Maharashtra State
Board of Technical Education

Certificate

This is to certify that Mr. / Ms ..Chirag..Rajiv..Thakur..... Roll No .....23..... of Third/Fourth Semester of Diploma in .Mechanical..Engineering..... of Institute ...V.E.S...Polytechic..... (Code....0004.....) has completed the term work satisfactorily in course **Theory of Machines (22438)** for the academic year 20..19..to 20...20 as prescribed in the curriculum.

Place .Chembur.....
Date:.....

Enrollment No...18.0004.0362
Exam Seat No. ..104606.....

Course Teacher **Head of the Department** **Principal**

Seal of the Institute

Contents

List of Practicals and Progressive Assessment Sheet

S. No	Practical Outcome	Page No.	Date of performance	Date of submission	Assessment marks(25)	Dated sign. of teacher	Remarks (if any)
1. 2.	Measure the ratio of time of cutting stroke to the return stroke in shaping machine available in institute's workshop by varying the stroke length. Following activities need to be performed: (Part I& II)	1			24		
3.	Estimate important kinematic data related to following mechanisms and sketch them. a) Bicycle free wheel sprocket mechanism b) Geneva mechanism	7					
4.	Estimate important kinematic data related to following mechanisms and sketch them. a) Ackerman's steering gear mechanism b) Foot operated air pump mechanism	7					
5.	Determine velocity and acceleration of various links of the given mechanism (any two) by relative velocity method for analysis of motion of links (Minimum 2 problems on A2 size drawing sheet).	13			24		
6.	Determine velocity and acceleration in an I. C. engine's slider crank mechanism by Kleins's construction (Minimum 2 problems on A2 size drawing sheet).	18			24		

S. No	Practical Outcome	Page No.	Date of performance	Date of submission	Assessment marks(25)	Dated sign. of teacher	Remarks (if any)
7.	Draw profile of a radial cam for given follower type to obtain the desired follower motion (Minimum 2 problems on A2 size drawing sheet). Part I&II	24			24		
8.							
9.	Estimate slip, length of belt, angle of contact in an open and cross belt drive.	30			25		
10.	Calculate breaking torque required in different breakes at different speeds and load situations.	36					
11.	Assemble and dissemble different clutches. (Part I). (Part II)	41					
12.							
13.	Measure radius and height of any two types of governors for different rotational speeds, mass of balls and spring stiffness (in spring loaded governors)	47					
14.	Perform balancing of rotating unbalanced system	54					
	Total						

Note: To be transferred to Proforma of CIAAN-2017.

Practical No.1&2: Measurement of Ratio of Time of Cutting Stroke to Return Stroke

I. Practical Significance

Quick return mechanism used in a shaper machine is an important and useful inversion of single slider crank mechanism. Knowing its working and its features is essential for a diploma engineer.

II. Relevant Program Outcomes (POs)

PO 2. Discipline knowledge: Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO 3. Experiments and practice: Plan to perform experiments and practices to use the results to solve broad-based Mechanical engineering problems.

PO 8.Individual and team work: Function effectively as a leader and team member in diverse/ multidisciplinary teams.

III. Competency and Skills

This practical is expected to develop the following skills for the industry identified competency

- ***Use principles of kinematics and dynamics in maintenance of various equipment.'***

1. Identify the components of the quick return mechanism used in shaper machine.
2. Adjust stroke length of the quick return mechanism by varying crank radius using spanner and other tools.
3. Measure time of stroke using appropriate instrument.

IV. Relevant Course Outcome(s)

- Identify various links in popular mechanisms.

V. Practical Outcome

Measure the ratio of time of cutting stroke to the return stroke in shaping machine available in institute's workshop by varying the stroke length

VI. Relevant Affective Domain related Outcomes

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. Follow ethical Practices.

VII. Minimum Theoretical Background

Knowledge of Single Crank Mechanism, its links and pairs , inversions of Single slider crank mechanism

VIII. Experimental setup

Figure 1 is schematic of the quick return mechanism used in shaper machine and figure 2 is a typical shaper machine available in the workshop of a polytechnic.

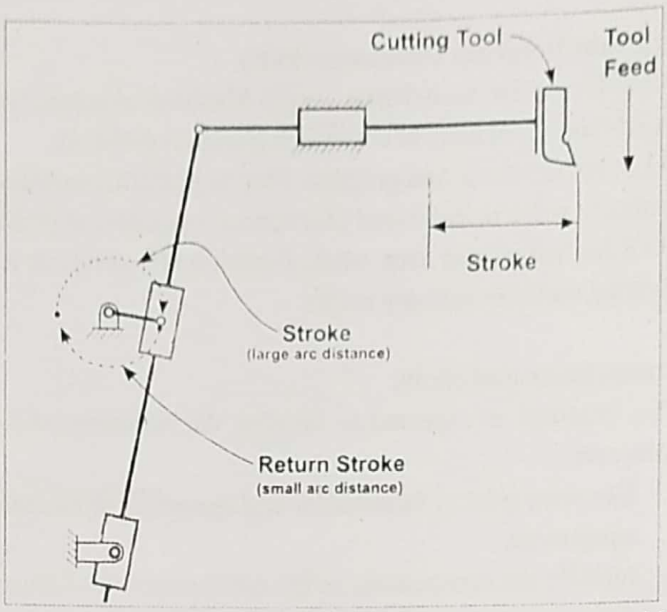

Figure 1 :Schematic of the quick return mechanism used in shaper machine

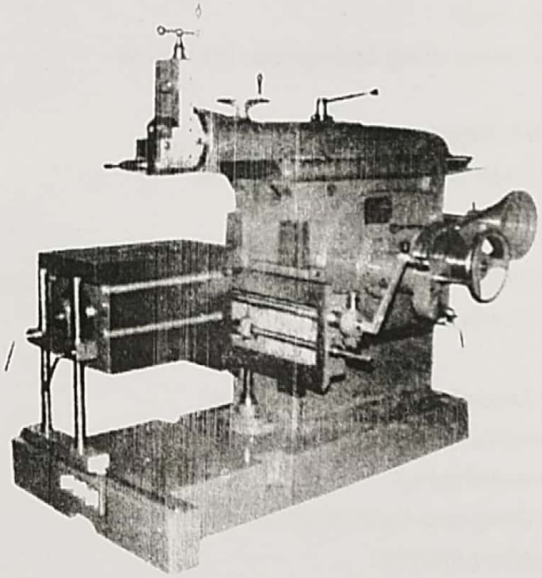

Figure 2: A typical shaper machine

IX. Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Shaper machine	Available in institute's workshop	1
2.	Stop watch	Mechanical stopwatch	1
3.	Steel rule	1 m length	1
4.	Spanner set, hammer and mallet	Available in workshop	1
5.	Tachometer	Mechanical or optical type of tachometer	1

X. Precautions to be followed:

1. Due safety precautions while operating a shaper machine.

XI. Procedure

1. Open the cover plate of shaper machine to observe the mechanism.
2. Rotate the bull gear manually and identify the various kinematic links and pairs formed among them.
   a. Mark a point on body of machine and ram.
   b. Start the machine and observe the movement of ram in cutting and idle stroke.
   c. Note down the movement of point on ram with respect to point on body of machine, this gives stroke length.
   d. Note down time required for cutting stroke and idle stroke.
   e. Now, adjust the stroke length by varying the radius of the crank.
   f. In order to adjust the position of the ram, the ram fixing screw is loosened. The ram is moved to the required position and the screw is tightened again.
   g. Again measure the time required for completion of cutting and idle stroke length
   h. Close the cover plate and ensure the proper working of the machine.
   i. Tabulate the observations.

XII. Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.	Stopwatch		Mechanical stopwatch	01	
2.	Steel rule		1m length	01	
3.	Tacho-meter		Mechanical or optical	01	

XIII. Actual Procedure Followed

Same as given

XIV. Precautions Followed

Due safety precautions while operating a shaper machine.

XV. Observations and Calculations

a. Identification of kinematic pair

Name of First Link	Name of Second Link	Type of Kinematic pair
Slotted link	Crank	Turning pair
Crank	Connecting rod	Turning pair
Connecting rod	Slider	Turning pair
Slider	Slotted link	Sliding pair

b. Ratio of cutting to idle time

Details	Time (s)		Time Ratio
	Cutting Stroke	Return Stroke	
Reading 1	1.8 sec	1.2 sec	1.5
Reading 2	1.7 sec	1.1 sec	1.545

* Minimum two readings are to be recorded by adjusting the crank radius.

Calculations

Calculations of time ratios

For Reading 1, Time ratio = $\frac{\text{Time req. for cutting stroke}}{\text{Time req. for return stroke}}$

$= \frac{1.8}{1.2}$

$= 1.5$

XVI. Results

Time ratio for shaping machine = for 1st reading = 1·5
for 2nd reading = 1·545.

XVII. Interpretation of Results

Measurement of Time ratio of cutting stroke to Return stroke : for 1st reading = 1:5 for 2nd reading : 1:5.45

XVIII. Conclusions

We were able to measure ratio of time of cutting stroke to return stroke

XIX. Practical Related Questions

1. List the link of which the motion is constrained in the quick return mechanism in a shaper machine.
2. List the sliding and turning pairs in the quick return mechanism.
3. State the procedure of changing the length of cutting stroke of the quick return mechanism.

[Space for Answers]

Ans-1] The links of which the motion is constrained in the quick return mechanism is slider.

