1. Introduction

1.1 Evolution of Theory of Mechanisms and Machines

The names of TMM (Theory of Mechanisms and Machines), are related to fields of Mechanical Engineering concerning with Mechanisms in broad sense. TMM is often misunderstood even in the engineering community, although it is recognized as the specific discipline of Mechanical Engineering related with mechanisms and machines. The meaning of TMM can be clarified by looking at the meaning of the topic over time through few definitions by significant Authors as in the following short list:

by Marco Pollione Vitruvius (he lived in 1st century B.C.), translated and discussed by Fra Giocondo in (1151): “A machine is a combination of materials and components that have the capability of moving weights”;

by Galileo Galilei in (1593): “A machine is a means by which a given weight will be transported to a given location by using a given force”;

by Jacob Leupold in (1724): He treated the description of machines and mechanisms referring to “their aim of modifying motion rather than just the construction of machinery”;

by Josè Maria de Lanz and Augustin de Betancourt in (1808): “In agreement with Mr. Monge, we consider as elements of machines the devices than can change the direction of the movements… the most complicated machines are only combinations of those capable of single movements”;

by Robert Willis in (1841): “I have employed the term Mechanisms as applying to combinations of machinery solely when considered as governing the relations of motion. Machinery as modifier of force”;

by Franz Reuleaux in (1875): “A machine is a combination of bodies capable of withstanding deformation, so arranged as to constrain the (mechanical) forces of nature to produce prescribed effect in response to prescribed input motions”.

by Francesco Masi in (1897): “Hence we name: as mechanism a kinematic chain that has been fixed on one of its components; as machine a mechanism whose components make mechanical work”;

by Richard S. Hartenberg and Jacques Denavit in (1964): “The term machine is associated with the use and transformation of force, and although motion is varying degree is encountered in a machine, the idea of force dominates. Mechanism, on the other hand, definitely conjures up the idea of motion, and while forces do exist, they are relatively small and unimportant compared with the exploitation of motion”.

In addition, the International Federation for the Promotion of MMS (IFToMM 1991) terminology gives:

- Machine: mechanical system that performs a specific task, such as the forming of material, and the transference and transformation of motion and force.
- Mechanism: system of bodies designed to convert motions of, and forces on, one or several bodies into constrained motions of, and forces on, other bodies.

The meaning for word “Theory” needs further explanation. The Greek word for Theory comes from the corresponding verb, whose main semantic meaning is related both with examination and observation of existing phenomena. But, even the Classic language the word theory includes practical aspects of observation as experiencing the reality of the phenomena, so that theory means also practice of analysis results. In fact, this last meaning aspect is what was included in the discipline of modern TMM as Gaspard Monge (1746-1818) established it in the Ecole Polytechnique, (Chasles 1886), at the beginning of XIXth century (see for example the book by Lanz and Betancourt (1808), whose text include early synthesis procedures).

In conclusion since the modern assessment, TMM has been considered as a discipline, which treats analysis, design and practice of mechanisms and machines. This will be also in the future, since we shall always have mechanical devices related with life and working of human beings. These mechanical devices need to be designed and enhanced with approaches from mechanical engineering because of the mechanical reality of the environment where the human beings will always live, although new technology will substitute some components or facilitate the operation of mechanical devices.

The term MMS (Machines and Mechanism Science has been adopted within the IFToMM Community since the year 2000 (IFToMM Constitution 2000) after a long discussion, with the aim to give a better identification of the enlarged technical content and broader view of Mechanism knowledge and practice.

Indeed, the use of the term MMS has also stimulated an in-depth revision in the IFToMM terminology so that in a current proposal one can find the definition of MMS as (IFToMM PC for Terminology 2002):

- Mechanism and Machine Science: Branch of science, which deals with the theory and practice of the geometry, motion, dynamics, and control of machines, mechanisms, and elements and systems thereof, together with their application in industry and other contexts, e.g. in Biomechanics and the environment. Related processes, such as the conversion and transfer of energy and information, also pertain to this field.

The evolution of the name from TMM to MMS can be considered as due both to an enlargement of technical fields to an Engineering Science but even to a great success in research and practice of TMM.

Mechanisms and Machines have addressed attention since the beginning of Engineering Technology and they have been studied and designed with successful activity and specific results. But TMM have reached a maturity as independent discipline only in XIXth century. It is usually said that TMM activity has been started with the foundation of the Ecole Polytechnique in Paris in 1794, at which the formation of industrial engineers was a specific goal with a specific teaching. The need for a Technical University was required by a need of properly educated engineers for the developing Industrial Revolution. Thus, the previous curricula at Universities or at Military Schools were not considered satisfactorily oriented to form engineers for growing industrial environments.

