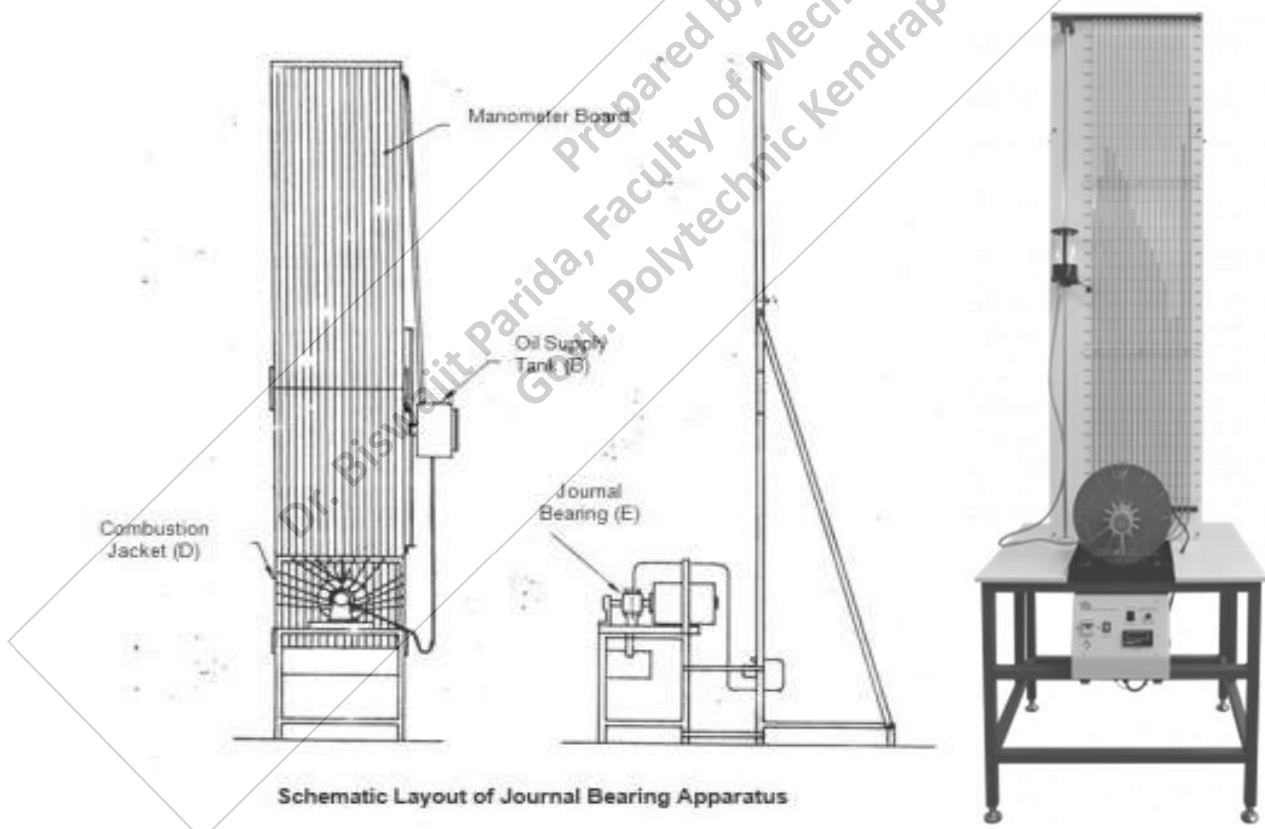
Where 'p' is the pressure of the oil film at the point measured anticlockwise from the line of common centers (00')

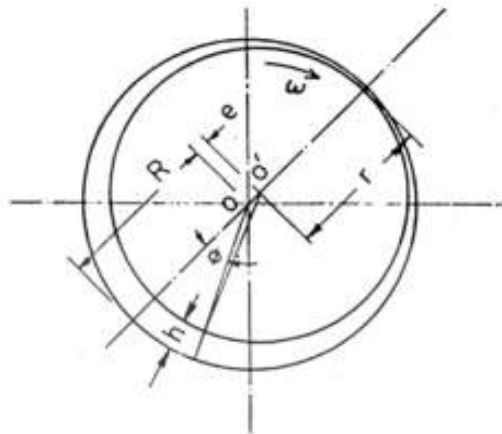
NOTE: Some books on lubrication give the Sommerfield function with a negative sign for 'n'. This is true if it is measured from the point of minimum thickness of the oil film.



## DESCRIPTION

The apparatus is illustrated in fig. It consists of a Brass bearing mounted freely on steel Journal shaft (A). This journal shaft is fixed directly on to a motor shaft (S). A Dimmer stat finely controls the speed of the DC motor. The Journal Bearing (E) has twelve (No.1 to 12) equi-spaced of  $30^\circ$  pressure tapings around its circumference, and two No, 13,14 additional axial pressure tapings are positioned on the topside of the journal bearing. The two sides of bearing are closed with two MS plates and sealed with gasket packing to avoid leakage. Balancing weights are provided to maintain the bearing in horizontal position while taking the readings. Both the weights can be adjusted freely along the rod. Oil film pressures are indicated in 14-tubes manometer frame and readings directly in head of oil. Clear flexible tubes are fixed on the manometer frame and connected to the tapings spaced around bearing and thus permit the bearing to turn freely. The oil reservoir can be adjusted at required height and is connected to the bearing by a flexible plastic tube. From this reservoir oil enters the bearing through this plastic tube.





- $\omega$  - Speed of rotation of Journal
- $r$  - Radius of Journal
- $\delta$  - Radial clearance ( $R - r$ )
- $e$  - Eccentricity  $OO'$
- $n = e/\delta$
- $\mu$  - viscosity of oil

GEOMETRY OF JOURNAL BEARING

## CONCLUSION

The working principle of a Journal Bearing has been studied successfully.

