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This document is very much a “work in progress” and has been assembled in a very short time frame. This document will be further developed and edited in the near future.

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LIVING WORLD
Disturbances

I understand and can use the definition of a disturbance in a community

Explanation of Concept:
An ecosystem can undergo a series of events that could lead to an alteration in the pre-existing biotic of abiotic factors. This in turn could lead to change in the relative abundance of species in that ecosystem. In such an event the ecosystem would be described as having been disturbed.

Questions:

Multiple Choice:
1. Which of the following events would lead to the disturbance of an ecosystem?
   a) Planting trees
   b) Mud slide
   c) Composting
   d) Fog

Short Answer:
2. Apply your understanding of the definition of a disturbance to explain how the construction of a hydroelectric dam is detrimental to an ecosystem.

Answers:
1. B
2. Ecosystems are often affected by the construction of dams because the need to flood the land to control the flow, level, etc of water. In this process of flooding many habitats are destroyed and contaminants dissolved in the water may be toxic. In addition, to build a hydroelectric dam, forests must be cleared for the construction of the power plant. This in turn destroys more habitats.
Disturbances

Explanation of Concept:
The impact of a disturbance is dependant on the type of disturbance, and how often the disturbance occurs.

Types of disturbances:

<table>
<thead>
<tr>
<th>Natural</th>
<th>Human</th>
</tr>
</thead>
<tbody>
<tr>
<td>A natural disturbance is an event triggered by environmental phenomena that can damage an ecosystem.</td>
<td>Human activity can severely effect the environment. Human disturbances are a major source of environmental damage to ecosystems.</td>
</tr>
<tr>
<td><strong>Examples:</strong> Earthquakes, volcanic eruptions, floods, droughts, forest fires, storms</td>
<td><strong>Examples:</strong> Oil spills, mining, logging operations, construction of hydroelectric dams, large scale burning fossil fuels</td>
</tr>
</tbody>
</table>

Questions:

Multiple Choice:

1. Which of the following statements is false?
   a) Drought is a natural disturbance.
   b) An oil spill is a natural disturbance.
   c) Flood from heavy rain is a natural disturbance.
   d) The fishing industry is a human disturbance.
2. Which is an example of a human disturbance?

a) b) c) d)

Short Answer:

3. Which is a major source of environmental disturbance, natural or human? Explain your answer.

Answers:

1. B
2. B
3. Humans are a major source of environmental disturbances. Humans have a damaging effect on ecosystems, whether small or large scale, more frequently (a daily occurrence compared to a more random occurrence of natural disturbances).
**Trophic Relationships**

*I understand and can describe the trophic levels (producers, autotrophs), consumers (heterotrophs), and decomposers in an ecosystem.*

**Explanation of Concept:**

Living organisms need energy. Organisms at the same position in a food chain are known as a *trophic level*. Organisms in various trophic levels interact with each other which results in *trophic relationships*.

**Producers:**
- Convert inorganic matter (carbon dioxide, water) into organic matter (glucose) through photosynthesis;
- are *autotrophs*;
- They introduce energy and matter to ecosystems.
- E.g. Plants, Algae, etc.

**Consumers:**
- These are organisms that get their energy by eating other living organisms.
- They are also known as *Heterotrophs* because they cannot make their own food;
- Primary consumers or First-Order Consumers consume producers.
- Second, Third or Fourth level consumers are usually carnivores as they consume animals that precede them in a food chain. Some animals are also omnivores as they eat both plants and animals.

**Decomposers:**
- Convert organic matter into inorganic matter
- Are connected to all trophic levels.
- They feed off of dead organic matter like leaves and carcasses.
- They are *heterotrophs*.
- E.g. Worms, bacteria, insects, etc.

![Food Chain Diagram](image-url)
Questions:

Multiple Choice:

A food web is shown below.

1. Based on the diagram, which organism can be classified as a Primary Consumer?
   a) Red Tailed Hawk
   b) Shrew
   c) Willow
   d) Snowshoe Hare

2. Based on the diagram, which organisms act both as a secondary and tertiary consumer depending on the individual food chain they are involved in?
   a) Shrew and Red Fox
   b) Lynx and Red Fox
   c) Lynx and Snowshoe Hare
   d) Red Tailed Hawk and Insects
Short Answer Questions:

1. Create a Food chain using the following organisms and label each organism based on its trophic level.

   **Owl – Frog - Grass - Snake – Grasshopper - Bacteria**

2. Using the Food web provided in questions 1 and 2 of the multiple choice questions indicate an example of a producer. Explain why producers can also be called autotrophs.

   Example of a **Producer**: ____________________________

Answers:

Multiple Choice:

1. D
2. B

Short Answer Questions:

1. **Producer**: Grass, **Primary Consumer**: Grasshopper, **Secondary Consumer**: Frog, **Tertiary Consumer**: Snake, **Fourth-Level Consumer**: Owl, **Decomposer**: Bacteria (This level is linked to all levels of this food chain as it is responsible for the decomposition of the dead organic matter).

2. **Example of a Producer**: Willow or White Spruce

   **Producers are called autotrophs** because they can produce their own food using the sunlight, water and Carbon Dioxide. They are therefore, self sufficient and are considered to be the first level in the food chain because they are the first organisms to introduce food into the ecosystem.
Trophic Relationships

I would be able to explain and interpret the relationships between the trophic levels of a food web.

Explanation of Concept:

Producers, Consumers and Decomposers can be arranged in a FOOD CHAIN. Several Food Chains can be interconnected and combined to form a FOOD WEB.

The direction of the arrows in a food web indicates the direction of energy flow (The energy of the eaten organism).

A disturbance at any point of the Food Web will produce other effects/inbalances in the Food web and lower trophic level.
Questions:

*Multiple Choice:*

1. Using the food web above, indicate which of the statements below is true:

   a) If the shrimp were to decrease in number, the salmon would die off because it is the only source of food available for them.
   b) The crab has no predators.
   c) Small fish consume salmon.
   d) The increase of plankton would be devastating to this food web because it would consume many of the organisms at the lower trophic levels.

2. The Sun is linked to the plankton because:

   a) Plankton gives the Sun energy.
   b) Plankton uses the Sun’s energy to grow.
   c) The Sun does not affect the Plankton.
   d) The Sun is considered an organism.

*Answers:*

*Multiple Choice:*

1. B
2. B
EARTH AND SPACE
Hydrosphere: Catchment Area

I understand and can define a catchment area (watershed) as ‘a territory surrounding a waterway’

Key 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.

Questions

Multiple Choice

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 area(s) is/are **not** in the same catchment area as “A”. Explain your answer.

Answers:

*Multiple Choice*

1- A

2- Area B is not in the same catchment area as A. Area B is on the opposite side of a mountain than area A. Therefore, water in Area B could not empty into the same body of water as the water that drains from Area A. (Water from Area B cannot drain “uphill” to the other side of the mountain).
Hydrosphere: Catchment Area

Key Concepts

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

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. Water pollution can therefore spread hundreds of kilometers from its original source.

Questions

Multiple Choice

1. Which of the following does not affect the flow of water into a catchment area?

   a) Hydroelectric dam  
   b) A farmer fertilizing the land  
   c) Clearing a forest  
   d) Building roads

Constructed Response

You are spending the weekend at your friend’s cottage in the Laurentian Hills. It is a nice spring day and your friend decides to wash his car with a heavy duty cleaning product. You tell him that you do not think it is a good idea to introduce the cleaner into the environment. He responds that it will just go into the soil. Understanding the concept of “catchment area”, how would you convince your friend otherwise?

Answers:

1-B

Constructed Response

The cleaning product will be dissolved in water. Water does not stay in one place, but naturally flows from higher to lower ground. Therefore, all the water in a catchment area will eventually collect further downstream in a larger body of water. If the cleaning product is introduced in the Laurentian Hills, which is naturally a higher ground, it will be transported a great distance and affect the environment along the way. One person introducing a pollutant might only have a small impact, but if this happens on a larger scale, the impact on the environment will increase significantly.
Renewable and Non-renewable Energy Sources

Explanation of Concepts

**LITHOSPHERE**

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Description</th>
</tr>
</thead>
</table>
| Fossil fuels        | • 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.  
• The burning of fossil fuels releases pollutants such as carbon dioxide: \( \text{CO}_2 \) and methane: \( \text{CH}_4 \). Other gases, such as sulfur dioxide: \( \text{SO}_2 \) and nitrous oxides: \( \text{NO}_x \), are also released. |
| Uranium (Nuclear)   | • **Uranium** is a radioactive element and exists naturally in the lithosphere.  
• Mining uranium and splitting its nucleus releases thermal energy and radioactivity  
• A small amount of radioactive material produces a lot of energy  
• The thermal energy can be transformed into mechanical and then electrical energy  
• Nuclear power plants have to be built according to specifications which will prevent radioactivity from escaping into the environment.  
• Nuclear waste is another by-product and needs to be buried since it continues to release radioactivity for hundreds of years |
| Geothermal          | • 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. |
**HYDROSPHERE**
The energy contained in the movement of water, for example the flow of a river, the rise and fall of waves, and circulating currents, can be harnessed and transformed into electrical energy.

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Description</th>
</tr>
</thead>
</table>
| Hydroelectric | - **Hydroelectric power plants** use the movement of falling water to spin turbines which are located inside dams built across a river.  
- The turbines are connected to alternators which convert mechanical energy into electrical energy.  
- Hydroelectricity is the main source of energy in Quebec. |
| Wave energy   | - **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 energy  | Electricity can be generated from tides when water from a high tide is collected and then falls through turbines, similar to the ones found in hydroelectric power stations, to produce electricity. |

**ATMOSPHERE**

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Description</th>
</tr>
</thead>
</table>
| Wind energy   | - Wind energy is a renewable energy source and can be harnessed using wind turbines.  
- The wind causes the turbines to rotate and a generator converts the mechanical energy into electrical energy.  
- A disadvantage to using wind energy is that it cannot be stored, therefore it needs to be used in conjunction with another source of energy. Furthermore, winds are unpredictable and the large turbines can ruin the natural beauty of the land. |
| Solar energy  | - Solar energy is another renewable energy source which is commonly used in many parts of the world.  
- As the rays of the sun hit panels containing photovoltaic cells, they cause electrons to flow, creating current electricity.  
- Positioning homes in a way that most of the sun’s rays are absorbed is another way of taking advantage of solar energy. |
Questions:
Multiple Choice

1. Which of the following sources of energy is derived from the lithosphere?
   a) Moving water
   b) Wind
   c) Sun
   d) Molten rock

2. Which of the following is a renewable energy source derived from the hydrosphere?
   a) Solar panels
   b) Wind turbines
   c) Wave energy
   d) Geothermic

Answers:
1-D
2-C
Renewable and Non-renewable Energy Sources

I understand and would be able to 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. Some of these advantages and disadvantages are related to the environmental impact of using the energy resource.

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**

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Renewable or Non-Renewable</th>
<th>Environmental Impact</th>
</tr>
</thead>
</table>
| Fossil fuels    | Non-Renewable             | • When burned, fossil fuels give off atmospheric pollutants, including the greenhouse gases carbon dioxide and methane  
|                 |                           | • Other gases, such as sulfur dioxide: SO₂ and nitrous oxides: NOₓ, that cause acid rain, are also released. |
| Uranium (Nuclear) | Non-Renewable             | • No atmospheric pollutants are released  
|                 |                           | • Nuclear waste is highly toxic and must be stored for hundreds of years  
|                 |                           | • Leakage of nuclear materials could have a devastating effect on the environment |
| Geothermal      | Renewable                 | • Low 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 into the water supply, or the atmosphere through steam. |
### Impact of Energy Resources from the Hydrosphere

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Renewable or Non-Renewable</th>
<th>Environmental Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydroelectric</td>
<td>Renewable</td>
<td>• Causes little pollution.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The building of dams often floods large areas of land, affecting the habitat of various plant and animal species.</td>
</tr>
<tr>
<td>Wave energy</td>
<td>Renewable</td>
<td>• •</td>
</tr>
<tr>
<td>Tidal energy</td>
<td>Renewable</td>
<td>• Does not release atmospheric pollutants</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Tidal barrages (dams) can interfere with fish migration, force water level changes on the basin behind the barrage, reduce salinity in the basin due to low quantities of ocean water, and reduced the ability of currents to transport and suspend sediments</td>
</tr>
</tbody>
</table>

### Impact of Energy Resources from the Atmosphere

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Renewable or Non-Renewable</th>
<th>Environmental Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind energy</td>
<td>Renewable</td>
<td>• Does not release atmospheric pollutants</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Turbines produce sound</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Can disrupt the visual appeal of the landscape</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Birds can collide with the wind turbines</td>
</tr>
<tr>
<td>Solar energy</td>
<td>Renewable</td>
<td>• Does not release atmospheric pollutants</td>
</tr>
</tbody>
</table>
**Constructed Response**

A community in Gaspé is trying to choose between constructing a tidal power plant and a coal power plant.

For each of the energy resources the community is considering, state:
- Is the energy source renewable or non-renewable
- What would be the main environmental impact of each type of energy use?
- What form of energy is transformed and converted into electricity in each of the two cases?

