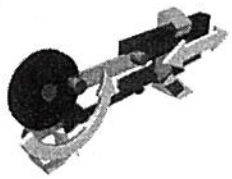
Mechanical Engineering

ST AST SE

Chapter 13
Observatory
pp. 424-454

What is Mechanical Engineering?

- It is the branch of engineering that focuses on the design, production, analysis, working and improvement of technical objects with moving parts.
- Main Topics
  - Links
  - Guiding
  - Transmission
  - Transformation



Please write this!

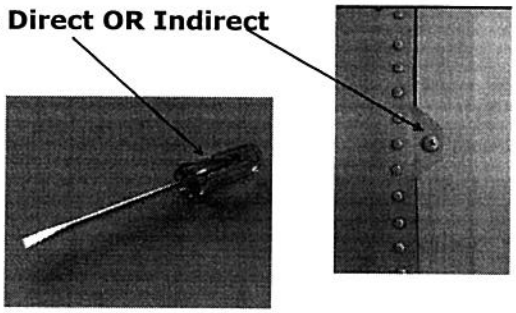
13.0 Linking in Technical Objects

- **Linking** is the mechanical function performed by any component that **connects** different parts of a technical object.
- You MUST know the types of links!
  - Workbook p218
  - **Chart on p. 428 in text**

Please write this!

Links

- **Direct OR Indirect**



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Links

- **Rigid OR Flexible**

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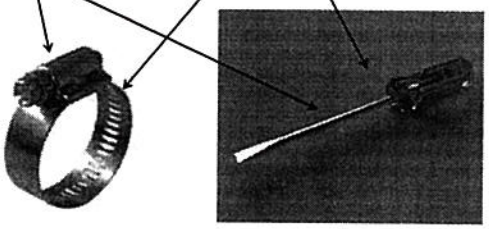
Links

- **Removable OR non-removable**
- **Complete OR Partial**



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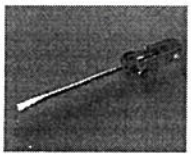
Examples



Between the metal & the handle

- **Direct**
- **Rigid**
- **non-removable**
- **Complete**

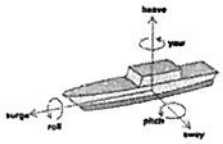
Between the screw & the loop

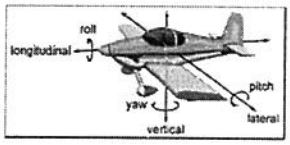
- **Indirect**
- **Rigid**
- **Removable**
- **Partial**

Please write this!

13.1 Degrees of Freedom of Movement

- are the set of independent movements that are possible for a given part in a technical object.

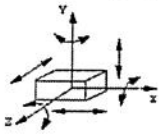




Please write this!

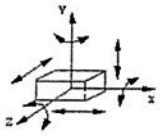
- The motion can be:
  - Translational (back & forth)
  - Rotational
- Which axis?
  - x (horizontal),
  - Y (vertical), or
  - Z (out at you!)
- Notation – 6 possible degrees of freedom

T_x, T_y, T_z, R_x, R_y, R_z

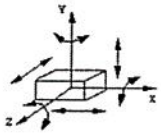


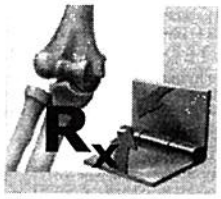
Please write this!

