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Name _____

Roll No. _____ Year 20____20____

Exam Seat No. _____

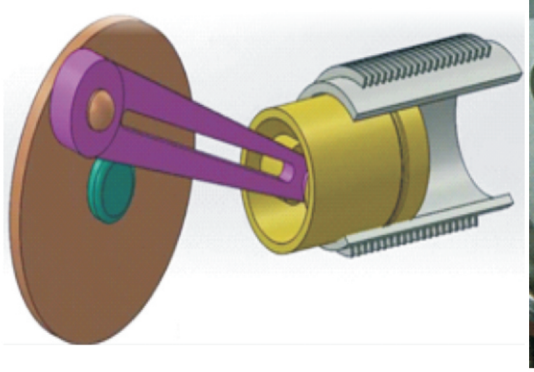
MECHANICAL GROUP | SEMESTER - IV | DIPLOMA IN ENGINEERING AND TECHNOLOGY

A LABORATORY MANUAL

FOR

THEORY OF MACHINES

(22438)



MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION, MUMBAI

(Autonomous) (ISO 9001 : 2015) (ISO / IEC 27001 : 2013)

A Practical Manual
For

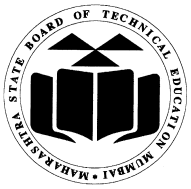
Theory of Machines

(22438)

Semester– IV

(PT/PG)

Maharashtra State
Board of Technical Education, Mumbai
(Autonomous) (ISO-9001-2015) (ISO/IEC 27001:2013)



Maharashtra State
Board of Technical Education, Mumbai

(Autonomous) (ISO-9001-2008) (ISO/IEC 27001:2013)

4th Floor, Government Polytechnic Building, 49, Kherwadi,
Bandra (East), Mumbai -400051.

(Printed on May, 2018)

Maharashtra State
Board of Technical Education

Certificate

This is to certify that Mr. / Ms ……. Roll No …….. of Third/Fourth Semester of Diploma in ……. of Institute ……..

(Code……..) has completed the term work satisfactorily in course **Theory of Machines (22438)** for the academic year 20…….to 20…..... as prescribed in the curriculum.

Place ……. Enrollment No……

Date:…..... Exam Seat No. …….....

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

Seal of the Institute

Preface

The primary focus of any engineering laboratory/ field work in the technical education system is to develop the much needed industry relevant competencies and skills. With this in view, MSBTE embarked on this innovative 'I' Scheme curricula for engineering diploma programmes with outcome-based education as the focus and accordingly, relatively large amount of time is allotted for the practical work. This displays the great importance of laboratory work making each teacher; instructor and student to realize that every minute of the laboratory time need to be effectively utilized to develop these outcomes, rather than doing other mundane activities. Therefore, for the successful implementation of this outcome-based curriculum, every practical has been designed to serve as a ***'vehicle'*** to develop this industry identified competency in every student. The practical skills are difficult to develop through 'chalk and duster' activity in the classroom situation. Accordingly, the 'I' scheme laboratory manual development team designed the practicals to ***focus*** on the ***outcomes***, rather than the traditional age old practice of conducting practicals to 'verify the theory' (which may become a byproduct along the way).

This laboratory manual is designed to help all stakeholders, especially the students, teachers and instructors to develop in the student the pre-determined outcomes. It is expected from each student that at least a day in advance, they have to thoroughly read through the concerned practical procedure that they will do the next day and understand the minimum theoretical background associated with the practical. Every practical in this manual begins by identifying the competency, industry relevant skills, course outcomes and practical outcomes which serve as a key focal point for doing the practical. The students will then become aware about the skills they will achieve through procedure shown there and necessary precautions to be taken, which will help them to apply in solving real-world problems in their professional life.

This manual also provides guidelines to teachers and instructors to effectively facilitate student-centered lab activities through each practical exercise by arranging and managing necessary resources in order that the students follow the procedures and precautions systematically ensuring the achievement of outcomes in the students.

