TECHNOLOGICAL WORLD

Mechanical Engineering: Linking of Mechanical Parts

I can recognize and describe the characteristics of the links in a technical object (direct or indirect, rigid or flexible, removable or permanent, partial or complete).

Explanation of Concepts

A link holds two or more parts of the same technical object together.

Every link displays four basic characteristics:

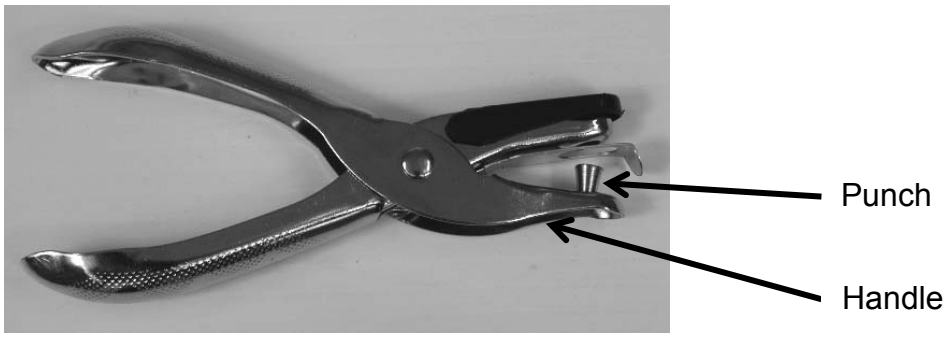
Direct two parts held together without a linking component	**OR**	**Indirect** a linking component is required to hold the two parts together
Rigid the linking component is not flexible	**OR**	**Flexible** the linking component can be deformed when used and has the ability to return to its initial position
Removable the linked parts can be separated without damaging either their surfaces or the linking component	**OR**	**Permanent** the linked parts cannot be separated without damaging either their surfaces or the linking component
Complete the linking component prevents the two parts from moving independently of one another	**OR**	**Partial** the linking component allows the two parts to move independently from one another

Questions to Help Identify the Characteristics of Links

Characteristic	Question
Direct or indirect?	*Do the parts require something else to hold them together?* Yes→ Indirect No → Direct
Rigid or flexible?	*Can the linking component be deformed when used and will it return to its initial position?* Yes→ Flexible No→ Rigid
Removable or permanent?	*Can the object be taken apart without causing damage to the object?* Yes→ Removable No → Permanent
Complete or partial?	*Is movement possible between the two parts?* Yes →Partial No → Complete

Example:

Characteristics of the link between the handle and the punch of a hole punch



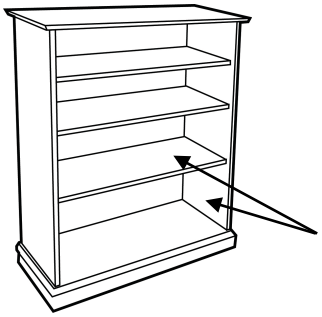
The characteristics of the link between the handle and the punch are:

Direct, rigid, permanent, and fixed

Questions

1. Select the four characteristics of the link between the components identified for each technical object shown below.

a) Bookshelf



Direct or Indirect

Complete or Partial

Removable or Permanent

Rigid or Flexible

b)

Direct or Indirect

Complete or Partial

Removable or Permanent

Rigid or Flexible

c) Clothespin

Direct or Indirect

Complete or Partial

Removable or Permanent

Rigid or Flexible

Answers

1.

a) Indirect, complete, permanent, rigid

b) Direct, complete, removable, rigid

c) Indirect, partial, removable, flexible

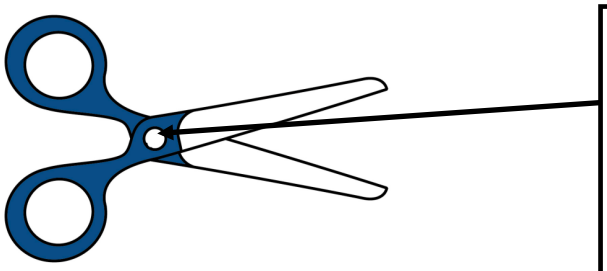
Mechanical Engineering: Linking of Mechanical Parts

I can determine the characteristics of links that are most suitable in the design of a technical object.

Explanation of Concepts

When objects contain two or more parts, engineers must determine how to connect these parts. When designing an object which will require links in its construction, how the object operates will determine the choice of link selected.

Example:



The two blades of the scissors must be linked in a way that allows the blades to slide over each other, but not to separate. In this case, a rivet was chosen as a linking component. The rivet provides a link which is moveable, indirect, rigid and non-

Questions

1. A washing machine contains many parts that may break down over time. What would be the best system to attach the back cover to the body of the washing machine to permit access for repairs.

   A) rivet

   B) glue (adhesive)

   C) screw

   D) nail

2. A small screw is usually used to link the arm of a pair of glasses to the frame. Explain why this is a good choice by referring to the characteristics of the link.

Answers

1. *C*
2. *The screw creates a link that is removable, indirect, so the arm can be replaced. The link is partial to permit movement.*

Mechanical Engineering: Linking of Mechanical Parts

I can judge the choice of assembly solutions in a technical object.

Explanation of Concepts

While engineers are designing technical objects, they must judge the appropriate choice for the materials used to initially construct the object and what to use to link the components together.

Example: Assembly Solutions for a Skateboard

Skateboard-truck:

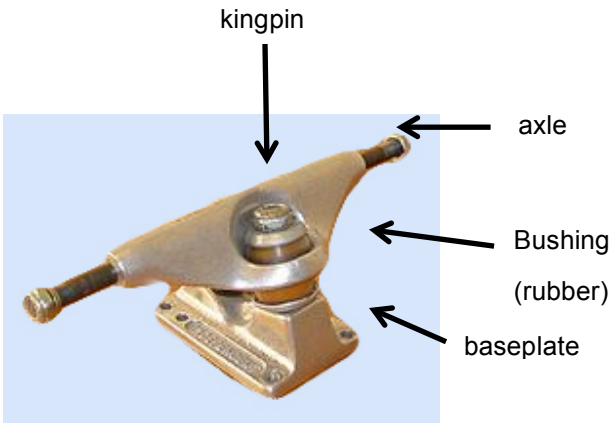


Image from: http://commons.wikimedia.org/wiki/File:Skateboard-truck.jpg, ***Retrieved*** November 2013

The baseplate of the truck is screwed to the deck of the skateboard.

A rubber bushing provides the cushion mechanism for turning the skateboard.

The kingpin runs through the axle piece, the bushing and the baseplate in order to keep these parts together.

A loosely screwed kingpin allows for better manoeuvring (turning).

A tightly screwed kingpin gives the skateboard more stability.

The wheels are removable to fit the needs of the rider and to replace when worn.

Questions

1. Explain the choice to assemble an upright bookshelf with nails instead of screws.

Answers

1. *The choice to use nails to assemble an upright bookshelf could be for the following reasons:*

   The bookshelf is meant to be permanently assembled without the need to be taken apart, nails are faster to use.

Mechanical Engineering: Linking of Mechanical Parts

I can explain the choice of a type of link in a technical object.