---

**Answer**

<table>
<thead>
<tr>
<th></th>
<th>Tidal Power Plant</th>
<th>Coal Power Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renewable or Non-Renewable</td>
<td>Renewable</td>
<td>Non-renewable</td>
</tr>
<tr>
<td>Environmental Impact</td>
<td>- Tidal barrages can disrupt marine life</td>
<td>- Releases greenhouse gases</td>
</tr>
<tr>
<td>Energy transformations</td>
<td>Kinetic energy of water $\rightarrow$ Mechanical energy(turbine) $\rightarrow$ electrical energy</td>
<td>Chemical energy in coal $\rightarrow$ thermal energy $\rightarrow$ (steam) $\rightarrow$ mechanical energy(turbine) $\rightarrow$ electrical energy</td>
</tr>
</tbody>
</table>
MATERIAL WORLD
**Chemical Changes: Combustion**

*I understand, can interpret and describe the recognizable manifestations of rapid combustion. E.g. Heat, light, Fuel*

**Explanation of Concept:**

**Combustion** is a form of oxidation (uses oxygen) that releases a large amount of energy.

**Rapid Combustion:** Within a short period of time, fuel can burn and release a great deal of energy mostly in the form of heat and light. E.g. A candle burning.

**Multiple Choice Questions:**

1. Which of the following is NOT example of rapid combustion:
   a) A log fire
   b) Candle Burning
   c) Digestion
   d) Gas stove

**Short Answer:**

1. Rusting is considered to be slow combustion whereas starting a campfire is rapid combustion. Explain why a campfire is an example of rapid combustion?

---

**Answers:**

**Multiple Choice:**

1. C

**Short Answer:**

Rapid combustion occurs when fuel is burned which results in the release of large amounts of energy. In the example of a campfire, the wood logs are releasing large amounts of heat and light which classifies this as rapid combustion.
Chemical Changes: Combustion

*I would be able to explain a combustion reaction using the fire triangle.*

**Explanation of Concept:**

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

1. **Oxidizing Agent:** Is something that can cause fuel to react like oxygen.
2. **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. **Fuel:** is a substance that releases a large amount of energy by reacting with an oxidizing agent. (E.g.: Wood)

Combustion will continue to occur until one of the three factors is significantly reduced or no longer present in the situation. E.g. Heat is significantly reduced by water cooling it down.

**Rapid Combustion:** Within a short period of time, fuel can burn and release a great deal of energy mostly in the form of heat and light. E.g. A candle burning

**Questions:**

**Short Answer:**
1. The fire triangle below illustrates the conditions required for combustion to occur.

A friend shows you three conclusions he arrived at after doing her research on forest fires:

1) If the wind increases, the forest fire will also increase.
2) Forest fires are more common in summer, when it is hot and dry, than in autumn, when it is cold and wet.
3) Forest fires are more likely to occur in mature forests than in young forests.
**Explain each of the conclusions by using the fire triangle.**

**Integration Question:**

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. Illustrate your answer with a diagram and/or chemical equations.

- Combustion
- Respiration
- Photosynthesis
- The Carbon Cycle
- Oxygen
- Carbon Dioxide

---

**Answers:**

**Short Answer:**

1. If the wind increases the fire as the potential to be spread. Strong winds will push the flames in the direction the wind is blowing and can cause the surrounding woods to catch fire thus causing the fire to spread. Also, more oxygen in the air feeds fire. This is an example of an increase in the OXIDIZER.

   "The hot summer months bring about a lot of sun. The sun’s warmth can dry out the trees making the dry wood more prone to being ignited. Also, the sun itself can trigger fire especially after long periods without rain. This is an example of IGNITION TEMPERATURE.

   Mature forests are more prone to fire because there is more FUEL to be burned. More trees means more burning options – more to burn."

2. Fires are a large contributor to the carbon cycle. The carbon that is in the structure of the plants being burned are 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 would be able to represent an oxidation reaction using the particle model.

I would be able to associate known chemical reactions with oxidation reaction (e.g. combustion, corrosion)

Key Concepts:

1. 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:

\[ 4 \text{Fe} + 3 \text{O}_2 \rightarrow 2 \text{Fe}_2\text{O}_3 \]

- 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\(_2\)O\(_3\).

- 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\(_2\)O\(_3\) molecule contains 2 atoms of Fe and 3 atoms of O.

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

\[ \text{Fe} \quad \text{Fe} \quad \text{O} \quad \text{O} \quad \text{Fe}_2\text{O}_3 \]

This example represents 4 individual Fe atoms, 3 O\(_2\) molecules and 2 Fe\(_2\)O\(_3\) molecules.
Constructed Response Question:

Represent the following oxidation reaction using the particle model:

\[ 2 \text{Mg} + \text{O}_2 \rightarrow 2 \text{MgO} \]

Legend:

- ●: O
- ○: Mg

Answer:

```
  ● + ○ → ○ ○
  ○ ○ ○ ○ ●
```

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Chemical Changes: Oxidation

I would be able to associate known chemical reactions with oxidation reaction (e.g. combustion, corrosion)

Key Concepts:

Common examples of oxidation reactions are:

a. Combustion
   Ex. combustion of methane: \[2\text{CH}_4 + 3 \text{O}_2 \rightarrow 2\text{CO}_2 + 4\text{H}_2\text{O}\]

b. Iron rusting:
   \[4\text{Fe} + 3 \text{O}_2 \rightarrow 2\text{Fe}_2\text{O}_3\]

c. Cellular respiration:
   \[\text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{O}_2 \rightarrow 6 \text{CO}_2 + 6 \text{H}_2\text{O} + \text{energy}\]

Multiple Choice Question:

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:
   \[2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}\]
**Constructed Response Question:**

2. State whether or not each of the following is an example of oxidation. Explain your answer.

   a) A campfire burning
   b) Photosynthesis.

---

**Answer**

1-C

2-

   a) *A campfire burning is an example of an oxidation reaction.* An oxidizing agent (i.e. 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 Concept(s):
An atom is composed of small particles of matter: protons, neutrons and electrons. The following illustration represents the distribution of these elementary particles inside the atom:

![Subatomic Particles Diagram]

**Electrical charge** is a property of protons and electrons. It was proven that:
- protons are *positively* charged (+);
- electrons are *negatively* charged(-);

Multiple Choice Questions
1) What do protons and electron 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

Constructed Response Question

4) The concepts listed in the box below relate to the structure of an atom. Draw arrows to represent the correct match between each elementary particle, its location and its electrical charge:

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

Answers

Multiple Choices

1. a)  
2. d)  
3. b)  

Constructed Response Question:

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 Concept(s):**

Brought close together, two electrically charged objects interact:
- when the charges are **similar**, the objects **repel** each other

<table>
<thead>
<tr>
<th>positive repels positive</th>
<th>![Diagram of positive repulsion]</th>
</tr>
</thead>
<tbody>
<tr>
<td>negative repels negative</td>
<td>![Diagram of negative repulsion]</td>
</tr>
</tbody>
</table>

- when the charges are **opposite**, the objects **attract** each other

| positive and negative attract | ![Diagram of opposite attraction] |
Questions
MULTIPLE CHOICE
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.

Table 1 ELECTROSTATIC SERIES CHART

<table>
<thead>
<tr>
<th>Substances</th>
<th>Charges</th>
</tr>
</thead>
<tbody>
<tr>
<td>acetate</td>
<td>[Weak hold on electrons]</td>
</tr>
<tr>
<td>glass</td>
<td></td>
</tr>
<tr>
<td>wool</td>
<td></td>
</tr>
<tr>
<td>cat's fur, human hair</td>
<td></td>
</tr>
<tr>
<td>calcium (Ca), magnesium (Mg), lead (Pb)</td>
<td></td>
</tr>
<tr>
<td>silk</td>
<td></td>
</tr>
<tr>
<td>aluminum (Al), zinc (Zn)</td>
<td></td>
</tr>
<tr>
<td>cotton</td>
<td></td>
</tr>
<tr>
<td>paraffin wax</td>
<td></td>
</tr>
<tr>
<td>ebonite</td>
<td></td>
</tr>
<tr>
<td>polyethylene (plastic)</td>
<td></td>
</tr>
<tr>
<td>carbon (C), copper (Cu), nickel (Ni)</td>
<td></td>
</tr>
<tr>
<td>rubber</td>
<td></td>
</tr>
<tr>
<td>sulphur (S)</td>
<td></td>
</tr>
<tr>
<td>platinum (Pt), gold (Au)</td>
<td>[Strong hold on electrons]</td>
</tr>
</tbody>
</table>

In the laboratory, a student rubs a cotton cloth with each of the following substances: ebonite, plastic, acetate and glass. He then brings different samples together:

1) ebonite and plastic
2) plastic and acetate
3) acetate and glass
4) glass and ebonite

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

A) 1 and 2  B) 1 and 3  C) 2 and 4  D) 3 and 4
2) Five metallic spheres were electrically charged and then suspended as shown in the diagram below:

If sphere A lost electrons, which of the spheres were negatively charged?  
A) B and C  
B) C and D  
C) D and E  
D) B and E

CONSTRUCTED RESPONSE  
3. 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.

<table>
<thead>
<tr>
<th></th>
<th>Electrical Charge (positive/negative)</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>balloons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>fur</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ruler</td>
<td></td>
<td></td>
</tr>
<tr>
<td>wool cloth</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Answer
1 – b
2 – d
3 .

<table>
<thead>
<tr>
<th></th>
<th>Electrical Charge (positive/negative)</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>balloons</td>
<td>negative</td>
<td>The charges transferred from the wool to the balloons were electrons, because only electrons can move from one atom to another. The balloons acquired a surplus of electrons and became negatively charged.</td>
</tr>
<tr>
<td>fur</td>
<td>positive</td>
<td>By transferring electrons to the balloons, the fur acquired a deficit of electrons and became positively charged.</td>
</tr>
<tr>
<td>ruler</td>
<td>negative</td>
<td>Since the ruler repels the two balloons, it must be negatively charged. By rubbing the ruler with the wool cloth, the ruler acquired electrons.</td>
</tr>
<tr>
<td>wool cloth</td>
<td>positive</td>
<td>The wool cloth has transferred electrons to the ruler so it acquired a deficit of electrons and became positively charged.</td>
</tr>
</tbody>
</table>
Electricity and Electromagnetism: Static Electricity

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

Explanation of Concept(s):

An electrically neutral body contains the same amount of protons (positive charges) and 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.*

![Figure 1: ELECTRICALLY CHARGED OBJECTS](image)

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

1) 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?
   E) The transfer of protons between the hair and the balloons.
   F) The transfer of electrons between the hair and the balloons.
   G) The transfer of electrons between the balloons and the wall.
   H) The transfer of protons between the balloons and the wall.

2) Among the statements below, find one that is TRUE.
   5) Positively charged objects have a deficit of protons.
   6) Positively charged objects have surplus of electrons.
   7) Negatively charged objects have a surplus of electrons.
   8) Negatively charged objects have a surplus of protons.

3) The following diagram shows four different objects and their electrical charge. The positive sign (+) represents the charge of the protons and negative sign (-) represents the charge of the electrons.
Which of these objects are positively charged?

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

**Constructed Response Question**

4. 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.
Answers

Multiple choices
1. B;  2. C;  3. D;

Constructed response question MW F.1.b.i

4.

A. 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 a surplus of electrons whereas the wool cloth has a deficit of 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 remains the same in both objects, because the positive charges cannot be transferred.

B. Since the ebonite has acquired a negative charge, when it is brought close to objects like small pieces of paper, Styrofoam etc, the positive charges in these objects will be attracted by the greater number of negative charges in the ebonite rod and will move towards it (get attracted to the ebonite rod).
 Electricity and Electromagnetism: Ohm’s Law

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

Explanation of Concept(s)
Ohm’s law describes the relationship between several important physical quantities used in electricity.

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

The potential difference (V) is the amount of 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 represents the ability of a material to oppose (resist) the flow of electric charges. (Imagine speed bumps slowing down the cars on a racetrack.)

Ohm’s Law states that: "FOR A GIVEN RESISTANCE, THE POTENTIAL DIFFERENCE IN AN ELECTRICAL CIRCUIT IS DIRECTLY PROPORTIONAL TO THE CURRENT INTENSITY”.

MUL TIPLE CHOICE QUESTIONS
1) In an electrical circuit, the number of electrons crossing through the section of a wire in one second has doubled. The total resistance of the circuit stayed the same.

How did potential difference change?

A) The potential difference halved.
B) The potential difference doubled.
C) The potential difference quadrupled.
D) The potential difference stayed the same.
2) What will happen to the current intensity in an electrical circuit if, for a given resistance the potential difference was reduced by half?

A) It will double.
B) It will not be modified.
C) It will be reduced to half of the initial value.
D) None of the above.

CONSTRUCTED RESPONSE QUESTION

3) The resistance of a circuit is increased while the current intensity is maintained at the same value.

A) How will the voltage vary?
B) Explain why.

ANSWERS
1. B
2. C
3. A) The voltage will increase.
   B) 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 (I can use Ohm’s law in calculations)

Explanation of Concept(s)
The mathematical expression of Ohm’s Law shows the direct proportionality between the potential difference and current intensity, for a given resistance:

\[ V = RI \]

The above formula can be also written as: \( R = \frac{V}{I} \) and \( I = \frac{V}{R} \)

Where:
- \( V \) is the potential difference (voltage) expressed in volts (V)
- \( I \) is the current intensity (current) expressed in amperes (A)
- \( R \) is the resistance expressed in ohms (Ω)

Questions
1. In the circuit diagram below the voltmeter measures 12 V and the ammeter measures 0.6 A.

What is the resistance of element \( R \)?
   A) 0.05 Ω  B) 7.2 Ω  C) 20 Ω  D) 7.2 J
2. What is the potential difference of a current of 10 A flowing through a resistance of 25 Ω?
   A) 250 Ω   B) 0.4 V   C) 2.5 V   D) 250 V

3. You have 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) 500 A   B) 4.5 mA   C) 2 A   D) 4.5 A

CONSTRUCTED RESPONSE QUESTION
In the laboratory, a student was asked to measure different electricity parameters of an electrical circuit that needs 0.5 amps of current to function optimally. He has experimented with four different resistors and recorded the data in the table below.

