BUREAU OF INDIAN STANDARDS

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Learning Science via Standards

IS 1293

CM/L-XXXXXXXXXX

Plugs and Sockets

Lesson 27

July 2023





STANDARDS CLUB
BUREAU OF INDIAN STANDARDS

Nurturing Young Minds as Ambassadors of Quality and Standards

Foreword

Everything around us, whether natural phenomena or manmade products can be explained through science. The product which are used in our daily life are outcome of conscious efforts by the mankind to fulfil and exceed the needs of the present and demands of the future. Students are taught science as part of their school curriculum, to enable them to understand the various scientific laws and principles and also to inculcate the habit of exploring the world through the lens of science. Quality characteristics of any product or service are decided based on the stated and implied needs and are generally described in a document called 'Standard'. Science and standards are inseparable and integral aspect of any product.

Bureau of Indian Standards (BIS), the national standards body of India, is mandated for establishment and promotion of standards and creating a quality ecosystem in the country. This is achieved through developing Indian Standards on products and services through the active involvement of relevant stakeholders and dissemination of information of such standards for their use and implementation across all sectors of economy. Academia, as an important stakeholder of BIS, has been contributing towards development of standards through research activities and providing inputs related to technological advancements in product development, their characteristics and use as well as methods of tests. BIS, on its part has also been promoting standards in academia through a variety of programmes. This has since been institutionalized in the form of "Standards Clubs" which are being established in educational institutions across India to nurture the young minds as ambassadors of quality and standards and prepare them for dealing with these aspects in future.

In this initiative of BIS, called "Learning Science via Standards", a series of Lesson Plans are made elaborating the various scientific concepts, laws and principles to help students understand their practical applications via standards. The series comprises of a variety of subjects for insights into the scientific laws and principles and relating them to the quality characteristics of products used in day-to-day life. First 10 Lesson Plans in the series are released on the occasion of World Consumer Rights Day on 15 Mar 2023. Second Set of 10 Lesson Plans were released on 10 Jun 2023 by Hon'ble Minister of State during the Governing Council Meeting of BIS.

The Lesson Plans are expected to serve as a useful tool for the teaching fraternity for imparting knowledge on scientific laws and principles through their practical applications in activities and products around us and facilitate an interactive learning experience for the students.

Plugs and Sockets

A plug and socket, also known as an electrical plug and outlet, are devices used to connect electrical equipment to a power supply. The plug is typically attached to the power cord of an electrical device, while the socket is installed in a wall or power outlet.

The plug consists of metal prongs or pins that fit into matching slots in the socket. The prongs are connected to wires inside the power cord, which carry the electrical current to the device. The socket, on the other hand, contains metal contacts that make contact with the prongs when the plug is inserted. This allows electricity to flow from the power source to the device.

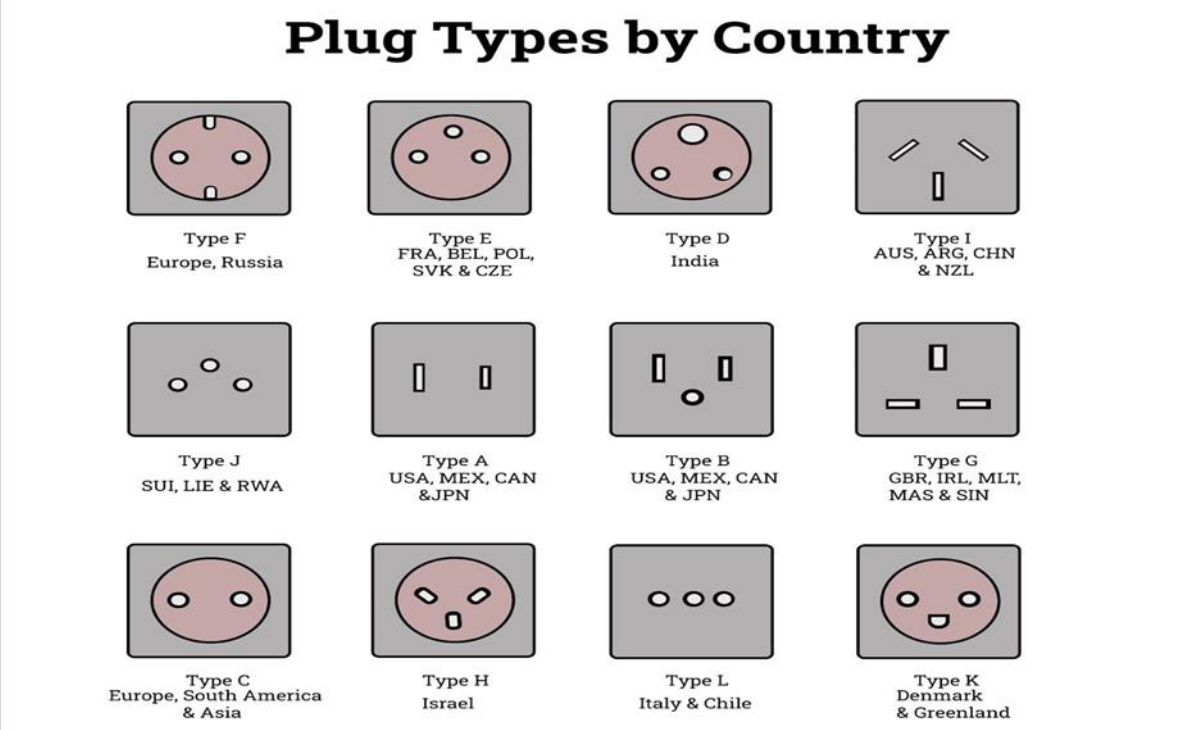
Plugs and sockets are designed to ensure a secure and reliable connection while maintaining electrical safety. They often include features such as grounding connections, polarized prongs, and child-safety mechanisms to prevent accidental shocks or damage.