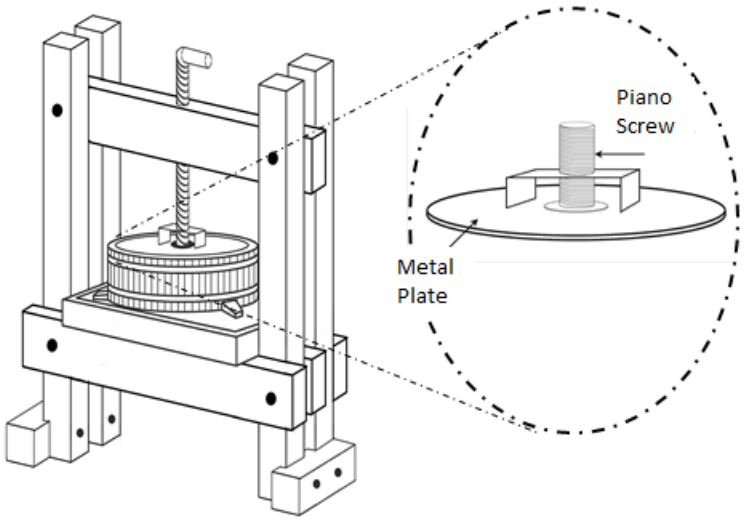
Explanation of Concepts

When analyzing a technical object, it is important to examine why a certain type of link has been used in its construction.

In order to do this, one must consider the characteristics of the link itself and how these characteristics play a role in the functioning of the object.

Example: A Cider Press

Function: A cider press is used to crush apples into an unfiltered, unsweetened juice.



A drawing of the squeeze plate system is shown in the circle above. In this system, a circular metal plate is welded to a piano screw.

The characteristics of the link between the metal plate and the piano screw are:

Direct, Rigid, Permanent, and Complete

In order for the cider press to function properly, it is important that the metal plate stays attached to the piano screw, and that all movement all of movement of the piano screw is transmitted to the metal. Therefore, the type of link used allows for the cider press to function properly.

Mechanical Engineering: Guiding Control

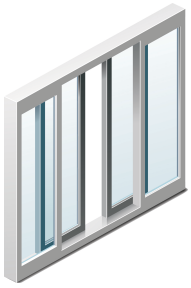
I can explain the choice of a type of guiding control in a technical object.

Explanation of Concepts

Guiding is the mechanical function performed by any component that controls the motion of one or more moving parts. A guiding component or control is a component whose mechanical function is to guide the motion of moving parts.

There are three main types of guiding: translational, rotational and helical.

1. **Translational** guidance ensures the straight translational motion of a moving part.

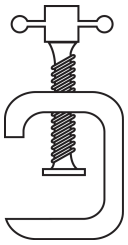


A track at the top and bottom of the window frame allows the translational guiding when the window is slid open.

2. **Rotational** guidance ensures the rotational motion of a moving part.

The axle attached to the bicycle frame guides the wheel in a rotational motion.

3. **Helical** guidance ensures the translational motion of a moving part while it rotates around the same axis.

- 

Threads inside the frame of the C-clamp control the helical guiding of the threaded shank.

Questions

View the video on this web page: bit.ly/QvCYAF

Which type of guiding control was used in the vice?

1. Rotational
2. Translational
3. Helical

A) 1 and 2 B) 1, 2, and 3 C) 2 and 3 D) 1 and 3

View the video on this web page bit.ly/1tys64c

Which type of guiding control was used in the vice?

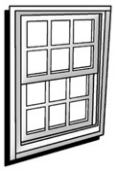
1. Rotational
2. Translational
3. Helical

A) 1 and 2 B) 1, 2, and 3 C) 2 and 3 D) 1 and 3

3. State the main type of guiding control for each item below.

a) Peanut Butter Jar

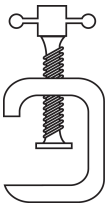
b) Window



c) File Cabinet Drawer

d) Door Handle

e) C-clamp



f) Laptop

Answers

1. *A: There is no helical guidance because the part in translation (vice jaw) does not rotate and the part that rotates (the screw) does not translate. See video:bit.ly/1hdEx01*
2. *C: The body of the vice provides helical guidance because the screw rotates and translates at the same time. The moving jaw of the vice translates. See video: bit.ly/RRZQvb (click on folder)*
3.
   a) *helical*
   b) *translational*
   c) *translational*
   d) *rotational*
   e) *helical*
   f) *rotational*

Mechanical Engineering:
Motion Transmission and Motion Transformation Systems

In Secondary 4, you are required to analyze certain motion transmission and motion transformation systems.

Here are some key points to consider:

1. **Identify the driver and driven components**
   - Kinematic chains have **driver** components, **intermediary** components, and **driven** (receptor) components.

     e.g. A bicycle has a front sprocket (driver) a chain (intermediary) and rear sprocket (driven component or "receptor")

2. **Identify whether the systems transmits or transforms motion.**
   - A **transmission of motion** occurs when the driven component has the same motion as the driver component (rotation to rotation, translation to translation).
   - A **transformation of motion** occurs when the driven component has a different motion from the driver component (rotation to translation, translation to rotation)

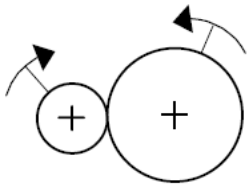
3. **Examine the system to see if a speed change is taking place.**
   - If necessary, refer to the section on speed changes.

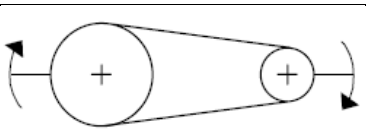
4. **Determine whether the system is reversible.**
   - A system is considered to be **reversible** if the driver component and the driven component can be interchanged and the system still functions. i.e. The driver can become the driven component and the driven component can become the driver
   - A system is considered to be **irreversible** if the exchange of the driver and the driven component results in a mechanical dysfunction.

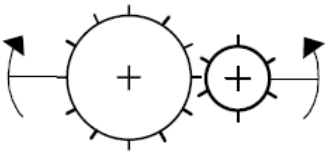
Mechanical Engineering: Motion Transmission Systems

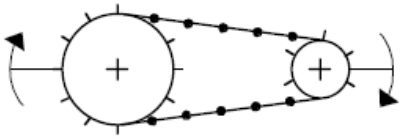
I understand the construction and characteristics of the following ***motion transmission systems.***

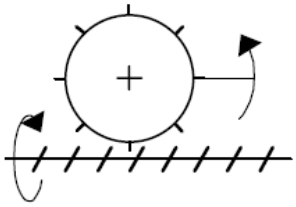
Explanation of Concepts

Friction Gears	
Symbol	
Description	• Rotational motion is transmitted from one wheel to the other • Transmission is done by friction between wheels • Rotation direction is opposite in each connecting wheel
Reversibility	Yes
Advantages	• Easy to assemble • Inexpensive to make • Will allow slippage, protecting it from damage • Gears can be positioned perpendicular or at any angle to each other
Disadvantages	• Wheels must always be together even as they wear away • Wheels can slip, causing interruption in transmission of motion • Must be kept clean(free of lubricants)

Pulley and Belt	
Symbol	
Description	• Rotational motion is transmitted from one pulley to the other by a belt • Rotation direction is opposite in each wheel • System can have more than two wheels
Reversibility	Yes
Advantages	• Easy to assemble • Will allow slippage, protecting it from damage • Allow for transmission of motion over long distances e.g. ski lift
Disadvantages	• Slippage will occur with wear and improper tension on the belt • Belt and Pulleys must be kept clean(free of lubricants) • Belt can be subject to premature wear

