Lecture 1

Introduction

INTRODUCTION

- Purpose
- Theory of Machines
- Kinematics and Kinetics
- Machines and Mechanisms
- A Brief History of Kinematics
- Applications of Kinematics

PURPOSE

- The purpose of this course is to explore the topics of **kinematics** and **dynamics of machinery** in respect to the **synthesis of mechanisms** in order to accomplish desired motions or tasks, and also the **analysis of mechanisms** in order to determine their rigid-body dynamic behavior.
- We will begin with careful definitions of the terms used in these topics.

THEORY OF MACHINES

- The subject **Theory of Machines** may be defined as that *branch of Engineering-science, which deals with the study of relative motion between the various parts of a machine, and forces which act on them*. The knowledge of this subject is very essential for an engineer in designing the various parts of a machine.

KINEMATICS AND KINETICS

- **Kinematics**

  The study of motion without regard to forces.
- **Kinetics**

  The study of forces on systems in motion.
- These two concepts are really *not physically separable*. One principal aim of kinematics is to create (design) the desired motions of the subject mechanical parts and then mathematically compute the positions, velocities, and accelerations which those motions will create on the parts.

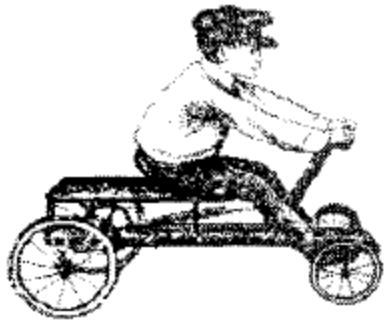
MACHINES AND MECHANISMS

- A **mechanism** is a device which transforms motion to some desirable pattern and typically develops very low forces and transmits little power.
- A **machine** typically contains mechanisms which are designed to provide significant forces and transmit significant power.

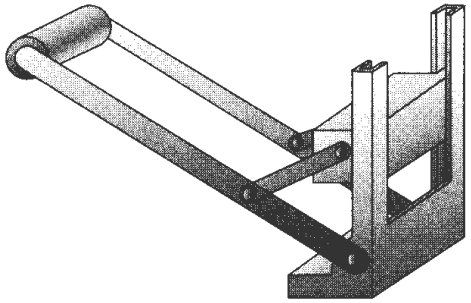
MACHINES AND MECHANISMS

- A useful working definition of a **mechanism** is *A system of elements arranged to transmit* **motion** *in a predetermined fashion.*
- On the other hand, a ***machine*** is *A system of elements arranged to transmit* **motion and energy** *in a predetermined fashion.*
- Some of the examples of mechanisms and machines are:

