CHAPTER 1

Knowledge and Comprehension Problems:

1.1 What are materials? List eight commonly encountered engineering materials.

Answer 1.1: Materials are substances of which something is composed or made. Steels, aluminum alloys, concrete, wood, glass, plastics, ceramics and electronic materials are commonly encountered engineering materials.

1.2 What are the main classes of engineering materials?

Answer 1.2: Metallic, polymeric, ceramic, composite, and electronic materials are the five main classes of engineering materials.

1.3 What are some of the important properties of each of the five main classes of engineering materials?

Answer 1.3:
Metallic Materials
-many are relatively strong and ductile at room temperature
-some have good strength at high temperature
-most have relatively high electrical and thermal conductivities

Polymeric Materials
-generally are poor electrical and thermal conductors
-most have low to medium strengths
-most have low densities
-most are relatively easy to process into final shape
-some are transparent

Ceramic Materials
-generally have high hardness and are mechanically brittle
-some have useful high temperature strength
-most have poor electrical and thermal conductivities

Composite Materials
-have a wide range of strength from low to very high
-some have very high strength-to-weight ratios (e.g. carbon-fiber epoxy materials)
-some have medium strength and are able to be cast or formed into a variety of shapes (e.g. fiberglass-polyester materials)
-some have useable strengths at very low cost (e.g. wood and concrete)

Electronic Materials
-able to detect, amplify and transmit electrical signals in a complex manner
-are light weight, compact and energy efficient

1.4 Define a composite material. Give an example of composite material.

Answer 1.4: A composite material is a materials system composed of a mixture or combination of two or more materials. Two examples are carbon-fiber epoxy and fiberglass polyester materials.

1.5 Provide a list of characteristics for structural materials to be used in space applications.

Answer 1.5: Some of the common characteristics of these materials are
Light weight to reduce thrust requirement at take-off,
Strong and shock resistant to sustain take-off loads
Ability to function appropriately at very high and very low (cyclic) temperatures
Resist radiation damage in space
Resist micro meteor impact

1.6 Define smart materials. Give an example of such material and an application for it.

Answer 1.6: Smart materials may be considered as a class of materials by their function or application. Smart materials are those materials that have the ability to sense external environmental stimuli (temperature, stress, light, etc..) and respond by changing their properties, structure, or function (sensing and actuating). Examples of such materials are shape memory alloys (to regain their shape after imposed deformation) and piezoelectric sensors (sensing pressure or applying force).

1.7 What are MEMs? Give an application for MEMs.

Answer 1.7: Micro-Electromechanical systems (MEMs) are devices that consist of micro-machines or microscopic mechanical elements fabricated on a semiconductor chip. Various applications include micro-pumps, locking systems, motors, mirrors, and sensors.

1.8 What are nanomaterials? What are some proposed advantages of using nanomaterials over their conventional counterparts?

Answer 1.8: Nanomaterials are defined as materials with a characteristic length scale smaller than 100 nm. The length scale could be particle diameter, grain size in a material, layer thickness in a sensor, etc. These materials have properties different than that at bulk or molecular scale. These materials often have enhanced properties and characteristics because of their nano-features in comparison to their micro-featured counterparts. The structural, chemical, electronic, and thermal properties (among other characteristics) are often enhanced at the nano-scale.

1.9 Nickel-base super alloys are used in the structure of aircraft turbine engines. What are the major properties of this metal that make it suitable for this application?

Answer 1.9: Some of the major properties of nickel-based superalloys for the stressful, hot, and corrosive environment of the aircraft turbine engine are i) high temperature strength,

ii) resistance to corrosion, and iii) resistance to damage under cyclic loading (fatigue).

1.10 Make a list of items that you find in your kitchen (at least 15 items). In each item, determine the class of materials (identify the specific material if you can) used in the structure of the item.