Knowledge of various mechanisms and machines is a pre-requisite for enabling a mechanical engineer to work in an industry. This course provides the knowledge of kinematics and dynamics of different machine elements and popular mechanisms such as four link mechanisms, cam-follower, belt-pulley, chain sprocket, gears, flywheel, brake and clutch to enable a diploma holder to carry out maintenance of these and it also serves as a prerequisite for course 'Elements of Machine Design' to be studied in later semester.

Although best possible care has been taken to check for errors (if any) in this laboratory manual, perfection may elude us as this is the first edition of this manual. Any errors and suggestions for improvement are solicited and highly welcome.

Programme Outcomes (POs) to be achieved through Practical of this Course:-

Following POs and PSO are expected to be achieved through the practicals of the (Engineering Metrology) course.

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.

PO 4. **Engineering tools:** Apply relevant mechanical technologies and tools with an understanding of the limitations

Program Specific Outcomes (PSOs):-

PSO 1: Modern Software Usage: Use latest mechanical related softwares for simple design, drafting, manufacturing, maintenance and documentation of mechanical components and proceses.

PSO 2: Maintenance and selection of machines, equipment, instruments: Maintain and select appropriate machine, equipment and instrument in field of Mechanical Engineering.

PSO 3: Manage Mechanical Process: Manage the mechanical process by selection and scheduling right type of machinery, equipment, substrates, quality control techniques, operational parameters and softwares for a particular mechanical process or job for economy of operations.

List of Industry Relevant Skills

The following industry relevant skills or the competency "Use principles of kinematics and dynamics in maintenance of various equipments" are expected to be developed in you by undertaking the practicals of this laboratory manual.

a. Identify various links in popular mechanisms.
b. Select suitable mechanism for various applications.
c. Analyze the motion of cams and followers.
d. Select relevant belts, chains and drives for different applications.
e. Select relevant brakes and clutches for various applications
f. Select suitable flywheel and governor for various applications.

Practical- Course Outcome matrix

Course Outcomes (COs)

a. Identify various links in popular mechanisms.
b. Select suitable mechanism for various applications.
c. Analyze the motion of cams and followers.
d. Select relevant belts, chains and drives for different applications.
e. Select relevant brakes and clutches for various applications
f. Select suitable flywheel and governor for various applications.

S. No.	Practical Outcome	CO a.	CO b.	CO c.	CO d.	CO e.	CO f.
1.	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) • Measuring dimensions of different links of given shaper machine • Sketching • Labeling of sketch	√	-	-	-	-	-
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 II) • Measuring dimensions of different links of given shaper machine • Sketching • Labeling of sketch	√	-	-	-	-	-
3.	Estimate important kinematic data related to following mechanisms and sketch them. a) Single slider Crank mechanism	√	-	-	-	-	-
4.	Estimate important kinematic data related to following mechanisms and sketch them. a) Scotch Yoke mechanism	√	-	-	-	-	-
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).	-	√	-	-	-	-
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).	-	√	-	-	-	-

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	-	-	√	-	-	-
8.	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 II	-	--	√	-	--	-
9.	Estimate slip, length of belt, angle of contact in an open and cross belt drive.	-	-	-	√	-	-
10.	Calculate breaking torque required in different breaks at different speeds and load situations.	-	-	--	√	-	-
11.	Assemble and dissemble different clutches. (Part I)	-	-	-	-	√	-
12.	Assemble and dissemble different clutches. (Part II)	-	-	-	-	√	-
13.	Measure radius and height of all types of governors for different rotational speeds, mass of balls and spring stiffness (in spring loaded governors)	-	-	-	-	-	√
14.	Perform balancing of rotating unbalanced system	-	-	-	-	-	√