Ans-2] a] Turning pair:
(i) slotted link and crank
(ii) crank and connecting rod
(iii) connecting rod and slider
b] Sliding pair
(i) slider and slotted link

Ans:-3] A Quick Return Mechanism is an apparatus to produce a reciprocating motion in which the time taken for travel in return stroke is less than in the forward stroke.

XX References / Suggestions for Further Reading

https://www.youtube.com/watch?v=nZCSvbuVU6E

XXI Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Handling of the measuring Instruments	30%
2	Calculation of final readings	10%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. Amey Rane
2. Pritesh Parmar
3. Chirag Thakur
4. Sushil Deshmukh

Marks Obtained			Dated signature of Teacher
Process Related(10)	Product Related(15)	Total (25)	
10	14	24	

Practical No.5: Velocity and Acceleration in Mechanisms

I. Practical Significance

Determination of velocity and acceleration of the links is essential for calculation of forces acting on those links in various mechanisms.

II. Relevant Program Outcomes (POs)

PO 2. Discipline knowledge: Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO 3. Experiments and practice: Plan to perform experiments and practices to use the results to solve broad-based Mechanical engineering problems.

III. Competency and Skills

This practical is expected to develop the following skills for the industry identified competency '***Use principles of kinematics and dynamics in maintenance of various equipment.***'

1. Calculate angular velocity and linear velocity of a link using given data.
2. Draw velocity and acceleration polygon.
3. Determine angular and linear velocity and angular and linear acceleration of a link using velocity and acceleration polygons.

IV. Relevant Course Outcome(s)

- Determine velocity and acceleration of a link in a given mechanism.

VI. Practical Outcome

Determine velocity and acceleration of various links of given mechanism by relative velocity method for analysis of motion of links

VII. Relevant Affective Domain Unrelated Outcomes

1) Follow safety practices.
2) Practice good housekeeping.
3) Demonstrate working as a leader/a team member.
4) Maintain tools and equipment.
5) Follow ethical Practices.

VIII. Minimum Theoretical Background

Knowledge of Various Mechanism and its links, Velocity and Acceleration analysis using Relative velocity Method

IX. Experimental setup

Any two working models of single slider crank mechanism / four bar chainavailable in Theory of Machine lab (or any other lab in Mech Engg. Dept.) in the institute.

X. Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Model of Single Slider crank mechanism		1
2	Steel rule	1 m length	1
3	Tachometer	Range 0-6000 RPM	1

XI. Precautions to be followed

- Due safety precautions to be taken while measuring angular speed.

XII. Procedure

a. Select any working model of single slider crank mechanism available in the laboratory. (Data obtained in experiment 3 can be used here.)
b. Measure the length of links of the mechanism.
c. Measure the angular speed of the crank.
d. Use this data to draw velocity and acceleration polygons using relative velocity method.

XIII. Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.	Model		Single slider four bar crank Mech	01	
2.	Steel rule		1m length	01	
3.	Tachometer		Range 0-6000 RPM	01	

XIV. Actual Procedure Followed

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.....Same as given.....

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XV. Precautions Followed

Due safety precautions to be taken while measuring angular speed.

XVI. Observations and Calculations

a. Lengths of various links

Name of the Link	Length(m)
Crank OA	0.03
Connecting Rod AB	0.12
slider B	0.145

b. Angular speed of crank

* Minimum two readings of angular velocities are to be recorded.

N = 200 rpm

$$\omega_{AO} = \frac{2\pi N}{60} = \frac{2 \times \pi \times 200}{60} = 20.94 \text{ rad/s.}$$

∴ Angular velocity of crank OA = 20.94 rad/s

Calculations

Calculation of angular, linear velocities and accelerations of various links

Velocity Diagram

$V_{AO} = 0.628$ m/s

$V_{BA} = 0.552$ m/s

$V_{BO} = 0.389$ m/s

$\omega_{AO} = 20.94$ rad/s

Acceleration diagram

$a_{BO} = 13.14$ m/sec^2

$a^t_{BA} = 6.307$ m/sec^2

$\alpha_{AB} = 52.55$ rad/s^2

$a_{OA} = 13.141$ m/sec^2

$a^r_{AB} = 2.539$ m/sec^2

XVII. Results

We determined graphically

(1) Angular Acceleration of Connecting rod AB = 52.55 rad/s^2

(2) Acceleration of slider = 13.141 m/s^2.

XVIII Interpretation of Results

As shown on sheet

XIV Conclusions

In this way, we studied how to find out velocity and acceleration of mechanism using relative velocity method

XX. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers should design more such questions so as to ensure the achievement of identified CO.

1. Calculate angular or linear velocities of various links.
2. Calculate angular or linear acceleration of various links.

[Space for Answers]

Ans 1: 1) Linear velocity of crank OA :

$V_{AO} = l(OA) \times \omega_{AO}$

$= 0.03 \times 20.94$

$V_{AO} = 0.628$ m/sec.

2) Linear velocity of connecting rod AB:

$V_{AB} = l(ab) \times$ scale

$= 4.4 \times 0.1256$

$V_{AB} = 0.552$ m/sec.

3) Angular velocity of connecting rod AB.

$\omega_{AB} = \frac{V_{AB}}{l(AB)}$

$= \frac{0.552}{0.12} = 4.6$ rad/sec

4) Linear and Angular velocities of slider 'B'.

$V_{BO} = l(bo) \times$ scale

$= 3.1 \times 0.1256$

$\therefore \omega_{BO} = 0.389$ rad/s

$\omega_{BA} = \frac{V_{BO}}{l(BO)} = \frac{0.389}{0.145} = 2.682$ rad/s

Ans-2) 1) Angular Acceleration of connecting rod AB:

$a^t_{ab} = l(bb') \times scale = 2.4 \times 2.628 = 6.3$ m/s^2.

$\alpha_{ab} = \frac{a^t_{ab}}{l(AB)} = \frac{6.3}{0.12} = 52.55$ rad/s^2.

2) Acceleration of slider (B)

$= l(ob) \times scale$

$a_{BO} = 5 \times 2.628 = 13.14$ m/s^2.

XX References / Suggestions for Further Reading

Similar resources are available on internet.

XXI. Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Handling of the measuring Instruments	30%
2	Calculation of final readings	10%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. Amey Rane
2. Pritesh Parmar
3. Chirag Thakur
4. Sushil Deshmukh

Marks Obtained			Dated signature of Teacher
Process Related(10)	Product Related(15)	Total (25)	
10	14	24	

Practical No. 6: Determination of Velocity and Acceleration by Klein's Construction

I. Practical Significance

Determination of velocity and acceleration of the links is essential for calculation of forces acting on those links in various mechanisms. Klein's construction, being a graphical method, is a simple method of calculation of velocity and acceleration in single slider crank mechanism.

II. Relevant Program Outcomes (POs)

PO 1. Basic knowledge: Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Mechanical engineering problems.

PO 2. Discipline knowledge: Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO 3. Experiments and practice: Plan to perform experiments and practices to use the results to solve broad-based Mechanical engineering problems.

III. Competency and Skills

This practical is expected to develop the following skills for the industry identified competency ***'Use principles of kinematics and dynamics in maintenance of various equipment.'***

1. Draw a space diagram of a single slider crank mechanism.
2. Draw velocity and acceleration polygons of the given mechanism using Klien's construction method.
3. Measure the velocities and acceleration of various links obtained using Klien's construction method.

IV. Relevant Course Outcome(s)

- Determine velocity and acceleration of a link in a given mechanism.

V. Practical Outcome

Determine Velocity and acceleration in an I C engine's slider crank Mechanism by Klein's construction

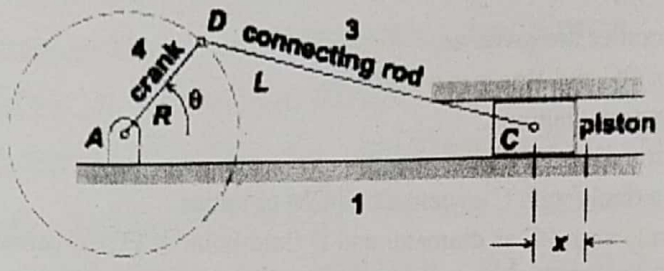
VI. Relevant Affective Domain Unrelated Outcomes

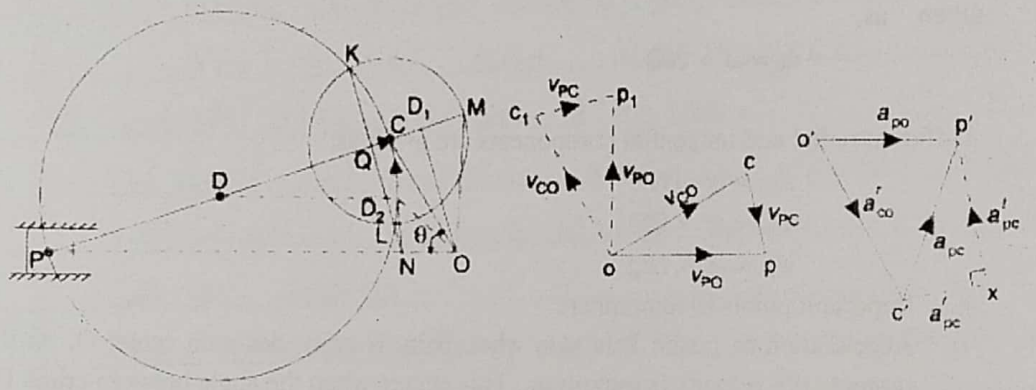
1) Follow safety practices.
2) Practice good housekeeping.
3) Demonstrate working as a leader/a team member.
4) Maintain tools and equipment.
5) Follow ethical Practices.

