Engineering Design *An Introduction*

Chapter 12

Designing Mechanical Systems

Karsnitz • O'Brien • Hutchinson

Engineering Design *An Introduction*

Introduction

- Mechanisms
  - Extend human ability
  - Create desired output of motion or force
  - Play an important role in shaping society
- Leonardo da Vinci
  - Famous painter
  - Designer and inventor of mechanisms

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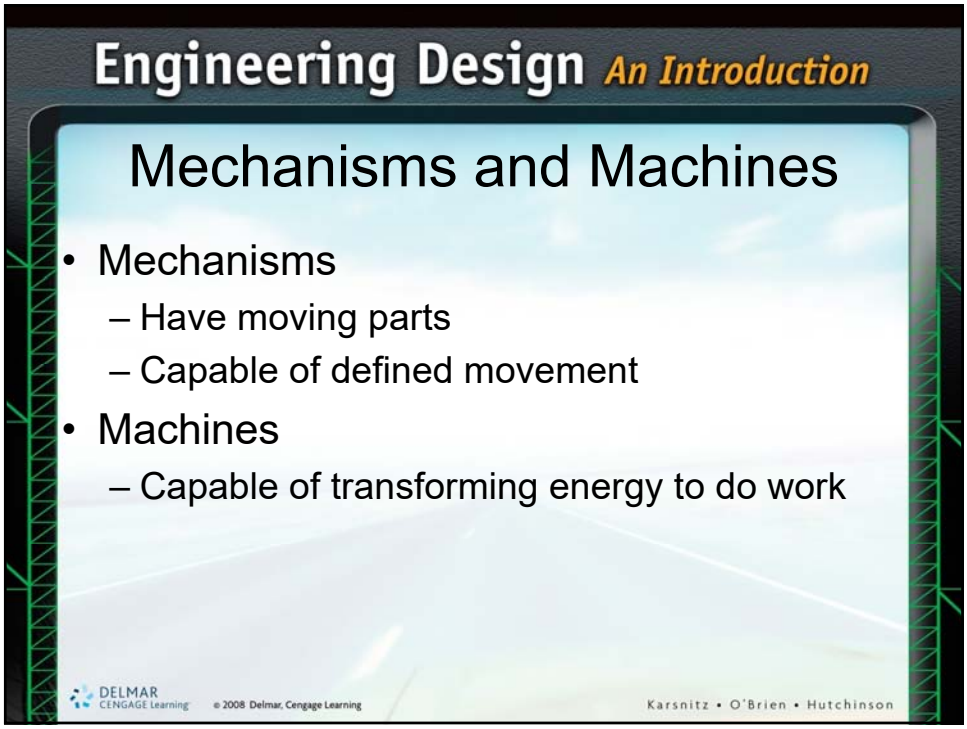
Engineering Design An Introduction
Mechanisms and Machines
• Mechanisms
– Have moving parts
– Capable of defined movement