Guidelines to Teachers -

1. Teacher need to ensure that a dated log book for the whole semester, apart from the laboratory manual is maintained by every student which s/he has to submit for assessment to the teacher in the next practical session.
2. There will be two sheets of blank pages after every practical for the student to report other matters (if any), which is not mentioned in the printed practicals.
3. For difficult practicals if required, teacher could provide the demonstration of the practical emphasizing of the skills which the student should achieve.
4. Teachers should give opportunity to students for hands-on after the demonstration.
5. Assess the skill achievement of the students and COs of each unit.
6. One or two questions ought to be added in each practical for different batches. For these teachers can maintain various practical related question bank for each course.
7. If some repetitive information like data sheet, use of software tools etc. has to be provided for effective attainment of practical outcomes, they can be incorporated in Appendix.
8. For effective implementation and attainment of practical outcomes, teacher ought to ensure that in the beginning itself of each practical, students mustread through the complete write-up of that practical sheet.
9. During practical, ensure that each student gets chance and takes active part in taking observations/ readings and performing practical.
10. Teacher ought to assess the performance of students continuously according to the MSBTE guidelines

Instructions for Students

1. For incidental writing on the day of each practical session every student should maintain a dated log book for the whole semester, apart from this laboratory manual which s/he has to submit for assessment to the teacher in the next practical session.
2. For effective implementation and attainment of practical outcomes, in the beginning itself of each practical, students need to read through the complete write-up including the practical related questions and assessment scheme of that practical sheet.
3. Student ought to refer the data books, IS codes, Safety norms, Electricity act/rules, technical manuals, etc.
4. Student should not hesitate to ask any difficulties they face during the conduct of practicals.

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)
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					
8.							
9.	Estimate slip, length of belt, angle of contact in an open and cross belt drive.	30					
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.

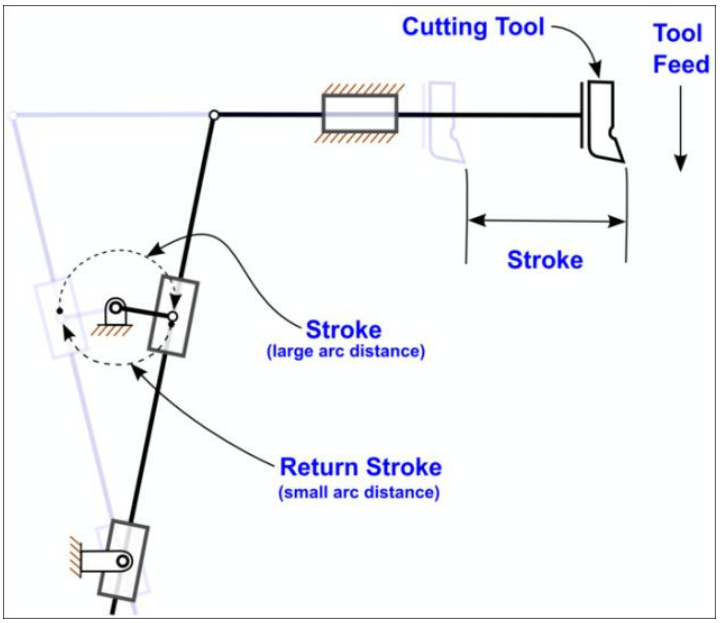


Figure 1 :Schematic of the quick return mechanism used in shaper machine

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.					
2.					
3.					

XIII. Actual Procedure Followed

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XIV. Precautions Followed

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XV. Observations and Calculations

a. Identification of kinematic pair

Name of First Link	Name of Second Link	Type of Kinematic pair

b. Ratio of cutting to idle time

Details	Time (s)		Time Ratio
	Cutting Stroke	Return Stroke	
Reading 1			
Reading 2			

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

Calculations

Calculations of time ratios

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XVI. Results

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XVII. Interpretation of Results

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XVIII. Conclusions

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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]

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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. ……
2. ……
3. ……
4. ……

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

Practical No. 3 &4: Measurement of Kinematic Data of Mechanisms

I. Practical Significance

A mechanism is one in which one of the links of a kinematic chain is fixed. Different mechanisms can be obtained by fixing different links of the same kinematic chain. These are called as inversions of the mechanism. By changing the fixed link, the number of mechanisms which can be obtained is equal to the number of links. The inversion of a mechanism does not change the motion of its links relative to each other.

