Go civil!

Start a club and shape the future of civil engineering!

Civil Engineering Club™ Guide

Launch and run a high school club with:
• Ideas for planning
• Guidelines for partnering with schools
• Hands-on engineering design projects
• Tips for working with students
Welcome Letter from ASCE

Dear Outreach Champion,

Congratulations! You have just taken the first step toward building a more sustainable relationship with high school students as part of your educational outreach program. By leading a Civil Engineering Club, you are, starting on a journey that will be personally satisfying, engage young minds, influence student’s perceptions of engineers, and ultimately open doors for them to the possibility of a career in civil engineering.

This guide was created by the Pre-College Outreach program of ASCE, in coordination with members, like you, who have a passion for sharing their love of all things Civil with kids and are interested in taking their outreach to a new level. Together with curriculum developers and high school teachers, these engineers set out to create a program model that would provide sound advice and solid tools for working with high schools in an after school setting.

Each engineer will bring their unique experience in outreach and engineering to this journey. For some, the content of this guide may be modified and adapted for other engineering outreach programs already in place. For those who are coming to outreach for the first time, we hope the tools inside will inspire you to jump into the game and help shape the future of high school civil engineering outreach.

Thank you for your enthusiasm and expertise. We look forward to working with you to support the launch of your civil engineering club, and wish you the best of luck as you build a lasting relationship with students that will change the way they see the world!

Ken Maschke, P.E., M.ASCE

www.asce.org/nextgeneration
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## Club Launch Module

**Students are introduced to the design process, civil engineering, and ASCE**

### Marshmallow Tower

- Build the tallest spaghetti structure that can support a marshmallow

### Bridges Module

**Students design and build three bridges and learn what makes them strong and stable**

**Module Introduction**

- Get activity overviews, planning tips, master materials list, other helpful resources

### Paper Bridge

- Build a bridge that holds 100 pennies using 1 sheet of paper
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West Point Bridge Contest
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• Customizable club introduction email
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Welcome to the ASCE Civil Engineering Club guide! If you’re looking to launch an outreach project that builds relationships with students, digs deep into engineering, and leaves a lasting impression, you’ve come to the right place. Civil Engineering Clubs are a great way for students to get to know civil engineering in an up close and personal way. In small-group gatherings, students participate in activities that inspire them to explore the field of engineering, including engineering design projects, field trips to engineering agencies and sites, guest speakers, community service projects, and opportunities to connect with professional engineers and college engineering students.

This guide will help you establish the key ingredients for a successful club:

• Enlisting volunteer and sponsor support
• Establishing a school partnership
• Leading engineering design projects
• Making the most of ASCE resources

Running a club takes time and commitment, but the payoff is big. You’ll have an opportunity to give students a pre-professional experience that will shape their impression of civil engineers—and possibly inspire them to choose engineering as a career path.

How a Club Works

Club Format
An ASCE Civil Engineering Club is composed of students, an Engineer Leader (you), a Faculty Advisor, Engineer Mentors, and other supporters who provide volunteers or sponsorship. Clubs will vary with each school partner.

Generally speaking, a club:

• **Begins in the fall and runs through the school year.** Most clubs begin in the fall and extend through the spring. This guide contains one topic module – Bridges – but watch for additional modules from ASCE that will help you facilitate a club that will easily span an entire school year. If you are invited to participate in an already-established club, it’s possible to lead one or several modules at different points in the year.

• **Meets weekly or bi-weekly after school.** Clubs typically meet in school classrooms in the afternoon, following the end of the school day.

• **Opens with the Club Launch.** Students will complete a fun design activity that gives students a taste of the club engineering projects and introduces them to the design process, civil engineering, and ASCE.
• **Explores civil engineering during meetings that last about an hour.** Meetings are typically one hour to an hour and a half, during which students delve into an engineering design project, discuss what happened, and make connections to civil engineering. Some projects can be completed in one meeting; others will extend over several meetings.

• **Connects students to real-world civil engineering experiences** such as: hearing from professional engineers and engineering college students, going on field trips, and taking part in community service projects.

• **Culminates with a final club meeting** during which students invite their families and club supporters to take part in a project or activity and celebrate their accomplishments.

For more information about how to run a club meeting and lead engineering design projects, see the Running a Club Meeting section (p. 16).

**Partnerships and Teamwork**
Teamwork—one of the hallmarks of engineering—is essential to running a successful club. You’ll be working in close partnership with a high school faculty advisor, engineer mentors, and other supporters (volunteers and sponsors). The basic roles for each partner are described below.

Further information about how to establish these partnerships is presented in the Getting Started section (p. 9).

<table>
<thead>
<tr>
<th>Club Partner</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead Engineer</td>
<td>Lead partner in facilitating the club: coordinates technical aspects of the club, coordinates with all club partners, subject matter expert, leads club projects and activities.</td>
</tr>
<tr>
<td>High School Faculty Advisor</td>
<td>Lead partner in facilitating the club: liaison between the Lead Engineer and the school administration; coordinates with Lead Engineer to schedule club activities; subject matter expert on teaching high school students; assists or leads club projects and activities. Faculty Advisor can be a teacher or school administrator.</td>
</tr>
<tr>
<td>Engineer Mentor(s)</td>
<td>Assists the Lead Engineer in planning and running club projects; may also assist Faculty Advisor or, if prepared, run activities when Lead Engineer is absent. Mentors can be professional engineers, volunteers from an ASCE section/branch, or faculty/students from an ASCE student chapter or engineering college or university.</td>
</tr>
<tr>
<td>Other Supporters (volunteers &amp; sponsors)</td>
<td>Provide volunteers (e.g., speakers, competition judges, mentors, field trip site hosts) and funding support (e.g., project materials, grants). Supporters may include ASCE chapters/branches, ASCE student chapters, colleges and universities, engineering agencies and firms.</td>
</tr>
</tbody>
</table>
ASCE Resources

Club Guide
This Guide provides information to help you plan your club, recruit volunteers, solicit funding support, and establish a school partnership.