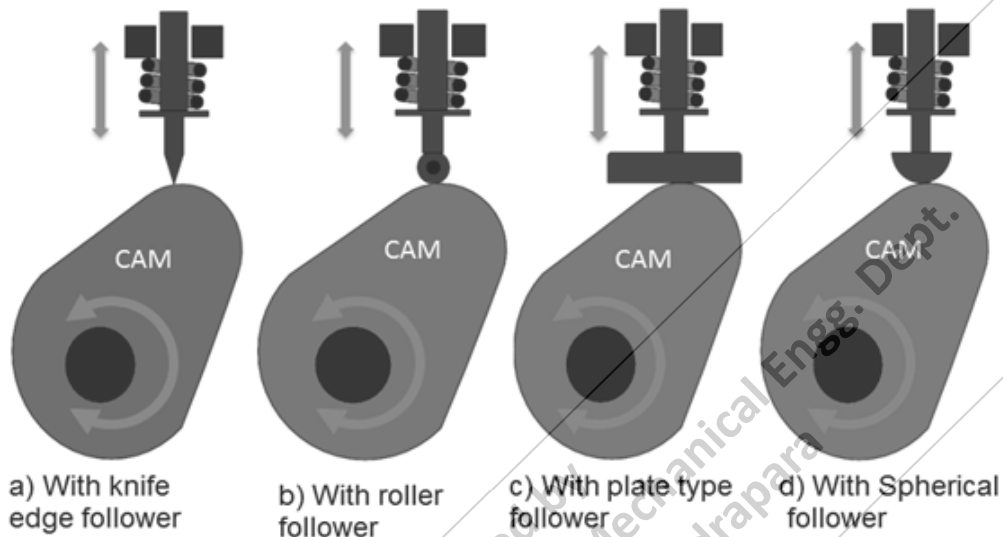
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## Experiment – 04

### Study of different types of Cam and followers.

#### AIM

To study of different types of Cam and followers.



#### APPARATUS/TOOLS/EQUIPMENTS/MACHINARIES REQUIRED

Models of Cams and Followers.

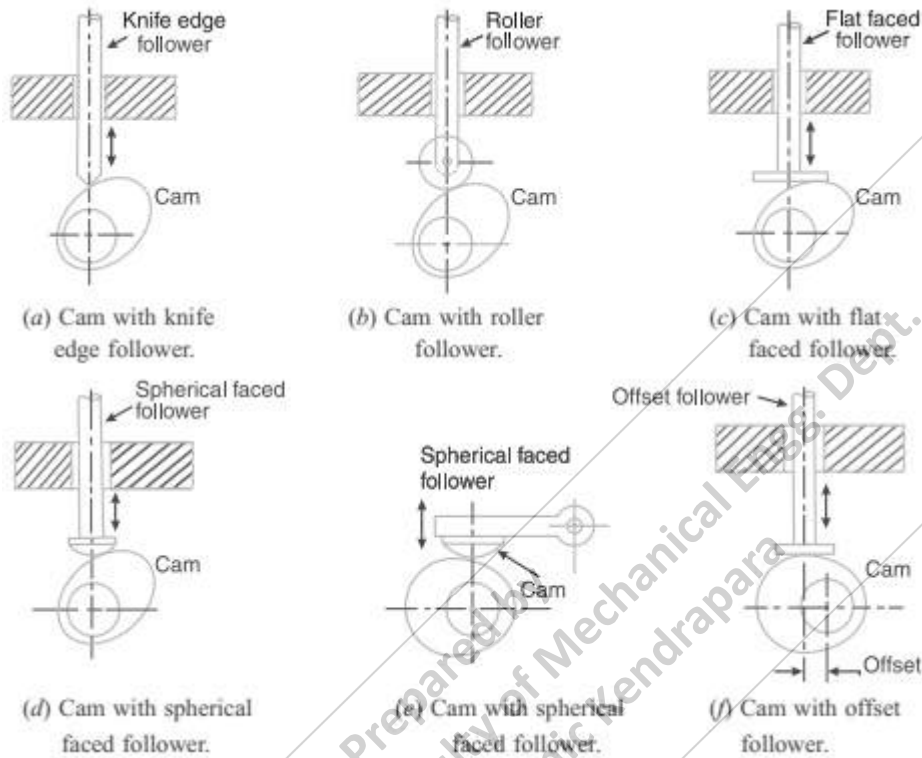
#### THEORY

A cam is a rotating machine element which gives reciprocating or oscillating motion to another element known as follower. The cam and the follower have a line contact and constitute a higher pair. The cams are usually rotated at uniform speed by a shaft, but the follower motion is predetermined and will be according to the shape of the cam.

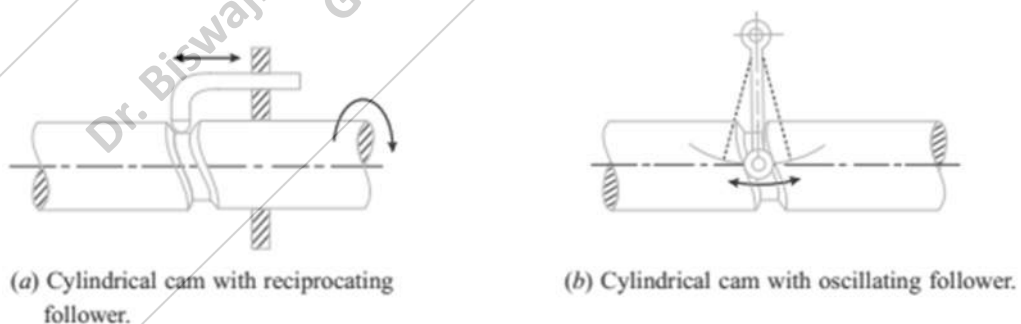


## Classification of Cams

1. **Radial or disc cam.** In radial cams, the follower reciprocates or oscillates in a direction perpendicular to the cam axis. All the below cams are radial cams.



2. **Cylindrical cam.** In cylindrical cams, the follower reciprocates or oscillates in a direction parallel to the cam axis. The follower rides in a groove at its cylindrical surface.



