

Transformation of Energy: Distinction between Heat and Temperature

I understand and would be able to describe the relationship between heat and temperature.

Explanation of Concept(s):

Heat is a form of energy. Whereas temperature is a measure of heat. Temperature is the average kinetic energy of particles.

If we have 50ml of water in a beaker versus 500ml of water in a larger beaker and they are both at the same temperature, the larger container has more heat energy due to its greater mass.

Multiple Choice

- What is a temperature a measure of?
 - The number of particles
 - The amount of matter in an object
 - The movement of particles
 - The relationship between the volume and mass of a liquid

Constructed Response Question

- Heat and temperature are often mistakenly used interchangeably. Describe the difference between heat and temperature at the molecular level.

Answers

- c
- Heat is thermal energy that is transferred from one object to another. Temperature is the average kinetic energy of particles; it is a measure of heat.

Technology
review

TECHNOLOGICAL WORLD

Mechanical Engineering: Linking of Mechanical Parts

I would be able to 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 Concept(s)

- A link holds two or more parts of the same technical object together. In mechanics, a component is a part or fluid that performs a mechanical function. Linking is the mechanical function performed by any component that connects different parts of a technical object.

- 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 or surface of the linked parts are rigid	OR	flexible the linking component or surface of the linked parts can be deformed
removable the linked parts can be separated without damaging either their surfaces or the linking component	OR	non-removable 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

Practice Questions

- State the four characteristics of the link between the components identified in each image below.

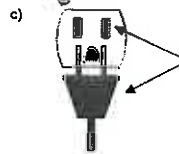


Direct or Indirect
Complete or Partial
Removable or Non-removable
Rigid or Flexible

(Note: the shelves are glued in place)



Direct or Indirect
Complete or Partial
Removable or Non-removable
Rigid or Flexible



Direct or Indirect
Complete or Partial
Removable or Non-removable
Rigid or Flexible

Answers:

- a) indirect, complete, non-removable, rigid
b) Direct, complete, removable, rigid
c) Direct, complete, removable, rigid

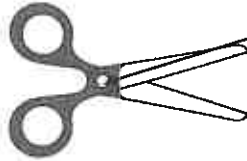
Mechanical Engineering: Linking of Mechanical Parts

I would be able to determine the characteristics of links that are most suitable in the design of a technical object

Explanation of Concept(s)

- 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-removable.

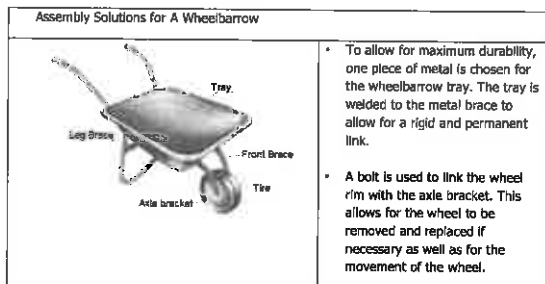
Mechanical Engineering: Linking of Mechanical Parts

I would be able to judge the choice of assembly solutions in a technical object

Explanation of Concept(s)

- 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:



Practice Questions

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

Answers:

- 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.

Practice Questions

- A metal shelf needs to be permanently attached to a metal frame. Which linking component should be used to secure the shelf to the frame?
 - Glue
 - Nail
 - Screw
 - Rivet
- Inside a hockey helmet there is a layer of flexible padding to protect the player's head. It is held in place with glue. What are the characteristics of the link between the padding and the helmet? Explain each characteristic.

Answers:

- D
- Indirect (glue is needed to link the two components)
Complete (padding is held in place – no movement between the two components)
Non-removable (glue is used – to separate the two components will damage them)
Rigid (The padding is flexible, but the link between the padding and the helmet is rigid)

Mechanical Engineering: Guiding Control

I understand and would be able to explain the choice of a type of guiding control in a technical object (e.g. the slide guides a drawer and reduces friction)

Explanation of Concept(s)

- 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 forms of guiding: translational, rotational and helical.

- 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 opened.

- Rotational guidance ensures the rotational motion of a moving part.



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

- Helical guidance ensures the translational motion of a moving part while it rotates about the same axis.



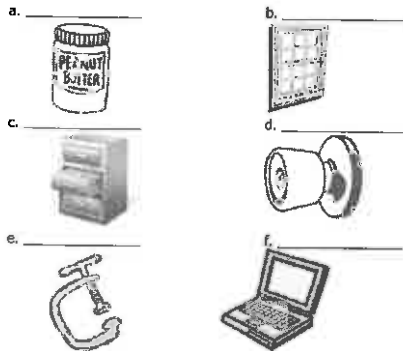
Threads inside the frame of the C-clamp control the helical guiding of the threaded shank.