Answer 1.10:
1- Eating utensils – mostly metals (stainless steel and titanium)
2- Plates – mostly ceramics (mixture of clay, silica, feldspar)
3- Cabinets – mostly composites materials (wood a natural composite material)
4- Ovens heating elements – temperature resistant metal alloys (stainless steel or nickel-chromium alloy)
5- Pans and pots coatings– mostly polymer (non-stick) coating (Teflon coating)
6- Picnic utensils – mostly polymers (polystyrene, polypropylene, and nylon)
7- Dishwasher – corrosion resistant metals, polymer seals
8- Digital clocks – light emitting diodes (silicon)
9- Food storage wraps – polymers and metals (aluminum foil and polyethylene)
10- Refrigerator seal – magnetic metals and polymers
11- Tiles – mostly ceramics or polymer
12- Glassware – mostly ceramics (silica)
13- Pots and pans – mostly metals (aluminum, copper, iron)
14- Stove-top kettle – mostly metals (stainless steel, copper)
15- Food storage containers – mostly polymers (polyethylene, polypropylene, etc) or ceramics

1.11 Make a list of all the major components of your school's basketball court. For each major component, determine the class of materials used in its structure (identify the specific material if you can).

Answer 1.11:
1- The basket support structure – mostly metals (steel and aluminum alloys)
2- Net – polymer (nylon)
3- Court – mostly composites materials (wood and other synthetic composites)
4- Ball – a polymer composite made of rubber and fibers
5- Digital clock – electronic materials for light emitting diodes (silicon based)

1.12 Make a list of major components in your automobile (at least 15 components). For each component, determine the class of materials used in its structure (identify the specific material if you can).

Answer 1.12:
1- The engine –metal (cast iron or aluminum alloys)
2- Body – metal (thin steel or aluminum alloys) also advanced composites (carbon fiber composites)
3- Front panel or dash board – mostly polymeric materials (polycarbonates)
4- Tires – polymeric composite (synthetic rubber, polyester fabric, steel belts)
5- Light fixture – polymeric glass (Plexiglass)
6- Wires- metals (high conductivity copper)

7- Windshield – laminated glass (ceramic glass, acrylic and cellulose)
8- Springs – mostly steel alloys
9- Airbag – mostly polymer (nylon)
10- Mirrors – mostly ceramic (glass) and metal (aluminum, silver, chrome)
11- Floor mats – polymer (PVC)
12- Windshield wipers – mostly polymer (rubber)
13- Bumpers – polymers or metals
14- Hub caps – mostly metal or polymer (ABS)
15- Tail pipe – metals (steel iron)

1.13 Make a list of major components in your computer (at least 10 components). For each component, determine the class of materials used in its structure (identify the specific material if you can).

Answer 1.13:
1-The monitor and tower housing –polymers (ABS, high impact polystyrene, blends)
2- Tower casing – metal (aluminum alloy)
3- Cable, cord covers – polymers (polyethylene, Teflon, PVC, etc.)
4- Chip materials – metals, ceramics, electronic materials (silicon, silicon dioxide, copper, gold, silver, etc…)
5- Monitor (cathode-ray tube type)- Polymers and metals (Glass, steel, copper, PVC, rubber)
6- Screen- ceramic (glass) and polymer materials
7- Keyboard – polymers (ABS, polystyrene)
8- Wires – conductive metals (copper)
9- LEDs – ceramic and electronic materials (semiconductors such as gallium arsenide, silicon, etc)
10- Headphone jacks and ports- polymer case with metal contact (brass, nickel, or gold)

1.14 Make a list of major components in your classroom including the constructional elements (at least 10 components). For each component, determine the class of materials used in its structure (identify the specific material if you can).

Answer 1.14:
1- Chairs – Polymers and metals (polycarbonate, polystyrene, steel for frames)
2- Board – synthetic wood or polymers
3- Walls – Composite materials and ceramics (Wood, gypsum [a calcium mineral], plaster)
4- Structural frame – metal (Steel beams)
5- Electrical wiring – polymers and metals
6- Flooring –mostly polymer material (vinyl)
7- Light fixtures – metals and ceramics
8- Windows – mostly ceramics (silica)
9- Table tops – mostly composite (wood) with polymer coating
10- Vents – metal (steel) or plastic (polypropylene)

1.15 Perform a search on the history of "automobiles" and report how the usage of various types of materials in the structure of an automobile has changed in this field over the years.

Answer 1.15:
Early cars were made out of steel, with either a wooden or steel compartment for the driver. As demands for lightweight vehicles rose, fiberglass panels (height strength, low weight) were used for the body of some vehicles, but it was costly for many people to afford. Currently, many vehicles are being made from aluminum alloys, which are strong and lighter weight than steel. Additionally, certain car parts (bumpers, for example) are now being made of hard plastics, instead of metal, to decrease the overall cost of materials.