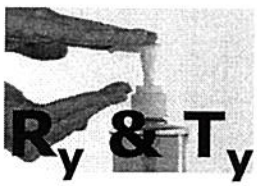
- The motion can be:
  - Translational (back & forth)
  - Rotational
- On the x-axis (horizontal),
- Y-axis (vertical) or
- Z-axis (out at you!)
  - E.g. A door can only rotate around the hinges – 1 degree freedom
- See p429 chart



Examples







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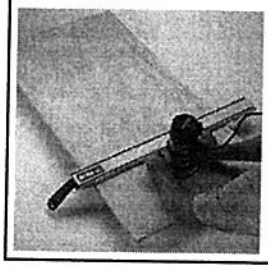
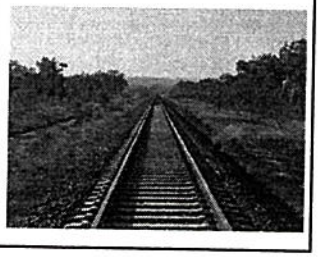
13.2 Types of Guiding Controls

- **Translational Guiding** ensures the straight translational motion of a moving part. E.g. a vertical window groove





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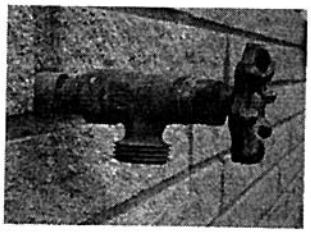
- **Rotational Guiding** ensures the rotational motion of a moving part. E.g. a bicycle wheel hub

Please write this!

- **Helical Guiding** ensures the translation motion of a moving part while it rotates about the same axis. E.g. threaded screw.



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13.3 Adhesion and Friction of Parts

- **Adhesion** = two surfaces remain in contact with each other without slipping.
- **Friction** is a force that resists the slipping
- **Lubrication** is the mechanical function performed by any component that reduces friction between two parts.

Please write this!

5 Factors affecting friction

1. Nature of materials (eg: steel on asphalt vs. rubber on asphalt)
2. Presence of a lubricant (water, oil, wax)
3. Temperature: the colder the temperature the less the adhesion
4. Surfaces (rough vs. smooth)
5. Mass of the object (a heavy object will have better adhesion, more friction)

NOT ON SURFACE AREA! Remember P = F/A

- Bill Nye on Friction!
  - William Sanford Nye
  - Mechanical Engineer & Science Educator

Please write this!

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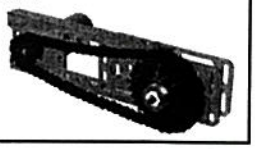
13.4 Motion Transmission Systems

- Motion Transmission is the mechanical function of relaying a motion from one part to another without altering the nature of the motion.
- A Motion Transmission System is a set of parts that transmit motion.



Please write this!

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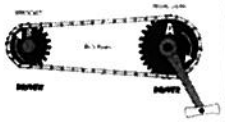
- Driver component: receives the force required to activate the system
  Eg: Pedal gear on a bike
- Driven component: receives the motion and transfers it to another part
  Eg: rear gears on a bike
- Intermediate component: located between the driver and driven component
  not all systems have this.
  Eg: the chain on a bike



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Please Write ONTO handout

- Common rotational transmission systems:
  1. Gear Trains
  2. Chain and Sprocket Systems
  3. Worm and Worm Gear Systems
  4. Friction Gear Systems
  5. Belt and Pulley Systems
     - Use text p437 when studying!

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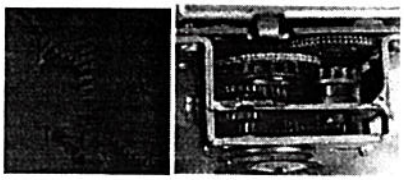
1. Gear Trains

- The direction of rotation changes from one wheel to the next.
- The system can be reversed.

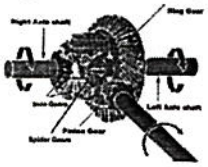


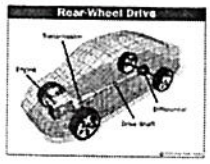
Gear Train Factors

- Gear teeth: all the gear teeth in a system must be identical – same shape, direction, size and be equally spaced.

E.g. Straight or helical or beveled

- Gear type: the rotational axis of the gears can be positioned different ways
  - eg: car differentials

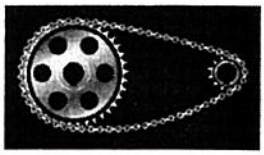




- Gear size: the higher the number of teeth, the lower the speed of rotation – or bigger diameter → slower speed.