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.'***

a) Collect the kinematic data from given mechanism
b) Identify the inversions of Mechanism

IV. Relevant Course Outcome(s)

- Identify various links in popular mechanisms.

V. Practical Outcomes

- Estimate important kinematic data related to following mechanisms and sketch them.
  a. Single slider Crank mechanism
  b. Scotch Yoke Mechanism

VI. Relevant Affective Domain Unrelated Outcomes

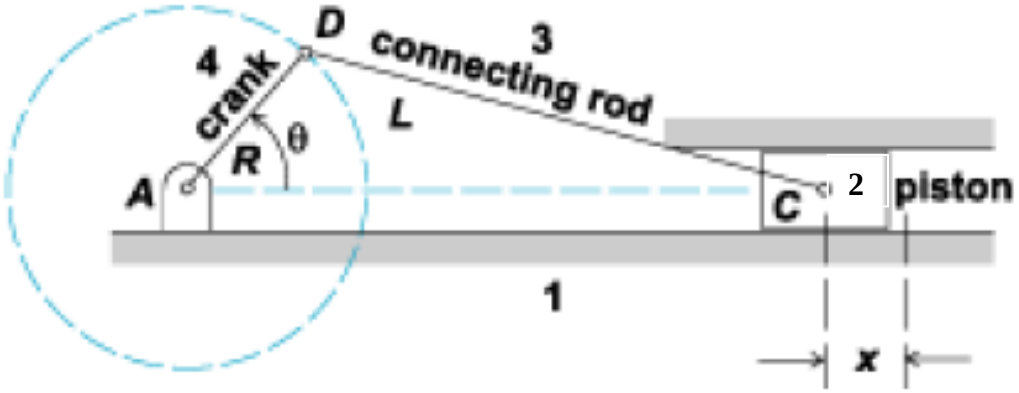
A. Follow safety practices.
B. Practice good housekeeping.
C. Demonstrate working as a leader/a team member.
D. Maintain tools and equipment.
E. Follow ethical Practices

VII. Minimum Theoretical Background

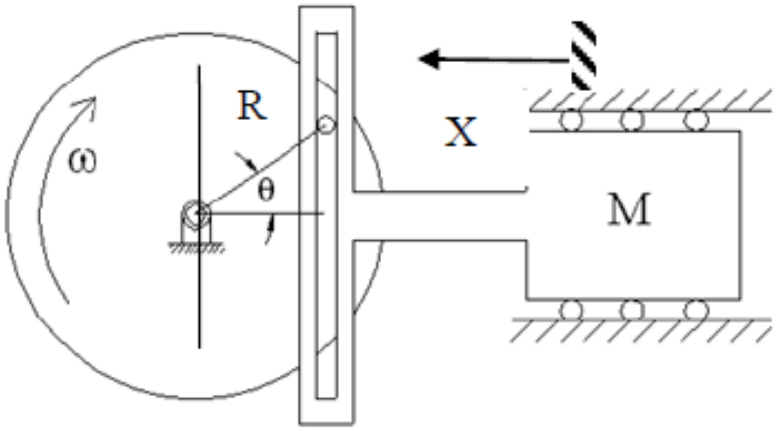
It is important to study the Kinematic response of the mechanism because of practical applications. It is also useful in determining the Kinematic equivalents of other mechanisms. While the motion of a Scotch-yoke mechanism is purely sinusoidal, that of the Slider-crank mechanism is not. Kinamatic data such as displacement, velocity and acceleration of a simple Slider-crank mechanism can be obtained and compare the same with Scotch yoke Mechanism.

