

**APPLIED SCIENCE AND TECHNOLOGY
SECONDARY 4**

**STUDY GUIDE
2015**

Version 3.0

This study guide has been developed by teachers and consultants to help students prepare for the MELS uniform examination for the secondary 4 Science & Technology courses. The production of this guide has been funded by an Anglophone community success project.

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EARTH AND SPACE

Hydrosphere: Catchment Area

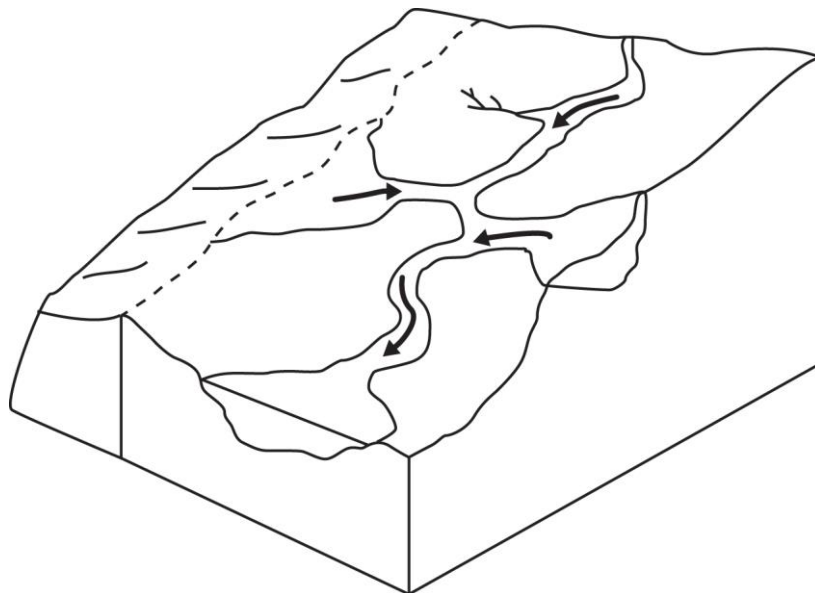
*I can define a **catchment area** as 'a territory surrounding a waterway'.*

Explanation of Concepts

Precipitation falls on the surface of the Earth, accumulates in streams, and infiltrates the ground. The natural slope of the land causes water to flow into rivers and accumulate in larger reservoirs, such as a lake. All the area from which water empties into the same large body of water is called a **catchment area or watershed**.

The boundaries of a catchment area are usually defined by natural high ground, such as a hill or peak.

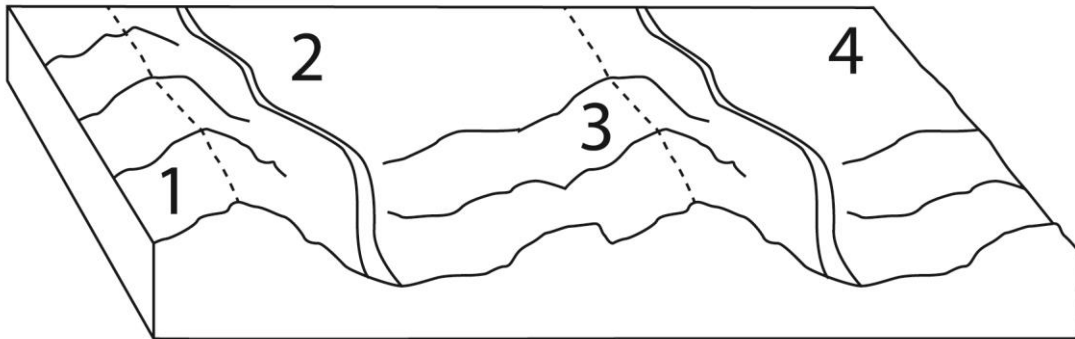
A Catchment Area



Questions

1. Which of the following does not affect the flow of water into a catchment area?
 - A) Depth and latitude of the water reservoir
 - B) Industrial and urban development
 - C) Shape and slope of the terrain
 - D) Density and diversity of the vegetation

2. Which location is in the same catchment area?



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

Answers

- 1. A
- 2. C

Hydrosphere: Catchment Area

I can describe and interpret some of the impacts of human activity on the waterways in a catchment area.

Explanation of Concepts

Human activity which impacts waters will not only affect the immediate area, but also the area downstream of the disturbance.

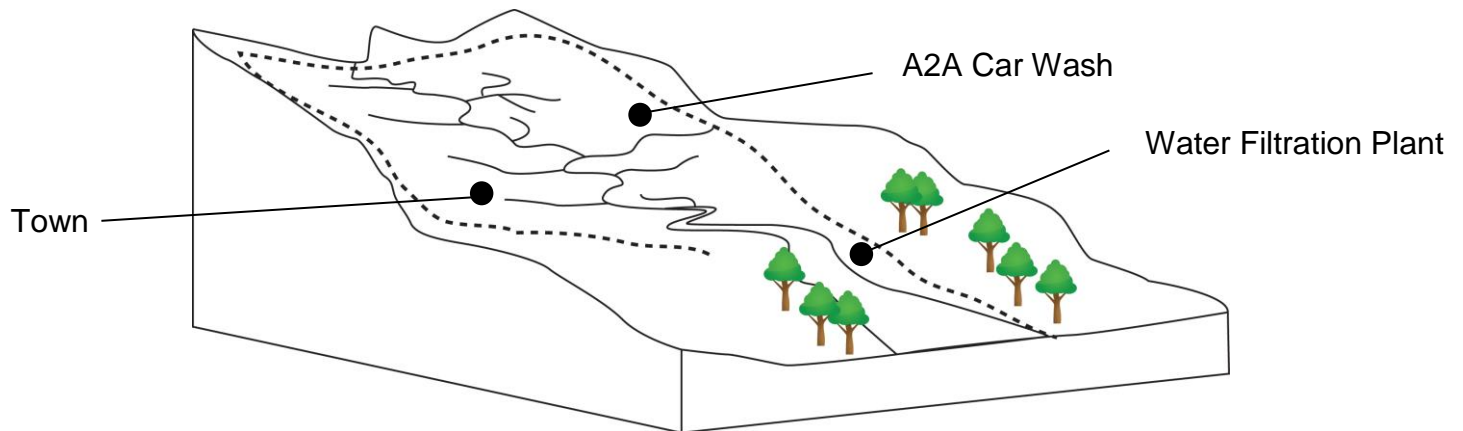
For example, excess fertilizer from a farm can seep into the soil and be washed into a river. The river is part of a catchment area and downstream of the farm will also be contaminated with the fertilizer. Locations upstream from the farm will not be affected. Water pollution can therefore spread hundreds of kilometers from its original source.

Questions

1. Which of the following activities has the greatest impact on the flow of water in a catchment area?
 - A) Filling up a child's swimming pool with 40 L of water.
 - B) Treating drinking water for a city in a municipal water treatment plant.
 - C) Rerouting rivers for the construction of a hydroelectric dam.
 - D) Repairing a bridge connecting Montreal's South Shore to the Island of Montreal.

2. An inspector for a town of has noticed that the wastewater for the A2A carwash has been flowing into a nearby stream. The inspector informed the A2A carwash owners that they would be fined since they were polluting the town's water source.

Use the map of the town's watershed below to explain whether the inspector was correct in fining the carwash. Explain your answer.



Answers

1. C
2. *The inspector was correct. The A2A carwash and the town's filtration plant are in the same catchment area (watershed). Since the A2A car wash is above the filtration plant, any wastewater it produces will flow downstream and enter into the river used to supply the town with drinking water.*

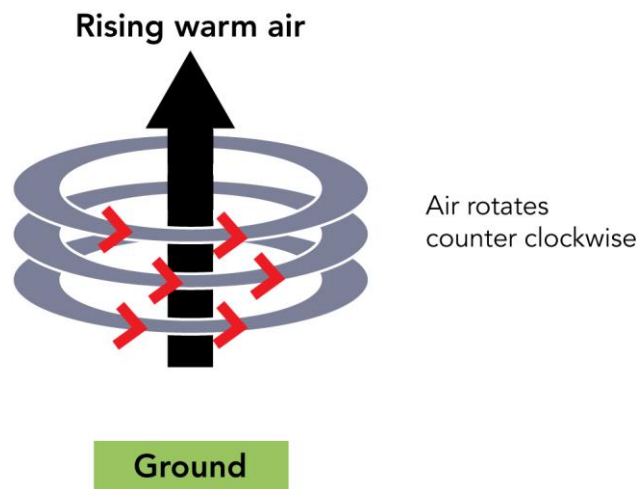
Atmosphere: Cyclone and Anticyclone

I can explain the formation of cyclones (low-pressure areas) and anticyclones (high pressure areas).

Explanation of Concepts

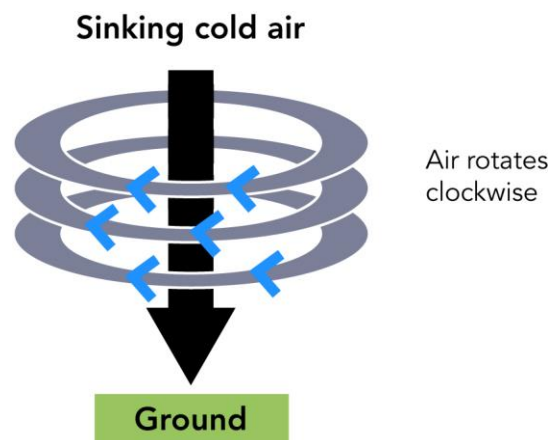
Cyclones (depressions) occur when warm air rises and leaves less air particles in the space beneath it. This space below becomes a low pressure area called a **depression**.

- The rising air cools and condenses and this leads to the formation of clouds. When depressions occur, the weather is cloudy and wet.
- In the Northern Hemisphere winds blow in the counter clockwise direction around a depression.
- When a depression occurs over warm tropical oceans, strong depressions occur and tropical storms arise.



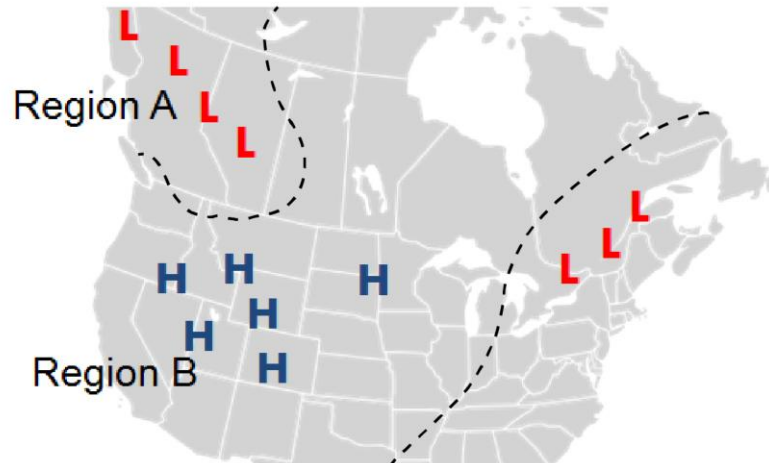
Anticyclones occur when air cools and sinks toward the ground creating an area with more air particles and therefore with high pressure. Falling air prevents clouds from forming.

- When anticyclones occur, the weather is stable; no precipitation or clouds.
- In the Northern Hemisphere winds blow in a clockwise direction around an anticyclone.
- Cyclones and anticyclones can occur at any time during the year.



Questions

1. A weather map is shown below.



The letter H on a weather map shows an area of High pressure and the letter L shows an area of Low pressure.

What kind of weather should people living in Region B expect?

- A) Clear skies and stable weather
 - B) Heavy rains and winds
 - C) Cloudy weather and showers
 - D) Tropical storm
2. Louise and Tom are going on an overnight camping trip. According to the weather channel, a low pressure system (cyclone or depression) is on its way.
- Should they bring their wet weather gear? Explain using scientific principles.

Answers

1. A
2. *Yes, they should bring their wet weather gear because depressions mean cloudy and rainy weather. Warm air is rising which encourages cloud formation.*

Renewable and Non-Renewable Energy Resources

I can describe technologies used to produce electricity using the energy resources in the lithosphere, hydrosphere and atmosphere.

Explanation of Concepts

Lithosphere

Energy Source	Description
Fossil Fuels	<ul style="list-style-type: none">Produced when animal and plant residues accumulate on the sea floor and gradually get covered by layers of sand and rock. Over millions of years, they are transformed into oil and natural gas.Humans mine fossil fuels and burn them to produce thermal energy, which can also be converted into mechanical and electrical energy in thermal power plants.The burning of fossil fuels releases pollutants such as carbon dioxide (CO₂) and methane (CH₄). Other gases, such as sulfur dioxide (SO₂) and nitrogen oxides (NO_x) are also released.
Uranium (Nuclear)	<ul style="list-style-type: none">Uranium is a radioactive element and exists naturally in the lithosphere.Nuclear power plants use mined uranium to transform thermal energy into mechanical and electrical energy.A small amount of radioactive material produces a lot of energyNuclear waste is another by-product and needs to be buried since it continues to release radioactivity for hundreds of years
Geothermal	<ul style="list-style-type: none">Below the lithosphere lies hot magma which releases thermal energy. Harnessing this energy is called geothermics.A fluid is circulated into the ground; it is heated naturally, then brought up to the surface. The hot liquid can be used to heat homes or its thermal energy can be transformed into electrical energy.It can be difficult to access geothermal energy. It can also be very expensive.

Hydrosphere

Energy Source	Description
Hydroelectric	<ul style="list-style-type: none"> • Hydroelectric power plants use the movement of falling water to spin turbines which are located inside dams built across a river. • Water falling through a dam spins a turbine that converts mechanical energy into electrical energy. • Hydroelectricity is the main source of energy in Quebec.
Wave and Ocean Current	<ul style="list-style-type: none"> • Wave energy is produced when the energy contained in the movement of water is harnessed using buoys, which rise and fall with the waves. • Ocean currents are able to spin underwater turbines, which are similar to wind turbines. The mechanical energy produced by the movement of the buoys and blades can be converted into electrical energy. • Harnessing energy from waves and ocean currents is not yet widespread due to the fact that they are, at the moment, too expensive.
Tidal	<ul style="list-style-type: none"> • Electricity can be generated from tides when water from a high tide is collected (sometimes using a dam) and then falls through turbines converting mechanical energy into electrical energy. • A tidal range of 5 m is necessary to use this technology.

Atmosphere

Energy Source	Description
Wind	<ul style="list-style-type: none"> • The wind causes the turbines to rotate and a generator converts the mechanical energy into electrical energy. • Wind energy cannot be stored; therefore it needs to be used in conjunction with another source of energy. • Wind energy can be unreliable and unpredictable.

Other

Energy Source	Description
Solar	<ul style="list-style-type: none">• As the rays of the sun hit panels containing photovoltaic cells, they cause electrons to flow, creating current electricity.• This technology is costly and is limited by the amount of sunlight present.

Questions

1. Which of the following technologies uses an energy source derived from the lithosphere?
 - A) Tidal barrage
 - B) Wind turbine
 - C) Photovoltaic cell
 - D) Coal-fired plant
2. The lithosphere and the hydrosphere provide us with many different resources that we can use to produce energy. Each resource has its advantages and disadvantages.

Complete the following table regarding the advantages and disadvantages of uranium and tidal energy:

Resource	Advantages	Disadvantages
Uranium	1. 2.	1. 2.
Tidal Energy	1. 2.	1. 2.

3. Wind farms are growing in importance in Quebec. In partnership with Hydro-Quebec, these farms require many years of planning and construction. The Gros-Morne wind park in the Gaspésie region will have over 140 wind turbines at the end of its construction. In order to begin construction of Phase I in the spring of 2010, deforestation work was performed in the fall of 2009.

What are the advantages and disadvantages of using wind energy?

Answers

1. D
2.

<i>Resource</i>	<i>Advantages</i>	<i>Disadvantages</i>
<i>Uranium</i>	1. <i>small quantity of uranium will produce much energy</i> 2. <i>does not produce and greenhouse gases</i>	1. <i>non-renewable form of energy</i> 2. <i>produces radioactive waste that is toxic to all organisms</i>
<i>Tidal Energy</i>	1. <i>renewable source of energy</i> 2. <i>tides are predictable; there are 2 high tides and 2 low tides a day</i>	1. <i>turbines can only be used in certain regions where tide height reaches a minimum of 5 meters.</i> 2. <i>turbines are placed in harsh salt water conditions, often far from city centers.</i>

3. **Advantages** to using wind energy is that it is a renewable, clean (no greenhouse gases) form of energy.

Disadvantages to using wind energy are that the wind is not predictable and that the energy itself cannot be stored. Some would say that the wind turbines create both visual pollution, ruining the natural beauty of the environment and noise pollution. Deforestation also needs to take place before some wind parks are constructed.

Renewable and Non-Renewable Energy Resources

I can describe the main impact of the use of energy resources in the lithosphere, hydrosphere and atmosphere.

Explanation of Concepts

There are advantages and disadvantages for using the different types of energy resources.

Note:

A **non-renewable** energy source is finite: It will eventually run-out or become so scarce that it is too expensive or environmentally damaging to retrieve.

A **renewable** energy source is constantly replenished and will never run out.

Impact of Energy Resources from the Lithosphere

Energy Source	Renewable or Non-Renewable	Environmental Impact
Fossil fuels	Non-Renewable	<ul style="list-style-type: none">• The refining and burning of fossil fuels produces atmospheric pollutants, including the greenhouse gases carbon dioxide (CO₂), methane (CH₄), and nitrogen oxides (NO_x).• The burning and refining of fossil fuels can also contribute to the production of acid rain.
Uranium (Nuclear)	Non-Renewable	<ul style="list-style-type: none">• No atmospheric pollutants are released.• Nuclear waste is highly toxic and must be stored safely for hundreds of years.• Leakage of nuclear materials could have a devastating effect.
Geothermal	Renewable	<ul style="list-style-type: none">• Low atmospheric pollution compared to fossil fuels.• The hot ground water used in geothermal plants contains sulfur, mercury, hydrogen sulfide, arsenic and ammonia. These chemicals can be released in to the water supply, or the atmosphere through steam.

Impact of Energy Resources from the Hydrosphere

Energy Source	Renewable or Non-Renewable	Environmental Impact
Hydroelectric	Renewable	<ul style="list-style-type: none"> • Causes little pollution. • The building of dams often floods large areas of land, affecting the habitat of various plant and animal species.
Wave	Renewable	<ul style="list-style-type: none"> • May disturb aquatic ecosystems. • Does not release atmospheric pollutants.
Tidal	Renewable	<ul style="list-style-type: none"> • Does not release atmospheric pollutants • Tidal barrages (dams) can interfere with fish migration and can affect water flow and levels.

Impact of Energy Resources from the Atmosphere

Energy Source	Renewable or Non-Renewable	Environmental Impact
Wind	Renewable	<ul style="list-style-type: none"> • Does not release atmospheric pollutants. • Turbines can produce sound pollution. • Can disrupt the visual appeal of the landscape. • Birds can collide with the wind turbines.

Impact of Energy Resources from Other

Energy Source	Renewable or Non-Renewable	Environmental Impact
Solar	Renewable	<ul style="list-style-type: none"> • Does not release atmospheric pollutants. • Can disrupt the visual appeal of the landscape.

Note: All of these technologies produce electricity by converting mechanical energy into electrical energy except the technology associated with solar energy

Questions

1. A community in Gaspé is researching the environmental impacts of different energy sources.

Below is a list of possible environmental impacts

1. Tidal barrages can disrupt marine life.
2. Tidal power plants and coal power plants release greenhouse gases.
3. Nuclear power plants create no harmful waste products.
4. Flooding is a concern in the building of hydroelectric dams.

Which of the above statements are true?

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

2. A community in Gaspé is researching the environmental impact of two different energy technologies: a tidal power plant and a coal power plant.

For each of the energy resources the community is considering, state:

- the energy source as renewable or non-renewable
- the main environmental impact for each type of energy

Answers

1. C
2. *Tidal Power Plant – renewable / tidal barrages can disrupt marine life*
Coal Power Plant – non-renewable / releases greenhouse gases

Concepts Related to Astronomy: Earth-Moon System

I can describe the tides in terms of the gravitational effect of the Earth-Moon system.

Explanation of Concepts

A **tide** is the regular rise and fall of water in the seas and the oceans.

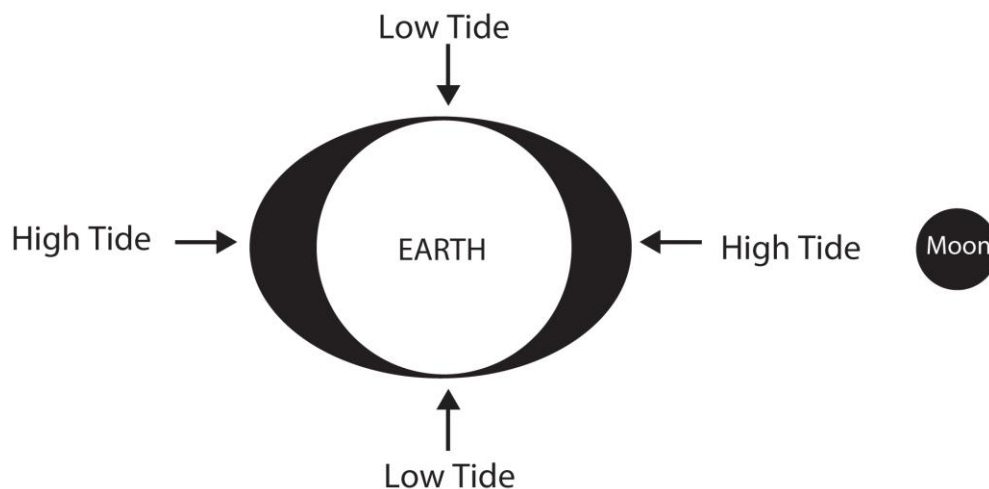
Bodies of water on Earth are attracted by the gravitational pull of the Sun and the Moon. This gravitational pull causes the water masses to swell up and form a bulge twice a day, producing tides. The size of the tides depends on the relative positions of the Sun, Moon and Earth.

The Moon has a greater effect on the tides than the Sun.

High tides occur in locations where the side of the Earth is facing the moon. As a result of the gravitational attraction between the Earth and the Moon, a bulge of water occurs on the side of the earth facing the moon.

High tides also occur on the opposite side of the Earth due to rotational forces of the Earth.

Low tides occur because the bulges of the high tides pull water away from the other parts of the ocean, causing a depression.



As the Earth rotates on its axis, the relative position of the Moon to the Earth changes. Therefore, most places on Earth have two high tides and two low tides every day.

Questions

1. A tide is the rise and fall of water in the seas and ocean. Which of the following statements are true?

1. There are two high tides and two low tides every day.
2. Tides are caused by the gravitational force of the sun.
3. The rotation of the earth causes tides
4. Tides are higher at the equator.

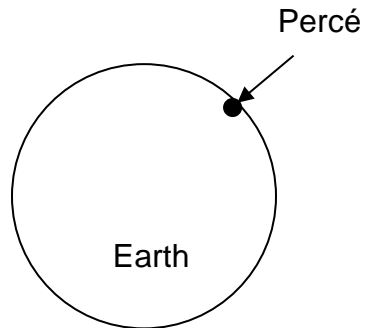
A) 1 and 2

B) 1 and 3

C) 2 and 4

D) 3 and 4

2. The circle below represents the Earth, with the location of the town of Percé indicated.



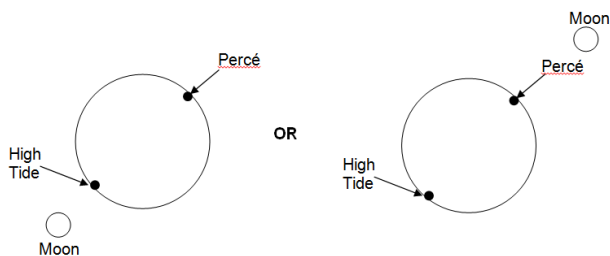
Draw a possible location of the moon when there is a high tide in Percé.

Indicate the position of the second high tide that would occur at the same time

Answers

1. B

2.



MATERIAL WORLD

Chemical Changes: Combustion

I can describe the recognizable manifestations of rapid combustion.

Explanation of Concepts

Rapid combustion is a form of oxidation (a reaction that uses oxygen) that releases a large amount of energy over a short period of time. The energy is released mostly in the form of heat and light. e.g. A candle burning.

Questions

1. Which of the following is NOT an example of rapid combustion?
 - A) A log fire
 - B) A candle burning
 - C) Digestion
 - D) A gas stove element burning

2. Why is rusting classified as an oxidation reaction and not a combustion reaction?

Answers

1. C
2. *During combustion, large amounts of heat and light are rapidly released. Rusting is an oxidation reaction that occurs at a rate too slow to be classified as combustion..*

Chemical Changes: Combustion

I can explain a combustion reaction using the fire triangle.

Explanation of Concepts

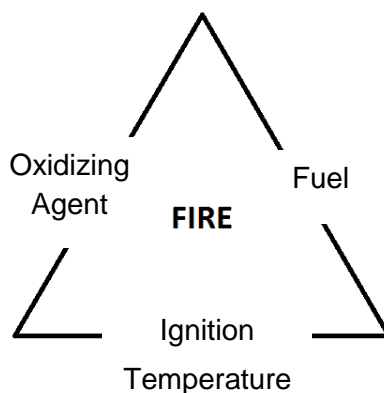
Combustion is a form of oxidation (a reaction that uses oxygen) that releases a large amount of energy. Three conditions must be met for combustion to occur:

- 1) The presence of an **oxidizing agent**, a substance that provides oxygen to react with a fuel
- 2) The **ignition temperature** has been reached.