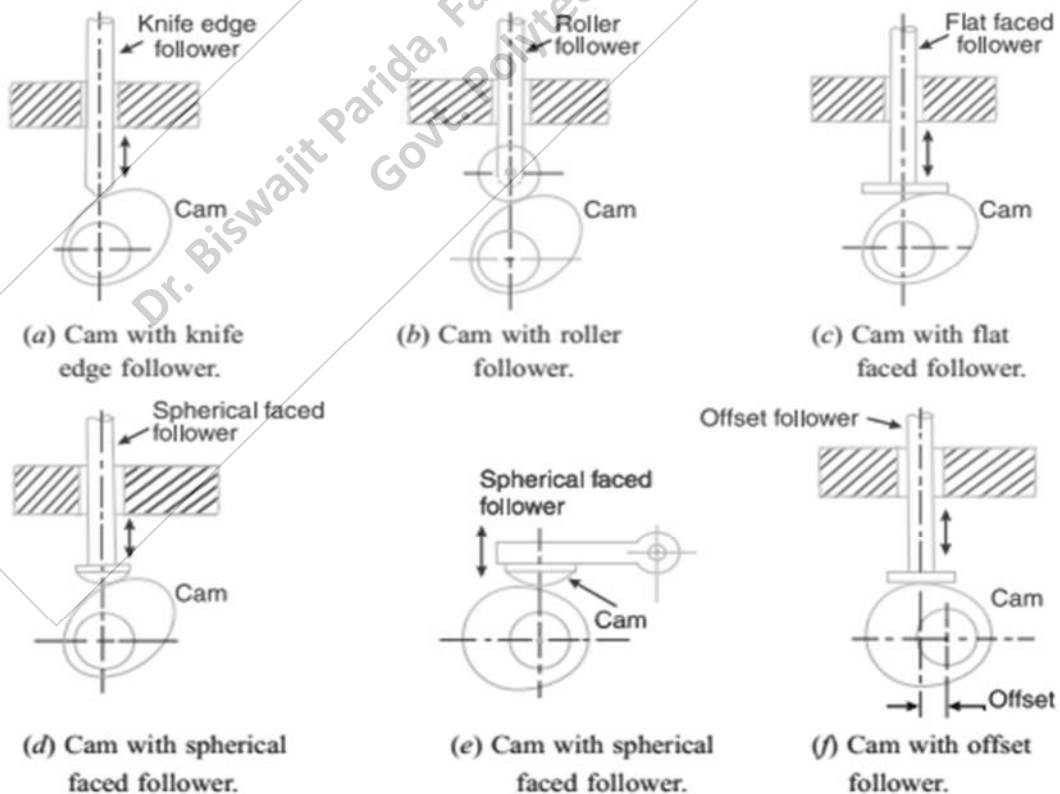
## Classification of Followers

### A. According to the surface in contact.

1. **Knife edge follower** When the contacting end of the follower has a sharp knife edge, it is called a knife edge follower. The sliding motion takes place between the contacting surfaces (i.e. the knife edge and the cam surface). It is seldom used in practice because the

small area of contacting surface results in excessive wear. In radial cams, the follower reciprocates or oscillates in a direction perpendicular to the cam.

2. **Roller follower.** When the contacting end of the follower is a roller, it is called a roller follower. Since the rolling motion takes place between the contacting surfaces (i.e. the roller and the cam), therefore the rate of wear is greatly reduced. In roller followers also the side thrust exists between the follower and the guide. The roller followers are extensively used where more space is available such as in stationary gas and oil engines and aircraft engines.
3. **Flat faced or mushroom follower.** When the contacting end of the follower is a perfectly flat face, it is called a flat-faced follower. It may be noted that the side thrust between the follower and the guide is much reduced in case of flat faced followers. The only side thrust is due to friction between the contact surfaces of the follower and the cam. The relative motion between these surfaces is largely of sliding nature but wear may be reduced by offsetting the axis of the follower.
4. **Spherical faced follower.** When the contacting end of the follower is of spherical shape, it is called a spherical faced follower. It may be noted that when a flat-faced follower is used in automobile engines, high surface stresses are produced. In order to minimise these stresses, the flat end of the follower is machined to a spherical shape.



## **B. According to the motion of the follower.**

1. ***Reciprocating or translating follower.*** When the follower reciprocates in guides as the cam rotates uniformly, it is known as reciprocating or translating follower. **[Fig. a-d]**
2. ***Oscillating or rotating follower.*** When the uniform rotary motion of the cam is converted into predetermined oscillatory motion of the follower, it is called oscillating or rotating follower. **[Fig. e]**

## **C. According to the path of motion of the follower.**

1. ***Radial follower.*** When the motion of the follower is along an axis passing through the centre of the cam, it is known as radial follower. **[Fig. a-e]**
2. ***Off-set follower.*** When the motion of the follower is along an axis away from the axis of the cam centre, it is called off-set follower. **[Fig. f]**

## **CONCLUSION**

Different types of Cam and Followers have been studied successfully.

# Experiment – 05

## Study & Demonstration of Epicyclic Gear Train

### AIM

To study the working of a Journal Bearing.

### APPARATUS/TOOLS/EQUIPMENTS/MACHINARIES REQUIRED

A Journal Bearing Test Rig/Apparatus.

### SPECIFICATIONS

- Diameter of Journal =  $2r = 52.5$  mm.
- Diameter of bearing =  $2R=50$ mm (with 12 radial tapings and 2 axial tapings).
- Bearing width (L) = 90mm.
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According to the equation the Sommerfield pressure function (when the velocity of the eccentricity and the whirl speed of the journal are both zero) is given by:

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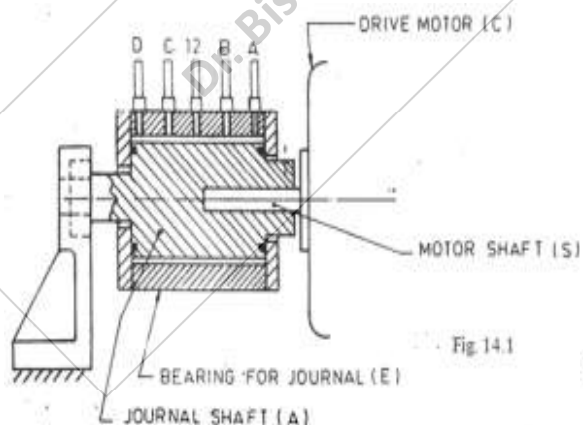
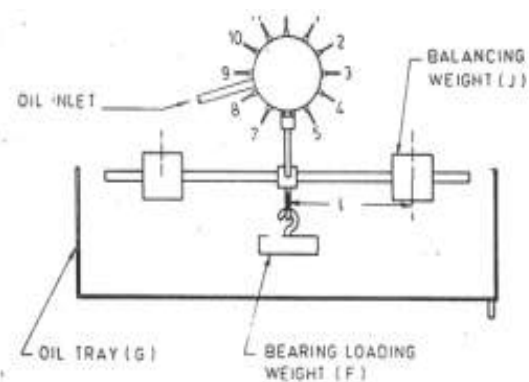