The maturity of TMM can be recognized when the teaching of TMM has been recognized as fundamental in the Engineering Academic curricula. We can fix the start of the Golden Age for TMM in the year 1831, when TMM discipline was considered as fundamental also at Sorbonne University in Paris. Just after, many other Universities in Europe have started courses on TMM, that were named on Kinematics as regular fundamental courses. At the same time, professional skill on Mechanism Design has enhanced machinery and industrial process over the XIXth century during the Industrial Revolution.

Thus, the successful activity increase was carried out at Universities both in teaching and research on TMM. The first approach by Monge was enlarged and criticized but was the inspiration to deepen Mechanism Analysis and Design through a mathematization that gave mainly graphical procedures and first analytical algorithms. After Monge's classification there were several attempts to have a unified view of mechanisms. Those mechanism classifications were proposed with a descriptive approach, like in (Giulio 1846); with an enlarged analysis of mechanism connections, like in (Willis 1841); by using the kinematic chain concept, like in (Reuleaux 1875), ; and even with practical view and formulation, like in (Masi 1883).

The analysis of mechanism was mathematized with suitable formulation even through closed-form expressions by using suitable kinetic models (Chebyshev 1899). In particular, the analytical approach of Chebyshev can be considered as fundamental in the modern mathematization process of mechanism analysis and design not only from historical viewpoint but still yet from practical engineering viewpoint for development of algorithms for design purposes.

Discovering and formulating basic kinematic and dynamic properties for practical procedures enhanced the analysis of mechanisms. Significant is the analysis of velocity and acceleration of mechanisms through the application of the relative motion in the form of vector sum. This analysis was well established at the end of the XIX-th century and it has been so widely applied that it is still a successful taught in courses on MMS.

Thus, the Golden Age of TMM can be considered in the second half of the XIX-th century when intense activity in teaching, research and practice on TMM was well established by giving as main results enhancements in machinery and automation in industrial processes.

At the beginning of the XX-th century TMM has been further assessed with great design activity. Mechanism designs achieved high complexity, never seen before, and they required further enhancements of analysis procedures, mainly for modeling and numerical aspects. At the same time 3D motion was attached not only from pure academic interest and was studied also to give first practical procedures.

The increased needs of industrial applications stimulated re-consideration of TMM with a modern view that is directed mainly to more efficient numerical calculations, yet on graphical basis, for optimized solutions. Thus, even new kinematic properties were re-discovered and newly formulated. New approaches were attempted as the successful case of matrix representation of mechanisms. In this period a great success of TMM can be recognized as due to demands of Industry for machinery and automatic systems with higher and higher speed and efficiency.

Modern TMM has approached the multi-dofs motions and 3D mechanisms. These subjects have requested further enhancement of knowledge and use of new means for developing and operating new solutions. Historically, TMM has included as main disciplines: Mechanism Analysis and Synthesis; Mechanics of Rigid Bodies, Mechanics of Machinery; Machine Design; Experimental Mechanics; Teaching of TMM; Mechanical Systems for Automation; Control and Regulation of Mechanical Systems; Rotor Dynamics; Human-Machine Interfaces; Biomechanics.

Although the future Technology seems to be directed mainly to Informatics and Electronics means, mechanical systems will be always needed since the mechanical nature of human beings -environment interaction. Therefore, mechanism and mechanical devices will be always needed but they will be asked with enhanced designs and performances.