VII. Minimum Theoretical Background

Velocity and acceleration of links in mechanism and procedure of Klein's construction.

VIII. Experimental setup





(*a*) Klien's acceleration diagram. (*b*) Velocity diagram. (*c*) Acceleration diagram.

Klien's construction

IX. Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Drawing Board	D2 size	1
2	Drawing sheet	A3 or A4 size	1
3	Mini drafter, steel rule (30 cm), sets squares		1 each

X. Precautions

Avoid improper handling of drawing instruments

XI. Procedure

1. Draw the configuration diagram of the given slider crank mechanism to some suitable scale.
2. Klein's velocity diagram: Draw OM perpendicular to OP and extend it to intersect line PC produced at M .The triangle OCM is the required velocity diagram.

Velocity of piston or slider P is given as,

$Vp = \omega \times OM$

Other velocities are given as,

$Vco = \omega \times OC$ and $Vpc = \omega \times CM$

3. Klein's acceleration diagram:

In the configuration diagram drawn already,

First of all draw a circle with C as center and CM as radius.

Draw another circle with PC as diameter and D (mid-point of PC) as center. This circle intersects previously drawn circle at point K and L .

Join KL and produce it to intersect PO at N. Let KL intersect PC at Q. Quadrilateral CQNO is the required acceleration diagram. Acceleration of piston (or slider) P is given as,

$$a_p = \omega^2 \times NO$$

Different radial and tangential components are given as,

$$a^r_{co} = \omega^2 \times OC$$

$$a^r_{pc} = \omega^2 \times QC$$

$$a^t_{pc} = \omega^2 \times NQ$$

4. Important points to remember:

i) Acceleration of piston P is zero when point N coincides with center O. At this moment the velocity is maximum. This occurs when the angle between crank OC and connecting rod PC is slightly less than 90^0.

ii) If point N lies to the right side of O, at this moment of crank rotation, the acceleration of piston is negative i.e. it is undergoing retardation.

XII. Resources Used

S. No	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.	Sheet		A2 size	2	
2.	Drawing board		D2 size	1	
3.	Drafter		-	1	

XIII. Actual Procedure Followed

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Same as given

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Procedure:

① Draw the configuration diagram of the given slider crank mechanism to some suitable scale.

② Klien's velocity diagram: Draw OM perpendicular to OP and extend it to intersect line PC produced at M. The triangle OCM is the required velocity diagram.

Velocity of piston or slider P is given as,

$V_P = \omega \times OM$

Other velocities are given as,

$V_{CO} = \omega \times OC$ and $V_{PC} = \omega \times CM$.

③ Klien's acceleration diagram:

In the configuration diagram drawn already, first of all draw a circle with C as a center and CM as radius.

Draw another circle with PC as diameter and D (midpoint of PC) as center. This circle intersects previously drawn circle at point K and L

Join KL and produce it to intersect PO at N. Let KL intersect PC at Q. Quadrilateral CQNO is the required acceleration diagram. Acceleration of piston (or slider) P is given as.

$a_P = \omega^2 \times NO$.

Different radial and tangential components are given as.

$a^r_{CO} = \omega^2 \times OC$.

$a^r_{PC} = \omega^2 \times QC$

$a^t_{PC} = \omega^2 \times NQ$.

(4) Important points to remember:

(i) Acceleration of piston P is zero when point N coincides with center O. At this moment the velocity is maximum. This occurs when the angle between crank OC and connecting rod PC is slightly less than 90°.

(ii) If point N lies to the right side of O, at this moment of crank rotation, the acceleration of piston is negative i.e. it is undergoing retardation.

Crank of the slider crank mechanism rotates clockwise at constant speed of 300 rpm. The crank is 150 mm and the connecting rod is 600 mm long. Determine

1) Velocity of crank.
2) velocity of connecting rod.
3) velocity of slider
5) Calculate the acceleration of all links.

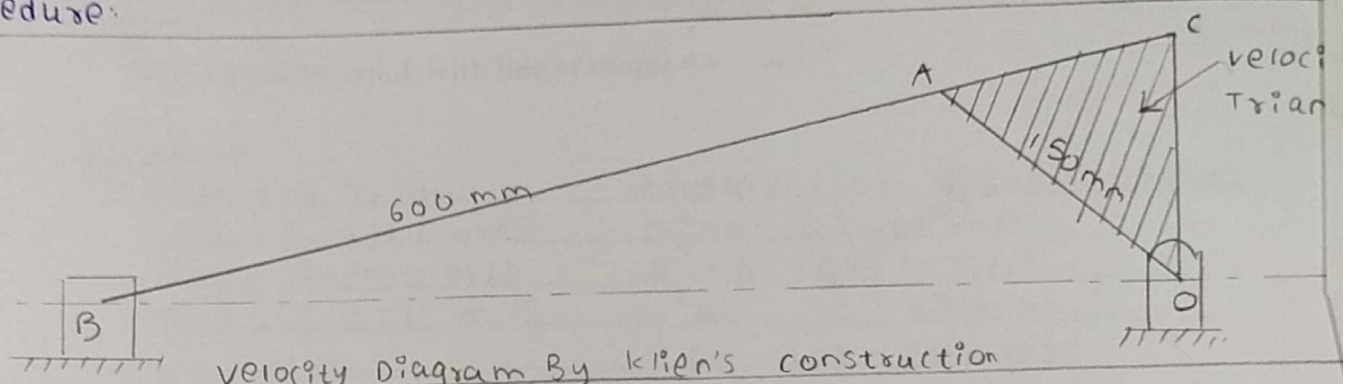
Crank makes an angle of 45° with I.D.C.

Given Data: N = 300 rpm.

Length of crank = 150mm = 0.15 m.

Length of connecting rod = 600 mm = 0.6 m.

Procedure:



Velocity Diagram By Klien's construction

$$\omega_{AO} = \frac{2\pi N}{60} = \frac{2 \times \pi \times 300}{60} = \frac{1884.95}{60} = 31.41 \text{ rad/sec.}$$

From velocity Triangle

1) Velocity of crank = $\omega_{AO} \times l(AO)$

$= 31.41 \times 0.15$

$$\boxed{V_{AO} = 4.7124 \text{ m/s}}$$

2) Velocity of connecting rod = $\omega_{AO} \times l(AC)$

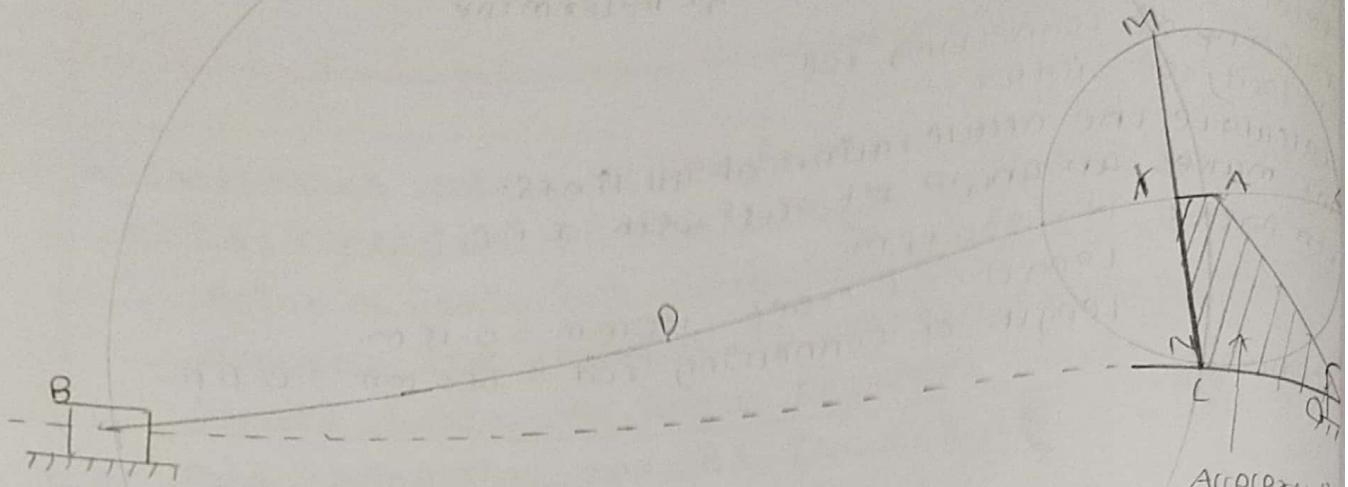
$= 31.41 \times 0.11$

$$\boxed{V_{AB} = 3.455 \text{ m/s}}$$

3) velocity of slider = $\omega_{AO} \times l(CO)$

$= 3.41 \times 0.125$

$$\boxed{V_{BO} = 3.927 \text{ m/s}}$$



Acceleration Diagram by Klien's Construction

From $\square AXLO$.

(i) Radial acceleration of crank AO $= \omega_{AO}^2 \times l(OA)$

$= (31.41)^2 \times 0.15$

$a^r_{AO} = 148.02 \ m/s^2$

(ii) Radial acceleration of connecting rod AB:

$a^r_{BA} = \omega^2_{AO} \times l(AX)$

$= (31.41)^2 \times 0.0199$

$a^r_{BA} = 19.73 \ m/s^2$

(iii) Tangential acceleration of connecting rod AB:

$a^t_{BA} = \omega^2_{AO} \times l(AL)$

$= (31.41)^2 \times 0.02$

$a^t_{BA} = 103.63 \ m/s^2$

(iv) Acceleration of slider:

$a^t_{BO} = \omega^2_{AO} \times l(LO)$

$= (31.41)^2 \times 0.11$

$a^t_{BO} = 108.56 \ m/s^2$

XIV. Precautions Followed

Avoid improper handling of measuring instruments.