Different countries and regions may have their own specific types of plugs and sockets, often following national or international standards. These standards define the shape, size, and electrical characteristics of the plugs and sockets used in a particular area. For example, the United States commonly uses the NEMA (National Electrical Manufacturers Association) standard, while Europe uses the IEC (International Electro technical Commission) standard with various regional variations. In India, the national standard for plugs and sockets is set by the Bureau of Indian Standards (BIS). The BIS specifies the requirements and guidelines for electrical plugs, sockets, and related accessories laid down in IS 1293.

It's important to note that plugs and sockets may have different configurations for various purposes. For instance, there are specialized plugs and sockets for appliances with high power requirements, such as those used for large appliances like refrigerators or air conditioners.

The most common type of plug and socket used in India is the 3-pin Type D plug and socket. This type of plug has three round pins in a triangular arrangement. The pins are large and have a relatively thick diameter compared to other plug types. The Type D plug is commonly referred to as the

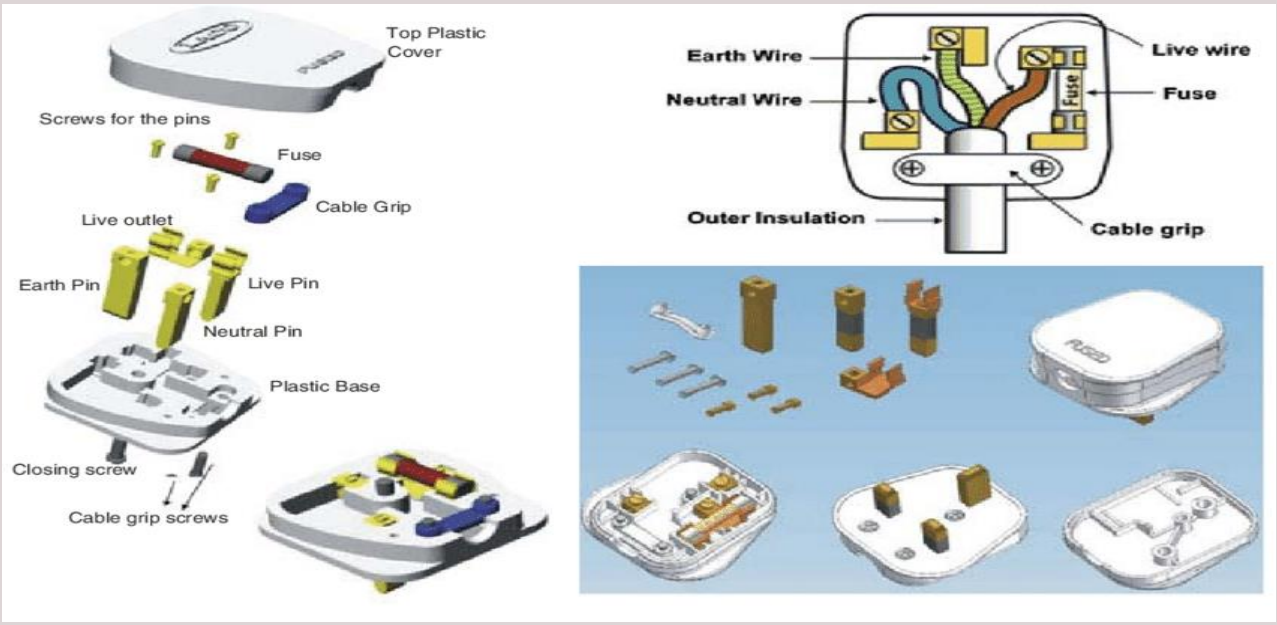
"Indian plug" and is used for domestic power supply. The standard voltage in India is 230 volts at a frequency of 50 hertz. The 3-pin Type D plug and socket are designed to handle this voltage and