Practice Questions

1. Which of the following is not a type of guiding control?

- Translational
- Seal
- Helical
- Rotational

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



Answers:

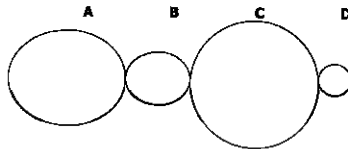
- B
- helical
 - translational
 - rotational
 - rotational
 - helical
 - rotational

Practice Questions

1. Friction gears operate on the concept of using friction between at least two wheels. Which of the following is false?

- Friction gears are economical.
- They can be used to transmit motion of parts that are close together.
- They are non-reversible.
- The touching wheels move in opposite directions.

2. If gear A is turning Clockwise and is transmitting its motion throughout this friction gear system, what direction will gear D be turning in?



- Clockwise
- It be turning the same direction like wheel A
- It will be turning the same direction like wheel C
- Counter clockwise

Answers:

- C
- D

Mechanical Engineering: Motion Transmission Systems

I understand the construction and characteristics of friction gears (wheels) as a motion transmission system.

Explanation of Concept(s)

1. Characteristics of Friction Gear Systems:

- Wheels that do NOT have teeth.
- Wheels move because of the friction between them due to direct contact.
- Used to transmit rotational motion between two or more parts that are close together.
- Wheel direction is opposite depending on the placing of wheels (See image)
- Easier to put together, costs less to make.
- Disadvantage is that the gears can slip.
- Can reverse motion.

2. Construction of Friction Gear Systems:

- Larger the diameter of the gear the slower the rotation.
- Material used to make the gear needs to be high friction like rubber.
- Can be positioned along parallel, perpendicular or other rotational axes depending on the need.

3. Symbols for Friction Gears

Friction Gears (side by side)	Friction Gears (vertical and horizontal)

Mechanical Engineering: Motion Transmission Systems

I understand the construction and characteristics of belt and pulley as a motion transmission system

Explanation of Concept(s)

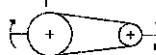
1. Characteristics of Belt and Pulley Systems

- At least 2 wheels are connected together by a belt.
- Wheels are toothless and therefore called pulleys.
- Are used to transmit rotational motion between parts that are farther apart.
- When more than two pulleys are used, only the pulley that touches the same side of the belt will turn in the same direction. (See image)
- Can reverse motion.

2. Construction of Belt and Pulley Systems

- In order for the pulley system to work the pulley must contain a groove that allows the belt to sit smoothly and securely in it.
- The belt must also stick to or adhere to the pulley to avoid slipping.
- The larger the pulley, the slower it turns.

3. Symbol for Belt and Pulley Systems

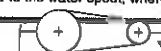


Practice Questions

1. Belt and pulley systems use a belt to connect at least two pulleys together. Which of the following is false?

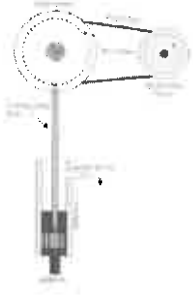
- Belt and pulley systems are used to transmit motion between parts that are farther apart.
- The smaller the pulley the slower it turns.
- Only the pulleys that touch the same side of the belt will turn in the same direction.
- The motion can be reversed.

2. A small hillside village has discovered a fresh water spring and wishes to pump the water up to the surface, into a bottling plant. A local engineer has developed a simple pump. As the motor spins, a pulley belt rotates a pulley wheel. A connecting rod then pushes a plunger downwards. Water rises through holes in the plunger and as the plunger rises water is lifted to the water spout, where it pours out. This cycle



of events continues until the motor is turned off. Answer the following questions based on the diagram below.

- As the motor and pulley wheel spin, how fast will the pulley wheel spin in relation to the first wheel?
- Explain why the belt and pulley system is an advantageous choice to this simple solution for a water pump.



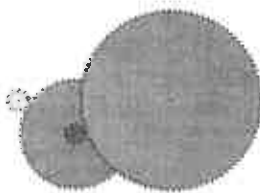
Answers:

- B
- a. The pulley wheel will spin slower in relation to the motor driven pulley wheel. The larger the pulley the slower it spins.
b. There are several components in this invention that need to work together. The motor and connecting rod are two key parts to this assembly, as such they need to be connected to each other and the best solution is a belt and pulley system because the motor and connecting rod are components that are further apart from each other. One pulley will be attached to the motor and the other to the connecting rod. With the help of a belt, the motion of the motor is easily transferred to the pulley attached to the connecting rod. The rotational motion of the connecting rod is transferred into translational motion which is what creates the pump action.