Table 2 RESISTANCE AND POTENTIAL DIFFERENCE VALUES

<table>
<thead>
<tr>
<th>Resistor</th>
<th>Resistance (Ω)</th>
<th>Potential difference (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>60</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>24</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>48</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>36</td>
<td>12</td>
</tr>
</tbody>
</table>

Perform the necessary calculations to show which of the resistors should be used for the optimal functioning of the circuit.

ANSWERS
1 – C
2 – D
3 – B
4 – CONSTRUCTED RESPONSE QUESTION

Resistor 1:
\[ I = \frac{V}{R} = \frac{12 \text{ V}}{60 \Omega} = 0.2 \text{ A} \]

Resistor 2:
\[ I = \frac{V}{R} = \frac{12 \text{ V}}{24 \Omega} = 0.5 \text{ A} \]

Resistor 3:
\[ I = \frac{V}{R} = \frac{12 \text{ V}}{48 \Omega} = 0.25 \text{ A} \]

Resistor 4:
\[ I = \frac{V}{R} = \frac{12 \text{ V}}{36 \Omega} = 0.3 \text{ A} \]

Answer: The resistor that should be used is RESISTOR 2 because IT PROVIDES THE OPTIMAL AMOUNT OF CURRENT FOR THIS CIRCUIT
Electricity and Electromagnetism: Electrical Circuits

I understand and can describe the function of different components of an electrical circuit (e.g. the wires transmit electrons along the circuit; resistors transform electrical energy into another form of energy).

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

Table 3 BASIC ELECTRICAL CIRCUIT COMPONENTS AND THEIR FUNCTIONS

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>ELECTRICAL FUNCTION</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>power source, battery</td>
<td>power supply</td>
<td>creates a potential difference; transfers energy to electrons</td>
</tr>
<tr>
<td>wires</td>
<td>Conduction</td>
<td>connect the elements and the power supply; carry electrons from the source to the elements and back to the source</td>
</tr>
<tr>
<td>resistors(elements)</td>
<td>electrical resistance</td>
<td>limit the flow of electrons; transform electrical energy into other forms of energy (light, heat, sound etc)</td>
</tr>
<tr>
<td>switch</td>
<td>control</td>
<td>allows the current control by connecting or breaking the circuit; (when a switch is off, the electron flow is interrupted)</td>
</tr>
<tr>
<td>ammeter</td>
<td></td>
<td>measures the current flowing through a circuit (connected in series)</td>
</tr>
<tr>
<td>voltmeter</td>
<td></td>
<td>measures the potential difference (energy) that electrons have between two points of the circuit (connected in parallel)</td>
</tr>
</tbody>
</table>
Multiple Choice Questions

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

    1)  
    
    2)  

    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?

    A)  
    B)  
    C)  
    D)  

A) 1 and 2  B) 1 and 3  C) 2 and 3  D) 2 and 4
3) Which of the circuit components below is designed to hinder the flow of electrons through an electrical circuit?

A) a copper wire  B) an alkaline battery  C) a light bulb  D) an electrical switch

**Constructed Response Question**

4) Draw arrows to match the components below with the right function they carry in electrical circuits:

1. converts electrical energy into other forms of energy
2. provides the energy to the circuit
3. controls the current
4. measures the current intensity
5. measures the voltage
6. carries the current
7. component that generates light

a. ammeter
b. resistor
c. light bulb
d. voltmeter
e. power supply
f. switch
g. wires

---

**Answers**

Multiple choices:

1) D
2) D
3) C

**Constructed question:**

---
Electricity and Electromagnetism: Electrical Circuits

I would be able to identify the two main types of electrical circuits (series, parallel)

Explanation of Concept(s):
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 ceases to flow through the entire circuit.

Diagram 1: SERIES CIRCUIT
PARALLEL CIRCUITS
A parallel circuit branches out at least at one point (node). The charges follow different pathways. If a part of the circuit is open or an element is defective, the current continues to flow through the other branches.

Diagram 2: PARALLEL CIRCUIT

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).

Example:
Diagram 3: MEASURING INSTRUMENTS

Questions

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

Which of the following statements regarding this circuit is TRUE?

<table>
<thead>
<tr>
<th></th>
<th>(S_1)</th>
<th>(S_2)</th>
<th>(L_1)</th>
<th>(L_2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Opened</td>
<td>Closed</td>
<td>Off</td>
<td>On</td>
</tr>
<tr>
<td>B</td>
<td>Closed</td>
<td>Opened</td>
<td>On</td>
<td>Off</td>
</tr>
<tr>
<td>C</td>
<td>Opened</td>
<td>Closed</td>
<td>On</td>
<td>Off</td>
</tr>
<tr>
<td>D</td>
<td>Closed</td>
<td>Opened</td>
<td>Off</td>
<td>On</td>
</tr>
</tbody>
</table>
2) Which of the circuits below are connected in parallel?

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

**Constructed Response Question:**

3) In the circuit below, if S₁ is open and S₂ is closed, which lightbulb(s) will light up?

**ANSWERS**

1- B
2- D
3 – All three light bulbs will light
Electricity and Electromagnetism: Electrical Circuits

I understand and can describe the differences between alternating and direct current

Explanation of Concept(s):

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 (ex. the current produced by a battery).

![Figure 1 MOTION OF ELECTRONS IN DIRECT CURRENT]

**ALTERNATING CURRENT** (AC) - electrons change direction many times every second (they flow back and forth); it is produced by power plants.

![Figure 2 MOTION OF ELECTRONS IN ALTERNATING CURRENT]

**EXTRA INFORMATION**

Power plants produce alternating current. This is more advantageous as during the electrical current distribution, less energy is lost. Since most electrical appliances and electronic devices function on direct current, they usually use a regulator that transforms alternating current into direct current.
Questions
Multiple Choice 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 and protons move in the opposite direction
   d) Electrons move in the same direction.

Constructed Response Question:
2) The following diagram consists of two light bulbs connected to a D-cell battery. The circuit uses direct current.

Use arrows to show electrons all along this circuit

ANSWERS
Multiple Choices
1) B

** All arrows must point in the same direction (negative to positive or positive to negative)**
Electricity and Electromagnetism: Electrical Circuits

I understand and would be able to represent a simple electrical circuit using a diagram and appropriate symbols.

Explanation of Concept(s):

A simple electrical circuit contains at least the following components:
- a power source
- resistors (elements)
- wires

Most circuits also contain one or more switches. In electricity, circuits are represented by precise diagrams. Certain symbols are used to represent the elements of an electrical circuit:

<table>
<thead>
<tr>
<th>Table 1 ELECTRICAL CIRCUIT SYMBOLS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>wire</strong></td>
</tr>
<tr>
<td>![Diagram of symbols]</td>
</tr>
</tbody>
</table>
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:

Figure 1: SERIES CIRCUIT

<table>
<thead>
<tr>
<th>circuit</th>
<th>electrical diagram</th>
</tr>
</thead>
</table>

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:

Figure 2: PARALLEL CIRCUIT

<table>
<thead>
<tr>
<th>circuit</th>
<th>electrical diagram</th>
</tr>
</thead>
</table>
Multiple Choice Questions

1) The figure below represents a simple electrical circuit containing a power source, two electrical bulbs and one resistor:

Which of the following diagrams could best represent this circuit?

A) [Diagram A]
B) [Diagram B]
C) [Diagram C]
D) [Diagram D]
**Constructed Response Questions:**

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.

![Circuit Diagram](image)

**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. In this circuit, all electrons follow the same pathway. The ammeter measures the current in both resistors whereas the voltmeter measures the potential difference of the first resistor only.
ANSWERS
Multiple Choices
1) B

Constructed Response Questions:
2) 

3)
Electricity and Electromagnetism: Relationship between Power and Electrical Energy

I would be able to use the equation \( P = VI \) to calculate power, voltage and current intensity in an electrical circuit.

Explanation of Concept(s):

**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:

\[ P = VI \]

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)

Questions

1) A student was asked to assemble a simple electrical circuit made of a resistor and a battery and calculate its electrical power. Since he was asked to perform further calculations, he also connected a voltmeter and an ammeter to his circuit. The diagram below represents the circuit that he assembled:

![Circuit Diagram]

The current intensity in the circuit is 0.8 A and the voltage across the resistor is 20 V. **What is the electrical power of this circuit?**

B) 0.04 W  B) 16 kW  C) 16 W  D) 25 kW
2) What is the current drawn when a kettle with a power of 1.65 kW is connected to an 110V power supply?

A) 0.015 A  
B) 1.5 A  
C) 15 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) 26.4 V  
D) 110 V

**Constructed Response Questions:**

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

![Electrical Circuit Diagram]

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

**ANSWERS**

Multiple Choice

1) B  
2) C  
3) D

Constructed Response Question:

Example of an appropriate procedure:

1) Find current intensity:

\[ I = \frac{P}{V} = \frac{2.2 \text{ kW}}{110 \text{ V}} = 0.02 \text{ A} \]

2) Find electrical power:

\[ P = I \times V = 0.02 \text{ A} \times 110 \text{ V} = 2.2 \text{ W} \]

Answer: the electrical power of the resistor is 200 W
Electricity and Electromagnetism: Relationship between Power and Electrical Energy

I understand and would be able to 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 Concept(s):
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. In other words, the more powerful an electrical appliance is, the more energy it consumes. 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. Use a cheap appliance.
   4. Reduce the operation time.
   5. Use an appliance with a higher power rating.

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

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:

<table>
<thead>
<tr>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>120 V 60 Hz 1200 W (1.2 kW)</td>
<td>120 V 60 Hz 1400 W (1.4 kW)</td>
</tr>
</tbody>
</table>

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
Multiple Choice
1) B

Constructed Response Questions:
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

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)
- \( \Delta t \) is the time interval expressed in seconds (s) or hours (h)

Questions

1) How much energy does an electric heater with a power of 200 W consume in 2 minutes?
   A) 0.01 kJ               B) 24 kJ               C) 100 J               D) 400 J

2) How much energy is consumed by an oven with an electrical power of 4 kW in use for 2.5 hours?
   A) 0.9 kWh            B) 10 kWh            C) 10 kJ            D) 0.625 kJ

3) How long does it take for a kettle with a power of 2 kW to use 30 000 J of energy?
   A) 15 s            B) 15000 s            C) 60 min            D) 0.07 h

4) What is the power of an electric bulb that gives off 3600 J of energy in 10 minutes?
   A) 6 kW            B) 2.8 kW            C) 6 W            D) 360 W
Constructed response question:

5) A water heater has a resistor working with a potential difference of 230 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) B
3) A
4) C
5) Example of an appropriate procedure:

1) Calculate the power of the resistor:
   \[ P = V \times I = 230V \times 50A = 11500W = 1.15kW \]

2) Express the time in hours:
   \[ \Delta t = 30min \times \frac{1h}{60min} = 0.5h \]

3) Calculate the energy consumed by the resistor:
   \[ E = P \times \Delta t = 1.15kW \times 0.5h = 0.575 \text{ kWh} \]

Answer: The resistor uses 0.575 kWh of energy in 30 minutes.

**Please note the equivalent answer in Ws is 20 700 000 Ws**
Electromagnetism: Forces of Attraction / Repulsion

I understand that for magnets, different poles attract, while similar poles repel. I would be able to describe and interpret the magnetic field of a magnet and the behavior of a compass in the magnetic field of a magnet.

Explanation of Concept(s):

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

2. Like poles repel.
   
   [Diagram showing repulsion between N and N, S and S.]

3. Opposite poles attract.
   
   [Diagram showing attraction between N and S, S and N.]

4. All magnets have a magnetic field. A magnetic field is the space around a magnet where magnetic forces are felt (both attraction and repulsion).
5. 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.

6. A compass needle is a magnet. Therefore, the compass needle may change direction when it is placed in a magnetic field.

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

![Diagram of compasses in a magnetic field](image)
Questions:

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

   A)  
   N   S
   
   B)  
   N   S
   
   C)  
   N   S
   
   D)  
   N   S
2. Indicate which pole is the North pole of the magnet.

a) __________

b) __________

Answer:

1. B
2. A

a) __________

b) __________
Electromagnetism: Magnetic Field of a Live Wire

I would be able to compare the behavior of a compass in the magnetic field of a magnet with the magnetic field created by a current-carrying wire

Explanation of Concept(s):
A straight wire with a current flowing through it has a 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.

Determining the direction of the magnetic field of a straight wire by 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.

Images from http://earthphysicsteaching.homestead.com/Magnetism_Magnetic_Fields_Lab.html
When a compass is placed in the magnetic field, the north end of the compass will point in the direction of the magnetic field.

2-4 Questions (with answers)

Multiple Choice Questions
1. Which of the following compasses is pointing in the correct direction?

   ![Compass Options]

   a) ![Compass A]
   b) ![Compass B]
   c) ![Compass C]
   d) ![Compass D]

Constructed Response Questions
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. d)
2.
Electricity and electromagnetism → Magnetic Field of a Live Wire

I would be able to identify ways of modifying the intensity of the magnetic field produced by a current-carrying wire (type of wire, current intensity)

Explanation of concept:

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

- Use a higher 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
2 - I would choose a copper wire, because copper is a better conductor than nichrome.
Electricity and electromagnetism: Magnetic Field of a Live Wire

I would be able to compare the behavior of a compass in the magnetic field of a magnet with that of a current-carrying wire

Explanation of concept:
Recall: The direction of the magnetic field is the direction that the North arrow points when the compass is placed in the magnetic field

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

![Diagram of a bar magnet with compasses showing magnetic field]

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

![Diagram of a current-carrying wire with compasses showing magnetic field]

PoL: Material World F.2.a.
Question:

Which of the statements below is TRUE?