Gear Assembly	
Symbol	
Description	• Rotational motion is transmitted from one gear to the other • Rotation direction is opposite in each connecting gear • System can have more than two gear wheels • Used in machinery where mechanical advantage is needed • The torque(force) of a small motor can be increased considerably through a gear train • Requires fine machining of parts so that the teeth fit together precisely
Reversibility	Yes
Advantages	• Will not allow slippage • Can be connected at various angles • Allows for large forces to transmitted
Disadvantages	• Needs lubrication • Subject to severe damage if there is a failure in any one part of the system • Requires elaborate machining

Sprocket Wheels and Chain	
Symbol	
Description	• Rotational motion is transmitted from one sprocket to the other by a chain • Rotation direction is opposite in each connecting sprocket • System can have more than two sprockets • Used in machinery where mechanical advantage is needed • The teeth of the sprockets must be identical so that one chain securely fits all the sprockets • In a given system, the smaller the sprocket the faster it will rotate
Reversibility	Yes
Advantages	• Will not allow slippage • Allows for large forces to be transmitted
Disadvantages	• Needs lubrication

Wheel and Worm Gear	
Symbol	
Description	• Rotational motion is transmitted from the worm gear to one or more wheel gears(sprocket) • Used in machinery where fine adjustment is needed • One turn of the worm gear advances the wheel by one tooth. the above example requires eight turns of the worm gear for one complete revolution of the wheel • Requires fine machining of parts so that the wheel gear teeth fit precisely in the worm gear
Reversibility	No. If a force is applied to the wheel gear(sprocket) the worm gear will not turn
Advantages	• Will not allow slippage • Allows for fine adjustment eg tuning pegs on a guitar
Disadvantages	• Needs lubrication

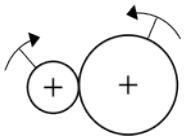
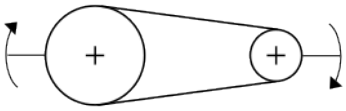
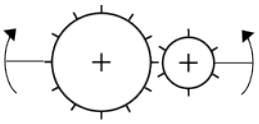
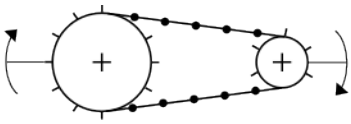
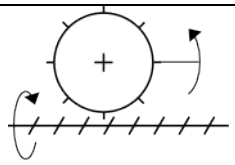
Symbols for mechanisms courtesy of Le Centre de Développement Pédagogique

Mechanical Engineering: Motion Transmission Systems

I am familiar with the symbols for the motion transmission systems.

Explanation of Concepts

Symbols for Motion Transmission Systems

Motion Transmission System	Symbol
Friction Gears	
Pulley and Belt	
Gear Assembly	
Sprocket Wheels and Chain	
Wheel and Worm Gear	

Symbols for mechanisms courtesy of Le Centre de Développement Pédagogique

Mechanical Engineering: Motion Transmission Systems

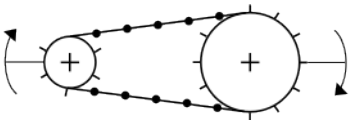
I can explain the choice of a motion transmission system in a technical object.

Explanation of Concepts

During the design of a technical object, one must consider which transmission systems are necessary and more advantageous than others. Being able to identify and explain these advantages involves the understanding of each of these systems.

For an explanation of these systems refer back to friction gears, pulley and belt, gear assembly, sprocket wheel and chain, and worm and worm gear systems in the previous sections.

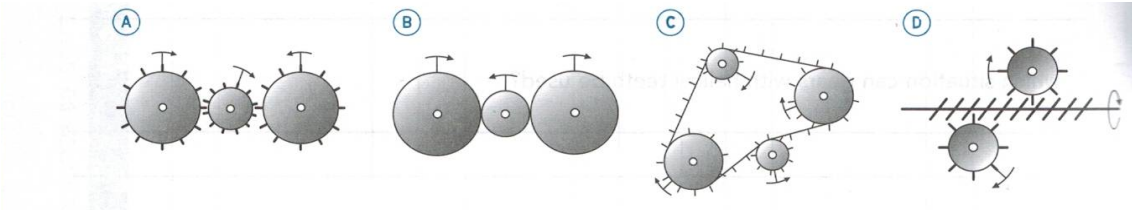
Example: Choice of Motion Transmission System for a Bicycle



A person riding a bicycle is regularly exerting a force on the pedals which drive the sprocket wheel and chain.. Engineers have chosen a sprocket wheel and chain system because of this force. The teeth of the gears fit perfectly into the chain, allowing the chain to stay on the sprockets as the force is exerted through the pedals. If a pulley and belt system was used, slipping would occur and the belt may not be able to withstand the force exerted by the bicycle rider.

Questions

1. Which of the following diagrams of a motion transmission system correctly illustrates the motion of the components?



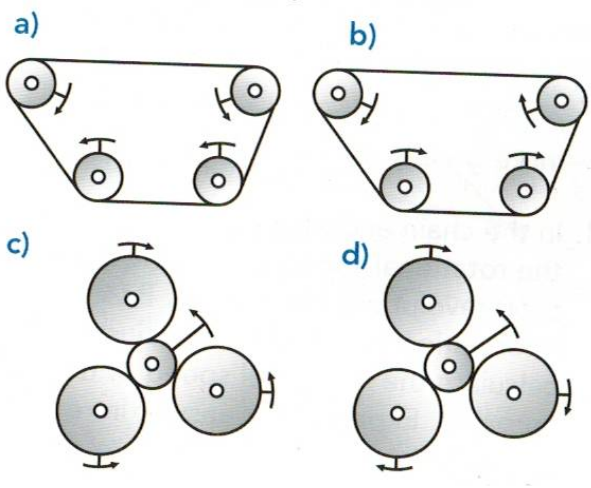
A) I and II only

B) II and III only

C) III and IV only

D) II, III and IV

2. Which of the following diagrams of a motion transmission system correctly illustrates the motion of the components?



A) I and II only

B) II and III only

C) II and IV only

D) I and III only

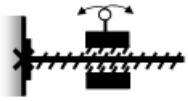
3. Explain why a sprocket wheel and chain system is used in a bicycle rather than a belt and pulley system

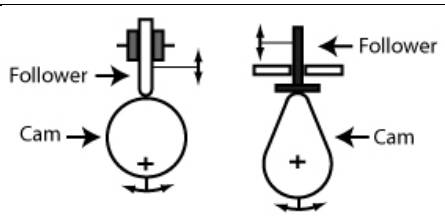
Answers

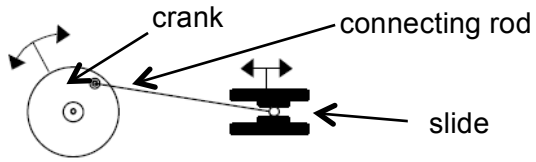
1. *B*
2. *C*
3. *The sprocket wheel and chain system does not permit slippage, therefore the forces applied to the pedals are transmitted to the back wheel*