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- For the following image, what direction will the largest gear turn if the first gear on the left is turning in a counter clockwise direction?



- Clockwise
- Counter Clockwise

Answers:

- A
- B

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Mechanical Engineering: Motion Transmission Systems

I understand the construction and characteristics of gear assembly (gear trains) as a motion transmission system

Explanation of Concept(s)

1. Characteristics of Gear Assembly Systems

- At least two gears that meet and fit perfectly into one another.
- Slippage between gears prevented by interlocking Gear teeth
- Used to transmit motion between parts that are close together.
- Can reverse motion.

2. Construction of Gear Assembly Systems

- For the two or more gears to work together, the teeth of each gear need to be the same size, shape, direction (straight or helical) and must be equally spaced out.
- The positioning of the gears can vary: Parallel (Straight Gears are used) , perpendicular (Bevel Gears are used). (See Image).
- The more teeth there are on a gear, the slower the rotation speed and vice versa.
- The smaller the diameter of the gear, the faster the rotation and vice versa.

3. Symbol for Gear Assembly Systems



Practice Questions

- Gear trains are used to transmit motion between objects that are close together. Which of the following statements is false?

- The teeth of either gear can be of different shapes in the same system.
- The teeth guarantee much less slipping between the parts.
- The more teeth there are in a gear the slower it turns.
- The less teeth there are in a gear the faster it turns.

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Mechanical Engineering: Motion Transmission Systems

I understand the construction and characteristics of sprocket wheels and chain as a motion transmission system

Explanation of Concept(s)

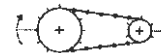
1. Characteristics of Sprocket Wheels and Chain Systems

- The teeth on the sprockets must be identical as ONE chain must fit on all sprockets in the system.
- The links in the chain are designed to fit securely on the teeth of the sprockets.
- This system requires lubrication such as grease or oil on a regular basis to avoid wear and tear.
- The larger the sprocket the slower it turns and vice versa.

2. Construction of Sprocket Wheels and Chain Systems

- The teeth on the sprockets must be identical as ONE chain must fit on all sprockets in the system.
- The links in the chain are designed to fit securely on the teeth of the sprockets.
- This system requires lubrication such as grease or oil on a regular basis to avoid wear and tear.
- The larger the sprocket the slower it turns and vice versa.

3. Symbol for Sprocket Wheels and Chain Systems



Practice Questions

- Chain and sprocket systems are used to link gears that are separated by distance. Which of the following statements is false?

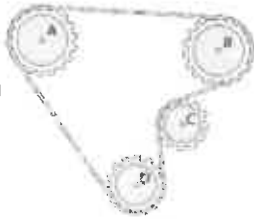
- The chain must fit directly into the gear teeth in order for the system to work.
- The system requires lubrication in order to maintain its efficiency.
- The larger the sprocket the slower it turns.
- The smaller the sprocket the slower it turns.

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2. If gear A is turning counter clockwise, indicate the correct combination of answers that indicate the direction all the other gears are rotating.

	Gear A	Gear B	Gear C	Gear D
A)				
B)				
C)				
D)				



3. When going up a steep hill on a bicycle, why should the smallest driver gear be selected?

Answers:

1. D
2. D
3. The chain should be on the smallest possible drive gear. This smaller gear will require less torque to be rotated. This will allow the rider to pedal more but would take less force/effort to go up the hill.

Mechanical Engineering: Motion Transmission Systems

I understand the construction and characteristics of wheel and worm gear as a motion transmission system

Explanation of Concept(s)

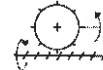
1. Characteristics of Wheel and Worm Gear Systems

- Made from a single worm (screw) that rotates. This motion is transmitted to one or more wheel gears.
- The worm can turn continuously.
- Movement is very slow however.
- Motion CANNOT be reversed.

2. Construction of Wheel and Worm Gear Systems

- The groove on the worm (screw component) must fit the wheel gear teeth so that they fit together and motion is possible.
- The drive component is always the worm and this is what makes this system non-reversible.

3. Symbol for Wheel and Worm Gear Systems



Practice Questions

1. Worm and wheel gear systems are used to greatly reduce the speed of systems.

Which of the following statement is true?

- a. The motion cannot be reversed and if it is forced it could break the system.
- b. The teeth do not have to match up because the pieces generally look different from each other.
- c. The worm has limited turning capabilities. It eventually stops.
- d. The movement is very fast in this system.