are rated voltage as not exceeding 250 V and a rated current not exceeding 16 A intended for household and similar purposes, either indoors or outdoors.

1. Components of Plugs and Sockets

a) Plug Pins: The plug pins are the metal prongs that make physical contact with the socket's corresponding terminals. They carry the electrical current from the power source to the device. The number and arrangement of pins may vary depending on the plug type and the electrical system's requirements.



b) **Socket Terminals:** The socket terminals are the receiving ends of the plug pins. They provide the electrical contact points for the plug to connect with. The socket terminals are typically madeof conductive materials that ensure a secure and reliable electrical connection.

c) **Insulating Housing:** The insulating housing surrounds the plug pins and socket terminals to provide electrical insulation and mechanical protection. It is usually made of durable materials like plastic or rubber. The housing design may also include features such as keyways or notches to ensure proper alignment and prevent incorrect insertion.

d) **Grounding Connections:** Many plug and socket designs include grounding connections to ensure electrical safety. Ground pins or sockets are specifically designated for grounding purposes, providing a path for electrical faults or excess current to safely dissipate into the ground.

e) **Locking Mechanism:** In certain plug and socket designs, a locking mechanism is incorporated to securely hold the plug in place once inserted into the socket. This prevents accidental disconnection, particularly in applications where vibration or movement may be present.

f) **Strain Relief:** Strain relief is a component that helps protect the electrical connections by relieving tension or strain on the cable attached to the plug. It prevents excessive bending or pulling of the cable, which could otherwise damage the wires or loosen the electrical connections.

g) **Insulation Displacement Connector (IDC) Contacts:** IDC contacts are commonly used in modular plugs and sockets. They allow for easy and efficient termination of multiple conductors by displacing the insulation and making direct contact with the conductive cores. This simplifies the installation process and ensures reliable electrical connections.

h) **Protective Covers:** Some plug and socket designs include protective covers or shields to safeguard the electrical contacts from dust, moisture, or accidental contact. These covers can be hinged or sliding mechanisms that open when the plug is inserted and close when it is removed.

2. Working Principle

The working principle of a plug and socket revolves around the concept of establishing a safe and reliable electrical connection between a power source and an electrical device. Here's a general overview of how plug and socket systems work:

a) **Plug Design:** The plug is designed with metal pins that correspond to specific socket terminals. The number, shape, and arrangement of pins depend on the plug type and the electrical system requirements.

b) **Socket Design:** The socket has terminals that match the configuration of the plug pins. When the plug is inserted into the socket, the pins make contact with the corresponding terminals.

c) **Electrical Conductivity:** The plug pins and socket terminals are made of conductive materials, typically metal, to allow the flow of electrical current. This conductivity ensures a complete electrical circuit from the power source to the device.

d) **Insulation:** Surrounding the conductive components of the plug and socket is an insulating housing made of materials such as plastic or rubber. The insulating housing prevents direct

contact between the conductive parts and provides electrical insulation, ensuring safety and preventing electrical shocks.

e) **Alignment and Insertion:** The plug is inserted into the socket, aligning the pins with the corresponding terminals. The housing of the plug and socket often includes keyways or notches to ensure proper alignment and prevent incorrect insertion.

f) **Mechanical Connection:** Once the plug is fully inserted into the socket, a mechanical connection is established. This connection may include a locking mechanism that secures the plug in place, preventing accidental disconnection.

g) **Electrical Contact:** With the plug securely inserted, the pins make physical contact with the socket terminals, establishing electrical connections. This allows the flow of electrical current from the power source to the device, powering its operation.