The ignition temperature is the minimum temperature at which there is enough energy to start the combustion. This varies from one type of fuel to another.

- 3) The presence of a **fuel**.

A **fuel** is a substance that releases a large amount of energy by reacting with an oxidizing agent. (e.g. Wood)



Combustion will only occur if all three conditions are present. If any one of these conditions is removed, then combustion will stop.

Examples:

Water will extinguish a fire because the water significantly reduces the temperature of the system. (Ignition temperature not reached)

A candle will eventually stop burning when all of its wax is consumed. (Fuel no longer present)

A frying pan fire is extinguished when a lid is placed on the pan. (Oxidizing agent (oxygen in the air) is prevented from reaching the fuel)

Questions

1. Firefighters use the following methods to extinguish a forest fire.
 - Covering the ground fire with soil (shoveling)
 - Spraying the fire with water
 - Cutting down trees on the outside perimeter of the fire

Explain each of these methods by using the fire triangle.

2. Each year, forest fires reduce a significant area of land in Quebec to cinders. Sometimes these fires are the results of human activity but most often, they are caused by lightning strikes.

The environmental impact of this natural phenomenon, which is part of the life cycle of the Boreal Forests, is often widespread. In July 2005, the smoke produced by a gigantic forest fire in northern Quebec darkened the skies as far south as the Montreal region.

Using the terms below, explain how forest fires affect the atmosphere.

Respiration

Photosynthesis

The Carbon Cycle

Oxygen

Carbon Dioxide

Combustion

Answers

1. *The soil prevents air (oxygen) from reaching the fire. This is an example of a decrease in the OXIDIZING AGENT.*

The water absorbs heat from the fire. This is an example of preventing IGNITION TEMPERATURE.

Cutting down trees ahead of the fire means that when the fire reaches this area (a firebreak) there is less FUEL to be burned.

2. *Fires are a large contributor to the carbon cycle. The carbon that is in the structure of the plants being burned is being combusted using oxygen and producing high quantities of carbon dioxide. This is how Carbon returns to the atmosphere. As a result this carbon dioxide is now available for plants to use as they undergo photosynthesis. They use the carbon dioxide, water and the sun's energy to make their own food. As a result plants will grow which provides a source of food for animals. Animals will consume these plants as part of their respiration process which involves breathing oxygen, eating plants for example and drinking water. As a result animals are consuming carbon through the plants they eat and are releasing carbon in the form of gas every time they exhale. It is remarkable how intertwined everything is in our ecosystem.*

Chemical Changes: Oxidation

I can represent an oxidation reaction using the particle model.

Explanation of Concepts

An oxidation reaction is a chemical reaction during which a substance reacts with oxygen.

The particle model can be used to represent an oxidation reaction.

Symbols are used to represent the atoms involved in a chemical reaction.

The chemical reaction that follows is an oxidation reaction because it involves oxygen:

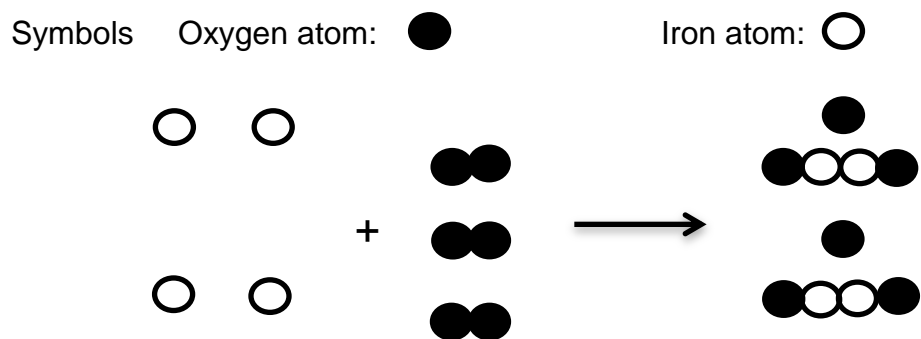


The number before the atom indicates the number of atoms or molecules.

For example, this equation shows 4 atoms of Fe, 3 molecules of O_2 and 2 molecules of Fe_2O_3 .

The number to the bottom right of an atom indicates how many atoms of that kind are bonded together in the molecule. For example, the O_2 molecule contains 2 atoms of O and the Fe_2O_3 molecule contains 2 atoms of Fe and 3 atoms of O.

This reaction can be represented using the particle model in the following way:



This example represents 4 individual Fe atoms, 3 O_2 molecules and 2 Fe_2O_3 molecules.

Question:

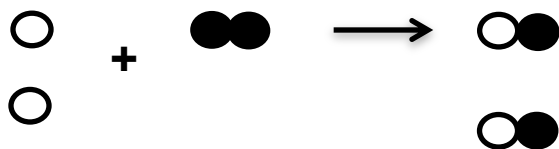
1. Represent the following oxidation reaction using the particle model:



Legend	
●	: O
○	: Mg

Answer:

1.



Chemical Changes: Oxidation

I can associate known chemical reactions with oxidation reaction.

Explanation of Concepts

Common examples of oxidation reactions are:

- Combustion
 - e.g., Combustion of methane: $\text{CH}_4 + 2 \text{O}_2 \rightarrow \text{CO}_2 + 2 \text{H}_2\text{O}$
- Corrosion of Metal
 - e.g., Iron rusting: $4 \text{Fe} + 3 \text{O}_2 \rightarrow 2 \text{Fe}_2\text{O}_3$
- Cellular respiration:
 - e.g., $\text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{O}_2 \rightarrow 6 \text{CO}_2 + 6 \text{H}_2\text{O} + \text{energy}$

Questions

1. Which of the following chemical reactions is **not** an oxidation reaction?
 - A) Iron rusting: $4 \text{Fe} + 3 \text{O}_2 \rightarrow 2 \text{Fe}_2\text{O}_3$
 - B) Cellular respiration: $\text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{O}_2 \rightarrow 6 \text{CO}_2 + 6 \text{H}_2\text{O} + \text{energy}$
 - C) Photosynthesis: $6 \text{CO}_2 + 6 \text{H}_2\text{O} + \text{solar energy} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{O}_2$
 - D) Synthesis of water: $2 \text{H}_2 + \text{O}_2 \rightarrow 2 \text{H}_2\text{O}$
2. State whether or not each of the following is an example of oxidation. Explain your answer.
 - a) A campfire burning
 - b) Photosynthesis

Answers

1. *C: This chemical reaction does not have oxygen as a reactant and therefore does not represent an oxidation reaction*
2.
 - a) *A campfire burning is an example of an oxidation reaction. An oxidizing agent (ie oxygen) is required for combustion to occur.*
 - b) *Photosynthesis is not an oxidation reaction. Oxygen is not required for the reaction to occur. Oxygen is a product.*

Electricity and Electromagnetism: Electrical Charge

I understand that different particles have different charges (i.e., that a proton has a positive charge, a neutron has neutral (no) charge and an electron has a negative charge).

Explanation of Concepts

An atom is composed of small particles of matter: *protons*, *neutrons* and *electrons*. The table below describes the charge and distribution of these elementary particles inside the atom.

Particle Charge and Location

Particle	Charge	Location in atom
Proton	Positive (+)	Nucleus
Electron	Negative (-)	Electron orbitals or shells
Neutron	Neutral (o)	Nucleus

Electrical charge is a property of protons and electrons.

- protons are positively charged (+);
- electrons are negatively charged(-);

Questions

1. What do protons and electrons have in common?
 - A) They both carry an electrical charge.
 - B) Neither of them carry an electrical charge.
 - C) They are both situated outside the nucleus of an atom.
 - D) They are both situated inside the nucleus of an atom.

2. Which of the following are positively charged?

1. The proton
2. The electron
3. The atom
4. The nucleus

A) 1 and 2

B) 2 and 3

C) 3 and 4

D) 1 and 4

3. Which of the following statements correctly describe a difference between electrons and protons?

- A) Protons are found outside the nucleus; electrons are found inside the nucleus.
- B) Protons are positively charged; electrons are negatively charged.
- C) Protons have no electrical charge; electrons have a positive charge.
- D) Protons are found inside the nucleus; electrons are found inside the neutrons

4. The concepts listed in the box below relate to the structure of an atom.

Draw arrows to represent the correct match between each particle, its location and its electrical charge:

a) proton	1) inside the nucleus
	2) outside the nucleus
	3) negative charge
	4) neutral
b) electron	5) positive charge

Answers

1. A

2. D

3. B

4. a) proton 1) and 5)

b) electron 2) and 3)

Electricity and Electromagnetism: Electrical Charge

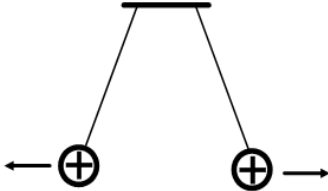
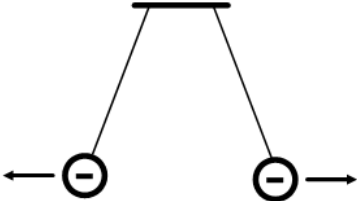
I understand that two objects with similar electrical charges will repel each other and that two objects with opposite electrical charges will attract each other.

Explanation of Concepts

Brought close together, two electrically charged objects interact.

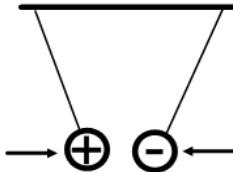
Possibility 1:

When the charges are **similar**, the objects **repel** each other

<p><i>positive repels positive</i></p>	 <p>A diagram illustrating the repulsion between two positive charges. A horizontal line at the top represents a support. Two lines extend downwards from this support to two circles, each containing a plus sign (+). From the left side of the left circle, an arrow points to the left. From the right side of the right circle, an arrow points to the right. The two circles are positioned such that they are moving away from each other, demonstrating that like charges repel.</p>
<p><i>negative repels negative</i></p>	 <p>A diagram illustrating the repulsion between two negative charges. A horizontal line at the top represents a support. Two lines extend downwards from this support to two circles, each containing a minus sign (-). From the left side of the left circle, an arrow points to the left. From the right side of the right circle, an arrow points to the right. The two circles are positioned such that they are moving away from each other, demonstrating that like charges repel.</p>

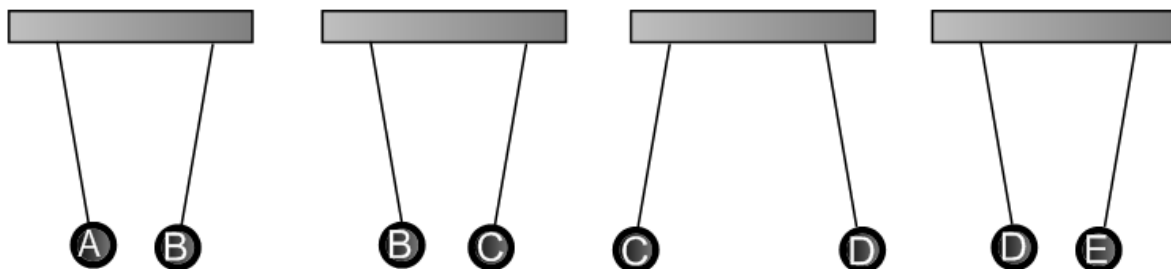
Possibility 2:

When the charges are **opposite**, the objects **attract** each other

<p><i>positive and negative attract</i></p>	 <p>A diagram illustrating the attraction between a positive and a negative charge. A horizontal line at the top represents a support. Two lines extend downwards from this support to two circles. The left circle contains a plus sign (+) and has an arrow pointing to the right. The right circle contains a minus sign (-) and has an arrow pointing to the left. The two circles are positioned such that they are moving towards each other, demonstrating that opposite charges attract.</p>
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Questions

1. Five metallic spheres were electrically charged and then suspended as shown in the diagram below:



If sphere A is positively charged, which of the spheres are negatively charged?

- A) B and C
- B) C and D
- C) D and E
- D) B and E

Answer

1. D

Electricity and Electromagnetism: Static Electricity

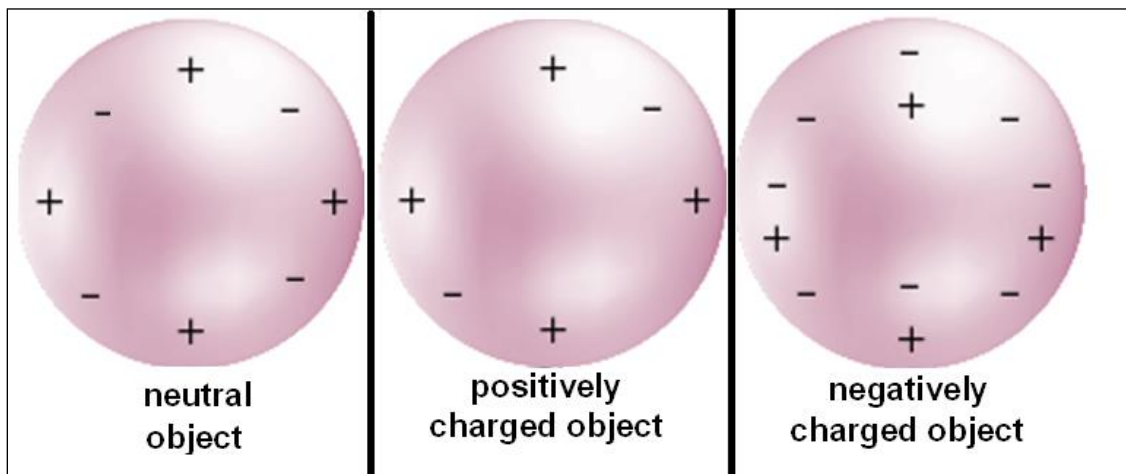
I can describe static electricity as the transfer of electrons from one body to another.

Explanation of Concepts

An electrically neutral body contains the same number of protons (*positive charges*) as electrons (*negative charges*). Protons are very tightly bound to the nucleus and cannot be easily removed. Some electrons however, are not so tightly bound and can be transferred from one body to another. These transfers usually occur when two bodies are rubbed against each other.

- The atom that loses electrons becomes **positively charged**.
- The atom that gains electrons becomes **negatively charged**.

Electrically Charged Objects



Electrical charges can also be transferred from one body to another by direct contact.

Questions

1. The list below arranges different substances in increasing order of their tendency to acquire electrons. When two of these substances are rubbed together, the one situated lower on the list attracts electrons from the substance above and becomes negatively charged.

Electrostatic Series Chart

Acetate	<i>Weak hold on electrons</i>
Glass	
Wool	
Cotton	
Ebonite	
Plastic	
Rubber	<i>Strong hold on electrons</i>

In the laboratory, a student rubs a cotton cloth with each of the following materials: ebonite, plastic, acetate and glass.

He then brings the different materials together:

1. Ebonite and plastic
2. Plastic and acetate
3. Acetate and glass
4. Glass and ebonite

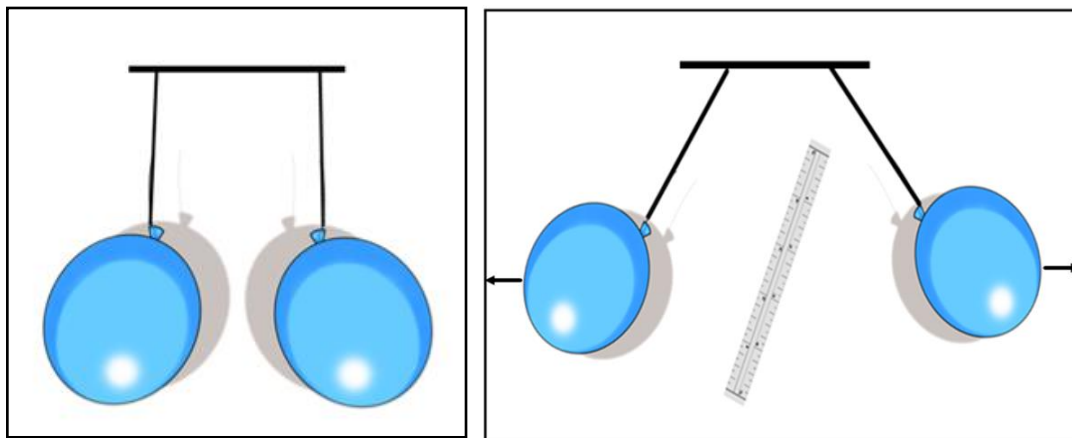
In which of the situations do the materials repel each other?

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

2. Tom wants to prepare a surprise party for his baby sister. Amongst other things, he wants to decorate the walls of their house with multi-coloured balloons. Once the balloons are inflated, Tom rubs them on his hair for a few seconds and then sticks them to the wall. He knows that this is possible due to friction, as the balloons become electrically charged and are attracted to the wall.

Which of the following produced the static electricity?

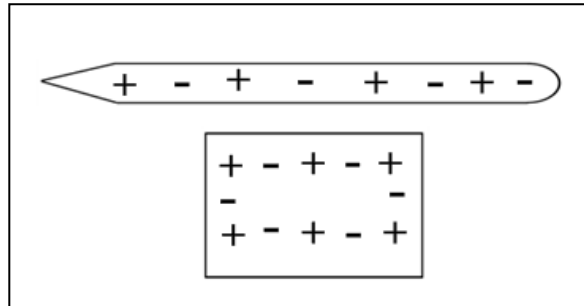
- A) The transfer of protons between the hair and the balloons.
 - B) The transfer of electrons between the hair and the balloons.
 - C) The transfer of electrons between the balloons and the wall.
 - D) The transfer of protons between the balloons and the wall.
3. Which of the statements below is TRUE?
- A) Positively charged objects have a fewer protons than electrons.
 - B) Positively charged objects have more electrons than protons.
 - C) Negatively charged objects have more electrons than protons.
 - D) Negatively charged objects have more protons than electrons.
4. A student rubbed two identical inflated balloons on a piece of fur and suspended them from a high stand. He then rubbed a plastic ruler with a piece of wool and placed it between the two suspended balloons. The balloons quickly went high in the air as shown in the diagrams below.



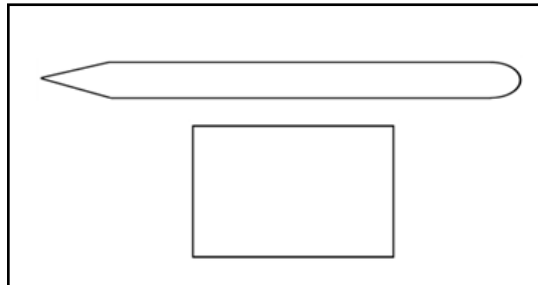
Knowing that the wool cloth transferred electrical charges to the ruler, determine the overall charge of the balloons, fur, ruler and wool cloth. Explain your answer.

Demonstrations using ebonite rods and wool cloth are very common in static electricity activities. After being rubbed with wool, an ebonite rod attracts small objects. Ebonite is known to hold its electrons very tightly when rubbed against other substances. Wool on the other hand, exerts very weak attraction on its electrons.

The diagram below shows the distribution of electrical charges before the two objects (ebonite rod and wool) are rubbed together:



- a) Show the distribution of electrical charges in the two substances after the two objects are rubbed together (*use + and -*). Explain your diagram.



- b) Explain why the ebonite rod attracts small objects after being rubbed with the wool cloth.

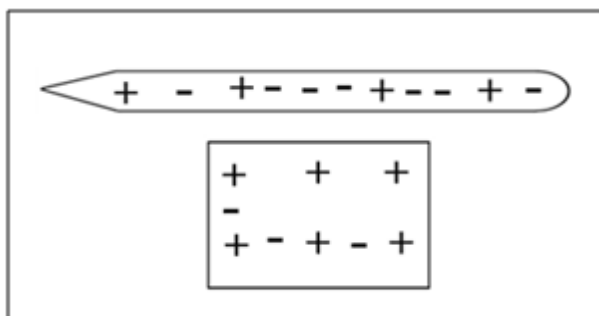
Answer

1. B
2. B
3. C
- 4.

	<i>Electrical Charge (positive/negative)</i>	<i>Explanation</i>
<i>balloons</i>	<i>negative</i>	<i>The charges transferred from the wool to the balloons were electrons, because only electrons can move from one atom to another. The balloons acquired electrons and became negatively charged.</i>
<i>fur</i>	<i>positive</i>	<i>By transferring electrons to the balloons, the fur lost electrons and became positively charged.</i>
<i>ruler</i>	<i>negative</i>	<i>Since the ruler repels the two balloons, it must be negatively charged. By rubbing the ruler with the wool cloth, the ruler gained electrons.</i>
<i>wool cloth</i>	<i>positive</i>	<i>The wool cloth has transferred electrons to the ruler. Then wool cloth lost electrons and became positively charged.</i>

5.

a.



- b. *The wool cloth does not hold its electrons tightly, like the ebonite rod. By rubbing these substances together some electrons are transferred from the wool cloth to the ebonite rod. Before being rubbed, both objects contain equal numbers of positive and negative charges. After rubbing, the ebonite rod has more electrons. The wool cloth has lost electrons.*

NOTE: The number of negative charges that are added to the ebonite should equal the number negative charges that were removed from the wool cloth. The number of positive charges(protons) remains the same in both objects, because the positive charges cannot be transferred.

The ebonite rod gained electrons. When the ebonite rod is brought close to objects like small pieces of paper and styrofoam etc, the positive charges(protons) in these objects are attracted by the electrons in the ebonite rod. The objects will move towards ebonite rod.

Electricity and Electromagnetism: Ohm's Law

I can explain the relationship between voltage, resistance and current intensity in an electrical circuit.

Explanation of Concepts

Ohm's Law describes the relationship between current, potential difference and resistance in a circuit.

The **current intensity (I)** is the amount of charge that flows through a point of an electrical circuit in one second. (Imagine the number of the cars (electrons) passing a point on a racetrack in one second.)

The **potential difference (V)** is the amount of energy provided by the power supply (battery). It is the energy transferred by electrons between two points of an electrical circuit. (Imagine the amount of push needed to get a car on a racetrack from point A to point B.)

The **resistance (R)** of an element or a circuit is a property of materials. It is the ability of a material to resist the flow of electric charges. (Imagine speed bumps slowing down the cars on a racetrack.)

Relationship between Current, Potential Difference and Resistance in a Circuit

There is a proportional relationship between potential difference and current intensity for a circuit of a given resistance.

For a circuit where the resistance is held constant,

- If $V \uparrow$ then $I \uparrow$
- If $V \downarrow$ then $I \downarrow$

There is an inversely proportional relationship between current intensity and resistance in a circuit of a given potential difference.

For a circuit where the potential difference is held constant,

- If $R \uparrow$ then $I \downarrow$
- If $R \downarrow$ then $I \uparrow$

There is a proportional relationship between potential difference and current resistance for a circuit of a given current intensity.

For a circuit where the current intensity must be held constant,

- If $V \uparrow$ then R must \uparrow
- If $V \downarrow$ then R must \downarrow
- If $R \uparrow$ then V must \uparrow
- If $R \downarrow$ then V must \downarrow

Questions

1. In an electrical circuit, the current intensity doubles. The total resistance of the circuit stays the same.

How does the potential difference change?

- A) The potential difference halves.
- B) The potential difference doubles.
- C) The potential difference quadruples.
- D) The potential difference stays the same.

2. What will happen to the current intensity in an electrical circuit if, for a given resistance, the potential difference is reduced by half?

- A) The current intensity will double.
- B) The current intensity will not change.
- C) The current intensity will reduce to half of the initial value.
- D) The current intensity will quadruple.

3. The resistance of a circuit is increased while the current intensity is maintained at the same value. How will the voltage change? Explain why.

Answers

1. *B*
2. *C*
3. *The voltage will increase. The resistance of an electrical circuit represents the capacity of a material to oppose the flow of electrical charges. As the current intensity and voltage are directly proportional, if the current is maintained constant and the resistance is increased, more energy will be needed for the current to flow through the resistor, so the voltage will increase.*

Electricity and Electromagnetism: Ohm's Law

I can use the equation ($V=RI$) to calculate voltage, resistance and current intensity in an electrical circuit.

Explanation of Concepts

The mathematical expression of Ohm's Law shows the direct proportionality between the potential difference and current intensity, for a given resistance:

$$V = R \cdot I$$

The above formula can be also written as:

$$R = \frac{V}{I}$$

or

$$I = \frac{V}{R}$$

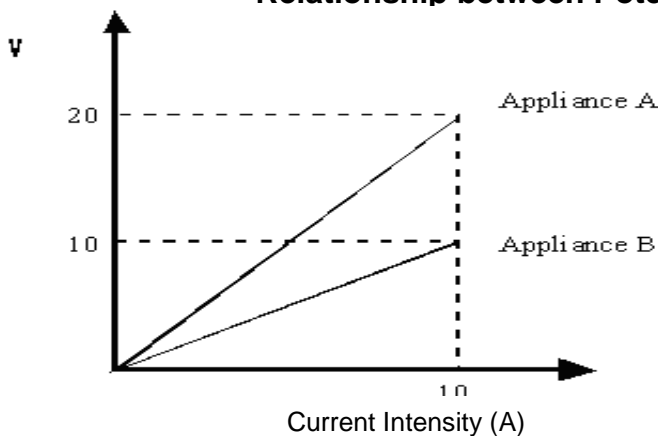
where:

- V is the potential difference (voltage) expressed in Volts (V)
- I is the current intensity expressed in Amperes (A)
- R is the resistance expressed in Ohms (Ω)

Using Ohm's Law to Calculate Resistance

The graph and table below show the relationship between the potential difference and the current intensity for the circuits of two different appliances. What is the resistance of the circuit for each appliance?