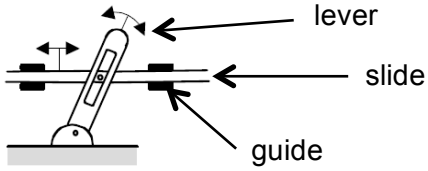
Mechanical Engineering: Motion Transformation Systems

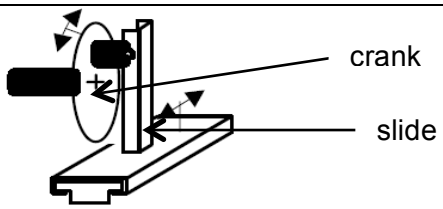
*I understand the construction and characteristics of the following **motion transformation systems**.*

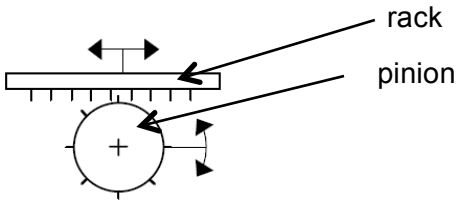
Screw Gear System		
Symbol	**Type 1**  Nut is free component Screw is fixed component	**Type 2**  Screw is free component Nut is fixed component
Description	• Rotational motion is applied to the free component to obtain translational motion in the other component • Transforms quick rotation to slower translation	
Reversibility	No, because you cannot transform translational to rotational motion in this system.	
Advantages	• Allows for precise adjustment in its use. Used in many types of tools and machinery	
Disadvantages	• Parts need to be lubricated	

Cam and Follower	
Symbol	
Description	• Rotational motion can be applied to cam to create translational motion on the follower. The follower must have guidance of some sort to operate properly. • Size and shape of cam and placement of axle will determine the length and action of the stroke
Reversibility	No, because applying a force to the follower (moving it up and down) will not cause the cam to rotate.
Advantages	• Allows for very precise and custom translational motion. Timing and distance of the follower can be determined by shape, size of cam and placement of axle on cam.
Disadvantages	• Parts need to be lubricated • A return mechanism (e.g. spring, gravityhas to be built into design

Connecting Rod and Crank	
Symbol	
Description	• Rotational motion can be applied to the crank to create translational motion in the slide. Connecting rod connects slide to crank. In order to achieve the change the slide must be guided. • Translational motion can be applied to slide to produce rotational motion in crank • Provides a mechanical advantage
Reversibility	Yes, because rotational motion can be applied to the crank to produce translational motion in the slide and translational motion can be applied to the slide to produce rotational motion in the pinion.
Advantages	• Allows force to be applied without slippage • Change motion from translational to rotational or vice versa • Allows force to be applied at a distance through the connecting rod
Disadvantages	• Parts need to be lubricated • Very precise fit needed between slider and guidance • Reversibility is only possible in a mechanism built to precise specifications

Lever and Slide	
Symbol	
Description	• Rotational motion can be applied to the lever to create translational motion in the slide and vice-versa. The slide must have guidance of some sort to operate properly. • The length of the lever will determine the distance that the slide will move. • Designed for short oscillatory movement
Reversibility	Yes
Advantages	• Simple mechanism
Disadvantages	• Parts need to be lubricated

Rotating Slider Crank Mechanism	
Symbol	
Description	• Rotational motion is transformed to translational motion in the slide • Translational motion of the slide is transformed into partial rotational motion in the crank • Provides a mechanical advantage which is determined by the size of the wheel • Produces oscillating motion
Reversibility	**Yes,** because rotational motion of the crank produces translational motion in the slide and translational motion of the slide produces partial rotational motion in the crank.
Advantages	• Change motion from translational to rotational or vice versa
Disadvantages	• Parts need to be lubricated • Reversibility is only partial

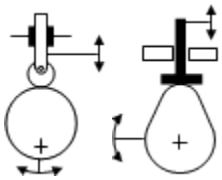
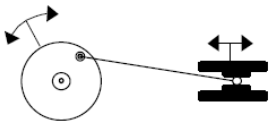
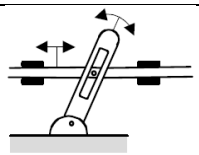
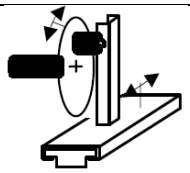
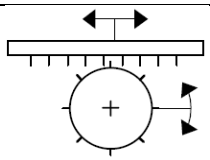
Rack and Pinion	
Symbol	
Description	• Rotational motion of pinion is transformed into translational motion of rack. • Translational motion can be applied to rack to produce rotational motion in the pinion • The rack is really a toothed gear wheel that has been straightened.
Reversibility	Yes because rotational motion can be applied to the pinion to produce translational motion in the rack and vice versa.
Advantages	• Allows force to be applied without slippage
Disadvantages	• Parts need to be lubricated, • Very precise fit needed between teeth of rack and pinion

Mechanical Engineering: Motion Transformation Systems

I am familiar with the symbols for the motion transformation systems.

Explanation of Concepts

Symbols for Motion Transformation Systems

Motion Transformation System	Symbol
Screw Gear System	
Cam and Follower	
Connecting Rod and Crank	
Lever and Slide	
Rotating Slider Crank Mechanism	
Rack and Pinion	

Mechanical Engineering: Motion Transformation Systems

I can explain the choice of a motion transformation system in a technical object.

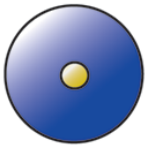
Explanation of Concepts

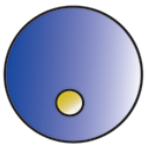
During the design of a technical object, one must consider which transformation systems are necessary and more advantageous than others. Being able to identify and explain these advantages involves the understanding of each of these systems.

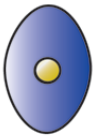
For an explanation of these systems refer back to screw gear system, cam and follower, connecting rod and crank, lever and slide, rotating slider crank mechanism and rack and pinion on the previous pages.

Questions

1. A cam and follower system transforms the rotational motion of a cam into the reciprocating translational motion of a follower. Which cam below would not allow for both clockwise and counter-clockwise motion?

A) 

B) 

C) 

D) 

2. A student wishes to build a pull toy of a clown sitting in a cart in which a mechanism will cause the hat of the clown to move up and down as the cart is pulled.

   Which one of the systems below would not be suitable for a mechanism in this toy?

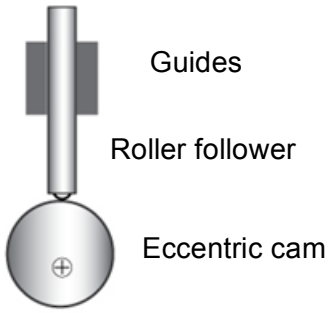
   A) Crank and slide

   B) Cam and follower

   C) Rack and pinion

   D) Crank, connecting rod, and slide

3. Examine the cam and follower system illustrated below.



Describe two ways the rise of the follower could be increased.