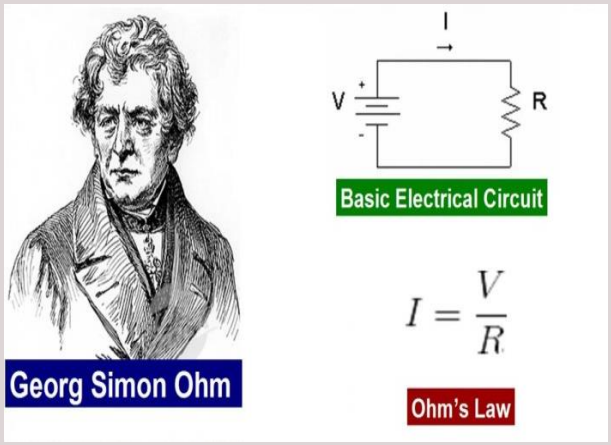
h) **Grounding:** In some plug and socket designs, there may be specific grounding connections, such as a ground pin or socket. These connections provide a path for electrical faults or excess current to safely dissipate into the ground, enhancing electrical safety.

i) **Disconnection:** When the device is no longer in use, or if it needs to be moved or serviced, the plug can be safely disconnected from the socket by pulling it out. The electrical circuit is broken, and the power supply to the device is interrupted.

The working principle of a plug and socket involves the physical alignment, electrical conductivity, insulation, and secure mechanical connection between the plug and socket components. These principles ensure the safe and reliable transfer of electrical power from the power source to the electrical device, enabling its operation.

3. Scientific Law and Concepts

a) **Ohm's Law**: Ohm's Law states that the current flowing through a conductor between two points is directly proportional to the voltage across the two points, given a constant resistance.



This principle helps in determining the appropriate size of conductors, voltage ratings, and current-carrying capacities of plugs and sockets, ensuring that they can handle the expected electrical load without overheating or causing damage.

b) **Conservation of Energy**: The principle of conservation of energy states that energy cannot be created or destroyed, only transformed from one form to another.

In plug and socket designs, this law informs the need for efficient electrical connections that minimize energy losses through resistance, heat dissipation, and other factors. Energy efficiency standards and safety regulations for plugs and sockets are influenced by this concept.

c) **Electrical Safety Standards**: Although not a scientific law per se, electrical safety standards are based on scientific principles and are crucial for plug and socket design. These standards incorporate knowledge about electrical conductivity, insulation materials, grounding, and protection against electric shocks. Compliance with safety standards helps ensure that plugs and sockets are designed to minimize the risk of electrical accidents, fires, and other hazards.

d) **Electromagnetic Compatibility (EMC)**: EMC refers to the ability of electronic devices, including plugs and sockets, to operate in close proximity without interfering with each other. Scientific knowledge about electromagnetic fields, electromagnetic radiation, and the behaviour of electrical circuits is used to design plugs and sockets that minimize electromagnetic interference, both to and from the devices they connect.

e) **Electrical Conductivity:** Electrical conductivity is capability of any material to let an electric current pass through it. Conductivity is essentially the inverse of 'Resistivity', which is a property of a material that measures how strongly passage of electric current is resisted by it.

The Electrical Resistivity "ρ" can be calculated by:

$$\rho = \frac{RA}{l}$$

Where, 'R' is the electrical resistance of a uniform specimen of the material

'l' is the length of the specimen

'A' is the cross-sectional area of the specimen

Conductivity, "σ", is the inverse of resistivity:

$$\sigma = \frac{1}{\rho}$$

Conductivity has SI units of siemens per metre (S/m).

In plugs and sockets, the length of the pins and cross section of pins can be fixed based on the calculated requirements. From the above formulae we can understand that based on the conductivity and resistivity of the material used for pins, the cross section are and length can be calculated.

The length of the conductor becomes significant from the contact point of the conductor with terminal in the socket to the contact point of the terminal in the plug.

4. Testing of Plug & Sockets & their importance

a) Strength of Terminals

Terminals used in plugs and socket-outlets are supposed to have adequate mechanical strength. This ensures robust connection of electrical wiring in these accessories.

b) Protection Against Electric Shock

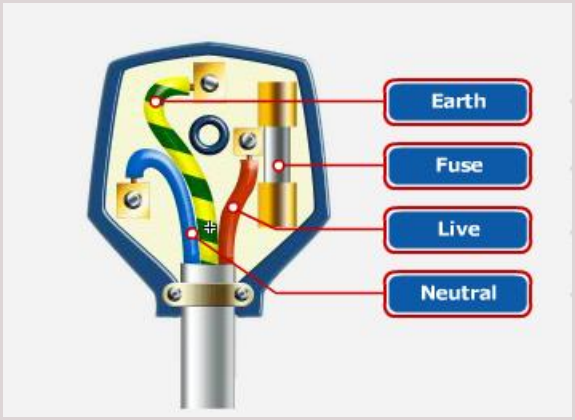
The idea is that when plugs and socket-outlets are in place for their normal use, current carrying parts should not be accessible. This prevents humans against electric shock during handling of the electrical accessories.