In addition, there is one civil engineering topic module that contains engineering design projects related to Bridges. Additional modules will be added to the Guide as they become available.

Each module consists of multiple meetings and includes:
• Engineering design projects that build on a topic
• Leader notes and student handouts for guiding projects
• Ideas for speakers, field trips, and community service projects

Modules are designed to be flexible. They can exclusively comprise the ASCE club experience, be combined with design projects from other sources, or be used independently as part of another program, such as a multi-disciplinary engineering club or career exploration club.

Support Materials
After you establish partnerships and register your club, ASCE will provide you with these additional resources:

<table>
<thead>
<tr>
<th>Promotion Materials</th>
<th>Use these to recruit students and recognize their participation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 15 club posters</td>
<td></td>
</tr>
<tr>
<td>• Club membership cards</td>
<td></td>
</tr>
<tr>
<td>• Certificates of participation</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Giveaways</th>
<th>Use these at your “club launch” meeting to market ASCE and the club, or as prizes for club competitions.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Drawstring backpack with slogan, “Engineers Make a World of Difference”</td>
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<tr>
<td>• ASCE graph pads</td>
<td></td>
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<tr>
<td>• ASCE mini engineers scales</td>
<td></td>
</tr>
<tr>
<td>• ASCE mechanical pencils</td>
<td></td>
</tr>
<tr>
<td>• “What Is a Civil Engineer?” brochures</td>
<td></td>
</tr>
<tr>
<td>• “It’s Your Life…Your World” brochures</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Books and Magazines</th>
<th>Use these to start a club library of civil engineering resources.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Building Big</td>
<td></td>
</tr>
<tr>
<td>• Changing Our World-True Stories of Women Engineers</td>
<td></td>
</tr>
<tr>
<td>• Civil Engineering magazine (current issue)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Posters</th>
<th>Decorate your club room with these engineering posters.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Engineer Your Life—Dream Big, Love What You Do.</td>
<td></td>
</tr>
<tr>
<td>• What makes ASCEville Greenville?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Website</th>
<th>Send students here to learn more about civil engineering, ASCE student chapters, and the latest tweets from ASCE.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• <a href="http://www.asce.org/nextgeneration">www.asce.org/nextgeneration</a></td>
<td></td>
</tr>
</tbody>
</table>
Club Close-Up

Who: New York City College of Technology & City Polytechnic High School of Engineering, Architecture, and Technology

Lead Engineer: Anthony Cioffi, Ph.D., P.E., M.ASCE

Where: Brooklyn, NY

When: Once a week, 1-1/2 hour meetings

How: At the first meeting, Cioffi explains to the students, “This is your club—what do you need to do to set up and how are we going to organize things?” Students take some leadership of what they want to explore; ASCE provides resources and people with experience and knowledge of civil engineering. In its first year, the City Poly club grew from six to 15 students, who engaged in a variety of civil engineering activities from constructing a model of a house (normally a project for college-level students) to attending the Met Section Steel Bridge Competition at Fairleigh Dickenson University. During its second year, Cioffi and the students built on the first years activities and completed a set design project for their school’s Drama Club. In its second year, Cioffi was joined by members of the civil engineering faculty at New York City College of Technology as well as mentors from the ASCE Met Section’s Younger Members Forum. The ASCE Met Section also provided a $250 start-up grant for club tools, materials, and field trip transportation.

Why: To expose students to things that they might not see in a classroom and provide opportunities to network with professionals which may lead to future internships. Students get immersed in not only the curriculum but the culture of civil engineering.

What’s Next: Using this guide and other clubs as models, the goal is to see Civil Engineering Clubs expand to ASCE Sections and Branches nationwide—reaching high school students everywhere.
Getting Started

Planning ahead will help ensure that your club runs smoothly. This section describes how to establish your two primary sources of support: (1) enlisting help from volunteers and sponsors, and (2) establishing a school partnership. The chart below outlines a basic timeline for club planning:

**Club Countdown**

<table>
<thead>
<tr>
<th>Step</th>
<th>Spring/Summer</th>
<th>Fall</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
</table>
| 1. Get started | - Review Club Guide  
- Think about modules you’d like to lead and the support you’ll need | | | |
| 2. Enlist volunteer and sponsor support | - Identify potential supporters and present idea  
- Recruit volunteers (engineer mentors, speakers, field trip hosts, competition judges, etc.)  
- Secure sponsors to provide financial support and/or donate resources | | | |
| 3. Establish a school partnership | - Contact school and present idea  
- Recruit a Faculty Advisor | | | |
| 4. Register with ASCE | - Register your club with ASCE  
- Order ASCE support resources | | | |
| 5. Run your club | - Recruit students  
- Hold first meeting  
- Guide students as they explore engineering design projects  
- Connect students to the “real-world” through speakers, field trips, and community service projects | | | |
| 6. Celebrate a great year | - Distribute certificates  
- Host a final meeting to celebrate accomplishments; invite families and club supporters  
- Debrief what worked, what can be improved  
- Share information with other clubs | | | |

**Questions?**

Contact ASCE National

As you plan your club, ASCE is here to help.

