



# Maryland Engineering Challenges

## 2022 Safe Racer Challenge

### Elementary Level – Grades 2 and 3

Supported By:  
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Engineer Contact:  
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## Important Dates

### Coaches' Information Session

⇒ **Thursday, October 14, 2021**

**Choose 3:30-4:30pm OR 6:30-7:30pm**

These “drop-in” virtual events hosted on Zoom are designed for adults interested in coaching a team and chat with engineers. Find out if a particular Challenge is a good fit for your students. The Coaches' Information Session is not required and there is no cost. Attendance is strongly encouraged.

Contact Jessica at [challenges@thebmi.org](mailto:challenges@thebmi.org). Register for the Information Session at this link:

<https://bit.ly/2022MECInformationSession>

### Registration Deadline

⇒ **February 18, 2022**

In order to be a registered team, each team must have their adult Coach complete the registration process at the link below with the **team name and the names of all the team members**:

- Register online at <https://bit.ly/MEC2022Registration>

### Written Report Due

⇒ **February 25, 2022**

**Prior to 4:00 p.m.**

- AND submit (hand deliver or by mail) the team's Written Report as a HARD COPY to the Baltimore Museum of Industry:  
**BMI, 1415 Key Highway, Baltimore MD 21230**
- AND pay a \$5 Coach's Fee here: <http://bit.ly/MECcoachfee>.

### Safe Racer Competition

⇒ **March 12, 2022**

**Doors open at 9:00 a.m.**

Full details about the Challenge will be emailed to Coaches after the registration deadline.

Questions about Challenge specifications or judging should be sent to the Engineer Contact:

Phil Han [phan@WBCM.com](mailto:phan@WBCM.com)

**Other questions?**

Jessica Celmer [challenges@thebmi.org](mailto:challenges@thebmi.org)

## THE CHALLENGE

Design and develop a fast, open-top racecar with suitable safety equipment to enable the racing driver, Eggbert[a]—an uncooked egg—to survive a crash test and then compete for the coveted Safe Racer Cup in the distance trials.

Students design and build model race cars, each containing a fragile raw-egg “driver,” which plunge down a 30-degree ramp and crash into a barrier. The cars will be designed for safety, however, so the eggs survive un-cracked. To demonstrate that the car has also been designed for egg-citement, the barrier is removed, and the car is free to speed down the track. Some cars travel more than 75 feet!

## ENGINEERING TEAM REQUIREMENT

Each team may consist of 1 to 6 students. **There is no limit to the number of teams a school may have, unless more than 50 teams register. If this happens, then schools with multiple teams will be asked to reduce the number of competing teams as directed by the Safe Racer Challenge Coordinator.**

## DESIGN & CONSTRUCTION STANDARDS

### Race car

- The car must be constructed by students from readily available recycled materials, except for the wheels and axles and for glue, tape and other materials used to connect car parts to one another. Points may be deducted at the discretion of the judges based on the lack of recycled materials.
- The car must have an open top.
- The team logo must be displayed clearly on the car for identification.
- The car must be no more than 5 inches wide, including the wheels, and no more than 9 inches long. Oversize cars will have points deducted and the team will be given the opportunity to correct the condition, where feasible, so they can continue with the competition.
- The total weight of car, safety equipment, and Eggbert[a], a **LARGE** uncooked egg, must be less than 12 ounces. Overweight cars will have points deducted and the team will be given the opportunity to correct the condition, where feasible, so they can continue with the competition.
- The car design must include driver safety equipment. Eggbert[a] must have a “face” (a circle one inch in diameter), which **must not be covered**, and [s]he must be upright and able to “see” the road. Either bring 1”-diameter labels with faces drawn on them or choose from assorted pre-printed labels at the Egg Selection Table.
- The egg must be oriented in the car with the small end of the egg (the head) pointed up.
- It must be possible to easily remove Eggbert[a] from the car and safety equipment to examine him/her for damage. The team members must remove Eggbert[a] from the car, not the Judges. Eggbert[a] should not be wedged in tightly. The “comfort and convenience” of the equipment will be considered when judging the design. **If Eggbert[a] cannot be easily removed from the car, the team will be given the opportunity to correct the condition, where feasible; otherwise points will be deducted at the discretion of the judges.**
- Eggbert[a] must wear a safety helmet, which must be easily removable.
- Other than a face for Eggbert[a], nothing else can be fastened to the egg with tape, glue, Silly Putty or any other adhesive.
- Obvious excessive help from adults will be penalized at the judges’ discretion.
- Nothing can be attached to the car that will purposefully slow the speed of the car as it goes down the ramp. Any such device will result in the disqualification of the car from the competition.