VII. Experimental setup

a) Single Slider Crank Mechanism



b) Scotch yoke Mechanism



VIII. Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Working Model of Single slider Crank mechanism	Scale for Displacement, Angle measuring arrangement,1/4 HP motor	1
2	Working Model of skotch Yoke Mechanism	Scale for Displacement, Angle measuring arrangement,1/4/HP motor	1
3	Tachometer	Range speed upto 2000RPM	1

IX. Precautions to be followed

1. Do not rotate the Mechanism with high speed

X. Procedure

1. Set the slider crank at 0 mm for the connecting rod, and 0° for the rotating disk.
2. Measure L the length of the connecting rod and R the radius for the rotating disk.
3. Change the angle for the disk by 30° each time until 360°, and each time measure X.
4. Plot the graphs of linear displacement, ‘X’, velocity ‘V’ and acceleration ‘a’ versus angular displacement.
5. Repeat the procedure for Scotch-Yoke mechanism.

XI. Resources Used

S. No	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					

XII. Actual Procedure Followed

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XIII. Precautions Followed

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XIV. Observations and Calculations

a) For single Slider Crank Mechanism

Angular Displacement (θ)	position X (mm)	Velocity V (mm/ sec)	Acceleration a (mm/sec^2)
0			
30			
60			
90			
120			
150			
180			

b) For Scotch yoke Mechanism

Angular Displacement (θ)	position X (mm)	Velocity V (mm/ sec)	Acceleration a (mm/sec^2)
0			
30			
60			
90			
120			
150			
180			

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Calculations

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XV. Results

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XVI. Interpretation of Results

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XVII. Conclusion and Recommendations

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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 the different inversions of single slider crank Mechanism
2. Name four applications of Single crank Mechanism

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XX References / Suggestions for Further Reading

- www.youtube.com/watch?v=HhX-8RyP214
- https://www.youtube.com/watch?v=zo0rPb-i6G4

XIX. 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. ……
2. ……
3. ……
4. …….

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

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.					
2.					
3.					

XIV. Actual Procedure Followed

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XV. Precautions Followed

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XVI. Observations and Calculations

a. Lengths of various links

Name of the Link	Length(m)

b. **Angular speed of crank**

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

Calculations

Calculation of angular, linear velocities and accelerations of various links

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XVII. Results

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XVIII Interpretation of Results

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XIV Conclusions

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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]

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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. ……...
2. ……..….……
3. ……
4. ……

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

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

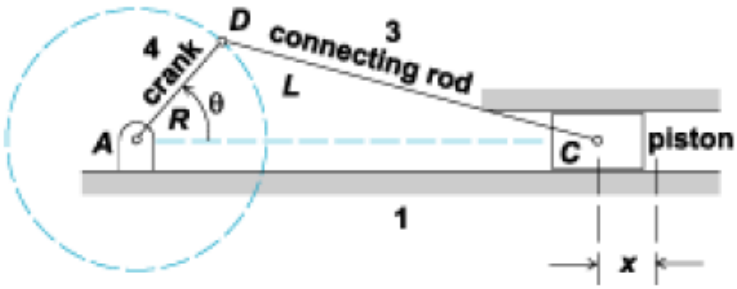
VI. Relevant Affective Domain Unrelated Outcomes

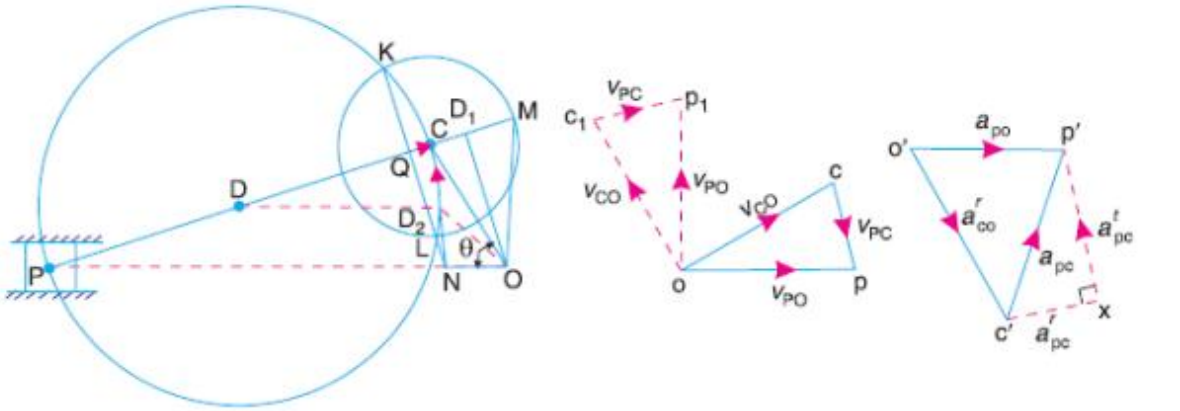
1) Follow safety practices.
2) Practice good housekeeping.
3) Demonstrate working as a leader/a team member.
4) Maintain tools and equipment.
5) Follow ethical Practices.