1.16 Perform a search on the history of "wheels" and report on how the material usage in this component has changed.

Answer 1.16:
The earliest wheels were generally made from stone or wood. For wood wheels, solid disk wheels were used first, and wooden-spoked wheels were developed later. It wasn't until the mid-late 1800s that wire-spoked wheels and pneumatic rubber/polymer tires were developed, since these allowed for the wheels to be lightweight and have high strength. Current wheels, such as those on automobiles and bicycles still use the polymer/rubber tires with wire-spokes (bicycle) or cast alloy (automobile) wheels.

1.17 Perform a search on the history of "recording media" and report on how the usage of materials as changed in this field over the years

Answer 1.17:
Phonograph records, and phonograph players were the earlier method for recoding and playing media. To make a recording, a hard stylus was vibrated by sound, and it cut grooves into the phonograph record. Due to this, the photograph record needed to be made of a soft material so that the stylus could cut the grooves, and this material was either shellac or polyvinyl chloride. After the phonograph, cassette tapes were used, and they consisted of a hard plastic shell and magnetic tape (generally polyester with a magnetic coating such as iron oxide or chromium). After the cassette, CDs became the most popular form or recording media, and were generally made from a polycarbonate plastic overtop of an aluminum layer (and a lacquer layer can be added on top for protection). Information could be recorded to it, or read from it, using a laser. The aluminum layer functioned to reflect the laser, and the polycarbonate was chosen since it is a soft material that allows for indentations to be made in it (the changes in height, caused by the indentations, reflects the laser differently, and this allows for the information to be read from it)

1.18 Perform a search on the history of "sport track materials" and report how the usage of materials has changed in this field over the years.

Answer 1.18:

Before artificial materials were used, grass, dirt, or cinder were used for track materials. The first artificial track material was made from polyurethane, and then ethylene propylene diene and rubber granulate materials were introduced shortly after. These polymer materials were popular since they provided shock absorption and deformed easily, which is ideal for track materials. Currently, recycled tire granules with polyurethane is a popular choice since it is deformable, absorbs shock, and makes use of recycled material

Application and Analysis Problems:

1.19 List some of the material usage changes that you have observed over a period of time in some manufactured products. What reasons can you give for the changes that have occurred?

Answer 1.19:
The modern automobile is being constructed with more and more plastic materials and less metallic due to the lower cost and weight of plastics.
The modern airplane is using more composite materials and plastics and less metallic materials to reduce plane weight.
Modern electronic equipment uses a great number of solid state devices made with electronic materials. These materials are more compact, weigh less, and provide higher overall energy efficiency. In many cases, they are the only type of material that can be used for specific applications such as complex computer memories.

1.20 a) What kind of materials is OFHC copper? b) What are the desirable properties of OFHC copper? c) What are the applications of OFHC copper in the power industry?

Answer 1.20: (a) Oxygen Free High Conductivity (OFHC) Copper is a 99.9% pure copper (a metal). (b) It has very high conductivity, is highly machineable, is easily welded, easily deforms (hot or cold). (c) It is used for high electrical conductivity applications such as power lines, vacuum tubes, and solid state devices.

1.21 a) To which class of materials does PTFE belong? b) What are its desirable properties? c) What are its applications in cookware manufacturing industries?

Answer 1.21: (a) Polytetrafluoroetheylene (PTFE) is a thermoplastic polymer. (b) It is a non-reactive polymer in the form of white powder that can easily be formed into a solid film with a low friction surface. It can reduce friction and wear. (c) It is used as a non-stick coating for pans and pots.

1.22 Why should Civil Engineers be knowledgeable about composition, properties, and processing of materials?

Answer 1.22: Civil engineers focus on problems and issues related to the nation's infrastructure (bridges, highways, buildings, etc.). Perhaps two of the major concerns is the structural safety and durability of the civil infrastructure. Knowledge of composition, properties, and processing of materials, such as steel alloys, concrete, and composites, is crucial from a structural, chemical (corrosion), and safety point of view. (you can highlight many more reasons for the importance of materials knowledge in your field)

1.23 Why should Mechanical Engineers be knowledgeable about composition, properties, and processing of materials?

Answer 1.23: All branches of mechanical engineering will require selection of materials for a variety of applications in automobiles, power plants, and machines (to name a few) based on a variety of requirements including weight, strength, stiffness, deformability, corrosion, conductivity, magnetism, etc. Knowledge of composition, properties, and processing is critical to select, modify, and apply materials to various applications. (you can highlight many more reasons for the importance of materials knowledge in your field)