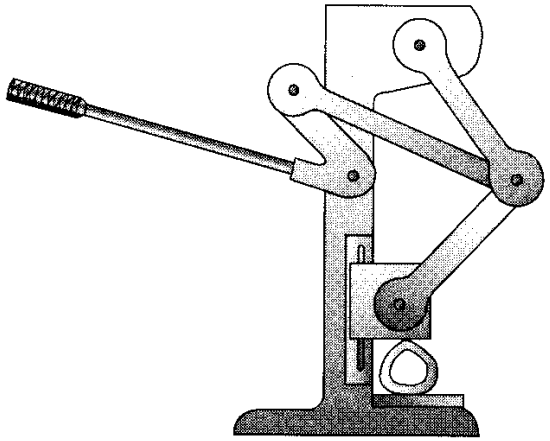
MECHANISMS



A mechanism

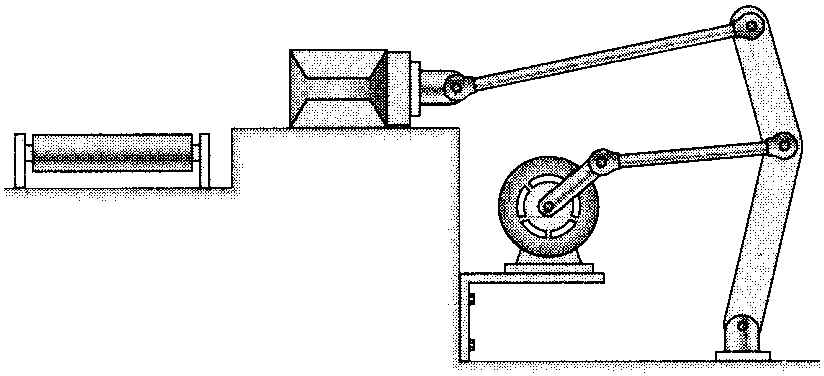


Can crusher



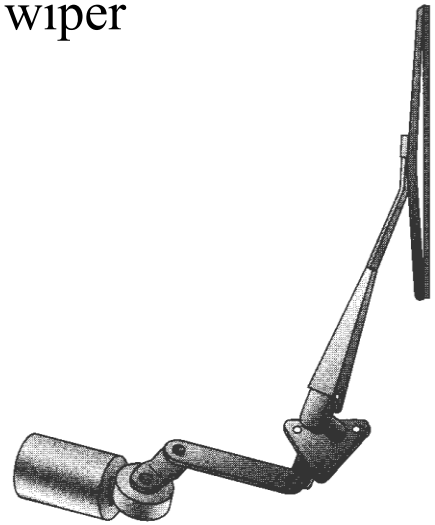
Simple press

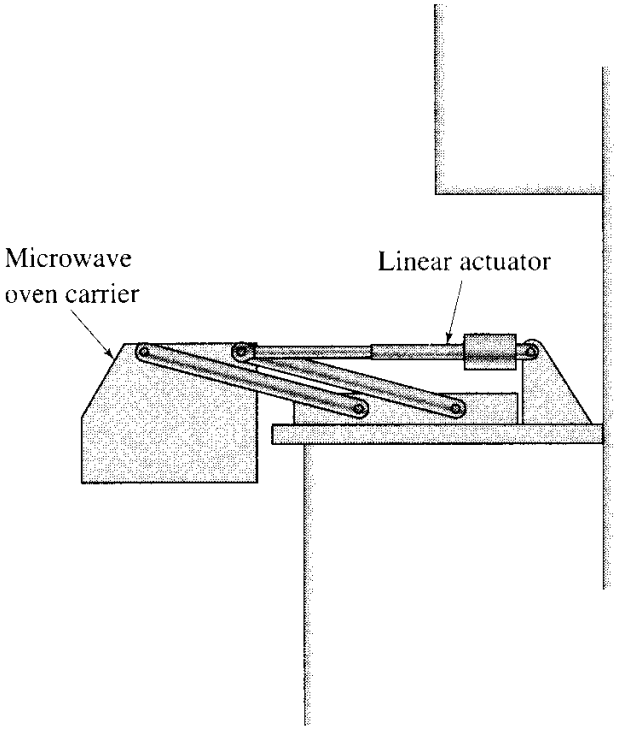
MECHANISMS



Moves packages from an assembly bench to a conveyor

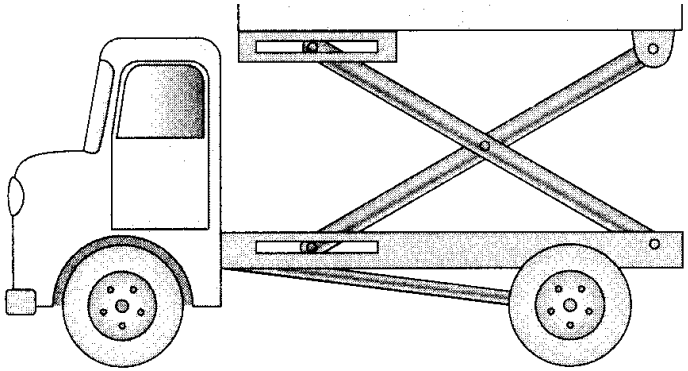
Rear-window wiper