2. The image below shows the motion transmission system that is used to direct the chute of a snow blower.



- a. Why do you think a wheel and worm system was chosen for this part?
- b. If the snow blower user decides to turn the chute manually, the motion transmission system could be damaged. Explain why.

Answers:

1. A
2. a. A worm gear was chosen for this system because the part itself, the chute, does not require that much range of motion nor does it need to turn with great speed. As a result, the driver of the snow blower can turn a crank that is attached to the worm component to slowly direct the chute in the direction desired.
b. It will break because a wheel and worm gear system is so strong both in torque and teeth interwoven strength that it is not designed to reverse the motion. As a result, any force in the opposite direction could result in damage.

Mechanical Engineering: Motion Transmission Systems

I am familiar with the symbols for the above five (5) systems

Explanation of Concept(s)

1. Symbols for Motion Transmission Systems

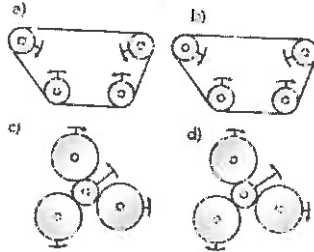
Friction Gears	
Belt and Pulley	
Gear Train	
Chain and Sprocket	
Wheel and Worm Gear	

Practice Questions

- Look at the motion transmission systems below and identify the ones whose rotational motions are correctly illustrated.



- Among the motion transmission systems below, identify those whose rotational motions are correctly illustrated.



Answers:
1. B and C
2. B and D

Practice Questions

- Explain why a worm and worm gear system is used to turn a snow blower chute rather than friction gears.



Answers:
1. Worm gear systems allow for a slow rotation which is what is necessary for the chute of a snow blower. In addition, because the snow can shoot out the opening at a high force it is imperative that a strong motions transmission system that is non-reversible be used for this job. Friction gears can slip, they are reversible therefore are not the system for this job.

Mechanical Engineering: Motion Transmission Systems

I would be able to explain the choice of a motion transmission system in a technical object

e.g., Using a gear assembly rather than friction gears to get better engine torque and avoid slipping

Explanation of Concept(s)

- Several motion transmission systems have been created in order to complete different tasks. In some situations, a combination of these transmission systems is used together. In the engineering process, one must consider which transmission systems are necessary and more advantageous than others when making a technological object. 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, belt and pulley, gear trains, chain and sprocket and worm and worm gear systems).



Example:

A person riding the bicycle is regularly putting pressure on the pedals which drive the chain and sprocket. Engineers have chosen a chain and sprocket system because of this constant force. The fact that the teeth of the gears fit perfectly into the chain is what help the chain stay on the sprockets and allow the rider to simply use the bike. If a belt and pulley system was used, slipping would occur and even the strength of the rubber belt would not survive the constant force from the driver.

Mechanical Engineering: Motion Transformation Systems

I understand the construction and characteristics of screw gear system as a motion transformation system

Explanation of Concept(s)

- Characteristics and Construction of Screw Gear Systems

- A screw gear, also known as a worm gear, is a gear consisting of a spirally threaded shaft and a wheel with marginal teeth that mesh into it.
- There are two types of screw gear systems that can transform motion from rotational → translational.



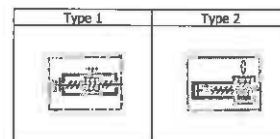
Type 1:

- The screw is the driver that transforms rotational motion into translational motion. The nut, attached to the screw, must connect in a way that does not allow it to rotate independently from the screw.

Type 2:

- The nut is the driver that transforms rotational motion into translational motion. The nut must be fixed in a way that only allows for rotation.

- Symbol for Screw Gear Systems



Practice Questions

- Which of the examples below is a Type 1 screw gear system?
 - A jack for lifting cars
 - A wrench
 - Gears of a clock
 - Pistons of a car
- State the driver component for type 1 and type 2 screw gear systems.

Answers:
1. A
2. Type 1: The screw
Type 2: The nut

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Mechanical Engineering: Motion Transformation Systems

I understand the construction and characteristics of cams as a motion transformation system

Explanation of Concept(s)

1. Characteristics and Construction of Cam Systems

- A cam is a rotating mechanism used especially in transforming rotational motion to translational motion.
- A cam and follower is formed by the direct contact of two mechanisms. The driver part is called the cam and the part that is driven through the direct contact of their surfaces is called the follower. The shape of the contacting surfaces of the cam and follower determines the movement of the mechanism.

