DESIGN SQUAD TEACHER'S GUIDE

FOR MIDDLE SCHOOL SCIENCE AND TECHNOLOGY CLASSROOMS

HANDS-ON ENGINEERING CHALLENGES TO BOLSTER YOUR ELECTRICITY, SOUND, AND FORCE UNITS
Dear Teachers,

Intel welcomes you to the Emmy and Peabody Award-winning PBS series, Design Squad®! Our sponsorship of Design Squad is an important component of our commitment to education and to inspiring tomorrow’s innovators.

Intel believes that young people are the key to solving global challenges. Design Squad’s substantive focus on math, science, and the design process is closely aligned with our mission of engaging young people’s curiosity and developing their critical thinking and problem-solving skills. We believe that Design Squad’s ability to bring innovation to life by showcasing engaging, real-life applications of engineering will increase students’ interest in the subject and in creative careers that turn science into reality.

We encourage you to use this Design Squad Teacher’s Guide—in concert with the television series and the media-rich Web site—to help your students investigate and solve challenging problems that just may change the world.

Sincerely,

Shelly Esque
President, Intel Foundation
**Design Squad® goes to school!** This guide is written especially for middle school teachers of science, technology, engineering, and mathematics (STEM). Its hands-on, standards-based activities focus on force, electricity, and sound—topics found in nearly every physical science curriculum. In the process of tackling the guide’s open-ended challenges, students develop a working understanding of core science concepts, deepen their understanding of the design process, and increase their motivation to learn science, technology, engineering, and math.

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Engineers’ initial ideas rarely solve a problem. Instead, they try different ideas, learn from their mistakes, and then try again. The steps engineers use to arrive at a solution are called the **design process**. As students work through a challenge, use the questions below to tie their work to specific steps of the design process.

**BRAINSTORM**
- What are some different ways to tackle today’s challenge?
- Off-the-wall suggestions often spark GREAT ideas. How creative can you be?

**DESIGN**
- Which brainstormed ideas are really possible, given your time, tools, and materials?
- What are some problems you need to solve as you build your project?
- How can a sketch help clarify your design?

**BUILD**
- What materials will you need?
- What can you learn by looking at other students’ projects?

**TEST, EVALUATE, AND REDESIGN**
- Why is it a good idea to keep testing a design?
- What specific goal are you trying to achieve, and how will you know if you’ve been successful?
- How does the design meet the criteria for success presented in the challenge?

**SHARE SOLUTIONS**
- What’s the best feature of your design? Why?
- What were the different steps you did to get your project to work?
- What was the hardest problem to solve?
- Did you have to do something a few times to get it to work? What?
- If you had more time, how would you improve your project?
WATCH CLIPS OF THE DESIGN PROCESS IN ACTION

There is a short video clip of each design process step on the Design Squad Web site. By watching the Design Squad teams work through each step of the design process, students will learn to think creatively when solving a problem and strengthen their critical-thinking abilities. Also, if your class is struggling with any particular step or with group dynamics, these videos offer a convenient way to talk through an issue. Download the clip(s) you want from the “Teacher’s Guide” page at pbs.org/designsquad.

Identify the Problem (1½ minutes)
Understanding the problem paves the way for solving it. This clip lets you emphasize to students the importance of defining the challenge(s) clearly before getting started. As a class, discuss how the Design Squad teams prepare to design and build furniture out of cardboard.

Brainstorm (1½ minutes)
Coming up with many possible solutions is a powerful way to begin a project. This clip shows Design Squad teams generating lots of ideas for devices that a dancer can use in an underwater performance. As a class, discuss what made this brainstorm successful.

Design (1 minute)
Now it’s time to choose the best solution and plan how to build it. In this clip, the Design Squad teams squabble about when to stop designing and start building their specialized bikes. As a class, discuss possible solutions for moving a team forward when there is disagreement.

Build, Test, Evaluate, and Redesign (1 minute)
Once kids settle on a design, it’s time to build, test, and redesign it. This clip shows that things don’t always work as planned. As a class, discuss how the Design Squad teams learn from their testing results and figure out how to redesign and make improvements.