Answers

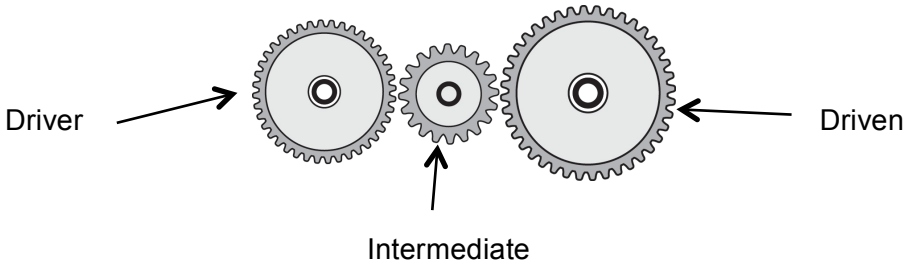
1. *D*
2. *C*
3. *Move the center of rotation closer to the outside of the cam. Increase the size of the cam.*

Mechanical Engineering: Speed Changes

I understand how systems can be used to allow for speed changes in the design of technical objects.

Explanation of Concepts

Speed Change occurs in a motion transmission system when the driven component rotates at a different speed than the driver.



Driver (Driving) Component: The component that receives the force needed for the system to start working and in most cases continue to work.

Driven Component: This component receives the motion from the driver component and transfers it to another part.

Intemediate Component: It is found between the driver and driven component. *Note that not all systems have an intermediate component.

The speed change in motion transmission systems depends on the relative diameters of the driver and driven components.

a) Speed Increase: Diameter of driven < diameter of driver

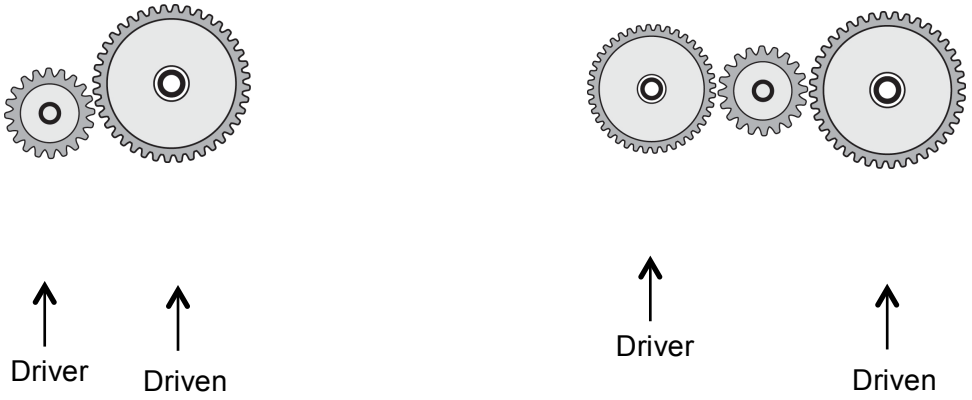
- When the diameter of the driven component is <u>less</u> than the diameter of the driver component, there is a speed increase in the system.

e.g.

b) Speed Decrease: Diameter of driven > diameter of driver

- When the diameter of the driven component is greater than the diameter of the driver component, there is a speed increase in the system.

e.g.



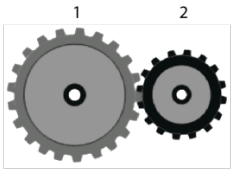
c) No Speed Change: Diameter of driven = diameter of driver

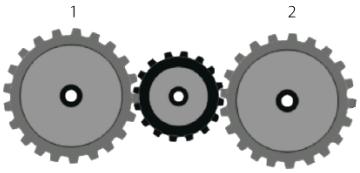
- When the diameter of the driven component is equal to the diameter of the driver component, there is a speed increase in the system.

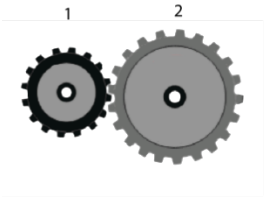
e.g.

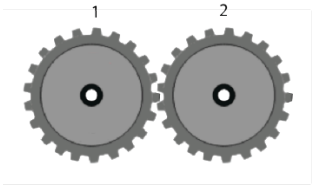
Questions

1. For which of the systems below will the Gear 2 turn more quickly than the Gear 1?

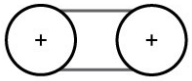
A) 

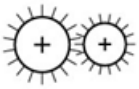
B) 

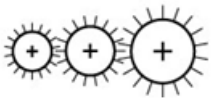
C) 

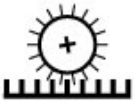
D) 

2. Which of the systems below could produce a change in speed similar to the one in a wheel and worm gear system?

A) Two pulleys of equal size connected by a belt 

B) A large driver gear turns a smaller driven (receptor) gear 

C) A small driver gear turns a middle size intermediary gear which turns a large driven (receptor) gear 

D) A rack and pinion system where the pinion is the driver and the rack is the driven (receptor). 

3. A wheel and worm gear system is shown below.

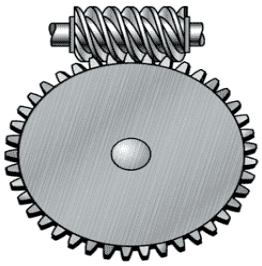


Image from: http://www.machinerylubrication.com/Read/1080/worm-gears
Retrieved: December 2013.

Given a constant speed of the driver (worm), what changes can be made to the components of the system to increase the speed of the driven gear?

Answers

1. *A*
2. *C*
3. *The best way to increase the speed in a worm and wheel transmission system is to have a gear that is smaller in diameter and/or a gear that has fewer teeth. A smaller diameter naturally takes less time to make one full rotation and few teeth means less time having each tooth mesh with this respective part on the worm component.*

Electrical Engineering: Power Supply

*I can define **power supply** as **'the ability to generate electrical current'**.*

Explanation of Concepts

A **power supply** has the ability to generate electrical current. A battery is an example of a power supply.

Questions

1. A circuit has many components. Which of the following components generates electrical current?

   A) Power supply

   B) Ammeter

   C) Voltmeter

   D) Switch

2. There are two types of electric drills. One has a battery while the other has to be plugged into an electrical outlet. Explain how a battery and an electrical outlet can be classified as power supplies in a circuit.

Answers

1. *A*
2. *The battery and electrical outlet both provide current and allow the electrons to flow through a circuit.*

Electrical Engineering: Power Supply

I can determine the source of current in technical objects with an electrical circuit.

Explanation of Concepts

Examples of the different power supplies (sources of current) in technical objects include:

Chemical battery: Chemical reactions inside the battery transform chemical energy into electrical energy.

Piezoelectric: Mechanical energy from vibrating crystals is transformed into electrical energy. Piezoelectric crystals are found in clocks, timers, lighters, ultra sound devices and speakers.

Solar cell (photovoltaic): Converts light energy to electrical energy.

Alternator: The mechanical energy of a rotating electromagnet is transformed into electrical energy.

Thermocouple: Thermal energy is transformed into electrical energy. A thermocouple is a sensor e.g. digital food thermometers, fridge thermometer, gas stoves and heaters.

Questions

1. A battery is a power source used in everyday objects. Which of the following objects does not use a chemical battery as a power supply?

   A) Flashlight

   B) Portable speakers

   C) Toaster

   D) Laptop

2. A piezoelectric quartz watch uses the vibration of crystals to keep track of time. Which type of energy transformation occurs in this system?

   A) Chemical energy into electrical energy

   B) Solar energy into electrical energy

   C) Magnetic energy into electrical energy

   D) Mechanical energy into electrical energy

3. Paul's calculator screen is dull when he sits in his living room where there is little light. When he walks into a well-lit room, the screen becomes brighter. What is the source of current in his calculator?