1.24 Why should Chemical Engineers be knowledgeable about composition, properties, and processing of materials?

Answer 1.24: Many chemical engineers become heavily involved in process design related to polymer design, production, and component manufacturing. Such engineers not only should be knowledgeable about the composition, properties, and processing of polymers, but should also

know how to integrate these materials in different applications in a safe and environmentally friendly manner. (you can highlight many more reasons for the importance of materials knowledge in your field)

1.25 Why should Ocean Engineers be knowledgeable about composition, properties, and processing of materials?

Answer 1.25: One important aspect of ocean engineering is designing equipment that will survive the ocean environment (corrosive salt water, windy and harsh conditions, fouling from marine life, etc), which requires a strong knowledge of material properties and composition. They should also be knowledgeable about the processing of these materials since they will be responsible for maintaining them and preparing them for use.

1.26 Why should Petroleum Engineers be knowledgeable about composition, properties, and processing of materials?

Answer 1.26: Four important areas related to petroleum engineering that require extensive materials knowledge are drilling, production, refining, and distribution. The use of materials in drilling requires extensive knowledge of metals, ceramics, and their interaction. In production and drilling, extensive knowledge of geologic materials is also required. Offshore drilling tasks introduce many new challenges regarding corrosion, strength, and the durability of machines and components on offshore platforms. Refining would require knowledge of materials selection for the design of heat exchangers, boilers, cooling towers, all in the presence of some very caustic chemicals. (you can highlight many more reasons for the importance of materials knowledge in your field)

1.27 Why should Electrical Engineers be knowledgeable about composition, properties, and processing of materials?

Answer 1.27: Electrical engineers would be interested in materials issues because of their interest in designing integrated circuits at very small scales. Although they mostly deal with electronic materials, other classes of materials including metals, ceramics, polymers, and composites are also extensively used. Electrical engineers would be very interested in electrical (conductive, semiconductive, and insulative) properties of all classes of materials. In addition to electrical properties, structural and thermodynamic issues are also of importance to electrical engineers. (you can highlight many more reasons for the importance of materials knowledge in your field)

1.28 Why should Biomedical Engineers be knowledgeable about composition, properties, and processing of materials?

Answer 1.28: Biomedical engineers are principally concerned about the biocompatibility of various materials inside the human body (a very corrosive environment). They must be aware of composition (for toxicity), properties (for weight bearing applications in orthopedics), and processing (which method of processing produces the best part). Also, biomedical engineers are using polymeric scaffolds in addition to biologic materials to produce new tissue (tissue engineering). (you can highlight many more reasons for the importance of materials knowledge in your field)

1.29 (a) To which class of materials does Kevlar belong? (b) what are its desirable properties? (c) What are its applications in space industries?

Answer 1.29:

(a) Kevlar is a polymer materials.
(b) Some of the attractive properties of Kevlar is that is has high impact resistance, has high tensile strength, and is light-weight.
(c) Due to its high strength and light weight, Kevlar is able to survive the force of space travel while keeping fuel consumption lower (less weight can result in less fuel consumption). It can also be combined with other materials, to make composite materials, which provides additional benefits and properties.

1.30 (a) To which class of materials does silicon belong? (b) What are its desirable properties? (c) What are its applications in chip manufacturing industries?

Answer 1.30:

(a) Silicon is an electronic material
(b) Some of the attractive properties of silicon is that it's a semiconductor with conductivity that can be changed with the addition of heat or doping with certain elements. This fine control of the conductivity allows it to be used for many electronic devices. It can also form an insulating layer when exposed to the right conditions, and it is abundant.
(c) Silicon is by chip manufacturing industries due to its ability to function as an insulator (if exposed to the right conditions), its ability to have controllable conductivity, and its abundance and low cost.

1.31 (a) To what class of materials does zirconium oxide belong? (b) What are its desirable properties? (c) What are its applications in manufacturing industries?

Answer 1.31:

(a) Zirconium oxide is a ceramic material
(b) Some off the attractive properties of zirconium oxide are its hardness, wear resistance, ability to be used in high temperature environments, and strength
(c) Due to its extreme hardness and wear resistance, zirconium oxide can be used for industrial cutting applications since they are much harder than steels. Due to their high heat resistance, they can also be used for heat resistant linings or holders during certain processes.