A) When placed in the magnetic field of a magnet, the compass always points to the North pole.
B) When placed in the magnetic field of a magnet, the compass always points to the South pole.
C) When placed in the magnetic field of a current carrying wire, the compass always points in the direction of the current.
D) When placed in the magnetic field of a current carrying wire, the compass always points in the opposite direction of the current.

Answer

B
Electricity and electromagnetism: Magnetic Field of a Solenoid

**I would be able to describe and interpret the magnetic field produced by a solenoid (right-hand rule or left-hand rule)**

**Explanation of concept:**

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.

An electrical current travels through a coiled wire around a core, a magnetic field occurs flowing through the core of the coiled wire, to the outside and around. This magnetic field has a direction which can be determined using the right hand rule*

![Diagram of a solenoid with magnetic field lines]

*Right hand rule = use your fingers and wrap them in the direction of the loops of the wire (starting at the positive end). The direction your thumb points, is the direction of the magnetic field (pointing towards the North side).

Your fingers wrap around the coil in the direction of the current flow and your thumb points in the direction of the magnetic field lines (points N).
Questions:

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

   a)  
   ![Diagram a)

   b)  
   ![Diagram b)

   c)  
   ![Diagram c)

   d)  
   ![Diagram d)
2. Which of the following correctly represents the shape of the magnetic field around a solenoid?

Answer:
1-D
2-D
Electricity and electromagnetism: Magnetic Field of a Solenoid

I would be able to 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 concept:

1. The intensity of the magnetic field produced by a solenoid is affected by these factors:
   - The nature of the core material
   - The current intensity, I, in the coil of the solenoid
   - The number of turns (loops) in the solenoid

2. 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. A ferromagnetic material must contain iron, nickel, or cobalt.

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

3. As the current intensity increases → strength of field increases
   As the current intensity decreases → strength of field decreases
Question:

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

   a) Soft Iron  
   \[ I = 10 \text{ A} \]

   b) Soft Iron  
   \[ I = 10 \text{ A} \]

   c) Aluminum  
   \[ I = 10 \text{ A} \]

   d) Aluminum  
   \[ I = 8 \text{ A} \]

Answer:
1-B
Electricity and electromagnetism: Electromagnetic Induction

I would be able to describe ways of inducing electrical current in a wire
E.g. movement of a magnet, changing the intensity of a magnetic field

Explanation of concept:

The opposite of magnetization by electricity (generating a magnetic field from an electric current) is electromagnetic induction (generating an electric current from a magnetic field).

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

1) Take a conductive material and move it WITHIN a magnetic field.

2) Take a magnet and move it INSIDE a coiled conductive material.
Questions:

1. What criteria 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.

Constructed Response:

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

![Generator Rotor Diagram]

Explain how the generator uses electromagnetic induction to generate electric energy.

Answers

1-A

2- *magnetic induction requires the core to be a magnet, not a conductive substance.*

*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.*

I understand and would be able to explain the law of conservation of energy.

Explanation of Concept(s):

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. More specifically, in a frictionless system, mechanical energy remains constant.

Multiple Choice Question

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) 10 joules  
   b) 20 joules  
   c) 30 joules  
   d) 50 joules

Short Answer Question

2. Jim is excellent at bowling. He routinely gets several strikes during a typical game. Explain how a strike (i.e. when the bowling ball knocks down all of the bowling pins) illustrates the law of conservation of energy.

_____________________________________________________________________

Answers

1. a
2. The ball rolling down the alley has mechanical energy. The mechanical energy is transferred to the pins upon contact and it causes the displacement of the pins.

I would be able to apply the law of conservation of energy in different situations.

Explanation of Concept(s):

Examples of the Law of conservation of energy include:

The heating elements on a stove convert electrical energy into thermal energy. Hydraulic energy from a waterfall is transformed into mechanical energy to spin a turbine, which is further transformed into electrical energy by a generator.

Multiple Choice

1. Consider a dishwasher. What energy path is taken for the dishes to be cleaned?
   a) electrical → mechanical → thermal (with some heat lost)
   b) electrical → mechanical → thermal
   c) mechanical → thermal → electrical
   d) mechanical → electrical → thermal
**Constructed Response Question**

2. **Hydro Electric Energy**

![Diagram of Hydro Electric Energy]

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

3. Self cleaning ovens have a special cycle (or mode) that will use extremely high temperatures to “cook-away” any residues or food deposits left within the oven walls. To protect the user from being exposed to extremely hot oven doors during this process, these ovens are typically over-insulated. How do you think this extra insulation affects the efficiency of the oven when used in normal “cooking-mode”.

---

**Answers**

1. a

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.

3. Since these ovens are more insulated they will allow less heat to escape, as a result, more of the oven’s heat will be used for cooking the food, and less will be lost to the oven's surroundings.
I understand and can use the definition of 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

\[
\text{Energy Efficiency (\%) } = \frac{\text{Amount of useful energy (J)}}{\text{Amount of energy consumed (J)}} \times 100
\]

Explanation of Concept(s):

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.

Thus the energy efficiency of a machine is the percent of energy that is transformed for its original purpose.

\[
\text{Energy Efficiency (\%) } = \frac{\text{Amount of useful energy (J)}}{\text{Amount of energy consumed (J)}} \times 100
\]

Multiple Choice Questions

1. A kettle consumes 15 500 J of energy. It is 85 % efficient. How much energy was used by the kettle?

   a) 18 235 J
   b) 1 317 500 J
   c) 182 J
   d) 13 175 J
**Constructed Response Question**

2. Some homes are still heated by hot water boiler furnaces which use domestic heating oil as their source of combustion. 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 from the combustions is used to heat water which is then pumped to radiators throughout the house. These radiators are designed to dissipate the heat evenly within the room. A schematic of this 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, assuming 7 600 kJ are lost to the exhaust, and 1 900 kJ are lost in transporting the hot water to the radiators; calculate the efficiency of this heating system.

---

**Answers**

1. D

\[
\text{% Energy Efficiency} = \frac{\text{Amount of useful energy}}{\text{Amount of energy consumed}} \times 100
\]

\[
\frac{85}{100} = \frac{x}{500}
\]

\[
x = 13175 \text{ J}
\]

2. % Energy Efficiency = \frac{\text{Amount of useful energy}}{\text{Amount of energy consumed}} \times 100

\text{Amount of useful energy: this is the energy used to heat the hot water. This is the total energy minus any energy that is wasted}

\[
38 000 - 7 600 - 1 900 \text{ kJ} = 28 500 \text{ kJ}
\]

\[
\text{% Energy Efficiency} = \frac{28 500}{38 000} \times 100 = 75\%
\]
Transformation of Energy: Energy Efficiency

I understand and would be able to explain how to improve the energy efficiency of an electrical appliance

Explanation of Concept(s):
Measures need to be taken to minimize the amount of energy lost in an electrical appliance.

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

Multiple Choice Questions

1. A carpenter is using a drill to make holes in a sheet of plywood, He is using an electric drill that is plugged into the wall. Which of the following are ways of increasing the efficiency of the drilling.

   1) Use a newer (sharper) drill bit.
   2) Use a shorter extension cord.
   3) Use a longer extension cord.

A) 1 only  
B) 2 only  
C) 1 and 2  
D) 1 and 3
2. The following is a schematic of an electric hot water heater that we find in most of our homes.

A cold water pipe intake fills the tank, the electrical elements heat the water which 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.*
Transformation of Energy: 
Distinction between Heat and Temperature

I understand and can describe heat as a form of energy.

Explanation of Concept(s):

The term heat is used to describe energy transfer from one body to another. The flow of heat is a transfer of energy that occurs due to a temperature difference. The unit for heat is the joule (J).

Multiple Choice Questions

1. A pot of water is put on the stove in order to make tea. The boiling water results from the kinetic energy of the excited water molecules. Which of the following statements are false:
   1) Heat is a measure of the energy of these water molecules.
   2) Temperature is a measure of the energy of these water molecules.
   3) The heat energy from the stove top burner is being transformed into energy in the water molecules.
   4) The temperature of the stove top burner is being transformed into energy in the water molecules

   a) 1 and 4
   b) 2 and 3
   c) 2
   d) 4

Constructed Response

2. A boy tightly clutches a snowball in his hands. Explain why the outer surface of the snowball begins to melt and why the boy’s hand becomes cold.

Answers

1. a
2. Heat is transferred from the warm body to the cold body until equilibrium is reached. The hand is cold due to loss of heat energy.
Transformation of Energy: Distinction between Heat and Temperature

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

Explanation of Concept(s):

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

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

Multiple Choice

1. What is a temperature a measure of?
   a) The number of particles
   b) The amount of matter in an object
   c) The movement of particles
   d) The relationship between the volume and mass of a liquid

Constructed Response Question

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

Answers

1. c
2. Heat is thermal energy that is transferred from one object to another. Temperature is the average kinetic energy of particles; it is a measure of heat.
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 would be able to explain the buoyancy of a body in terms of Archimedes' principle.

Key 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:

<table>
<thead>
<tr>
<th>( F(b) ) is greater than ( F(g) )</th>
<th>( F(b) ) is equal to ( F(g) )</th>
<th>( F(b) ) is less than ( F(g) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( F(b) )</td>
<td>( F(b) )</td>
<td>( F(b) )</td>
</tr>
<tr>
<td>Object Rises</td>
<td>Object Maintains depth</td>
<td>Object Sinks</td>
</tr>
<tr>
<td>( F(g) )</td>
<td>( F(g) )</td>
<td>( F(g) )</td>
</tr>
</tbody>
</table>

- There is an upward resultant force
- The object will rise to the surface
- The resultant force is 0
- The object will maintain the same depth in the water
- There is a downward resultant force
- The object will sink to the bottom
Multiple Choice Question:

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) \( F_{(g)} = 10 \text{ N} \)
   \[ F_{(b)} = 5 \text{ N} \]

Constructed Response Question:

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.

Answer:

1. D

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.
Fluids: Pascals Law

Key Concepts:

Pascal’s principle states that when pressure is increased in a closed system, it is distributed equally inside that system. Hydraulic system 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.

Multiple Choice Question:

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.
Constructed Response Question:

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. B
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 would be able to explain the concept of lift in terms of Bernoulli’s principle

Explanation of Concept(s)

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

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

3. 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.

4. 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.
Question:

Two ping-pong balls are suspende from strings. A straw is used to bloe 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.

Answer: D
Motion: Force

Explanation of Concept(s)
1. A **force** is a push or pull on an object. Forces are measured in Newtons, N.

2. 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:

   ![Force Diagram](image)

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

   ![Acceleration Diagram](image)

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

   ![Deceleration Diagram](image)

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

   ![Change Directions Diagram](image)

3. 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.
Practice Questions

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

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 would be able to recognize different types of forces in technical objects or technological systems (e.g. gravitational force in a chute, magnetic force exerted by an electromagnet)

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

1. Gravitational force:
   - It is a force of attraction between two 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/s²
     - What goes up, must come down
     - The Moon exerts a gravitational force on Earth that causes tides

2. Electromagnetic Force:
   - It is the force of attraction or repulsion between two charged objects.
   - When magnets are brought close to one another, a magnetic force of attraction or repulsion acts on them.
   - Electric force exists between stationary charged particles (ex. mechanical, frictional forces)
   - Moving charged particles produce magnetic forces
   - Electromagnetic forces are found in the bonds between atoms

3. Friction
   - 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.

4. Nuclear force:
   - It is a force of attraction between the protons and the neutrons of an atom that keeps them together inside the nucleus.
Multiple Choice Question:

1. A car is accelerating on a highway.

Types of forces are listed below:
   i) Gravitational
   ii) Electromagnetic
   iii) Nuclear
   iv) Frictional

Which forces are acting on the car as it accelerates on the highway?

A) i only
B) i and iv only
C) i and iii only
D) i, ii and iv
**Constructed Response Question:**

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

![Generator Rotor Diagram](http://commons.wikimedia.org/wiki/File:Hawkins_Electrical_Guide_-_Figure_292_-_Eddy_currents_in_a_solid_armature.jpg)

A rotor consists of a metal conductor rotating inside two magnets. Which type(s) of force(s) is/are involved in a generator? Explain.

**Answer**

1. D
2. Acceptable answers are:
   
   *Electromagnetic force because a generator generates an electrical current, which involves the attraction and movement of charged particles (electrons).*

   *Magnetic force because a rotating metal component is subjected to two magnets’ magnetic field, therefore being subjected to forces of attraction and repulsion.*
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 point. 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 is moving at a constant speed.
Multiple Choice Question:

In which of the following drawings is the box in equilibrium?

A) 

\[ \begin{align*}
F &= 5N \\
F &= 10N
\end{align*} \]

B) 

\[ \begin{align*}
F &= 25N \\
F &= 5N
\end{align*} \]

C) 

\[ \begin{align*}
F &= 17N \\
F &= 17N \\
F &= 5N
\end{align*} \]

D) 

\[ \begin{align*}
F &= 17N \\
F &= 17N \\
F &= 5N
\end{align*} \]

Constructed Response Question:

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

Answer:

1. D
2. The resultant force is 0 N because Tina and her bicycle are in equilibrium. She is travelling at a constant speed.
Distinction Between Mass and Weight

Key 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 following formula:

\[ V = \frac{d}{\Delta t} \]

where

- \( v \) = speed (m/s or km/h)
- \( d \) = distance (m or km)
- \( \Delta t \) = variation in time (s or h)

Example:

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

\[ v = \frac{96 \text{ m}}{12 \text{ s}} \]

\[ v = 8 \text{ m/s} \]

The runner’s speed is 8 m/s.

Multiple Choice Question:

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 hours. How far is Quebec city from the departure location?