Protection against electric shock in plugs and sockets is of utmost significance as it ensures personal safety, prevents accidents and injuries, reduces the risk of electrical fires, promotes compliance with safety standards, and instills public confidence in electrical systems. By incorporating safety measures such as grounding, insulation, polarization, shutters, and fuses/circuit breakers, the potential for electric shocks is minimized, protecting individuals from severe burns, cardiac arrest, and other fatal consequences. This focus on electrical safety creates a secure environment for the use of electrical appliances and devices, safeguarding human life and promoting responsible and worry-free electricity usage.

c) Temperature Rise

It is important that the accessories and its part don't get abnormally heated during their use, and their functioning is not impaired consequently. Temperature rise refers to the rise of temperature of pins of plugs/metal parts of socket-outlets, over temperature of surroundings, while the plugs/socket-outlets are in operation.

d) Provision of Earthing:



Provision for earthing in plugs is an important safety feature in electrical systems. It involves the inclusion of a dedicated ground pin and corresponding ground terminal in plug designs. When a plug is inserted into a socket, the ground pin makes contact with the ground terminal, establishing a conductive path to the grounding system of the building or electrical installation.

This connection enables any electrical faults or excess current to safely dissipate into the ground, protecting users from electric shocks and preventing damage to equipment. Additionally, an earth wire within the electrical cable

connects the device's metal casing or exposed conductive parts to the ground, ensuring that any faults are directed away from users. Proper provision for earthing in plugs is essential to maintain electrical safety and should be regularly inspected and maintained to ensure its effectiveness.

e) **Insulation Resistance**:

Insulation resistance refers to the ability of the insulation materials used in plugs and sockets to resist the flow of electrical current. It is crucial to prevent unintended leakage or short circuits that could result in electric shocks or equipment damage. A high insulation resistance indicates that the insulation effectively isolates the conductive parts, reducing the risk of electrical faults.

f) Resistance to Aging

Resistance to aging testing is conducted to assess the durability and reliability of plugs over time. Aging refers to the gradual degradation or deterioration of materials and components due to exposure to environmental factors, usage conditions, and other external influences.

Resistance to aging allows these components to withstand these conditions without significant deterioration, ensuring that they continue to provide secure electrical connections. Aging resistance helps prevent issues such as insulation breakdown, contact corrosion, and mechanical failures, which could lead to electrical faults, short circuits, or electric shocks. By maintaining their integrity and functionality over time, plugs and sockets with resistance to aging contribute to electrical safety, reliability, and customer satisfaction**.**

g) Force necessary to withdraw the plug

The force necessary to withdraw a plug from a socket depends on various factors, including the design of the plug and socket, the materials used, and the fit between them. The withdrawal force is typically designed to provide a balance between a secure connection and ease of removal. It should be sufficient to maintain a stable connection during normal use but not so strong that it becomes difficult or hazardous to unplug. The force required can vary depending on the specific application and safety standards in place. Manufacturers consider factors such as the contact area, friction, and insertion/removal forces to ensure that the plug can be withdrawn safely and effortlessly by users.

h) Ratings and Marking

Information about the electrical parameters is the first step in appropriate usage of the accessories. Some of the markings commonly used in electrical installations and appliances are as given below,

Earthing Symbol ⏚

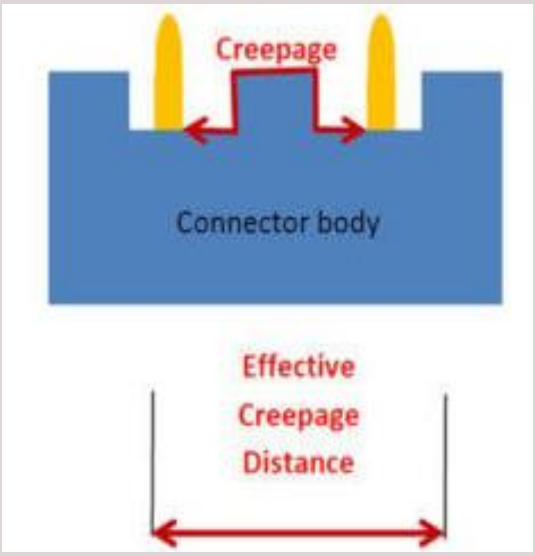
6 Amperes, 250 Volts, Symbol of Alternating Current ∿