Synthesis and Evaluation Problems:

1.32 What factors might cause materials usage predictions to be incorrect?

Answer 1.32:
If a war breaks out and, as a consequence, a raw material's supply is cut off. For example, if a major war broke out in the Middle East, the price of oil would increase, and hence the price of plastic materials would also increase.

If a major new discovery is made, some materials' usage may change.

If defects show up in a specific material after a certain length of its service, the material's usage may decrease. For example, a high strength composite material used for aircrafts may start showing some delamination defects.

1.33 Consider the common household component in a light bulb: a) identify various critical components of this item, b) determine the material selected for each critical component, and c) design a process that would be used to assemble the light bulb.

Answer 1.33: (a and b) The bulb itself is a ceramic glass (sometimes coated with silica to reduce glare). The screw thread contact is aluminum alloy. The filament is made of tungsten (a metal). The structure that holds the wire is also ceramic glass. Stiff metallic wires (nickel-iron alloy) connect the filament to the electrical contact at the bottom of the screw. The bulb is filled with inert gas (argon/nitrogen mixture). (c) Glass is blown through holes into molds to form the casing. The filament base (stem assembly to hold wires) is also made using molds. The filament is manufactured using a process called wire-drawing. The filament is placed on the stem, and the glass bulb is placed on the stem and filament. Air is extracted, argon/nitrogen is introduced and the base is sealed.

1.34 a) Name the important factors in selecting materials for the frame of a mountain bike.
b) Steel, aluminum and titanium alloys have all been used as the primary metals in the structure of a bicycle; determine the major weaknesses and strengths of each. c) The more-modern bikes are made of advanced composites. Explain why, and name a specific composite used in the structure of a bike.

Answer 1.34: (a) The material must be strong (resist permanent deformation) and stiff (not bend easily-resist elastic deformation); Must be light-weight; Must resist failure due to cyclic loading (fatigue); Must resist corrosion. (b) Steel is too heavy; Aluminum alloy is lighter but not as strong or stiff; Titanium alloy is strong, stiff, and light, but it is also expensive. (c) advanced composites such as

graphite-epoxy are very light weight, strong and stiff (best strength-to-weight ratio), but these are expensive.

1.35 a) Name the important criteria in selecting materials for a protective sports helmet. b) Identify materials that would satisfy the above criteria. c) Why would a solid metal helmet not be a good choice?

Answer 1.35: (a) The material, or combination of materials, must first and foremost absorb a significant amount of the energy due to impact, and must not allow that energy to transfer to the skull. The material must also be light weight. (b) The helmet material is the polymer polycarbonate. There is also a polymer foam (vinyl) placed inside the helmet. The helmet and the foam absorb a great deal of impact energy by deforming. The form also protects the skull from a sharp directed blow and distributes the blow. The face mask is made of metal (steel wire coated with plastic) or another hard polymer such as ABS. (c) A solid metal helmet will not distribute the blow or deform substantially from an impact and will transfer most of the energy to the skull. It is also too heavy.

1.36 Why is it important or helpful to classify materials into different groups as we have done in this chapter?

Answer 1.36: Classification of materials allows the engineer to associate certain general characteristics with a specific material. This knowledge is very important. For instance, one you realized that material x is classified as a ceramic, without actually knowing the exact properties, you will immediately know that it will be brittle, low density, chemically stable, low friction etc. You will also know the nature of its atomic structure (chapters 2 and 3). In general, it gives you the ability to seek candidates for your materials selection applications.

1.37 A certain application requires a material that must be very hard and corrosion resistant at room temperature and atmosphere. It would be beneficial, but not necessary, if it is impact resistant. a) If you only consider the major requirements, which classes of materials would you search for this selection? b) If you consider both major and minor requirements, which classes would you search? c) Suggest a material.

Answer 1.37: (a) If we are looking to satisfy the major requirements, hard and corrosion resistant materials, we can look to some metals and ceramics. Some metal alloys such as heat treated stainless steel or ceramics such as silicon carbide are both hard and corrosion resistant. (b) To satisfy the minor requirement as well, we should search in metals because they are more impact resistant (less brittle) than ceramics.