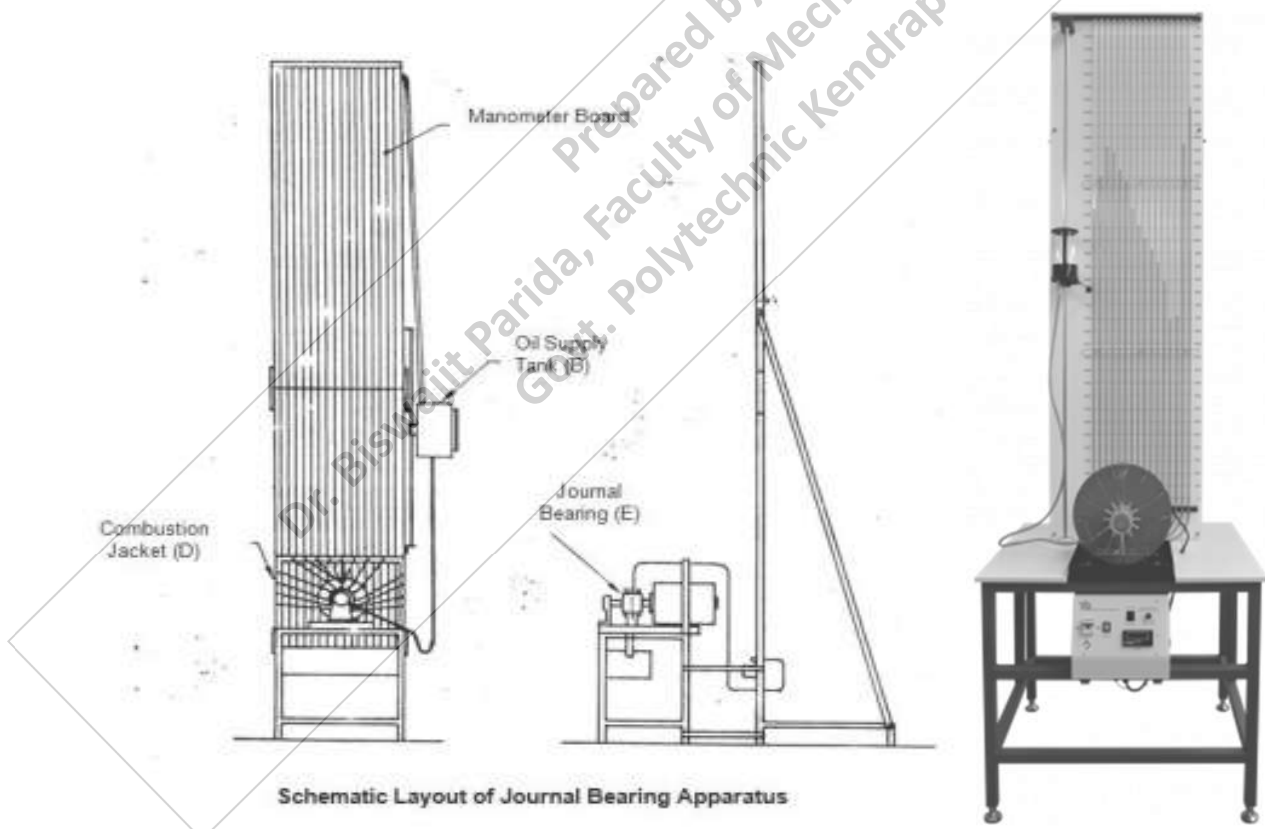
Fig. 14.1

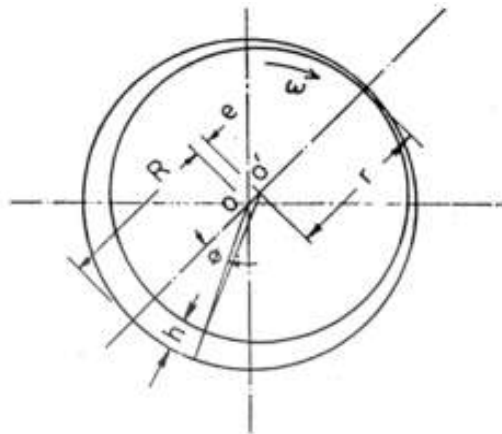


DETAILS OF JOURNAL, BEARING & LOADING ARRANGEMENT

## DESCRIPTION

The apparatus is illustrated in fig. It consists of a Brass bearing mounted freely on steel Journal shaft (A). This journal shaft is fixed directly on to a motor shaft (S). A Dimmer stat finely controls the speed of the DC motor. The Journal Bearing (E) has twelve (No.1 to 12) equispaced of 30° pressure tapings around its circumference, and two No, 13,14 additional axial pressure tapings are positioned on the topside of the journal bearing. The two sides of bearing are closed with two MS plates and sealed with gasket packing to avoid leakage. Balancing weights are provided to maintain the bearing in horizontal position while taking the readings. Both the weights can be adjusted freely along the rod. Oil film pressures are indicated in 14-tubes manometer frame and readings directly in head of oil. Clear flexible tubes are fixed on the manometer frame and connected to the tapings spaced around bearing and thus permit the bearing to turn freely. The oil reservoir can be adjusted at required height and is connected to the bearing by a flexible plastic tube. From this reservoir oil enters the bearing through this plastic tube.





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GEOMETRY OF JOURNAL BEARING

### CONCLUSION

The working principle of a Journal Bearing has been studied successfully.