• Machines
– Capable of transforming energy to do work
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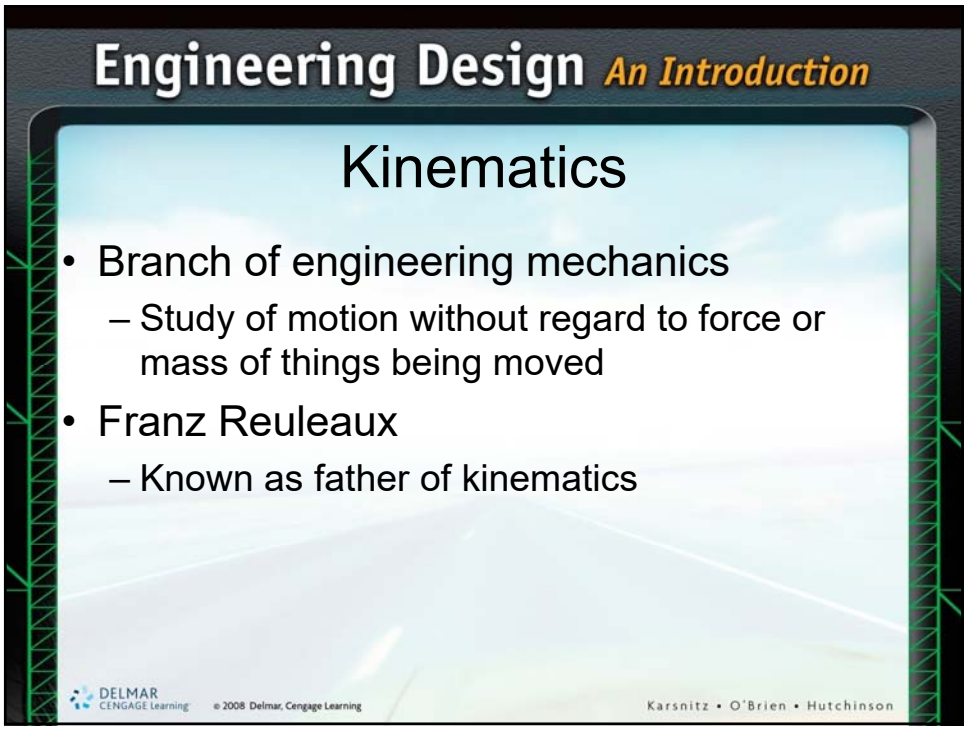
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Kinematics
• Branch of engineering mechanics
– Study of motion without regard to force or mass of things being moved
• Franz Reuleaux
– Known as father of kinematics
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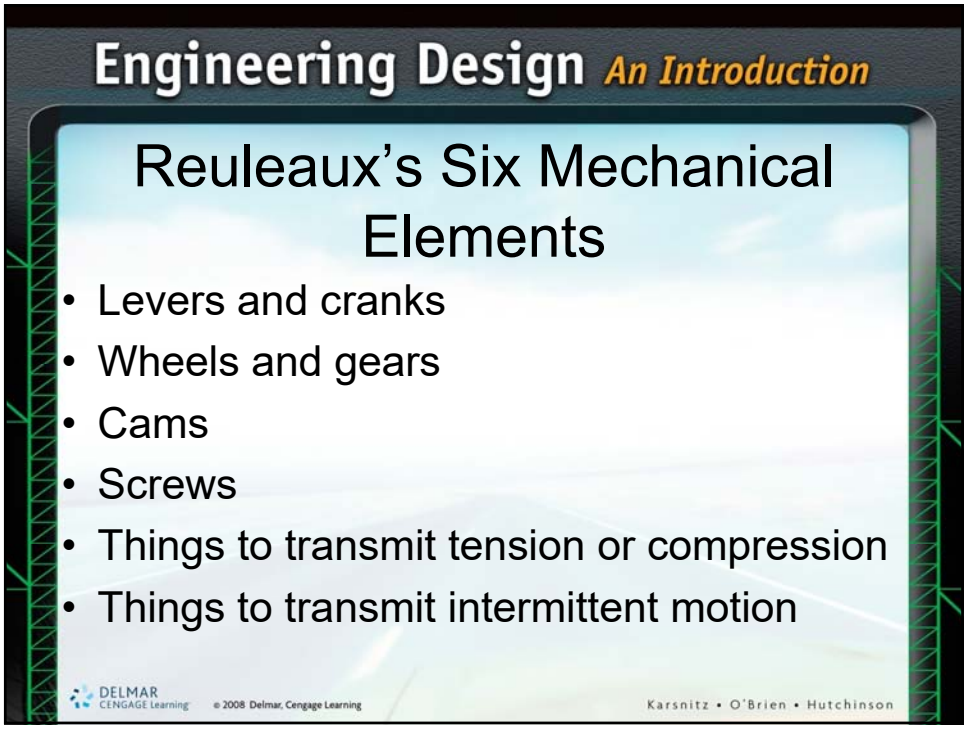
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Reuleaux's Six Mechanical Elements
• Levers and cranks