1.38 Give as many examples as you can on how materials science and engineering is important to the topic in the cover image

Answer 1.38: The cover image shows a go-kart driving on a course. Materials science and engineering are important for the performance of the go-kart since lightweight materials will ensure that the kart moves faster and consumes less fuel, high strength materials will be useful for protecting

components, rust and corrosion resistant materials will ensure a long life for components, and materials able to withstand impact would be useful in case of collisions. Electronic materials, such as silicon chips and LEDs, can be used to control the car and provide lighting. Additionally, the selection of tire materials will change the wear resistance and puncture resistance of the tires, the sliding friction in different conditions (in the image we can see water on the track), and the deformation of the tires due to the weight of the vehicle.

1.39 When selecting materials to be used inside the human body, what are some major factors that must be considered?

Answer 1.39:
Whenever a material is going to be used inside the human body, the following factors should be considered:

- Biocompatibility: material must be able to survive and function within the human body (which is a corrosive environment) without causing harm or toxic affects
- Degradation resistance: if the material is being used inside the body for an extended period of time, it should resist degradation and maintain structural integrity. However, some temporary materials (such as dissolving stitches) should degrade within the body in a specific time frame

- Mechanical properties (hardness, elasticity, brittleness, etc): If the material is needed for a structural function, it may need to be hard, resist impact, and resist wear. For example, bone prosthetics can be commonly made from metals or ceramics. However, some devices, such as contact lenses, require flexibility and elasticity for improved comfort and function
- Toxic or carcinogenic effects: any material used in the human body should not cause unnecessary harm, and should be safe and free of toxic or carcinogenic effects

1.40 In the sport of tennis, for optimal performance, the racket face and handle must be made of a material that is very stiff (resistant to elastic deformation). Why is this important?

Answer 1.40:
In tennis, it is important that the racket face and handle materials are resistant to elastic deformation. If the material is elastically deformed, energy is being consumed, and the ball will have less energy as it leaves the racket. So, a stiffer material will resist in a higher ball speed.

1.41 Classify materials used in engineering products in terms of environmental impact. For each classification, explain the designation and give specific examples.

Answer 1.41: In terms of Environmental impact, materials may be classified as renewable and non-renewable. Renewable materials, also called organic or biomass, are derived from living organisms while non-renewable materials, also called inorganic, are generally extracted from earth's crust.

1.42 What is life cycle analysis?

Answer 1.42:
To achieve sustainability and reduce environmental impact, engineers and product developers engage in **life cycle analysis** which *simultaneously considers six distinct stages in the design process: 1) raw material availability and selection, 2) material processing, 3) component manufacturing, 4) transportation, 5) utilization, and 6) recyclability.*

1.43 Consider the case of selecting the materials for an automobile fender. As a life cycle analyst, you must choose the safest material for the fender and your choices include 1) steel, 2) fiber reinforced composite, and 3) Polycarbonate (PC/PBT). Develop a table that considers factors important in life cycle analysis and propose the most effective, economical and environmentally friendly choice of materials.

Answer 1.43:
The impact of the usage of each material for various life cycle analysis factors is included in the table below:

	Material Availability	Materials Processing and Environment	Manufacturing	Transportation	Utilization	Recycleability
Steel	Available - low cost - mining is required	energy usage is high, chemicals, heavy machinary, water usage, pollution of air and water, global warming	easy but heavy machinery is required	heavy, expensive, more pollution	Steel is heavy and reuires more fuel	high
Carbon Compiste	Available - high cost - both mining and synthetic	energy usage is moderate , chemicals, water and air poolution	difficult - Curing ovens are required	light, less expensive	light - vehicle is lighter less fuel	low
Polycarbonate	Available - synthetic - Meduim cost	Energy usage is lower, chemical use is extensive, water and air pollution	easy - injection techchnology is required	light, less expensive	light - vehicle is lighter less fuel	low

As you can see the decision is not an easy one, but recyclability should drive the choice. Because steel is recyclable, it will put less stress on resources and environment. But it is heavy, and designers should make stronger steels to reduce the thickness and therefore weight.

1.44 In life cycle analysis of a computer display, investigate the environmental impact of Liquid crystal displays. What can computer display manufacturers do to reduce the environmental impact?

Answer 1.44:
The environmental impact of are as follows:

- LCDs use more electricity than conventional displays used for the same application.
- LCDs are lighter than conventional displays so less transportation cost.
- LCD contains less lead (a toxic material) than conventional displays.
- LCD has currently low recyclability but can improve in the future.