Share Solutions (2 minutes)
Presenting one’s work to others is a constructive way to conclude a project. As a class, discuss how the Design Squad team’s presentation validates the team’s work, places it in a broader context, and lets the team members reflect on how effectively they communicated and collaborated.

EXPAND YOUR SKILLS

Let the Design Squad teams model the steps of the design process for your students. Download these five brief videos from the Teacher’s Guide page at pbs.org/designsquad.

Build your skills and confidence in guiding students through engineering activities using the design process. Through this free, self-guided, NASA–Design Squad online training, you’ll see what the design process looks like in the classroom, learn a host of implementation strategies, and experience the fun and relevance of engineering. Find it at: pbs.org/designsquad/educators.
This guide will help you integrate standards-based design challenges into your science, technology, engineering, and mathematics (STEM) units.

**START WITH THE UNIT OVERVIEW**
Each unit opens with an overview that describes the activities and shows how they can enrich your curriculum and target what you want your students to learn. Use the overview to choose the challenge(s) that fit your curricular goals and the time you have available. Each challenge is designed to take 50 minutes.

**REVIEW THE EASY-TO-USE TEACHER NOTES**
- **Preparation**: Lists things to do to get ready for the activity.
- **Introduce the challenge**: Presents the challenge and puts it in a *Design Squad* context by having students watch a short, relevant video clip from the show.
- **Brainstorm**: Identifies the activity’s key elements and offers talking points to jump-start student thinking about ways to meet the challenge and apply related science concepts.
- **Summarize the problem to solve**: Asks students to identify the specific tasks they’ll need to accomplish in the class period and to consider how to order them. This pre-planning helps students make effective use of class time.
- **Build, test, and redesign**: Lists issues that might surface during a challenge and suggests strategies you can use with students who face these issues.

**COPY THE STUDENT HANDOUT**
Nate Ball is a mechanical engineer and the 20-something host of *Design Squad*. His cartoon alter ego serves as a mentor and guide, introducing the challenges, offering tips for carrying out the projects, and encouraging students to find creative solutions and achieve success.

**DRIVE HOME THE UNIT’S SCIENCE AND ENGINEERING**
Make a unit relevant by helping students see how the unit’s science and engineering matter beyond the walls of the classroom. In each unit’s *Making It Real* session, students present their work and discuss how they’ve applied the design process and the unit’s science concepts. They also watch short video clips featuring young engineers doing interesting, rewarding work. These clips help students relate their own work to real-world engineering applications—they discover that they’re thinking and working like engineers. *(In our testing, we found that it’s far more constructive to have this presentation and discussion at the end of a unit, rather than at the end of a challenge, when students are so engaged in what they’re doing that it’s counterproductive to divert them from the task at hand.)*
Design Squad is a multimedia experience, with rich educational resources, designed to inspire the next generation of engineers. Find all of these resources at: pbs.org/designsquad.

Design Squad TV Episodes
Design Squad takes the competition and intensity of reality TV and merges it with great educational content. In the show, kids use the design process to solve real-world challenges and learn to work as a team. We’ve taken clips from episodes and produced a library of 1- to 3-minute video segments that relate well to the guide’s challenges. In the Teacher Notes, we suggest when and how to use them to introduce or wrap up a challenge.

ProFiles
In these 2- to 3-minute videos, meet dozens of engaging young engineers who demonstrate that engineering is a rewarding, creative career where you get to work with great people, solve interesting problems, and design things that matter. In Making It Real, we list relevant ProFile videos and suggest ways of using them.

Online Design Squad games
Students can use their problem-solving and engineering skills online to “save” small, cute creatures called Fidgits with the multiplayer game DESIGNit, BUILDit, FIDGIT. With String Thing (a game used in the Sounds Good unit), students can change the tension, gauge, and length of strings and compose music.