XV. Observations and Calculations

Name of link	Length (m)
Crank	0.15
Connecting Rod	0.6
Use Data obtained in experiment 3 can be used here.	

Angle made by crank with line of stroke θ = 45°

Calculations

Velocity Triangle

$V_{AO} = 4.7124$ m/s

$V_{AB} = 3.455$ m/s

$V_{BO} = 3.927$ m/s

Acceleration Quadrilateral

$a^r_{AO} = 148.02$ m/s^2

$a^r_{AB} = 19.73$ m/s^2

$a^t_{BA} = 103.63$ m/s^2

$a^t_{BO} = 108.506$ m/s^2

XVI. Results

Details	
Velocity of piston	3.927 m/sec.
Angular velocity of connecting rod	5.75 rad/sec.
acceleration of piston	108.56 m/s^2
Radial component of Acceleration of connecting rod	19.13 m/s^2
Tangential component of Acceleration of connecting rod	103.63 m/s^2
Total component of Acceleration of connecting rod	123.36 m/s^2

XVII. Interpretation of Result

Same as shown on A4 size paper

XVIII. Conclusions

We were able to determine the velocity and acceleration by klien's construction.

XIV. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers should design more such questions so as to ensure the achievement of identified CO.

a. State the significance of Kleins construction

b. Compare Kleins construction with relative velocity-acceleration method.

[Space for Answers]

Ans-1] The significance of klien's construction is as follows:

1) klien's construction being a graphical method, is a simple method of calculation of velocity and acceleration in single slider crank mechanism.

Ans-2]

klien's construction method	Relative velocity Acceleration mtd.
1) It is a simple graphical method used to calculate velocity and acc^{n} of a mechanism	1) It is a difficult graphical method than klein's construction due to its lengthy calculations
2) It is only used to calculate velocity and acceleration of single slider crank mechanism	2) It is used to calculate velocity and acceleration of both mechanisms such as four bar chain & single slider crank mechanism

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XX References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=jgwprdibxRc
2. https://www.youtube.com/watch?v=k202Yisjc5g

XXI Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Handling of the measuring Instruments	30%
2	Calculation of final readings	10%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. Amey Rane
2. Pritesh Parmar
3. Chirag Thakur
4. Sushil Deshmukh

Marks Obtained			Dated signature of Teacher
Process Related(10)	Product Related(15)	Total (25)	
10	14	24	

Practical No.7& 8: Cam Profile

I. Practical Significance

Cam followers are used for conversion of rotary motion into translatory motion. These are widely used in machines, engines and mechanisms. Cam profile determines desired motion of the follower.

II. Relevant Program Outcomes (POs)

PO 2. Discipline knowledge: Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO 3. Experiments and practice: Plan to perform experiments and practices to use the results to solve broad-based Mechanical engineering problems.

III. Competency and Skills

This practical is expected to develop the following skills for the industry identified competency '• ***Use principles of kinematics and dynamics in maintenance of various equipment.***'

1. Select suitable cam and follower for a given application to obtain desired motion.
2. Select the type of motion to the follower for a given application.
3. Draw displacement diagram of the follower.
4. Draw the cam profile.

IV. Relevant Course Outcome(s)

- Analyze the motion of cams and followers.

V. Practical Outcome

Draw profile of a radial cam for given follower type to obtain the desired follower motion

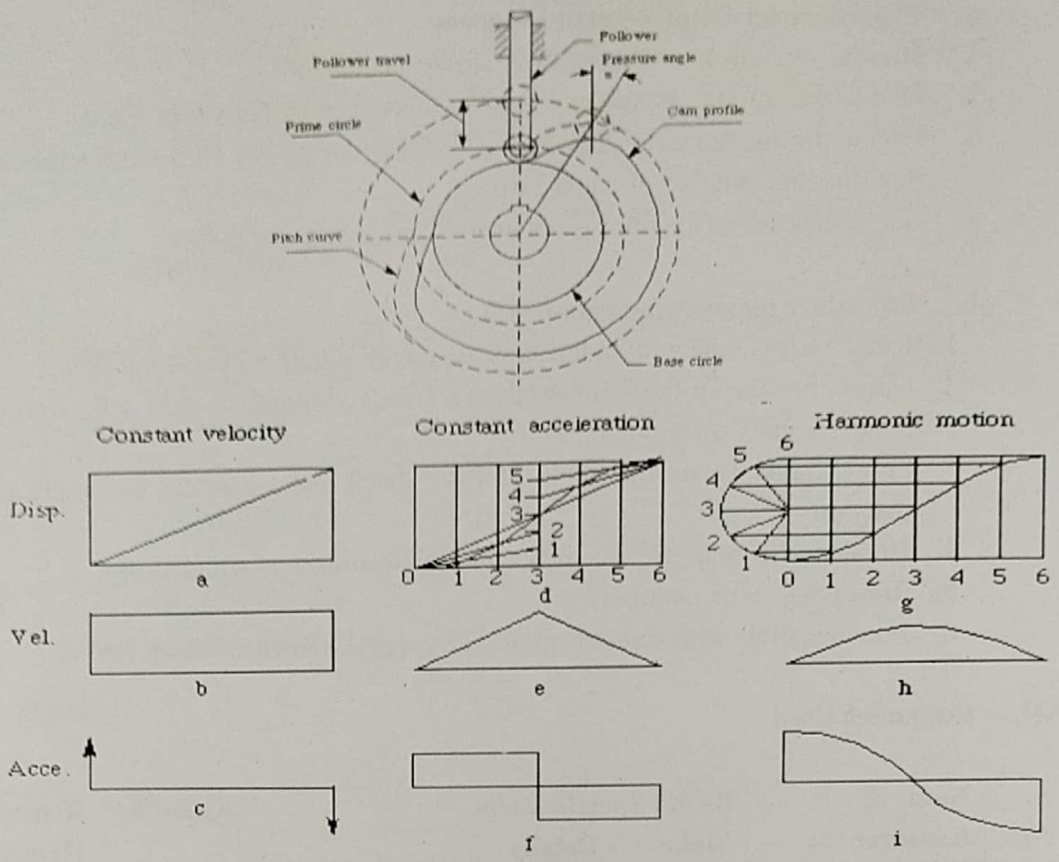
VI. Relevant Affective Domain Unrelated Outcomes

1) Follow safety practices.
2) Practice good housekeeping.
3) Demonstrate working as a leader/a team member.
4) Maintain tools and equipment.

VII. Minimum Theoretical Background

Classification of Cams and Followers, Applications of Cams and Followers, Types of follower motions and their displacement diagrams - Uniform velocity, Simple harmonic motion, uniform acceleration and retardation

VIII. Experimental setup



Cam Profile and Follower Motions

IX. Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Drawing Board	A2 size	1
2	Drawing sheet	A3 or A4 size	1
3	Mini drafter, steel rule (30 cm), sets squares		1 each

X Precautions

Avoid improper handling of the drawing instruments.

XI. Procedure

(Solve any 4 problems with different cams and follower with different motions of follower)

a. Procedure for Displacement Diagram

1. Draw a semi-circle on the follower stroke as diameter.
2. Divide the semi-circle into any number of even equal parts (say eight).
3. Divide the angular displacements of the cam during out stroke and return stroke into the same number of equal parts.
4. The displacement diagram is obtained by projecting the points

b. Procedure for drawing cam profile

1. Draw a base circle with radius equal to the minimum radius of the cam
2. Check the axis of the follower passes/offsets through the axis of the cam shaft, therefore mark trace point
3. From Crank, locate the angle of Rise, dwell and fal as per the displacement diagram
4. Divide the angular displacements during outstroke and return stroke
5. Joins points with centre 'O'
6. Join the points with smooth curve. The curve is known as ' Cam Profile'

XII. Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.	Drawing board		A2 size	01	
2.	Drawing sheet		A2 or A3	01	
3.	Mini Drafter		30cm		

XIII. Actual Procedure Followed

Same as Given.

XIV. Precautions Followed

Avoid improper handling of drawing instruments

XV. Observations and Calculations

Sr No	Details	Problem1	Problem2	Problem3	Problem4
1	Type of follower	Knife Edge	Roller	knife Edge	Roller
2	Type of cam	Radial	Radial	Radial	Radial
3	Lift of cam	40 mm	40mm	40mm	30 mm
4	Offset of cam	-	-	20 mm	20 mm
5	Follower motion with angle of cam (Acceleration, dwell, deceleration)	D-90(SHM) D-30 D-60(SHM) D-180	D-110(SHM) D-80 D-120(UAR) D-50	D-60 (UV) D-30 D-60 (SHM) D-210	D-90 (UAR) D-90 D-120 (SHM) D-60
6	Minimum radius of cam	40 mm	30 mm	50 mm	60 mm
7	Roller radius	-	10 mm	-	15 mm
8	Any other Information				

XVI. Results

As mentioned on sheet

XVII. Interpretation of Results

As mentioned on sheet

XVIII. Conclusions

we able to draw profile of a radial cam for given follower type using 3 diff methods such as simple Harmonic Motion, Uniform Acc^n & Retn and Uniform velocity

XIX. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers should design more such questions so as to ensure the achievement of identified CO.