Relationship between Potential Difference and Current



Appliance	Potential Difference (V)	Current Intensity (A)
A	20	10
B	10	10

To calculate resistance, use Ohm's Law, $V = RI$

- Rewrite the equation to solve for R

$$R = \frac{V}{I}$$

- Substitute in known values.

Appliance A

Appliance B

Remember the units.

$$R = \frac{20\text{V}}{10\text{A}}$$

$$R = \frac{10\text{V}}{10\text{A}}$$

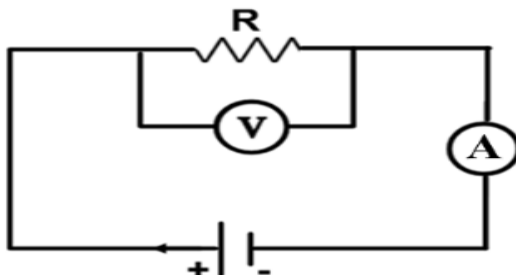
- Solve for R

$$R = 2\ \Omega$$

$$R = 1\ \Omega$$

Questions

1. In the circuit diagram below the reading on voltmeter is 12 V and the reading on the ammeter is 0.6 A.

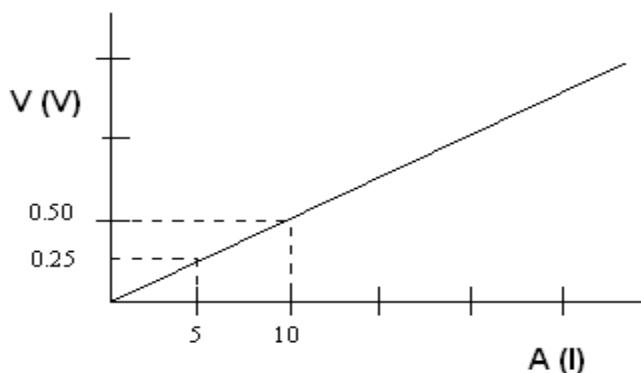


What is the resistance of element R?

- A) 0.05 Ω
B) 7 Ω
C) 10 Ω
D) 20 Ω
2. What is the potential difference of a circuit if the resistance is 25 Ω and the current intensity is 10 A?
- A) 250 Ω
B) 0.40 V
C) 2.5 V
D) 250 V
3. A large flashlight that requires a 1.5 V battery. If the resistance of the light bulb is 3 Ω , what is the current flowing through the light bulb?
- A) 0.50 A
B) 1.5 A
C) 2.0 A
D) 4.5 A

4. The graph below shows the variation in the current intensity, I , as a function of the potential difference (voltage), V , across a resistor.

Relationship between Potential Difference and Current



What is the resistance, R , of the resistor?

- A) 0.05Ω
 - B) 1Ω
 - C) 5Ω
 - D) 20Ω
5. In the laboratory, a student was asked to measure resistance and potential difference in an electrical circuit. The circuit requires 0.5 A of current to function optimally. He has experimented with four different resistors and recorded the data in the table below.

Resistance and Potential Difference Values

Resistor	Resistance (Ω)	Potential Difference (V)
1	60	12
2	24	12
3	48	12
4	36	12

Which resistors could be used for the optimal functioning of the circuit?

Answers

1. *D*
2. *D*
3. *B*
4. *A*
5. *Resistor 2. It provides the optimal amount of current for this circuit.*

Resistor 1:

$$I = \frac{V}{R} \quad I = \frac{12 \text{ V}}{60 \Omega} \quad I = 0.2 \text{ A}$$

Resistor 2

$$I = \frac{V}{R} \quad I = \frac{12 \text{ V}}{24 \Omega} \quad I = 0.5 \text{ A}$$

Resistor 3:

$$I = \frac{V}{R} \quad I = 0.25 \text{ A}$$

Resistor 4:

$$I = \frac{V}{R} \quad I = \frac{12 \text{ V}}{36 \Omega} \quad I = 0.3 \text{ A}$$



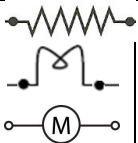



Electricity and Electromagnetism: Electrical Circuits

I can describe the function of different components of an electrical circuit.

Explanation of Concepts

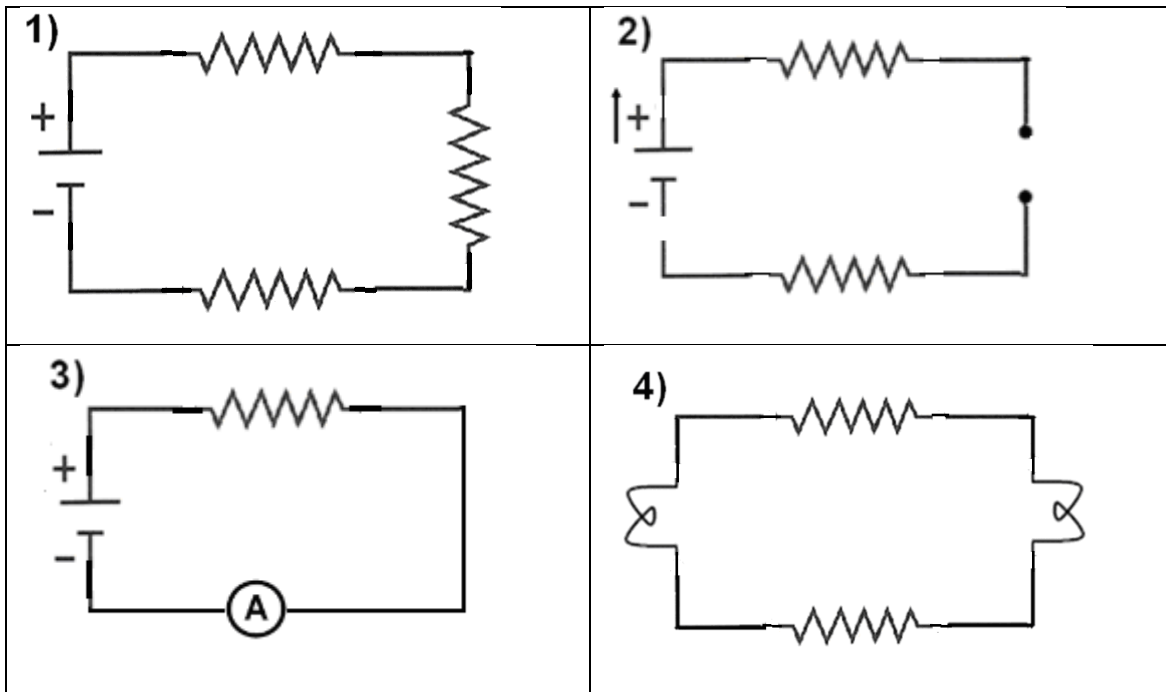
Electrical circuits transform electrical energy into other forms of usable energy (light, heat, sound, mechanical energy etc). The table below describes some components of electrical circuits and their specific role.

Basic Electrical Circuit Components and their Functions

Component(s) and Symbol	Electrical Function	Description
Power source, battery 	Power Supply	Creates a potential difference; transfers energy to electrons
Wires 	Conduction	Connect the circuit components and the power supply; carry electrons from the source to the components and back to the source
Resistor Light Motor 	Electrical Resistance	Limit the flow of electrons; transform electrical energy into other forms of energy (light, heat, sound, motor etc)
Switch 	Control	Allows the control of current by connecting or breaking the circuit; (when a switch is off, the electron flow is interrupted)
Ammeter 	N/A	Measures the current flowing through a circuit (connected in series)
Voltmeter 	N/A	Measures the potential difference (energy) that electrons have between two points of the circuit (connected in parallel)

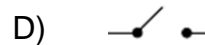
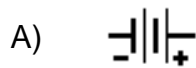
Questions

1. In which of the following electrical circuits is electron flow *NOT* possible?



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

2. Which of the components depicted by the symbols below is used to STOP the electron flow in an electrical circuit?



3. Match the components below with the right function they carry in electrical circuits:

Functions

Components

- | | | | |
|----|---|---|--------------|
| 1. | converts electrical energy into other forms of energy | A | ammeter |
| 2. | provides the energy to the circuit | B | resistor |
| 3. | controls the current | C | light bulb |
| 4. | measures the current intensity | D | voltmeter |
| 5. | measures the voltage | E | power supply |
| 6. | carries the current | F | switch |
| 7. | component that generates light | G | wires |

Answers

1. D
2. D
3. 1.B, 2.E, 3.F, 4.A, 5. D, 6. G, 7 C.

Electricity and Electromagnetism: Electrical Circuits

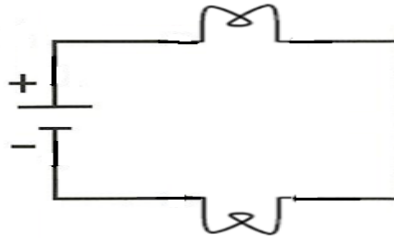
I can identify the two main types of electrical circuits (series, parallel).

Explanation of Concepts

In an **electrical circuit** electrical charges flow continuously. In order for charges to flow, all parts of the circuit must be connected together.

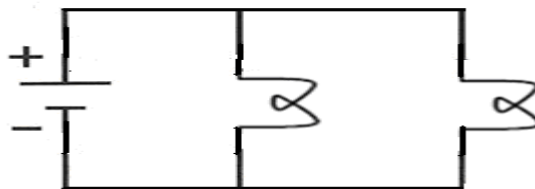
Series Circuits

In a series circuit, elements are linked directly together (connected end to end). All charges follow the same pathway. If a part of the circuit is open or an element is defective, the current stops flowing through the entire circuit.



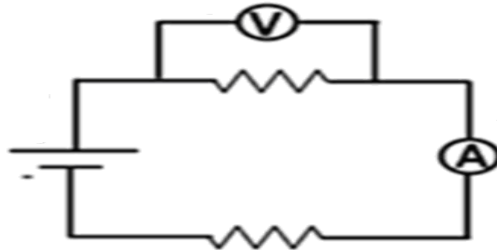
Parallel Circuits

A parallel circuit branches out at least at one point. The charges follow different pathways. If part of one pathway or branch in a parallel circuit is open or an element is defective, the current continues to flow through the other branches.



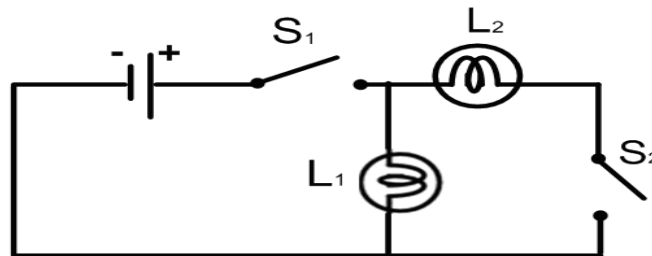
Measuring Instruments

- **Ammeters** are connected IN SERIES (the current passes through the ammeter).
- **Voltmeters** are connected IN PARALLEL (outside the element whose voltage is measured).



Questions

1. The diagram below shows a circuit made of two light bulbs, two switches and a power source.

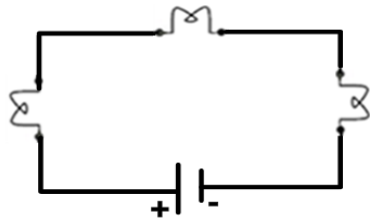


Which of the following statements about this circuit is TRUE?

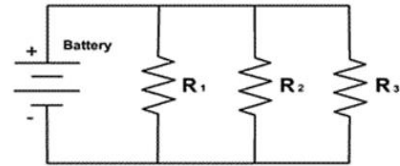
	S₁	S₂	L₁	L₂
A)	Opened	Closed	Off	On
B)	Closed	Opened	On	Off
C)	Opened	Closed	On	Off
D)	Closed	Opened	Off	On

2. Which of the circuits below are connected in parallel?

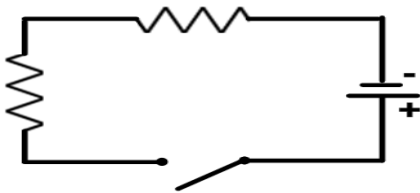
1)



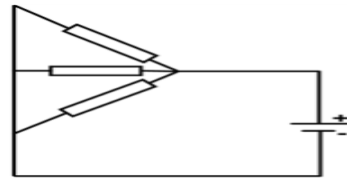
2)



3)



4)



A) 1 and 4

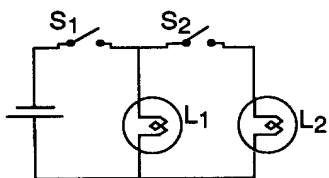
B) 2 and 4

C) 1 and 3

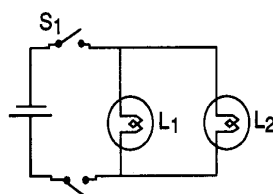
D) 2 and 3

3. In the three circuits below, if S_1 is closed and S_2 is open, which light bulb(s) will light up?

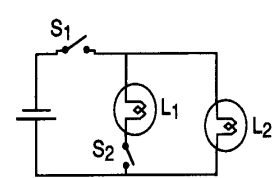
Circuit 1



Circuit 2



Circuit 3



Answers

1. *B*
2. *B*
3. *Circuit 1: light bulb 1 will light up*
Circuit 2: neither light bulb will light up
Circuit 3: light bulb 2 will light up

Electricity and Electromagnetism: Electrical Circuits

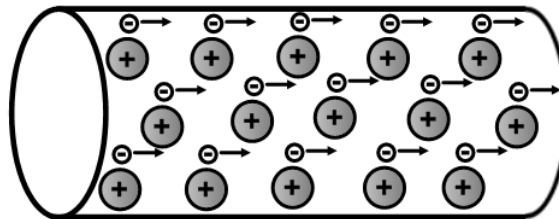
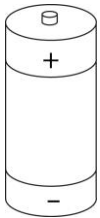
I can explain the differences between alternating and direct current.

Explanation of Concepts

An **electric current** is an orderly flow of electrical charges. There are two types of electric current:

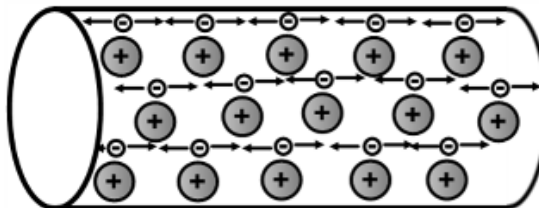
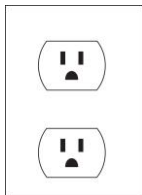
Direct Current (DC)

Electrons continuously move in the same direction. Batteries produce DC current.



Alternating Current (AC)

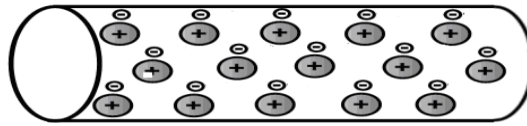
Electrons change direction many times every second (they flow back and forth). AC current is provided by an electric outlet.



Questions

1. Which of the following statements describe an alternating current (AC)?
 - A) It is produced by a battery
 - B) Electrons change direction continuously.
 - C) The electrons do not move.
 - D) Electrons move in the same direction.

2. The diagram below shows the charges inside a wire.

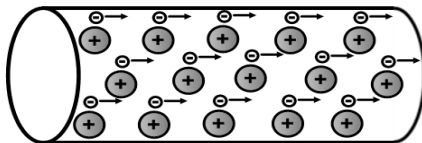


- a) Use arrows to show the motion of the electrons if this wire was part of a circuit that had a battery as a power supply.
- b) Draw a second wire with charges to show the motion of electrons if the wire was part of a circuit that is connected to an electrical outlet.

Answers

1. B

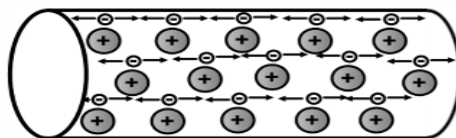
2.



a.

All arrows must point in the same direction

Originate ONLY with the electrons



b.

Arrows point in both directions

Originate ONLY with the electrons

Electricity and Electromagnetism: Electrical Circuits

I can represent a simple electrical circuit using a diagram and appropriate symbols.


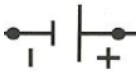





Explanation of Concepts

A simple electrical circuit contains at least the following components:

- a power source
- components (resistors, light bulbs, motors, heating elements)
- wires
- a switch


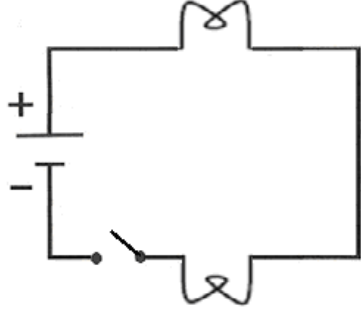
Circuits are represented by precise diagrams. Certain symbols are used to represent the elements of an electrical circuit:

Electrical Circuit Symbols

Wire	Power Supply	Resistor	Light Bulb	Switch	Ammeter	Voltmeter
						


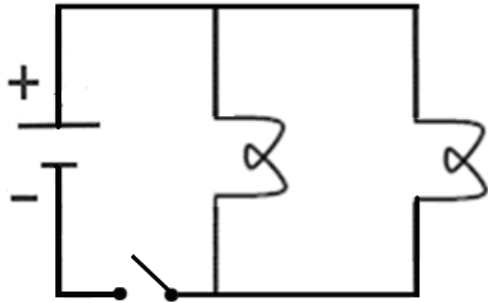
Series Circuit

The figure below represents a series circuit consisting of a power supply (electrical battery) and two resistors (light bulbs) along with its representation using symbols, in an electrical diagram:

Circuit	Circuit Diagram
 A photograph of a physical series circuit. It consists of a battery with a '+' sign on top, a switch, and two light bulbs connected in a single loop by red wires.	 A schematic diagram of a series circuit. It shows a battery symbol with '+' and '-' signs, a switch symbol, and two resistor symbols (zig-zag lines) connected in a single loop.

Parallel Circuit

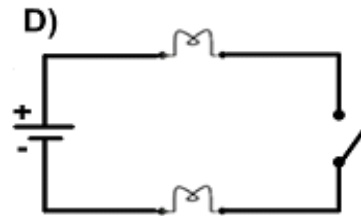
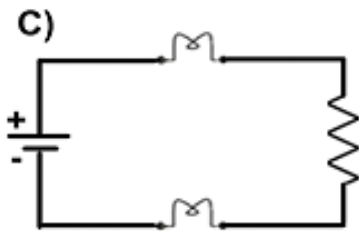
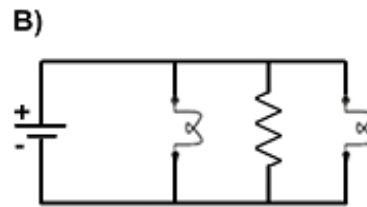
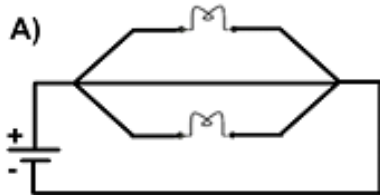
The figure below represents a parallel circuit consisting of a power supply (electrical battery) and two resistors (light bulbs) along with its representation using symbols, in an electrical diagram:

Circuit	Circuit Diagram
 A photograph of a physical parallel circuit. It consists of a battery with a '+' sign on top, a switch, and two light bulbs connected in parallel by red wires. A label 'node' points to a junction point in the circuit.	 A schematic diagram of a parallel circuit. It shows a battery symbol with '+' and '-' signs, a switch symbol, and two resistor symbols connected in parallel branches.

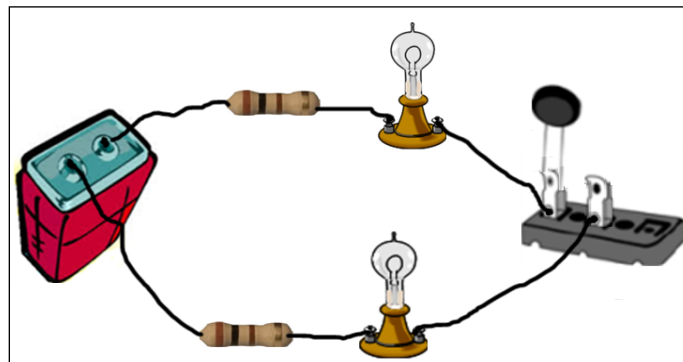
Questions

1. The figure below represents an electrical circuit containing a power source, two electrical bulbs and one resistor connected in parallel:

Which of the circuit diagrams below best represents this circuit?



2. The electrical circuit below contains two resistors, two light bulbs, a power supply and a switch - all connected by copper wires as shown in the figure below.



Draw a diagram of this circuit using appropriate symbols used in electricity. Show the flow of charges on your diagram.

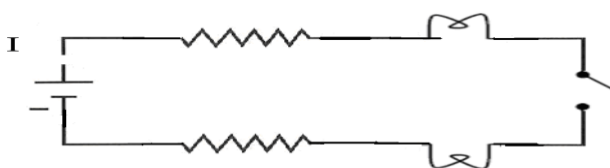
3. An electrical circuit is made of two resistors connected to a power supply, an ammeter and a voltmeter. All circuit components (resistors) are connected in parallel. The ammeter measures the current in both resistors. The voltmeter measures the potential difference of the first resistor only.

Draw the circuit diagram, indicating also the measuring instruments.

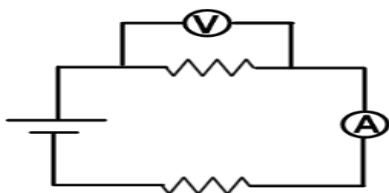
Answers

1. B

2.



3.



Electricity and Electromagnetism: Relationship between Power and Electrical Energy

I understand the relationship between power, voltage and current intensity.

I can use the equation $P = VI$ to calculate power, voltage and current intensity in an electrical circuit.

Explanation of Concepts

Electrical power is the amount of work an electrical device can perform in one second.

The electrical power of a circuit is directly proportional to both voltage and current intensity and can be expressed in a formula as:

$$P = V I$$

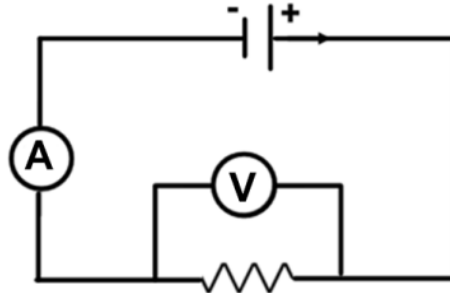
where:

- P is the electrical power expressed in watts (W)
- V is the voltage (potential difference) expressed in volts (V)
- I is the current intensity expressed in amperes (A)

Remember: 1000 W = 1 kW

Questions

1. A student was asked to assemble a simple electrical circuit made of a resistor and a battery, an ammeter and a voltmeter. The diagram below represents the circuit that he assembled:

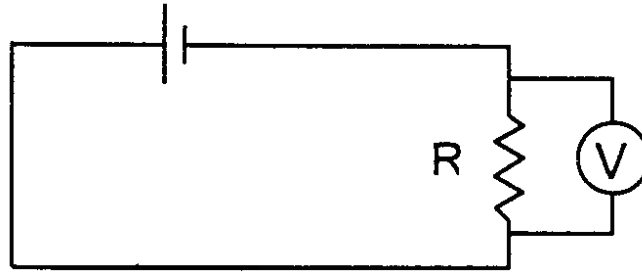


The ammeter reads is 0.80 A and the voltmeter reads 20 V.

What is the electrical power of this circuit?

- A) 0.040 W
B) 16 W
C) 6 W
D) 25 W
2. What is the current drawn when a kettle with a power of 1.65 kW is connected to a 110V power supply?
- A) 0.0150 A
B) 1.50 A
C) 15.0 A
D) 66.7 A
3. What is the voltage required by an electric grill with a power of 2.2 kW and current 20 A?
- A) 0.11 V
B) 9.1 V
C) 26 V
D) 110 V

4. In the electrical circuit represented below, the voltage is 100 V and resistor R has a value of 50 Ω .



Calculate the electrical power of resistor R. Show all your work.

Answers

1. B
2. C
3. D
4. Find current intensity:

$$I = \frac{V}{R} \quad I = \frac{100 \text{ V}}{50 \Omega} \quad I = 2 \text{ A}$$

Find electrical power:

$$P = V \cdot I \quad P = 100 \text{ V} \cdot 2 \text{ A} \cdot P = 200 \text{ W}$$

Answer: The electrical power of the resistor is 200 W

Electricity and Electromagnetism: Relationship between Power and Electrical Energy

I can explain the relationship between the power of an electrical appliance, the electrical energy it consumes and the amount of time it is in operation.

Explanation of Concepts

The **electrical energy** consumed by an electrical appliance is directly proportional to the **power** of the appliance and the amount of **time** it is in operation.

- The more powerful an electrical appliance is, the more energy it consumes for a period of time.
- The longer an appliance is in operation, the more energy it consumes.

