



Learning Science via Standards



HELMET

Lesson 6
Mar 2023

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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 mind as ambassadors of quality and standards and prepare them for dealing with these aspects in future.

In this latest initiative of BIS, called "Learning Science via Standards", a series of Lesson Plans are being 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 products. Student would also understand as to how the same scientific law or principle applies to many products having similar characteristics. The subjects have also been chosen based on their relevance to education as part of the course curriculum as well as to industrial applications.

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



Helmet

Nearly 1 lakh lives are lost every year due to road accidents in India. Majority of these fatalities are associated with two wheelers. Helmets are one of the prominent riding gears which avert fatalities during accidents.

Protective helmets for 2-wheeler riders are a crucial safety equipment that reduces the risk of head injuries in case of accidents. Helmets have been used for centuries in various forms, but the modern-day helmet was invented in the early 20th century. Today, helmets are mandatory in many countries and have become an essential accessory for riders.

The primary application of helmets is to protect the head from impact and prevent brain injury in case of accidents. Helmets are designed to absorb the impact energy and disperse it across the helmet's surface, reducing the force exerted on the skull.

The safety feature of helmet works on the concept of kinetic energy. In case of an accident, the kinetic energy of the rider's head is transferred to the helmet, which absorbs it and reduces the force exerted on the skull. This is achieved through the use of materials that can deform and absorb energy, such as polycarbonate, fiberglass, and foam.

1. Genesis of Helmet

Cloth wrapped around head called Bandana was a common practice in ancient history protection of head from heat and other purposes. Shirastrana was a helmet or head guard worn by soldiers to protect the head. Helmets serve different purposes in different situations and were in use since the ancient history.



**Corinthian Helmet from the tomb of
Denda 500- 490 BC**



Picture Of Celtic Parade Helmet 350 BC

Despite wearing this headgear for centuries, the term “helmet” was not coined until in later years. Etymology experts agree that the word is derived from the Middle English word “helm”, which was used to describe the medieval protective headgear.

Since then, the word “helmet” became the general term used to describe any protective headgear. Whether it’s for riding a bike, engaging in extreme sports, welding, or engaging in combat, you can count on the appropriate helmet to save your life.

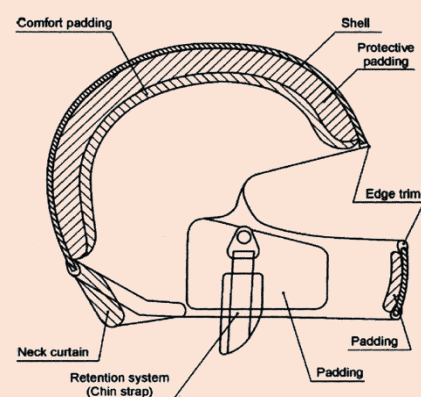
2. What is Helmet

A helmet is a form of protective gear worn to protect the head. Specifically, a helmet complements the skull in protecting the human brain. It has a hard shell on the outside to evenly distribute impact across the whole surface of the head in contact with helmet and foam to increase the area of contact with the head on the inside, and to dissipate the energy due to the impact by deformation of the foam thereby reducing the chances of injury to the head.



3. Components of Helmet

- ✓ Outer Shell
- ✓ Protective Padding
- ✓ Comfort Padding
- ✓ Neck Curtain
- ✓ Retention System (Chin Strap)
- ✓ Edge Trim
- ✓ Other Paddings for comforts



4. Types of Helmet

There are majorly 3 types of helmets

- a) Full Face
- b) Half Face
- c) Hybrid Face



5. Understanding Impact

Injury occurs during application or stopping force due to impact. For understanding this concept let us do a simple thought experiment.

Q. What happens when you hit surface of water in a swimming pool with fast movement of your hand?

A. You experience pain in your hand. The faster you hit the water, greater is the impact.



This can be expressed in a simple mathematical equation of Impact force as given below,

$$\text{Impact Force} = \frac{2 \times \text{mass} \times \text{velocity}}{\text{time}}$$

Which means that the faster the movement of the object, greater is the impact. And also the impact force keeps acting until the velocity of your hand becomes zero.

But what about time in the above equation? If we repeat the same thought experiment of hitting hand over a surface of a rock with same speed of movement of hand, we are sure that the injury to the hand is much greater than that on the surface of water. From this we can

understand that the lesser time it takes for hand to reach zero velocity, more impact force is observed on the hand.

