MECHANICAL ENGINEERING

ESE TOPICWISE

CONVENTIONAL SOLVED PAPER-II

1995-2019

IES MASTER PUBLICATION

Office: F-126, (Lower Basement), Katwaria Sarai, New Delhi-110 016

Phone: 011-2652 2064 ▪ **Mobile:** 81309 09220, 97118 53908

Email: info.publications@iesmaster.com, info@iesmaster.org

Web: iesmasterpublications.com, iesmaster.org

IES MASTER PUBLICATION

F-126, (Lower Basement), Katwaria Sarai, New Delhi-110016

Phone : 011-26522064, **Mobile :** 8130909220, 9711853908

E-mail : info.publications@iesmaster.com

Web : iesmasterpublications.com

First Edition : 2017

Second Edition : 2018

Third Edition : 2019

Typeset at : IES Master Publication, New Delhi-110016

PREFACE

Engineering Services Exam (ESE) is one of most coveted exams written by engineering students aspiring for reputed posts in the various departments of the Government of India. ESE is conducted by the Union Public Services Commission (UPSC), and therefore the standards to clear this exam too are very high. To clear the ESE, a candidate needs to clear three stages – ESE Prelims, ESE Mains and Personality Test.

It is not mere hard work that helps a student succeed in an examination like ESE that witnesses lakhs of aspirants competing neck to neck to move one step closer to their dream job. It is hard work along with smart work that allows an ESE aspirant to fulfil his dream.

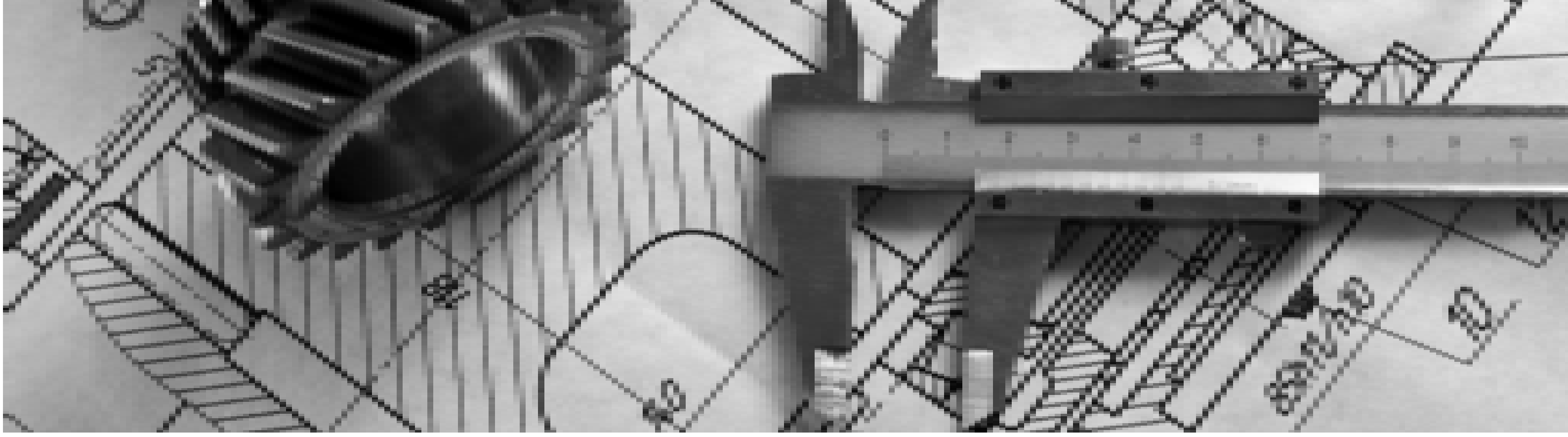
After detailed interaction with students preparing for ESE, IES Master has come up with this book which is a one-stop solution for engineering students aspiring to crack this most prestigious engineering exam. The book includes previous years' solved conventional questions segregated Topicwise along with detailed explanation. This book will also help ESE aspirants get an idea about the pattern and weightage of questions asked in ESE.

IES Master feels immense pride in bringing out this book with utmost care to build upon the exam preparedness of a student up to the UPSC standards. The credit for flawless preparation of this book goes to the entire team of IES Master Publication. Teachers, students, and professional engineers are welcome to share their suggestions to make this book more valuable.

IES MASTER PUBLICATION
NEW DELHI

CONTENTS

1.	THEORY OF MACHINES	01 – 126
2.	STRENGTH OF MATERIALS	127 – 235
3.	MACHINE DESIGN	236 – 342
4.	PRODUCTION ENGINEERING	343 – 579
5.	INDUSTRIAL ENGINEERING	580 – 664
6.	MECHATRONICS AND ROBOTICS	665 – 689



UNIT-1 THEORY OF MACHINES

SYLLABUS

Types of Kinematics Pair, Mobility, Inversion, Kinematic Analysis, Velocity and Acceleration Analysis of Planar Mechanisms, CAMs with Uniform Acceleration and Retardation, Cycloidal Motion, Oscillating Followers, Vibrations-Free and Forced Vibrations of Undamped and Damped SDOF Systems, Transmissibility Ratio, Vibration Isolation, Critical Speed of Shafts. Gears-Geometry of Tooth Profiles, Law of Gearing, Involute Profile, Interference, Helical, Spiral and Worm Gears. Gear Trains-Simple, Compound and Epicyclic. Dynamic Analysis-Slider-Crank Mechanisms, Turning Moment Computations, Balancing of Revolving and Reciprocating Masses. Gyroscopes-Effect of Gyroscopic couple on Automobiles, Ships and Aircrafts, Governors.