### Test Ramp

- Test ramps will be available at the competition for all teams to practice.
- All cars will be tested on the same design crash test ramp and distance trial ramp.
- Test ramp size = 6 feet long set at an angle of 30 degrees. The ramp is made with a 1x6 board ( $\frac{3}{4}$ " thick by 5 $\frac{1}{2}$ " wide) with 1x2 board ( $\frac{3}{4}$ " thick x 1 $\frac{1}{2}$ " wide) side rails, providing a chute 5 $\frac{1}{2}$  inches wide (maximum width of car is 5 inches).
- The test ramp should have a curved surface made from stiff cardboard (such as the backing of a pad of paper) at the base to allow a smooth transition from the angled ramp to the floor or track surface.
- A crash barrier made of  $\frac{1}{2}$ " x 8" x 8" plywood [minimum] should be fastened to the end of the test ramp for the crash test element of the performance demonstration.
- *Note: A LIMITED number of Safe Racer test ramps are available from the BMI. A ramp may be purchased for \$50 or may be rented for \$20 with an additional \$30 refundable deposit. In addition, free construction plans are available electronically. To arrange, contact Jessica Celmer at [challenges@thebmi.org](mailto:challenges@thebmi.org) after October 14, 2021.*

### Required Construction Elements

- All cars must use the same wheel and axle components.
- Wheels: 1 $\frac{3}{8}$ " diameter, 3/16" tread width,  $\frac{1}{8}$ " axle size. Source: [www.kelvin.com](http://www.kelvin.com) item # 990171
- Axles: 1/8" diameter metal rod, length to suit width of car. Source: any hobby store. (For the specified wheels, the maximum length of the axles is 4 $\frac{3}{4}$ " to stay within the 5 inches overall width limitation.)
- *Each Coach for the Safe Racer Challenge may request one free Safe Racer kit per team registered. Each kit consists of 4 wheels, two axles, and two straws to serve as axle bushings. It is not mandatory to use the axles in the kit; you may use axles of any length up to a maximum of 4 $\frac{3}{4}$ ". Also, it is not mandatory to use the straws provided in the kit as axle bushings, you may use any other recycled material for axle bushings (No ball bearings). To request your kit(s), contact Jessica Celmer at [challenges@thebmi.org](mailto:challenges@thebmi.org) after October 14, 2022.*
  - Note: Do not attempt to shorten the axels provided with ordinary wire cutters. The cutters will be damaged. Use an abrasive cutoff wheel.
- Additional wheels may be purchased from [www.kelvin.com](http://www.kelvin.com) item # 990171
- There will be no external propulsion or braking of the car during the crash test and distance trials. Only the potential energy of the car due to gravity will propel the car freely down the test ramps; and only the friction of inadvertent rubbing of the wheels against the side rails will be allowed to retard the car.
- Only a dry lubricant can be used on the axles. Oil or grease will not only be messy, but will attract dust causing the oil or grease to gum up and be less slippery than no lubricant at all.
- No modification of the cars is allowed after the car has left the Design and Construction Judging Station except for emergency repairs after the crash test. After such repairs, the repaired car must be examined by the crash test judges before proceeding to the distance trials.

### PERFORMANCE DEMONSTRATION GUIDELINES

The winner of the Safe Racer Cup is the car that travels furthest, but the overall Challenge grading also takes into account a written report, an interview with the judges, team poster design, and the design and construction of the vehicle. The team that is the overall winner must demonstrate a wide range of skills.

Teams must bring a 20" x 30" poster displaying the school name and team name in 3" high letters and a logo to identify your team during the demonstrations.

Performance demonstrations are conducted as follows:

- **Part 1 – Written Report**

The written reports will be reviewed by a group of Judges several days before the day of the Safe Racer Engineering Challenge. The Judges will be evaluating the reports for the following aspects:

- Completeness
- Neatness
- Presentation, including use of drawings and photos
- Originality of design ideas
- Safety features
- Report Cover and Logo
- Other aspects that the Judges may deem worthy of recognition
- Only hard copies of the Written Reports will be accepted. Emailed scanned copies will not be accepted.