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

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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.					
2.					
3.					

XIII. Actual Procedure Followed

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XIV. Precautions Followed

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XV. Observations and Calculations

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

Angle made by crank with line of stroke θ =

Calculations

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XVI. Results

Details	
Velocity of piston	
Angular velocity of connecting rod	
acceleration of piston	
Radial component of Acceleration of connecting rod	
Tangential component of Acceleration of connecting rod	
Total component of Acceleration of connecting rod	

XVII. Interpretation of Result

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XVIII. Conclusions

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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]

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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. ……..…
2. ……...
3. ……
4. ……

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

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

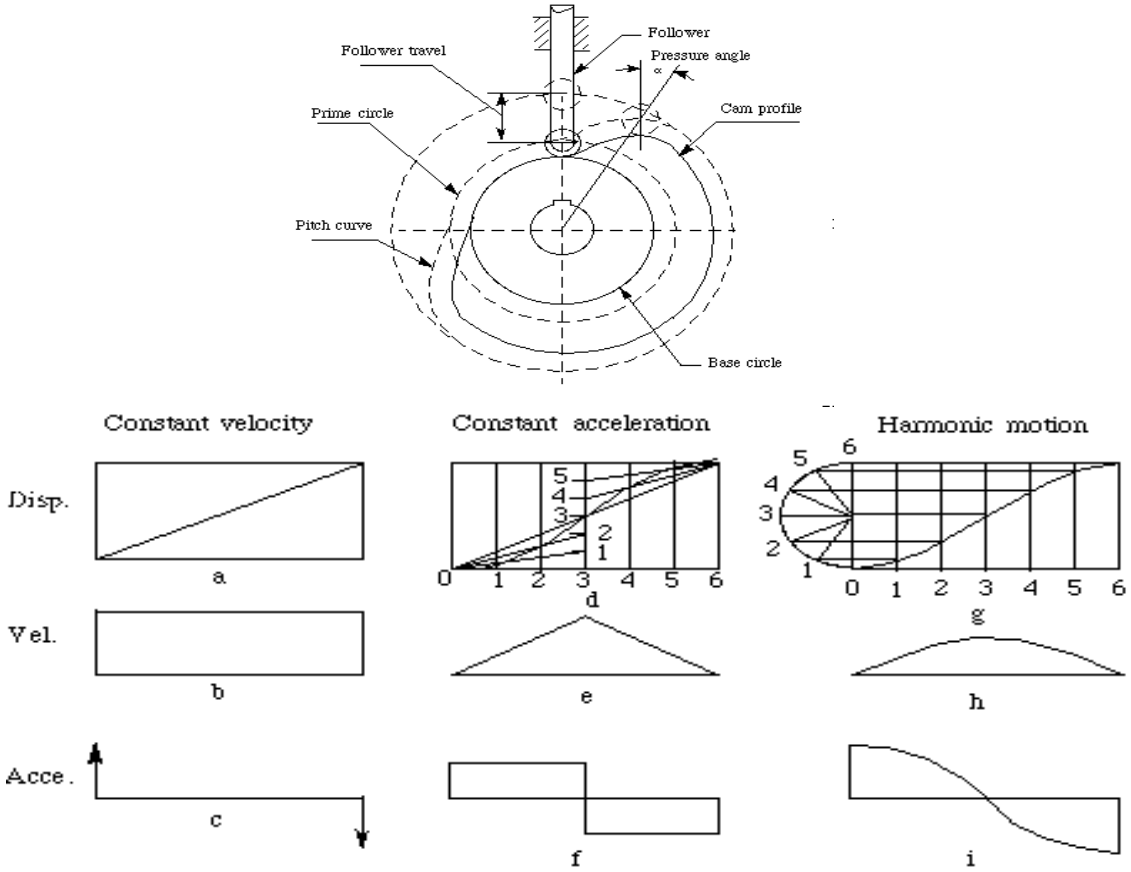
VI. Relevant Affective Domain Unrelated Outcomes