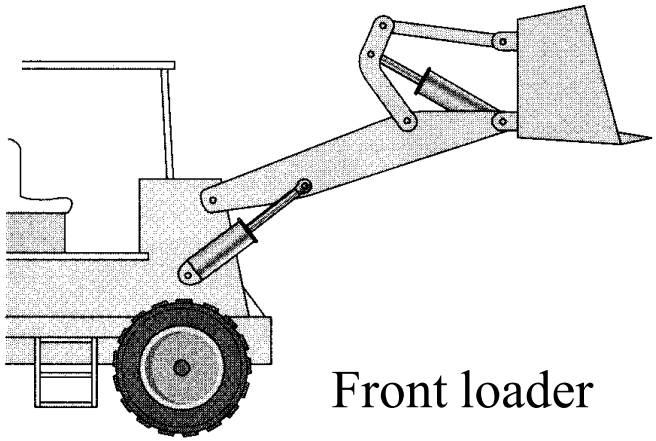


Microwave carrier to assist people on wheelchair

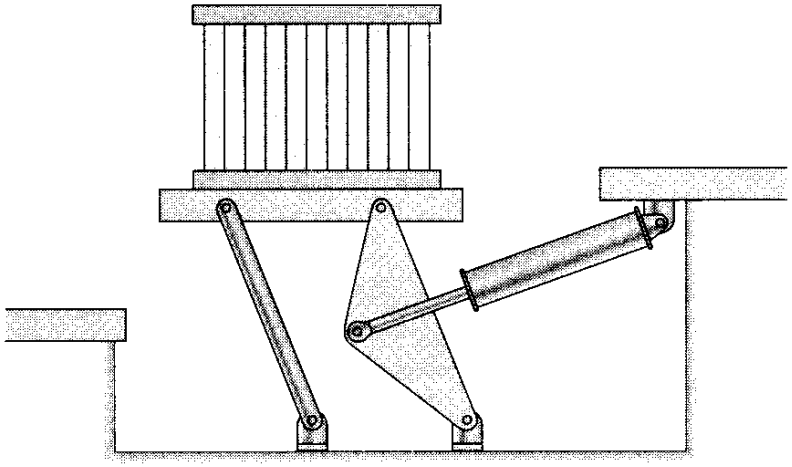
MECHANISMS



Lift platform

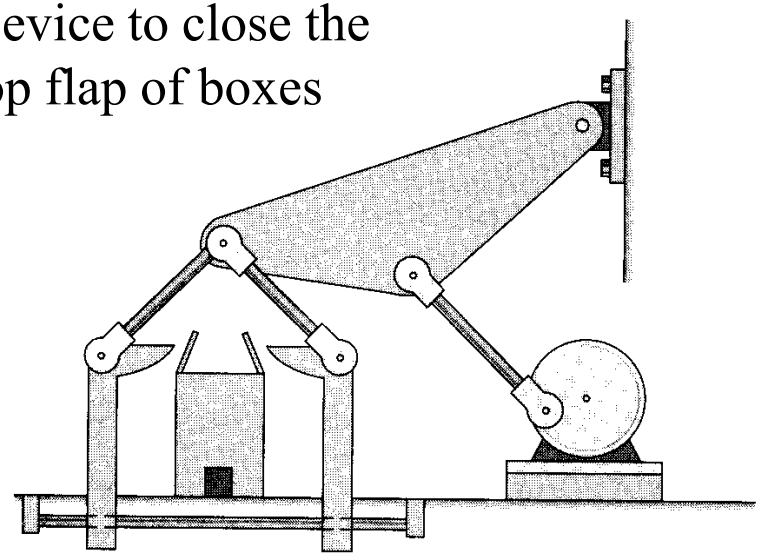


Front loader

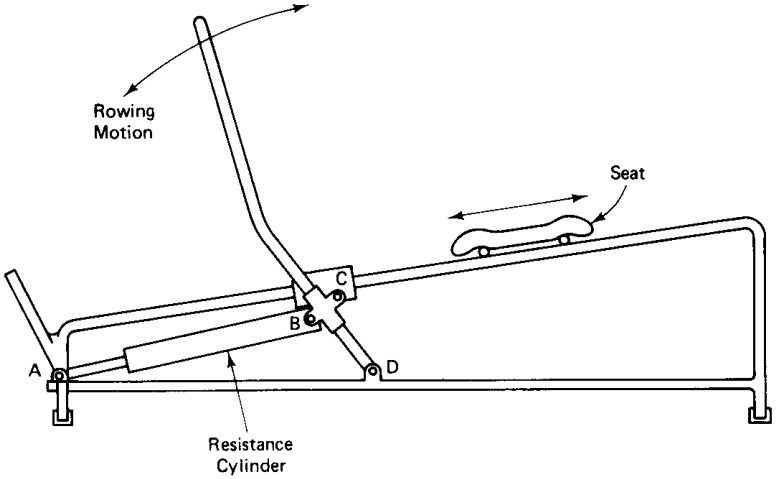


Lift platform

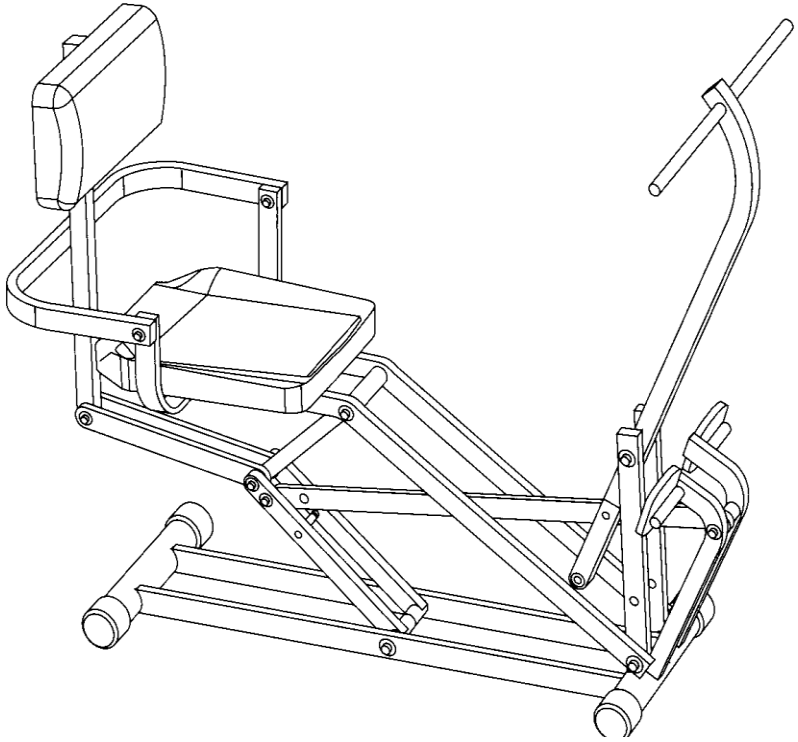
Device to close the top flap of boxes



MECHANISMS