   A) 330 km
   B) 0.03 km
   C) 36.7 km
   D) 1188 km
**Constructed Response Question:**

2. Four race car drivers are competing for maximum speed achieved on a straight road. The results are shown in the following table:

<table>
<thead>
<tr>
<th>Drivers</th>
<th>Distance Travelled</th>
<th>Elapsed Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver 1</td>
<td>27.39 km</td>
<td>5 minutes</td>
</tr>
<tr>
<td>Driver 2</td>
<td>39 910 m</td>
<td>0.13 h</td>
</tr>
<tr>
<td>Driver 3</td>
<td>59.84 km</td>
<td>20 minutes</td>
</tr>
<tr>
<td>Driver 4</td>
<td>81 250 m</td>
<td>0.25 h</td>
</tr>
</tbody>
</table>

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

**Answers**

1-A

2. Driver 1:  
\[ V = \frac{d}{\Delta t} \]  
\[ V = \frac{27.39 \text{ km}}{0.083 \text{ h}} = 330 \text{ km/h} \]

2. Driver 2:  
\[ V = \frac{d}{\Delta t} \]  
\[ V = \frac{39.91 \text{ km}}{0.13 \text{ h}} = 307 \text{ km/h} \]

2. Driver 3:  
\[ V = \frac{d}{\Delta t} \]  
\[ V = \frac{59.84 \text{ km}}{0.33 \text{ h}} = 180 \text{ km/h} \]

2. Driver 4:  
\[ V = \frac{d}{\Delta t} \]  
\[ V = \frac{81.25 \text{ km}}{0.25 \text{ h}} = 325 \text{ km/h} \]
Force and Motion: Distinction Between Mass and Weight

I can explain the relationship between mass and weight
I would be able to use the equation $F_g = mg$ to calculate mass and weight

Key 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:

$$F_g = m \times g$$

where

- $F_g =$ gravitational force or weight (N)
- $m =$ mass (kg)
- $g =$ intensity of gravitational field (N/kg or m/s²)

- The intensity of the gravitational force on Earth is always equal to 9.8 N/kg (or m/s²).
- 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.

Multiple Choice Question:

1. The following statements contain information about mass or weight.

   i. Measures the amount of matter in an object
   ii. Is measured in Newtons
   iii. Is not a force
   iv. Remains constant regardless of location
   v. Measures the force of gravity on an object
Which of the statements refer to the measurement of mass?

A)  i only  
B)  ii and v only  
C)  i and iv only  
D)  i, iii and iv  

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)  106.2 N  
B)  106.2 kg  
C)  63.6 kg  
D)  63.6 N  

Constructed Response Question:

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

The following information was recorded:

<table>
<thead>
<tr>
<th>Gravitational Force Acting on Object (N)</th>
<th>Mass of Object (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planet 1</td>
<td>10.98</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Planet 2</td>
<td>16.74</td>
</tr>
<tr>
<td></td>
<td>4.5</td>
</tr>
<tr>
<td>Planet 3</td>
<td>60.34</td>
</tr>
<tr>
<td></td>
<td>7</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Planet</th>
<th>Intensity of Gravitational Field (N/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturn</td>
<td>11.27</td>
</tr>
<tr>
<td>Mercury</td>
<td>3.63</td>
</tr>
<tr>
<td>Venus</td>
<td>8.62</td>
</tr>
<tr>
<td>Neptune</td>
<td>11.56</td>
</tr>
<tr>
<td>Mars</td>
<td>3.72</td>
</tr>
</tbody>
</table>

Answers:
1- D  
2-A

3.

<table>
<thead>
<tr>
<th>Planet 1</th>
<th>Planet 2</th>
<th>Planet 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F = mg$</td>
<td>$F = mg$</td>
<td>$F = mg$</td>
</tr>
<tr>
<td>$g = F/m$</td>
<td>$g = F/m$</td>
<td>$g = F/m$</td>
</tr>
<tr>
<td>$g = 10.89 N/3$ kg</td>
<td>$g = 16.74 N/4.5$ kg</td>
<td>$g = 60.34 N/7$ kg</td>
</tr>
<tr>
<td>$g = 3.63$ N/kg</td>
<td>$g = 3.72$ N/kg</td>
<td>$g = 8.62$ N/kg</td>
</tr>
</tbody>
</table>

$\text{Planet 1 is Mercury}$  
$\text{Planet 1 is Mars}$  
$\text{Planet 1 is Venus}$
TECHNOLOGICAL WORLD
Graphical Language: Exploded View

I can interpret an exploded view drawing of a technical object

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

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

e.g. Exploded view of a C-Clamp.
The legend indicates the name and quantity of each numbered part. In this example, there is only one of each part.

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>C-clamp Base</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>Screw swivel</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>Protection pad</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>Shaft screw</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>Tension bar</td>
</tr>
</tbody>
</table>

C-clamp Exploded View Assembly, Steven Combs, Flickr,
http://www.flickr.com/photos/bimp/3897040409/
Graphical Language: Multiview orthogonal Projections

I would be able to draw a multi view orthogonal projection of a simple object.

Explanation of concept:

It is important to understand which view one is looking at when analyzing a drawing diagram. For manufacturing purposes an engineer may need a side view, or another time a top view.

In particular, when a multiview projection of a technological object is being displayed, only the top, front and side views are needed to understand the specifics of the object.

e.g.

```
Top

Front

Side
```
What is the correct FRONT view in the figure below?

Note to students: You should be able to complete multiview projections of simple solids.

*Answer: A*
Graphical Language: Functional Dimensioning

I understand and can use the definition of functional dimensioning

Functional Dimensioning is ‘the set of specific tolerances related to certain parts responsible for the smooth operation of an object’

E.g. the distance between two axes is a determining factor in the operation of sprocket wheels in a gear assembly

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

Explanation of concept:

1. Reminder: Tolerance is the total amount the dimension of a part may vary when it is manufactured.

   \[ 4.27 \pm 0.04 \text{ mm} \] means the manufactured part can measure

   A maximum of \[ 4.27 + 0.04 = 4.31 \text{ mm} \]
   A minimum of \[ 4.27 - 0.04 = 4.23 \text{ mm} \]

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

2. In order to have an object with moving parts, there needs to be ROOM for movement! This bit of space (that allows for components to fit/move properly) is known as play.

3. When the components of an object with moving parts are designed and manufactured, the need for play must be taken into account. The functional dimensioning of the components, is the set of dimensions for those moving components, with the tolerances, so that the object will function when it is assembled. That is, the functional dimensioning ensures there is enough play (but not too much) so that the parts can move freely.
Ex. An axle needs to fit tightly into a wheel so that they rotate together BUT the axle needs a bit of space in order to rotate in the frame of a toy car.

Questions:

1. Refer to the diagram of the wheel, axle and car frame above. Which set of dimensions will allow for the axle to fit into the hole in the car frame?

<table>
<thead>
<tr>
<th>Diameter of Axle (mm)</th>
<th>Diameter of hole in Car Frame (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 5.27 ± 0.03</td>
<td>5.26 ± 0.01</td>
</tr>
<tr>
<td>B 5.26 ± 0.01</td>
<td>5.27 ± 0.03</td>
</tr>
<tr>
<td>C 5.26 ± 0.03</td>
<td>5.27 ± 0.01</td>
</tr>
<tr>
<td>D 5.27 ± 0.01</td>
<td>5.26 ± 0.03</td>
</tr>
</tbody>
</table>

2. Why does functional dimensioning need to be taken into consideration when building an object that uses a rack and pinion system?

Answers:
1. b: component A = 5.25-5.27 mm
   component B = 5.24-5.30 mm
2. There needs to be some space between the rack and pinion to allow for movement. If there was no space between the two components then there would be neither rotation nor translation. If there were too much space, the pinion would slip.
**Graphical Language: Developments**

*I understand how three-dimensional shapes (prism, cylinder, pyramid, cone) can be created from sheet stock (e.g. cardboard boxes, metal air ducts)*

**Explanation of concept:**

There are many objects that start off as a sheet of plastic or metal and, with some folding of edges, become a three dimensional object. In math, the unfolding of a 3D object is called the 'development' or 'net'.

When visualizing the actual three dimensional object from its development/net, keep in mind that separated, nearby edges usually attach to each other.

* e.g. 

---

**Questions:**
1. Which of the following developments does not represent this figure?

![Figure 1](image1)

![Figure 2](image2)

![Figure 3](image3)

![Figure 4](image4)

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

*Answer:*
1. Figure 2
2. A development is needed to see the entire surface area of a technological object. This will help see how the dimensions of the edges of the object fit together.
Graphical Language: Developments

I can draw developments of simple solids (e.g. pyramid, cylinder, cube)

Explanation of concept:

<table>
<thead>
<tr>
<th>Solid</th>
<th>Example of Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyramid</td>
<td>![Pyramid Diagram]</td>
</tr>
<tr>
<td>Cylinder</td>
<td>![Cylinder Diagram]</td>
</tr>
<tr>
<td>Cube</td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td></td>
</tr>
<tr>
<td>Rectangular Prism</td>
<td></td>
</tr>
</tbody>
</table>

![Cube Diagram](image1)

![Rectangular Prism Diagram](image2)
Graphical Language: Standards and Representations

I would be able to choose the appropriate type of diagram for a given representation. E.g. use a construction diagram to represent assembly solutions, a diagram of principles to represent the operation of an object.

Explanation of concept:

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

**Design plans**: focuses on the forces applied to the object and the resulting motion of parts of an object.

**Technical diagram**: focuses on specific building information for an object.  
Ex. To properly manufacture scissors, you need a diagram with labeled parts, materials needed, any links/guides and dimensions of specific components.

**Circuit diagram**: focuses on the electrical components a circuit.
Graphical Language: Standards and Representations

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

I can identify and use force and motion symbols.

### Motion and Force Symbols

<table>
<thead>
<tr>
<th>Motion</th>
<th>Force</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motion is characterized by the change in the position of a body relative to another, which is called an <em>inertial</em> or <em>non-inertial reference system</em>.</td>
<td>Force refers to the capacity to act or produce an effect or any action that changes a body’s state of rest or motion.</td>
</tr>
<tr>
<td>Rectilinear translation in one direction</td>
<td>Force that tends to STRETCH the bodies or PULL them.</td>
</tr>
<tr>
<td>Rectilinear translation in two directions</td>
<td>Force that tends to SQUEEZE the bodies or PUSH them.</td>
</tr>
<tr>
<td>Rotation in one direction</td>
<td>Force that tends to TWIST bodies.</td>
</tr>
<tr>
<td>Rotation in two directions</td>
<td>Force that tends to SPLIT bodies.</td>
</tr>
<tr>
<td>Helical</td>
<td></td>
</tr>
</tbody>
</table>
Mechanical Engineering: Adhesion and Friction of Parts

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

Explanation of Concept(s)

1. **Adhesion** occurs when two surfaces can remain in contact with each other without slipping. Ex. The tires of a car adhere to the road.

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

3. Sometimes some adhesion and friction is desired between moving parts of a technical object. Ex. When the brakes are applied on a bicycle, the friction between the brake pads and the wheel, slows the motion of the wheel.

4. Sometimes friction and adhesion needs to be minimized between parts. In machines with moving parts, friction can cause the parts to wear down or a build up of heat. Friction is often reduced by adding a lubricant.

5. The amount of friction or adhesion between parts can be taken into account in the design of objects. Different factors affect the amount of adhesion between surfaces.
   - The nature of the material (ex. 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 the surface
Mechanical Engineering: Linking of Mechanical Parts

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

Explanation of Concept(s)

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

8. Every link displays four basic characteristics:

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Description</th>
<th>OR</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>direct</strong></td>
<td>two parts held together without a linking component</td>
<td>OR</td>
<td><strong>indirect</strong></td>
</tr>
<tr>
<td><strong>rigid</strong></td>
<td>the linking component or surface of the linked parts are rigid</td>
<td>OR</td>
<td><strong>flexible</strong></td>
</tr>
<tr>
<td><strong>removable</strong></td>
<td>the linked parts can be separated without damaging either their surfaces or the linking component</td>
<td>OR</td>
<td><strong>non-removable</strong></td>
</tr>
<tr>
<td><strong>complete</strong></td>
<td>the linking component prevents the two parts from moving independently of one another</td>
<td>OR</td>
<td><strong>partial</strong></td>
</tr>
</tbody>
</table>
Practice Questions
2. State the four characteristics of the link between the components identified in each image below.

a) Direct or Indirect
   Complete or Partial
   Removable or Non-removable
   Rigid or Flexible
   (Note: the shelves are glued in place)

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

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

Answers:
2. a) Indirect, complete, non-removable, rigid
   b) Direct, complete, removable, rigid
   c) Direct, complete, removable, rigid
Mechanical Engineering: Linking of Mechanical Parts

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

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

Example:

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

1. A metal shelf needs to be permanently attached to a metal frame. Which linking component should be used to secure the shelf to the frame?
   - a. Glue
   - b. Nail
   - c. Screw
   - d. Rivet

2. Inside a hockey helmet there is a layer of flexible padding to protect the player’s head. It is held in place with glue. What are the characteristics of the link between the padding and the helmet? Explain each characteristic.

---

**Answers:**

1. D

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

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

Explanation of Concept(s)
1. 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:

<table>
<thead>
<tr>
<th>Assembly Solutions for A Wheelbarrow</th>
</tr>
</thead>
<tbody>
<tr>
<td>• To allow for maximum durability, one piece of metal is chosen for the wheelbarrow tray. The tray is welded to the metal brace to allow for a rigid and permanent link.</td>
</tr>
<tr>
<td>• A bolt is used to link the wheel rim with the axle bracket. This allows for the wheel to be removed and replaced if necessary as well as for the movement of the wheel.</td>
</tr>
</tbody>
</table>

Practice 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

**Explanation of Concept(s)**

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

2. 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.