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

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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.					
2.					
3.					

XIII. Actual Procedure Followed

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XIV. Precautions Followed

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XV. Observations and Calculations

Sr No	Details	Problem1	Problem2	Problem3	Problem4
1	Type of follower				
2	Type of cam				
3	Lift of cam				
4	Offset of cam				
5	Follower motion with angle of cam (Acceleration, dwell, deceleration)				
6	Minimum radius of cam				
7	Roller radius				
8	Any other Information				

XVI. Results

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XVII. Interpretation of Results

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XVIII. Conclusions

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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]

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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. ……..……...
2. ……
3. ……..……
4. ……

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

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.					
2.					
3.					

XIII. Actual Procedure Followed

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XIV. Precautions Followed

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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

Speed of driven pulley without slip = (N2) =

Using Formula for velocity ratio,

(N2) theoretical = N1 * D1/D2 = ……. = …… rpm.

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

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

Hence, total percentage slip‘s’ is given by,

$$\frac{N_2}{N_1} = \frac{D_1}{D_2}\left(1 - \frac{s}{100}\right)$$

$\therefore$ Slip, s =

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 = m

Angle of lap or contact,

$$\theta = 180° - 2\alpha$$

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

R_1 & R_2 = Radii of Pulleys

$\therefore$ θ =……..radian.

XVI. Result

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XVII. Interpretation of Results

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XVIII. Conclusions

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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.

[Space for Answers]

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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. ……..
2. …….
3. ……..……
4. …….

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

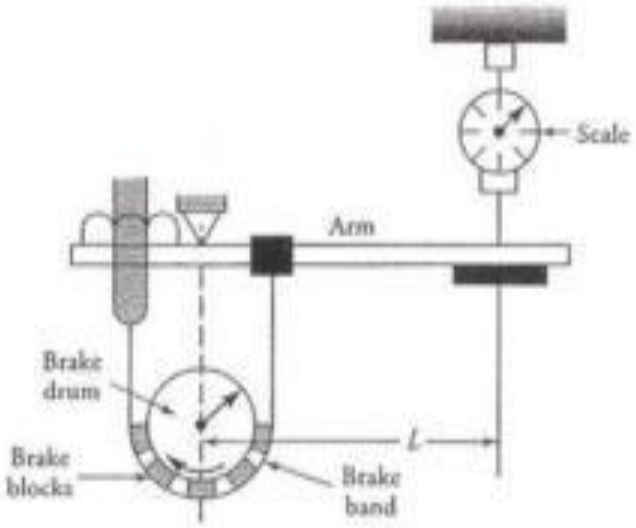
VI. Relevant Affective Domain Unrelated Outcomes

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	Details		
1.					
2.					
3.					

XIII. Actual Procedure Followed

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XIV. Precautions Followed

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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					
3					

Calculations

Braking Torque = $F_T R$ N.mm

F_T = Tangential Braking Force N

R = Radii of the Brake Drum mm

$F_T = (T_1 - T_2)$

T_1 = Tension on Tight side

T_2 = Tension on Slack side

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

μ = Coeff. of Friction

Θ =Angle of Contact

Braking Torque = N.mm

XVI. Results

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XVII. Interpretation of Results

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XVII. Conclusions

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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

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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. ……
2. ……
3. ……
4. …….