Email your questions to: outreach@asce.org

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**What Comes First: Enlisting Support or Establishing a School Partnership?**

Begin either way. Find a school; then recruit volunteers and sponsors who will be excited to know a school is already on board. Or start with a group of interested volunteers and sponsors, and locate a school that is looking for a partnership that's ready to go.
Enlisting Support

By enlisting help from a variety of sources, your job as club leader will be more rewarding and successful. Supporters can participate in two ways: as volunteers and as sponsors.

Volunteers fill a variety of roles that are ongoing (such as engineer mentors who regularly assist at club meetings) or one-time (such as speakers, competition judges, and field trip hosts).

Volunteers provide more than an extra set of hands; they act as professional role models, mentors, and career advisors. Ideally they are passionate about what they do and committed to contributing their time and expertise to the students in your club.

Sponsors provide financial support that funds club projects. They also donate other resources such as project supplies and equipment.

Recruiting Engineer Mentors

One of the most exciting parts of the club for students is meeting and working with engineering professionals and college students. Having other engineer advisors available also helps you—your job will be easier with other adults to help prepare and guide projects. While it’s possible to run a club on your own, we highly recommend working with other mentors.

• College students are excellent candidates since they have flexible schedules and are more able to attend club meetings that happen in the afternoon. Keep in mind that transportation may be an issue for college students.
• ASCE Student Chapter meetings are great places to recruit student engineer mentors.
• Discuss scheduling and determine the time a mentor is able to commit (the entire school year, one semester, one module, etc.)
• Invite male and female engineers of different ethnicities and backgrounds. That way students will be able to interact with engineers who are similar to and different from them.
• Recruit lots of mentors. You’ll want extra volunteers in case some can’t make club meetings every week. Meetings are easier to run and more beneficial to club members if the ratio of students to adults is low—ideally 5:1.

Important:

Background Checks and CORI Forms

Same schools require background checks for all adults working with students. Make sure your volunteers know this up front. You can work with your faculty advisor to obtain the necessary forms for volunteers to fill out. Keep in mind that these forms take time to be processed.
# Ideas for Recruiting Volunteers and Sponsors

This chart describes different partners, the types of support they can potentially provide, and ways to bring them on board.

<table>
<thead>
<tr>
<th>Local Organization</th>
<th>Type of Support</th>
<th>Ways to Enlist Support</th>
</tr>
</thead>
</table>
| **ASCE Sections and Branches**            | Volunteers                  | • Present at ASCE section board meeting  
• Meet with leaders interested in Pre-College Outreach  
• Contact the local Younger Member Forum Section president and/or Outreach coordinator  
• Write an article for the local ASCE Newsletter |
|                                           | Sponsors                    |                                                                                        |
|                                           |                             | • Provide funds for club project supplies  
• Offer HS scholarships and grants            |
| **ASCE College/University Student Chapters** | Volunteers                  | • Talk with chapter faculty advisor  
• Present at student chapter meeting |
|                                           | Sponsors                    |                                                                                        |
|                                           |                             |                                                                                        |
| **Colleges/Universities**                 | Volunteers                  | • Talk with dean of engineering school  
• Talk with ASCE student chapter faculty advisor |
|                                           | Sponsors                    |                                                                                        |
|                                           |                             |                                                                                        |
| **Agencies or Engineering Firms**         | Volunteers                  | • If you are on an ASCE outreach committee, leverage contacts through ASCE to engage other businesses  
• Reach out to your own business colleagues |
|                                           | Sponsors                    |                                                                                        |
Tips on Selling the Idea
Whether you’re enlisting the help of volunteers or sponsors, you’ll want to prepare a one page proposal that describes the club purpose and structure, suggestions for ways supporters can get involved, and the potential benefits for joining the team. (A sample proposal is located in the Appendix.) Here are some key messages to share in your proposal or when talking with potential supporters:

- **Introduce yourself and your affiliation** (ASCE Section, Branch, company, college).
- **Describe the club**: You’d like to lead a club for high school students interested in civil engineering. The club meets at regular intervals for about 1.5 hours, and introduces students to civil engineering through hands-on engineering design projects, field trips, and interactions with engineering professionals and students.
- **Emphasize the teamwork involved**: They’ll be one of a team of individuals supporting the club. As the Lead Engineer, you’ll be working in partnership with a Faculty Advisor, Engineer Mentors, and other volunteers and sponsors.
- **Highlight the support of ASCE**: ASCE is the primary sponsor of the club and is providing a curriculum guide and club supplies such as promotional materials, books, posters, and giveaways.
- **Describe ways to support the club**: Explain that individuals can help lead activities, give a presentation about their work or college studies, give a tour of their office/facility, provide funding, etc. Support can be a one-time event or ongoing.
- **Underscore the potential benefits of supporting the club**: See below for unique messages to highlight for different supporters.
- **Leave written materials**: Distribute a written proposal that describes the club and ways supporters can participate.
- **Exchange contact information for follow up**: Share your contact information and inquire about potential dates to discuss the club further.