L – Line, N – Neutral

IP Rating (Ingress Protection of Solids and Liquids) Optionally marked

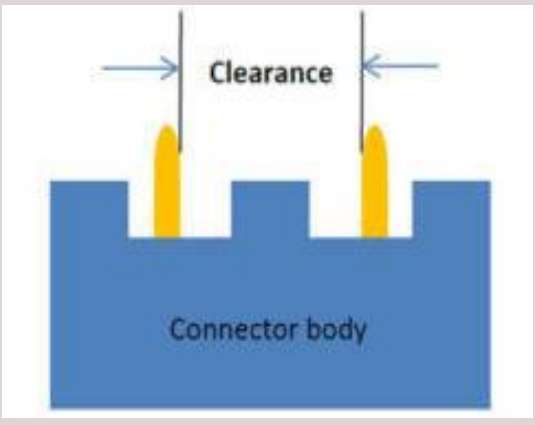
i) Creepage Distance:

Creepage distance refers to the shortest path along the surface of an insulating material between two conductive parts, such as pins or contacts. It is measured in millimeters (mm) and is designed to prevent the unintentional flow of electrical current between these conductive parts, especially in the presence of moisture or contaminants. Creepage distance helps ensure electrical insulation and reduce the risk of electric shock or short circuits.



j) Clearance:

Clearance, on the other hand, is the shortest distance in air (or other insulating medium) between two conductive parts, such as the distance between pins or contacts in a plug and socket. Like creepage distance, clearance is measured in millimeters (mm) and is also crucial for electrical safety. Adequate clearance prevents arcing or sparking between conductive parts and reduces the risk of short circuits or electrical fires.



5. Ways to make the Plugs and Socket more environment-friendly

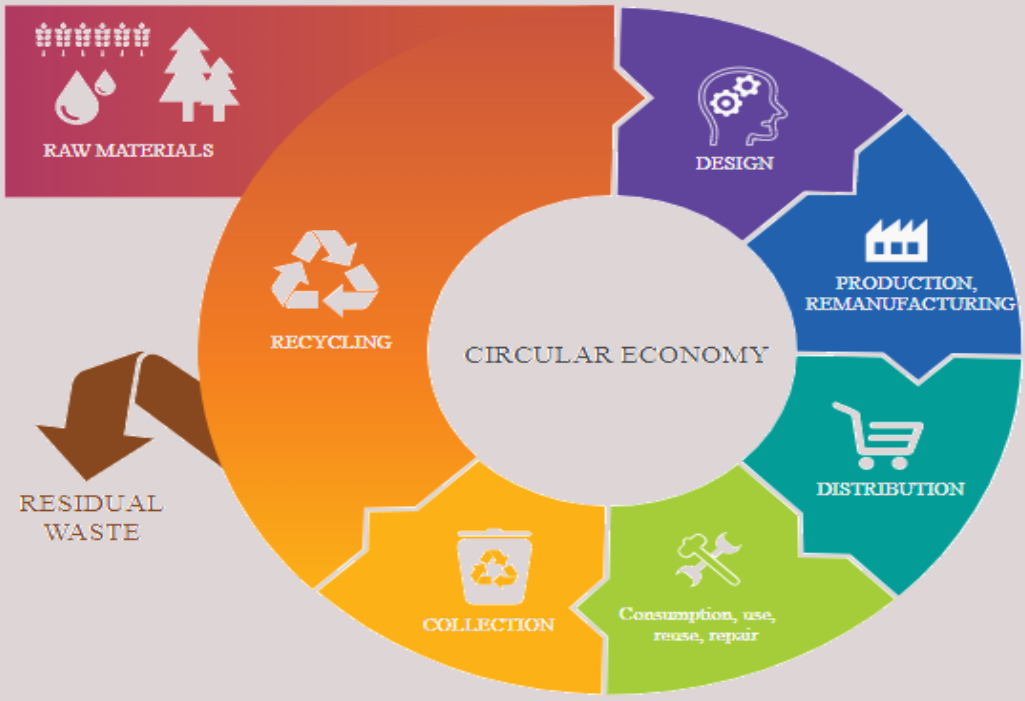
Students are told about the environmental challenges we face today viz. pollution via burning usage of coal in energy-producing thermal power plants, land-use disruption and loss of vegetation due to hydel and nuclear power projects etc. Hence there is a need to co-exist harmoniously with nature. That is where the concept of **Sustainable Development** kicks in.