Each team will be awarded a certificate of achievement for some outstanding aspect of its written report. One team will be awarded a certificate for the Best Written Report.

#### **DESIGN REPORT REQUIREMENTS**

The Team shall submit a formal written report containing the minimum information listed below. It is recommended that each team member keep a personal journal addressing the topics below. Teams are encouraged to provide additional information as well as each Team members' journals. You should keep the order of the presentation as outlined below; but, the team is encouraged to personalize the report with photos, sketches, art work, etc...and add supplemental sections that you believe the judges may find useful. All written reports must have the Coaches' names and email addresses clearly indicated. The report should be preferably typed or neatly printed by the students. The reports will not be judged for spelling or grammar, but for the design and construction process and for content and presentation.

- REPORT COVER - The report cover should have the team name, the school (if applicable) and the team logo as a minimum.
- TEAM INFORMATION – Provide Team Name, Grade Level, Team Member names, Team's School Name (if applicable) and County, Adult Coach(s) and email addresses
- SKETCHES/DRAWINGS – Provide sketch (with date) of your final Safe Racer Car design. Provide any supplemental sketches made during design.
- DESCRIPTION OF CAR – Provide final car measurements (length, width, & weight) of the car and describe how your design was selected.
- TESTING - Describe how your design was tested (include sketches and drawings), explain the improvements or changes made to your design after testing, describe distances measured during distance testing, and describe if the egg survived during testing.
- PROJECT MILESTONES AND RESEARCH - List the dates of important milestones in your project and describe those milestones, describe math and science skills needed in this challenge, list all the information resources used to solve the challenge problem (Include books, pictures, and websites), and list the materials used in developing and constructing your project (materials, cost, tools used).

- ADULT ASSISTANCE - Explain what help adults gave your team (name of adults and type of assistance provided).
- CERTIFICATION - Reports shall conclude with the following certification statement, **TO BE SIGNED BY ALL STUDENTS, ADULT HELPERS, AND TEAM COACH:**

We hereby certify that the majority of the ideas, design, and work was originated and performed by the students, with limited assistance by adults, as described above.

Printed Name

Signature

Date

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- **Part 2 – Check-In**

Upon arrival at the BMI on the day of the Challenge, each team must check in at the Check-In Station. (Each Team must be accompanied by an adult Coach.)

- The Check-In Judge will record each team member present and verify the spelling of names.
- Each team will be given a team packet containing:
  - The Written Report
  - The order of team testing so each team can tell just when it is their turn
  - A Team Number Sign to be displayed along with the Team Poster at each judging station
  - Other material that may be important information during the course of the day.
  - If any team member arrives late, after the course of judging has started, the late member's team may have to go to the end of the testing order unless the team decides to start the judging without the late member. The late member may join the team at any point during the judging except for the Oral Report judging.

- **Part 3 – Egg Selection**

Each team will be called in turn to visit the Egg Selection Station. Each team will select their uncooked **LARGE** egg from the eggs available at the Egg Selection Station. Bright lights and magnifying glasses will be available for the team to carefully examine the eggs to be sure there are no cracks that would weaken the chosen egg.

- **Part 4 – Construction Judging**

Each car will be carefully examined for conformance to the construction rules. Teams whose car does not conform to the rules will be given an opportunity to modify their car at the Repair Pit.

- **Part 5 – Crash Test**

Just prior to the Crash Test, a photo portrait will be taken of each race car and Egbert[a] at the Portrait Station. Also, each team will pose for a group photo with their car and their poster in the background.

### **Mandatory Front Crash Test**

The car and Eggbert[a] will be rolled down the BMI's test ramp to crash into the barrier at the end. Eggbert[a] will then be carefully examined by the judges. A maximum of 20 points will be awarded based on the performance of the car and the condition of Eggbert[a]. Injured drivers (damaged eggs) will be replaced with an alternate driver (a fresh egg chosen by the team at the Alternate Driver Selection Table adjacent to the Crash Test Station).