Answers

1. *C*
2. *D*
3. *Solar cell*

Electrical Engineering: Conduction, Insulation and Protection

*I can define **conduction** as the '**ability to conduct electricity'**.*

Explanation of Concepts

Conduction is the flow of electrons through a material.

Questions

1. Conduction plays an important part in an electrical circuit. Which of the following does NOT describe conduction?

   A) The flow of current through a switch

   B) The flow of current through a wire

   C) The flow of electrons through a wire

   D) The ability to prevent the current from flowing

2. The procedure for a lab on electricity states that the wires connecting the switch must touch the metal part and not the plastic part of the switch. Why is it important to connect the wire to the switch correctly?

Answers

1. *D*
2. *Conduction is the ability to allow the current to flow. The current can flow through the wire and the metal because they are conductors, but will not be able to flow through the plastic part of the switch because plastic is an insulator.*

Electrical Engineering: Conduction, Insulation and Protection

I can distinguish between electrical conductors and insulators in a technical object.

Explanation of Concepts

Conductor: A substance that allows electrical current to flow through it. Examples of good conductors are metals and electrolytic solutions.

Insulator: A substance that does not allow current to pass through it. Examples of good insulators are wood, plastics, paper, rubber, glass and ceramics.

Questions

1. Insulators are used in electronic toys. What material could a manufacturer use to insulate a part of a toy?

    1. Plastic
    2. Ceramic
    3. Metal
    4. Cardboard
    5. Glass

    A) 1, 2, and 4 B) 1, 2, and 5 C) 1, 2, 4, and 5 D) 1, 2, 3, 4, and 5

2. You are asked to build a circuit that will light up one light bulb with a switch. You have no wires available. The only materials in the classroom are listed below.

Chalk	Plastic fork
Cardboard	Nail
Wooden spoon	Ceramic coaster
Metal knife	Paperclip

    Which of the above materials could be used to complete the circuit? Explain your answer.

3. An ammeter is used to measure the current intensity; a voltmeter measures the potential difference in a circuit.

    Why do the terminals on an ammeter and a voltmeter have plastic casings over the metal components?

Answers

1. *C*
2. *The materials that could be used to replace the broken wire are the metal knife, nail and paperclip. They are all made out of metal and are good conductors. They all will allow the current to flow through them.*
3. *The plastic casing covers the metal component because it is an insulator. It does not allow the current to flow through it. Therefore, when you touch the knobs the current will not transfer to you and you will not get an electric shock.*

Electrical Engineering: Conduction, Insulation and Protection

I can describe the role of a protective device in a circuit (fuse, breaker).

Explanation of Concepts

Fuses and **breakers** are used to protect electrical circuits.

A high current intensity can result in a power surge which can damage electrical devices in a circuit and/or cause a fire. The protective components will then automatically cut off the flow of electrons (current) when there is too much of it passing through the circuit.

Fuses contain a thin wire that melts and breaks the circuit when there is too much current. The fuse needs to be replaced to restore the circuit.

Breakers contain a thin metal strip. When too much current passes through the breaker the metal becomes hot and bends. The metal is no longer in contact with the circuit and the current cannot pass through the breaker. Breakers can be used multiple times. By resetting the switch on a breaker the metal strip is returned to its original position and the current is restored.

Questions

1. Fuses and breakers are used in all buildings. What is the function of a fuse and breaker?

   A) Control the flow of the current

   B) Prevent the current from flowing

   C) Automatically cut the current

   D) Allow the current to flow in a circuit

2. While making toast, John turned on the coffee maker and almost immediately, both machines stopped functioning. Explain what happened.

Answers

1. *C*
2. *The electrical circuit was surcharged therefore; it couldn't handle operating both machines. The breaker was released disrupting the flow of electricity.*

Electrical Engineering: Conduction, Insulation and Protection

I can analyze the factors that affect electrical conductivity (section, length, nature, temperature of conductor).

Explanation of Concepts

The **conductivity** of a substance (how well it conducts) depends on the type of material, length, diameter and the temperature of the conductor.

The conductivity of a wire can be increased by:

- Increasing the diameter of the wire
- Decreasing the temperature of the wire
- Decreasing the length of the wire
- Changing the type of material (copper is one of the best and most affordable materials)

Questions

1. The conductivity of a wire in an electrical toy needs to be decreased. How should the electrical engineers change the wire?

    1. Increase the length
    2. Increase the diameter
    3. Decrease the length
    4. Decrease the diameter

    A) 1 and 2 B) 1 and 4 C) 2 and 3 D) 2 and 4

2. The properties of four copper wires are described in the table below.

Properties of Copper Wires

Wire	Length	Diameter	Temperature
A	10 m	2 mm	25 OC
B	10 m	3 mm	20 OC
C	20 m	2 mm	20 OC
D	20 m	3 mm	25 OC

Which of the copper wires has the best conductivity? Explain your answer.

Answers

1. *B*
2. *Wire B would have the highest conductivity. It has the shortest length, widest diameter and the lowest temperature, all of which are properties that increase conductivity.*

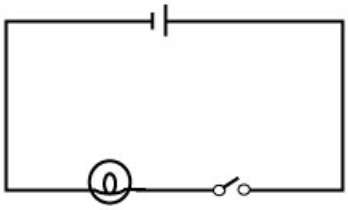
Electrical Engineering: Control

I can define ***control*** *as the* ***'ability to control the travel of electrical current'****.*

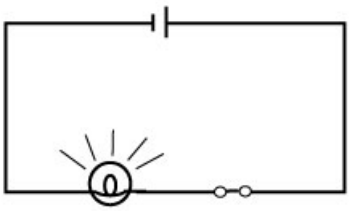
Explanation of Concepts

A **control** is a component placed in a circuit that helps regulate the flow of electricity.

A switch is the most common example of a control. When a switch is closed, current can flow through the circuit. When the switch is open, the current's pathway is broken and current cannot flow through the circuit.



Open Circuit



Closed Circuit

Questions

1. Controls play an important role in electrical engineering. Which of the following statements about control is false?

   A) A control is another word for switch

   B) A control regulates the electrical current in a circuit

   C) A control can be open or closed

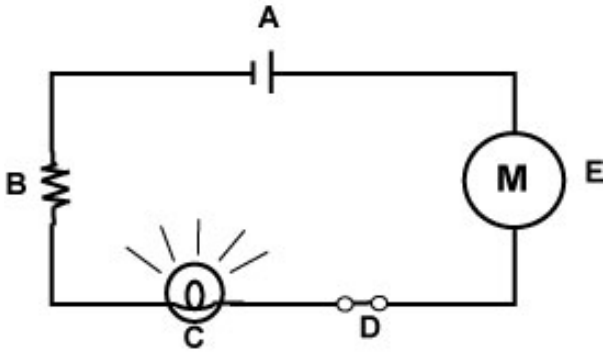
   D) A control regulates the speed of electrons in a circuit

2. In which of the situations below is current flowing through the circuit?

   1. The magnetic switch is closed in the presence of a magnetic field
   2. The magnetic switch is open in the presence of a magnetic field
   3. The flip-flop switch is closed in a circuit.
   4. The flip-flop switch is open in a circuit.