CONTENTS

Chapter No.	Topic	Page No.
1.	Mechanisms	01 – 10
2.	Velocity and Acceleration	11 – 19
3.	CAMS and Governor	20 – 36
4.	Gears and Gear Trains	37 – 66
5.	Slider Crank Mechanism, Flywheel and Hooke’s Joint	67 – 79
6.	Balancing of Masses	80 – 102
7.	Vibration Analysis	103 – 124
8.	Gyroscope	125 – 126

CHAPTER 1

MECHANISMS

Q–1: ***What is kinematic pair? How are kinematic pairs classified? Explain.***

[6 Marks ESE–2019]

Sol: **Kinematic Pair:** When two links of a machine is in contact, this contact is called a pair. If the motion between the links forming the pair is in a specific directions irrespective of the directions of force, the pair is called kinematic pair and the motion of link is called as completely or successfully constrained.

Classification of Kinematic Pair

(1) Kinematic Pairs according to Relative Motion between links

(a) Turning Pair

(b) Sliding Pair

(c) Rolling Pair

(d) Screw Pair

(e) Spherical Pair

(2) Kinematic pair According to Nature of Contact

(a) Lower Pair

(b) Higher Pair

(3) Kinematic pair According to Mechanical construction

(a) Closed Pair

(b) Open (Forced-closed) Pair

Q–2: ***Distinguish and differentiate between machine and mechanism. Define the term inversion of a kinematic chain.*** ***[6 Marks ESE–2018]***

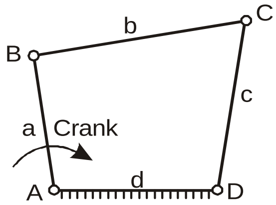
Sol: Difference Between Machine and Mechanism

Machine	Mechanism
(i) A machine is mechanism or a collection of mechanism which transmit force from the source of power to the resistance to be overcome and thus perform a mechanical work.	(i) A mechanism is a combination of rigid or restraining bodies so shaped and connected that they move upon each other with a definite relative motion.
(ii) Machine may have many mechanisms for transfer of force/motion.	(ii) It is the skeleton outline of machine to produce definite motion between links. No links is fixed/grounded.
Examples Lathe machine–motion + force i.e. work done	**Examples** Mechanical clock, typewriter, Engine p–V diagram, drawing Indirector Mechanical clock : No power output i.e. energy stored (spring work) is used to run the hands.

Inversion of kinematic chain: The process of fixing different links of a kinematic chain one at time to produce distinct mechanism is called kinematic inversion. Here the relative motion of the links of the mechanism remains unchanged.

Q–3: Discuss about the possible inversions (with figures) of a four bar chain. [6 Marks ESE–2018]

Sol: **Inversion of four bar Chain :** The process of fixing different links of a kinematic chain is known as kinematic inversion.



Consider a 4-bar mechanism shown in the figure.

The length of four links are a, b, c and d as shown in figure.

Now fix each link one by one and get a different inversion,

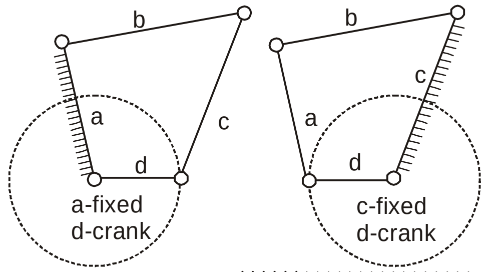
(a) Shortest length link ‘d’ is fixed i.e. d < b, c,a.

Sum of shortest and longest link length is less than sum of rest two.

- In above conditions both ‘a’ and ‘c’ can make full revolution and ‘b’ also make full revolution relative to fixed link ‘d’. This type of mechanism is called as crank-crank, or double cranks or rotatory-rotatory or drag-crank mechanism.

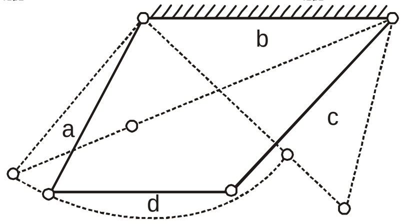
(b) Link adjacent to Shortest (a or c) is fixed

- Both the cases, ‘d’ makes complete revolution.
- But link ‘b’ oscillates.
- This mechanism is called as crank-rocker or crank-lever or rotatory-oscillatory mechanism.



(c) Fix link ‘b’ opposite to shortest link

Here links adjacent to shortest i.e. ‘a’ and ‘c’ can oscillate only. This mechanism is called as double rocker or double lever or oscillating-oscillating mechanism as Class-II of mechanism when sum of shortest and longest links is more than sum of rest two.



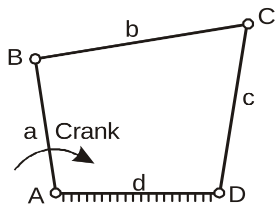
Q–4: Explain Grashof’s linkage. Explain the inversions of this linkage. [4 Marks ESE–2015]

Sol: A very important consideration when designing a mechanism is to ensure that the input crank can make a complete revolution. Mechanisms in which no link makes a complete revolution would not be useful in such applications. Grashof’s law states that for a planar four-bar linkage, the sum of the shortest and longest link lengths cannot be greater than the sum of the remaining two link lengths if there is to be continuous relative rotation between two members. Let the longest link has length *l*, the shortest link has length s, and the other two links have lengths p and q. In this notation. Grashof’s law states that one of the links, in particular the shortest link, will rotate continuously relative to the other three links if and only if

$$s + l \leq p + q$$

If this inequality is not satisfied, no link will make a complete revolution relative to another.

By fixing different links one by one in a mechanism, different mechanisms are obtained. This process of getting different mechanism is called inversion of mechanisms. The relative motion between the links remain same irrespective of any link fixed.



1. Inversion of Four Bar Chain

Consider a 4-bar mechanism shown in the figure.