Questions

1. Which of the following would reduce the cost of using an electrical appliance?

1. Increase the operation time.
2. Use an appliance with a lower power rating.
3. Reduce the operation time.
4. Use an appliance with a higher power rating.

A) 1 and 3

B) 1 and 4

C) 2 and 3

D) 3 and 4

2. Lynn wants to buy a new hair dryer. The store sells two different models. The rating plates of the two appliances are shown below:

Model 1

120 V 60 Hz 1200 W (1.2kW)

Model 2

120 V 60 Hz 1400 W (1.2kW)

She usually dries her hair for about 15 minutes daily and she would like to use the least amount of energy possible.

Which of the two models should Lynn buy? Explain your answer.

Answers

1. C
2. Lynn should buy **Model 1**.

The power rating of Model 2 is lower. Since the amount of energy consumed by an appliance is directly proportional to its electrical power, for the same amount of operating time this model is going to use less energy.

Electricity and Electromagnetism: Relationship between Power and Electrical Energy

I can use the equation $E = P\Delta t$ to calculate the electrical energy consumed, the power of an electrical appliance and the amount of time it is in operation.

Explanation of Concepts

The electrical energy of an electrical circuit can be calculated using the formula:

$$E = P \Delta t$$

where:

- E is the electrical energy expressed in joules (J) or kilowatt hour (kWh)
- P is the electrical power expressed in W (watt) or kilowatt (kW)
- Δt is the time interval expressed in seconds (s) or hours (h)

Remember:

- Since P is calculated as VI, energy can also be solved as: $E = VI \Delta t$
- $1000 \text{ J} = 1 \text{ kJ}$
- In questions where the answer is in Joules, you will use time measured in seconds
- In questions where the answer is in kWh, you will use time measured in hours (and energy will be measured in kW)

Questions

1. How much energy does an electric heater with a power of 200 W consume in 2.0 minutes?
A) 0.010 kJ
B) 24 kJ
C) 100 J
D) 400 J

2. How much energy is consumed by an oven with an electrical power of 4000 W in use for 2.5 hours?

- A) 10 kWh
- B) 10 000 kWh
- C) 1600 kWh
- D) 1.6 kWh

3. How long does it take for a kettle with a power of 2 000 W to use 30 000 J of energy?

- A) 15 s
- B) 15000 s
- C) 15 min
- D) 15 h

4. What is the power of an electric bulb that gives off 3600 J of energy in 10 minutes?

- A) 6.0 kW
- B) 2.8 kW
- C) 6.0 W
- D) 360 W

5. A water heater has a resistor working with a potential difference of 220 V and a current of 50 A.

Calculate the energy consumed by this water heater in 30 minutes. Show all your work.

Answers

1. B
2. A
3. A
4. C

5. Calculate the power of the resistor:

$$P = VI \qquad P = 220 \text{ V} \times 50 \text{ A} \qquad P = 11\,000 \text{ W} = 1.1 \text{ kW}$$

Express the time in hours:

$$t = 30 \text{ min} \cdot \frac{1 \text{ h}}{60 \text{ min}} \quad t = 0.5 \text{ h}$$

Calculate the energy consumed by the resistor:

$$E = P \Delta t \qquad E = 11 \text{ kW} \times 0.5 \text{ h} \qquad E = 5.5 \text{ kWh}$$

Answer: The resistor uses 5.5 kWh of energy in 30 minutes.

** Please note the equivalent answer in Js is 20 700 000 Js **

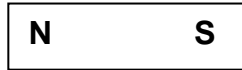
Electromagnetism: Forces of Attraction / Repulsion

I understand that for magnets, different poles attract, while similar poles repel.

I can describe and interpret the magnetic field of a magnet and behaviour of a compass in the magnetic field of a magnet.

Explanation of Concepts

Every magnet has two poles: North (N) and South (S)



Like poles **repel**.



Opposite poles **attract**.

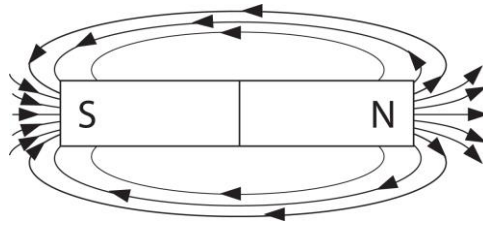


All magnets have a magnetic field. A magnetic field is the space around a magnet where magnetic forces are felt (both attraction and repulsion).

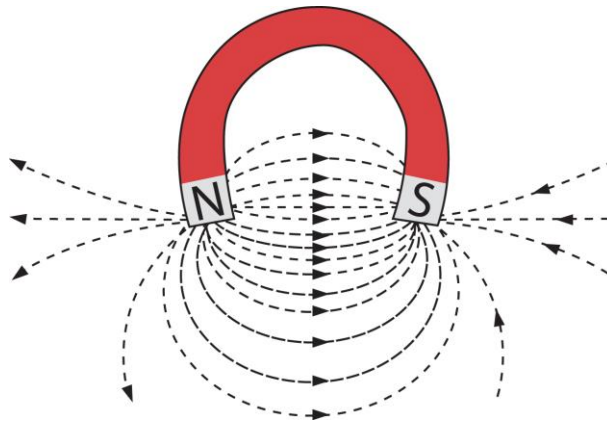
Lines of Force show you the shape, direction, and strength of the magnetic field around a magnet.

- **Shape** is shown by lines of force which can be straight, curved, circular, etc.
- **Direction** is shown by arrowheads. The direction is always from North to South.
- **Strength** is shown by how close the lines are to each other. The closer the lines of force are, the stronger the magnetic field.

Example: Magnetic Field of a Bar Magnet

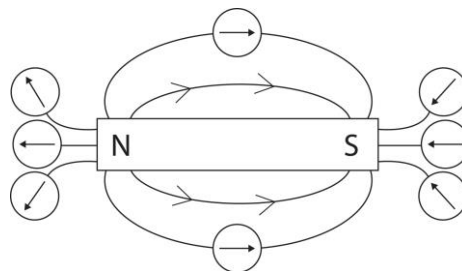


Example: Magnetic Field of a Horseshoe Magnet



A compass needle is a free moving magnet. The North pole of the compass needle is attracted to the South pole of a magnet. The compass needle will position itself parallel to the field lines that are beneath it.

The behaviour of a compass in the magnetic field of a bar magnet is shown below.



Geographic north attracts the north of a compass needle. This means that magnetically speaking, geographic north is really a magnetic south pole.

Earth's Magnetic Field

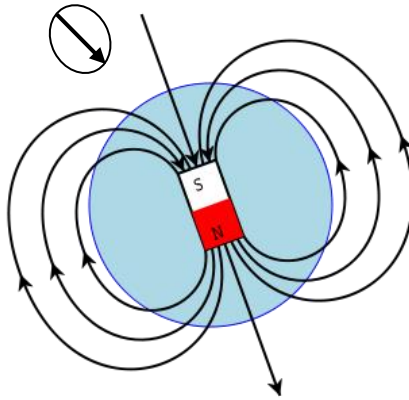


Image modified from http://commons.wikimedia.org/wiki/File:Earths_Magnetic_Field_Confusion.svg Retrieved January 2014

Questions

- Which of the following correctly illustrates the behavior of a compass in the magnetic field of a bar magnet?

A)	
B)	
C)	
D)	

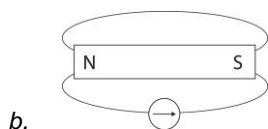
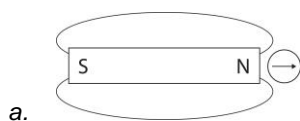
2. Indicate which pole is the North pole of the magnet. Draw the field lines.



Answers

1. *B*

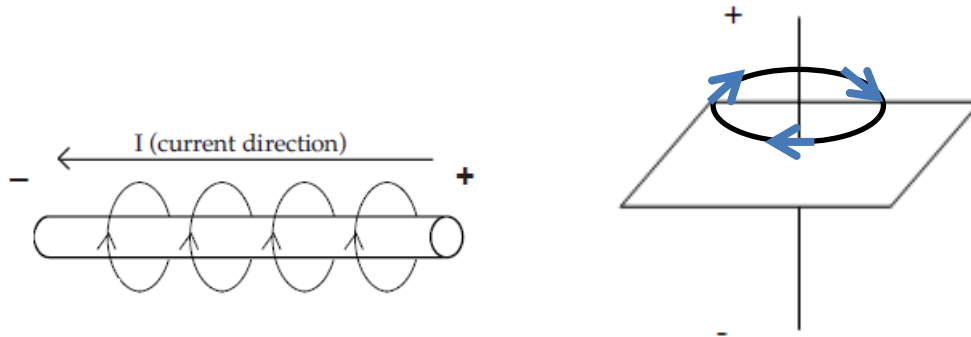
2.



Electromagnetism: Magnetic Field of a Live Wire

I can describe and interpret the magnetic field produced by a current-carrying wire (right-hand rule or left-hand rule).

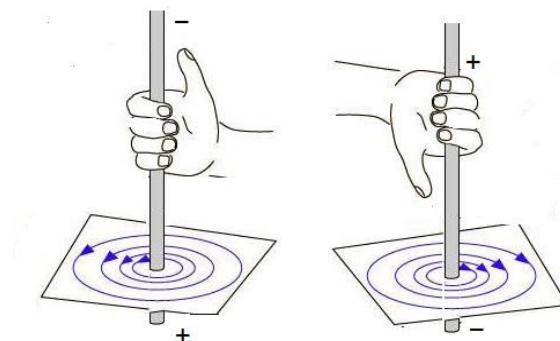
Explanation of Concepts



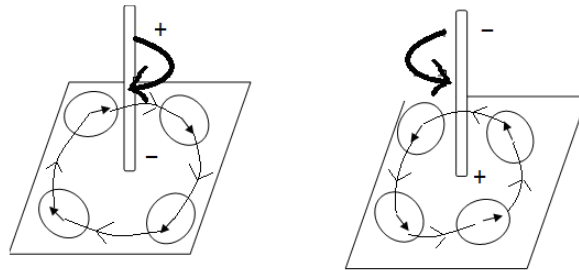
A straight wire with a current flowing through it has a circular magnetic field around it. The magnetic field is represented by circular lines around the wire.

The magnetic field of a straight conductor can be determined using the Right Hand Rule:

- Using your RIGHT hand, point your thumb towards the negative end of the wire (the direction of the current).
- Your fingers wrap around the wire and the curl of your fingers show the direction of the magnetic field.



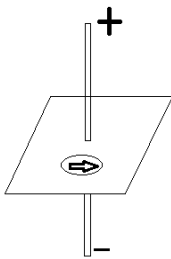
When a compass is placed in the magnetic field, the north end of the compass will point in the direction of the magnetic field.



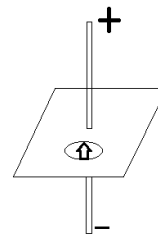
Questions

1. Which of the following diagrams correctly represents the behavior of a compass in the magnetic field of a live wire?

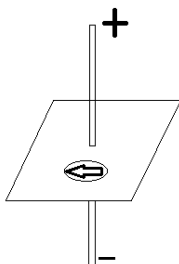
A)



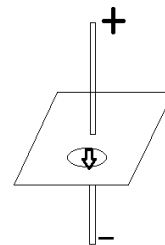
C)



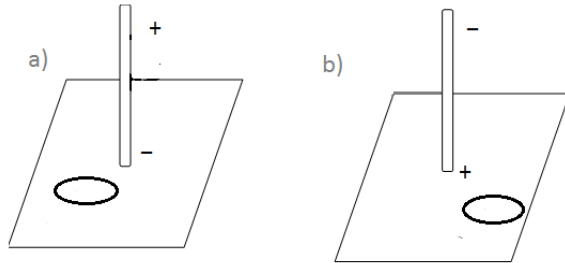
B)



D)

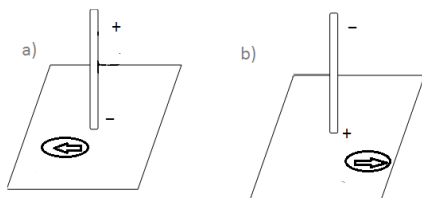


2. A compass (shown as a circle below) is placed on a paper which has a live wire going through it. Place an arrow on the compass showing the direction in which the compass will point.



Answers

1. *B: When using the right hand rule, the thumb points in the direction of the conventional current. The thumb will therefore point towards the negative terminal and the fingers will wrap around the wire. The direction of the magnetic field is shown by the direction of the fingers.*
- 2.



Electromagnetism: Magnetic Field of a Live Wire

I can identify ways of modifying the intensity of the magnetic field produced by a current-carrying wire (type of wire, current intensity).

Explanation of Concepts

To increase the intensity of the magnetic field of a live wire (wire with electric current running through it),

- Increase the current intensity.
- Use a better conductor.
- Remember: Metals are conductors. Some metals are better conductors than others
- Examples of good conductors: gold, silver, copper
- Examples of poor conductors: nichrome

Questions

1. An electrical engineer is trying to figure out how to maximize the intensity of a magnetic field generated from a live wire. Which scenario should she choose?
 - A) A copper wire with 5 A.
 - B) An aluminum wire with 5 A.
 - C) A copper wire with 10 A.
 - D) An aluminum wire with 10 A.
2. You are trying to increase the strength of the magnetic field around a current carrying wire. You have a choice between using a copper and a nichrome wire. Which one would you use? Explain your answer.

Answers

1. *C: A combination of copper and a strong intensity make for a good conductor*
2. *I would choose a copper wire, because copper is a better conductor than nichrome.*

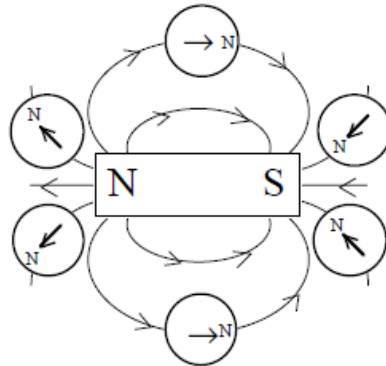
Electromagnetism: Magnetic Field of a Live Wire

I can compare the behaviour of a compass in the magnetic field of a magnet with that of a current-carrying wire.

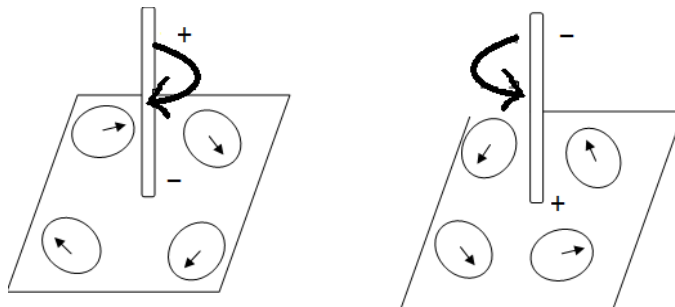
Explanation of Concepts

Recall: The magnetic field lines travel from the magnetic N pole to the S pole. The lines are drawn out of the North end and into the South end.

For a bar magnet, the behavior of the compass is shown below:



The behaviour of a compass in the magnetic field of a current-carrying wire is shown below:



Question:

1. Which of the statements below is TRUE?
 - A) When a compass is placed in the magnetic field of a magnet, the North end of the compass always points to the North pole.
 - B) When a compass is placed in the magnetic field of a magnet, the North end of the compass always points to the South pole.
 - C) When placed in the magnetic field of a current carrying wire, the compass will point towards the positive end of the wire.
 - D) When placed in the magnetic field of a current carrying wire, the compass will point towards the negative end of the wire.

Answers

1. *B*

Electromagnetism: Magnetic Field of a Solenoid

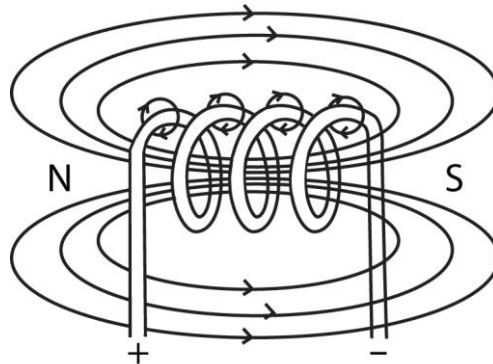
I can interpret the magnetic field produced by a solenoid (right-hand rule or left-hand rule).

Explanation of Concepts

A solenoid is a coiled wire with current flowing through it.

A solenoid has a magnetic field when the current travels through the coiled wire. The magnetic field around a solenoid looks like the magnetic field around a bar magnet.

Magnetic Field of a Solenoid



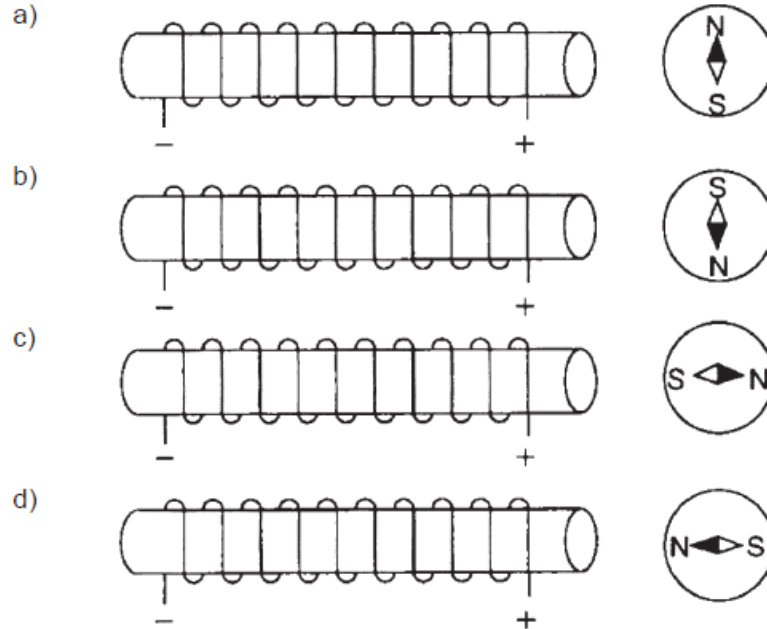
The direction of the field lines (magnetic North and South) is determined using the Right Hand Rule:

- Starting at the positive end of the power supply, wrap your fingers around the coil by following the wires (go over or under the core depending on the relative position of the wire to the power supply)
- Your thumb points north.

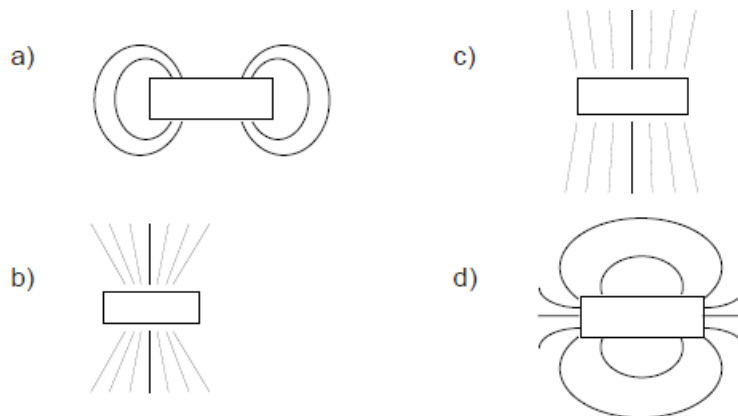
Note: Before using the right hand rule, YOU MUST DROP YOUR PENCIL IF YOU ARE RIGHT HANDED! This will allow you to free this hand when applying the rule.

Questions

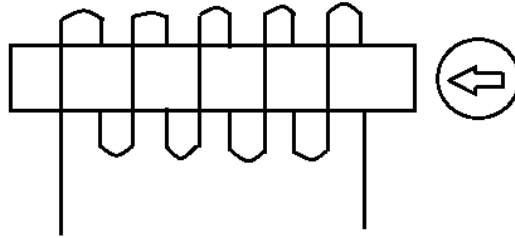
1. A compass is placed at one end of a solenoid. In which illustration is the compass needle pointing in the correct direction?



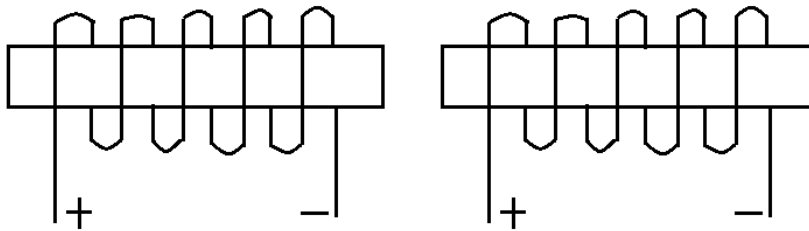
2. Which of the following correctly represents the shape of the magnetic field around a solenoid?



3. Determine the direction of the current of the wire shown below:

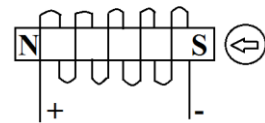


4. Determine whether the magnetic fields of the following two solenoids will appear to attract or repel.

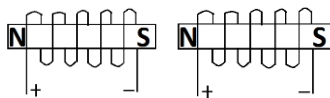


Answers

1. *D: We can determine that the solenoid will have its north end on the left and south end on the right. We can therefore conclude that the compass' north end will be attracted to the south side of the solenoid.*
2. *D: The only diagram that resembles a bar magnet.*
- 3.



4. *The magnetic field of the two solenoids will look like to bar magnets that are attracting one another, North to South*



Electromagnetism: Magnetic Field of a Solenoid

I can name ways of changing the intensity of the magnetic field produced by a solenoid (nature of the core, intensity of the current, number of turns).

Explanation of Concepts

The intensity of the magnetic field produced by a solenoid is affected by these factors:

The Nature of the Core When a ferromagnetic core is inserted in the centre of a solenoid, the magnetic field of the solenoid is increased. A ferromagnetic material is a metal that is strongly attracted to magnets and can be magnetized. Iron, nickel, and cobalt are ferromagnetic materials.

- A solenoid with an iron core will have a stronger magnetic field than an equivalent solenoid with an aluminum core.

The Current Intensity, I , in the Coil of the Solenoid

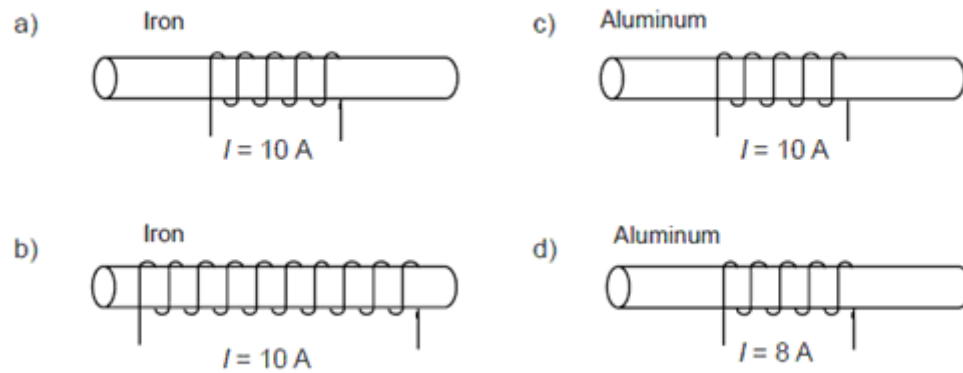
- As the current intensity increases, the intensity of the magnetic field increases.
- As the current intensity decreases, the intensity of the magnetic field decreases.

The Number of Turns (Loops) in the Solenoid

- When the number of loops on a solenoid is increased, the intensity of the magnetic field increases.
- When the number of loops on a solenoid is decreased, the intensity of the magnetic field decreases.

Questions

1. The electromagnets below produce magnetic fields of different intensities. Which electromagnet produces the strongest field?



Answers

1. *B: This solenoid has the greatest number of turns, the highest current intensity value and a ferromagnetic core.*

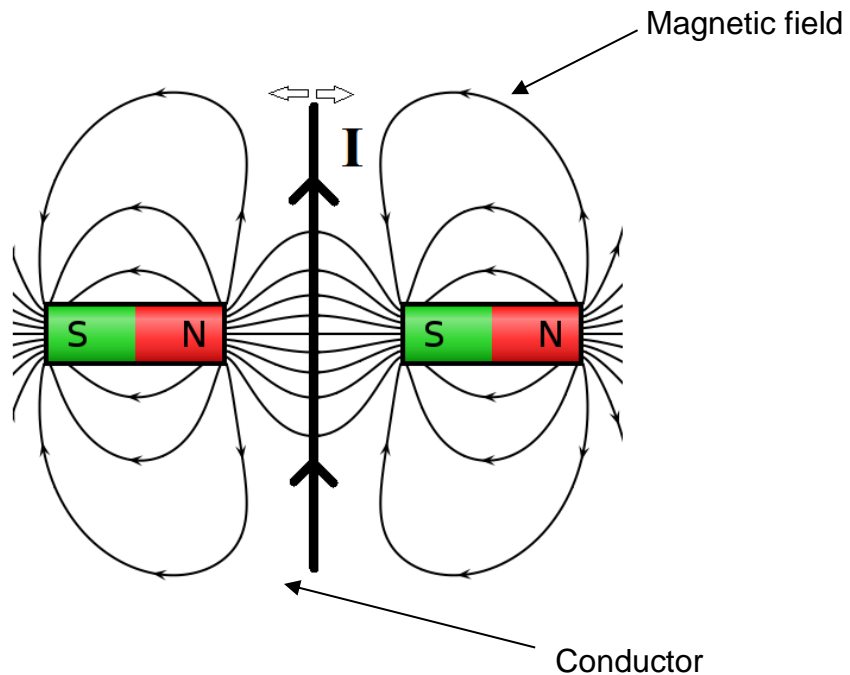
Electromagnetism: Electromagnetic Induction

I can describe ways of inducing electrical current in a wire.