• Wheels and gears
• Cams
• Screws
• Things to transmit tension or compression
• Things to transmit intermittent motion
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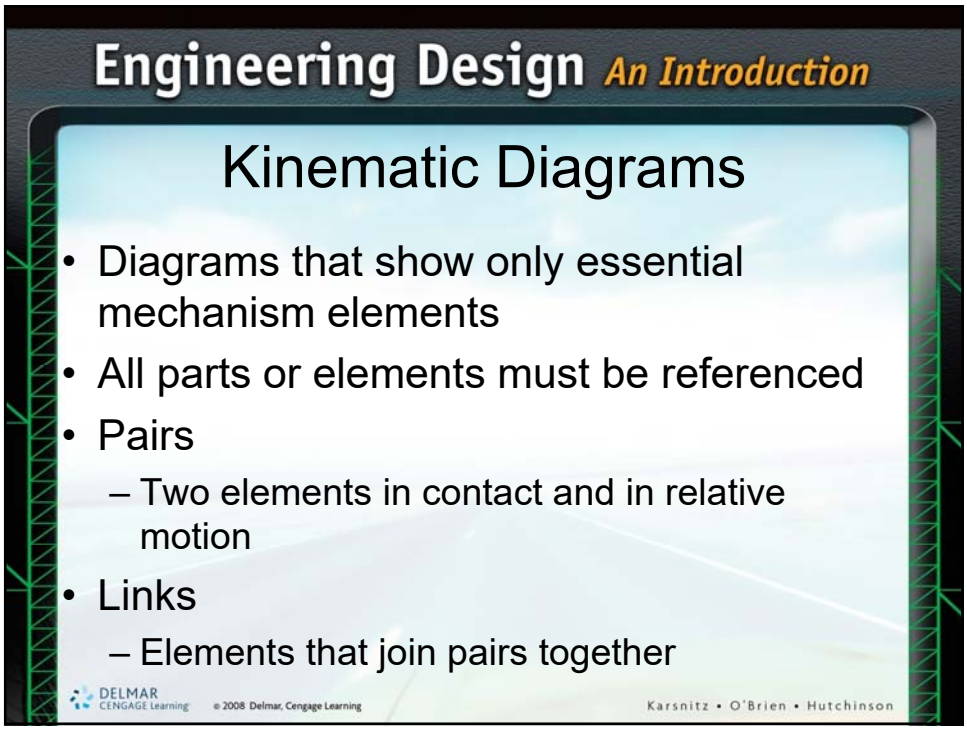
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Kinematic Diagrams
• Diagrams that show only essential mechanism elements
• All parts or elements must be referenced
• Pairs
– Two elements in contact and in relative motion
• Links
– Elements that join pairs together
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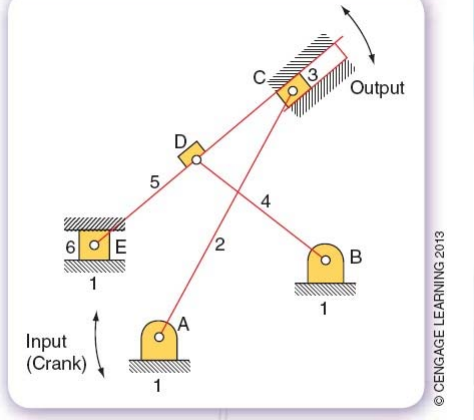