Unique Benefit Messages
Customize your proposal and talking points by highlighting the unique benefits for different supporters:

**ASCE Section/Branch**
- Offers direct involvement with students interested in engineering
- Engages members in pre-college outreach and helps members develop soft skills and leadership
- Builds lasting relationships with school partners and the community
- Strengthen ties with college student members who may want to get involved and network
- Opportunity to establish a scholarship and develop a pool of talent
- Provides clear guidance to make planning and running a club less stressful

**Engineer Mentors**
- Direct student involvement with kids interested in engineering
- One of a team of individuals working with the Club
- Flexible time commitment
- Provides “plug and play” resources
- Personal satisfaction

**Sponsors**
- Offers direct involvement with students interested in engineering
- Engages employees in pre-college outreach and helps develop soft skills and leadership
- Opportunity to provide financial support for proven model
- Opportunity to invite highly interested students into your professional world
- Contributes to building the future pipeline for our profession
• Opportunity to develop scholarship pool
• Market participation in outreach activities to clients to show your company’s commitment to the community/profession

ASCE Student Chapters
• Opportunity to make a difference in a high school student’s life
• Engages students in pre-college outreach and helps students develop soft skills and leadership
• Opportunity to tell students about what it’s like to be an engineering student in college
• Recruit students to civil engineering

Colleges/Universities
• Access to potential engineering students
• Opportunity to promote engineering programs

Establishing a School Partnership

A strong school partnership sets the foundation for your club’s success. In developing your partnership, you’ll want to identify a promising school to work with; then collaborate with a Faculty Advisor who is committed to helping you run the club within the school. The following steps will help you build a partnership that works:

1. **Start early.** Ideally you want to contact a school about setting up a club at the end of the school year so you can plan together during the summer months. Teachers are typically busy during school hours and can be difficult to reach by phone. The best approach is through email. Be aware that a lot of teachers use the summer to attend classes and professional workshops, so plan ahead to coordinate schedules in July and August.

2. **Identify a local high school with which you’d like to work.** Schools with strong technology programs or Project Lead the Way (PLTW) engineering courses are good places to start. To find a PLTW school near you, visit: www.pltw.org

3. **Determine if the school already has a club.** School websites often post lists of student clubs. If the school already has a club (focused on either general engineering or civil engineering), it may be looking for new volunteers and fresh projects. If it doesn’t, your next step is to get them excited about starting one.

4. **Identify people to talk with** such as the science department chair, curriculum director, and STEM outreach teachers. The school website can usually provide these names and contact information.

5. **Send an introductory email** that explains the club purpose and structure. (See sample email in Appendix.)
Set a time for a phone call or meeting to discuss the club further. During the discussion, highlight the following:
- **Benefits to the school.** An ASCE Civil Engineering Club brings students in direct contact with engineering professionals who can discuss their careers, and share real world experiences and engineering students who can speak about college and career preparation. Through engineering projects, students will see how civil engineering involves creativity, how they design things that matter, and how they build things that make a difference.
- **Support of ASCE.** ASCE is the primary sponsor of the club. It provides a curriculum guide, club supplies (such as promotional materials, books, posters, and giveaways), connections to its local Sections/Branches, and ongoing support to Engineer Leaders.
- **Ready-to-go resources.** Bring along the ASCE Club Guide to illustrate the types of projects students might do. If you already have engineer volunteers and sponsors on board or are actively recruiting, let the school know.
- **Team approach.** You will be the club’s lead engineer and you will work in partnership with the school’s Faculty Advisor to schedule club activities and lead club projects. You will also have assistance from other engineering professionals and college students.

Identify a Faculty Advisor. Work with the school to identify a faculty advisor (a teacher or administrator) who will co-lead the club with you. This individual will help schedule and oversee club activities and serve as a liaison between you and the school administration. Ideally, you want to partner with a faculty member who is dedicated to your club—a true champion of civil engineering. Their enthusiasm, commitment, and understanding of the student members are essential to the success of the club.

Confirm the school and Faculty Advisor’s commitment to the club. Establish a commitment in the spring so you can plan over the summer. That way you’ll be ready to launch in the fall.

Start planning the club with the Faculty Advisor. Individual high schools set basic requirements for setting up a club (such as liability, forms, fundraising, etc.) and the Faculty Advisor can assist with making sure your club meets these specifications. Establish roles and responsibilities for running the club (see Roles and Responsibilities, for ideas). Set a time and date for visiting the school to see the club classroom or location, coordinate schedules, etc.

Keep regular contact with your Faculty Advisor. Schedule monthly check-ins via phone, email, or in person.
Launching Your Club

Now that your partners are in place (engineer volunteers, sponsors, school partnership, and faculty advisor), it’s time to register your club and start planning. This section contains information for establishing roles and responsibilities with your Engineer Mentors and Faculty Advisor, tips for running a club meeting, and ideas for planning real-world engineering experiences.

Roles and Responsibilities*

Before the club starts, meet with the Faculty Advisor and Engineer Mentor(s) to go over roles, responsibilities, rules, and expectations. Things to discuss include:

- Scheduling the club meetings (bi-weekly or weekly), taking into account the students’ schedules and the adults’ work/school obligations.
- How the materials and giveaways (if provided) will be paid for. Costs per module vary (see the master materials list for details).
- How you will communicate with each other.
- What ground rules and routines should be established for the club, such as expectations for behavior, attendance, etc.
- Guidelines and permission forms necessary for working with, and communicating with, students (e.g., CORI forms, travel permission forms, permission forms for using tools, etc).

Before the club starts...