3. 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.

I understand and would be able to explain the purpose of limiting motion (degrees of freedom) in a technical object.
Mechanical Engineering: Guiding Control

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

Explanation of Concept(s)
1. 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.

2. There are three main forms 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 opened.

   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 about the same axis.

      Threads inside the frame of the C-clamp control the helical guiding of the threaded shank.
Practice Questions
1. Which of the following is not a type of guiding control?
   a. Translational
   b. Seal
   c. Helical
   d. Rotational

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

   a. 
   b. 
   c. 
   d. 
   e. 
   f. 

Answers:
1. B
2. a. helical
   b. translational
   c. translational
   d. rotational
   e. helical
   f. rotational
Mechanical Engineering: Motion Transmission Systems

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

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

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

3. Symbols for Friction Gears

<table>
<thead>
<tr>
<th>Friction Gears (side by side)</th>
<th>Friction Gears (vertical and horizontal)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Friction Gears Side by Side" /></td>
<td><img src="image2" alt="Friction Gears Vertical and Horizontal" /></td>
</tr>
</tbody>
</table>
Practice Questions
1. Friction gears operate on the concept of using friction between at least two wheels. Which of the following is false?
   a. Friction gears are economical.
   b. They can be used to transmit motion of parts that are close together.
   c. They are non-reversible.
   d. The touching wheels move in opposite directions.

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

A   B   C   D

a. Clockwise
b. It be turning the same direction like wheel A
c. It will be turning the same direction like wheel C
d. Counter clockwise

Answers:
1. C
2. D
Mechanical Engineering: Motion Transmission Systems

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

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

3. Symbol for Belt and Pulley Systems

![Symbol for Belt and Pulley Systems]

Practice Questions
1. Belt and pulley systems use a belt to connect at least two pulleys together. Which of the following is false?
   a. Belt and pulley systems are used to transmit motion between parts that are farther apart.
   b. The smaller the pulley the slower it turns.
   c. Only the pulleys that touch the same side of the belt will turn in the same direction.
   d. The motion can be reversed.

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

a. As the motor and pulley wheel spin, how fast will the pulley wheel spin in relation to the first wheel?

b. Explain why the belt and pulley system is an advantageous choice to this simple solution for a water pump.

Answers:
1. B
2. a. The pulley wheel will spin slower in relation to the motor driven pulley wheel. The larger the pulley the slower it spins.

   b. There are several components in this invention that need to work together. The motor and connecting rod are two key parts to this assembly, as such they need to be connected to each other and the best solution is a belt and pulley system because the motor and connecting rod are components that are farther apart from each other. One pulley will be attached to the motor and the other to the connecting rod. With the help of a belt, the motion of the motor is easily transferred to the pulley attached to the connecting rod. The rotational motion of the connecting rod is transferred into translational motion which is what creates the pump action.
Explanation of Concept(s)
1. Characteristics of Gear Assembly Systems
   - At least two gears that meet and fit perfectly into one another.
   - Slippage between gears prevented by interlocking Gear teeth
   - Used to transmit motion between parts that are close together.
   - Can reverse motion.

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

3. Symbol for Gear Assembly Systems

Practice Questions
1. Gear trains are used to transmit motion between objects that are close together. Which of the following statements is false?
   a. The teeth of either gear can be of different shapes in the same system.
   b. The teeth guarantee much less slipping between the parts.
   c. The more teeth there are in a gear the slower it turns.
   d. The less teeth there are in a gear the faster it turns.
2. For the following image, what direction will the largest gear turn if the first gear on the left is turning in a counter clockwise direction?

   a. Clockwise
   b. Counter Clockwise

**Answers:**
1. A
2. B
Mechanical Engineering: Motion Transmission Systems

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

Explanation of Concept(s)
1. Characteristics of Sprocket Wheels and Chain Systems
   • The teeth on the sprockets must be identical as ONE chain must fit on all sprockets in the system.
   • The links in the chain are designed to fit securely on the teeth of the sprockets.
   • This system requires lubrication such as grease or oil on a regular basis to avoid wear and tear.
   • The larger the sprocket the slower it turns and vice versa.

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

3. Symbol for Sprocket Wheels and Chain Systems

Practice Questions
1. Chain and sprocket systems are used to link gears that are separated by distance. Which of the following statements is false?
   a. The chain must fit directly into the gear teeth in order for the system to work.
   b. The system requires lubrication in order to maintain its efficiency.
   c. The larger the sprocket the slower it turns.
   d. The smaller the sprocket the slower it turns.
2. If gear A is turning counter clockwise, indicate the correct combination of answers that indicate the direction all the other gears are rotating.

<table>
<thead>
<tr>
<th></th>
<th>Gear A</th>
<th>Gear B</th>
<th>Gear C</th>
<th>Gear D</th>
</tr>
</thead>
<tbody>
<tr>
<td>A)</td>
<td>![Diagram]</td>
<td>![Diagram]</td>
<td>![Diagram]</td>
<td>![Diagram]</td>
</tr>
<tr>
<td>B)</td>
<td>![Diagram]</td>
<td>![Diagram]</td>
<td>![Diagram]</td>
<td>![Diagram]</td>
</tr>
<tr>
<td>C)</td>
<td>![Diagram]</td>
<td>![Diagram]</td>
<td>![Diagram]</td>
<td>![Diagram]</td>
</tr>
<tr>
<td>D)</td>
<td>![Diagram]</td>
<td>![Diagram]</td>
<td>![Diagram]</td>
<td>![Diagram]</td>
</tr>
</tbody>
</table>

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

**Answers:**
1. D
2. D
3. The chain should be on the smallest possible drive gear. This smaller gear will require less torque to be rotated. This will allow the biker to pedal more but would take less force/effort to go up the hill.
Explanation of Concept(s)
1. Characteristics of Wheel and Worm Gear Systems
   • Made from a single worm (screw) that rotates. This motion is transmitted to one or more wheel gears.
   • The worm can turn continuously.
   • Movement is very slow however.
   • Motion CANNOT be reversed.

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

3. Symbol for Wheel and Worm Gear Systems

Practice Questions
1. Worm and wheel gear systems are used to greatly reduce the speed of systems. Which of the following statement is true?
   a. The motion cannot be reversed and if it is forced it could break the system.
   b. The teeth do not have to match up because the pieces generally look different from each other.
   c. The worm has limited turning capabilities. It eventually stops.
   d. The movement is very fast in this system.

2. The image below shows the motion transmission system that is used to direct the chute of a snow blower.
a. Why do you think a wheel and worm system was chosen for this part?
b. If the snow blower user decides to turn the chute manually, the motion transmission system could be damaged. Explain why.

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

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

### Explanation of Concept(s)

1. Symbols for Motion Transmission Systems

<table>
<thead>
<tr>
<th>System</th>
<th>Diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friction Gears</td>
<td><img src="friction_gears.png" alt="Friction Gears Diagram" /></td>
</tr>
<tr>
<td>Belt and Pulley</td>
<td><img src="belt_pulley.png" alt="Belt and Pulley Diagram" /></td>
</tr>
<tr>
<td>Gear Train</td>
<td><img src="gear_train.png" alt="Gear Train Diagram" /></td>
</tr>
<tr>
<td>Chain and Sprocket</td>
<td><img src="chain_sprocket.png" alt="Chain and Sprocket Diagram" /></td>
</tr>
<tr>
<td>Wheel and Worm Gear</td>
<td><img src="wheel_worm_gear.png" alt="Wheel and Worm Gear Diagram" /></td>
</tr>
</tbody>
</table>
Practice Questions
1. Look at the motion transmission systems below and identify the ones whose rotational motions are correctly illustrated.

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

Answers:
1. B and C
2. B and D
Mechanical Engineering: Motion Transmission Systems

I would be able to explain the choice of a motion transmission system in a technical object
e.g., Using a gear assembly rather than friction gears to get better engine torque and avoid slipping

Explanation of Concept(s)
1. Several motion transmission systems have been created in order to complete different tasks. In some situations, a combination of these transmission systems is used together. In the engineering process, one must consider which transmission systems are necessary and more advantageous than others when making a technological object. Being able to identify and explain these advantages involves the understanding of each of these systems. (For an explanation of these systems refer back to friction gears, belt and pulley, gear trains, chain and sprocket and worm and worm gear systems).

Example:

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

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

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

**Explanation of Concept(s)**

1. Characteristics and Construction of Screw Gear Systems
   - A screw gear, also known as a worm gear, is a gear consisting of a spirally threaded shaft and a wheel with marginal teeth that mesh into it.
   - There are two types of screw gear systems that can transform motion from rotational $\rightarrow$ translational.

   **Type 1:**
   - The screw is the driver that transforms rotational motion into translational motion.
     The nut, attached to the screw, must connect in a way that does not allow it to rotate independently from the screw.

   **Type 2:**
   - The nut is the driver that transforms rotational motion into translational motion.
     The nut must be fixed in a way that only allows for rotation.

2. Symbol for Screw Gear Systems

<table>
<thead>
<tr>
<th>Type 1</th>
<th>Type 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Type 1 Diagram" /></td>
<td><img src="image2.png" alt="Type 2 Diagram" /></td>
</tr>
</tbody>
</table>
Practice Questions
1. Which of the examples below is a Type 1 screw gear system?
   a. A jack for lifting cars
   b. A wrench
   c. Gears of a clock
   d. Pistons of a car

2. State the driver component for type 1 and type 2 screw gear systems.

Answers:
1. A
2. Type 1: The screw
   Type 2: The nut
Mechanical Engineering: Motion Transformation Systems

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

Explanation of Concept(s)
1. Characteristics and Construction of Cam Systems
   - A cam is a rotating mechanism used especially in transforming rotational motion to translational motion.
   - A cam and follower is formed by the direct contact of two mechanisms. The driver part is called the cam and the part that is driven through the direct contact of their surfaces is called the follower. The shape of the contacting surfaces of the cam and follower determines the movement of the mechanism.

2. Symbol for Cam Systems

![Symbol for Cam Systems](image)

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

   a. ![Cam A](image)  
   b. ![Cam B](image)  
   c. ![Cam C](image)  
   d. ![Cam D](image)

**Answers:**
1. D
Mechanical Engineering: Motion Transformation Systems

Explanation of Concept(s)
1. Characteristics and Construction of Connecting Rod Systems
   - A connecting rod acts as a link for transmitting motion from the crank to the slide. Together with the crank, they form a simple mechanism that converts translational motion into rotational motion. Connecting rods allow for reversibility, able to convert rotational motion into translational motion.

2. Symbol for Connecting Rod Systems

Practice Questions
1. Which of the following is a true statement about connecting rods?
   a. A connecting rod is attached to only one moving mechanism.
   b. A connecting rod can allow for reversibility in a system
   c. A connecting rod is always needed to transform rotational to translational motion.
   d. A connecting rod can function without being attached to the system.

2. Explain the purpose of the connecting rod in a motion transformation system.

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

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

Explanation of Concept(s)
1. Characteristics and Construction of Slide Systems
   - Slides can allow for the transformation of linear motion to rotational motion and vice-versa.

2. Symbol for Slide Systems

<table>
<thead>
<tr>
<th>Crank and Slide</th>
<th>Lever and Slide</th>
</tr>
</thead>
</table>

Practice Questions
1. Which statement is false about slides?
   a. Slides allow for different types of translational motion.
   b. Slides are an example of a connecting rod.
   c. Slides never allow for reversibility of motion.
   d. Slides connect two mechanisms to transform motion from one to another.

2. Slides can often be seen on the side of old locomotives. Explain the purpose for the slide on the locomotive.

Answers:
1. C
2. The slide on the locomotive’s wheels allows the transformation of linear motion to rotational motion of the wheel along the track.
Mechanical Engineering: Motion Transformation Systems

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

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

   ![Diagram of Crank System]

   - The connecting rod (or slider) is linked to the crank pin and transfers the movement.
   - The crank shaft both supports the crank and rotates it.

**Practice Questions**
1. Which of the following is not an example of a mechanism that uses a crank to transform motion?
   - a. A wishing well
   - b. Internal combustion engine
   - c. A wrench
   - d. A winch

2. Explain the difference between a crank and a cam.

---

**Answers:**
1. C
2. *The difference between cranks and cams is that cranks only ever work in a rotational motion and only have one drive action per revolution.*
I understand the construction and characteristics of rotating slider crank mechanisms as a motion transformation system

Explanation of Concept(s)
1. Characteristics and Construction of Rotating Slider Crank Mechanism Systems
   - Slider-crank mechanisms involve both rotational and translational motion. For most of these mechanisms, a crank rotates at constant speed in order to repeatedly move an object in a linear motion to perform some task. This device is a simple way to convert rotational motion to translational motion and has the ability to be reversible.
Mechanical Engineering: Motion Transformation Systems

Explanation of Concept(s)
1. Characteristics and Construction of Rack-and-Pinion Drive Systems
   • Rack and pinion is a type of mechanism that is comprised of a pair of gears which convert rotational motion into translational motion. A circular gear called "the pinion" engages teeth on a linear "gear" bar called "the rack".
   • A rack and pinion system is reversible.
   • Rotational motion applied to the pinion causes the rack to move, thereby transforming the rotational motion of the pinion into the translational motion of the rack. The linear motion of the rack can cause the pinion to rotate, transforming linear motion into rotational motion.

2. Symbol for Rack-and-Pinion Drive Systems

Practice Questions
1. If the pinion in the diagram below rotates in a clockwise direction, in which direction does the rack move?