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## Experiment – 06

### Determination of the Thickness of ground M.S flat to an accuracy of 0.02 mm using Vernier Caliper.

#### AIM

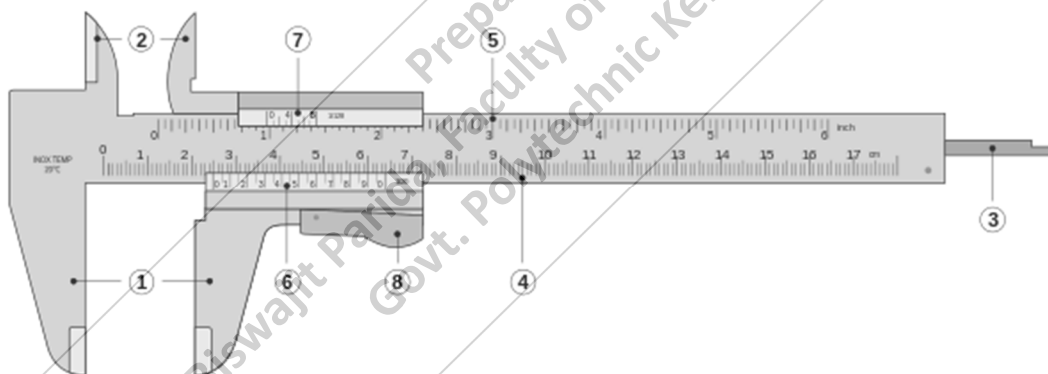
To Determine the Thickness of ground M.S flat to an accuracy of 0.02 mm using Vernier Caliper.

#### APPARATUS/TOOLS/EQUIPMENTS/MACHINARIES REQUIRED

1. Vernier Caliper.
2. M. S. Flat

#### THEORY

A vernier calliper is defined as a measuring device that is used for the measurement of linear dimensions. It is also used for the measurement of diameters of round objects with the help of the measuring jaws.



The labelled parts are

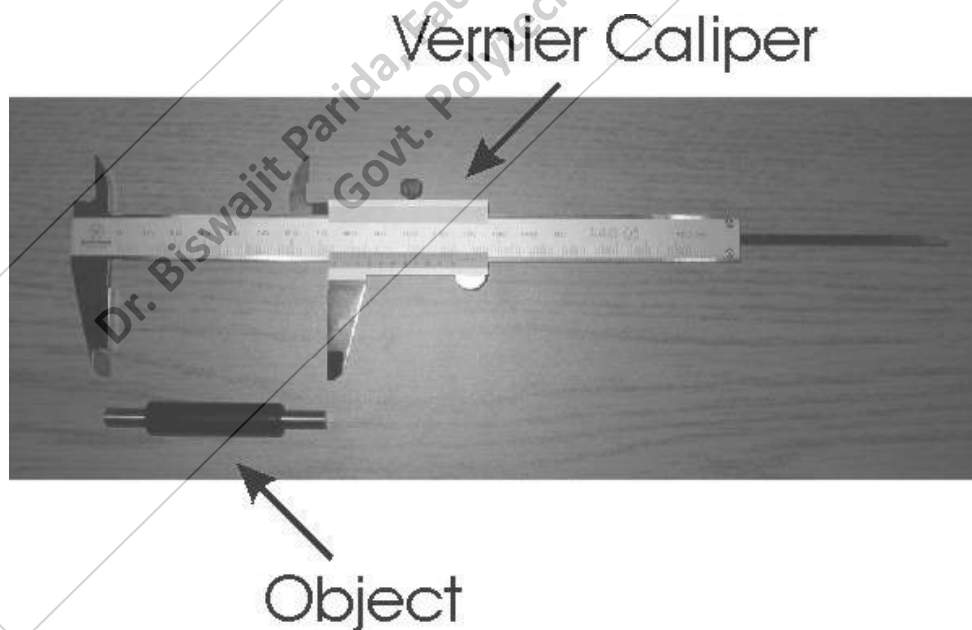
1. **Outside large jaws:** used to measure external diameter of an object (like a hollow cylinder) or width of an object (like a rod), diameter of an object (like a sphere).
2. **Inside small jaws:** used to measure the internal diameter of an object (like a hollow cylinder or pipe).
3. **Depth probe/rod:** used to measure depths of an object (like a small beaker) or a hole.
4. **Main scale (Metric):** marked every millimeter and helps to measure length correct up to 1 mm.
5. **Main scale (Imperial):** marked in inches and fractions.
6. **Vernier scale (Metric)** gives interpolated measurements to 0.1 mm or better.

7. **Vernier scale (Imperial)** gives interpolated measurements in fractions of an inch.
8. **Retainer:** used to block movable part to allow the easy transferring of a measurement.

The principle of vernier is that when two scales or divisions slightly different in size are used, the difference between them can be utilized to enhance the accuracy of measurement. The vernier calliper essentially consists of two steel rules and these can slide along each other. One of the scales, i.e., main scale is engraved on a solid L-shaped frame. One end of the frame contains a fixed jaw which is shaped into a contact tip at its extremity

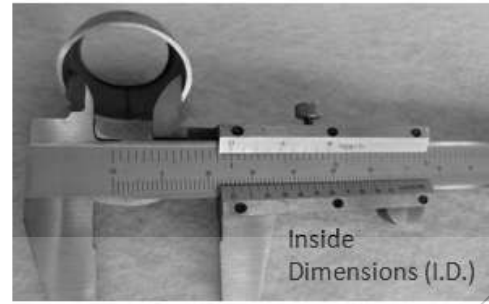
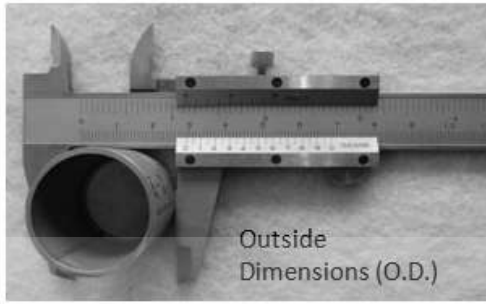
### PROCEDURE

- a) The least count is to be determined
- b)  $L.C = 1 \text{ main scale division} - 1 \text{ Vernier Scale Division}$
- c) The work piece is placed between the jaws of vernier calliper.
- d) The reading on the main scale which is just behind the first vernier scale division is noted as main scale reading (MSR)
- e) The division on the vernier scale which coincide with the line on main scale is noted down as vernier coincidence (VSD)
- f) The thickness (MD) can be calculated using the given formula



Least Count is the smallest length that can be measured accurately and is equal to the difference between a main scale division and a Vernier scale division.

$$\text{LEAST COUNT} = 1 \text{ Main Scale Division} - 1 \text{ Vernier Scale Division}$$