1. State the types of motions of followers.
2. List the any four applications of cams in the Machinery/equipments

[Space for Answers]

Ans-1) Types of motion of follower:

a) Reciprocating or Translating follower

i) when follower reciprocates in guides due to uniform rotation of cam, it is known as Reciprocating or Translating follower.

ii) Eg - ① Spherical faced follower

② knife Edge follower

b) Oscillating or Rotating follower

i) When the follower is able to convert uniform rotary motion of cam into predetermined oscillatory motion of follower, the follower is called as oscillating or rotary follower

ii) Eg Radial follower.

Ans-2) Applications of cam in machinery / Equipments

(i) Robotic milling machines

(ii) Lathes.

(iii) Welding machines.

(iv) Glass working.

(v) Wood turning.

(vi) Metal working

(vii) Spinning.

(viii) Graphical optimization

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XX References / Suggestions for Further Reading

https://www.youtube.com/watch?v=AaHPDLCe_gU

https://www.youtube.com/watch?v=JqkyHIj0YAs

XXI. Assessment Scheme

	Performance Indicators	Weightage
	Process Related (10 Marks)	**(40%)**
1	Handling of the measuring Instruments	30%
2	Calculation of final readings	10%
	Product Related (15 Marks)	**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. Amey Rane.....
2. Pritee Pawar
3. Chirag Thakur....
4. Sushil Deshmukh

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	
10	14	24	

Practical No.9: Measurement of Parameters of Belt Drive

I. Practical Significance

Slip in belt drives is an undesirable phenomenon. It needs to be measured for the estimation of performance of a machine using the belt drive. Geometrical parameters of belt such as length of belt and angle of contact are essential for selection of appropriate belt for a given application.

II. Relevant Program Outcomes (POs)

PO 2. Discipline knowledge: Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO 3. Experiments and practice: Plan to perform experiments and practices to use the results to solve broad-based Mechanical engineering problems.

PO 8. Individual and team work: Function effectively as a leader and team member in diverse/ multidisciplinary teams.

III. Competency and Skills

This practical is expected to develop the following skills for the industry identified competency ***'Use principles of kinematics and dynamics in maintenance of various equipment.'***

1. Measurement of angular speed using tachometer.
2. Computation of slip using measured speeds.
3. Computation of length of belt using given formula.

IV. Relevant Course Outcome(s)

- Select relevant belts, chains and drives for different applications

V. Practical Outcome

Measure slip, length of belt, angle of contact in an open and cross belt drive.

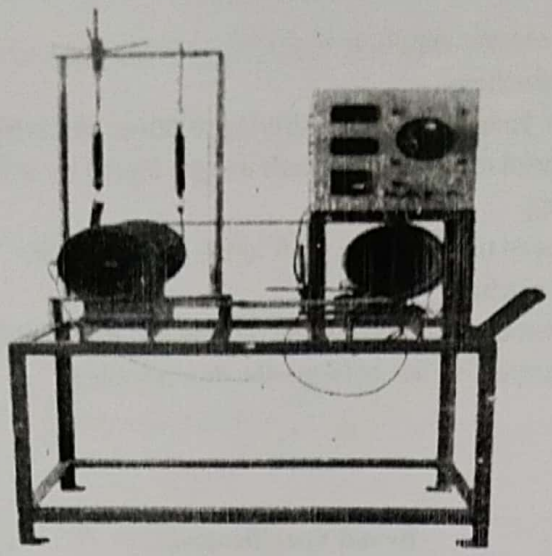
VI. Relevant Affective Domain Unrelated Outcomes

1) Follow safety practices.
2) Practice good housekeeping.
3) Demonstrate working as a leader/a team member.
4) Maintain tools and equipment.

VII. Minimum Theoretical Background

To transmit power from one shaft to another, Pulleys are mounted on the shaft. The pulleys are connected by endless belt passing over the pulleys. The connecting belt is kept in tension so that motion of pulley is transferred to other without slip. The speed of driven shaft can be varied by varying the diameters of two pulleys.

VIII. Experimental setup for measurement



IX. Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Belt drive test bench	A test bench comprising of following pulleys, belts, electrical motor, arrangement for adjusting belt tensions and regulating speed of the driving motor and a suitable mounting frame Note:- Various manufacturers offer such test bench with their own proprietary design. Hence the institutes are advised to purchase any suitable bench for measuring the slip of belt.	1
2	Tachometer		1

X. Precautions to be followed

1. Carefully adjust the tension on Belt
2. Take care during measurement of speed

XI. Procedure

1. Ensure proper electric supply to it.
2. Switch on the machine.
3. Observe power transmission from driving to driven shaft/drum.
4. Measure the speed of the driving shaft using a digital (or analogue) tachometer.
5. Note the reading.
6. Measure the speed of the driven shaft in the same manner.
7. Switch off the machine.
8. Measure the diameters (radius) of the driving and driven pulley
9. Measure the centre distance between the drums/pulleys.

XII. Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.	Belt Drive test bench	Bench comprising of pulleys belt electrical motor		01	
2.					
3.	Tachometer			01	

XIII. Actual Procedure Followed

Refer XI

XIV. Precautions Followed

① Carefully adust the tension on belt

② Take care during measurement of speed

XV. Observations and Calculations

Speed of pulley		Diameter of Pulley		Centre Distance
Driver (N1 rpm)	Driven (N2 rpm)	Driver (D1 mm)	Driven (D2 mm)	C mm
800	1150	120	80	1000

Speed of driven pulley without slip = (N2) = 1150 rpm

Using Formula for velocity ratio,

(N2) theoretical = N1 * D1/D2 $= \frac{800 \times 120}{80}$ = 1200. rpm.

Speed of driven pulley N2 = 1150.. rpm. (from above table)

Speed of driving pulley N1 = 800 rpm.(from above table)

Hence, total percentage slip's' is given by,

$$\frac{N_2}{N_1} = \frac{D_1}{D_2}\left(1 - \frac{s}{100}\right) \qquad \therefore \frac{1150}{800} = \frac{120}{80}\left(\frac{100-S}{100}\right)$$

$\therefore$ Slip, s = 4.16 %

Length of the open belt,

$$L = \frac{\pi}{2}(D_1 + D_2) + 2C + \frac{(D_1 - D_2)^2}{4c} \text{ m}$$

$\therefore L = 2.314 \text{ m}$

Angle of lap or contact,

$\theta = 180° - 2\alpha$ $\qquad \alpha = 0.02$ rad

$$\alpha = \sin^{-1}\left(\frac{R_1 - R_2}{c}\right)$$

R_1 & R_2 = Radii of Pulleys

$\therefore \theta =$ 3.101 radian.

XVI. Result

Slip S = 4.16 %

L = 2.314 m

Angle of lap (θ) = 3.101 radian.

XVII. Interpretation of Results

XVIII. Conclusions

Hence, we learned the measurement of Parameters of belt drive

XIV. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers should design more such questions so as to ensure the achievement of identified CO.

Questions [Space for Answers]

1) State the parameters on which selection of drive depends:

2) Differentiate between open Belt Drive and Cross Belt Drive:

Answers

1) Parameters for selection of drive depends on:
① speed required
② Power to be transmitted
③ length available between the centres to centres
④ Direction of rotation for the driven pulley
⑤ Size of the belt
⑥ Working condition
⑦ Cost

2)

Open belt drive	Cross belt drive
① velocity ratio is high	① velocity ratio is comparatively low
② Direction of driven pulley is same as driving pulley	② Direction of driven pulley is different than driving
③ Angle of lap $\theta = \pi - 2\alpha$	③ Angle of lap $\theta = \pi + 2\alpha$
④ $\alpha = \sin^{-1}\left(\frac{r_2 - r_1}{x}\right)$	④ $\alpha = \sin^{-1}\left(\frac{r_2 + r_1}{x}\right)$
⑤ Applications: Bucksaws Saw mills	⑤ Applications: Conveyors

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XX References / Suggestions for Further Reading

- https://www.youtube.com/watch?v=NPjenJmlGbQ
- https://www.youtube.com/watch?v=Jq35SP5lQOs

XXI. Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Handling of the measuring Instruments	30%
2	Calculation of final readings	10%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. Amey Rane.....
2. Pritesh Parmar.....
3. Chirag Thakur...
4. Sushil Deshmukh

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	
10	15	25	

Practical No.10: Braking Torque in Brakes

I. Practical Significance

A brake is a device used to exert frictional resistance over a moving body to stop or retard it within a short time period. In braking action, the kinetic energy of moving body is absorbed. In a two wheeler, mechanically operated brake is commonly is used to brake the motion of wheel.

II. Relevant Program Outcomes (POs)

PO 2. Discipline knowledge: Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO 3. Experiments and practice: Plan to perform experiments and practices to use the results to solve broad-based Mechanical engineering problems.

PO 8. Individual and team work: Function effectively as a leader and team member in diverse/ multidisciplinary teams.

III. Competency and Skills

This practical is expected to develop the following skills for the industry identified competency '• ***Use principles of kinematics and dynamics in maintenance of various equipment.***'

IV. Relevant Course Outcome(s)

- Select relevant brakes and clutches for various applications

V. Practical Outcome

- Calculate breaking torque required in different breaks at different speeds and load situations.