Answers:
1. To the left
Mechanical Engineering: Motion Transformation Systems

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

Explanation of Concept(s)
1. Symbols for Motion Transformation Systems

<table>
<thead>
<tr>
<th>TRANSFORMATION OF MOTION:</th>
<th>Rack and pinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical action that changes the nature of motion (rotation to translation, translation to rotation)</td>
<td></td>
</tr>
</tbody>
</table>

- **Crank and slide**

- **Connecting rod and crank**

<table>
<thead>
<tr>
<th>Screw and nut</th>
<th>Screw and nut</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cam and roller</strong></td>
<td><strong>Crank and slide</strong></td>
</tr>
</tbody>
</table>

**Answers:**
Mechanical Engineering: Motion Transformation Systems

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

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

Explanation of Concept(s)
1. When observing the motion transformation system of a technical object engineers must judge the appropriate choice for the use and construction of the systems used.

Example:

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

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

2. What is the purpose of the spring in this cam system?

Answers:
1. A
2. The spring ensures the constant pressure of the follower on the surface of the cam.
Mechanical Engineering: Speed Changes

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

   Remember:
   - **Driver (Driving) Component:** The component that receives the force needed for the system to start working and in most cases continue to work.
   - **Driven Component:** This component receives the motion from the driver component and transfers it to another part.
   - **Intermediate Component:** It is found between the driver and driven component.
     *Note that not all systems have this.

2. Factors that affect Speed Changes
   - The change of speed in motion transmission systems depends on:
     - Gear diameter
     - Number of teeth

   Example:

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

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

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

   A) 
   B) 
   C) 
   D) 

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

   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 fewer teeth means less time having each tooth mesh with this respective part on the worm component.

Answers:
1. A
2. 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 fewer teeth means less time having each tooth mesh with this respective part on the worm component.
Explanation of Concept(s)
1. Power supply is the ability to generate electrical current. A battery is an example of a power supply.

Practice 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

Explanation of Concept(s)
1. Sources of Energy:
   - Chemical battery: Chemical reactions inside the battery transform chemical energy into electrical energy.
   - Piezoelectric: Mechanical energy from vibrating crystals is transformed into electrical energy. Piezoelectric crystals are found in clocks, timers, lighters, ultra sound devices and speakers.
   - Solar cells: When sunlight hits the solar cells an imbalance of electrons is produced causing an electric current. Therefore solar energy is transformed electrical energy.
   - Alternator: The mechanical energy of a rotating electromagnet is transformed into electrical energy.
   - Thermocouple: Thermal energy is transformed into electrical energy. A thermocouple is a sensor. Examples include digital food thermometers, fridge thermometer, gas stoves and heaters.

Practice Questions
1. A battery is a power source used in everyday objects. Which of the following objects does not use a chemical battery as a power supply?
   a. Flashlight
   b. Portable speakers
   c. Toaster
   d. Laptop

2. A piezoelectric quartz watch uses the vibration of crystals to keep track of time. Which type of energy transformation occurs in this system?
   a. Chemical energy into electrical energy
   b. Solar energy into electrical energy
   c. Magnetic energy into electrical energy
   d. Mechanical energy into electrical energy
3. Paul’s calculator screen is dull when he sits in his living room where there is little light. When he walks into a well-lit room, the screen becomes brighter. What is the source of current in his calculator?

Answers:
1. C
2. D
3. Solar cell
Electrical Engineering: Conduction, Insulation and Protection

Explanation of Concept(s)
1. Conduction is the ability to conduct electricity. It allows the current/electrons to flow through a material, such as a metal.

Practice Questions
1. Conduction plays an important part in an electrical circuit. Which of the following does NOT describe conduction?
   a. The flow of current through a switch
   b. The flow of current through a wire
   c. The flow of electrons through a wire
   d. The ability to prevent the current from flowing

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

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

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

Explanation of Concept(s)
1. Conductors vs. Insulators
   • Conductors: Substances that allow current to flow through them. Examples of good conductors are metals and electrolytic solutions.
   • Insulators: Substances that do not allow current to pass through them. Examples of good insulators are wood, plastics, paper, rubber, glass and ceramics.

Practice Questions
1. Insulators are used in electronic toys. What material could a manufacturer use to insulate a part of a toy?
   
   i. Plastic
   ii. Ceramic
   iii. Metal
   iv. Cardboard
   v. Glass

   a. i, ii, iv
   b. i, ii, v
   c. i, ii, iv, v
   d. i, ii, iii, iv, v
2. You are asked to build a circuit that will light up one light bulb with a switch. You have no wires available. The only materials in the classroom are listed below.

<table>
<thead>
<tr>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chalk</td>
</tr>
<tr>
<td>Carboard</td>
</tr>
<tr>
<td>Wooden spoon</td>
</tr>
<tr>
<td>Metal knife</td>
</tr>
<tr>
<td>Plastic fork</td>
</tr>
<tr>
<td>Nail</td>
</tr>
<tr>
<td>Ceramic coaster</td>
</tr>
<tr>
<td>Paperclip</td>
</tr>
</tbody>
</table>

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

3. An ammeter is used to measure the current intensity; a voltmeter measures the potential difference in a circuit. Why do the knobs on an ammeter and a voltmeter have plastic casings over the metal components?

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

1. Role of Fuses and Breakers
   - Fuses and breakers are used to protect electrical circuits. A high current intensity can result in a power surge which can damage electrical devices in a circuit and/or cause a fire. The protective components will then automatically cut off the flow of electrons (current) when there is too much of it passing through.

2. Fuses vs. Breakers
   - Fuses: Contain a thin wire that melts and breaks the circuit when there is too much current. The fuse needs to be replaced to restore the circuit.
   - Breakers: Contain a thin metal strip. When too much current passes through the breaker the metal becomes hot and bends. The metal is no longer in contact with the circuit and the current cannot pass through the breaker. Breakers can be used multiple times. By resetting the switch on a breaker the metal strip is returned to its original position and the current is restored.

Practice Questions
1. Fuses and breakers are used in all buildings. What is the function of a fuse and breaker?
   - a. Control the flow of the current
   - b. Prevent the current from flowing
   - c. Automatically cut the current
   - d. Allow the current to flow in a circuit

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

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

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

Explanation of Concept(s)
1. Factors that Affect Electrical Conductivity:
   - The conductivity of a substance (how well it conducts) depends on the type of material, length, diameter and the temperature of the conductor.

   The conductivity of a conducting wire can be increased by:
   - Increasing the diameter of the wire
   - Decreasing the temperature of the wire
   - Decreasing the length of the wire
   - Changing the type of material (copper is one of the best and most affordable materials)

Practice Questions
1. The conductivity of a wire in an electrical toy needs to be decreased. What should the electrical engineers do to the wire?
   - Increase the length
   - Increase the diameter
   - Decrease the length
   - Decrease the diameter

   a. i, ii
   b. i, iv
   c. ii, iii
   d. ii, iv
2. Which of the following copper wires in the table below has the best conductivity? Explain your answer.

Properties of different wires

<table>
<thead>
<tr>
<th>Wire</th>
<th>Length</th>
<th>Diameter</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10 m</td>
<td>2 mm</td>
<td>25 °C</td>
</tr>
<tr>
<td>B</td>
<td>10 m</td>
<td>3 mm</td>
<td>20 °C</td>
</tr>
<tr>
<td>C</td>
<td>20 m</td>
<td>2 mm</td>
<td>20 °C</td>
</tr>
<tr>
<td>D</td>
<td>20 m</td>
<td>3 mm</td>
<td>25 °C</td>
</tr>
</tbody>
</table>

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 would be able to use the colour code to determine the electrical resistance of a resistor*

Explanation of concept:

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

The electrical resistance of a resistor is marked using a colour code. The coloured bands on a resistor indicate the resistance of a resistor.

*The results will give a range of the resistance of the resistor.*

To calculate the range of resistance;

1) The first band is associated with the first digit.
2) The second band is associated with the second digit.
3) The third band is associated with the multiplier (x 10^n)
4) 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 Colour Chart*

<table>
<thead>
<tr>
<th>Colour</th>
<th>Black</th>
<th>Brown</th>
<th>Red</th>
<th>orange</th>
<th>Yellow</th>
<th>Green</th>
<th>Blue</th>
<th>Purple</th>
<th>Grey</th>
<th>White</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digit</td>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Multiplier</td>
<td>10^0</td>
<td>10^1</td>
<td>10^2</td>
<td>10^3</td>
<td>10^4</td>
<td>10^5</td>
<td>10^6</td>
<td>10^7</td>
<td>10^8</td>
<td>10^9</td>
</tr>
</tbody>
</table>

Ex. Given the following resistor, calculate the value of the range of resistance.

- 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 ± 10%

So; $32 \times 10^5 \pm 10\%$ Ω is the value of this resistor.
To take the range further, find how much 10% is of 3 200 000 (i.e. 32 x 10^5)

3 200 000 x 0.1 = 320 000

Now take that value and both add and subtract it from 3 200 000.
3 200 000 – 320 000 = 2 880 000
3 200 000 + 320 000 = 3 520 000

Range of resistance: 2 880 000 – 3 520 000 Ω

Questions:

a) Based on the chart above, what is the value of the resistance of a resistor with the coloured bands: blue, green, red and gold?

b) What are the minimum and maximum values determined by the tolerance?

Answers:

a) 65 x 10^2 ± 5% Ω
b) 6 175 – 6 825 Ω
Electrical Engineering: Control

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

Explanation of Concept(s)
1. Explanation of Control:
   A control is also known as a switch. When a switch is closed, current can flow through the circuit. When the switch is open, the current’s pathway is broken and cannot flow through the circuit.

Practice Questions
1. Controls play an important role in electrical engineering. Which of the following statement DOES NOT correctly describe a control?
   a. A control is another word for switch
   b. A control regulates the electrical current in a circuit
   c. A control can be open or closed
   d. A control regulates the speed of electrons in a circuit

2. A switch is a component of a circuit. Why is a switch is classified as a control?

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

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

Practice Questions

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

   i. The magnetic switch is closed in the presence of a magnetic field
   ii. The magnetic switch is open in the presence of a magnetic field
   iii. The flip-flop switch is closed in a circuit.
   iv. The flip-flop switch is open in a circuit.

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

Answers:
1. A

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

A control (or switch)’s function is to open and close an electrical circuit. Different types of switches exist.

- A unipolar (single –pole) switch has one conductive bar and opens and closes one contact at a time.
- A bipolar switch (double-pole) has two conductive bars and opens and closes two contacts 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.

Different types of switches can be combined:

<table>
<thead>
<tr>
<th>Switch Description</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>S₁</strong> Unipolar/unidirectional switch <em>(single pole/single throw)</em></td>
<td>![S1]</td>
</tr>
<tr>
<td>a single conductive bar, used for one circuit (in series or in parallel), that can open or close a circuit in one direction.</td>
<td></td>
</tr>
<tr>
<td><strong>S₂</strong> Unipolar/bidirectional switch <em>(single pole/double throw)</em></td>
<td>![S2]</td>
</tr>
<tr>
<td>a single conductive bar, used to open/close one of two circuits.</td>
<td></td>
</tr>
<tr>
<td><strong>S₃</strong> Bipolar/unidirectional switch <em>(double pole/single throw)</em></td>
<td>![S3]</td>
</tr>
<tr>
<td>a double conductive bar, used to open/close two circuits.</td>
<td></td>
</tr>
<tr>
<td><strong>S₄</strong> Bipolar/bidirectional switch <em>(double pole/double throw)</em></td>
<td>![S4]</td>
</tr>
<tr>
<td>a double conductive bar, used to open/close four circuits, but only two at the same time.</td>
<td></td>
</tr>
</tbody>
</table>
Question:

1. What type of switch is needed in a device where two circuits are closed at the same time? Explain.

Answer:
1. A double pole, single throw or double pole, double throw, will allow for two circuits to run an electric current through it.
Electrical Engineering: Transformation of Energy

I would be able to identify and explain the transformation of energy in different components of a circuit
e.g., Bulbs transform electrical energy into light and heat

Explanation of Concept(s)
1. Electrical energy can be transformed into light energy, sound energy, mechanical energy or thermal energy.

Remember: Batteries transform chemical energy into electrical energy.

Practice Questions
1. A battery transforms chemical energy into electrical energy. Which of the following components of a circuit transforms energy?
   i. LED light
   ii. switch
   iii. battery
   iv. wires
   a. ii, iv
   b. i, iii
   c. i, ii, iii
   d. i, iii, iv

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.

Answers:
1. B
2. A doorbell transfers electrical energy into sound energy. The light of the doorbell will transfer electrical energy to light energy.
I would be able to describe the energy transformations that take place in electrical or electronic appliances

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

Explanation of Concept(s)
1. Energy Transformations in Electrical/Electronic Devices
   - Electronics and electrical appliances transform electrical energy into other forms of energy depending on the device used in the system.

   Electrical Energy can be transformed into:
   - Light (luminous) Energy
   - Sound Energy
   - Mechanical (movement) Energy
   - Thermal (heat) Energy.

Practice Questions
1. Electrical energy in a fan is transformed into:
   a. Sound energy
   b. Mechanical energy
   c. Thermal energy
   d. Light energy
2. Identify the transformations that occur in each of the appliances listed below as electrical energy is transformed into other forms of energy.

<table>
<thead>
<tr>
<th>Appliance</th>
<th>Useful energy (purpose of appliance)</th>
<th>Other form(s) of energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>T.V.</td>
<td>Light, sound</td>
<td>Thermal</td>
</tr>
<tr>
<td>Toaster</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flashlight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hairdryer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radio</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Answers:
1. B
2. 