### **Optional Rear Crash Test**

**A Team is only eligible to participate in the Optional Rear Crash Test if the egg survives the Mandatory Front Crash Test!** Each eligible Team may, if they choose to, try to gain bonus points by participating in the Optional Rear Crash Test. **Although this is an opportunity to gain additional points, there is also the risk of losing points.**

**Should a Team attempt the Optional Rear Crash Test and Eggbert[a] is injured (the egg is damaged), the Team is ineligible to continue with the other Optional Crash Tests (Super Crash Test – See Part 8)**

- To simulate a rear-end crash and test the car's ability to protect Eggbert[a], the car will be released one-quarter of the way down the ramp. If Eggbert[a] survives, five (5) bonus points will be awarded. If Eggbert[a] is injured, there will be a five point **penalty**, so be careful in deciding whether to go after the bonus points.

### **• Part 6 – Distance Trials**

Each car will be run 3 times along the distance track and the best (longest) run will be used for scoring. The car that travels the furthest will receive the Safe Racer Cup and 10 points. The second furthest will be awarded 8 points, the third furthest 7 points, and so on.

Should Eggbert[a] be injured during the Distance Trials, injured drivers (damaged eggs) will be replaced with an alternate driver (a fresh egg chosen by the team at the Alternate Driver Selection Table adjacent to the Distance Trials Station).

### **• Part 7 – Oral Report**

Each team will present an Oral Report to several Judges. The Oral Report has two parts:

- The Judges will ask several questions of each team from a list of prepared questions. (No, you cannot have a copy of the questions.)
- The Judges may ask the team to explain certain aspects of the design of its car, its design process, problems encountered, help from grownups, the safety features of the car, and other questions that may come to their minds.

The Orals will be from 5 to 8 minutes depending on the number of teams competing and the number of available Orals Judges. The Judges will base the scoring on:

- Preparation
- Knowledge
- Poise of team members

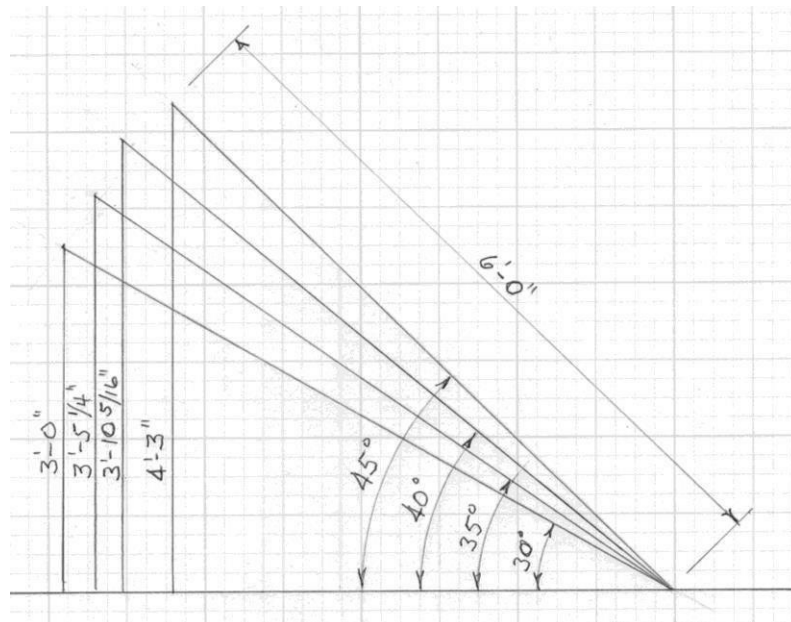
After the Oral Report is complete, the car, poster, and written report must be left with the judges for further comparative judging of all posters and cars.

### **• Part 8 – Optional Super Crash Tests**

**A Team is only eligible to participate in the Optional Super Crash Test if the egg survives the Mandatory Front Crash Test! If a Team attempted the Optional Rear Crash Test, the egg must have survived to participate in the Optional Super Crash Test as well.** After the Oral Report and at any time up until 15 minutes after the completion of the last Oral Report, each eligible Team may, if they choose to do so, try to gain some bonus points by participating in the Optional Super Crash Test. **Although**