Rowing type exercise machine

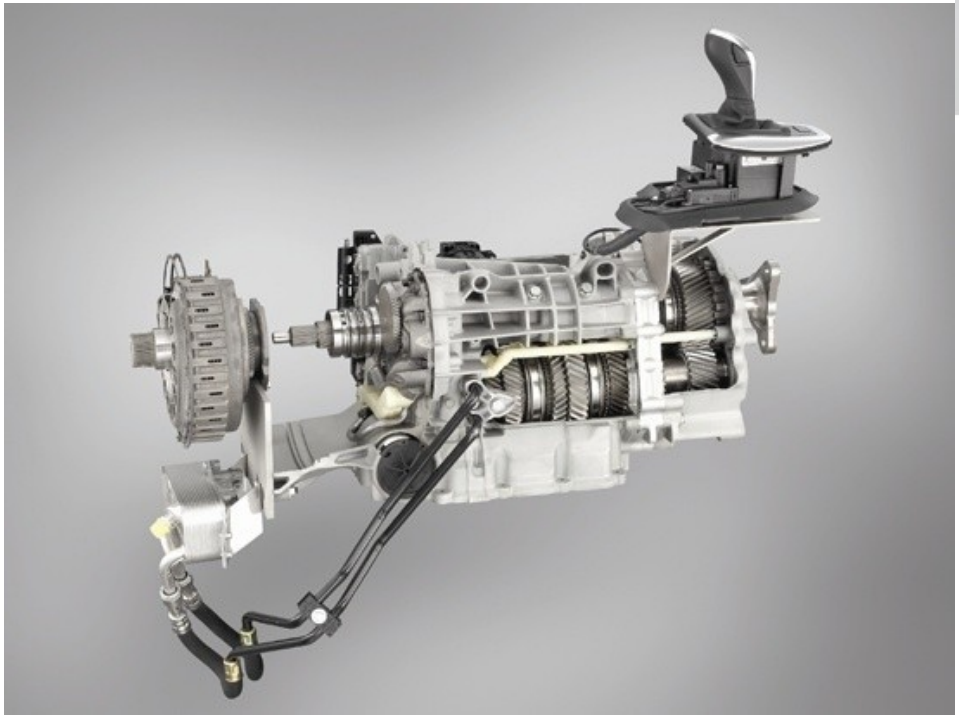


Conceptual design for an exercise machine

MACHINES

A machine

Food Blender



Automatic
Transmission

MACHINES

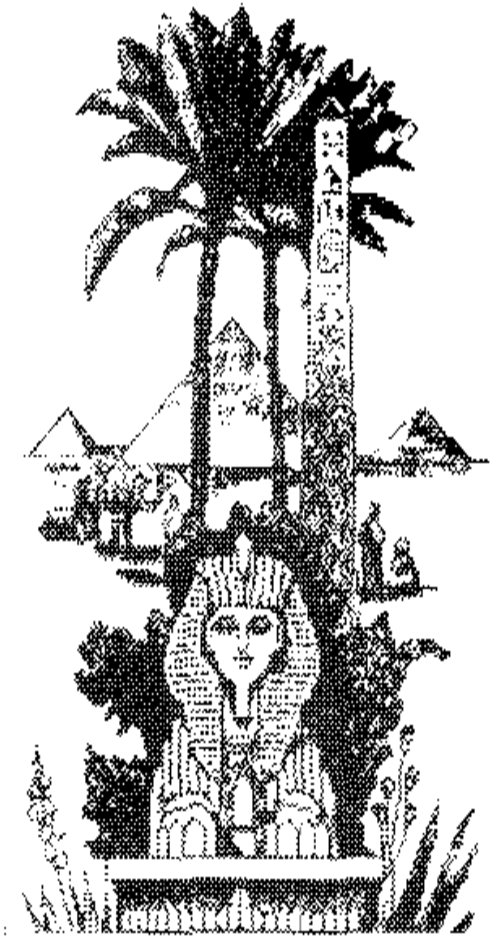
Bulldozer

Spider Robot

Amusement
Park Ride

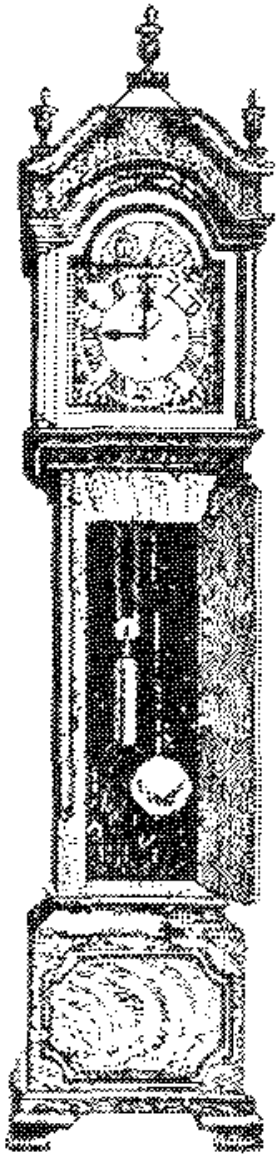
A BRIEF HISTORY OF KINEMATICS

- Machines and mechanisms have been devised by people since the dawn of history.
- The ancient **Egyptians** devised primitive machines to accomplish the building of the pyramids and other monuments. Though the wheel and pulley (on an axle) were not known to the Old Kingdom Egyptians, they made use of the lever, the inclined plane (or wedge), and probably the log roller.