Figure 12-9: A kinematic or skeleton diagram of a casement window opening mechanism.

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Kinematic Members

- All mechanical elements:
  - Can be represented as kinematic members
- Motion
  - Describes a change in an object's position over time
- Momentum
  - Object's mass times its velocity

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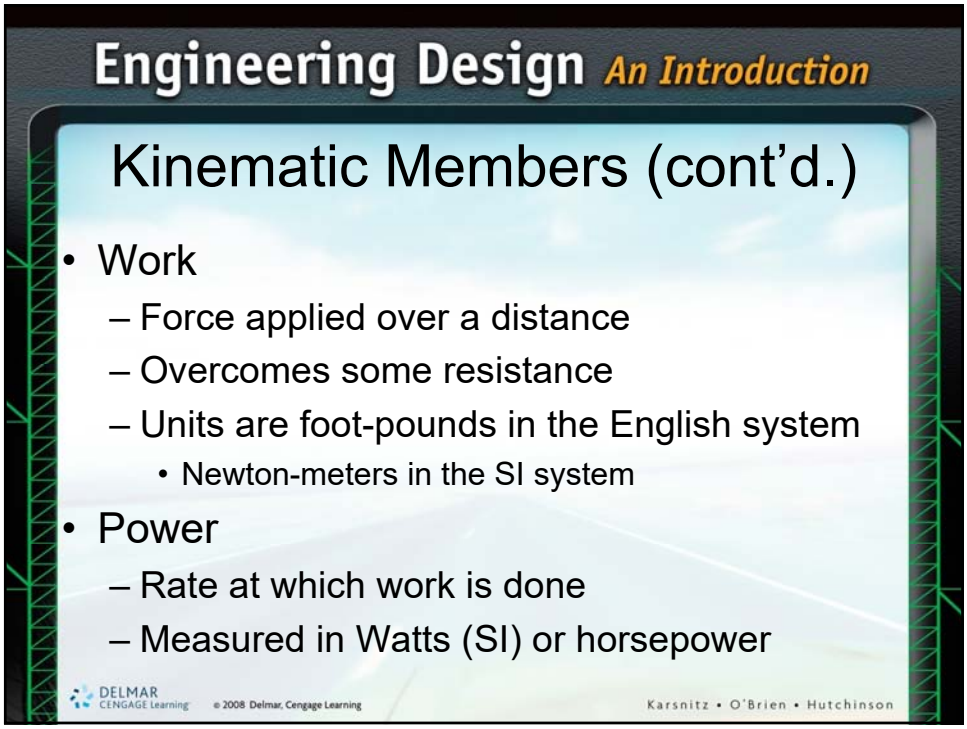
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Kinematic Members (cont'd.)
• Work
– Force applied over a distance
– Overcomes some resistance
– Units are foot-pounds in the English system
• Newton-meters in the SI system
• Power
– Rate at which work is done
– Measured in Watts (SI) or horsepower
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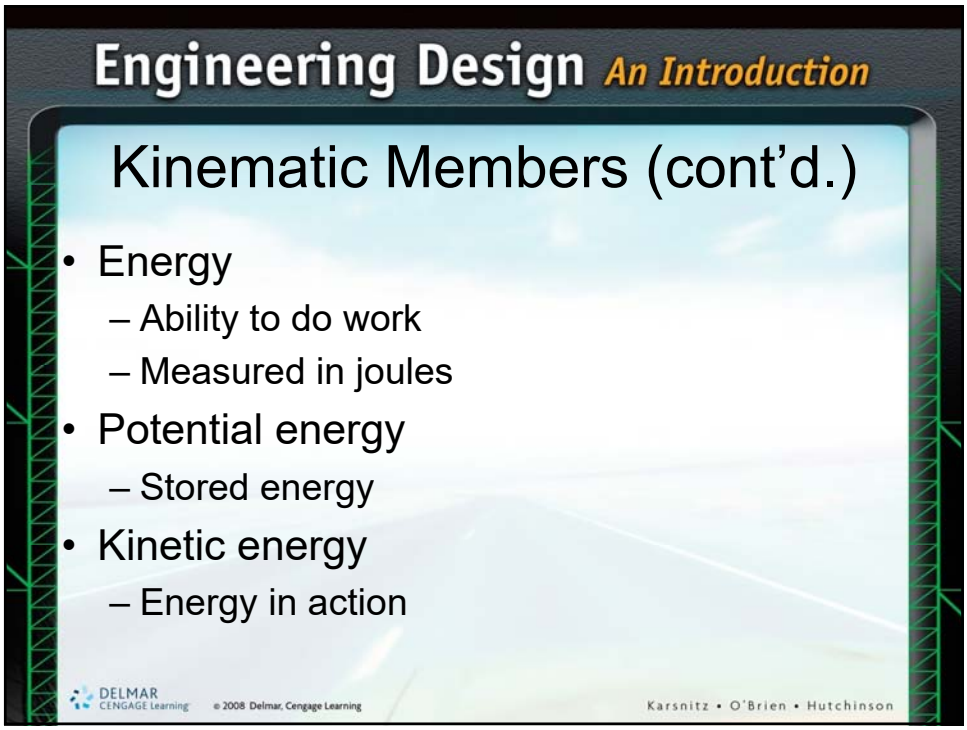
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Kinematic Members (cont'd.)