<table>
<thead>
<tr>
<th>Lead Engineer /Mentor(s)</th>
<th>Faculty Advisor</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Discuss how you will divide tasks with your faculty advisor and mentor(s), such as buying materials and leading parts of the activity.</td>
<td>- Provide guidance on school policy and procedures (e.g., late bus schedules, parking, entrances, checking in/out of school, CORI forms, blanket permissions for using tools, guest speakers, field trips).</td>
</tr>
<tr>
<td>- Plan which modules you’ll do with students.</td>
<td>- Communicate with school administration.</td>
</tr>
<tr>
<td>- Purchase/gather the materials.</td>
<td>- Gather any materials available on site; discuss with engineer mentors what materials the school can provide and the process for borrowing materials.</td>
</tr>
<tr>
<td>- Plan with Faculty Advisor how to recruit students.</td>
<td>- Help recruit students.</td>
</tr>
</tbody>
</table>

*Adapted from Time to Invent Activity Guide
- Work with the Faculty Advisor to determine how materials can be stored.
- Establish a safe storage area on site for materials and projects.
- Plan any field trips, speakers, or community service events and work with the Faculty Advisor to identify necessary forms and arrangements to make.
- Secure dedicated club meeting location.

**While the club is running...**

<table>
<thead>
<tr>
<th>Lead Engineer /Mentor(s)</th>
<th>Faculty Advisor</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Show up each week prepared to lead. (Review leader notes, test activity before doing it with students).</td>
<td>- Work with Lead Engineer to ensure club meets school requirements (e.g., student leadership, club constitution, etc.).</td>
</tr>
<tr>
<td>- Arrive at least 15 minutes early to set up.</td>
<td>- Provide guidance to Lead Engineer about school policy for organizing field trips and guest speakers.</td>
</tr>
<tr>
<td>- If sick or the unexpected arises, communicate absence to Mentors and Faculty Advisor.</td>
<td>- Run activities when the Lead Engineer and Mentors are not present.</td>
</tr>
<tr>
<td>- Check in with Faculty Advisor to get feedback on the club activities and working with students.</td>
<td>- Check in with Lead Engineer to offer feedback and find ways to provide support.</td>
</tr>
<tr>
<td>- Check in with students to get feedback on club activities.</td>
<td>- Check in with students to get feedback on club activities.</td>
</tr>
</tbody>
</table>

**Running a Club Meeting**

As you guide club meetings, consider these tips about managing time, sending positive messages about engineering, working with teens, and leading engineering design projects:

**Anatomy of a Meeting***

Meetings will vary based on the type of project you are doing, but in general a 90-minute meeting might look like the chart below.

<table>
<thead>
<tr>
<th>10 min.</th>
<th>10 min.</th>
<th>20 min.</th>
<th>30 min.</th>
<th>40 min.</th>
<th>50 min.</th>
<th>60 min.</th>
<th>70 min.</th>
<th>80 min.</th>
<th>90 min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ice Breaker &amp; Introduce the Challenge</td>
<td>Brainstorm, Design, Build, Test, Club Huddle, Redesign</td>
<td>Share Results</td>
<td>Wrap Up</td>
<td>Clean Up</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

* If you have only 60 minutes, simply reduce the time for each segment.
As you prepare and run a meeting, these tips will keep things running smoothly.

Before Every Meeting
- **Read the Leader Notes and try out the project yourself.** This lets you anticipate where students might need help and how to modify materials or instructions to fit your situation.
- **Get to know the Big Idea!** Located on the Leader Notes, this is the key engineering concept behind each engineering design project. Think about ways to reinforce the idea as you guide the project.
- **Collect materials.** Prepare what you can, such as dividing materials into groups, etc. Have extras on hand in case your group is larger than expected or students want to “re-do” activities.
- **Plan extension ideas** in case some students move through a project ahead of the rest of the group.

During the Meeting
- **Clarify the problem.** Suggest students rephrase the challenge in their own words to be sure they understand. Understanding a problem is key to finding a solution.
- **Wait to distribute materials.** Hand out materials once you’re ready for students to begin building. Otherwise, they’ll get distracted and miss important instructions.
- **Highlight when students are following steps of the design process,** such as identify the problem, brainstorm solutions, design, build, test and evaluate, redesign, share solutions.
- **Ask guiding questions.** As students design and test, ask guiding questions rather than telling them what to do. For example, ask: “Why do you think this is happening?” or “What is another thing you could try?” Sample guiding questions are listed in each module.
- **Encourage visual as well as verbal communication.** Have students record and sketch their ideas and results in design notebooks.
- **Keep things moving.** Recognize students’ attention spans and move on when things aren’t working. Set meeting breaks and changes in activities to keep kids interested.
- **Encourage idea sharing.** Point out things different teams are doing. Invite groups to present their ideas and help each other solve problems that arise.
- **Reflect on learning.** Take time to summarize what students did and discuss results and ideas learned.
- **Make connections to civil engineering.** Connect the “Big Idea” of the project back to the real world. If relevant, make connections to your own work. You can also point students to the Go Civil! Website [http://blogs.asce.org/nextgeneration/](http://blogs.asce.org/nextgeneration/) to learn more about civil engineering careers and updates.
- **Keep kids returning.** High school students are busy with multiple activities vying for their attention. Reveal what they’ll explore at the next meeting to encourage them to attend the next meeting.