2. Symbol for Cam Systems



Practice Questions

- 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?
 -
 -
 -
 -

Answers:
1. D

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Mechanical Engineering: Motion Transformation Systems

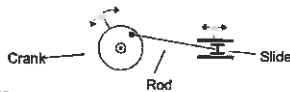
I understand the construction and characteristics of connecting rods as a motion transformation system

Explanation of Concept(s)

1. Characteristics and Construction of Connecting Rod Systems

- A connecting rod acts as a link for transmitting motion from the crank to the slide. Together with the crank, they form a simple mechanism that converts translational motion into rotational motion. Connecting rods allow for reversibility, able to convert rotational motion into translational motion.

2. Symbol for Connecting Rod Systems



Practice Questions

- Which of the following is a true statement about connecting rods?
 - A connecting rod is attached to only one moving mechanism.
 - A connecting rod can allow for reversibility in a system
 - A connecting rod is always needed to transform rotational to translational motion.
 - A connecting rod can function without being attached to the system.
- Explain the purpose of the connecting rod in a motion transformation system.

Answers:
1. B
2. The purpose of the connecting rod is to attach one end to a mechanism that rotates (example a crank) to another mechanism that moves in a linear motion (example a piston)

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Mechanical Engineering: Motion Transformation Systems

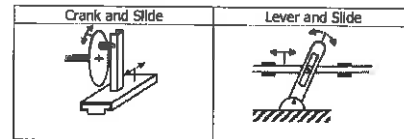
I understand the construction and characteristics of slides as a motion transformation system

Explanation of Concept(s)

1. Characteristics and Construction of Slide Systems

- Slides can allow for the transformation of linear motion to rotational motion and vice-versa.

2. Symbol for Slide Systems



Practice Questions

- Which statement is false about slides?
 - Slides allow for different types of translational motion.
 - Slides are an example of a connecting rod.
 - Slides never allow for reversibility of motion.
 - Slides connect two mechanisms to transform motion from one to another.
- Slides can often be seen on the side of old locomotives. Explain the purpose for the slide on the locomotive.



Answers:
1. C
2. The slide on the locomotive's wheels allows the transformation of linear motion to rotational motion of the wheel along the track.

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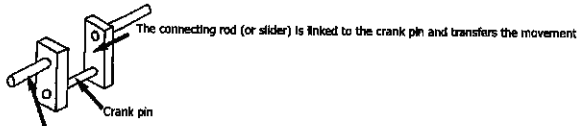
Mechanical Engineering: Motion Transformation Systems

I understand the construction and characteristics of **cranks** as a motion transformation system

Explanation of Concept(s)

1. Characteristics and Construction of Crank Systems

- Cranks are similar to a simple cam. They convert rotational motion into translational motion (up and down motion) or vice versa. The difference between cranks and cams is that cranks only ever work in a rotational motion and only have one drive action per revolution.



The crank shaft both supports the crank and rotates it.

Practice Questions

- Which of the following is not an example of a mechanism that uses a crank to transform motion?
 - A wishing well
 - Internal combustion engine
 - A wrench
 - A winch
- Explain the difference between a crank and a cam.

Answers:

1. C
2. The difference between cranks and cams is that cranks only ever work in a rotational motion and only have one drive action per revolution.

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Mechanical Engineering: Motion Transformation Systems

I understand the construction and characteristics of **rack-and-pinion drive** as a motion transformation system

Explanation of Concept(s)

1. Characteristics and Construction of Rack-and-Pinion Drive Systems

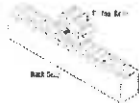
- Rack and pinion is a type of mechanism that is comprised of a pair of gears which convert rotational motion into translational motion. A circular gear called "the pinion" engages teeth on a linear "gear" bar called "the rack".
- A rack and pinion system is reversible.
- Rotational motion applied to the pinion causes the rack to move, thereby transforming the rotational motion of the pinion into the translational motion of the rack. The linear motion of the rack can cause the pinion to rotate, transforming linear motion into rotational motion.

2. Symbol for Rack-and-Pinion Drive Systems



Practice Questions

- If the pinion in the diagram below rotates in a clockwise direction, in which direction does the rack move?



Answers:

1. To the left

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Mechanical Engineering: Motion Transformation Systems

I understand the construction and characteristics of **rotating slider crank mechanisms** as a motion transformation system

Explanation of Concept(s)

1. Characteristics and Construction of Rotating Slider Crank Mechanism Systems

- Slider-crank mechanisms involve both rotational and translational motion. For most of these mechanisms, a crank rotates at constant speed in order to repeatedly move an object in a linear motion to perform some task. This device is a simple way to convert rotational motion to translational motion and has the ability to be reversible.