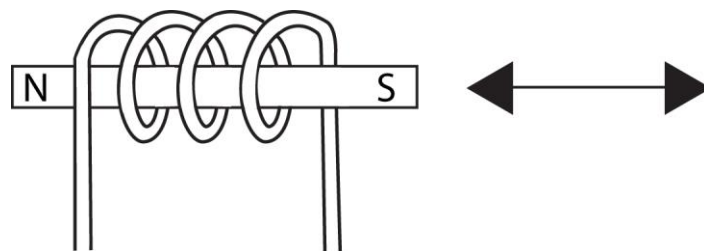
Explanation of Concepts

There are two ways in which an electric current can be generated from a magnetic field:

Move a Conductive Material within a Magnetic Field



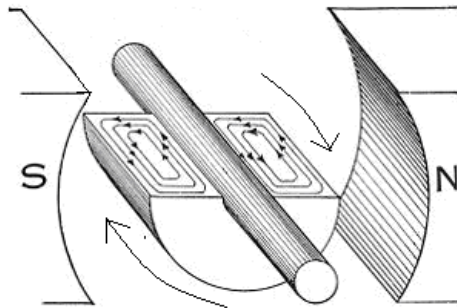
Move a Magnet inside a Coiled Conductive Material



Questions

1. Which of the following conditions is not necessary to increase the current intensity generated by an electromagnetic generator?
 - A) A highly conductive core.
 - B) A strong magnetic field.
 - C) Many loops of the coiled wire.
 - D) Very fast moving magnet within magnetic field.

2. A generator is used to transform mechanical energy into electrical energy. The following image shows a generator's rotor:



Explain how the generator generates electrical energy.

Answers

1. *A: Magnetic induction requires the core to be a magnet, not a conductive substance.*
2. *This electric generator works when the permanent magnet is moved relative to the coiled wires, a conductive material. The motion of the magnets relative to the coils will generate an electric current. This means that the mechanical energy will transform into electric energy.*

Transformation of Energy: Law of Conservation of Energy

I can explain the law of conservation of energy.

I can apply the law of conservation of energy in different situations.

Explanation of Concepts

The law of conservation of energy states that energy can neither be created nor destroyed, but it can be transferred or transformed from one form to another.

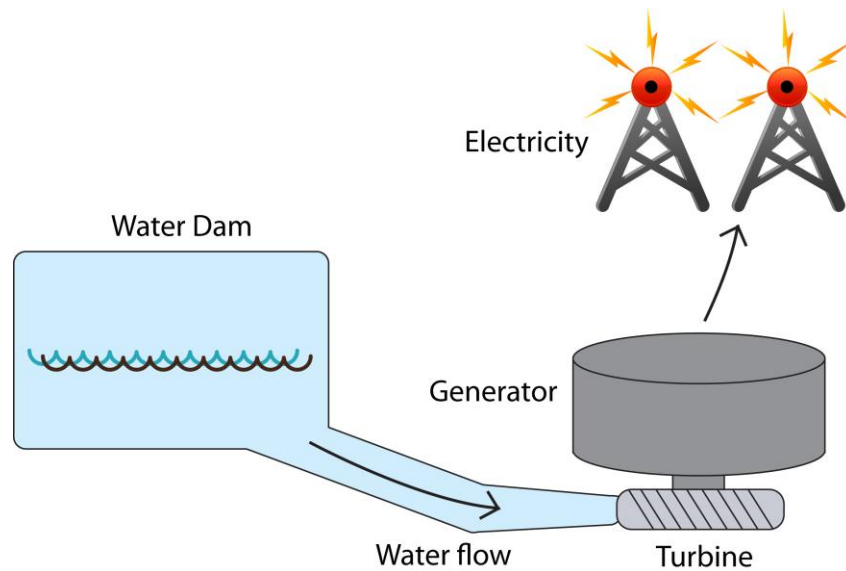
In an isolated system, the total amount of energy remains constant.

Energy may have the appearance of being “lost” but in reality the energy is transformed to heat, light, or other forms of energy.

Questions

1. 30 Joules of energy enter a light bulb. 20 joules of energy are transformed into light, how much energy is dissipated as heat?
 - A) 6.7 joules
 - B) 10 joules
 - C) 13 joules
 - D) 100 joules

2. A simple diagram of a Hydro-Electric System is shown below.



Describe why all the energy from the water flowing into the turbine is not transformed into electrical energy.

Answers

1. *B*
2. *The water travels along the following path: It flows into the turbine which turns causing the generator to produce electricity which is then transferred along power lines. Due to this long process, not all the water's energy will be converted into electricity. Some will be lost in the process.*

Transformation of Energy: Energy Efficiency

*I can define **energy efficiency** of a device or system as ‘**the proportion of energy consumed that is transformed into effective work**’.*

I can determine the energy efficiency of a device by using the formula

$$\text{Energy Efficiency} = \frac{\text{amount of useful energy}}{\text{amount of energy consumed}} \times 100.$$

Explanation of Concepts

Machines cannot convert all of the energy they use into a useful form. Some is changed into another form or released as heat in the environment.

The energy efficiency of a machine is the percentage of energy consumed by the machine or device that is transformed into useful energy.

$$\text{Energy Efficiency (\%)} = \frac{\text{Amount of Useful Energy (J)}}{\text{Amount of Energy consumed (J)}} \times 100$$

The amount of useful energy is the energy that the machine actually uses to perform its intended task.

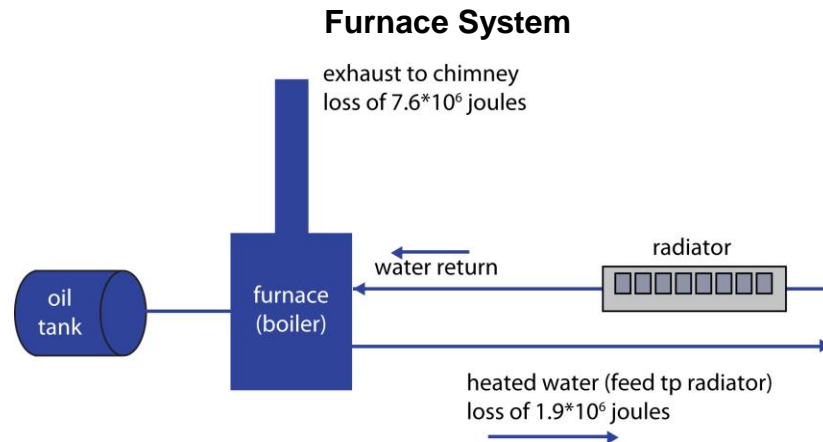
The amount of energy consumed is the total amount of energy that the machine uses.

Questions

1. A kettle consumes 15 500 J of energy to boil water. It is 85 % efficient. How much energy was used by the kettle to boil water?
 - A) 182 J
 - B) 13 175 J
 - C) 18 235 J
 - D) 1 317 500 J

2. Some homes are still heated by hot water boiler furnaces. The components of the system are an oil tank, a furnace, water pipes and radiators.

The furnace burns the oil from the storage tank. The heat released is used to heat water which is then pumped to radiators throughout the house. A diagram is shown below.



If all the heat from the combustion was used to heat the water, the system would be 100% efficient. However, some heat is lost in the furnace exhaust and some is lost from the pipes delivering the water to the radiators.

One litre of oil delivers 38 000 kJ of energy. 7 600 kJ are lost to the exhaust, and 1 900 kJ are lost in transporting the hot water to the radiators.

Determine the efficiency of this heating system

Answers

1. B

2.
$$\% \text{ Energy Efficiency} = \frac{\text{Amount of Useful Energy (J)}}{\text{Amount of Energy consumed (J)}} \times 100$$

$$\frac{85}{100} = \frac{\text{Amount of Useful Energy (J)}}{15\,500 \text{ J}}$$

$$\text{Amount of Useful Energy} = 13\,175 \text{ J}$$

$$\% \text{ Energy Efficiency} = \frac{\text{Amount of Useful Energy (J)}}{\text{Amount of Energy consumed (J)}} \times 100 \quad \%$$

$$\text{Amount of useful energy} = : 38\,000 - 7\,600 - 1\,900 \text{ kJ} = 28\,500 \text{ kJ}$$

(This is the energy used to heat the hot water. the total energy minus any energy that is "lost")

$$\% \text{ Energy Efficiency} = \frac{28\,500 \text{ kJ}}{38\,000 \text{ kJ}} \times 100$$

$$\% \text{ Energy Efficiency} = 75\%$$

Transformation of Energy: Energy Efficiency

I can explain how to improve the energy efficiency of an electrical appliance.

Explanation of Concepts

Measures can be taken to minimize the amount of energy “lost” in an electrical appliance. When the amount of energy that is “lost” as non useful forms of energy is reduced, then the energy efficiency is increased.

Examples:

- Replacing incandescent light bulbs with energy efficient light bulbs
- A cell phone’s screen goes to “sleep” when not in use

Questions

1. An electrician installs patio lights in a back yard. Which of the following will increase the efficiency of the wiring system to the back yard?

1. Bury the extension cord deep underground.
2. Use a shorter extension cord.
3. Use a longer extension cord.
4. Use compact fluorescent patio lights

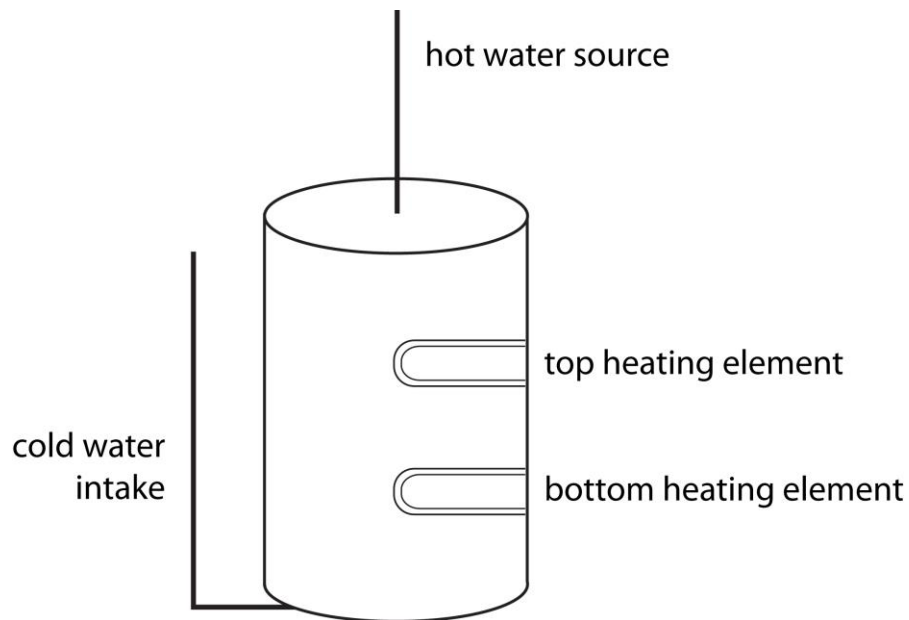
A) 1 and 2

B) 1 and 3

C) 2 and 4

D) 3 and 4

2. The following is a schematic of an electric hot water heater that we find in most of our homes. (cannot change diagram)



A cold water pipe intake fills the tank, the electrical elements heat the water and then the water leaves the tank from the top pipe whenever we turn on a hot water faucet.

How can we prevent the heat loss from the hot water tank?

Answers

1. C
2. *Insulation can be placed around the tank to prevent heat leakage from the tank. The water intake pipe can be insulated. The hot water pipe leaving the tank can be insulated.*

Fluids: Archimedes' Principle

I can describe the relationship between the weight of the water displaced by an immersed body and the upward acting force.

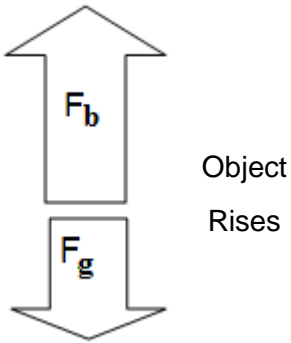
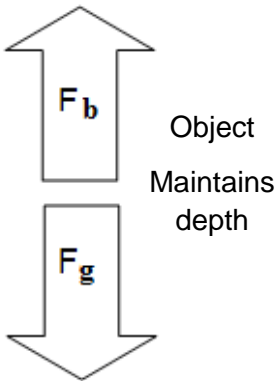
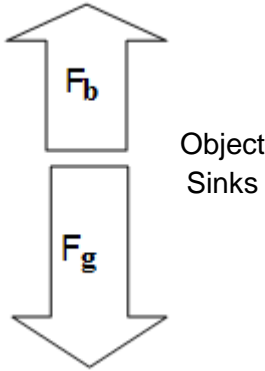
I can explain the buoyancy of a body in terms of Archimedes' principle.

Explanation of Concepts

When an object is immersed in water, it is subjected to two forces: The weight of the object pulling it downward (F_g) and the buoyant force pushing it upward (F_b).

Archimedes principle states that the weight of the water displaced by the object is equal to the buoyant force acting on that object.

The buoyancy of an object in water can be determined as follows:

F_b is greater than F_g	F_b is equal to F_g	F_b is less than F_g
		
<ul style="list-style-type: none"> • There is an upward resultant force • The object will rise to the surface 	<ul style="list-style-type: none"> • The resultant force is 0 • The object will maintain the same depth in the water 	<ul style="list-style-type: none"> • There is a downward resultant force • The object will sink to the bottom

3Questions

1. In which of the following conditions will a toy boat sink?

A) $F_g = 5 \text{ N}$

$F_b = 10 \text{ N}$

B) $F_g = 5 \text{ N}$

$F_b = 5 \text{ N}$

C) $F_g = 10 \text{ N}$

$F_b = 15 \text{ N}$

D) $F_g = 10 \text{ N}$

$F_b = 5 \text{ N}$

2. A toy submarine with a weight of 10 N is placed in the bathtub.

What weight of water must be displaced for the toy submarine to float? Explain your answer.

3. A scuba diver wants explore the bottom of a reef, but he is not able to dive more than 1 meter below the water surface. Use Archimedes principle to explain what the diver must modify in order to be able to dive deeper below the surface of the water.

Answer:

1. *D: The gravitational force is greater than the buoyant force $F_g > F_b$*
2. *Any value greater than 10 N of water. In order to float, the buoyant force must be greater than the force due to gravity. Archimedes principle states that the buoyant force is equal to the weight of the water displaced.*
3. *The diver does not have enough gravitational force to overcome the buoyant force of the water. By adding more mass to the diver's equipment, the gravitational force exerted by the diver will be greater than the buoyant force of the water.*

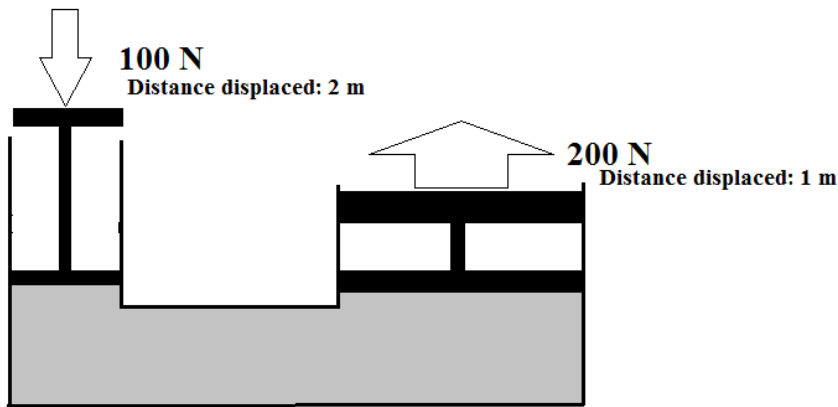
Fluids: Pascal's Law

I can recognize technical objects or technological systems whose operation is based on Pascal's principle.

Explanation of Concepts

Pascal's principle states that when pressure is increased in a closed system, it is distributed equally inside that system. Hydraulic systems are good examples of this concept.

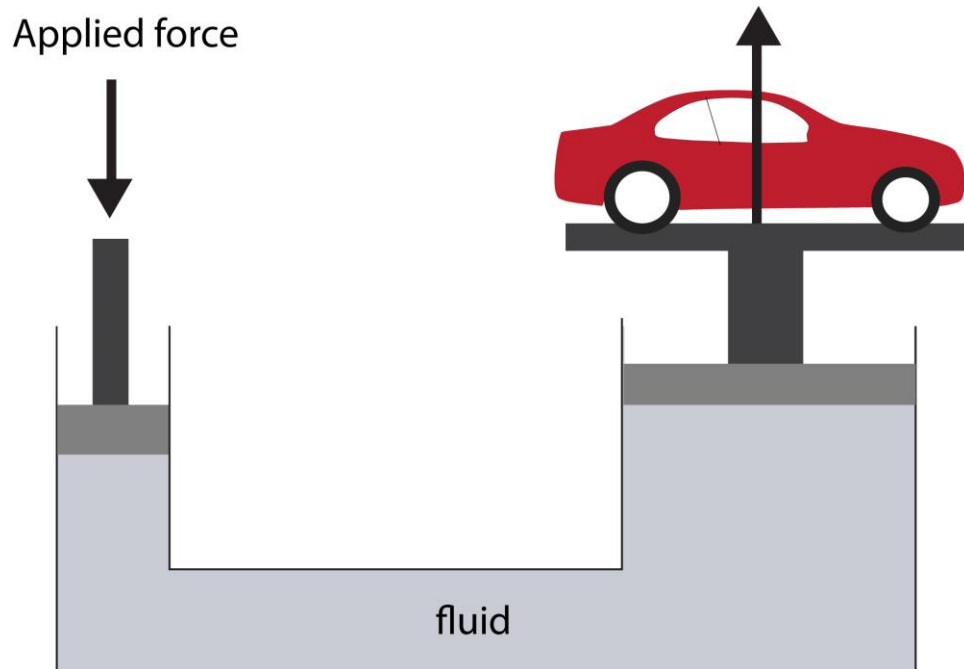
In a hydraulic system, the initial pressure applied on the first piston is distributed equally inside the closed system. The pressure is therefore distributed to all the components of the system, including the second piston, causing it to rise.



Questions

1. Which of the following technological objects or systems involves Pascal's principle?
 - A) Water is released from a submarine ballast tank and the submarine rises
 - B) A Tire Pressure gauge is attached to a valve of a tire and the pin is forced outwards.
 - C) A boat floats on the water
 - D) A paraglider in the air.

2. The following image represents a hydraulic car lift system.



Using your knowledge of Pascal's principle, explain how the pressure initially exerted by the mechanic can lift up a car.

Answers

1. *When the pressure of the tire is applied to the gauge, the pressure is distributed evenly throughout the gauge. The distribution of the pressure will force the pin outwards.*
2. *The mechanic exerts pressure that is transmitted to piston 1, then to the fluid, and finally to piston 2. This transmission of pressure happens because the hydraulic lift is a closed system, meaning that the pressure applied will be transmitted uniformly in all directions, without being lost. **The pressure is also increased because of the difference in the size of the pistons.** Please note that the last sentence is not a compulsory part of the answer.*

Fluids: Bernoulli's Principle

I can describe the relationship between the velocity of a fluid and its pressure.

I can explain the concept of lift in terms of Bernoulli's principle.

Explanation of Concepts

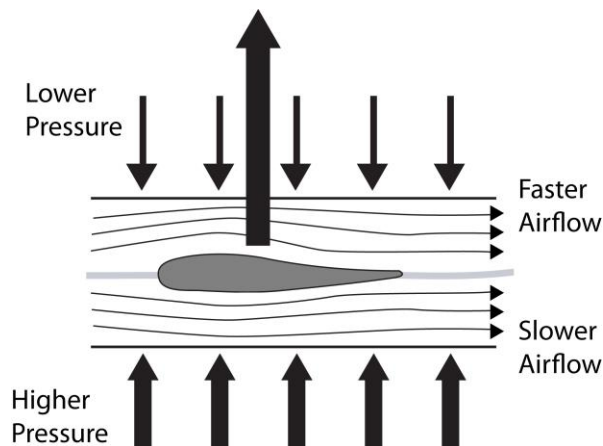
Bernoulli's Principle describes the relationship between the velocity of a fluid and its pressure.

Slower moving air allows for an accumulation of air particles, leading to an increase in air pressure.

Faster moving air allows for air particles to spread out, resulting in a decrease in pressure.

If there are faster moving air particles above an object (lower pressure) and slower moving air particles below an object (higher pressure), the difference in pressure will cause the object to be lifted upwards.

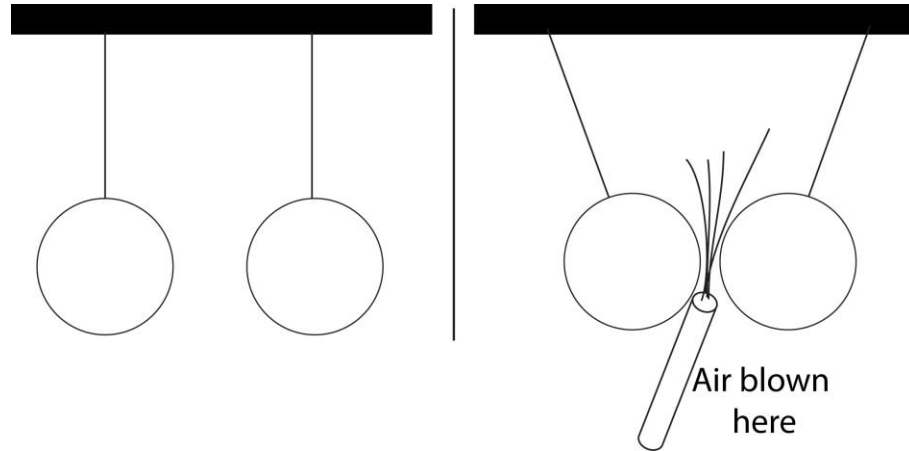
Bernoulli's Principle is the principle that allows wings to produce lift and planes and helicopters to fly. The shape of the wing forces the air to travel at different speeds. In general, the wing's upper surface is curved so that the air rushing over the top of the wing speeds up and stretches out to reach the other side of the wing at the same time as the air travelling under the wing. The air flowing below the wing moves in a straighter line, thus its speed and pressure remain about the same. Since high pressure always moves toward low pressure, the air below the wing pushes upward toward the air above the wing.



Questions

1. Two ping-pong balls are suspended from strings. A straw is used to blow some air between the two ping pong balls.

The situation is illustrated in the diagram below.



Which of the following best explains why the ping pong balls move closer together?

- A) The air pressure between the ping pong balls increased due to the decreased speed of air flow.
- B) The air pressure between the ping pong balls increased due to the increased speed of air flow.
- C) The air pressure between the ping pong balls decreased due to the decreased speed of air flow.
- D) The air pressure between the ping pong balls decreased due to the increased speed of air flow.

Answers

1. *D: When you blow air between the ping pong balls, you increase the speed of the particles, therefore lowering pressure.*

Force and Motion: Force

I can describe the effects produced by a force (change in the state of motion of a body, distortion of a body).

Explanation of Concepts

A **force** is a push or pull on an object. Forces are measured in Newtons (N).

When a force is applied to an object, it can cause a **change** in the motion of the object. The object may accelerate, decelerate or deflect (change directions).

For example, consider an object with 10 N force acting on it:



Adding a force of 5 N in the same direction as an initial force of 10 N causes the object to accelerate.



Adding a force of 5 N in the opposite direction as an initial force of 10 N causes the object to decelerate.



Adding a force of 15 N in the opposite direction as an initial force of 10 N causes the object to change directions.



An object can also be deformed when it is subjected to a force. This occurs when the force causes a change in motion of only part of the object.

Questions

1. The following diagram shows what happens to a golf ball when it is struck by the player's golf club.



Explain the two effects that the force applied by the golf club has on the golf ball.

Answers

1. *The force exerted on the golf ball causes the ball to temporarily deform when it comes into contact with the golf club. The resulting force exerted on the golf ball changes the ball's motion. The ball accelerates, going from a resting position to movement.*

Force and Motion: Types of Forces

I can recognize different types of forces in technical objects or technological systems.

Explanation of Concepts

Many types of forces act on objects at any given time. Some of these forces are:

Gravitational Force:

- A force of attraction between two masses (objects).
- It increases when the mass of the object increases.
- It decreases when the distance between the two objects increases.
- Earth exerts a gravitational force on objects that cause them to accelerate towards the Earth at 9.8 m/s^2
- What goes up, must come down
- The Moon exerts a gravitational force on Earth that causes tides

Electromagnetic Force:

- The fundamental force that is associated with electric and magnetic fields
- It is responsible for atomic structure and chemical reactions,
- It is responsible for the attractive and repulsive forces associated with electrical charge and magnetism.

Friction Force:

- A type of electromagnetic force (also known as a contact force) that stops two objects from slipping past one another when they are in contact.

Nuclear Force:

- It is a force of attraction between the particles that make up the nucleus of an atom. It is the force keeps them together inside the nucleus.