Students are then informed about the 17 **Sustainable Development Goals** being furthered by nations across the globe, under the aegis of United Nations (UN). Special emphasis is then laid during the lesson on **Goal 7 – Affordable and Clean Energy,** with a target to ensure access to affordable, reliable, sustainable and modern energy for all.

It is then impressed upon the students that due to climate change, biodiversity loss, warming of earth, frequent and intense adverse weather events (e.g. flash floods, forest fires, cyclones etc.), mankind is facing an urgent need to reduced its carbon footprint. Greenhouse gas emissions, and the consequent global warming, are poised to cause catastrophic phenomena, such as rising of sea levels and submergence of many inhabited islands, food scarcity, wildlife destruction, among others.

Anthropogenic excesses have led to a lot of waste generation that is harming the planet. In such a scenario, extracting the most out of products and efficient waste management has become the need of the hour. This is where the idea of **Circular Economy** becomes vital for human development.

Circular economy proposes a new production-consumption paradigm, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. In this way, the life cycle of products is extended, enhancing their value. In practice, it implies minimum generation of waste.



To conclude, the teacher informs the students that Sustainable Development consists of three pillars: economic development, social inclusion and the protection of the environment. In setting out parameters for manufacturing of energy-efficient products (e.g. motors, transformers), Standards further the goal of sustainable energy consumption. This also helps in financial savings and consequent economic prosperity. The ethos of efficiency and recycling, reflected in Indian Standards (e.g. the ECO-Mark scheme) – can go a long way in helping industries be more environment friendly. Ultimately, cleaner manufacturing leads to efficient and cost-effective products, enabling their accessibility to all. And this is enabled by robust standardization, with eyes on the future.

6. Question and Answers

Q. **Why are insulators used?**

A. Insulators are used to protect us from the dangerous effects of electricity flowing through conductors.

Q. **What materials are used for insulation**?

A. Some common insulator materials are glass, plastic, rubber, and wood. That is why thermoplastic or elastomeric material is used to make the bodies and other non-metallic parts of plugs and socket-outlets.

Q. What materials are used for making plug pins?

A. Brass, an alloy of copper and zinc, is one of the most commonly used material to manufacture pins for plugs. Brass has high strength and hence better wear resistance. It is a good compromise between the three competing needs for low cost, good electrical resistivity and good wear resistance.

Q. **What materials are used for making terminals of plugs and socket-outlet**s?

A. Brass, copper, copper alloys and stainless steel are some of the common materials used for manufacturing terminals.

The terminals and other current-carrying parts are made of a metal having good mechanical strength, electrical conductivity and resistance to corrosion.

Q. **Why temperature rise test is done**?

Ans. Temperature rise tests are used to make sure that a product does not get overheated during operation.

Q. **What causes temperature rise**?

One of the most common causes of temperature rise is overloading of the electrical circuit. Higher current flowing through the circuit is a sure cause of more heat generation.

Sometimes, after a significant period the metal contacts within the socket which mate with the plug pins can become slightly loose. The loose connection generates heat, the heat increases the resistance of the connection, which in turn generates even more heat. This causes rise in temperature.

7. Interesting Facts

a) The world's first standardized electric plug and socket design was introduced in 1883. It was developed by Thomas Edison and was known as the Edison plug and socket. This design became the basis for the modern-day two-pin plug used in many countries.

b) The different types of plugs and sockets used around the world can be traced back to historical practices and regional preferences. For example, in the United Kingdom, the three-pin plug and socket design was introduced in 1947 and was intended to provide a safer connection with a built-in fuse. Today, there are over 15 different plug and socket types worldwide.

c) The shape and design of plugs and sockets can vary significantly between countries. For instance, in some countries, such as the United States and Canada, plugs have two flat pins, while in others, like the United Kingdom, plugs have three rectangular pins. Additionally, some countries have plugs with two round pins, like in Europe.

d) The concept of grounding in electrical systems is an important safety feature. Some plugs and sockets have an additional third pin, often referred to as an "earth" or "ground" pin. This pin is designed to redirect electrical current in the event of a fault, protecting the user from electric shocks and preventing electrical fires.

e) In recent years, there has been an increased focus on developing universal plugs and sockets to simplify international travel and reduce the need for adapters. One such example is the USB Type-C connector, which is becoming more common in electronic devices. USB Type-C can carry both power and data and is reversible, making it convenient for users around the world.

8. Questionnaire

Q1. What is the name of the material that allows electricity to flow through it?

(a) Conductor

(b) Insulator

(c) Switch

(d) Socket

Answer: (a)

Q2. What is the name of the material that does not allow electricity to flow through it?