With this science knowledge, we can understand that placing a sponge on the surface of a rock will not injure our hand as much as that without a sponge. Also, the thicker the sponge, more time it takes for our hand to reach zero velocity, lesser is the injury.

6. Impact Absorption in Helmet

In mechanics, an impact is a high force or shock applied over a short time period when two or more bodies collide. Such a force or acceleration usually has a greater effect than a lower force applied over a proportionally longer period. The effect depends critically on the relative velocity of the bodies to one another.

At normal speeds, during a perfectly inelastic collision, an object struck by a projectile will deform, and this deformation will absorb most or all of the force of the collision. Viewed from a conservation of energy perspective, the kinetic energy of the projectile is changed into heat and sound energy, as a result of the deformations and vibrations induced in the struck object. Impact resistance decreases with an increase in the modulus of elasticity, which means that stiffer materials will have less impact resistance. Resilient materials will have better impact resistance.

7. Let's design a helmet now

With the above knowledge, we can be sure that the helmet shall be made of sponge rather than a rock or metal. Good enough!



But will this be really enough?

Let us do another thought experiment, where the rider was unlucky enough to fall on the edge of a divider made of strong, good quality concrete. Will the rubber/sponge of thickness of a 100 page note book be able to absorb all the energy and give sufficient time for velocity of the rider to slowly reach zero?

The answer is no. The rubber/sponge helmet will not give enough time for velocity to reach zero, nor it will give enough protection against sharp objects. This is because the mass of a head of an average human being is 3 to 5 kgs and also it is a sensitive part of the human

body with all 5 sense organs. Any sharp object would pierce through the sponge or rubber. This material will not give any protection by itself against sharp objects.

Hard materials like rock or hard plastics offer good protection against sharp objects.

Can we use both soft and hard materials in combination? Yes, we can use materials in combination.

What if we use a hard plastic inside and rubber/sponge cushioning outside? After all the human body is also made in such a way with hard skull inside and soft skin and hair outside right!

It would solve the purpose as far as the energy absorption is concerned. But there are few problems,

- i. Will it be durable in different weather conditions like rainy and sunny days?
- ii. Do we feel comfortable with hard plastic against our skin/hair?
- iii. Our head would still be injury prone as the chances of hard plastic not able to dispense the energy equally across the surface of the head.
- iv. Also, the rubber padding outside will not allow smooth sliding of our head over the surface of the road, thereby increasing the chances of breakage of neck bones.



On the contrary, if we place the hard-plastic frame outside and soft cushion padding inside, the following advantages are achieved,

- i. Durable material for environment.
- ii. Comfortable design with cushion padding around the head.
- iii. Dispensing energy equally across the surface of helmet and head.
- iv. Smooth sliding on any surface not creating any additional forces on neck due to friction between Helmet and the sliding surfaces.



8. The major principles that applies to Helmet Protection

a) Energy Absorption:

When a helmet collides with an object or surface, it must absorb the energy of the impact to protect the head from injury. This is achieved by using materials that can deform or crush on impact, which dissipates the energy of the impact and reduces the force that is transmitted to the head. Materials like expanded polystyrene (EPS) foam are commonly used in helmets because they can compress on impact and absorb a significant amount of energy.

b) Momentum Transfer:

Another principle of helmet protection is momentum transfer. When a helmet collides with an object or surface, it experiences a change in momentum. The force of the impact is transmitted through the helmet and into the head, which can cause injury. To reduce the force that is transmitted to the head, helmets are designed to increase the time over which the impact occurs. This is achieved by using materials that can deform and compress, which slows down the rate of momentum transfer.

c) Corrosion Resistance:

Corrosion of a helmet can occur due to exposure to moisture, salt, and other corrosive substances. Corrosion can weaken the structural integrity of the helmet, which can be dangerous, especially if the helmet is used for protective purposes.

Corrosion can occur on any metal parts of the helmet, such as the chin strap, buckle, rivets, and other metallic components. To prevent corrosion, it's important to keep the helmet clean and dry, especially after exposure to moisture or saltwater. Wiping down the helmet with a dry cloth can help remove any moisture and prevent the formation of rust.

d) Friction:

Friction in a helmet refers to the force that opposes the movement of the helmet as it interacts with another surface. In the context of helmets, friction is an important factor in ensuring that the helmet does not create unnecessary forces on the neck due to friction between road and the helmet, thereby averting neck injuries. Helmet is expected to slide smoothly on the road or any surface.