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

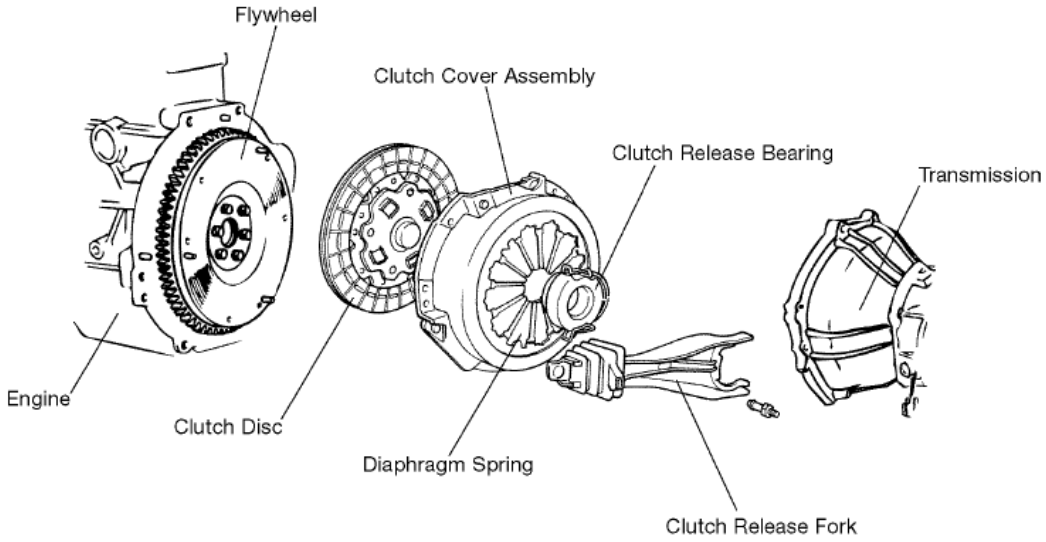
VI. Relevant Affective Domain Unrelated Outcomes

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.					
2.					
3.					

XIII. Actual Procedure Followed

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XIV. Precautions Followed

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XV. Observations and Calculations

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

Sr No	Name of Part	Functions

b. Draw the sketches of Following Parts

Name of Part	**Sketch**
Clutch plate	
Pressure plate	

XVI. Results

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XVII. Interpretation of Results

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XVIII. Conclusions

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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]

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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. ……
2. ……
3. ……
4. ……

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.					
2.					
3.					

XIII. Actual Procedure Followed

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XIV. Precautions Followed

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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

Calculations

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

H = h - X/2 =

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

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XVII. Interpretation of Results

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XVIII. Conclusions

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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]

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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. ……
2. ……
3. ……
4. ……

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.

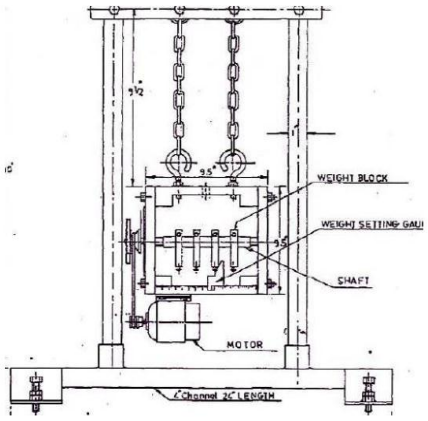
VII. Minimum Theoretical Background

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		

XIII. Actual Procedure Followed

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XIV. Precautions Followed

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XV. Observations and Calculations

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

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

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

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

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

Angle between 2 & 3 = $\theta 3$ Angle between 2 & 4 = $\theta 4$ Angle between 2 & 1 = $\theta 1$

Plane	Weight No	Mass (m)	Radius (r)	Angle θ	Mass Moment (m.r)	Distance from Weight (L)	Couple (mrL)

XVI. Results

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XVII. Interpretation of Results.

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XVIII. Conclusions

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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]

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XX References / Suggestions for Further Reading

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

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XXI. Assessment Scheme

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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. ……
2. ……
3. ……
4. …….

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