### OBSERVATION

$$50 \text{ V.S.D} = 49 \text{ M.S.D}$$

$$1 \text{ V.S.D} = 49/50 \text{ M.S.D}$$

$$1 \text{ M.S.D} = 1\text{mm.}$$

$$\text{Least Count} = 1 \text{ M.S.D} - 1 \text{ V.S.D}$$

$$= 1\text{mm} - 49/50 = 0.02\text{mm.}$$

$$\text{MD} = [\text{MSR} + (\text{VSD} \times \text{LC})]$$

- MD-Measured Dimension
- MSR-Main Scale Reading
- VSD-Vernier Scale Division
- LC-Least Count

### TABULATION

Least Count of vernier = 0.02mm Vernier Calliper Reading 'mm'					
Sl. No	MSR	VSD	VSR=VSD X LC	MD = MSR + VSR	Remarks
1					
2					
3					
4					
5					

### CONCLUSION

The measuring instrument Vernier Calliper is studied and thickness of ground M.S flat is measured to an accuracy of 0.02mm using it.

## Experiment – 07

### Determination of Diameter of a Cylindrical Component to an accuracy of 0.01mm using Micrometer

#### AIM

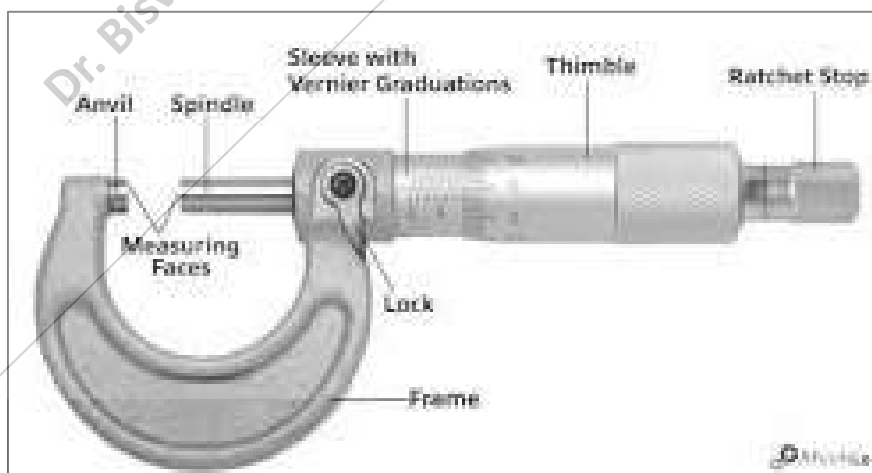
Determination of diameter of a cylindrical component to an accuracy of 0.01mm using Micrometer

#### APPARATUS/TOOLS/EQUIPMENTS/MACHINARIES REQUIRED

1. Outside Micrometer
2. 02 Digital Micrometer
3. 03 Cylindrical component

#### THEORY

The micrometer screw gauge essentially consists of an accurate screw having about 10 or 20 threads per cm and revolves in a fixed nut. The end of the screw forms one measuring tip and the other measuring tip is constituted by a stationary anvil in the base of the frame. The screw is threaded for certain length and is plain afterwards. The plain portion is called sleeve and its end is the measuring surface. The spindle is advanced or retracted by turning a thimble connected to the spindle. The spindle is a slide fit over the barrel and barrel is the fixed part attached with the frame.. A lock nut is provided for locking a dimension by preventing motion of the spindle.



The principle of vernier is that when two scales or divisions slightly different in size are used, the difference between them can be utilized to enhance the accuracy of measurement. The

vernier calliper essentially consists of two steel rules and these can slide along each other. One of the scales, i.e., main scale is engraved on a solid L-shaped frame. One end of the frame contains a fixed jaw which is shaped into a contact tip at its extremity

$$\text{LEAST COUNT} = \frac{\text{Pitch scale division}}{\text{Number of threads}}$$
$$\text{Pitch scale division} = \frac{\text{Distance moved}}{\text{number of rotation}}$$

### PROCEDURE

- a) The micrometer is checked for Zero error
- b) The given component is held between the face of the unvil and the spindle
- c) The spindle is moved by rotating the thimble until the anvil and spindle touches the
- d) cylindrical surface of the component
- e) Final adjustment is made by ratchet. The main scale reading and thimble scale reading is noted
- f) Two more reading are taken at different place of the component
- g) The readings are tabulated and calculated.

### USES:-

1. Outside micrometer is used to measure the diameter of solid cylinder.
2. Inside micrometer is used to measure the internal diameters of hollow cylinders and spheres.

### OBSERVATION

Least count:-

The distance moved by the spindle during one rotation of thimble is 0.5mm.

Movement of one division of the Thimble =  $0.5 \times \frac{1}{50} = 0.01\text{mm}$ .

## TABULATION

Least Count of micrometer= 0.01mm								
Micrometer Reading 'mm'								
SL.NO	Barrel Reading(x)	Thimble Division	Least Count	Thimble(y) Reading L.C x T.D	X +Y	Reading	Digital micrometer Reading	Error
01								
02								
03								
04								
05								

## CONCLUSION

The precision measuring instrument micrometer is studied and diameter of a cylindrical component is measured using an accuracy of 0.01mm using micrometer.

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## Experiment – 08

### **Determine the heights of gauge blocks or parallel bars to accuracy of 0.02mm using Vernier Height Gauge**

#### AIM

Determine the heights of gauge blocks or parallel bars to accuracy of 0.02mm using Vernier height gauge.

#### APPARATUS/TOOLS/EQUIPMENTS/MACHINARIES REQUIRED

1. Vernier height gauge
2. Parallel bars
3. Gauge blocks

#### THEORY

##### **Vernier height gauge**

Vernier height gauge is similar to vernier calliper but in this instrument the graduated bar is held in a vertical position and it is used in conjunction with a surface plate.