Sending Positive Messages about Engineering
Before you start, think about how you'll be talking to students about engineering—the message you send matters. Most students understand what engineering is but have a limited sense of what engineers actually do and tend to think engineering is “not for them.” The message Students hear about engineering typically focus on the process and hard work of becoming an engineer. Recent research has developed new messages that more accurately capture the creativity and inspiring nature of engineering. Focus on the inspirational aspects of engineering. Explain that math and science understanding are only two of the many skills needed to become an engineer. The “Talking about Civil Engineering” handout in the Appendix describes engineering using these new messages. Read it yourself, distribute to students, and share with volunteers who will be working with your students.

Tips for Working with Teens
Your best resource for managing students and keeping them engaged is your Faculty Advisor—he or she is experienced with working with teens and likely knows individual students on a personal level. In addition, consider the following:
• **Teens like to have a voice and choice in what they do.** Talk with students about upcoming topics and projects, and find out which are of interest to them.

• **Teens are able to work independently** but still need direction and adult supervision. An ideal student adult ratio is 5:1. Have engineer mentors available to assist during meetings.

• **High school students are busy** and may not attend every meeting because of schedule conflicts. Encourage them to return by giving them a preview of the next meeting’s activities. If projects extend beyond one meeting, make time to catch up students who missed a meeting or had to leave early for late bus schedules.

• **Teens are developing math and science skills.** Talk with the math and science teachers to find out what topics students are studying and how you might connect these topics to club projects. Consider inviting these teachers to be guest speakers.

• **Teens are developing leadership skills.** Each year older club members graduate and new members join. Assign experienced club members to be “leads” and mentor newer club members. This is a great way to let students practice leadership skills and to keep projects fresh for returning students.

• **Teens are looking for experiences to put on their college applications.** Help them (and their parents) understand what club participation offers: opportunities to list club membership, leadership roles, involvement in community service activities, access to scholarships, and access to letters of recommendation.

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**Guidelines for Adult/Student Interactions**

There are strong protections for students when it comes to interactions with adults—personal, written, and electronic. Work with your Faculty Advisor to determine the school policies for establishing boundaries of communicating with students. When in doubt, ASK! This is for the protection of the students and the adults.
Tips for Leading Engineering Design Projects
When engineers design solutions to problems, they go through a process of brainstorming, testing different ideas, learning from mistakes, and trying again. This is called the Engineering Design Process.

To help you guide each project, the Leader Notes provide step-by-step instructions that are organized using the steps of the design process. This reinforces for students how the steps of the design process can be used to solve a problem. There are also questions you can ask to connect their work to specific steps of the design process.

1. **Introduce the Challenge, Brainstorm, Design**
   Before building, engineers define the problem they want to solve and come up with a variety of solutions—the more, the better. At the start of every challenge, provide a few minutes for students to individually brainstorm solutions, jot notes, and sketch possible designs in their notebooks. Then have them share their ideas and brainstorm as a group.

2. **Build, Test, and Redesign**
   Once students finish the brainstorm, have them settle on a design idea to start with. It’s unlikely that students’ first solutions will be their best, and as they build, they’ll need to refine their ideas and solve problems that come up. At the heart of the design process is the attitude that “if at first you don’t succeed, try, try again.” The design process offers students a structured way to take an idea from its initial stage to its “finished product” stage, learning from mistakes they make along the way.

3. **Club Huddle**
   At the huddle, bring the group together to reflect on the process of design and redesign. They can talk about their designs, see other team’s ideas, and even incorporate new design specifications.

4. **Share Results**
   Engineers present their work to colleagues to show how they solved a problem. This way, they learn new ideas and approaches from each other. At the end of each meeting, have students show each other what they built and talk about how they used the design process to solve the challenge. Also, point out interesting solutions and examples of creative thinking and effective teamwork.
Make It Real/Make a Difference

Connect students to real-world engineering experiences through field trips, speaker presentations, and community service projects. You’ll find specific ideas for real-world experiences in each module’s Make It Real/Make a Difference section. The following tips will help you plan for any module.

General Tips

- **Decide when real-world experiences could happen in the module.** For example, you might choose to have a speaker introduce a module topic or present midway to give context to the club projects. A field trip might occur as a culminating activity.
- **Plan events at least 4 weeks before the module begins.** You’ll need time to schedule events and process any necessary forms (see next bullet).
- **Become familiar with school requirements.** Work with your Faculty Advisor to make sure you follow all school policies and prepare necessary forms (e.g., CORI checks for speakers, student health and permission forms for field trips or community service projects outside of the school).
- **Determine if transportation is needed** for a field trip or community service project. Work with Faculty Advisor to follow school requirements and prepare necessary permission forms.
- **Have a back-up plan** in case a speaker cancels last minute or weather prohibits travel.

Speakers (professional engineers, engineering students and faculty from colleges/universities)

- **Explain the purpose of the club** and what students have been doing.
- **Prepare speakers for talking with teens.** Share information from the Running a Club Meeting section (p. 16-20) and the *Let’s Talk about Civil Engineering* handout (see Appendix).
- **Suggest topics for discussion.** Each module lists suggested topics that relate to the module theme.
- **Encourage “show and tell.”** Suggest speakers share stories about their work, how they got into their career, what they did when they were the students’ ages. Invite them to bring in video and samples/tools from their work.
- **Don’t forget the nitty-gritty.** Let your guests know where to park, how to enter the school, how to contact you in case plans change, etc.
- **Keep track of invited speakers** and contact information each year, in case you want to have return visits.
Go Civil

See what Civil Engineering is all about!