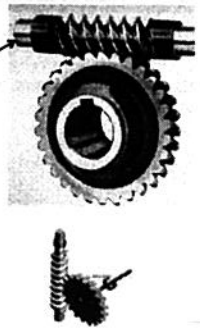
2. Chain & Sprocket Systems

- The direction of rotation of all sprockets on the same side of the chain is the same. (opposite on the other)
- It can be reversed.
- The smaller the sprocket the faster it turns
- Requires frequent lubrication



3. Worm &Worm Gear Systems

- The direction of rotation depends on the direction of the threads on the worm screw shaft.
- It is not reversible.
- **Worm** must be the driver
- Larger worm gear = slower rotation

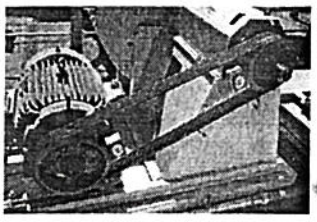


4. Friction Gear Systems

- The direction alternates from one gear to the next.
- It is reversible.
- The smaller the diameter of the gear, the faster its rotation

- Friction gear systems are similar to gear trains except that motion is transferred by FRICTION and not by the GEAR TEETH.
- They are less efficient because of slippage
- Factors that affect friction gear systems are: gear type (straight, bevel or spherical), gear size and choice of material.

Belt and Pulley systems

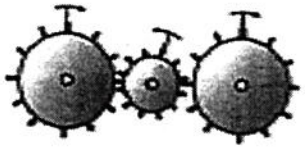
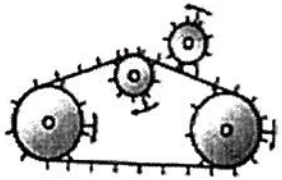
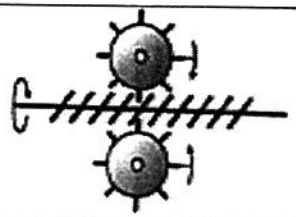
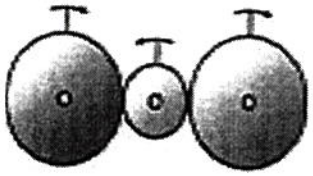
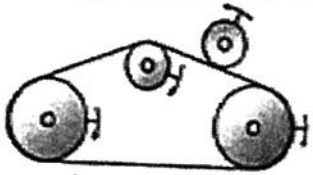


5. Belt and Pulley Systems

- Similar to the chain and sprocket system.
- The chain is replaced by a belt.
- The sprocket is replaced by a pulley.
- The choice of the belt material and the tightness of the belt affect the friction and hence the efficiency of the system.
- The direction is the same for any pulley on the same side of the belt.
- It is reversible.
- The smaller the pulley, the faster its rotation

Characteristics of Motion Transmission Systems

Name: _____

Motion transmission system		Direction of rotation	Is it reversible?	Other information
Gear Train System		Alternates from one gear to the next.	Yes	Gear teeth must have same shape, direction, size & be equally spaced out! Larger gears (more teeth) rotate slower! Smaller gears rotate faster!
Chain & Sprocket System		Same direction for sprockets on the same side. Opposite Direction for sprockets on the opposite side.	Yes	Requires frequent lubrication. Larger gears (more teeth) rotate slower! Smaller gears rotate faster!
Worm & Worm Gear System		Direction depends on the direction of the threads on the worm screw shaft.	No	Worm must be the driver! Larger the worm gear, slower the rotation
Friction Gear System		Alternates from one gear to the next.	Yes	Motion is transferred by friction. Less efficient due to slippage. Friction is affected by gear type, size & material Larger gears (more teeth) rotate slower! Smaller gears rotate faster!
Belt & Pulley System		Same as chain & sprocket	Yes	Choice of belt material & belt tightness affects the efficiency. Larger gears (more teeth) rotate slower! Smaller gears rotate faster!