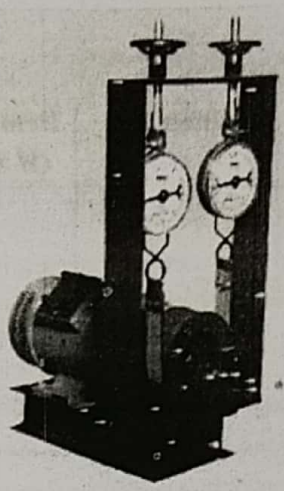
VI. Relevant Affective Domain Unrelated Outcomes

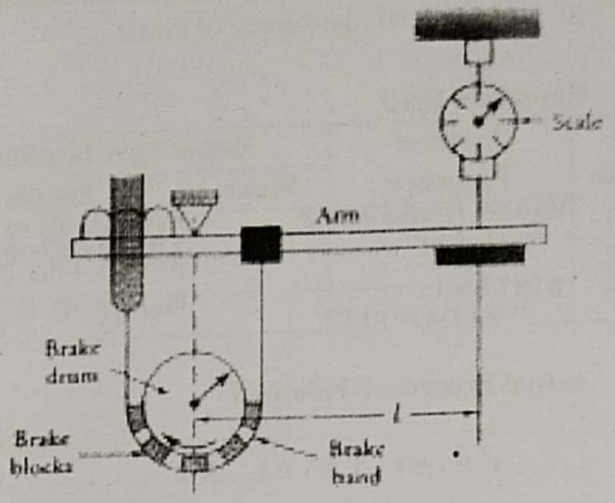
1 Follow safety practices.
2 Practice good housekeeping.
3 Demonstrate working as a leader/a team member.
4 Maintain tools and equipment.
5 Follow ethical Practices.

VII. Minimum Theoretical Background

A Brake is used to apply frictional resistance to a moving body to stop or retard it by absorbing its Kinetic Energy. When the brake pedal is pressed, brake shoes expand or move outwards and get pressed against the inner surface of the brake drum. The force of friction applied to the rotating drum produces a brake torque in the opposite direction, which retards or stops the rotating wheel.

VIII. Experimental setup





IX. Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Brake performance test rig	A test bench comprising of following drum, flat belt, electrical motor, arrangement for adjusting& measuring belt tensions and regulating speed of the driving motor and a suitable mounting frame Note:- Various manufacturers offer such test bench with their own proprietary design. Hence the institutes are advised to purchase any suitable bench for measuring the slip of belt.	01
2	Digital Tachometer	Range 0 to 3000RPM	01

X. Precautions to be followed

1. Clean the brake drum surface
2. Check the tension on Band belt
3. Measure the Speed of Brake drum with the help of tachometer
4. Note the reading
5. Apply Load manually over Drum with the help of band
6. Note down the Readings of Load measuring scale (Tight and Slack side)
7. Note down the speed under loaded condition
8. Take three more readings for different loads

XI. Procedure

1) Check the zero reading over load measuring scale
2) Switch 'ON' the Supply of motor

XII. Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Detaiis		
1.	Brake Performance Test Rig		A test bench comprising of drum, flat belt	01	
2.					
3.	Digital Tachometer		Range - 0 to 3000 RPM	01	

XIII. Actual Procedure Followed

Refer Point XI

XIV. Precautions Followed

① Clean the brake drum surface.
② Check the zero reading over load measuring scale.
③ Switch 'ON' the supply of motor.

XV. Observations and Calculations

Radius of Brake drum = mm

Sr No	Load on Measuring Scale (Tight side) T_1 Kg	Load on Measuring Scale (Slack side) T_2 Kg	Drum Speed RPM		Remark
			Initial	Final	
1	2.75	0	2200	2200	OK
2	4.75	0	2200	2200	OK
3	7.75	0	2200	2200	OK

Calculations

Braking Torque = $F_T R$ N.mm

F_T = Tangential Braking Force N

R = Radii of the Brake Drum mm = 140 mm

$F_T = (T_1 - T_2)$ = (7.75 - 0) x 9.81 = 76.0275N

T_1 = Tension on Tight side

T_2 = Tension on Slack side

$T_1 / T_2 = e^{\mu}$

μ = Coeff. of Friction

Θ = Angle of Contact

Braking Torque = 10643.35 N.mm

XVI. Results

Braking Torque = 10643.35 N.mm

XVII. Interpretation of Results

XVII. Conclusions

We were able to determine the Braking Torque in Brakes

XVIII. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers should design more such questions so as to ensure the achievement of identified CO.

1) List Different types of Brakes
2) State the significance of Braking Torque

[Space for Answers]

1) Different types of Brakes is as follows
   ① Block or shoe brake. ④ Drum and shoe brake
   ② Band brake. ⑤ Disc brake.
   ③ Band & block brake

2) Braking torque is the force applied at the brake wheel to stop the motion of the motion equipment. Assuming the operation conditions for the equipments are constant, a brake having

...reading torque equal to the full load torque of the motor.

XX References / Suggestions for Further Reading

a. https://www.youtube.com/watch?v=4PIhvPTONug
Similar resources are available on internet. The students should be encouraged to search and see these resources.

XIV. Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Handling of the measuring Instruments	30%
2	Calculation of final readings	10%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. Amey Rane
2. Pritesh Parmar
3. Chirag Thakur
4. Sushil Deshmukh

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No. 11&12: Assembly and Disassembly of Clutches

I. Practical Significance

Clutches are used in for engaging and disengaging the prime over and power transmission systems. These are commonly used in most of the automobiles and many industrial systems.

II. Relevant Program Outcomes (POs)

PO 2. Discipline knowledge: Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO 3. Experiments and practice: Plan to perform experiments and practices to use the results to solve broad-based Mechanical engineering problems.

PO 8. Individual and team work: Function effectively as a leader and team member in diverse/ multidisciplinary teams.

III. Competency and Skills

This practical is expected to develop the following skills for the industry identified competency '• ***Use principles of kinematics and dynamics in maintenance of various equipment.***'

IV. Relevant Course Outcome(s)

- Select relevant brakes and clutches for various applications

V. Practical Outcome

Assemble and dissemble different clutches

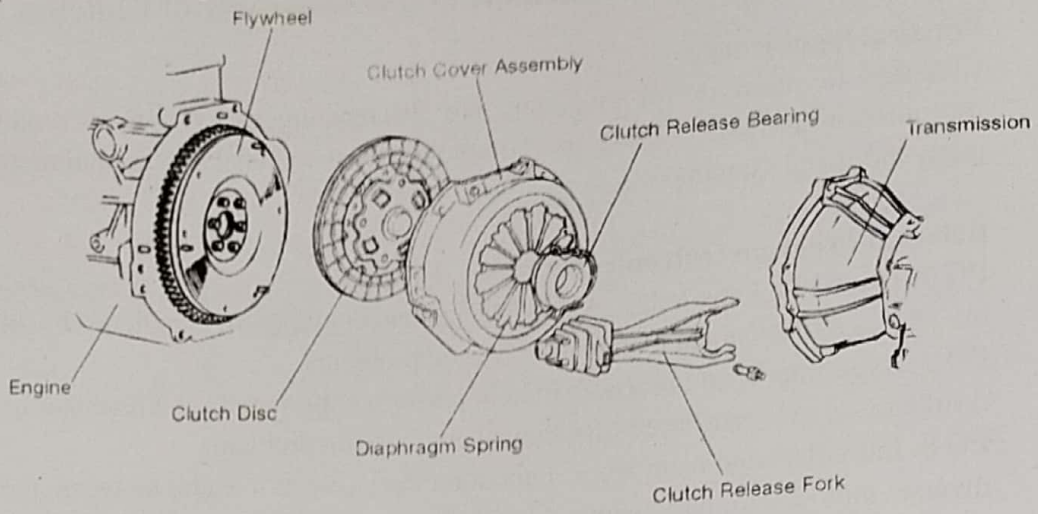
VI. Relevant Affective Domain Unrelated Outcomes

1. Follow safety practices.
2. Practice good housekeeping.
3. Demonstrate working as a leader/a team member.
4. Maintain tools and equipment.

VII. Minimum Theoretical Background

The clutch disc is connected to the input shaft of the transmission, and is located between the flywheel and clutch cover assembly. The flywheel is connected to the engine crankshaft and the clutch cover assembly is attached to the flywheel. The clutch release fork forces the clutch release bearing against the diaphragm spring of the clutch cover assembly.

VIII. Experimental setup



IX. Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Single plate clutch		1
2	Tool Box		1

X. Precautions to be followed

1. Due safety precautions while dismantling the clutch.
2. Carefully handle the different tools

XI. Procedure

1 Clean the single plate clutch thoroughly.
2 Carefully dismantle the single plate clutch step by step.
3 Arrange the components sequentially in a clean tray during dismantling process.
4 Note constructional features of each part and its role in working of clutch.
5 Loosely assemble the components in the clutch housing and observe the changes occurring inside
6 The assembly during engagement and disengagement.
7 Observe and understand the mechanism of power transmission.
8 Reassemble the unit and ensure its smooth working.