Answers:

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Mechanical Engineering: Motion Transformation Systems

I am familiar with the symbols for the above seven (7) systems

Explanation of Concept(s)

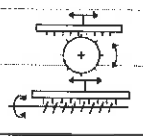
1. Symbols for Motion Transformation Systems

TRANSFORMATION OF MOTION:
Mechanical action that changes the nature of motion (rotation to translation, translation to rotation)

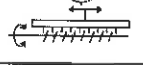
Crank and slide



Rack and pinion



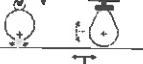
Screw and rack



Connecting rod and crank



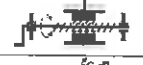
Cam and roller



Screw and nut



Screw and nut



Screw and nut



Crank and slide



Answers:

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Mechanical Engineering: Motion Transformation Systems

I would be able to explain the choice of a motion transformation system in a technical object

e.g., Most car jacks use a screw gear system rather than a rack-and-pinion system, because the force of the arm on the small crank provides more force and because, given that it is nonreversible, the system is safer

Explanation of Concept(s)

- When observing the motion transformation system of a technical object engineers must judge the appropriate choice for the use and construction of the systems used.

Example:

The steering column connected to the pinion allows the rotation of the steering wheel to transmit motion to the wheels via the rack.



Practice Questions

- You are asked to construct a mechanism that can allow for an object to transform motion from translational to rotational. Which of the following systems could be used?
 - Rack and pinion system
 - Screw gear system
 - Friction gears
 - Cam and follower system

- What is the purpose of the spring in this cam system?



Answers:

- A
- The spring ensures the constant pressure of the follower on the surface of the cam.

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Mechanical Engineering: Speed Changes

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

Explanation of Concept(s)

- Cause of Speed Changes

- Speed Change occurs in a motion transmission system when the driver does not turn at the same speed as the driven component or components. For example, when the diameter of the gears in a friction gear system are different.

Remember:

- 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.
- Intermediate Component:** It is found between the driver and driven component. *Note that not all systems have this.

- Factors that affect Speed Changes

- The change of speed in motion transmission systems depends on:
 - Gear diameter
 - Number of teeth

Example:

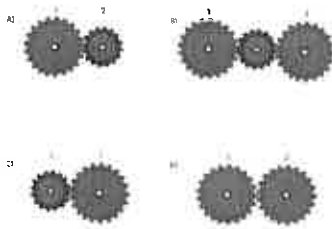
To increase the speed in a friction gear system, motion is transmitted from one gear to another gear of smaller diameter. The driver gear will turn more slowly than the driven gear.

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Practice Questions

- For which of the following systems will the Gear 2 turn more quickly than the Gear 1?



- How is it possible to increase the speed of rotation in a worm gear system?



Answers:

- A
- 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.

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Electrical Engineering: Power Supply

I understand and can use the definition of power supply as 'the ability to generate electrical current'

Explanation of Concept(s)

- Power supply is the ability to generate electrical current, such as a battery.

Practice Questions

- A circuit has many components. Which of the following components generates electrical current?
 - Power supply
 - Ammeter
 - Voltmeter
 - Switch
- 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:

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

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Electrical Engineering: Power Supply

I would be able to understand and determine the source of current in technical objects with an electrical circuit (e.g. chemical battery, solar cell, alternator, thermocouple, piezoelectric)

Explanation of Concept(s)

1. Sources of Energy:

- 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 cells: When sunlight hits the solar cells an imbalance of electrons is produced causing an electric current. Therefore solar energy is transformed 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. Examples include digital food thermometers, fridge thermometer, gas stoves and heaters.

Practice 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 understand and can use the definition of conduction as the 'ability to conduct electricity'

Explanation of Concept(s)

1. Conduction is the ability to conduct electricity. It allows the current/electrons to flow through a material, such as a metal.

Practice 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 would be able to distinguish between electrical conductors and insulators in a technical object

Explanation of Concept(s)

1. Conductors vs. Insulators

- Conductors: Substances that allow current to flow through them. Examples of good conductors are metals and electrolytic solutions.
- Insulators: Substances that do not allow current to pass through them. Examples of good insulators are wood, plastics, paper, rubber, glass and ceramics.

Practice Questions

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

- i. Plastic
- ii. Ceramic
- iii. Metal
- iv. Cardboard
- v. Glass

- a. i, ii, iv
- b. i, ii, v
- c. i, ii, iv, v
- d. i, ii, iii, iv, v

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
Cardboard
Wooden spoon
Metal knife
Plastic fork
Nail
Ceramic coaster
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 knobs 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.