• Energy
– Ability to do work
– Measured in joules
• Potential energy
– Stored energy
• Kinetic energy
– Energy in action
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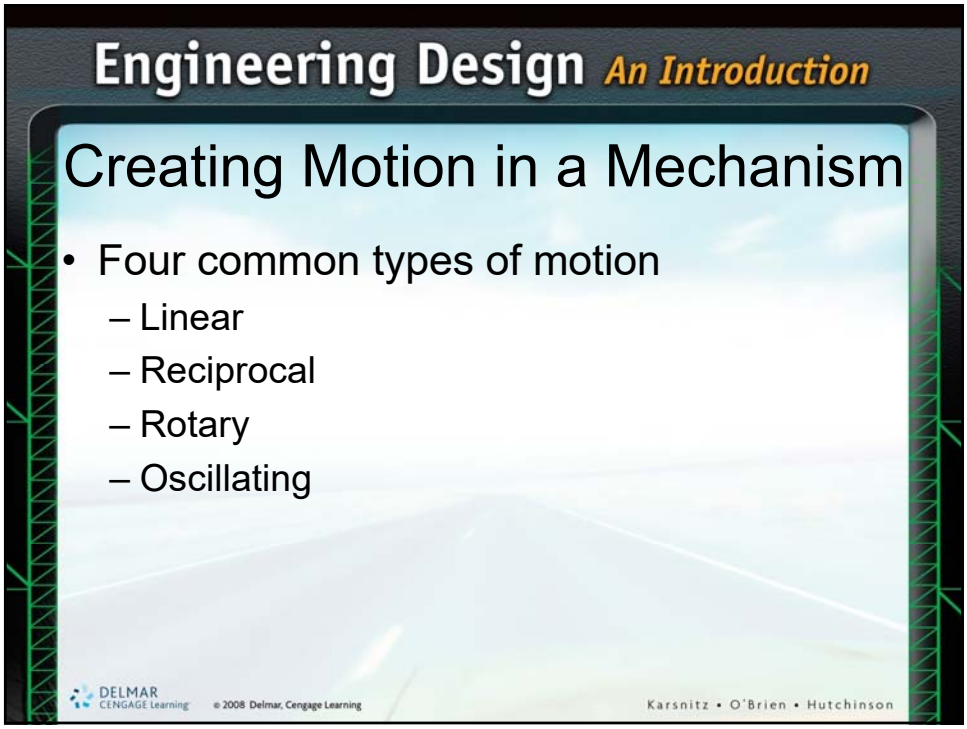
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Creating Motion in a Mechanism
• Four common types of motion
– Linear
– Reciprocal
– Rotary
– Oscillating
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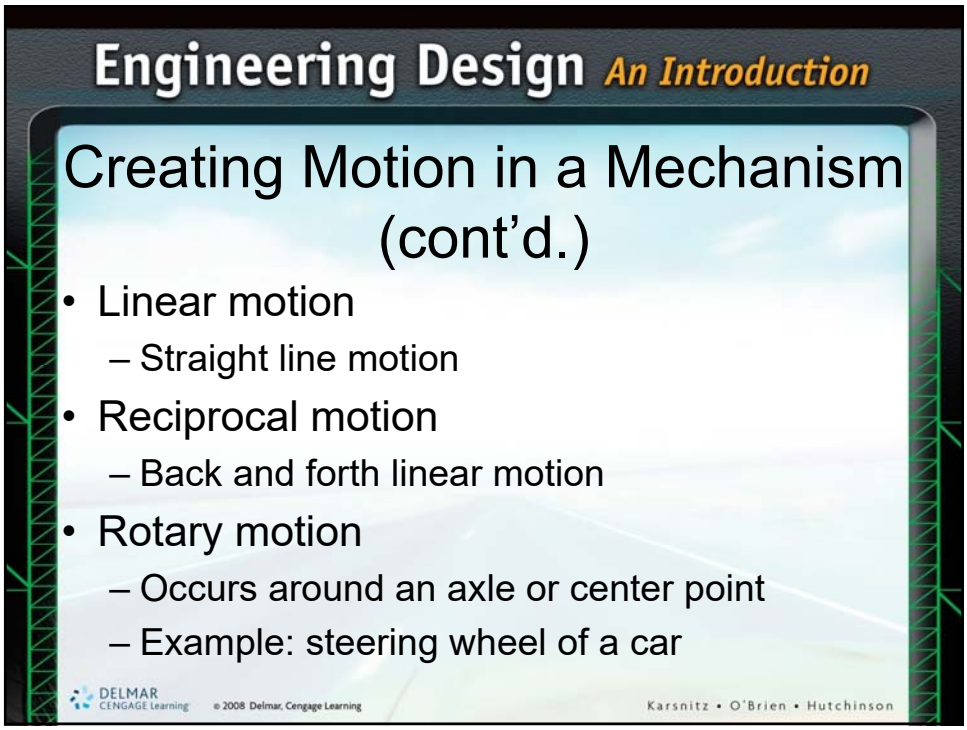
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Creating Motion in a Mechanism (cont'd.)
• Linear motion
– Straight line motion
• Reciprocal motion
– Back and forth linear motion
• Rotary motion
– Occurs around an axle or center point
– Example: steering wheel of a car
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Creating Motion in a Mechanism (cont'd.)