XII. Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.	Single Patch			01	
2.	Clutch.				
3.	Tool Box			01	

XIII. Actual Procedure Followed

Same as Given

XIV. Precautions Followed

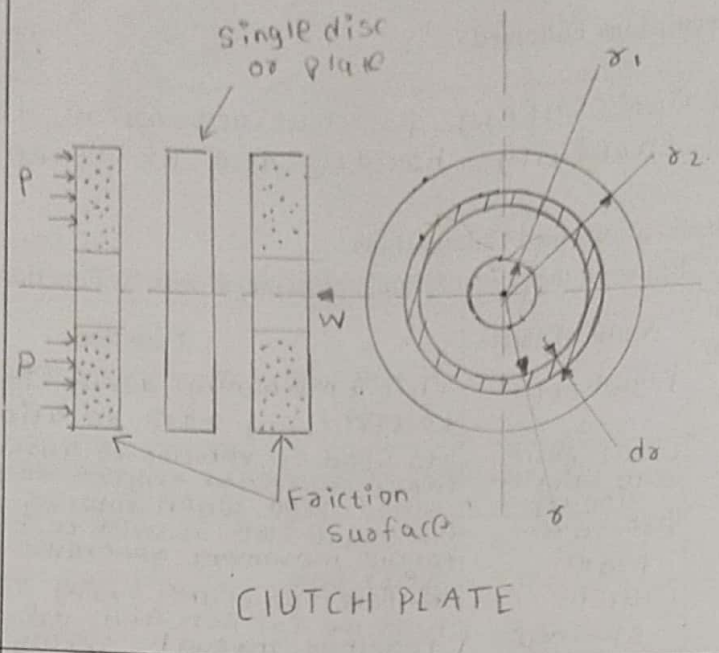
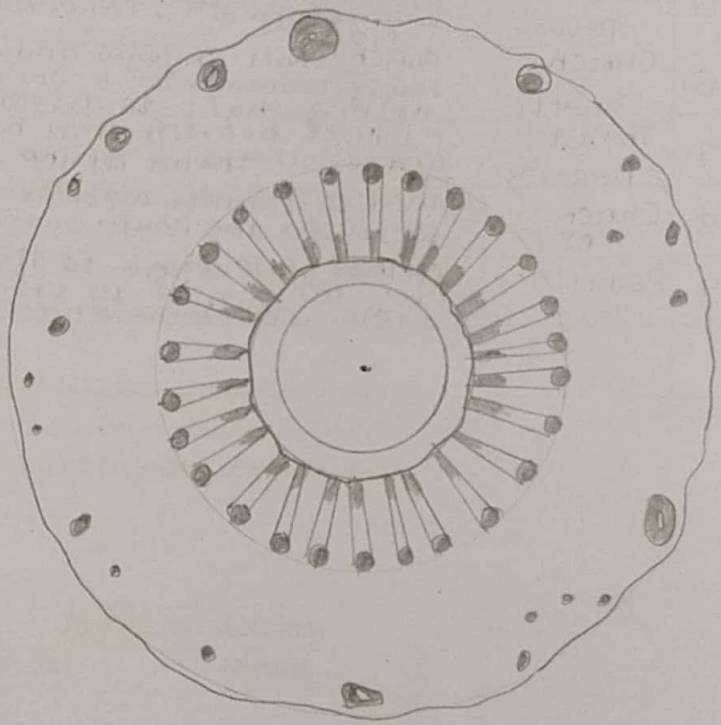
① Due safety precautions while dismantling clutch.
② Carefully handle the different tools.

XV. Observations and Calculations

a. Enlist all the parts of Single plate clutch with its Function

Sr No	Name of Part	Functions
1.	Flywheel	It is a mechanical device specially designed to efficiently store rotational energy.
2.	Clutch plate with friction linning.	Its used in vehicles to allow the transmission input shaft and engine to run after the same speed when rotating.
3.	Pressure plate.	Pressure plate is used to transfer the torque movement generated by engine to gear box.
4.	Clutch springs	The function of this spring is to continuously hold the friction and driven plates together through spring tension.
5.	Release lever	It helps to move the pressure plate away from clutch disc, interrupting power flow.
6.	Clutch shaft	Clutch shaft engages and disengages power transmission especially from driving shaft to driven shaft.
7.	Thrust bearing.	A type of bearing that helps rotation and resists thrust at the same time.
8.	Clutch Disc.	Used to connect a power source to whatever the power source is driving.
9	Pedal	Method of leverage to disengage drive from the engine to transmission from within the vehicles

b. Draw the sketches of Following Parts

Name of Part	Sketch
Clutch plate	
Pressure plate	

XVI. Results

We were able to identify the parts of single plate clutch and able to draw the clutch plate and pressure plate.

XVII. Interpretation of Results

different parts of singe plate clutch with the help of diagram given in referene books.

XVIII. Conclusions

We were able to draw the clutch plate and pressure plate and also were able to give the function of different parts of clutch.

XIX. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers should design more such questions so as to ensure the achievement of identified CO.

1. List different components of Clutch
2. State the function of diaphragm spring

[Space for Answers]

Ans-1) Different components of clutch

① Flywheel

② Pressure Plate

③ Clutch Plate

④ Friction Plate

⑤ Clutch Spring

Ans-2) The function of diaphragm is to disengage the pressure plate and clutch plate. The diagram plate is more comfort to do this operation.

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XX References / Suggestions for Further Reading

https://www.youtube.com/watch?v=HlIj32kZptc

Similar resources are available on internet. The students should be encouraged to search and see these resources.

XX. Assessment Scheme

	Performance Indicators	Weightage
	Process Related (10 Marks)	**(40%)**
1	Handling of the measuring Instruments	30%
2	Calculation of final readings	10%
	Product Related (15 Marks)	**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. Amey Rane
2. Paiten Parmar
3. Chirag Thakur
4. Sushil Deshmukh

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No. 13: Governor Characteristics

I. Practical Significance

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 controls the supply of working fluid to the engine with the varying load conditions and keeps the mean speed within certain limits.

II. Relevant Program Outcomes (POs)

PO 2. Discipline knowledge: Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO 3. Experiments and practice: Plan to perform experiments and practices to use the results to solve broad-based Mechanical engineering problems.

PO 8. Individual and team work: Function effectively as a leader and team member in diverse/ multidisciplinary teams.

III. Competency and Skills

This practical is expected to develop the following skills for the industry identified competency ***Use principles of kinematics and dynamics in maintenance of various equipment.***

- Operate governor of a given system
- Measure the lift of sleeve
- Plot a graph between position of sleeve and rotational speed

IV. Relevant Course Outcome(s)

- Select suitable flywheel and governor for various applications

V. Practical Outcome

- Measure radius and height of all types of governors for different rotational speeds, mass of balls and spring stiffness

VI. Relevant Affective Domain Unrelated Outcomes

1. Follow safety practices.
2. Practice good housekeeping.
3. Demonstrate working as a leader/a team member.
4. Maintain tools and equipment.
5. Follow ethical Practices

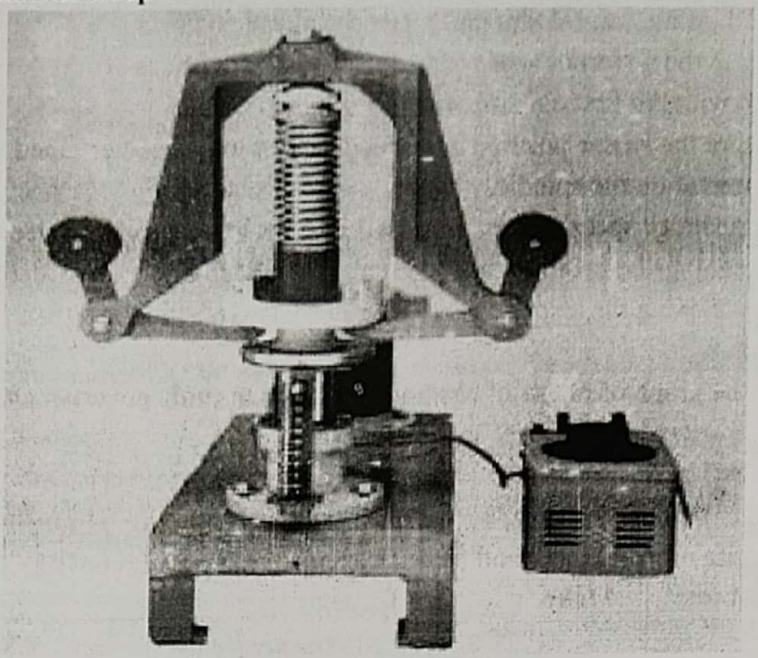
VII. Minimum Theoretical Background

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 .These balls are known as governor balls or fly balls. The balls revolve with a spindle, which is driven by the engine through bevel gears. The upper ends of the arms are pivoted to the spindle, so that the balls may rise up or fall down as they revolve about the vertical axis. The arms are connected by the links to a sleeve, which is keyed to the spindle. This sleeve revolves with the spindle; but can slide up and down. The balls and the sleeve rises when the spindle speed increases, and falls when the speed decreases. In order to limit the travel of the sleeve in upward and down-ward directions, two stops S, are provided on the spindle. The sleeve is connected by a bell crank lever to a throttle valve. The supply of the working fluid decreases when the sleeve rises and increases when it falls.

The following terms used in governors are important from the subject point of view;

1. **Height of a governor**. It is the vertical distance from the center of the ball to a point where the axes of the arms intersect on the spindle axis. It is usually denoted by h.
2. **Equilibrium speed.** It is the speed at which the governor balls, arms etc., are in complete
   equilibrium and the sleeve does not tend to move upwards or downwards.
3. **Mean equilibrium speed.** It is the speed at the mean position of the balls or the sleeve.
4. **Maximum and minimum equilibrium- speeds.** The speeds at the maximum and minimum radius of rotation of the balls, without tending to move either way are known as maximum and minimum equilibrium speeds respectively.