**this is an opportunity to gain additional points, there is also the risk of losing points.**

- **OPTIONAL Super Crash Test** – An opportunity to gain even more bonus points.
  - The ramp for the regular Crash Test is inclined at 30 degrees. For the Super Crash Test, the incline of the ramp will be increased to 35 degrees. If Eggbert[a] survives the 35-degree ramp crash, 5 bonus points will be awarded. If Eggbert[a] is injured, a 5-point penalty will be assessed. If Eggbert[a] is uninjured, the team may decide to try for more bonus points with the ramp increased to 40-degree incline. If Eggbert[a] survives the 40-degree ramp crash, another 5 bonus points will be awarded. If Eggbert[a] is injured, a 10-point penalty will be assessed. If Eggbert[a] is uninjured on the 40-degree ramp crash, the team may decide to try for even more bonus points with the ramp increased to a 45-degree incline. If Eggbert[a] survives the 45-degree ramp crash, another 5 bonus points will be awarded. If Eggbert[a] is injured, a 15-point penalty will be assessed. (A team can possibly earn 15 bonus points but not lose more than 5 points.)
  - For the 35-degree ramp, the car will hit the barrier with approximately 1.15 times the force as for the 30-degree ramp, 1.30 times for the 40-degree ramp and 1.41 times for the 45-degree ramp.



Geometry of the Super Crash Test Ramp

- **Part 9 – Judging of Posters and Race Cars**

After all teams have completed the Oral Reports, the Judges will review all of the Written Reports, Posters, and Race Cars and determine which team will receive the following award certificates:

- Best Poster
- Best Logo
- Best Engineered Car
- Best Constructed Car
- Cutest/Coollest Car
- Most Aerodynamic Car
- Best Safety Features
- Other aspects that the Judges may deem worthy of recognition

- **Part 10 – Awards Ceremony**

After the Oral Judging and any Optional Testing is complete, the Judges will require about one hour to complete the judging, tally the final scores and prepare the awards certificates. After the awards ceremony, on your way out of the Museum, be sure to pick up your race car, poster, and written report from the Oral Report Judging Room.

## EVALUATION STANDARDS

This elementary school-level competition involves four main components: the design and construction of the project, a written report, an oral report, and the performance demonstration.

1. WRITTEN REPORT *	Competition value: 15 points
• <i>Late penalty</i>	<i>(-)5 points</i>
2. ORAL REPORT	Competition value: 15 points
3. POSTER	Competition value: 5 points
4. CAR CONSTRUCTION & DESIGN	Competition value: 10 points
5. SAFETY EQUIPMENT	Competition value: 15 points
6. SIZE & WEIGHT	Competition value: 10 points
• <i>One point will be deducted for each ounce or portion thereof over the 12 oz. weight limit. There will be no bonus points for underweight cars. Oversize cars will be given the opportunity to correct the condition where feasible; otherwise, points will be deducted at judges' discretion.</i>	
7. PERFORMANCE DEMONSTRATION	
Distance Trials	Competition value: 10 points
Crash Test	
• Front-end crash	Competition value: 20 points
• Optional rear-end crash	
○ Successful	(+)5 points
○ Failure	(-)5 points
• Optional Super Crash Test	<u>35 degrees</u> <u>40 degrees</u> <u>45 degrees</u>
○ Successful	(+) 5 points      (+) 5 points      (+) 5 points
○ Failure	(-) 5 points      (-) 10 points      (-) 15 points

An outline of what is required for each component, and general guidance on preparing for the competition, is in the "[Elementary School Guide to Entry](https://bit.ly/BMIchallenges)" which should be read in connection with this document and can be accessed on the MEC webpage <https://bit.ly/BMIchallenges>