Questions

1. A car is accelerating on a highway. Which force is not acting on the car as it accelerates on the highway?
 - A) Gravity
 - B) Electromagnetic
 - C) Tension
 - D) Friction

Answers

1. *D: Gravitational force is exerted by the Earth, electromagnetic forces and frictional forces act at the molecular level between the road and the tires.*

Force and Motion: Equilibrium of Two Forces

I can understand and describe conditions under which a body subjected to two forces can be in equilibrium.

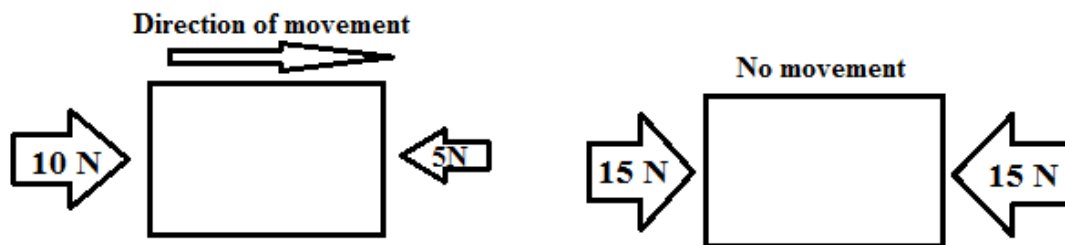
Explanation of Concepts

In most cases, many forces are acting on an object at any given time. The resultant force is the combination of all the forces acting on an object. An object is in equilibrium when the resultant force is zero.

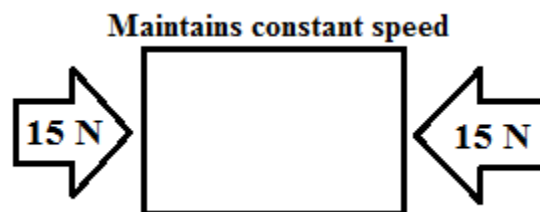
If an object at rest is in equilibrium, it will remain at rest.

If an object in motion is in equilibrium, it will continue moving at a constant speed.

Forces applied to an object at rest:

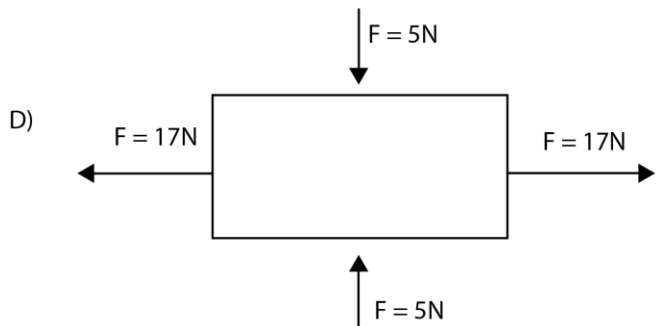
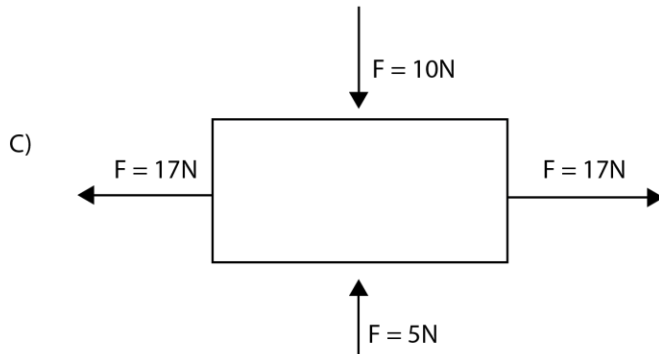
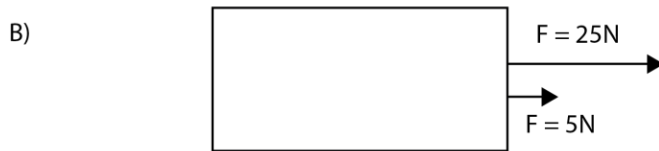
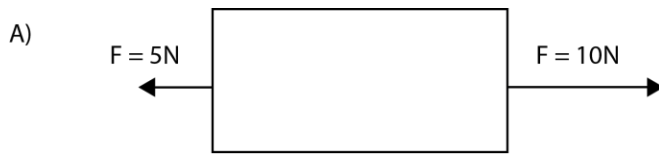


Forces applied to an object in motion at constant speed:



Questions

1. In which of the following situations is the box in equilibrium?



2. Tina is travelling on her bicycle at a constant speed of 50 km/h. What is the resultant force acting on Tina and her bicycle? Explain.

2.

Answers

1. *D: All forces that are opposite from one another have the same value and are pointing in opposite directions.*
2. *The resultant force is 0 N because Tina and her bicycle are in equilibrium. She is travelling at a constant speed.*

Force and Motion: Relationship between Constant Speed, Distance and Time

I can explain the relationship between speed, distance and time.

I can use the equation $v = d/\Delta t$ to calculate constant speed, distance and time.

Explanation of Concepts

An object's speed is its rate of motion. The speed is the distance that is traveled per unit of time.

If a car has a speed of 40 km/h, it means that in one hour, it travels 40 km.

Speed can be determined using the formula below:

$$v = \frac{d}{\Delta t}$$

where

v = speed (m/s or km/h)

d = distance (m or km)

Δt = change in time (s, h)

$$v = \frac{d}{\Delta t}$$

so

$$1\text{ km/h} = \frac{1\text{ km}}{1\text{ h}}$$

so

$$1\text{ m/s} = \frac{1\text{ m}}{1\text{ s}}$$

Example:

What is the speed of a runner who runs 96 m in 12 seconds?

$$v = \frac{d}{\Delta t}$$

$$v = \frac{96\text{ m}}{12\text{ s}}$$

$$v = 8\text{ m/s}$$

The runner's speed is 8 m/s.

Questions

1. A car is travelling at a speed of 110 km/h to get to the winter carnival in Quebec city. The trip takes 3.0 hours. How far is Quebec city from the departure location?
A) 0.030 km
B) 37 km
C) 330 km
D) 1188 km
2. Four race car drivers are competing for maximum speed achieved on a straight road. The results are shown in the following table:

Race Results

Driver	Distance Travelled	Elapsed Time
1	27 km	5.0 minutes
2	40000 m	0.13 h
3	60 km	20 minutes
4	81 000 m	0.25 h

Which driver is the winner by having attained the highest average speed? Show your calculations.

Answers

1. C

$$d = v \times \Delta t$$

$$v = 110 \text{ km/h} \times 3.0 \text{ h}$$

$$v = 330 \text{ km}$$

2. Driver 1

Driver 1:

$$5/60 = 0.083 \text{ h}$$

$$V = d/\Delta t$$

$$V = 27\text{km}/0.083\text{h}$$

$$V = 330 \text{ km/h}$$

Driver 2:

$$40,000 / 1000 = 40 \text{ km}$$

$$V = d/\Delta t$$

$$V = 40\text{km}/0.13\text{h}$$

$$V = 310 \text{ km/h}$$

Driver 3:

$$20/60 = 0.33 \text{ h}$$

$$V = d/\Delta t$$

$$V = 60 \text{ km}/0.33\text{h}$$

$$V = 180 \text{ km/h}$$

Driver 4:

$$81000\text{m} / 1000 = 81.25\text{km}$$

$$V = d/\Delta t$$

$$V = 81.25\text{km}/0.25\text{h}$$

$$V = 320 \text{ km/h}$$

Force and Motion: Distinction between Mass and Weight

I can explain the relationship between mass and weight.

I can use the equation $F_g = mg$ to calculate mass and weight.

Explanation of Concepts

Mass

An object's mass represents the amount of matter it contains. It is measured in kilograms (kg).

Weight

An object's weight represents the gravitational force acting on it. It is measured in Newtons (N). The weight of an object depends on an object's mass.

The weight of an object can change if the gravitational force changes.

The weight of an object can be found using the following mathematical formula:

$$F_g = m g$$

where

F_g = gravitational force or weight (N)

m = mass (kg)

g = intensity of gravitational field (N/kg or m/s^2)
(acceleration due to gravity)

Note:

- The intensity of the gravitational force on Earth is always equal to 9.8 N/kg (or m/s^2).
- The gravitational force between two objects depends on their masses and the distance between them.
- Since the intensity of the gravitational field depends on its mass, "g" is different for other planets or the moon.

Questions

1. Consider the following statements:

1. Measures the amount of matter in an object
2. Is measured in Newtons
3. Is not a force
4. Remains constant regardless of location
5. Measures the force of gravity on an object

Which statements refer to the measurement of mass?

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

2. Luca has a mass of 63.6 kg. What is Luca's weight on the moon given that the gravitational acceleration of the moon is 1.67 N/kg?

- A) 106 N
B) 106 kg
C) 63.6 kg
D) 63.6 N

3. A robot was designed by NASA to explore three planets. Its function was to land on each planet and to perform tests with dynamometers (spring scales). The data collected was used to confirm the gravitational fields of those planets.

The following information was recorded:

Planet	Gravitational Force Acting on Object (N)	Mass of object (kg)
Planet 1	10.98	3.0
Planet 2	16.74	4.5
Planet 3	60.34	7.0

Unfortunately, the planets' names were missing from the data gathered. Based on the data above and the table below, identify each unknown planet. Show your work.

Planets' Gravitational Fields

Planet	Intensity of Gravitational Field (N/kg)
Saturn	11.27
Mercury	3.63
Venus	8.62
Neptune	11.56
Mars	3.72

Answers

- D
- A: $F_g = m g = 63.6 \text{ kg} \times 1.67 \text{ N/kg}$
-

Planet 1	Planet 2	Planet 3
$F = mg$ $g = F/m$ $g = 10.89\text{N}/3.0 \text{ kg}$ $g = 3.6 \text{ N/kg}$ Planet 1 is Mercury	$F = mg$ $g = F/m$ $g = 16.74 \text{ N}/4.5 \text{ kg}$ $g = 3.7 \text{ N/kg}$ Planet 2 is Mars	$F = mg$ $g = F/m$ $g = 60.34 \text{ N}/7.0 \text{ kg}$ $g = 8.6 \text{ N/kg}$ Planet 3 is Venus

TECHNOLOGICAL WORLD

Graphical Language

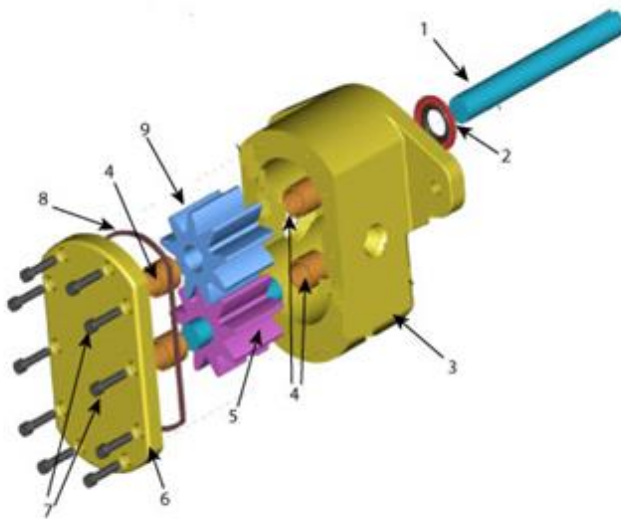
I can interpret an exploded view drawing of a technical object.

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









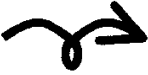
In the example above, the component labelled, “1” is the axle and there is one axle in the Gear Pump. The component labelled “7” is a bolt and there are 10 bolts in the gear pump.

Graphical Language

I can identify and use 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 <i>inertial</i> or <i>non-inertial reference system</i> .		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			

Graphical Language: Multiview Orthogonal Projection

I can draw a multiview orthogonal projection of a simple object.

Explanation of Concepts

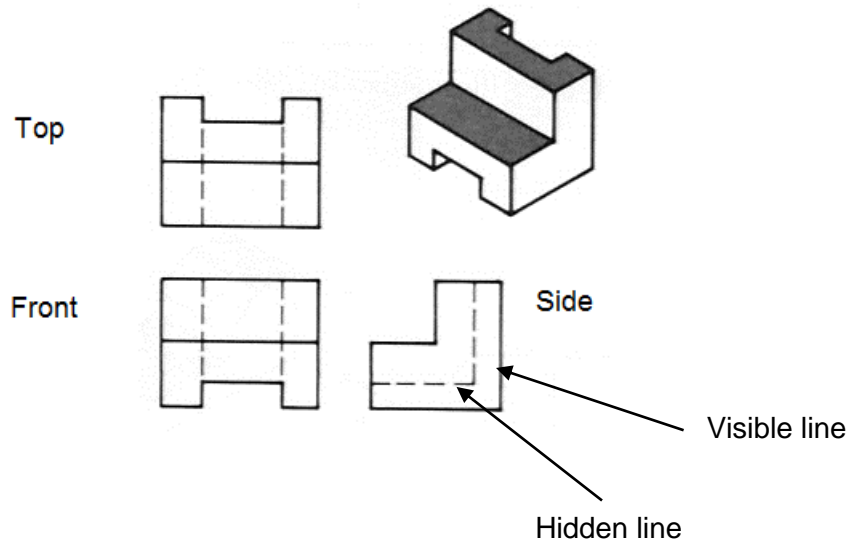
A **multiview orthogonal projection** is a type of technical drawing that shows multiple views of the same object (e.g. top, side and front).

The principal view or **front view** is the view that shows the most about the product. It is usually the longest view and shows the major shape or profile.

Visible lines are shown as solid lines and hidden lines are shown as dotted lines on the same view.

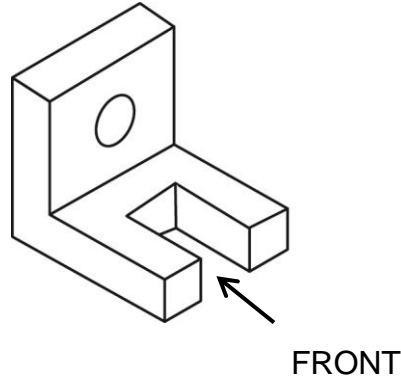
Example:

Multiview Orthogonal Projection of an Object

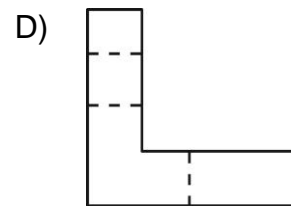
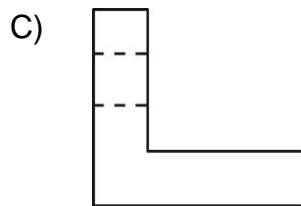
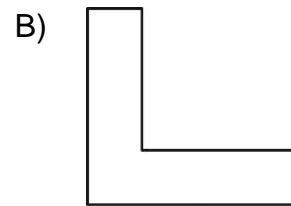
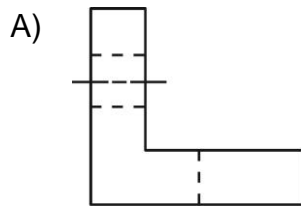


Questions

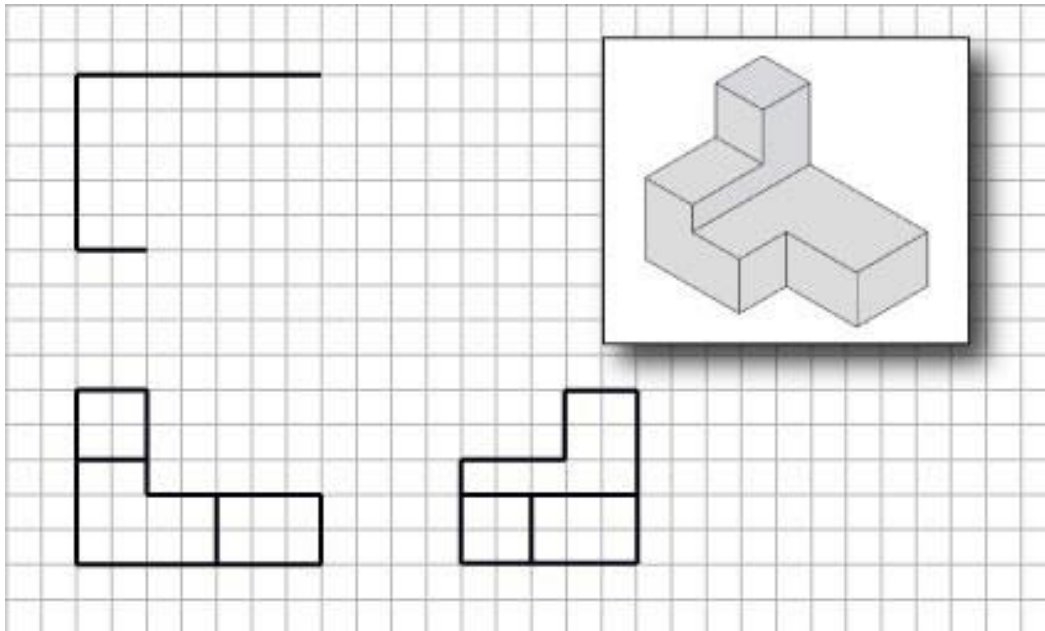
1. An isometric projection of a three-dimensional object is shown below.



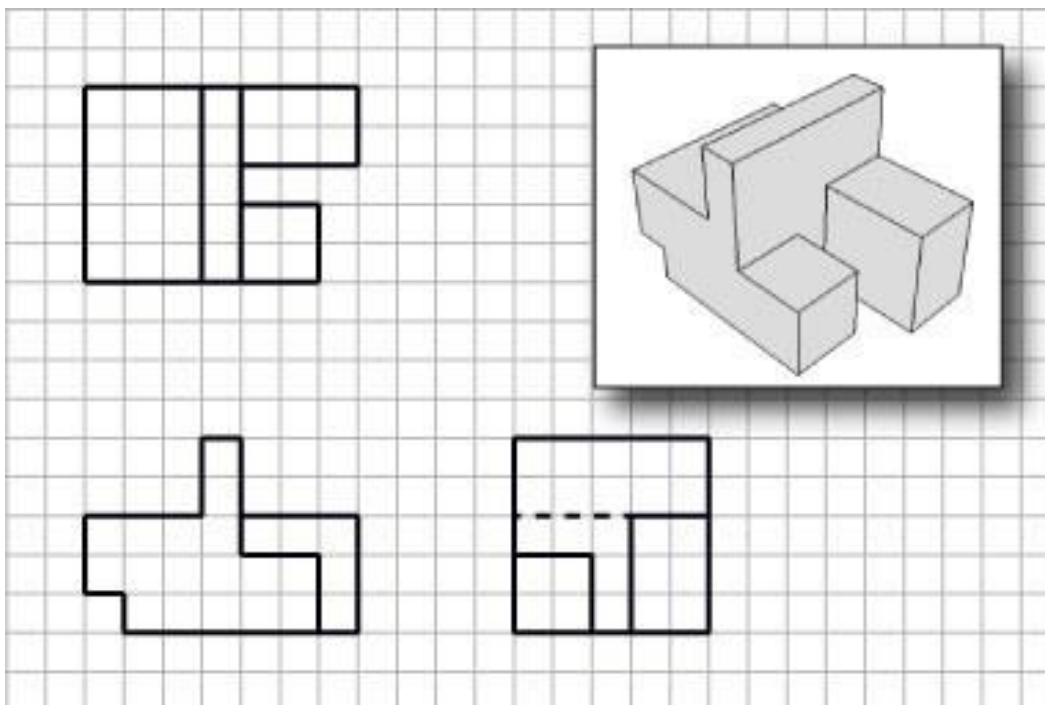
What is the correct SIDE view of the object?



- Complete the top view of the isometric projection by drawing the missing feature lines.



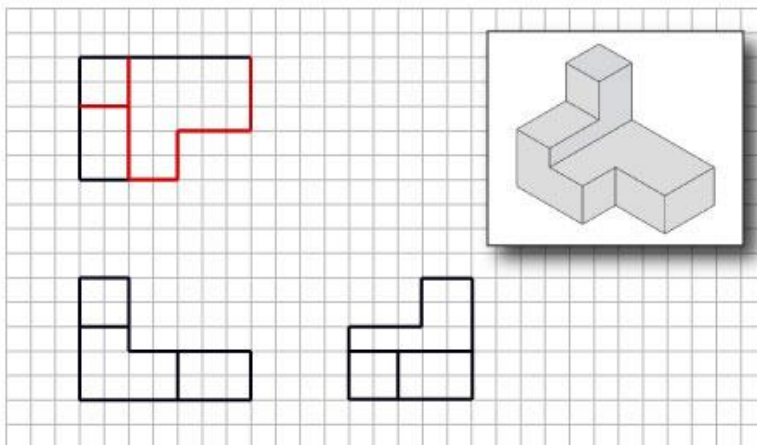
- Complete all three views of the isometric projection by drawing the missing hidden feature lines.



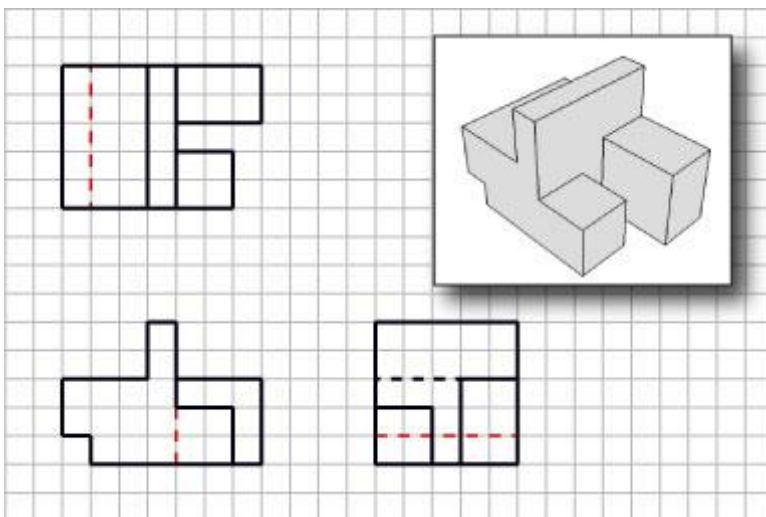
Answers

1. A

2.



3.



Graphical Language: Multiview Orthogonal Projection

I can interpret assembly drawings of technical objects consisting of a small number of parts.

An **assembly drawing** is a graphical representation of technical objects that have more than one component.

An **assembly drawing** includes details such as:

- a list of all the components and sub-assemblies
- the general arrangement of these components and sub-assemblies
- how these components and sub-assemblies fit together in the fully assembled object
- the overall dimensions
- how parts link together and/or what types of lubricant to use.

Assembly drawings do not contain enough information to manufacture the components but are intended to show how the manufactured components combine together to form the object.

The exploded view drawing on page 111 is an example of an assembly drawing.

Graphical Language: Functional Dimensioning

I can define functional dimensioning as 'the set of specific tolerances related to certain parts responsible for the smooth operation of an object'.

I understand that play is 'the space allowed between two parts to ensure that they can move freely'.

Explanation of Concepts

Tolerance is the amount of acceptable deviation from the precise dimension of a part.

Tolerance can have an upper (maximum) and lower (minimum) limit.

e.g., 4.27 ± 0.04 mm means the manufactured part can measure:

- A maximum of $4.27 + 0.04 = 4.31$ mm
- A minimum of $4.27 - 0.04 = 4.23$ mm

Sometimes the acceptable deviation above the dimension and the acceptable deviation below the dimension are different.

Examples of Functional Dimensioning

Functional Dimension (mm)	Maximum dimension of manufactured part (mm)	Minimum dimension of manufactured part (mm)
$32.5^{+0.1}$	32.6	32.5
$32.5_{-0.1}$	32.5	32.4
$32.5_{\pm 0.1}^{+0.3}$	32.8	32.4
32.5 ± 0.1	32.6	32.4

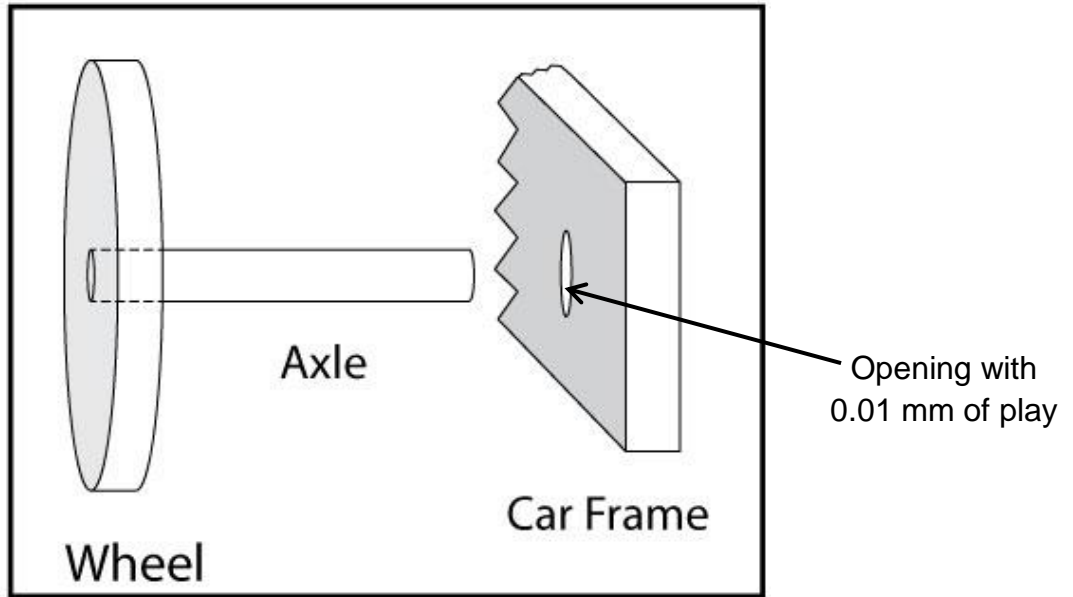
If tolerance is not respected, the components may not fit together when an object is assembled.