Friction between the helmet and the head opposes this downward force and keeps the helmet in place. The friction also helps to distribute the force of an impact across a larger area, reducing the risk of injury. However, if the friction between the helmet and the head is too high, it can be uncomfortable and cause pressure points. On the other hand, if the friction is too low, the helmet may shift or even come off during an impact, reducing its protective capability. Therefore, it is important to choose a helmet that fits properly and has appropriate padding to achieve the right balance of friction and comfort.

Roads are made of asphalt for better grip/friction between tyres and road surface. On the other hand, if there is snow fall and formation of ice on the road, it will



be dangerous for driving. On the contrary, an icy road is relatively safer for averting injuries due to less friction.

f) Effect of Aging

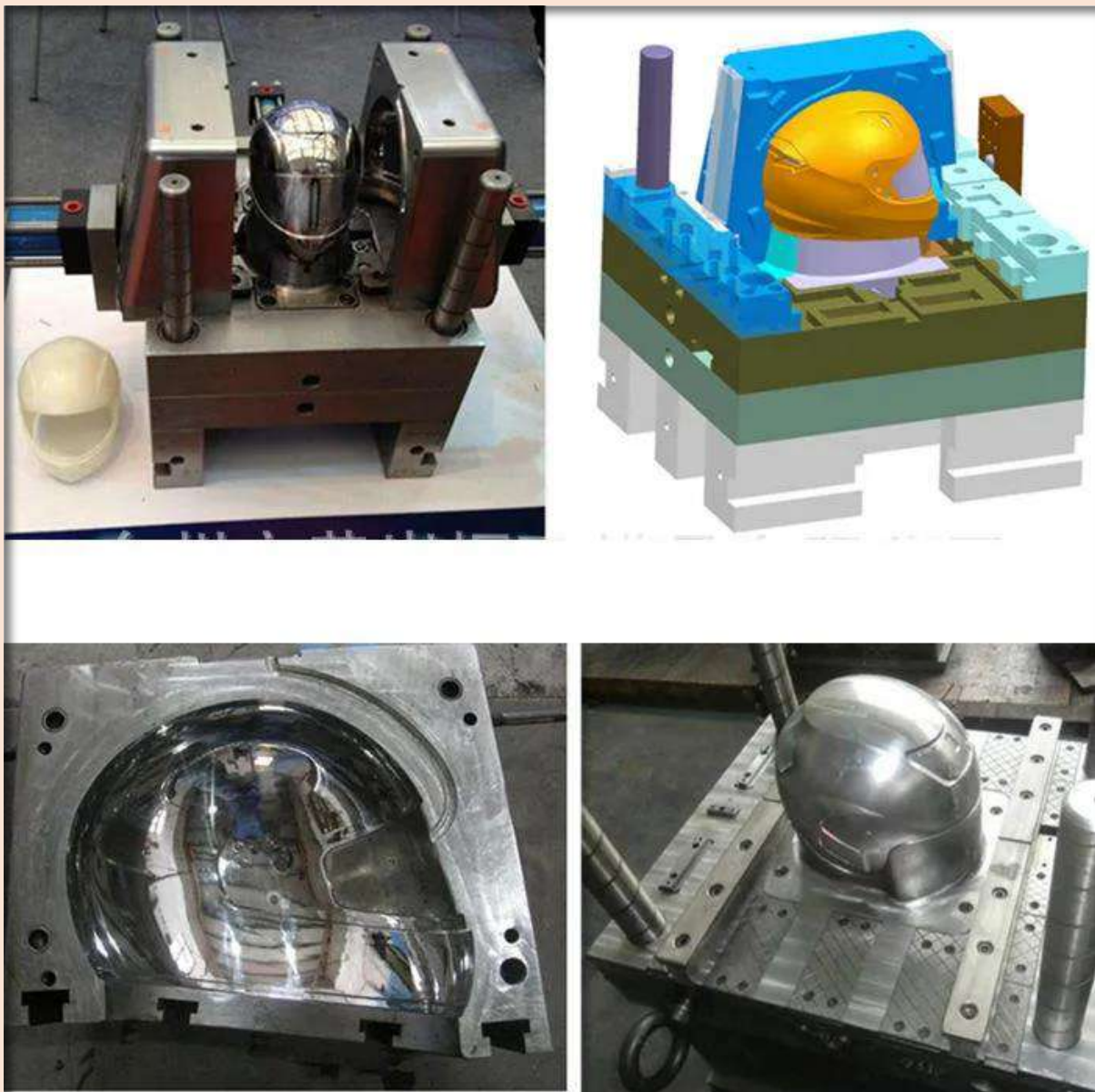
The Helmets are being used in all weather conditions and therefore, it is being tested after 5 type of conditioning which is as under:

1. Solvent + Ambient Temperature and Hygrometry Conditioning
2. Solvent + Heat Conditioning
3. Solvent + Low Temperature Conditioning
4. Solvent + Ultraviolet Radiation Conditioning
5. Moisture Conditioning

9. Manufacture of Helmets

The Helmet has three layers serving different purposes during its use, the outer shell is made up of hard plastic. The inner shell is made up of fibre composite material and the padding is placed inside this inner shell for cushioning around the head. The helmet is then fitted with straps.

The plastic shell is in general is manufactured using injection moulding. Injection moulding is a process in which plastic is heated to high temperatures to make it into a soft and flowable material. It is then injected into a die of required shape. The die is then cooled to room temperature to harden the plastic.



Q. What are the plastic materials used in manufacture of Helmets?

A. Acrylonitrile butadiene styrene (ABS) and Poly vinyl chloride(PVC).

Q. Why plastic is the most widely used material in engineering. Is it possible to replace plastic with metal in Helmets?

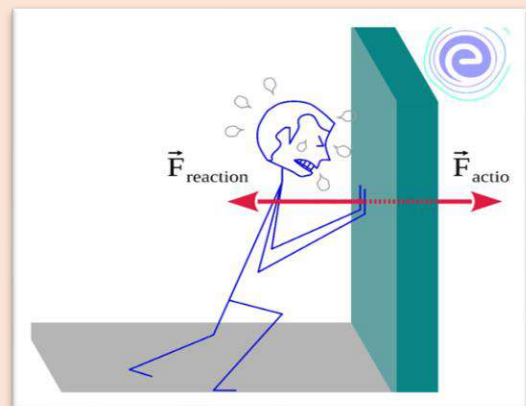
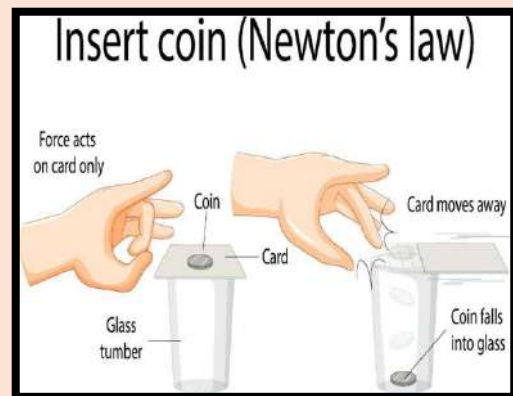
A. Plastic is preferred over metal for use in Helmet due to its low softening temperature, light weight, and easier to mould and drill.

10. Unstrapped helmet is as good as no helmet

Newton's first law of motion states that an object at rest will remain at rest, or an object in motion will continue to move at a constant velocity in a straight line, unless acted upon by an external force. In the case of a helmet, when it is at rest, it will remain at rest until an external force is applied, such as when a person puts it on their head. Similarly, when a person wearing a helmet is in motion, the helmet will tend to stay in motion unless acted upon by external forces, such as air resistance or impact with another object.

Most of the helmets are not custom made for the rider and the size and shape of the helmet may not fit perfectly on the head of the rider. When the two-wheeler moves over a road hump or drives through a pot hole or during an accident, the sudden movement of the rider in the vertical direction or change in the velocity in the horizontal direction would result in helmet continuing to move with the existing velocity and getting removed. During an accident, the chances of unstrapped helmet getting removed is almost certain. Hence, it is always necessary to strap the helmet while in use.

Newton's Third Law states that for every action, there is an equal and opposite reaction. In the case of a helmet, when it experiences an impact, it exerts an equal and opposite force on the object or surface it meets.



Q. According to the newton's third law, the force acting up on the helmet due to it hitting the road/divider is same as the force acting on the head of a human wearing the helmet. Then how does the Helmet avert injuries?