- Oscillating motion
  - Involves back and forth motion in an arc
  - Example: clock pendulum

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Levers and Linkages

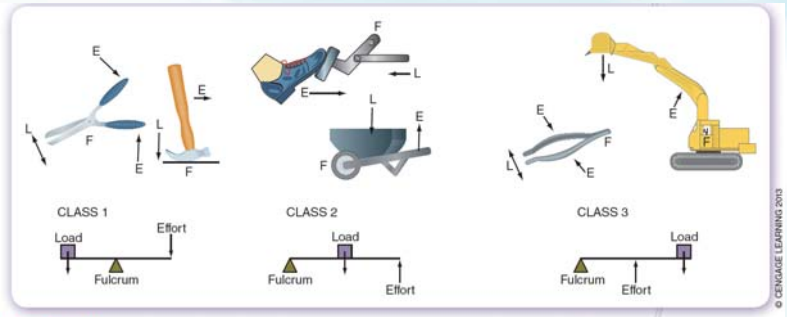

Figure 12-17: Examples of Class 1, 2, and 3 levers.

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Levers and Linkages (cont'd.)

- Linkages
  - Transmit input motion or force to desired output location
  - Change force direction
  - Change length of motion of the force
  - Split the motion or force

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Levers and Linkages (cont'd.)

- Bell crank and reversing linkages

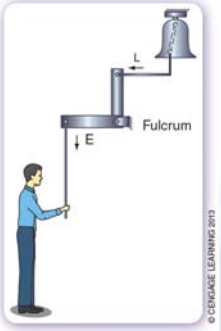

Figure 12-21: An example of a bell crank linkage.

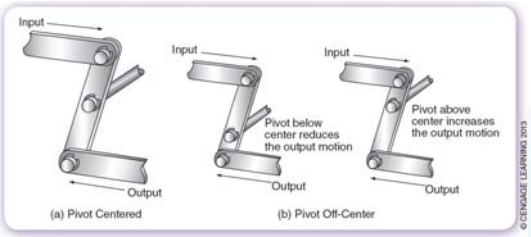

Figure 12-23: Motion-reversing linkage.

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Levers and Linkages (cont'd.)

- Parallel linkages

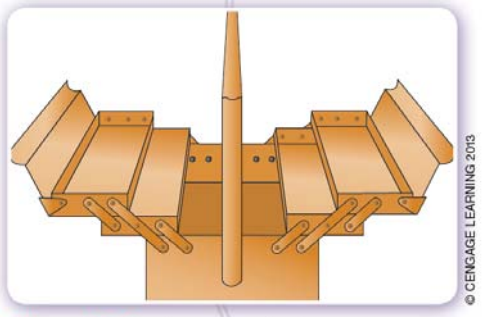

Figure 12-24: A toolbox design using parallel linkages.

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Levers and Linkages (cont'd.)

- Treadle linkage

Figure 12-25: Treadle-operated traditional spinning wheel.