In order to have an object with moving parts, there needs to be room for movement. This bit of space that allows the components to fit or move properly is known as **play**. The need for **play** must be taken into account when designing an object.

The **functional dimensioning** includes the range of measurements that will ensure there is enough play so that the parts can move appropriately.

Questions

1. A diagram of a wheel axle and car frame is shown below.



Which set of dimensions will allow the axle to fit **into** the opening in the car frame?

	Diameter of Axle (mm)	Diameter of opening in Car Frame (mm)
A)	5.27 ± 0.03	5.26 ± 0.01
B)	5.26 ± 0.01	5.27 ± 0.03
C)	5.26 ± 0.01	5.29 ± 0.01
D)	5.27 ± 0.01	5.26 ± 0.03

Answers

1. C: Axle can be 5.25 mm to 5.27 mm and fit in an opening of 5.28 mm to 5.30 mm given a play of 0.01mm

Graphical Language: Developments

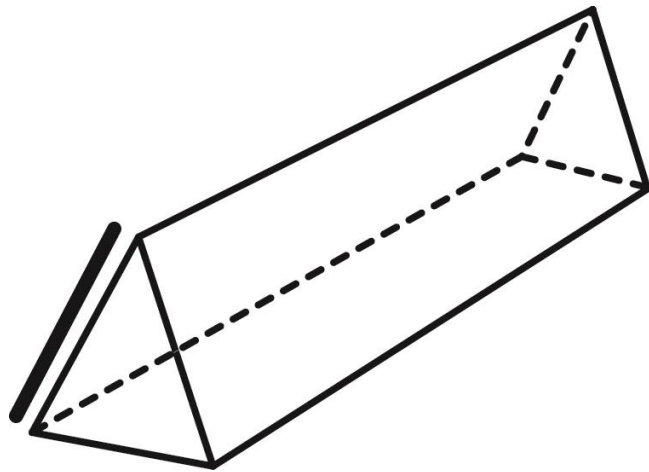
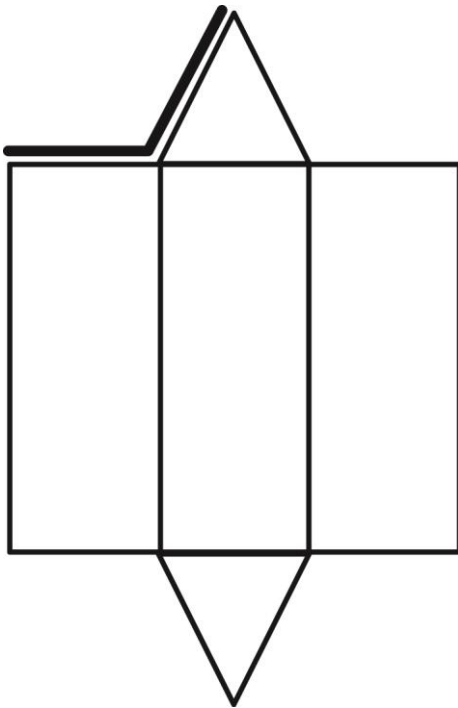
I understand how three-dimensional shapes (prism, cylinder, pyramid, cone) can be created from sheet stock.

Explanation of Concepts

Many objects are fabricated from sheets of plastic or metal and, with some folding, become three dimensional objects. The unfolded 3D object is called the '**development**' or in mathematics, the 'net'.

When visualizing an object from its development/net, it is important to remember that separated, nearby edges usually join.

Example:

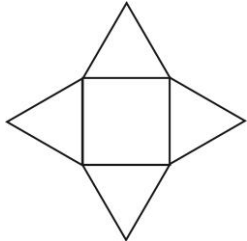
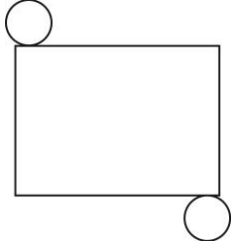
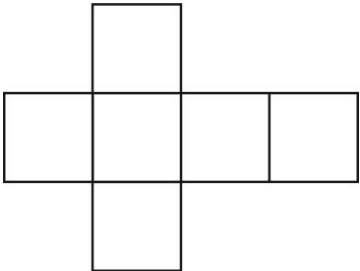
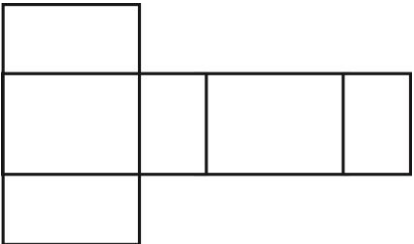


Graphical Language: Developments

I can draw developments of simple solids.

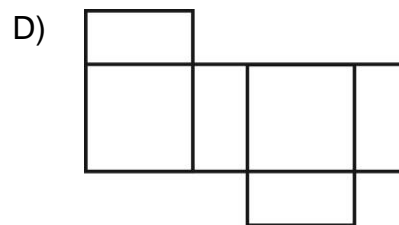
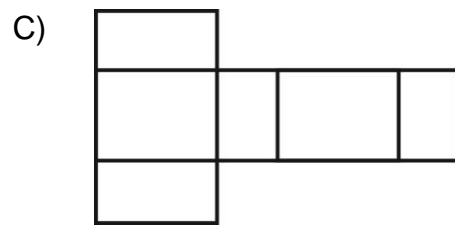
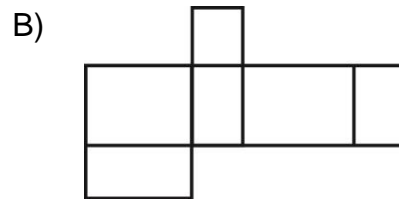
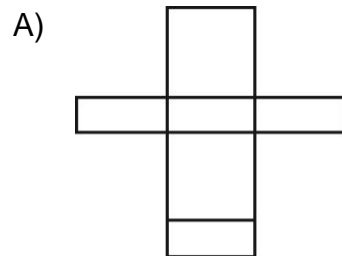
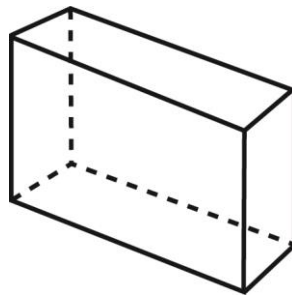
Explanation of Concepts

Developments of Simple Solids

Solid	Example of Development
Pyramid	
Cylinder	
Cube	
Rectangular Prism	

Questions

1. Which one of the following developments does not represent this figure?



2. Why is a development helpful in the design and building of a technical object?

Answers

1. B
2. A development/net is useful because it shows how to manufacture a 3D object from a flat material (e.g. sheets) by folding.

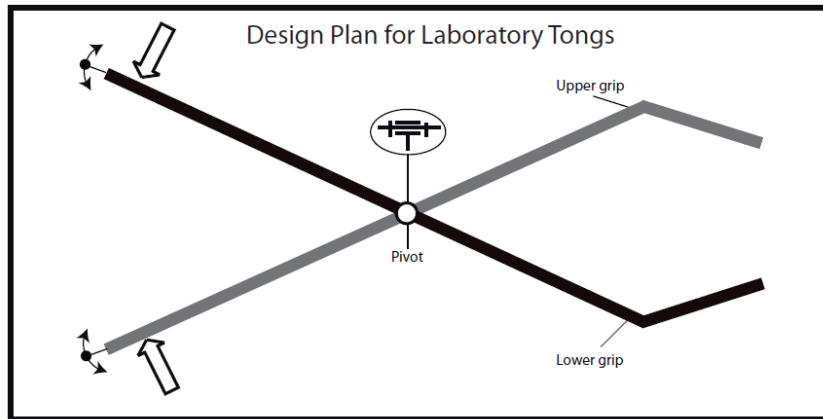
Graphical Language: Standards and Representations

I can choose the appropriate type of diagram for a given representation.

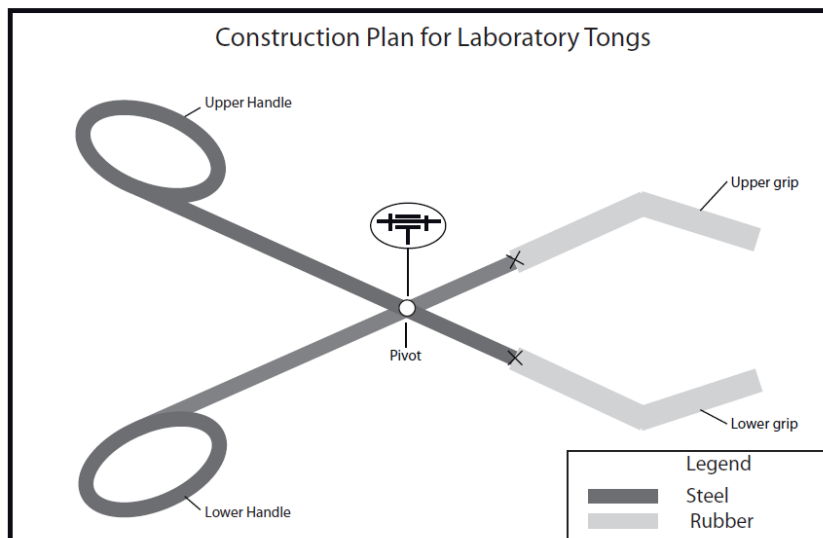
Explanation of Concepts

Depending on the purpose of the representation, the following types of diagrams can be used to represent a technical object.

Diagram of principle (design plan): focuses on the **forces** applied to the object and the resulting **motion** of parts of an object



Construction diagram: focuses on specific **building information** for an object







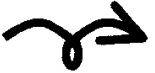
Graphical Language: Standards and Representations

I can represent different types of motion related to the operation of an object using the appropriate symbols (rectilinear translation, rotation, helical).

Explanation of Concepts

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*.

Motion Symbols

Rectilinear translation in one direction	
Rectilinear translation in two directions	
Rotation in one direction	
Rotation in two directions	
Helical	

Mechanical Engineering: Adhesion and Friction of Parts

I can describe the advantages/ disadvantages of the adhesion and friction of parts in a technical object.

Explanation of Concepts

Adhesion occurs when two surfaces can remain in contact with each other without slipping e.g. the tires of a car adhere to the road.

Friction is a force that acts in the opposite direction to movement. Friction resists the slipping of one surface moving over another.

Advantage of adhesion and friction: controlling motion. e.g. When the brakes are applied on a bicycle, the friction between the brake pads and the wheel, slows the motion of the wheel.

Disadvantages of adhesion and friction: wearing down of parts of an object and production of unwanted heat. e.g. Friction occurs between the moving parts of a car engine. The friction is reduced by adding a lubricant such as oil. Nonetheless, the car engine does heat up with use.

Factors that affect the amount of adhesion and friction between two surfaces:

- The amount of surface area in contact
- The nature of the material (e.g. Teflon can be used to coat a pan so food does not stick, tires are made from rubber so they adhere to the road)
- Temperature (In general, the lower the temperature, the less adhesion)
- The texture of the surface (rough or smooth)
- The amount of perpendicular force applied to a surface area

Examples of Adhesion and Friction for a Bicycle

The rough surface of the pedal allows for **adhesion** between the shoe of the cyclist and the pedal



The **friction** between the chain and the sprocket may cause wearing of the parts over time. This can be reduced with proper cleaning and the use of a lubricant.



Images from:

1. <http://commons.wikimedia.org/wiki/File:13-01-06-fahrradkram-05.jpg> Retrieved November 2013
2. http://commons.wikimedia.org/wiki/File:Shimano_xt_rear_derailleur.jpg Retrieved November 2013

Questions

1. A bicyclist is planning a 100 km circuit. Which one of the following measures will increase the effort it takes to complete the circuit?

1. Increase the width of the tires
2. Add weight over the rear wheel
3. Slightly deflate the tires.

A) 1 and 2

B) 1 and 3

C) 2 and 3

D) 1, 2, and 3

2. Explain the advantages and disadvantages of replacing narrow racing tires on a bike with wider tires.

Answers

1. *D: Increasing the width of the tire (by deflation or other) and adding weight on the tire would increase the amount of friction thus, slowing the cyclist.*
2. *Wider tires would increase the amount of adhesion. This is an advantage since it will provide better traction (grip).*

Wider tires will increase the amount of friction. This can be a disadvantage since friction will cause the cyclist to use more energy. This can tire out the cyclist causing the cyclist to slow down.

Mechanical Engineering: Linking of Mechanical Parts

I can 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:

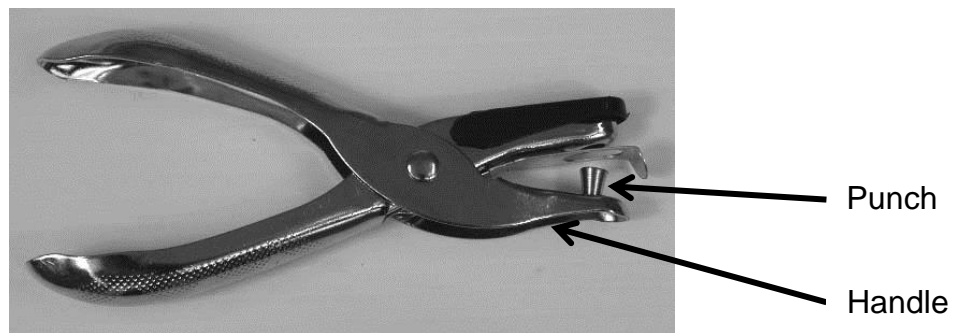
Direct two parts held together without a linking component	OR	Indirect a linking component is required to hold the two parts together
Rigid the linking component is not flexible	OR	Flexible the linking component can be deformed when used and has the ability to return to its initial position
Removable 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?	<i>Do the parts require something else to hold them together?</i> Yes → Indirect No → Direct
Rigid or flexible?	<i>Can the linking component be deformed when used and will it return to its initial position?</i> Yes → Flexible No → Rigid
Removable or permanent?	<i>Can the object be taken apart without causing damage to the object?</i> Yes → Removable No → Permanent
Complete or partial?	<i>Is movement possible between the two parts?</i> Yes → Partial No → Complete

Example:

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



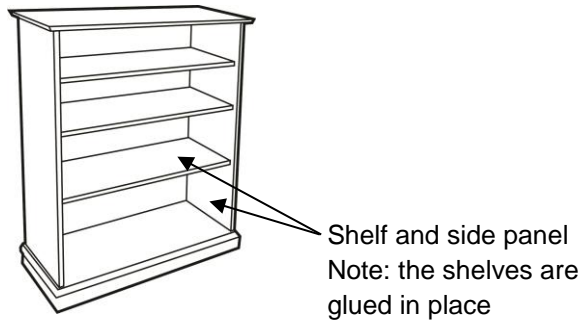
The characteristics of the link between the handle and the punch are:

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*

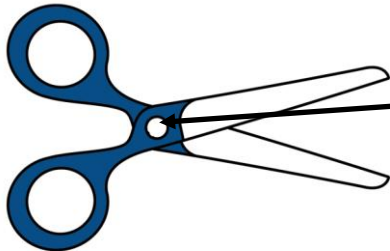
Mechanical Engineering: Linking of Mechanical Parts

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:

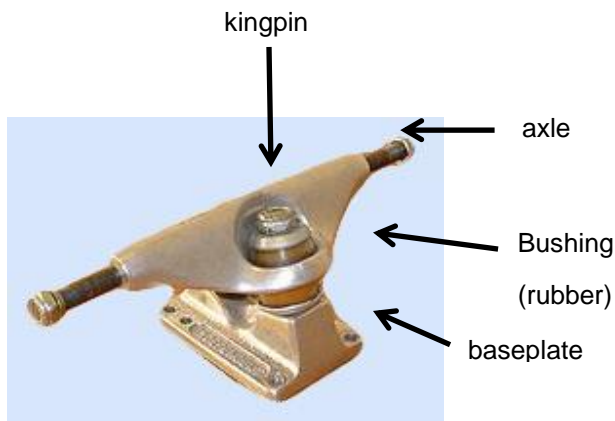


Image from:

<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 purpose of limiting motion (degrees of freedom) in a technical object.

Explanation of Concepts

The **degrees of freedom** of a part are the number of ways a part can move independently.

If an object could exist totally independent from any other object it would have 6 degrees of motion freedom, translation along 3 axes, and rotation around the same three axes.

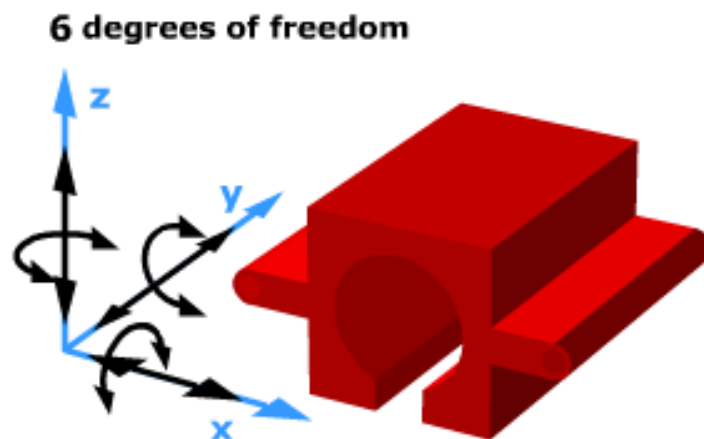


Image courtesy of the Science and Technology Implementation Committee (STIC)

When components are linked in a technical object, the independent motion of one part with respect to another is limited. The extent to which the motion of the components is limited depends on how the object needs to function.

Example:

The motion of a drawer in a filing cabinet is limited to translation along one axis. (1 degree of freedom) In order to function properly rotation or translation along other axes is limited.

Mechanical Engineering: Linking of Mechanical Parts

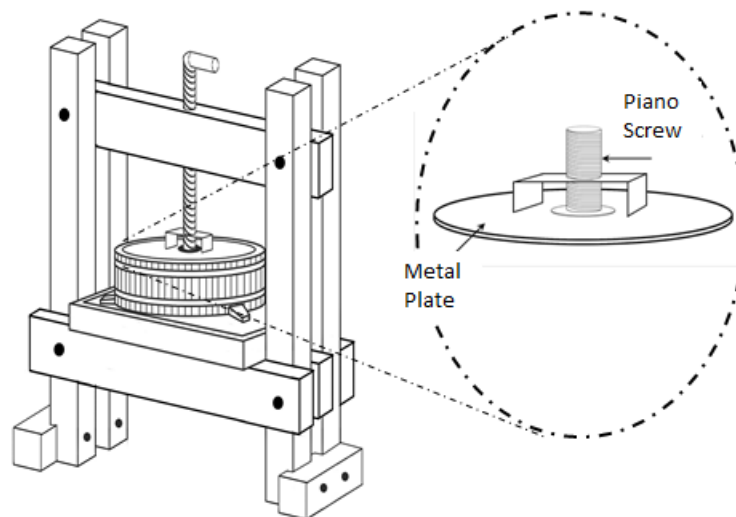
I can explain the choice of a type of link in a technical object.

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 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.



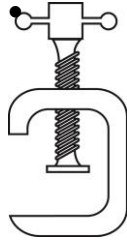
A track at the top and bottom of the window frame allows the translational guiding when the window is slid open.

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

2. 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.

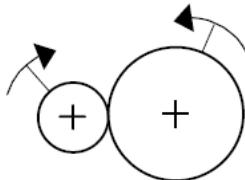
4. Determine whether the system is reversible.

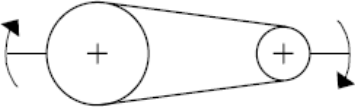
- A system is considered to be **reversible** if the driver component and the driven component can be interchanged and the system still functions. i.e. The driver can become the driven component and the driven component can become the driver
- A system is considered to be **irreversible** if the exchange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

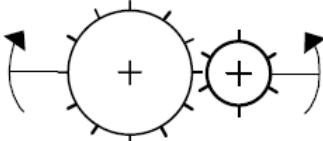
Mechanical Engineering: Motion Transmission Systems

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

Explanation of Concepts

Friction Gears	
Symbol	
Description	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Easy to assemble • Will allow slippage, protecting it from damage • Allow for transmission of motion over long distances e.g. ski lift
Disadvantages	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Will not allow slippage • Can be connected at various angles • Allows for large forces to be transmitted
Disadvantages	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Will not allow slippage • Allows for large forces to be transmitted
Disadvantages	<ul style="list-style-type: none"> • Needs lubrication

Wheel and Worm Gear	
Symbol	
Description	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Will not allow slippage • Allows for fine adjustment eg tuning pegs on a guitar
Disadvantages	<ul style="list-style-type: none"> • Needs lubrication

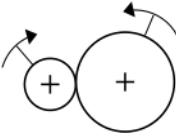
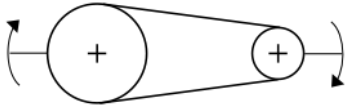
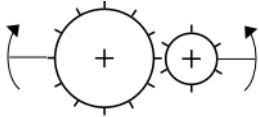
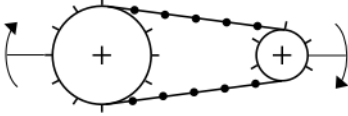
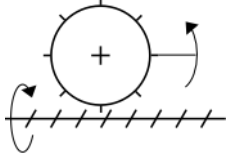
Symbols for mechanisms courtesy of Le Centre de Développement Pédagogique

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

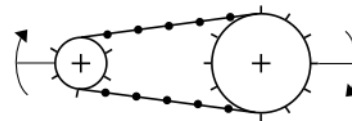
I can explain the choice of a motion transmission system in a technical object.

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.

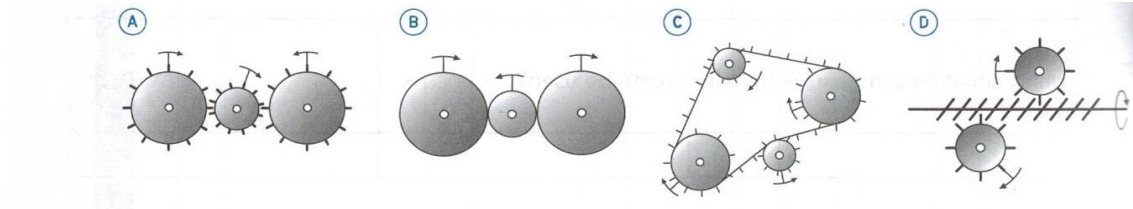
Example: Choice of Motion Transmission System for a Bicycle



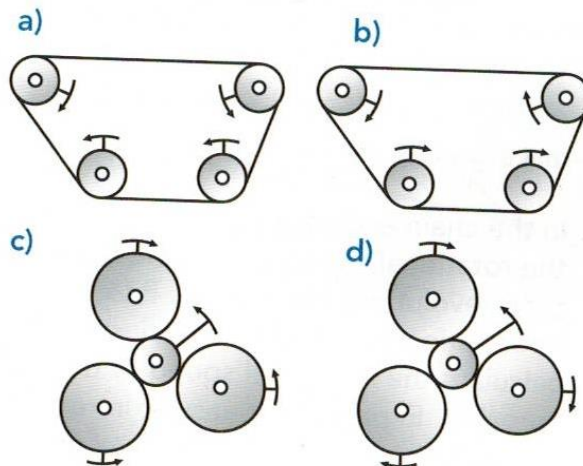
A person riding a bicycle is regularly exerting a force on the pedals which drive the sprocket wheel and chain.. Engineers have chosen a sprocket wheel and chain system because of this force. The teeth of the gears fit perfectly into the chain, allowing the chain to stay on the sprockets as the force 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

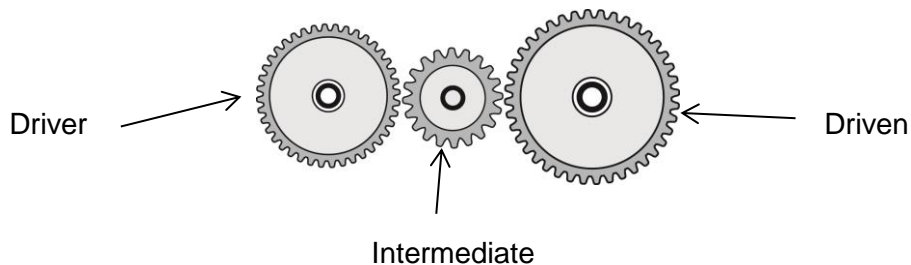
1. *B*
2. *C*
3. *The sprocket wheel and chain system does not permit slippage, therefore the forces applied to the pedals are transmitted to the back wheel*

Mechanical Engineering: Speed Changes

I can explain speed changes in a technical object.

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.

Intermediate 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 driver $>$ diameter of driven

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

e.g.



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

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

e.g.



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

- When the diameter of the driver component is equal to the diameter of the driven component, there is no speed change in the system.

e.g.