   A) 1 and 3 B) 1 and 4 C) 2 and 3 D) 2 and 4

3. Which of the following circuit components is a control?



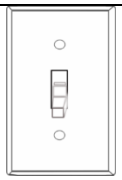
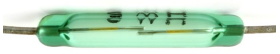
Answers

1. *D*
2. *A*
3. *D*

Electrical Engineering: Control

I can describe different types of switches (lever, pushbutton, flip-flop, magnetic control).

Explanation of Concepts

Type of Switch	Definition	Example
Lever	A **lever switch** is an electrical switch controlled by a mechanically moving arm through a small arc.	 1
Push Button	A **push button switch** completes an electric circuit when pressed. Push button switches can be found in computer keyboards (power button), doorbells, and calculators.	 2
Flip-flop (rocker)	A **flip-flop switch** (**rocker switch**) is an on/off switch that rocks (back and forth) when pressed. One side of the switch is raised while the other side is lowered. A flip-flop switch can be found on a power bar.	 3
Magnetic Control	A **magnetic control switch** has two pieces of metal that are separated by a gap. When the switch is near a magnetic field, the two pieces of metal come in contact with each other to close the circuit and allow the current to pass through it. A magnetic switch can be found home alarms on doors and windows.	 4

Images from:

1: http://www.clker.com/clipart-light-switch-off.html **Retrieved** December 2013

2: http://upload.wikimedia.org/wikipedia/commons/a/a6/Knopka_8_ugolnik.jpg, **Retrieved** December 2013

3: http://openclipart.org/detail/46741/switch-black-on-built-in-by-palomaironique **Retrieved** December 2013

4: http://commons.wikimedia.org/wiki/File:Reed_switch_(aka).jpg.**Retrieved** December 2013

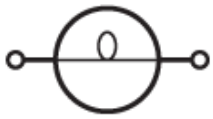
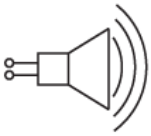
Electrical Engineering: Transformation of Energy

I can identify and explain the transformation of energy in different components of a circuit.

Explanation of Concepts

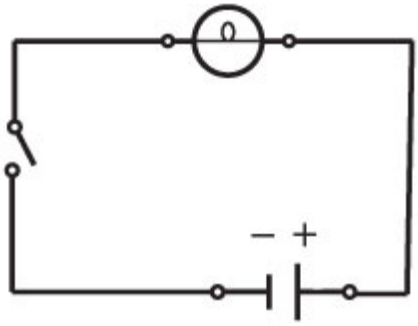
Electrical energy can be transformed into light energy, sound energy, mechanical energy or thermal energy.

Examples of Energy Transformations in Different Circuit Components

Component	Symbol	Transformation
Light Bulb		Electrical Energy →Light and Heat
Battery		<u>In Use:</u> Chemical Energy → Electrical Energy and Heat <u>Being Charged:</u> Electrical Energy → Chemical Energy and Heat
Motor		Electrical Energy →Mechanical Energy and Heat and Sound
Speaker		Electrical Energy → Sound and Mechanical Energy and Heat

Questions

1. Which of the following components of a circuit transforms energy?



1. light
2. switch
3. battery
4. wires

A) 2 and 4 B) 1 and 3 C) 1, 2, and 3 D) 1, 3, and 4

Answers

1. *B*

Electrical Engineering: Transformation of Energy

I can describe the energy transformations that take place in electrical or electronic appliances.

Explanation of Concepts

Electronics and electrical appliances *transform* **electrical energy** into **other forms** of energy depending on the device used in the system.

Electrical Energy can be transformed into:

- Light (luminous) Energy
- Sound Energy
- Mechanical (movement) Energy
- Thermal (heat) Energy.

Questions

1. A fan is designed to transform electrical energy to:
   A) Sound energy
   B) Mechanical energy
   C) Thermal energy
   D) Light energy

2. Identify the transformations that occur in each of the appliances listed below as electrical energy is transformed into other forms of energy.

Appliance	Useful energy (purpose of appliance)	Other form(s) of energy
T.V.	Light, sound	Thermal
Toaster		
Flashlight		
Blender		
Hairdryer		
Radio		

Answers

1. *B*
2. *A doorbell transforms electrical energy into sound energy. Electrical energy to light energy.*
3.

Appliance	*Useful energy (purpose of appliance)*	*Other form(s) of energy*
T.V.	*Light, sound*	*Thermal*
Toaster	*Thermal, Mechanical*	*Light*
Flashlight	*Light*	*Thermal*
Blender	*Mechanical*	*Sound, Thermal*
Hairdryer	*Thermal, Mechanical*	*Sound*
Radio	*Sound, Light*	*Thermal*

Materials: Constraints

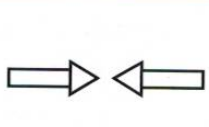
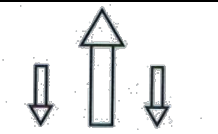
I can define ***constraint*** *as '****an external force (shearing, compression, deflection, torsion and tension) that is exerted on materials and that has a tendency to deform them'****.*

Explanation of Concepts

The parts of a technological object may be subjected to one or more external **constraints** or forces.

These forces can **deform** the parts.

Types of Constraints and Their Symbols

Constraint	Description	Symbol	Examples
Compression	Forces that tend to crush it.		Crushing a can. Squeezing a wet sponge.
Tension	Forces that tend to stretch it.		Copper being stretched into wire. Tug of war.
Torsion	Forces that tend to twist it.		Hands wringing a towel. Earthquake twisting a bridge.
Deflection	Forces that tend to bend it.		Fish bending a fishing rod. Clothes pushing down on a clothesline.
Shearing	Forces that tend to cut.		Scissors cutting paper.

Questions

1. The following image is an example of what type of constraint?

   A) Compression
   B) Torsion
   C) Deflection
   D) Tension

2. The following image is an example of what type of constraint?

   A) Compression
   B) Torsion
   C) Deflection
   D) Tension

3. A new bridge is being built for cars to cross the St. Lawrence River. What types of constraints must an engineer consider when he is designing the bridge?

Answers

1. *C*
2. *B*
3. *The top of the beams will be subjected to compression force by the traffic on the bridge, while at the same time the bottom of the beam is subjected to tension. Where the beams are supported on the pillars shearing forces must be taken into account. The pillars are subjected to compression forces from the weight of the bridge.*

Materials: Characteristics of Mechanical Properties

*I can define certain **mechanical properties** of materials: ductility, hardness, elasticity, fragility, malleability, resilience and stiffness.*

Explanation of Concepts

The **mechanical properties** of a material describe how it reacts when subjected to one or more constraints (forces).

Types of Mechanical Properties

Mechanical Property	Definition
Hardness	Ability to resist indentation (nicks) or abrasion (scratches)
Elasticity	Ability to return to their original shapes after undergoing a constraint
Resilience	Ability to resist shocks without breaking
Ductility	Ability to be stretched without breaking
Malleability	Ability to be flattened or bent without breaking
Stiffness	Ability to retain their shapes when subjected to various constraints

Materials: Characteristics of Mechanical Properties

I can explain the choice of a material based on its properties.

Explanation of Concepts

Materials used in construction of technical objects have different properties.

When choosing a material for an object, the forces or constraints the object will be subjected to will help determine which material is most suitable.

Examples:

- Steel is selected for the construction of manhole covers because it is malleable, hard and resistant.
- Copper is selected for the construction of electrical cables. In addition to being conductive, it is highly ductile, allowing it to be drawn into long wires and cables.
- Glass is selected for the cover of fire alarms. The fragility of the glass allows it to be broken easily so the fire alarm can be accessed.