A. As we have read before,

- i. Since the helmet, offers frictionless surface than unprotected head with the road, scratches and bruises could be reduced.***
- ii. Though the force acting on the head is same, the time it takes to dissipate the energy is larger due to flexibility and deformability of padding inside the helmet, hence the impact is reduced. With the same force, but increased time, the impact gets reduced.***
- iii. A force acting for 1 milli second could be prolonged to 10 milli seconds time due to deformation of padding inside the helmet. This would reduce the impact force acting on the head by 10 times***

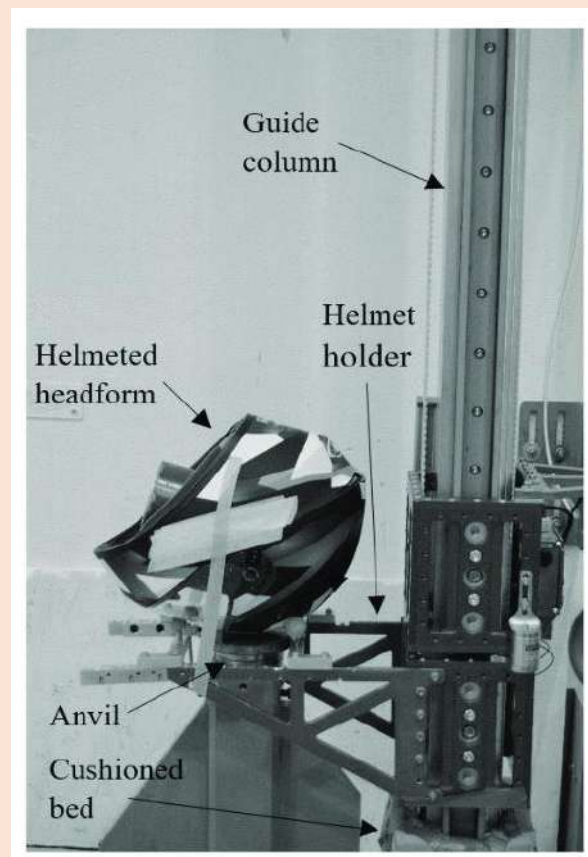
11. Helmet Testing

a) Testing of Peripheral Vision:

This test is performed to ensure there is no obstruction of vision during the regular use of the helmet. The last thing as user needs is a helmet which would inhibit the vision thereby creating more dangers, than it averts. Hence this test is important. In this test, the required angle of vision from different planes is tested.

b) Test for impact energy absorption:

For impact testing, the typical test apparatus consists of a rig that drops a helmet with weight in a guided freefall to an anvil on the floor. Testing is usually required with conditioning. Like hot, cold, and wet helmets as well as those at ambient room temperature behave differently. Some foams are adversely affected by heat, others stiffen in cold, or may take up water and lose



their effectiveness because the water does not compress. Temperatures chosen vary with the activity the helmet is designed for.

c) Test for mass:

The mass of helmet is an important factor which should be in consideration. A helmet is to be worn for continuous periods. Approximately, an average rider in busy cities spends more than an hour on the road per day. A heavy helmet is the last thing that the rider wants.

d) Test for retention system:

Strap testing is either dynamic or static. A dynamic force is usually delivered by hooking a rod on the strap with a weight on it, lifting the weight and allowing it to fall to a stop at the end of the rod, delivering a calibrated force. Some labs have production machines to reproduce this effect. A static test is done by simply hanging weight on the strap. In all of those tests, the strap must not release, and must not stretch or give more than a set amount.

e) Audibility Test:

Helmet also needs to be tested for audibility as sounds are to be heard during driving a two-wheeler. Horns are one of the ways of communication or warning during driving. If the helmet covers ears and no sound is heard from outside, then there is a great danger of misjudgement. To avoid this, the helmets are designed in such a way to reduce the loss of sound from outside to inside.

f) Abrasion Resistance of Chin Strap:

The chin strap of the helmet is tested for resistance to abrasion. The test involves rubbing the chin strap against a representative surface covered with an abrasive material, for a specified number of revolutions. The surface rotates at a certain speed, and the amount of wear and tear on the chin strap is evaluated after the test. The test is designed to simulate the effect of regular use on the chin strap and ensure that it can withstand the wear and tear associated with daily use. The resistance to abrasion of the chin strap is an important factor in determining the overall durability and safety of the helmet, as a weak or damaged chin strap may not provide adequate protection in case of an accident.