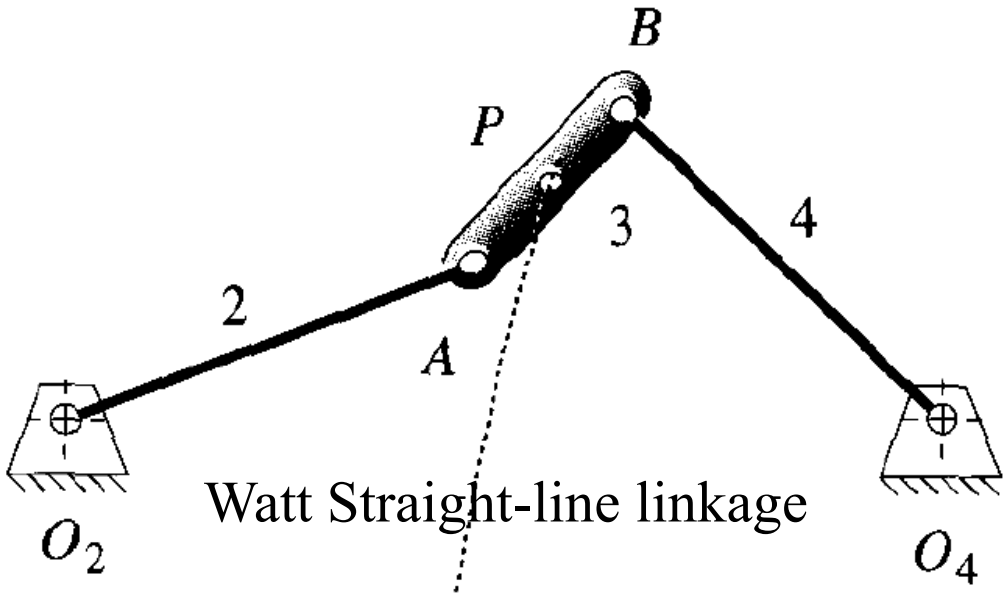
A BRIEF HISTORY OF KINEMATICS

- A great deal of design effort was spent from early times on the problem of timekeeping as more sophisticated clockworks were devised. Much early machine design was directed toward military applications (catapults, wall scaling apparatus, etc.).



A BRIEF HISTORY OF KINEMATICS

- **James Watt** (1736-1819) probably deserves the title of first kinematician for his synthesis of a **straight-line linkage** to guide the very long stroke pistons in the then new steam engines. Watt was certainly the first on record to recognize the value of the motions of the coupler link in the four-bar linkage.



Watt Straight-line linkage

A BRIEF HISTORY OF KINEMATICS

- **Oliver Evans** (1755-1819) an early American inventor, also designed a straight-line linkage for a steam engine.

A BRIEF HISTORY OF KINEMATICS

- **Euler** (1707-1783) presented an analytical treatment of mechanisms in his *Mechanicasive Motus Scienta Analytice Exposita (1736-1742), which included the concept that planar* motion is composed of two independent components, namely, translation of a point and rotation of the body about that point. Euler also suggested the separation of the problem of dynamic analysis into the "geometrical" and the "mechanical" in order to simplify the determination of the system's dynamics.

A BRIEF HISTORY OF KINEMATICS

Gaspard Monge (1746-1818), inventor of descriptive geometry, created a course in elements of machines and set about the task of classifying all mechanisms and machines known to mankind!

His colleague, **Hachette**, completed the work in 1806 and published it as what was probably the first mechanism text in 1811.

Gaspard Monge

Jean Nicolas
Pierre Hachette

A BRIEF HISTORY OF KINEMATICS

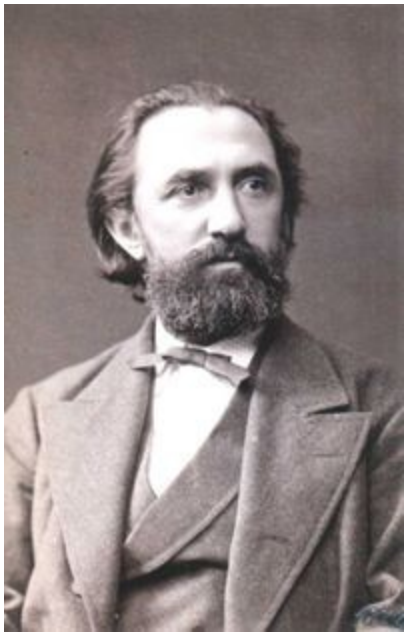
- **Andre Marie Ampere** (1775-1836), set about the formidable task of classifying "all human knowledge."
- In his *Essai sur la Philosophie des Sciences, he was the first to use the term "**cinematique**,"* from the Greek word for motion,* to describe the study of motion without regard to forces, and suggested that "this science ought to include all that can be said with respect to motion in its different kinds, independently of the forces by which it is produced."