Questions

1. John wants to build a go-cart in order to enter a race taking place this summer. What material(s) should he use for each of the parts listed below? Explain your answer.
   a) Tire
   b) Body Frame
   c) Seats

2. Hockey sticks are made from a material that can resist indentation and shock when coming into contact with a puck or the ice. The material also has to be lightweight to be easily handled by the player. Here is a list of possible materials to choose from:

Materials	Properties
Steel	Hardness Resilience Ductility High density High thermal conductivity
Carbon fibre	Low density Hardness Resilience Electrical conductivity Resistant to corrosion Rigidity
Polymethyl (acrylic)	Hardness Rigidity Comes in a variety of colours Malleability Brittleness
Polyamide (nylon)	Resilient Medium hardness Flexible High moisture absorbance

Which of the materials above would be the best material to use for a hockey stick? Explain your choice by using the properties of the materials.

Answers

1.

a) *The tires should be made of rubber. The material needs to be strong enough to resist friction due to driving at fast speeds. It also needs to be able to grip the asphalt and provide as smooth a ride as possible. It must also be easily changeable in case of damage or accident.*

b) *The body frame should be made of aluminum due to its malleability and lightweight properties. This will allow the go-cart to go faster because it is lightweight and the malleability allows the builder to bend the structure according to their vision for the final product.*

c) *The seats should be made of various materials. Metal can be used to make the shape of the seat. Foam, covered by leather, vinyl, or cloth, can be used for the cushion*

2. *The best material would be carbon fibre because:*

Low density: light weight
Hardness and resilience: resistance to denting and shocks
Resistance to corrosion: subjected to ice and water
Rigidity: resistance to application of constraints.

Materials: Other Properties

*I can define certain **properties of materials**: corrosion resistance, electrical conductivity and thermal conductivity.*

Explanation of Concepts

Properties of Materials

Property	Definition
Resistance to Corrosion	Ability to resist the effects of corrosive substances, which cause the formation or rust for example.
Electrical Conductivity	Ability to carry an electric current.
Thermal Conductivity	Ability to transmit heat.

Questions (refers to previous 2 statements)

1. What mechanical properties should materials for a hard-hat have? Explain your answer.

White hard hat by Jessica, http://www.clker.com/clipart-white-hard-hat-5.html **Retrieved**: December 2013

Answers

1. *The purpose of a helmet is to protect the wearer from any dangers. The mechanical properties involved in the choice of material are:*
   - ***Hardness:*** *To avoid as much as possible any scratches or dents.*
   - ***Resilience:*** *In case of shocks or impact, the helmet needs to stay intact without breaking to protect the wearer.*
   - ***Stiffness:*** *The helmet needs to hold its shape when it is confronted with many constraints again to protect the wearer.*
   - ***Non-****electrically conductive*

Materials: Modification of Properties

I can describe different treatments to prevent degradation of materials.

Explanation of Concepts

Over time materials can degrade. As a result, several techniques and treatments have been developed to help prevent degradation and allow the material last longer.

Some techniques used to prevent degradation are described below.

Wood and Modified Wood*:*

- Varnish
- Paint
- Treatment with a special protective coating like an alkaline solution that contains copper (Turns the wood bluish).
- Subjecting it to high temperature

Ceramics:

- Heating
- Coating them in enamel a protective coating
- Avoiding exposing them to acids, bases and thermal shock
- Note: Ceramics are generally very durable. They are even found in archeological digs.

Metals and Alloys:

- Coating the metal with treatments.
- Metallic Coatings: zinc, chrome, gold, silver, nickel, aluminum, lead
- Other Coatings: paint, enamel, grease, resin
- Exposing to high heat to make the material harder like steel

Plastics:

- Protecting the plastic with waterproof coatings
- Adding antioxidants like carbon to prevent oxidation
- Adding pigments that absorb UV rays

Composites:

- Two main problems with composites that lead to degradation are deformation and loss of adherence between the materials.
- To prevent degradation again depends on the materials used in making the composite and applying the protection to the material.

Questions

1. You are thinking of building of a deck in your backyard. You look at a neighbor's deck and see that it is discolored and rotten in certain places.
   a) How can you explain the state of your neighbor's deck?
   b) How could you prevent your deck from looking like your neighbor's?

Answers

1.

a) The neighbor's deck is discolored and rotten due to the fact that the wood was not treated against possible degradation. As a result, rotting occurred.

b) It is best to use wood that has been pressure treated with a preservative. The wood also needs to be sealed with varnish or a weather treatment to prolong the life span of the wood especially if it will be exposed to harsh climate conditions and many forms of precipitation

Graphical Language

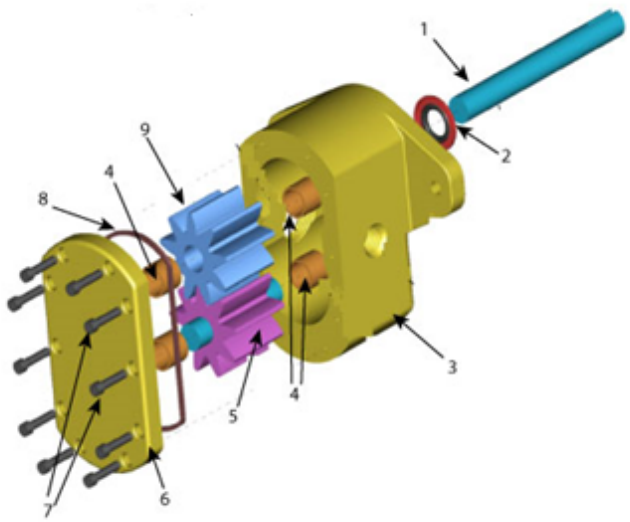
I can interpret an exploded view drawing of a technical object.

Explanation of Concepts

An **exploded view** is a technical diagram of an object that shows the relationship or the order of assembly of the various components. The components of the object are shown slightly separated.

An example of an exploded view drawing is shown below. The legend indicates the name of each numbered component as well as the quantity (QTY) of those components required for the assembly of the object.

Gear Pump – Exploded View Drawing



Item	QTY	Name
1	1	Axle
2	1	Seal
3	1	Housing
4	4	Bushings
5	1	Idler gear
6	1	Housing Cover
7	10	Bolts
8	1	Case seal
9	1	Driver Gear

Image from:
http://commons.wikimedia.org/wiki/File:Gear_pump_exploded.png

In the example above, the component labelled, “1” is the axle and there is one axle in the Gear Pump. The component labelled “7” is a bolt and there are 10 bolts in the gear pump.

Graphical Language

I can identify force and motion symbols.

Explanation of Concepts

Motion and Force Symbols

Motion		**Force**	
Motion is characterized by the change in the position of a body relative to another, which is called an *inertial* or *non-inertial reference system.*		Force refers to the capacity to act or produce an effect or any action that changes a body's state of rest or motion.	
Rectilinear translation in one direction		Force that tends to STRETCH the bodies or PULL them.	
Rectilinear translation in two directions		Force that tends to SQUEEZE the bodies or PUSH them.	
Rotation in one direction		Force that tends to TWIST bodies.	
Rotation in two directions		Force that tends to SPLIT bodies.	
Helical