VIII. Experimental setup



IX. Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Centrifugal Governor Test bench	A test bench comprising of following A centrifugal governor, electrical motor, arrangement for regulating speed of the driving motor and a suitable mounting frame. Arrangement for measurement displacement of slider. Note:- Various manufacturers offer such test bench with their own proprietary design. Hence the institutes are advised to purchase any suitable bench for measuring the slip of belt.	1
2	Tachometer	Range 0-3000 RPM	1

X. Precautions to be followed

1. Do not increase the speed of governor exceeding maximum limit.

XI. Procedure

1) Switch on the control unit and rotate the speed control knob slowly.
2) Increase the governor speed until the center sleeve rises off the lower stop and aligns with the first division on the graduated scale.
3) Measure the sleeve position and speed. Speed may be determined using a tachometer on the spindle.
4) The governor speed is then increased in steps to give suitable sleeve movement, and readings be taken at each interval throughout the range of sleeve movement.
5) While closing the test bring the dimmer to zero position and then switch off the motor.
6) Plot the graph of radius of rotation Vs. speed to study governor characteristics

XII. Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.	Centrifugal governer test bench		Electric motor, To measure displacement of slider	01	
2.					
3.	Tachometer		Range = 0-30000 rpm	01	

XIII. Actual Procedure Followed

Same as given

XIV. Precautions Followed

Do not increase the speed of governer exceeding maximum limit

XV. Observations and Calculations

1 Length of arm ' L' = ...mm.

2. Initial height of governor ' h ' = ...mm.

3. Initial radius of rotation 'r ' = ...mm.

4. Diameter of sleeve, D = ... mm.

Sr. No.	Speed (N) RPM	Sleeve Displacement (X) mm	Height (H) mm	Cos α=H /L	Radius of Rotation 'R' mm
1.	153	3	98.5	0.31	161.25
2.	172	4	98	0.307	162
3.	204	5	97.5	0.90	162.75
4.	240	7	96.5	0.89	164.25

Calculations

Height ' H ' = Initial height of governor - Sleeve displacement / 2

H = h - X/2 = 161.25

Find angle α, using cos α = H / L

Radius of rotation ' R ' = D/2 + (L sin α)

Where, D = Diameter of sleeve at which arms are attached.

XVI. Results

We calculated the Radius of Rotation of different speeds

XVII. Interpretation of Results

XVIII. Conclusions

We studied the characteristics of Governor and find the Radius of Rotation

XIX. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers should design more such questions so as to ensure the achievement of identified CO.

1. Classify Governors
2. Name the important components of Governor
3. Applications\

[Space for Answers]

Ans-1) Classifications of Governers are as follows:

① Centrifugal governers

(i) Pendulum type

(ii) Dead weight type

(iii) Spring controlled type

② Inertia governers.

Ans-3) Applications

① Petrol and Diesel engines

② Jet engines

③ Marine engines

④ Steam and Gas turbines, etc.

⑤ Medium speed range application.

Ans-2) The important components of governers are as follows

① Sensing device.

② Comparator

③ Governer's behaviour

④ Correction device.

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XX References / Suggestions for Further Reading

https://www.youtube.com/watch?v=HS_YGZXP2xY

Similar resources are available on internet. The students should be encouraged to search and see these resources.

XXI Assessment Scheme

	Performance Indicators	Weightage
	Process Related (10 Marks)	**(40%)**
1	Handling of the measuring Instruments	30%
2	Calculation of final readings	10%
	Product Related (15 Marks)	**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. Amey Rane....
2. Paiten Parmar
3. Chirag Thakur
4. Sushil Deshmukh.

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No. 14: Balancing of Masses

I. Practical Significance

In many engineering systems, various masses are rotating in either a single plane or in different planes. Due to this, a system of forces is in existence which may have imbalanced forces. These imbalanced forces cause vibrations, noise and other mechanical failures. Hence, for longer life of the system and its operation with minimum vibration and noise, the balancing of masses is essential.

II. Relevant Program Outcomes (POs)

PO 2. Discipline knowledge: Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO 3. Experiments and practice: Plan to perform experiments and practices to use the results to solve broad-based Mechanical engineering problems.

PO 8. Individual and team work: Function effectively as a leader and team member in diverse/ multidisciplinary teams.

III. Competency and Skills

This practical is expected to develop the following skills for the industry identified competency ***'Use principles of kinematics and dynamics in maintenance of various equipment.'***

- Identify causes of Unbalancing of rotary element

IV. Relevant Course Outcome(s)

- Select suitable flywheel and governor for various applications.

V. Practical Outcome

- Perform balancing of rotating unbalanced system

VI. Relevant Affective Domain Unrelated Outcomes

1. Follow safety practices.
2. Practice good housekeeping.
3. Demonstrate working as a leader/a team member.
4. Maintain tools and equipment.
5. Follow ethical Practices.

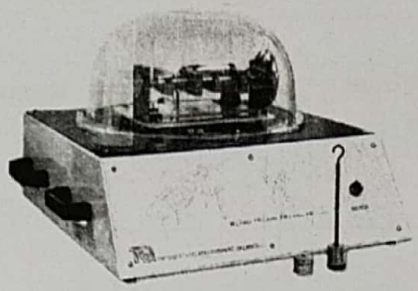
VII. Minimum Theoretical Background

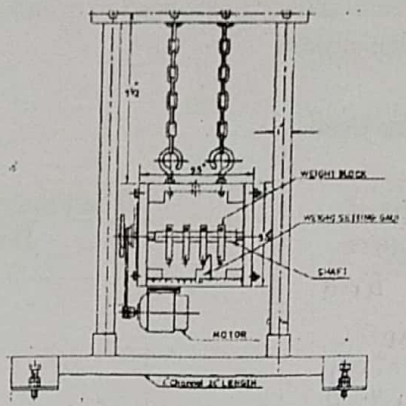
When several masses revolve in different planes, they may be transferred to a reference plane, which may be defined as the plane passing through a point on the axis of rotation and perpendicular to it. The effect of transferring a revolving mass (in one plane) to a reference plane is to cause a force of magnitude equal to centrifugal force of the revolving mass to act in the reference plane, together with a couple of magnitude equal to the product of the force and the distance between the plane of rotation and the reference plane. In order to have a complete balance of the several revolving masses in different planes, the following conditions must be satisfied:

1. The forces in the reference plane must balance i.e. the resultant force must be zero.

2. The couple about the reference plane must balance, i.e. the resultant couple must be zero.

VIII. Experimental setup





IX. Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Static & Dynamic Balancing Machine	Single phase motor connected to a shaft, containing 4 rotating masses. Each rotating mass has a facility to insert. Pulley is provided to add weights to balance the unbalance shaft	01

X. Precautions to be followed

1. Do not run the motor at low voltage i.e. less than 180 volts.
2. Increase the motor speed gradually

XI. Procedure

1. Insert all the weights in sequence 1-2-3-4 from pulley side.
2. Fix the pointer and pulley on shaft.
3. Fix the pointer on 0° (θ2) on the circular protractor scale.
4. Fix the weight no.1 in horizontal position.
5. Rotate the shaft after loosening previous position of pointer and fix it on θ3.
6. Fix the weight no. 2 in horizontal position.
7. Loose the pointer and rotate the shaft to fix pointer on θ4.
8. Fix the weight no.3 in horizontal position.
9. Loose the pointer and rotate the shaft to fix pointer on θ1.
10. Fix the weight no. 4 in horizontal position.
11. Now the weights are mounted in correct position.
12. For static balancing, the system will remain steady in any angular position.

13. Now put the belt on the pulleys of shaft and motor.
14. Supply the main power to the motor through dimmer stat.
15. Gradually increase the speed of the motor. If the system runs smoothly and without vibrations, it shows that the system is dynamically balanced.
16. Gradually reduced the speed to minimum and then switch off the main supply to stop the system.

XII. Resources Used

	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Mae	Details		
1	Static and Dynamic				
	Balancing machine				

XIII. Actual Procedure Followed

Same as given

XIV. Precautions Followed

① Do not run the motor at low voltage i.e less than 180 volts.
② Increase the motor speed gradually.

XV. Observations and Calculations

Mass of 1 = m1 gms = 400 Plane 1 = 1 Weight No. = 1

Mass of 2 = m2 gms = 160 Plane 2 = 2 Weight No. = 2

Mass of 3 = m3 gms = 300 Plane 3 = 3 Weight No. = 3

Mass of 4 = m4 gms = 200 Plane 4 = 4 Weight No. = 4

Radius 1, 2, 3, 4 = 0.04 r cm. (Same radius)

Angle between 2 & 3 = θ3 Angle between 2 & 4 = θ4 Angle between 2 & 1 = θ1

Plane	Weight No	Mass (m)	Radius (r)	Angle θ	Mass Moment (m.r)	Distance from Weight (L)	Couple (mrL)
1	1	100	0.04	0°	4	0.04	0.16
2	2	160	0.04	45°	6.5°	0.08	0.512
3	3	300	0.04	90°	12	0.12	1.44
4	4	200	0.04	135°	8	0.16	1.28

XVI. Results

we calculate the balancing of masses

XVII. Interpretation of Results.

XVIII. Conclusions

we performed the balancing of rotating unbalanced system

XIX. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers should design more such questions so as to ensure the achievement of identified CO.

1. State the causes of Unbalancing of rotary element
2. State the importance of Balancing

[Space for Answers]

Ans:1)

a: Bent or bowed between support bearings

b: Overhang weight bends shaft under gravity

c: Loose parts on the motor

d: Loose drive coupling flap about

e: Loose tolerances between assembled parts on the motor

Ans:-2)

a: Balancing plays a very important part in machines

b: Balancing in machines helps to rotating bodies to avoid vibrations; Vibration in machines can lead to failure

c: Common failure occurs in generation and heavy machinery so understanding in balancing can help to avoid machines from breaking down:

XX References / Suggestions for Further Reading

https://www.youtube.com/watch?v=p1JDMvWGdsk

Similar resources are available on internet. The students should be encouraged to search and see these resources.

XXI. Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Handling of the measuring Instruments	30%
2	Calculation of final readings	10%
Product Related (15 Marks)		**(60%)**
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5	Practical related questions	20%
Total (25 Marks)		**100 %**

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Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	