DS XCHANGE
In this online community, students can submit photos and sketches of their own designs and see what other kids have made. Also use DS XCHANGE as a source of project ideas for your students.

Resources for Educators
Find five guides chock full of Design Squad challenges, all with student handouts and step-by-step leaders’ notes. (See page 46 for details.) You can also get signs, posters, certificates, and other resources to decorate your classroom, recognize students’ work, and run events.

Online NASA–Design Squad Professional Development Training
Take this self-guided online workshop for educators and afterschool leaders to build skills and confidence in guiding kids through hands-on engineering activities. This free training shows you what the design process looks like in the classroom, offers tips on using the Design Squad resources, and emphasizes the fun and relevance of engineering.
All of the materials in this guide can be found at local electronics, hardware, craft, grocery, and office supply stores. For large quantities, search online. For example:

<table>
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<th>Material</th>
<th>Item #</th>
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<td>3-volt motor with gear</td>
<td>RM3 with plastic pinion</td>
<td>solarbotics.com</td>
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<td>BAL100EA</td>
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<td>Buzzers</td>
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<td>americanpiezo.com</td>
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<td>Corrugated cardboard</td>
<td>S-3585</td>
<td>uline.com</td>
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<td>2611711</td>
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<td>Plastic hose</td>
<td>00917821000</td>
<td>sears.com</td>
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<td></td>
<td>BWP-NA105</td>
<td>backyardcitypools.com</td>
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<td>Wire stripper and cutter</td>
<td>503606</td>
<td>bicwarehouse.com</td>
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<td></td>
<td>KT-11047</td>
<td>cableorganizer.com</td>
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<td>Hookup wire (e.g., 22-gauge, stranded)</td>
<td>278-1224</td>
<td>radioshack.com</td>
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<td></td>
<td>H03447-10U</td>
<td>hobbyengineering.com</td>
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<td>Latex balloons (12-inch)</td>
<td>12JAS-699</td>
<td>balloonideas.com</td>
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<td></td>
<td>912100</td>
<td>bargainbaloons.com</td>
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<tr>
<td>Paint stirrers (14-inch)</td>
<td>PSP14B</td>
<td>jamestowndistributors.com</td>
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<td>thegreathardwarestore.com</td>
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<td>Ping Pong balls</td>
<td>SUPINGB</td>
<td>rinovelty.com</td>
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<tr>
<td></td>
<td>Z1140</td>
<td>zymetrical.com</td>
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</table>
| if you are buying small quantities, try these types of stores: Electronic: Wire strippers, buzzers, batteries and battery connectors, motors with gears Hardware: Plastic hose, flat faucet washers, paint stirrers Craft: Latex balloons, Mylar balloons, balloon pump Grocery: Latex balloons, Mylar balloons Office: Corrugated cardboard Sporting Goods: Ping Pong balls Dollar Store: Helium-filled Mylar balloons, balloon pumps
## Challenge name:


## Names of team members:


<table>
<thead>
<tr>
<th>Identified the problem(s) and brainstorming solutions</th>
<th>Showed a clear understanding of the problem(s) to solve. Independently brainstormed possible solutions.</th>
<th>Needed some teacher direction to define the problem(s) and brainstorm possible solutions.</th>
<th>Needed lots of teacher direction to define the problem(s). Little if any independent brainstorming.</th>
<th>Points:</th>
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<tbody>
<tr>
<td>Working as a team member</td>
<td>Worked well together. All team members participated and stayed on task.</td>
<td>Some team members were occasionally off task.</td>
<td>Most team members were often off task and not cooperating or participating fully.</td>
<td>Points:</td>
</tr>
<tr>
<td>Using the design process</td>
<td>Team brainstormed many design ideas and tested and improved the design. Final design complete or nearly complete and shows creative problem solving.</td>
<td>Some team members were occasionally off task.</td>
<td>Team brainstormed few design ideas and did little testing or redesigning. Final design lacks clear design idea(s).</td>
<td>Points:</td>
</tr>
<tr>
<td>Processing the science and engineering</td>
<td>Team gave a strong presentation of its solution to the challenge and showed clear understanding of the science concepts and design process.</td>
<td>Team gave a basic presentation of its solution to the challenge and showed basic understanding of the science concepts and design process.</td>
<td>Team gave a weak presentation of its solution to the challenge and showed little understanding of the science concepts and design process.</td>
<td>Points:</td>
</tr>
</tbody>
</table>

**Total Points:**
Like the challenges in this guide? There are 32 more on the Design Squad Web site—five guide’s worth! Read the details below and download them for free at: pbs.org/designsquadsquad.