A BRIEF HISTORY OF KINEMATICS

- **Robert Willis** (1800-1875) wrote the text *Principles of Mechanism in 1841 while a* professor of natural philosophy at the University of Cambridge, England. He attempted to systematize the task of mechanism synthesis. He counted five ways of obtaining relative motion between input and output links: rolling contact, sliding contact, linkages, wrapping connectors (belts, chains), and tackle (rope or chain hoists).

A BRIEF HISTORY OF KINEMATICS

- **Franz Reuleaux** (1829-1905), published *Theoretische Kinematik in 1875*. Reuleaux defined six basic mechanical components: the link, the wheel, the cam, the screw, the ratchet, and the belt. He also defined "higher" and "lower" pairs. He is generally considered the father of modem kinematics and is responsible for the symbolic notation of skeletal, generic linkages used in all modem kinematics texts.

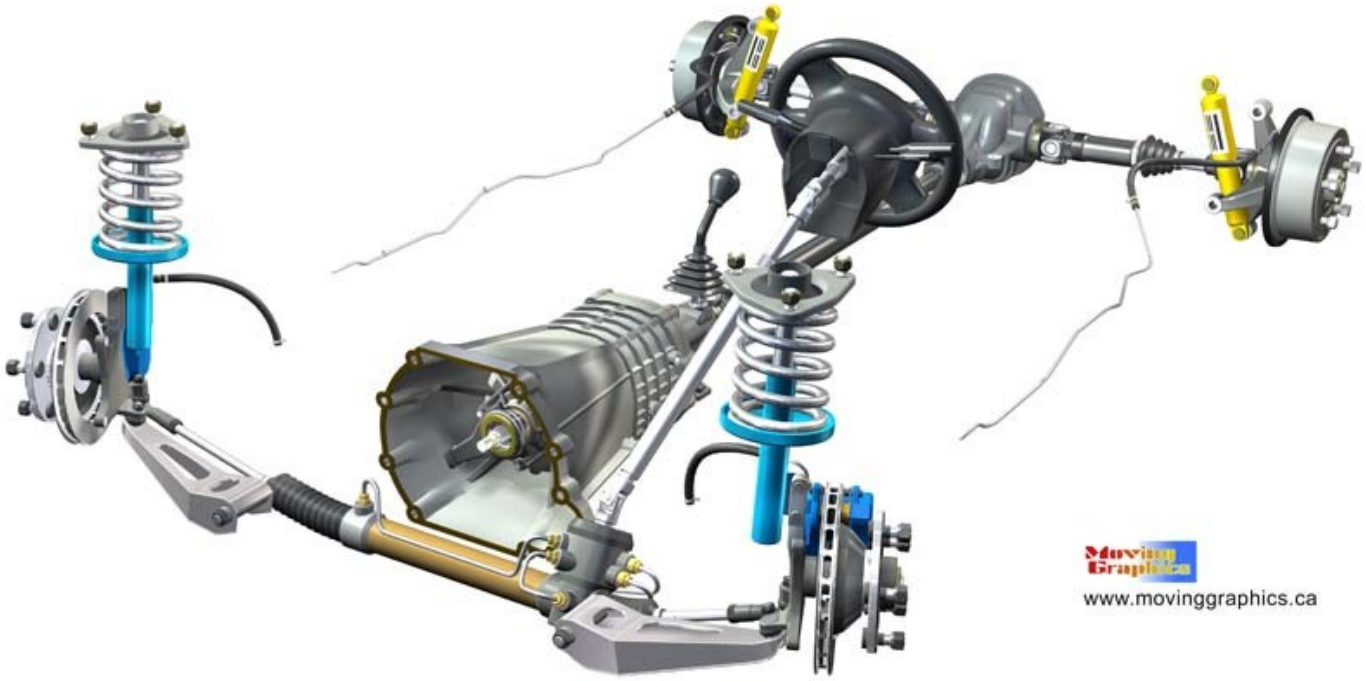


APPLICATIONS OF KINEMATICS

Virtually any machine or device that moves contains one or more kinematic elements such as linkages, cams, gears, belts, chains. Your bicycle is a simple example of a kinematic system that contains a chain drive to provide torque multiplication and simple cable-operated