(a) Conductor

(b) Insulator

(c) Switch

(d) Socket

Answer: (b)

Q3. What is the name of the part of a plug that fits into a socket?

(a) Terminal

(b) Contact

(c) Pin

(d) Receptacle

Answer: (c)

Q4. What is the name of the part of a socket that the plug fits into?

(a) Terminal

(b) Contact

(c) Pin

(d) Receptacle

Answer: (d)

Q5. What is the name of the device that breaks the circuit when there is too much current flowing through it?

(a) Fuse

(b) Switch

(c) Socket

(d) Receptacle

Answer: (a)

Q6. What is the name of the unit of measurement for electrical current?

(a) Ampere

(b) Volt

(c) Watt

(d) Ohm

Answer: (a)

Q7. What is the name of the unit of measurement for electrical potential difference?

(a) Ampere

(b) Volt

(c) Watt

(d) Ohm

Answer: (b)

Q8. What is the name of the unit of measurement for electrical power?

(a) Ampere

(b) Volt

(c) Watt

(d) Ohm

Answer: (c)

Q9. What is the name of the law that states that the current flowing through a circuit is proportional to the voltage across the circuit?

(a) Ohm's law

(b) Kirchhoff's law

(c) Coulomb's law

(d) Faraday's law

Answer: (a)

Lesson Plan Subjects

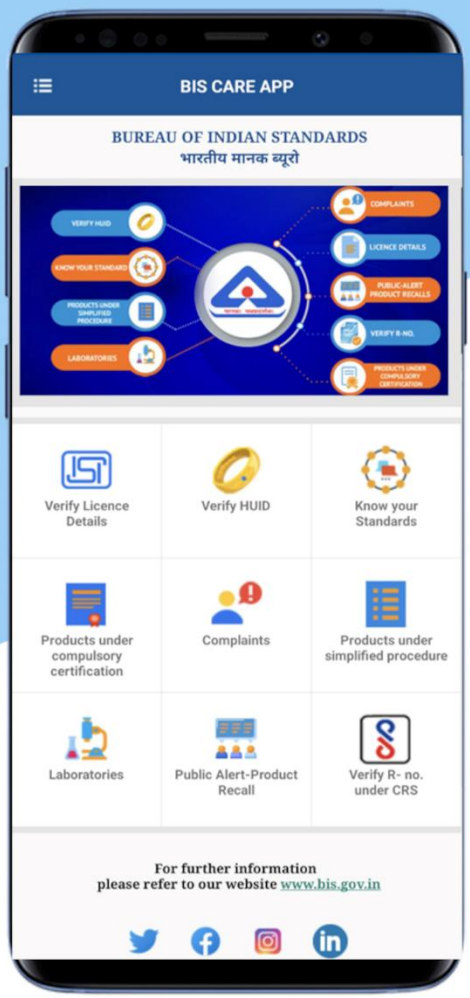
Published

1.	Caustic Soda	**16.**	Headphones
2.	Football	**17.**	Milk Powder
3.	Cement	**18.**	Pressure Cooker
4.	Gas Stove	**19.**	Plywood
5.	Geyser	**20.**	Multipurpose dry batteries
6.	Helmet	**21.**	Ballpoint Pen
7.	LED Bulb	**22.**	Bicycle
8.	LPG Cylinders	**23.**	Electric Iron
9.	Cement Ash Brick	**24.**	Loudspeakers
10.	Paints	**25.**	Pasteurized Milk
11.	Boric Acid	**26.**	Paver Blocks
12.	Ceiling Fan	**27.**	Plugs and Socket
13.	Cables	**28.**	Solar Flat Plate Collectors
14.	Ceramics Tiles	**29.**	Precast Concrete
15.	Rear View Mirrors	**30.**	Stainless Steel

Forthcoming…

31.	Drinking Water	**42.**	PVC Pipes
32.	Electric Mixer	**43.**	Refrigerator
33.	Family Sized Biogas Plant	**44.**	Solid and Hollow Block
34.	Fire Extinguisher	**45.**	Steel Bar
35.	Power Threshers	**46.**	Submersible Pump set
36.	Conduits	**47.**	Thermometer
37.	CNG Cylinders	**48.**	Tyres for buses and trucks
38.	Hearing Aids	**49.**	Vacuum Flask
39.	Microwave Oven	**50.**	Water Meter
40.	Water Storage Tank	**51.**	Wheel Rim
41.	Weighing balance	**52.**	Geosynthetics

BIS CARE APP



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