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Levers and Linkages (cont'd.)

- Toggle linkage

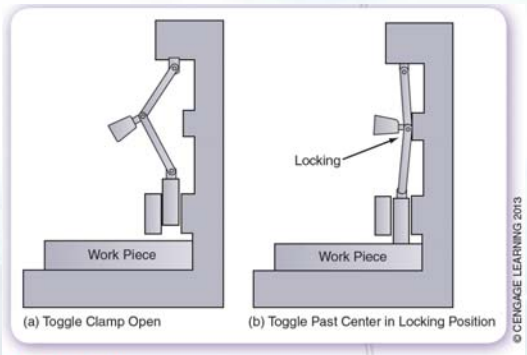

Figure 12-27: Locking a toggle mechanism.

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Rotary Mechanisms

- Transfer or change input rotational motion and force to output motion or force
- Examples
  - Gears
  - Pulleys
  - Cams

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Gears

- Toothed wheels fixed to an axle
- Driver gear
  - Fixed to the input axle
- Driven gear
  - Fixed to the output axle
- Gear train
  - System of gears fixed together

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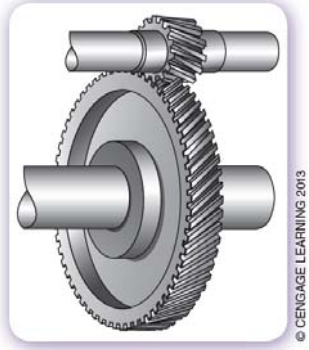

Figure 12-35: Helical gears.

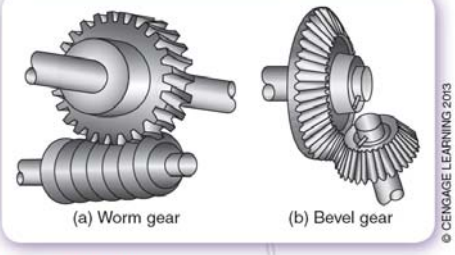

Figure 12-36: Worm and bevel gears change the rotation axis.

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Gears (cont'd.)

- Other rotary systems
  - Pulley and sprocket
  - Pulley and belt
  - Sprocket and chain
  - Conveyor

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Cam and Crank Slider Mechanisms

- Like gears but not always round

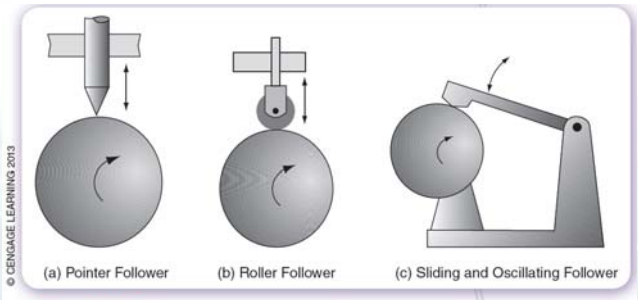

Figure 12-41: Eccentric cams with different types of followers.

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Ratchet Mechanisms

- Oldest form of mechanism to create intermittent motion

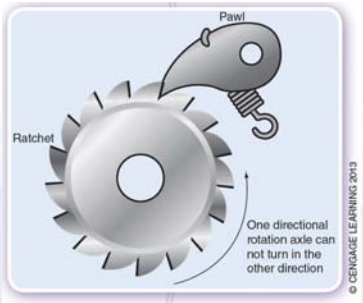

Figure 12-44: Pawl ratchet.

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Clutches and Brakes

- Used to disrupt motion created by a mechanical system
- Clutch
  - Form of coupling
  - Can be easily connected and disconnected
- Brakes
  - Use friction to reduce mechanism speed

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Modeling Mechanical Designs

Figure 12-47: Kits for modeling mechanical systems. (a) Fischertechnik systems are used to model mechanical and structural systems and subsystems. Profi kits are available that utilize solar energy, pneumatic power, electronic sensors and logic gates, and even automotive technology with gearboxes and differentials. (b) Vex Robotic kits are used to model robotic and autonomous systems. Kits can include a programmable microcontroller, variable speed motors, gears and wheels, and chassis components.

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