Civil Engineering CLUB LAUNCH

asce.org/nextgeneration
**Introduction**

Many students will attend your first meeting to “check out” the club. Your goal is to hook their interest so they’ll want to return for more. The Club Launch gives students a taste of the club engineering projects and introduces them to the design process, civil engineering, and ASCE.

In the feature activity, *Marshmallow Tower*, students will have 18 minutes to build the tallest spaghetti structure that can support a marshmallow. This activity immerses students in the design process and shows how creativity, communication, teamwork, and innovation are all part of the engineering profession. This fun competition is followed up by a discussion of how students were thinking like engineers and an invitation to further explore civil engineering by joining the club. Wrap it up by offering students snacks and ASCE giveaways—a great way to leave a positive and lasting impression!

**Planning Tips**

- **Prepare a poster of the design process.** When introducing the steps of the design process, it helps to have a visual. You can use one from Design Squad (on the next page), or create your own. Post it in your club meeting room so students can refer to it as they do club projects.

- **Decide if you will offer snacks.** Food is a great way to get teens attention. Work with your Faculty Advisor to determine whether food can be served and what types are allowed.

- **Decide if you will offer a prize to the winning team** (such as an iTunes gift card).

- **Gather giveaways.** “Free stuff” is also appealing to teens. Be sure to offer a mix of items that are educational and fun:
  - Use the materials you received when you registered for the CE Club with ASCE.
  - Order free and low cost resources from ASCE  [www.asce.org/precollege-resources](http://www.asce.org/precollege-resources).
  - Request giveaways from corporate sponsors or your local colleges.
  - Ask your Section or Branch outreach chair for leftovers from other events.

- **Post a sign-up sheet.** Prepare a clipboard and pen for students to write their names and contact information (such as email) if appropriate. Work with your Faculty Advisor to determine the best approach for signing up students and creating a way to communicate club information.
Resources

Countdown Timers

Timeanddate.com has a timer available at: http://www.timeanddate.com/timer/.


For a Mac, consider, http://www.baldgeeks.com/3-2-1.htm

Introducing the Design Process


The Marshmallow Challenge

Additional information from the creator of this activity, Tom Wujec, including instructions, photos, and blog. http://marshmallowchallenge.com/Welcome.html
The Challenge:
Build the tallest spaghetti structure that can support a marshmallow!

Time: 1 meeting

Overview: Students build freestanding structures in 18 minutes and explore ways to make a flexible material (spaghetti) support more weight. They will also reflect on ways engineers collaborate to design, test, and improve their ideas.

Learning Objectives:

Students will be able to:

- Explain the importance of teamwork and failure in engineering
- Describe ways to change the strength and stiffness of a material
- Describe ways to make a structure more stable (wide base, less weight on top, strong joints, etc.)

*Activity adapted from Tom Wujec’s Marshmallow Challenge at: http://marshmallowchallenge.com/Instructions.html

Preparation:

Preview the 7-minute TED talk video “Tom Wujec: Build a Tower, Build a Team” for an overview of the Marshmallow Tower activity.
http://www.ted.com/talks/tom_wujec_build_a_tower.html

Important Points

- Kids Do Better than Business Students: On virtually every measure of innovation, kindergarteners create taller and more interesting structures than most adults. Engineers and architects do the best.

- Prototyping Matters: The reason kids do better than business school students is kids spend more time playing and prototyping. They naturally start with the marshmallow and stick in the spaghetti sticks. The business school students spend a vast amount of time planning, then executing on the plan, with almost no time to fix the design once they put the marshmallow on top.

- The Marshmallow is a Metaphor for the Hidden Assumptions of a Project: The assumption in the Marshmallow Challenge is that marshmallows are light and fluffy and easily supported by the spaghetti sticks. When you actually try to build the structure, the marshmallows don’t seem so light. The lesson in the Marshmallow Challenge is that we need to identify the assumptions in our project – the real customer needs, the cost of the product, the duration of the service – and test them early and often. That’s the mechanism that leads to effective innovation.

*from Engineering Go For It http://teachers.egfi-k12.org/marshmallow-design-challenge/
Review the activity, and try it out yourself.

Gather materials (per team of 4 students)
- 20 sticks of spaghetti (uncooked, regular—not thin)
- 3 feet cotton string
- 3 feet masking tape*
- Scissors
- Marshmallow (standard size, not mini or jumbo; not stale)
- Paper lunch bag (for containing materials)
- 1 sheet of graph paper and pencil (for sketching ideas—not for building)
[Assemble a building kit for each team by placing, everything except the tape, into the paper lunch bag.]

*Attach tape in strips to side of a table, back of a chair, or nearby wall for teams to collect.

Gather additional materials for the leader running the activity:
- Measuring tape
- Stopwatch or timer
- Tables for each team
- Computer with downloaded TED talk video “Tom Wujec: Build a Tower, Build a Team” at: http://www.ted.com/talks/tom_wujec_build_a_tower.html
- Projector and screen for projecting video
- Prizes (optional)

Opening Activity: (1 hour)

1. Introduce the Design Process (5 minutes)
   • Ask students whether they have heard of the engineering Design Process and get them to share what they know.
   - If the concept is new, you can show students the Design Process poster and explain:
     1. When engineers set out to solve a problem, their first solution is rarely their best. Instead, they tinker, try different ideas, fail, learn from mistakes, and try again. The series of steps engineers use to arrive at a solution is called: the Design Process.
     2. You can approach almost any problem using the steps of the Design Process—it’s a great way to come up with lots of ideas, improve a design, and learn from mistakes. In fact, the Design Process is something people use every day—planning an outing, writing a letter, making breakfast, or doing any task where they create something that did not exist before.