**Educator’s Guide**
Show students the fun, creative side of engineering by having them design secret alarms, electronic dance pads, rubber band-powered racecars, tall towers, moving sculptures, and automatic ball servers. Science topics include circuits, energy, motion, force, and structures.

**On the Moon**
NASA and Design Squad team up to bring you engineering design challenges focused on NASA’s moon missions. Kids investigate force, energy, structures, and motion by designing and building rockets, landing systems, rovers, cranes, zip lines, and solar hot water heaters.

**Invent It, Build It**
Show your students that engineering is about working to make the world a better place. Students use the design process to invent solutions to environmental, social, and everyday problems.

**Activity Guide**
Use these five hands-on design challenges to spark students’ interest in science and engineering. They’ll build kayaks, paper tables, zip-line delivery systems, paddle-powered boats, and grabbing devices. Science topics include buoyancy, force, structures, energy, motion, and simple machines.

**Event Guide**
Need quick activities for a science night, event, or extra period? Engage students with fun hands-on engineering design challenges that require few materials and little set up. Science topics include energy, structures, force, motion, circuits, and simple machines.
**Ages 3-6**
Celebrate the curiosity and adventure of young children with simple science exploration.
peepandthebigwideworld.org

**Ages 3-6**
Discover science, engineering, and math in the world around us.
pbskids.org/curiousgeorge

**Ages 8–11**
Try ZOOM’s fun science and engineering activities, featuring ideas sent in by real kids.
pbskidsgo.org/zoom

**Ages 9-12**
Investigate environmental issues and take action to protect the planet.
pbskidsgo.org/greens

**Ages 6–10**
Put problem-solving skills to the test to tackle science challenges inspired by ones seen on the show.
pbskidsgo.org/fetch

**Ages 11 and up**
Dig deep into science topics with classroom-ready resources from the most-watched science television series on PBS.
pbs.org/wgbh/nova

**Ages 11 and up**
Find out the latest research and meet intriguing personalities in science and technology.
pbs.org/wgbh/nova/sciencenow

**Ages 14-18**
Meet inspiring women engineers who make a real difference in the world. Find out whether engineering might be your dream job.
engineeryourlife.org

**Educators**
Use this media-rich library of teaching resources to make concepts come alive in engaging and interactive ways.
teachersdomain.org
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<th>National Science Education Standards</th>
<th>Grades 5–8</th>
<th>History and Nature of Science</th>
<th>Science and Technology</th>
<th>Physical Science</th>
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<td>The Designed World</td>
<td>Abilities for a Technological World</td>
<td>Design</td>
<td>Technology and Society</td>
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<td>Massachusetts Science and Technology/Engineering Curriculum Framework</td>
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<td>Physical Science</td>
<td>Transportation Technologies</td>
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<td>Engineering Design</td>
<td>Materials, Tools, and Machines</td>
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| Materials, Tools, and Machines | Kick Stick | Electric Gamebox | Making It Real | Headphone Helper | Making It Real | Sky Rover | Sky Glider | Blimp Jet | Making It Real |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
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| 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
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| 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
Design Squad gets kids and teens thinking like engineers and shows them that engineering is fun, creative, and something they can do themselves.

Tell us what you think about the guide.

Take our quick online survey, and we’ll send you a Design Squad class pack (while supplies last*). Find it at: pbs.org/designsquad/survey.

* The Design Squad class pack is subject to change; available only while supplies last.