##### **Construction:**

A vernier height gauge consists of

1. A vernier height gauge consists of A finely ground and lapped base. The base is massive and robust in construction to ensure rigidity and stability.
2. A vertical graduated beam or column supported on a massive base.
3. Attached to the beam is a sliding vernier head carrying the vernier scale and a clamping screw.
4. An auxiliary head which is also attached to the beam above the sliding vernier head. It has fine adjusting and clamping screw.
5. A measuring jaw or a scriber attached to the front of the sliding vernier

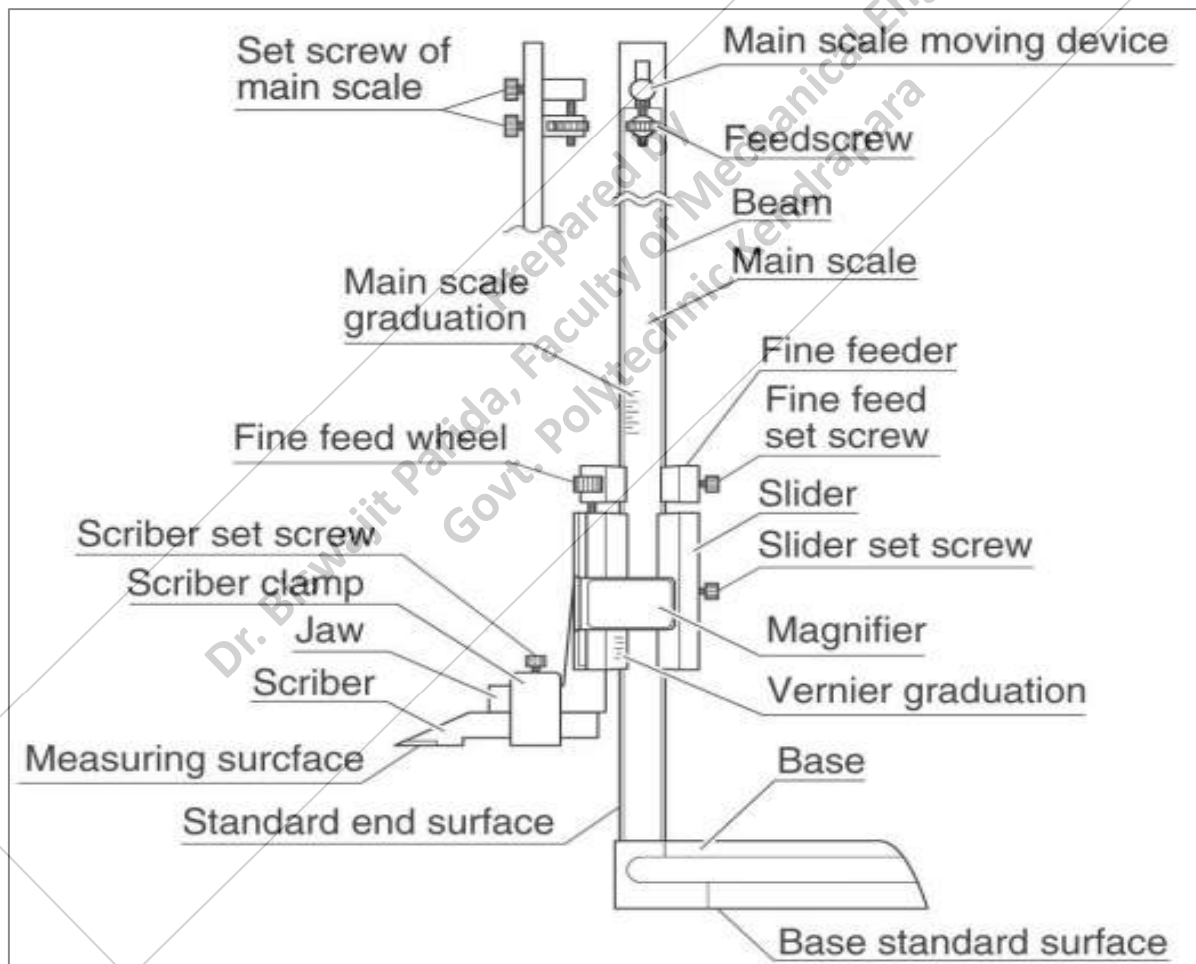
##### **Use.**

The vernier height gauge is designed for accurate measurements and marking of vertical heights above a surface plate datum. It can also be used to measure differences in heights by taking the vernier scale readings at each height and determining the difference by subtraction.

It can be used for a number of applications in the tool room and inspection department. The important features of vernier height gauge are:

All the parts are made of good quality steel or stainless steel.

- The beam should be sufficiently rigid square with the base.
  - The measuring jaw should have a clear projection from the edge of the beam at least equal to the projection of the base' from the beam.
  - The upper and lower gauging surfaces of the measuring jaw shall be flat and parallel to the base.
  - The scriber should also be of the same nominal depth as the measuring jaw so that it may be reversed.
  - The projection of the jaw should be at least 25 mm



## PROCEDURE

- a) The micrometer is checked for Zero error
- b) Clean the main scale, Vernier scale and measuring jaws of the Vernier Height gauge

- c) The vernier height gauge is checked for zero error
- d) Place the job in Surface plate.
- e) Place the measuring jaw such that it touches the surface to be measured from the Smooth surface
- f) Measure the main scale reading and Vernier scale coincidence of the Vernier Height gauge

### OBSERVATION

$$50 \text{ V.S.D} = 49 \text{ M.S.D}$$

$$1 \text{ V.S.D} = 49/50 \text{ M.S.D}$$

$$1 \text{ M.S.D} = 1\text{mm.}$$

$$\text{Least count} = 1 \text{ M.S.D} - 1 \text{ V.S.D}$$

$$= 1\text{mm} - 49/50$$

$$= 0.02\text{mm}$$

### FORMULA

$$\text{MD} = [\text{MSR} + (\text{VSC} \times \text{LC})]$$

- MD-Measured Dimension
- MSR-Main Scale Reading
- VSC-Vernier Scale Coincide
- LC-Least Count

### TABULATION

Least Count of vernier = 0.02mm Vernier height gauge Reading 'mm'				
Sl no	MSR	VSC	VSR=VSCXLC	MD=MSR +VSR
1				
2				
3				
4				
5				

### CONCLUSION

The precision measuring instrument vernier height gauge is studied and thickness of mild steel flat specimen is measured.

## Experiment – 09

### Determine the thickness of ground MS plates using Slip Gauges

#### AIM

Determination the thickness of M.S. Plates using slip gauges.