12. Interesting facts about helmets

- a) Helmets have been used for centuries, with evidence of helmets being used in ancient civilizations such as the Greeks and Romans.
- b) Helmets are not just for humans - helmets are also designed and used for animals like dogs, horses, and even cows in various applications, such as protecting the animal's head during transportation or for medical treatment.
- c) The first motorcycle helmet was invented by a neurosurgeon - Dr. Eric Gardner, a neurosurgeon from the United Kingdom, invented the first motorcycle helmet in 1953.
- d) Helmets can help you ride faster - Studies have shown that wearing a helmet can help riders achieve higher speeds due to reduced wind resistance.
- e) The helmets used in fighter jet aircrafts like HAL LCA Tejas, cost more than 3 crore INR and serve multiple purposes apart from protection to head and projecting information to pilots eye.
- f) Helmets are not only designed for motorcycle riders but also have many other applications. For example, helmets are commonly used by construction workers, firefighters, and athletes in various sports such as football, hockey, and cycling. They are also used in military and law enforcement settings to provide protection to personnel in dangerous situations. In addition, helmets are used in activities such as rock climbing, horseback riding, and skydiving to reduce the risk of head injuries. With the advancement of technology, helmets are being designed to incorporate features such as built-in cameras, communication devices, and even augmented reality displays, making them more versatile and useful in various applications.
- g) Helmets of different sizes are manufactured so that they can easily snugged on to the head of the rider.



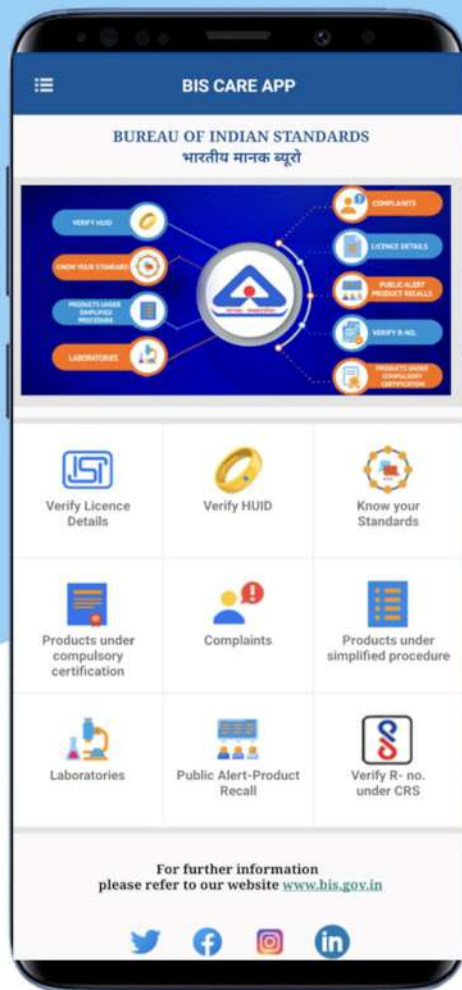
Forthcoming Lesson Plans...

Sl. No.	Subject	Sl. No.	Subject
1.	Ballpoint pen	27.	Microwave Oven
2.	Bicycle	28.	Milk Powder
3.	Boric Acid	29.	Multipurpose dry batteries
4.	Cables	30.	Paints
5.	Caustic Soda	31.	Pasteurized Milk
6.	Ceiling fan	32.	Paving Block
7.	Cement	33.	Plugs and Socket
8.	Cement Ash Brick	34.	Plywood
9.	Ceramics Tiles	35.	Power Threshers
10.	CNG Cylinders	36.	Precast Concrete
11.	Conduits	37.	Pressure Cooker
12.	Drinking Water	38.	PVC Pipes
13.	Electric Iron	39.	Rear View Mirrors
14.	Electric Mixer	40.	Refrigerator
15.	Family Sized Biogas Plant	41.	Solar Flat Plate Collector
16.	Fire Extinguisher	42.	Solid and Hollow Block
17.	Football	43.	Stainless Steel
18.	Gas Stove	44.	Steel Bar
19.	LPG Gas Cylinders	45.	Submersible Pump set
20.	Geosynthetics	46.	Thermometer
21.	Geyser	47.	Tyres for buses and trucks
22.	Headphones	48.	Vacuum Flask
23.	Hearing Aids	49.	Water Meter
24.	Helmet	50.	Water Storage Tank
25.	LED bulb	51.	Weighing balance
26.	Loudspeakers	52.	Wheel Rim

...Keep looking for other Lesson Plans in the series



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