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Electrical Engineering: Conduction, Insulation and Protection

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

Explanation of Concept(s)

1. Role of Fuses and Breakers

- 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.

2. Fuses vs. Breakers

- 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.

Practice Questions

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

- Control the flow of the current
- Prevent the current from flowing
- Automatically cut the current
- Allow the current to flow in a circuit

2. Holly just bought a very old house. Her electrician inspects the house and tells her that the electrical circuit in the kitchen is unsafe. Identify and describe a component that the electrician might insert into the circuit to make it safer.

Answers:

1. C
2. The electrician should insert fuses or breakers because they will stop the flow of the current when there is too much. If the electrician does not install a fuse or a breaker the wires will become very hot and can cause a fire.

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Electrical Engineering: Conduction, Insulation and Protection

I understand and would be able to analyze the factors that affect electrical conductivity (section, length, nature, temperature of conductor)

Explanation of Concept(s)

1. Factors that Affect Electrical Conductivity:

- 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 conducting 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)

Practice Questions

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

- Increase the length
- Increase the diameter
- Decrease the length
- Decrease the diameter

- i, ii
- i, iv
- ii, iii
- ii, iv

2. Which of the following copper wires in the table below has the best conductivity? Explain your answer.

Properties of different wires

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

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.

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Electrical Engineering: Control

I understand and can use the definition of control as the 'ability to control the travel of electrical current'

Explanation of Concept(s)

1. Explanation of Control:

A control is also known as a switch. When a switch is closed, current can flow through the circuit. When the switch is open, the current's pathway is broken and cannot flow through the circuit.

Practice Questions

- Controls play an important role in electrical engineering. Which of the following statement DOES NOT correctly describe a control?
 - A control is another word for switch
 - A control regulates the electrical current in a circuit
 - A control can be open or closed
 - A control regulates the speed of electrons in a circuit
- A switch is a component of a circuit. Why is a switch classified as a control?

Answers:

1. D
2. A control is the ability to control the travel of electrical current. It is also called a switch. When a switch is closed current can flow through the circuit. When the switch is open the current's pathway is broken and cannot flow through the circuit.

- Your grandfather has very bad arthritis and has trouble using a thumb and index finger to turn on his light because his light switches are all levers. His doctor recommends he changes his light switches to flip flop or push buttons. Explain why these switches would make it easier for your grandfather to turn on and off his lights.

Answers:

1. A
2. Lever switches require a person to use two fingers to turn on a light. The grandfather would have to hold on to the lever switch for a longer time than a flip flop because a lever has to rotate in an arc motion to turn off and on. When you push on push button switch the metal comes in contact with the wires of the circuit. A flip flop switch you also need to push and the top and bottom side rock up or down. Turning a flip flop and a push button only requires one finger.

Electrical Engineering: Control

I would be able to describe different types of switches (lever, pushbutton, flip-flop, magnetic control)

Explanation of Concept(s)

1. Types of Switches:

- A **lever switch** is an electrical switch controlled by a mechanically moving arm through a small arc.
- A **push button switch** completes an electric circuit when pressed. Push button switches can be found in computer keyboards (power button), doorbells, and calculators.
- 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.
- A **magnetic 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.

Practice Questions

- In which of the situations below is current flowing through the circuit?
 - The magnetic switch is closed in the presence of a magnetic field
 - The magnetic switch is open in the presence of a magnetic field
 - The flip-flop switch is closed in a circuit.
 - The flip-flop switch is open in a circuit.
 - i, iii
 - i, iv
 - ii, iii
 - ii, iv

Electrical Engineering: Transformation of Energy

I would be able to identify and explain the transformation of energy in different components of a circuit

e.g., Bulbs transform electrical energy into light and heat

Explanation of Concept(s)

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

Remember: Batteries transform chemical energy into electrical energy.

Practice Questions

- A battery transforms chemical energy into electrical energy. Which of the following components of a circuit transforms energy?
 - LED light
 - switch
 - battery
 - wires
 - ii, iv
 - i, iii
 - i, ii, iii
 - i, iii, iv

- A doorbell for the hearing impaired produces a sound and turns on a light. Explain the type of energy transformations that occur in this system.

Answers:

1. B
2. A doorbell transfers electrical energy into sound energy. The light of the doorbell will transfer electrical energy to light energy.

Electrical Engineering: Transformation of Energy

I would be able to describe the energy transformations that take place in electrical or electronic appliances

e.g., In a cell phone, electricity is transformed into light for the display and vibrations for the sound

Explanation of Concept(s)

1. Energy Transformations in Electrical/Electronic Devices

- 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.