# Maryland Engineering Challenges and the Next Generation Science Standards

<p><b><i>PK-2<sup>nd</sup> Grade - S1.0 Skills and Processes - Topic A. Constructing Knowledge</i></b></p> <p>Raise questions about the world around them and be willing to seek answers to some of them by making careful observations and trying things out.</p>	<p><b>In preparing for the challenge, students will:</b></p> <ul style="list-style-type: none"> <li>• Seek information through reading, observation, exploration, and investigations. Objective b</li> <li>• Use tools such as thermometers, magnifiers, rulers, or balances to extend their senses and gather data.</li> </ul> <p>Objective c</p> <ul style="list-style-type: none"> <li>• Participate in multiple experiences to verify that science investigations generally work the same way in different places. Objective e</li> </ul>
<p><b><i>3<sup>rd</sup>-5<sup>th</sup> Grade - S1.0 Skills and Processes - Topic A. Constructing Knowledge</i></b></p> <p>Gather and question data from many different forms of scientific investigations which include reviewing appropriate print resources, observing what things are like or what is happening somewhere, collecting specimens for analysis, and doing experiments.</p>	<ul style="list-style-type: none"> <li>• Support investigative findings with data found in books, articles, and databases, and identify the sources used and expect others to do the same.</li> </ul> <p>Objective a</p> <ul style="list-style-type: none"> <li>• Recognize that the results of scientific investigations are seldom exactly the same, and when the differences are large, it is important to try to figure out why. Objective d</li> <li>• Follow directions carefully and keep accurate records of one's work in order to compare data gathered. Objective e</li> </ul>
<p><b><i>PK-2<sup>nd</sup> Grade - S1.0 Skills and Processes - Topic B. Applying Evidence and Reasoning</i></b></p> <p>People are more likely to believe your ideas if you can give good reasons for them.</p> <p><b><i>3<sup>rd</sup>-5<sup>th</sup> Grade - S1.0 Skills and Processes - Topic B. Applying Evidence and Reasoning</i></b></p> <p>Seek better reasons for believing something than "Everybody knows that..." or "I just know" and discount such reasons when given by others.</p>	<p><b>In designing their projects, students will:</b></p> <ul style="list-style-type: none"> <li>• Provide reasons for accepting or rejecting ideas examined. Objective a</li> <li>• Develop reasonable explanations for observations made, investigations completed, and information gained by sharing ideas and listening to others' ideas. Objective b</li> <li>• Offer reasons for their findings and consider reasons suggested by others. Objective b</li> <li>• Keep a notebook that describes observations made, carefully distinguishes actual observations from ideas and speculations about what was observed, and is understandable weeks or months later. Objective d</li> </ul>

<p><b><i>PK-2<sup>nd</sup> Grade - S1.0 Skills and Processes - Topic C. Communicating Scientific Information</i></b></p> <p>Ask, "How do you know?" in appropriate situations and attempt reasonable answers when others ask them the same question.</p>     <p><b><i>3<sup>rd</sup>-5<sup>th</sup> Grade - S1.0 Skills and Processes - Topic C. Communicating Scientific Information</i></b></p> <p>Recognize that clear communication is an essential part of doing science.</p>	<p><b>In composing the written and oral reports, students will:</b></p> <ul style="list-style-type: none"> <li>• Describe things as accurately as possible and compare observations with those of others. Objective a</li> <li>• Describe and compare things in terms of number, shape, texture, size, weight, color, and motion. Objective b</li> <li>• Have opportunities to work with a team, share findings with others, and recognize that all team members should reach their own conclusions about what the findings mean. Objective d</li> </ul>   <ul style="list-style-type: none"> <li>• Make use of and analyze models, such as tables and graphs to summarize and interpret data. Objective a</li> <li>• Avoid choosing and reporting only the data that show what is expected by the person doing the choosing. Objective b</li> <li>• Construct and share reasonable explanations for questions asked. Objective d</li> </ul>
<p><b><i>PK-2<sup>nd</sup> Grade - S1.0 Skills and Processes - Topic D. Technology</i></b></p> <p>Design and make things with simple tools and a variety of materials.</p>   <p><b><i>3<sup>rd</sup>-5<sup>th</sup> Grade - S1.0 Skills and Processes - Topic D. Technology</i></b></p> <p>DESIGN CONSTRAINTS: Develop designs and analyze the products: "Does it work?" "Could I make it work better?" "Could I have used better materials?"</p> <p>DESIGNED SYSTEMS: Investigate a variety of mechanical systems and analyze the relationship among the parts.</p>	<p><b>In building their projects, students will:</b></p> <ul style="list-style-type: none"> <li>• Make something out of paper, cardboard, wood, plastic, metal, or existing objects that can actually be used to perform a task. Objective a</li> <li>• Recognize that some kinds of materials are better than others for making any particular thing. Objective d</li> </ul>  <ul style="list-style-type: none"> <li>• Realize that there is no perfect design and that usually some features have to be sacrificed to get others. Objective b</li> <li>• Identify factors that must be considered in any technological design-cost, safety, environmental impact, and what will happen if the solution fails. Objective c</li> </ul> <ul style="list-style-type: none"> <li>• Explain that something may not work as well (or at all) if a part of it is missing, broken, worn out,</li> </ul>