Speed Ratio

The **speed ratio** can be used to describe the speed change for a system.

$$\text{Speed ratio} = \frac{\text{diameter(or number of teeth) of driver component}}{\text{diameter(or number of teeth) of driven component}}$$

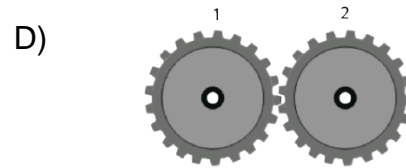
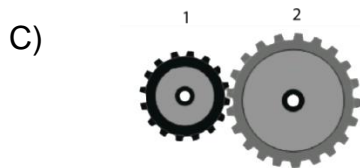
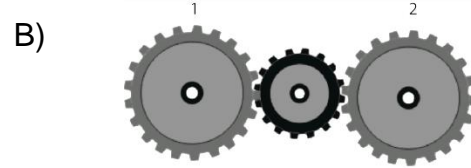
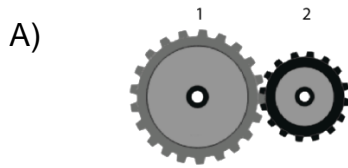
If the speed ratio = 1, then there is no change in speed.

If the speed ratio > 1, then there is an increase in speed

If the speed ratio is < 1, then there is a decrease in speed.

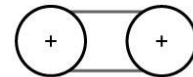
Questions

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

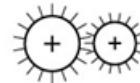


2. Which of the systems below could produce a change in speed similar to the one in a wheel and worm gear system?

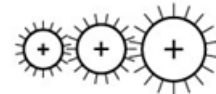
A) Two pulleys of equal size connected by a belt



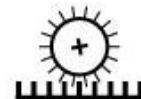
B) A large driver gear turns a smaller driven (receptor) gear



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.

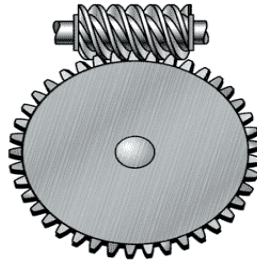
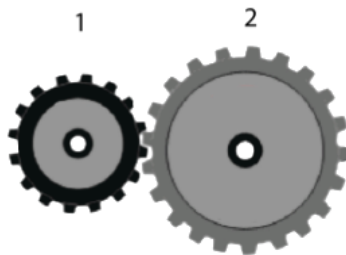


Image from: <http://www.machinerylubrication.com/Read/1080/worm-gears>

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?

4. A gear system is shown below.



Gear 1 is the driver gear and has a diameter of 8 cm. Gear 2 has a diameter of 10.5 cm.

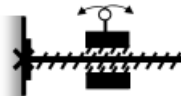

Which gear turns faster and what is the speed ratio for the system?

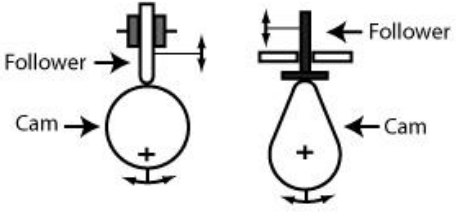
Answers

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.*
4. *Gear 1 turns faster and the speed change ratio is 0.76.*

Mechanical Engineering: Motion Transformation Systems

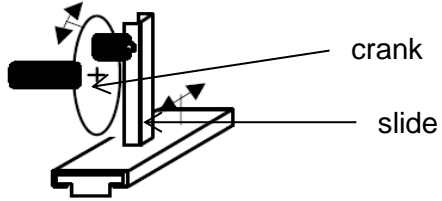
*I understand the construction and characteristics of the following **motion transformation systems**.*

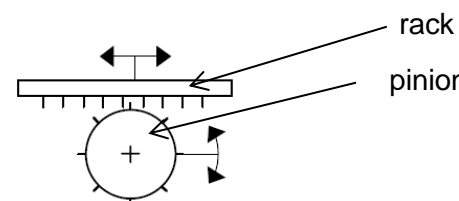
Screw Gear System	
Symbol	<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <p>Type 1</p>  <p>Nut is free component Screw is fixed component</p> </div> <div style="text-align: center;"> <p>Type 2</p>  <p>Screw is free component Nut is fixed component</p> </div> </div>
Description	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Allows for precise adjustment in its use. Used in many types of tools and machinery
Disadvantages	<ul style="list-style-type: none"> • Parts need to be lubricated

Cam and Follower	
Symbol	
Description	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Parts need to be lubricated • A return mechanism (e.g. spring, gravity) must be built into design

Connecting Rod and Crank	
Symbol	
Description	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Simple mechanism
Disadvantages	<ul style="list-style-type: none"> • Parts need to be lubricated

Rotating Slider Crank Mechanism	
Symbol	
Description	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Change motion from translational to rotational or vice versa
Disadvantages	<ul style="list-style-type: none"> • Parts need to be lubricated • Reversibility is only partial


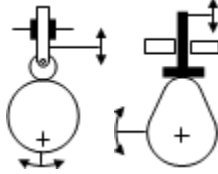
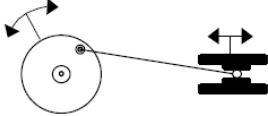
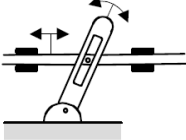
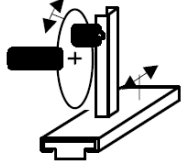
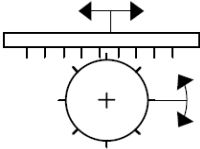
Rack and Pinion	
Symbol	
Description	<ul style="list-style-type: none"> • Rotational motion of pinion is transformed into translational motion of rack. • Translational motion can be applied to rack to produce rotational motion in the pinion • The rack is really a toothed gear wheel that has been straightened.
Reversibility	Yes because rotational motion can be applied to the pinion to produce translational motion in the rack and vice versa.
Advantages	<ul style="list-style-type: none"> • Allows force to be applied without slippage
Disadvantages	<ul style="list-style-type: none"> • 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?

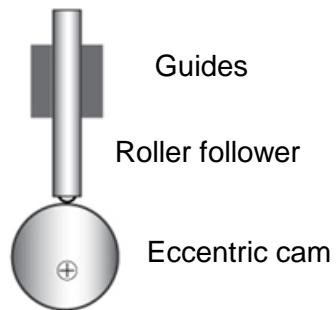


2. A student wishes to build a pull toy of a clown sitting in a cart in which a mechanism will cause the hat of the clown to move up and down as the cart is pulled.

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

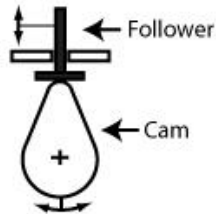
1. *D*
2. *C*
3. *Move the center of rotation closer to the outside of the cam. Increase the size of the cam.*

Mechanical Engineering: Motion Transformation Systems

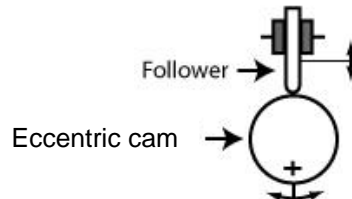
I can distinguish between cams and eccentric cams.

The most common type of **cam** is a rotating component with a curved outline or curved groove that is used to transform rotational motion into the translation motion of the follower or vice versa.

There is a great variety of cam shape. The motion of the follower depends on the shape of the cam.



An **eccentric cam** is a disc with the centre of rotation placed off-centre. As the eccentric cam rotates, the follower rises and falls.



Electrical Engineering: Power Supply

*I understand that a **power supply** has ‘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 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

2. 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

3. 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 °C
B	10 m	3 mm	20 °C
C	20 m	2 mm	20 °C
D	20 m	3 mm	25 °C

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: Conduction, Insulation and Protection

I can use the colour code to determine the electrical resistance of a resistor.

Explanation of Concepts

A **resistor** is a device that slows down the flow of an electric current in a circuit. The **resistance** of a resistor is measured in ohms (Ω).

The electrical resistance of a resistor is marked using a color code.

The colored bands on a resistor indicate the resistance of a resistor:

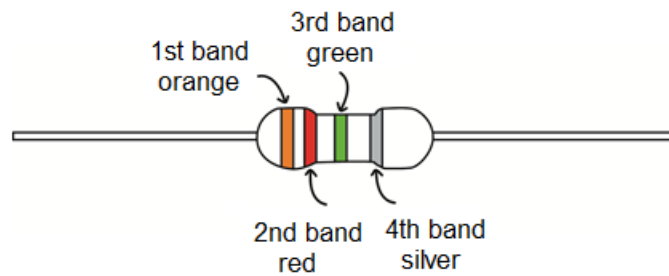
- The first band is associated with the first digit.
- The second band is associated with the second digit.
- The third band is associated with the multiplier (x 10x)
- The fourth band is associated with the tolerance (this is a percentage that is both added and subtracted to the entire value, therefore giving you a range of resistance).

Resistor Color Chart

Colour	Black	Brown	Red	Orange	Yellow	Green	Blue	Purple	Grey	White
Digit	0	1	2	3	4	5	6	7	8	9
Multiplier	10^0	10^1	10^2	10^3	10^4	10^5	10^6	10^7	10^8	10^9

Example:

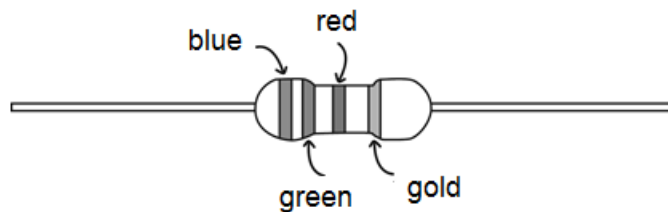
The resistance of the resistor shown below is $32 \times 10^5 \pm 10\% \Omega$.



- The first band is orange, so the first digit is 3
- The second band is red, so the second digit is 2
- The third band is green, so the multiplier is 10^5
- The last band is silver, so the range is $\pm 10\%$

Questions

1. Determine the resistance of the resistor below. Use the resistor color chart on the previous page.



Answers

1. $65 \times 10^2 \pm 5\% \Omega$

Electrical Engineering: Control



I can identify both unipolar and bipolar switches.

I can distinguish between unidirectional and bidirectional switches.

Explanation of Concepts

The function of a switch is to turn an electrical circuit on or off. Different types of switches exist.

Types of Switches

Switch	Symbol
Unipolar/unidirectional switch (single pole/single throw)	
Unipolar/bidirectional switch (single pole/double throw)	

A **unipolar** (single-pole) switch has one conductive bar and opens and closes one contact at a time.

A **unidirectional** (single-throw) switch is used in circuits where the current can follow only one path.

A **bidirectional** (double-throw) switch is used in circuits where the current can follow two paths.


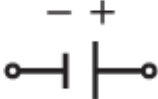

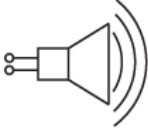
Electrical Engineering: Transformation of Energy

I can identify and explain the transformation of energy (electricity, light, heat, vibration, magnetism) in different components of a circuit.

Explanation of Concepts

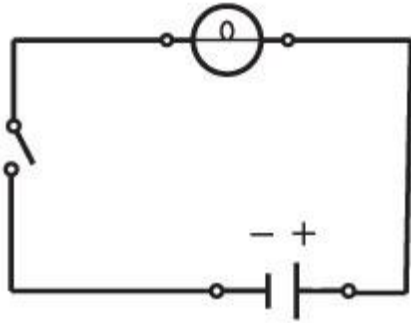
Electrical energy can be transformed into light energy, sound energy, mechanical energy or thermal energy.

Examples of Energy Transformations in Different Circuit Components

Component	Symbol	Transformation
Light Bulb		Electrical Energy → Light and heat
Battery		<p><u>In Use:</u> Chemical energy → Electrical energy and heat</p> <p><u>While being charged:</u> Electrical energy to chemical energy and heat</p>
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 (electricity, light, heat, vibration, magnetism) 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

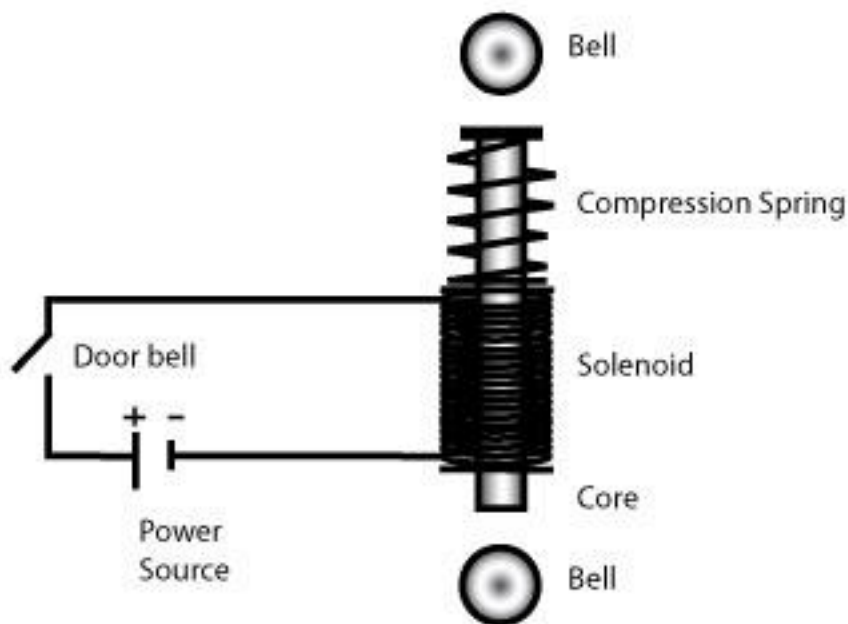
1. A fan is designed to transform electrical energy to:
 - A) Sound energy
 - B) Mechanical energy
 - C) Thermal energy
 - D) Light energy

2. 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.

3. 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		

4. A diagram of a doorbell is shown below.



Using the diagram above, explain the energy transformations that occur in between the doorbell being pushed and the doorbell sounding.

Answers

1. *B*
2. *A doorbell transfers electrical energy into sound energy. The light of the doorbell will transfer electrical energy to light energy.*
- 3.

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

4. *When the doorbell is pushed, the circuit is closed. The electrical energy of the circuit is transformed into magnetic energy in the solenoid. The magnetic energy is transformed into kinetic energy as the bar in the solenoid is attracted to the bell. The kinetic energy is then transformed into sound energy when the bar hits the bell.*

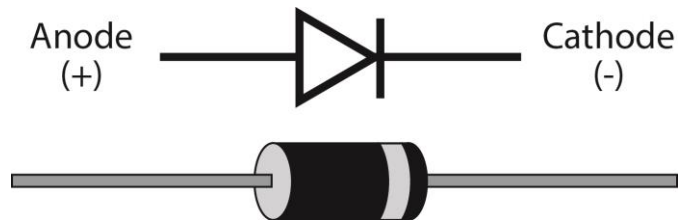
Electrical Engineering: Other Functions

*I can describe the function of a **diode**.*

Explanation of Concepts

A **diode** is an electronic component that only allows current to travel in one direction within a circuit.

The symbol for a diode and a drawing of a diode is shown below.



Light emitting diodes (LEDs) give off light when a current flows through them.

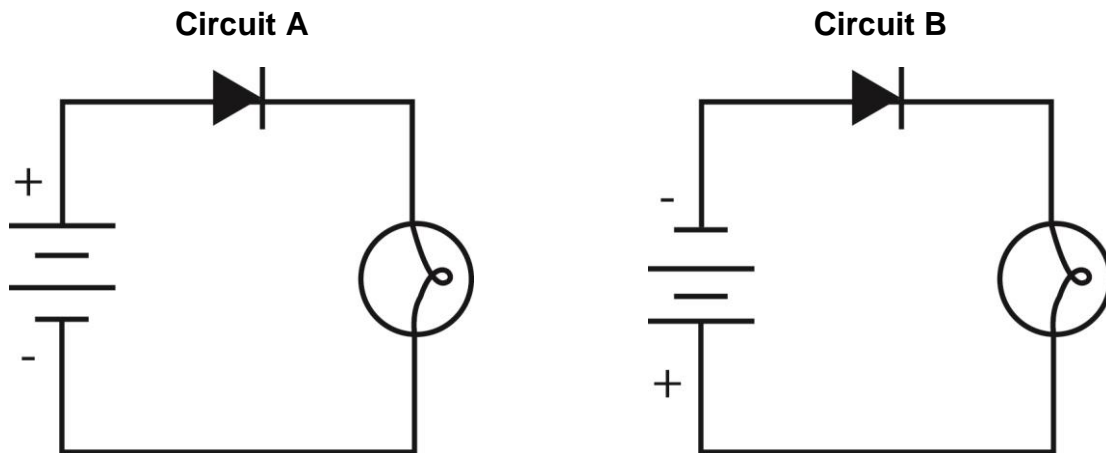
Questions

1. The circuit is designed so that electrons can only flow in one direction to prevent damage to the circuit.

Which electronic component makes this possible?

- A) A transistor
- B) A switch
- C) A fuse
- D) A diode

2. Two circuits containing a diode are shown below.



In which circuit(s) will the light bulb light up? Explain your answer.

Answers

1. D
2. *The light bulb will light up in Circuit A only. Current only flows in one direction through a diode. The current flows in the correct direction through the diode in circuit A, but in circuit B, the current flows in the opposite direction than what the diode allows.*

Electrical Engineering: Other Functions

*I can describe the function of a **condenser**.*

Explanation of Concepts

A **condenser** or **capacitor** stores electrical energy and releases it either all at once or in small parts for use.

A capacitor allows for the accumulation of electrical charges and can be easily recharged. For a capacitor to be able to charge, the source must be at a higher voltage than the capacitor's terminals.

Symbol: 

Functions

To store charge for high-speed use:

An electronic flash on a camera uses a capacitor. A capacitor can discharge more rapidly than a battery. Therefore, a battery is used to charge up the flash's capacitor, and then the capacitor can release the charge into the flash tube almost instantly when needed.

To “smooth out” electrical current:

Sometimes the supplied current may not be constant. The capacitor can store the supplied charges and slowly release the charge at a constant rate, smoothing out dips or peaks in the current.

Electrical Engineering: Other Functions

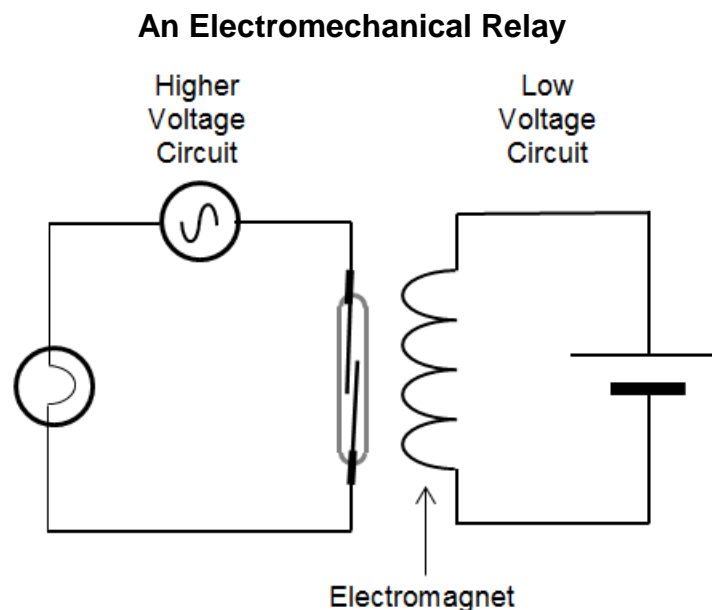
*I can describe the function of a **solid-state relay**.*

Explanation of Concepts

A **relay** is type of control that is activated by a very low voltage. A low voltage circuit with a relay can activate other devices in a second, higher voltage circuit.

Relays turn on or off the power being supplied to other devices in a similar fashion as a physical switch. However, instead of being switched manually by the operator, relays are switched electronically. With relays, high-current devices such as lights or appliances can be controlled with low-current signals.

Relays are either electromechanical relays or solid-state relays. In electromechanical relays contacts are opened or closed by a magnetic force. With solid-state relays, there are no contacts and switching is electronic.



When a current flows through the low voltage circuit, the magnetic field in the electromagnet causes the reed switch to close in the higher voltage circuit. In this way, the current in the higher voltage circuit flows.

Advantages of using a relay:

The low voltage circuit can be made up of small conductors, allowing for relatively small switches to be used to control a much bigger circuit.

The risk of electrocution is lessened when a relay is used.

Examples:

A thermostat sends a small current to the relay in the motor of a furnace. The relay then activates a circuit that controls a large amount of voltage, the motor for the furnace.

Security alarms in homes use electromechanical relays. The primary, lower voltage circuit is closed when all doors and windows are closed. The electromagnet in the primary circuit is activated, and its magnetic field maintains the switch in the secondary, higher voltage alarm circuit, to stay in the “open” or “off” position. If a door is opened, the primary circuit is broken, and the magnetic field is no longer present. The switch in the secondary circuit then falls into the “closed” or “on” position and the alarm sounds.

Materials: Constraints

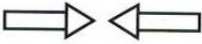
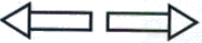



*I can define a **constraint** as ‘an external force (shearing, compression, deflection, torsion and tension) that is exerted on materials and that has a tendency to deform them’.*

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: Constraints

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: Heat Treatments

*I understand that **heat treatments** can be used to change the properties of materials (quenching increases hardness but fragility as well).*

Explanation of Concepts

The properties of some materials can be changed using various heat treatments. For example, heating wood to a high temperature can protect it from degradation by enhancing its properties.

Quench hardening and **tempering** are techniques used to enhance the hardness of steel, making it less brittle. First, the metal is heated to reorganize the atoms inside it. Then it is cooled by a liquid to set the new atom arrangement. This results in hard, but brittle steel. Lastly, the steel is made less brittle by a second heating period.

Annealing is another kind of heat treatment used to restore the properties of steel once they have been modified by welding, for example.

Questions

1. Which of the following is **not** an example of a type of heat treatment?
 - A) The side windows of cars are made of glass that is heated to increase its hardness and make it more brittle.
 - B) Aluminum alloys used to make the body of a car are treated with heat to increase hardness and strength.
 - C) Brass instruments are heat treated to increase strength and prevent cracking.
 - D) Two metal rods are joined together by heating metal (welding).
2. Knives are made by heating steel blades at very high temperatures and then dipping them in liquid nitrogen (very cold). Name the heat treatment(s) described and explain its advantages as far as the properties of the steel blades are concerned.

Answers

1. D
2. *Heating rearranges the atoms inside the steel blade. Cooling in liquid nitrogen is called quench hardening. This process makes the steel blades much harder and resistant to indentation and keeps the blade sharper longer.*

Materials: Types and Properties

*I can relate the use of **thermoplastics** to their properties.*

*I can relate the use of **thermosetting plastics** to their properties.*

Explanation of Concepts

Plastics are materials made of polymers that combine in different ways to obtain various properties.

Plastics fit into two categories: thermoplastics and thermosetting plastics.

Thermoplastics can be heated to soften and shaped over and over again. They can harden when cooled and keep their properties. Some properties of thermoplastics are:

- Chemical neutrality (unreactive)
- Elasticity
- Lightness
- Resilience
- Corrosion resistance

Thermosetting plastics can only be heated and shaped once. Once shaped, they remain hard, even when re heated. Some properties of thermosetting plastics are:

- Hardness
- Resilience
- Heat resistance
- Stiffness

Since thermosetting plastics retain their shape and strength when heated, they are used in situations where resistance to heat is important. Cooking pot handles, kitchen counters and electrical fittings are made from thermoplastics.

Materials: Types and Properties

*I can relate the use of **ceramics** to their properties.*

Explanation of Concepts

Ceramics are the result of heating inorganic matter. Some properties of ceramics are:

- Hardness
- Low electrical conductivity
- Wear resistance
- Heat resistance
- Corrosion resistance

Questions

1. Why would a homeowner choose a ceramic floor in the kitchen and bathroom rather than a wooden floor?

Answers

1. *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 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*

Manufacturing: Characteristics of Drilling, Tapping, Threading and Bending

I can describe the characteristics of the tools needed to shape a material.



Explanation of Concepts

Different tools are used to shape materials.

Drilling: The appropriate drill bit for a task depends on the type of material being drilled into (i.e. bored into), the diameter of the hole needed, and the speed at which the bit will rotate.

Example:

The tip of a drill bit for metal is conical and the tip of a drill bit for wood is double fluted.

Metal Drill Bit	Wood Drill Bit
	

Tapping: Tapping is the process to make screw threads inside the hole of a bored material. This makes it easier for threaded objects to fit into the hole. The tool used to make the inner threads is called a **tap**. The tap already has threads and requires a 'tap wrench' to tap a material.

Threading: Threading is the process by which screw threads are etched or formed on the outside of a rod. The tool used to make the outer thread is called a **diestock**. A diestock already has threads and is rotated around the rod to make the threads on the rod (wood, metal or plastic). A diestock must be used slowly in order to avoid any errors.

Bending: is the process by which a material is pressed into shape. The tool used to form a piece of sheet metal or thermoplastic is a **machine press**.

Questions

1. Which manufacturing technique is used to prepare the inside of a material so that a screw can go in it securely?
 - A) Drilling
 - B) Tapping
 - C) Threading
 - D) Bending

2. What factor must be considered when determining the speed of rotation of a diestock?

Answers

1. *B*
2. *A diestock should rotate at a constant speed and not too quickly. The slow speed will ensure that the threads are made evenly with minimal distortion.*