Practice Questions

1. Electrical energy in a fan is transformed into:

- Sound energy
- Mechanical energy
- Thermal energy
- 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:

- B
-

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

e.g., A diving board is subject to deflection

e.g., The top of a beam is subject to compression

Explanation of Concept(s)

1. Explanation of Constraints:

- The parts of a technological object may be subjected to one or more external forces.
- These forces can **deform** the parts.

2. Types of Constraints and Their Symbols:

Type of 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.

Practice Questions

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



- Compression
- Torsion
- Deflection
- Tension

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



- Compression
- Torsion
- Deflection
- Tension

3. When building a tall structure like a skyscraper, engineers have to take into consideration the many constraints that the building will be subjected to. What constraints do you think a skyscraper would have to endure?

Answers:

- C
- B

3. A tall building undergoes deflection. The higher the building the more it needs to deal with wind so the materials used to build the building need to take into account a bit of movement due to wind. It also deals greatly with compression. The weight of all the materials used in construction subjects the entire building to a regular degree of compression.

Materials: Characteristics of Mechanical Properties

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

Explanation of Concept(s)

1. Explanation of Mechanical Properties

- There are several types of materials, all with their own advantages and disadvantages. There is no material that is perfect. As a result, it is an engineer's responsibility to select the appropriate material(s) when building a technological object. The **mechanical properties** of a material describe how it reacts when subjected to one or more constraints and this is what needs to be taken into consideration when building an object.
- Example: A sponge will return to its original shape after it has undergone torsion.

2. 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: Other Properties

I would be able to understand and explain the choice of a material based on its properties

e.g., The malleability of aluminum makes it useful for making thin-walled containers

Explanation of Concept(s)

1. 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.

Practice Questions

- 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.
 - Wheels
 - Body Frame
 - Seats
- Why would a homeowner choose a ceramic floor in the kitchen and bathroom rather than a wooden floor?

Materials: Other Properties

I understand and can define certain properties of materials

Other Properties

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

Practice Questions (refers to previous 2 statements)

- What mechanical properties were desired when choosing materials for a hard-hat?



Answers:

- 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.

Answers:

- The wheels should be made of rubber in the plastic category. 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 a smooth ride as possible. It must also be easily changeable in case of damage or accident. Plastic provides these options best.
 - 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.
 - The seats should be made of composites because the covering of the seat should be made with vinyl or some sort of plastic but underneath cushion is necessary for comfort while driving and going over bumps in the road. Metal is used also to make the shape of the seat so a composite is necessary encompassing all these materials.
- Ceramic floors in the kitchen and bathrooms are ideal because these rooms deal with water. Wood would rot if it was exposed to water over a longer period of time whereas ceramic does not absorb water, can be easily cleaned if exposed to water and can last a long time.

Materials: Modification of Properties

I would be able describe different treatments to prevent degradation of materials

e.g., metal painting, antirust treatments, painting

Explanation of Concept(s)

1. Explanation of Reasons for Degradation Prevention:

- **Wood and Modified Wood, Ceramics, Metals and Alloys, Plastics and Composites** make up the categories of materials. However, over time they can degrade. As a result, several techniques and treatments have been designed to help prevent degradation and allow the material last longer.

2. Techniques Used to Prevent Degradations:

• **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.

Practice 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. Wood 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: Exploded View

I can interpret an exploded view drawing of a technical object

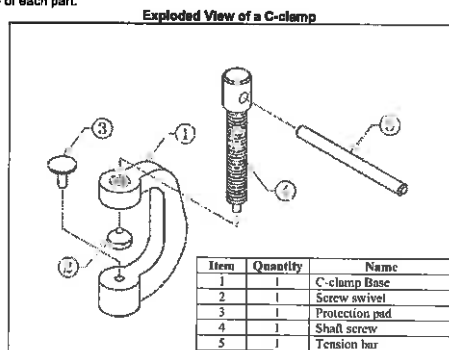
Explanation of concept:

Understanding how an object is manufactured is important when it comes to the actual building process. Therefore, properly interpreting an assembly drawing (labeled exploded view) is critical!

Be sure to read the legend (list of labeled components) in which all information about items used to build the object is included.

e.g. Exploded view of a C-Clamp.

The legend indicates the name and quantity of each numbered part. In this example, there is only one of each part.



C-clamp Exploded View Assembly, Steven Combs, Flickr.

Graphical Language: Standards and Representations

I can identify and use force and motion symbols.

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 <i>inertial</i> or <i>non-inertial</i> 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	↻		