Please write this!

13.5 Speed Changes in a Pulley or Sprocket Transmission System

- You can compare:
  - # of teeth
  - Diameter
  - Circumference
- E.g. Driver Diameter = 15cm = 3 or 3:1
  Driven Diameter 5 cm 1

So the driven pulley is 3 times FASTER.

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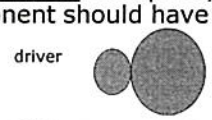
- To **increase** the speed, the driven component should have a **smaller** diameter

Please write this!

- To **decrease** the speed, the driven component should have a **larger** diameter.



- To keep the **same** speed, the two pulleys should have the **same** diameter.

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Calculating Gear Ratios

Ex. 1

Please write this!

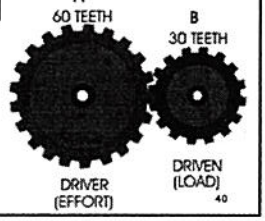
Driver Diameter (A) = 60 cm = 2 = 2:1
Driven Diameter (B) 30 cm 1

Reduce the fraction

Driven is twice as fast!

(see p. 443)

1A.



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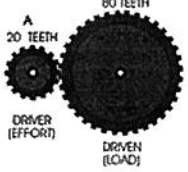
- Ex. 2

Please write this!

Reduce the fraction

A= 20 cm = 1 = 1:4
B 80 cm 4

3A.



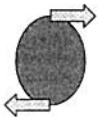
B rotates at a speed ¼ that of A
Or
A turns 4 times faster than B
Or
B does 1 revolution for every 4 of A

Lets always describe B! ☺ Stick to one!

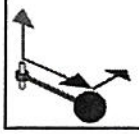
41

Please write this!

13.6 Torque



- Torque involves 2 equal forces in opposite directions.
- Causes a rotation
- Engine Torque increases the rotational speed of components
  - Power from engine
- Resisting Torque slows or stops the rotation
  - caused by friction, air resistance, gravity



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Please write this!

Torque and Speed Change

engine torque = resisting torque,
→No speed change

engine torque > resisting torque,
→speed increases

engine torque < resisting torque,
→speed decreases

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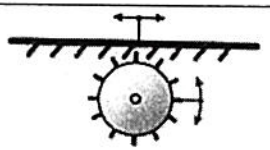
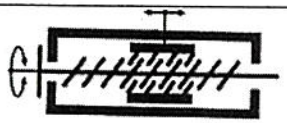
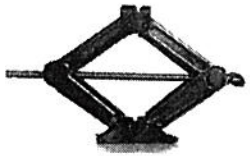
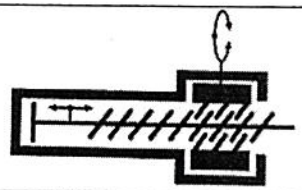
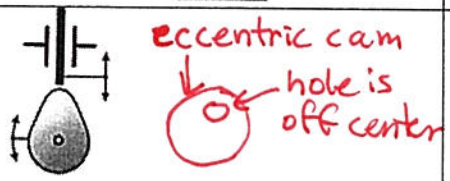
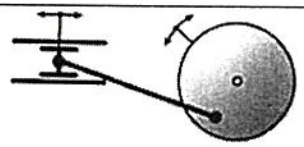
Characteristics of Motion Transformation Systems

Name: _____

Motion transformation		Possible transformations	Example	Is it reversible?
Rack & Pinion system		Rotational → Translational Or Translational → Rotational	Car steering	Yes
Screw gear system type 1	 The nut does not rotate! But moves to the left or right.	Rotational → Translational The screw is the driver!	Car jack 	No
Screw gear system type 2		Rotational → Translational The nut is the driver!	 Pipe Wrench	No
Cam & follower system		Rotational → Translational	Sewing machine needle You automaton	No
Slider-crank mechanism		Rotational → Translational Or Translational → Rotational	Car Piston	Yes