<table>
<thead>
<tr>
<th>Appliance</th>
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<tr>
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<td>Thermal, Mechanical</td>
<td>Light</td>
</tr>
<tr>
<td>Flashlight</td>
<td>Light</td>
<td>Thermal</td>
</tr>
<tr>
<td>Blender</td>
<td>Mechanical</td>
<td>Sound, Thermal</td>
</tr>
<tr>
<td>Hairdryer</td>
<td>Thermal, Mechanical</td>
<td>Sound</td>
</tr>
<tr>
<td>Radio</td>
<td>Sound, Light</td>
<td>Thermal</td>
</tr>
</tbody>
</table>
Electrical Engineering: Other functions

I understand and would be able to describe the function of a diode

Explanation of concept:

**Diode**: an electronic component that only allows current to travel in one direction within a circuit.

Light emitting diodes (LEDs) give off light when a current flows through them. The current must flow in the correct direction for the diode to function.

**Diode operation**

- **Current permitted**
  - Positive current flow from anode to cathode
- **Current prohibited**
  - Negative current flow from anode to cathode

https://commons.wikimedia.org/wiki/File:Diode_pinout_en_fr.svg

Question:
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

Answer: D
**Electrical Engineering: Other functions**

*I understand and would be able to describe the function of a transistor*

**Explanation of concept:**

**Transistor:** Transistors can control the movement of current. A transistor can boost or completely stop an electric current from flowing through a circuit. It is made up of a casing and three mini-components. They are typically made from semiconducting material like silicon.

<table>
<thead>
<tr>
<th>Component</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector</td>
<td>allows the electrons to enter the transistor.</td>
</tr>
<tr>
<td>Base</td>
<td>the amount of current in the base determines whether the current will flow from the Collector to the Base.</td>
</tr>
<tr>
<td>Emitter</td>
<td>allows the current to exit the transistor.</td>
</tr>
</tbody>
</table>

Transistors are used as switches or amplifiers and are found as a component in a wide variety of electrical circuits.
Materials: Constraints

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

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

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

Explanation of Concept(s)

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

2. Types of Constraints and Their Symbols:

<table>
<thead>
<tr>
<th>Type of Constraint</th>
<th>Description</th>
<th>Symbol</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression</td>
<td>Forces that tend to crush it.</td>
<td></td>
<td>Crushing a can. Squeezing a wet sponge.</td>
</tr>
<tr>
<td>Tension</td>
<td>Forces that tend to stretch it.</td>
<td></td>
<td>Copper being stretched into wire. Tug of war.</td>
</tr>
<tr>
<td>Torsion</td>
<td>Forces that tend to twist it.</td>
<td></td>
<td>Hands wringing a towel. Earthquake twisting a bridge.</td>
</tr>
<tr>
<td>Deflection</td>
<td>Forces that tend to bend it.</td>
<td></td>
<td>Fish bending a fishing rod. Clothes pushing down on a clothesline.</td>
</tr>
<tr>
<td>Shearing</td>
<td>Forces that tend to cut.</td>
<td></td>
<td>Scissors cutting paper.</td>
</tr>
</tbody>
</table>
Practice 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. When building a tall structure like a skyscraper, engineers have to take into consideration the many constraints that the building will be subjected to. What constraints do you think a skyscraper would have to endure?

Answers:
1. C
2. B
3. A tall building undergoes deflection. The higher the building the more it needs to deal with wind so the materials used to build the building need to take into account a bit of movement due to wind. It also deals greatly with Compression. The weight of all the materials used in construction subjects the entire building to a regular degree of compression.
Explanation of Concept(s)

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

2. Types of Mechanical Properties

<table>
<thead>
<tr>
<th>Mechanical Property</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hardness</strong></td>
<td>Ability to resist indentation (nicks) or abrasion (scratches).</td>
</tr>
<tr>
<td><strong>Elasticity</strong></td>
<td>Ability to return to their original shapes after undergoing a constraint.</td>
</tr>
<tr>
<td><strong>Resilience</strong></td>
<td>Ability to resist shocks without breaking.</td>
</tr>
<tr>
<td><strong>Ductility</strong></td>
<td>Ability to be stretched without breaking.</td>
</tr>
<tr>
<td><strong>Malleability</strong></td>
<td>Ability to be flattened or bent without breaking.</td>
</tr>
<tr>
<td><strong>Stiffness</strong></td>
<td>Ability to retain their shapes when subjected to various constraints.</td>
</tr>
</tbody>
</table>
Materials: Other Properties

I understand and can define certain properties of materials

Other Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance to Corrosion</td>
<td>Ability to resist the effects of corrosive substances, which cause the formation or rust for example.</td>
</tr>
<tr>
<td>Electrical Conductivity</td>
<td>Ability to carry an electric current.</td>
</tr>
<tr>
<td>Thermal Conductivity</td>
<td>Ability to transmit heat.</td>
</tr>
</tbody>
</table>

Practice Questions (refers to previous 2 statements)
1. What mechanical properties were desired when choosing materials for a hard-hat?

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

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

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

Explanation of Concept(s)
1. Materials used in construction of technical objects have different properties. When choosing a material for an object, the forces or constraints the object will be subjected to will help determine which material is most suitable.

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

Practice Questions
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. Wheels
   b. Body Frame
   c. Seats

2. Why would a homeowner choose a ceramic floor in the kitchen and bathroom rather than a wooden floor?
Answers:
1. a. The wheels should be made of rubber in the plastics category. The material needs to be strong enough to resist friction due to driving at fast speeds. It also needs to be able to grip the asphalt and provide as smooth a ride as possible. It must also be easily changeable in case of damage or accident. Plastic provides these options best.
   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 composites because the covering of the seat should be made with vinyl or some sort of plastic but underneath cushion is necessary for comfort while driving and going over bumps in the road. Metal is used also to make the shape of the seat so a composite is necessary encompassing all these materials.
2. 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 no absorb water, can be easily cleaned if exposed to water and can last a long time.
Materials: Heat Treatments

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

Key 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.

Multiple Choice Question:

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).

Constructed Response Question:

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.

   Answer:
   Answer 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
Materials: Types and Properties

I can relate the use of thermosetting plastics to their properties E.g. Bakelite is used to mold electrical parts because it is a good electrical insulator

Key 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. E.g. ceramics are used in ovens because they are very hard and heat- and wear-resistant.

I can relate the use of **composites** to their properties. E.g. carbon fibre is used for hockey sticks because of its hardness, resilience and lightness.

**Key Concepts**

Ceramics are the result of heating inorganic matter. Some properties of ceramics are:
- Hardness
- Low electrical conductivity
- Wear resistance
- Heat resistance
- Corrosion resistance

Composites are made by combining different materials to obtain the desired properties. Composites are made of the matrix (skeleton of material) that gives it its shape and of the reinforcement that is inserted into the matrix to give the material its strength. Some properties of composites are:
- Durability
- Hardness
- Elasticity
- Lightness
- Resilience
- Stiffness
- Corrosion resistance

**Multiple Choice Question:**

1. An oven should be made of a material that has the following properties:
   - Resistance to heat
   - Hardness
   - Low thermal conductivity
   - Resistance to corrosion

Which of the following materials should be used to make an oven?

A) Ceramics  
B) Thermosetting plastic  
C) Thermoplastic  
D) Metal
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:

<table>
<thead>
<tr>
<th>Materials</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>• Hardness</td>
</tr>
<tr>
<td></td>
<td>• Resilience</td>
</tr>
<tr>
<td></td>
<td>• Ductility</td>
</tr>
<tr>
<td></td>
<td>• High density</td>
</tr>
<tr>
<td></td>
<td>• High thermal conductivity</td>
</tr>
<tr>
<td>Carbon fibre</td>
<td>• Low density</td>
</tr>
<tr>
<td></td>
<td>• Hardness</td>
</tr>
<tr>
<td></td>
<td>• Resilience</td>
</tr>
<tr>
<td></td>
<td>• Electrical conductivity</td>
</tr>
<tr>
<td></td>
<td>• Resistant to corrosion</td>
</tr>
<tr>
<td></td>
<td>• Rigidity</td>
</tr>
<tr>
<td>Polymethyl (acrylic)</td>
<td>• Hardness</td>
</tr>
<tr>
<td></td>
<td>• Rigidity</td>
</tr>
<tr>
<td></td>
<td>• Comes in a variety of colours</td>
</tr>
<tr>
<td></td>
<td>• Malleability</td>
</tr>
<tr>
<td></td>
<td>• Brittleness</td>
</tr>
<tr>
<td>Polyamide (nylon)</td>
<td>• Resilient</td>
</tr>
<tr>
<td></td>
<td>• Medium hardness</td>
</tr>
<tr>
<td></td>
<td>• Flexible</td>
</tr>
<tr>
<td></td>
<td>• High moisture absorbance</td>
</tr>
</tbody>
</table>

Which of the materials above would be the best material to build a hockey stick with? Justify your choice by using the properties of the materials.

Answers
1-A: Ceramic
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.

Students can also justify their choice by describing why other materials are inappropriate.
Materials: Modification of Properties

I would be able describe different treatments to prevent degradation of materials
e.g., metal painting, antirust treatments, painting

Explanation of Concept(s)
1. Explanation of Reasons for Degradation Prevention:
   - **Wood and Modified Wood, Ceramics, Metals and Alloys, Plastics and Composites** make up the categories of materials. However, over time they can degrade. As a result, several techniques and treatments have been designed to help prevent degradation and allow the material last longer.

2. Techniques Used to Prevent Degradations:
   - **Wood and Modified Wood:**
     - Varnish
     - Paint
     - Treatment with a special protective coating like an alkaline solution that contains copper (Turns the wood bluish).
     - Subjecting it to high temperature
   - **Ceramics:**
     - Heating
     - Coating them in enamel a protective coating
     - Avoiding exposing them to acids, bases and thermal shock
     - **Note:** Ceramics are generally very durable. They are even found in archeological digs.
   - **Metals and Alloys:**
     - Coating the metal with treatments.
     - Metallic Coatings: zinc, chrome, gold, silver, nickel, aluminum, lead
     - Other Coatings: paint, enamel, grease, resin
     - Exposing to high heat to make the material harder like steel
   - **Plastics:**
     - Protecting the plastic with waterproof coatings
     - Adding antioxidants like carbon to prevent oxidation
     - Adding pigments that absorb UV rays
Composites:
- Two main problems with composites that lead to degradation are deformation and loss of adherence between the materials.
- To prevent degradation again depends on the materials used in making the composite and applying the protection to the material.

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

Answers:
1. a. The neighbor’s deck is discolored and rotten due to the fact that the wood was not treated against possible degradation. As a result, rotting occurred.
   b. Wood needs to be sealed with varnish or a weather treatment to prolong the life span of the wood especially if it will be exposed to harsh climate conditions and many forms of precipitation.
Manufacturing: Characteristics of Drilling, tapping, threading and bending

I can describe the characteristics of the tools needed to shape a material (e.g. the tip of a metal drill is conical, while that of a wood drill is double fluted)

Explanation of concept:

There are different tools needed to shape materials.

Drilling: there are various drills used to make a hole in a material. Choosing the right drill bit is dependent on the type of material being drilled into (i.e. bored into) and the diameter of the hole needed. Also, the speed at which the bit is rotating is also influenced by the latter two factors.

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

<table>
<thead>
<tr>
<th>Metal Drill Bit</th>
<th>Wood Drill Bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Metal Drill Bit Image]</td>
<td>![Wood Drill Bit Image]</td>
</tr>
</tbody>
</table>

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

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’. It already has threads and is rotated around the rod to make the threads on a 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.

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?

   Answer:
   1. b) Tapping threads the inside of a bored material.
   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.
RESOURCES AND REFERENCES
Resources

Mechanical Engineering: Linking of Mechanical Parts
- http://sciencewilson.weebly.com

Mechanical Engineering: Guiding Control
- http://sciencewilson.weebly.com

Mechanical Engineering: Motion Transmission Systems
- http://www.explorelearning.com/
- http://en.wikipedia.org/wiki/Pulley

Mechanical Engineering: Motion Transformation Systems

Mechanical Engineering: Speed Changes
- http://www.explorelearning.com/

Electrical Engineering: Conduction, Insulation and Protection

Electrical Engineering: Control

Electrical Engineering: Transformation of Energy

Materials: Constraints
- http://www.explorelearning.com/

Materials: Characteristics of Mechanical Properties
Materials: Modification of Properties

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• I Modified from  
  http://earthphysicsteaching.homestead.com/Magnetism_Magnetic_Fields_Lab.html  
• Resources links, gizmos, videos (1 or 2  
• highly relevant targeted resources IF applicable)
Resources links, gizmos, videos (1 or 2 highly relevant targeted resources IF applicable)


Colorado pHet: Magnets and Electromagnets
Allows students to watch the flow of electrons in relation to the number of loops of an electromagnet.
Allows students to see how a solenoid is able to make a doorbell work.
http://www.youtube.com/watch?v=gfJG4M4wi1o
Video at http://www.youtube.com/watch?v=g6aErhwFXsg or youtube then type conceptual physics Demo of Archimedes principle
Video at http://www.youtube.com/watch?v=VxLTDtaRCZk or youtube then type Pascal’s law and hydraulic break systems
Video at http://www.youtube.com/watch?v=EOT-3p8JZ8Q or youtube then type Pascal’s Law - Mechanical Properties Of Fluids - CBSE Class 11 Science
short video on electromagnetic induction and how it related to a battery-less flashlight
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Video at: http://www.youtube.com/watch?v=zQR45NAkq0w or youtube, then type scientific eye parachute forces clip.
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Video on forces at: http://www.youtube.com/watch?v=eXge8pZ-mDU or youtube, then type in QUEST Lab: Properties of Plastic - KQED QUEST
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