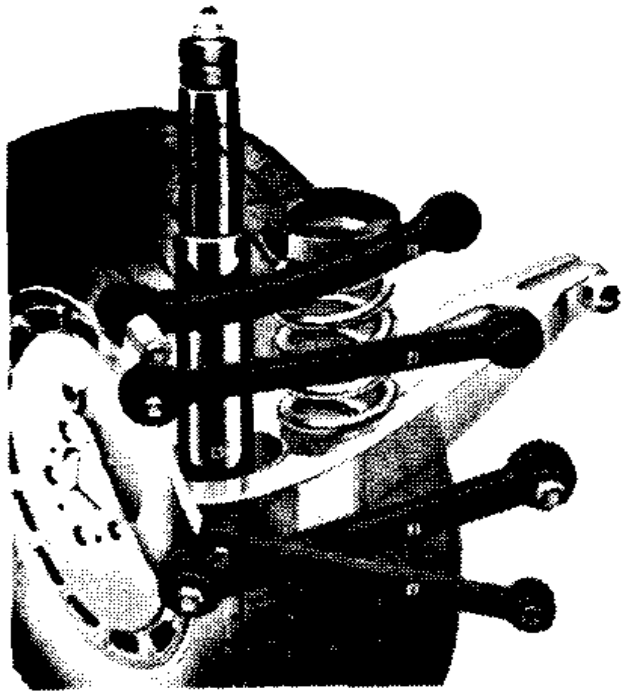
APPLICATIONS OF KINEMATICS

An automobile contains many more examples of kinematic devices. Its steering system, wheel suspensions, and piston-engine all contain linkages; the engine's valves are opened by cams; and the transmission is full of gears. Even the windshield wipers are linkage-driven.



APPLICATIONS OF KINEMATICS

Figure (a) shows a spatial linkage used to control the rear wheel movement of a modem automobile over bumps.



(a) Spatial linkage rear suspension
Courtesy of Daimler Benz Co.

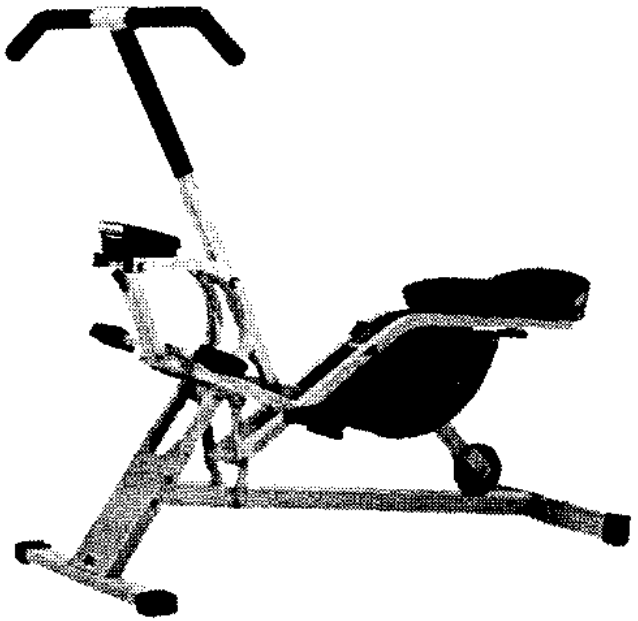
APPLICATIONS OF KINEMATICS

Construction equipment such as tractors, cranes, and backhoes all use linkages extensively in their design. Figure (b) shows a small backhoe that is a linkage driven by hydraulic cylinders.

(*b*) Utility tractor with backhoe
Courtesy of John Deere Co.

APPLICATIONS OF KINEMATICS

Another application using linkages is that of exercise equipment as shown in Figure (c).



(c) Linkage-driven exercise mechanism
Courtesy of ICON Health & Fitness, Inc.