1.2 Study Object

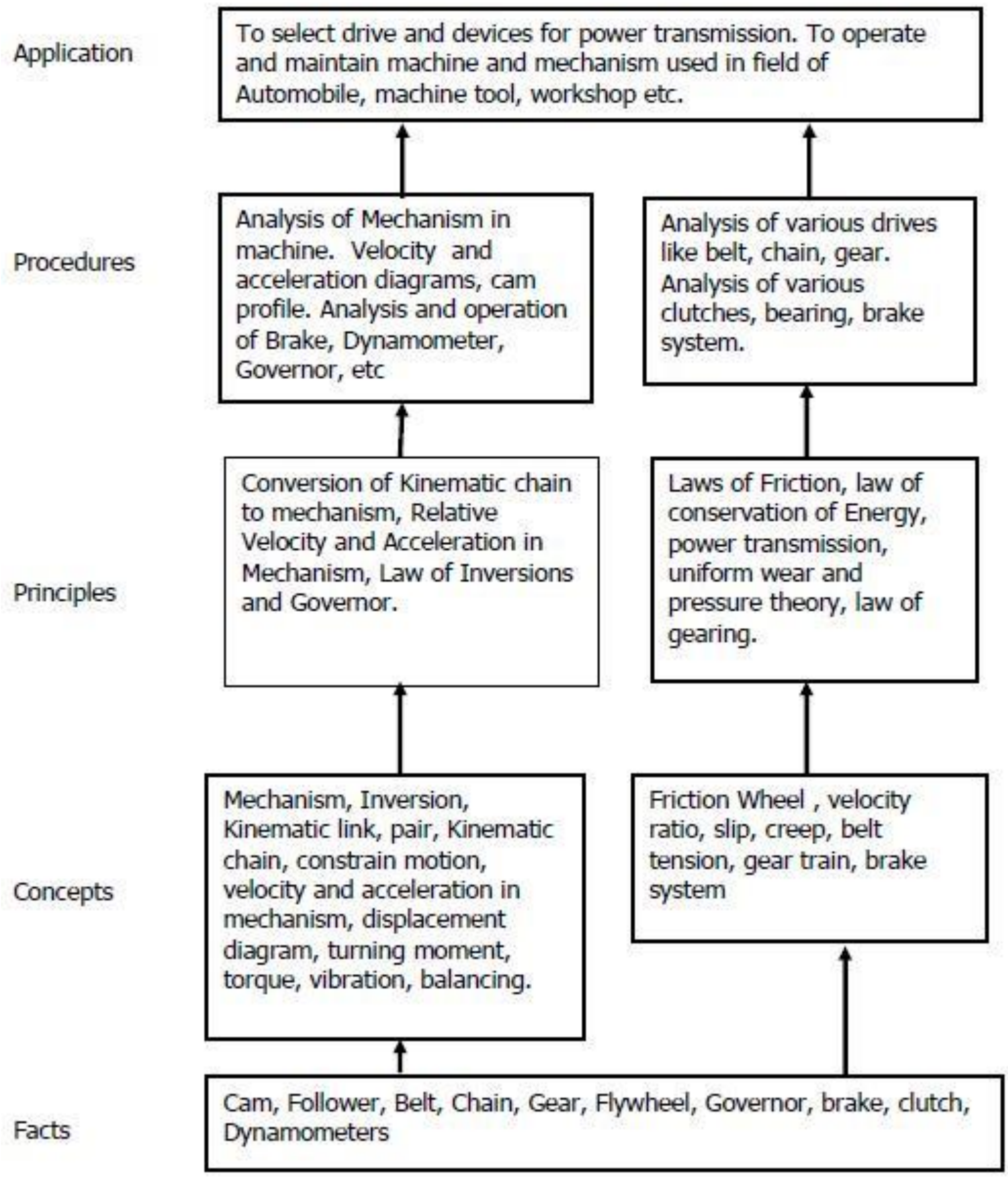
Rationale:

It is a core Technology subject in Mechanical Engineering Discipline. Mechanical Engineering Diploma Holders often come across various mechanisms in practice. He should be able to analyze, identify and interpret various mechanisms and machines in day-to-day life. In maintaining various machines, a diploma technician should have sound knowledge of fundamentals of machine and mechanism. It will be helpful to technician to understand the mechanisms from operational point of view in better way. This subject imparts the facts, concepts, principles, procedure, kinematics and dynamics involved in different machine elements and mechanisms like lever, gear, cam, follower, belt, flywheel, brake, dynamometer, clutch, etc.

Detail knowledge of above-mentioned aspect with deep insight to the practical applications develops a professional confidence in them to become successful Engineer.

Student will be able to:

1. Know different machine elements and mechanisms.
2. Understand Kinematics and Dynamics of different machines and mechanisms.
3. Select Suitable Drives and Mechanisms for a particular application.
4. Appreciate concept of balancing.
5. Develop ability to come up with innovative ideas.



Objectives:
1. To study Mechanics of machines, principles and also it's related application areas.
2. To familiarize with various types of Mechanisms and Motion analysis.
3. To develop problem solving capabilities in the topics of velocity and acceleration.
4. To study kinematics and kinetics of simple machine elements and devices.
5. To provide an understanding and appreciation of the variety of mechanisms employed in
modem complex machines, such as automobiles, machine tools etc.

Outcomes: The learner should able to>
1. Understand the rigid body dynamics (kinematics) of linkages, design of four bar mechanisms, gyroscopic devices etc.
2. Understand the direct relevance of problems discussed in engineering practice.
3. Understand validation of certain theoretical models thorough laboratory experiments.

4. determine degrees of freedom for a link and kinematic pair,
5. describe kinematic pair and determine motion,
6. distinguish and categories different type of links,
7. know inversions of different kinematic chains,
8. understand utility of various mechanisms of four bar kinematic chain,
9. make kinematic design of a mechanism,
10. know special purpose mechanisms,
11. know terminology of cams, and
12. know classification of followers and cams.