#### APPARATUS/TOOLS/EQUIPMENTS/MACHINARIES REQUIRED

1. M.S Plates
2. Slip gauge
3. Surface Plate
4. Vernier height gauge

#### THEORY

Slip gauges or gauge blocks are universally accepted end standard of length in industry. These were introduced by Johnson, a Swedish engineer, and are also called as johanson gauges. Slip gauges are rectangular blocks of high grade steel with exceptionally close tolerances. These blocks are suitably hardened through out to ensure maximum resistance to wear. They are then stabilized by heating and cooling successively in stages so that hardening stresses are removed, After being hardened they are carefully finished by high grade lapping to a high degree of finish, flatness and accuracy. For successful use of slip gauges their working faces are made truly flat and parallel. A slip gauge is shown in fig. Slip gauges are also made from tungsten carbide which is extremely hard and wear resistance.



The cross-sections of these gauges are 9 mm x 30 mm for sizes up to 10 mm and 9 mm x 35 mm for larger sizes. Any two slips when perfectly clean may be wrung together. The dimensions are permanently marked on one of the measuring faces of gauge blocks. Gauges blocks are used for:

- Direct precise measurement, where the accuracy of the work piece demands it.

- For checking accuracy of vernier callipers, micrometers, and such other measuring instruments.
- Setting up a comparator to a specific dimension.
- For measuring angle of work piece and also for angular setting in conjunction with a sine bar.
- The distances of plugs, spigots, etc. on fixture are often best measured with the slip gauges or end bars for large dimensions.
- To check gap between parallel locations such as in gap gauges or between two mating parts.

## PROCEDURE

- At first we cleaned the surface of slip gauge.
- Then we inserted the slip gauge for measuring the thickness by taking attention such that minimum number of slip gauges is used.
- Then we removed the gauge from jobs.
- We calculated the thickness by adding individual slip gauge reading which is mentioned on the surface of slip gauge.
- In this way by repeating above procedure we took 5 reading.

For measuring the thickness of M.S plate by using set of 112 pieces.

Range in mm	Steps	No of pieces
1.005		01
1.001 to 1.009	0.001	09
1.01 to 1.49	0.01	49
05 to 24.5	0.05	49
25 to 100	25.00	04

## OBSERVATION

$$50 \text{ V.S.D} = 49 \text{ M.S.D}$$

$$1 \text{ V.S.D} = 49/50 \text{ M.S.D}$$

$$1 \text{ M.S.D} = 1\text{mm.}$$

$$\text{Least count} = 1 \text{ M.S.D} - 1 \text{ V.S.D}$$

$$= 1\text{mm} - 49/50$$

$$= 0.02\text{mm}$$

## FORMULA

$$MD=[MSR+(VSCXLC)]$$

- MD-Measured Dimension
- MSR-Main Scale Reading
- VSC-Vernier Scale Coincide
  - LC-Least Count

## TABULATION

SL.NO	Select the slip gauges	Select the slip	Select 2 <sup>nd</sup>	Select 3 <sup>rd</sup>	Select 4 <sup>th</sup>	Total reading	Average reading
01	1.005	1.002	1.37	1.5	0	4.8725	4.1515
02	1.0005	1.003	1.25	2	0	5.2535	
03	1.0005	1.001	1.15	1.2	0	4.1515	
04	1.0005	0.008	1.13	0.5	0	3.6385	
05	1.0005	1.008	1.45	2.5	0	5.9585	

## CONCLUSION

From the above experiment we find the thickness of M.S plate by using the range of slip gauges.

## Experiment – 10

### Determination of angel of Machined surfaces of components using Sin Bar with slip gauges

#### AIM

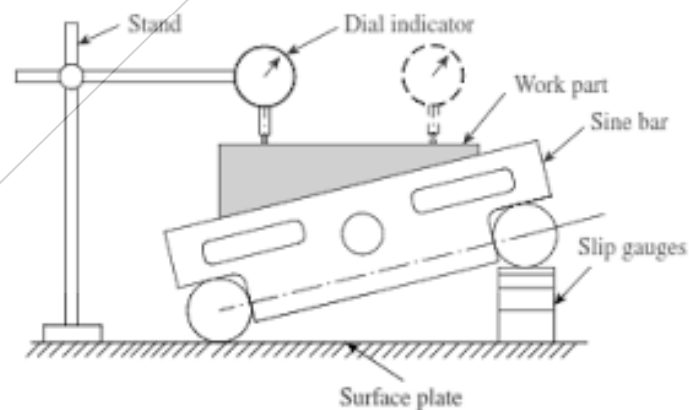
Determination of angel of Machined surfaces of components using sin bar with slip gauge

#### APPARATUS/TOOLS/EQUIPMENTS/MACHINARIES REQUIRED

- One machined surface in any angle
- Sine bar
- Slip gauge box

#### THEORY

The sine principle uses the ratio of the length of two sides of a right triangle in deriving a given angle. It may be noted that devices operating on sine principle are capable of “self generation.” The measurement is usually limited to 450 from loss of accuracy point of view. The accuracy with which the sine principle can be put to use is dependent in practice, on some form of linear measurement. The sine bar in itself is not a complete measuring instrument. Another datum such as a surface plate is needed, as well as other auxiliary equipment, notably slip gauges, and indicating device to make measurements. Sine bars used in conjunction with slip gauges constitute a very good device for the precise measurement of angles. Sine bars are used either to measure angles very accurately or for locating any work to a given angle within very close limits. Sine bars are made from high carbon, high chromium, corrosion resistant steel, hardened, ground and stabilized.



## PROCEDURE

- The given component is placed on the surface plate.
- One roller of sine bar is placed on surface plate and bottom surface of sine bar is seated on the taper surface of the component.
- The combination of slip gauges is inserted between the second roller of sine bar and the surface plate.
- The angle of the component is then calculated by the formula given below

## FORMULA

$$\sin \theta = H/L$$

Where,

H = (h1-h2) = Height of the slip gauge

L - Distance between the centres

## TABULATION

SL.NO	h1 in mm.	h2 in mm.	h1-h2 in mm.	L in mm	Sin $\theta = h1-h2/L$ in(0)	$\theta = \sin^{-1}(h1-h2)/L$ in radian
1	3.25	1.5	1.75	200	1.75/200	5 radian=28.72

## CONCLUSION

Thus the angle in the work pieces were Determined using Sine bar

Angle measured in work piece ,1 =-----‘degree’

Angle measured in work piece ,2 =-----‘degree’