   *from Design Squad Educator’s Guide
   http://pbskids.org/designsquaddis/types/educators_guide.html

   • Ask students to think about how they use the Design Process as they do the project you are about to introduce.

2. Introduce the Challenge (5 minutes)
   • Tell students today’s challenge is to build the tallest, freestanding structure in 18 minutes that will support a marshmallow on top. The materials available to them are spaghetti, string, masking tape,
scissors, and a marshmallow.

• Explain the design requirements:
  - They have 18 minutes to design and build.
  - The tower must be freestanding (can’t be propped up, held, or suspended from the ceiling).
  - The entire marshmallow must be on top of the structure.
  - The tower will be measured from the surface of the table to the top of the marshmallow.
  - They can use all the materials in the paper bag EXCEPT for the paper bag, graph paper, and pencil.
  - The graph paper and pencil are for sketching ideas as they design.
  - They can break the string and spaghetti and use as much or as little as they need.

3 Brainstorm (5 minutes)

• Hold a strand of spaghetti by one end and wiggle it; then snap it in half. Ask, what are some strengths and weaknesses of using this material for building a tall tower. What are some ways to make this material stronger?

4 Build, Test, and Redesign (18 minutes)

• Divide the group into teams of four.

• Distribute the student handouts and paper bag building kits. Do not let teams open their kits until you start the timer and give them the signal.

• Remind teams that they can use the graph paper and pencil for sketching ideas—not for building.

• As teams design and build, circulate around the room, and ask:
  - What are some different ways to tackle this challenge?
  - What are some problems you’ll need to solve as you build?
  - What have you tried? How did it work? What else could you try?
  - What can you learn by looking at other team’s designs?
  - Would it help to redesign now that you’ve learned what does and does not work?

• Remind teams of the time remaining (9 minutes—half way, 5 minutes, 1 minute, 30 seconds, stop!)

5 Share Results (15 minutes)

• Measure the towers and call out or record the heights. Give a club cheer or a prize for the winning tower!

• Have each team talk about their designs and how they solved any problems that came up.
  - Compare the towers. What design elements are similar? What elements are different?
  - Spaghetti is thin and flexible. How did you use it to make a tower? What did you do to strengthen the structure?
  - How was the string useful in stabilizing the tower?
  - Does the size of the base alter the stability of the tower?
  - If you could replace one of your construction materials, what would it be and why?
  - Does your final product resemble your schematic sketch? Why? Why not?

• Show students the TED Talk video “Build a Tower, Build a Team” (7 minutes). Invite students to reflect on teamwork and using the design process by asking:
  - How did your team work together to solve the challenge? What roles did you assume? Did all teams work together in the same way?
  - In what ways did you use the design process (identify the problem; brainstorm and design; build, test, and
- How did your team use brainstorming (sketch as you think; defer judgment; encourage wild ideas; build on others’ ideas; and go for quantity)?
- In what ways did you use prototypes?
- When did your team put on the marshmallow?
- Did your team look at other team’s designs for ideas?
- What did you learn about collaboration and the design process from doing this activity?
- Are you as smart as a kindergarten student?!!

Activity Wrap Up (10 minutes)

- Connect to engineering. Ask students to describe ways they were thinking like engineers (collaborating, working within design constraints, designing, testing and improving ideas for solving problems, etc.).

CE Club Intro: (15 minutes)

Talk about civil engineering. Civil engineers build skyscrapers that reach thousands of feet in the air. They hang suspension bridges that support tons of trucks and cars each day. They ensure our water supply is safe by setting rigorous security standards. Like all engineers, civil engineers design things that matter. They are the people behind the inventions and advancements that make modern life possible. Civil engineering includes a number of specialties (construction, environmental, geotechnical, structural, transportation, urban planning, water resources) and during the club students will get to do projects and meet people connected to these specialties.

Talk about ASCE. ASCE is a professional organization for civil engineers. Over 140,000 civil engineers belong. ASCE’s mission is to help civil engineers in their careers—from college to finding a job, early career changes, technical resources to help them grow in their knowledge of civil engineering, and a means to give back to their community. Now high schools can be a part of that experience.

Tell students about the club. Explain that they will:
- Do more design projects like this one
- Work with Engineer Mentors—professional engineers and engineering college students who will assist during club projects
- Hear from civil engineer speakers
- Go on field trips to places like engineering firms, construction sites, and water treatment plants
- Take part in community service projects such as repairing community bridges and even teaching elementary school children about engineering
- Have fun!!!

Introduce what’s next.
- Give students a preview of the first module topic and the design projects they do. Encourage students to select activities that are of interest to them. The more you ask students what their interests are and connect engineering with those interests, the more likely they will be to see civil engineering as relevant to their lives.
- If you plan to have student officer elections at the next meeting, encourage students to consider running. Consult with your Faculty Advisor about roles and responsibilities of club officers.

Distribute any hand outs, giveaways.

Extension Ideas:

Build more structures using spaghetti and marshmallows, and determine which can support the greatest load. See the Leaning Tower of Pasta activity at: http://teachers.egfi-k12.org/class-activity-leaning-tower-of-pasta/
**Your Challenge:** Build the **TALLEST** tower that will support a marshmallow on top. You’ve got 18 minutes!

**Brainstorm and Design**

Look at your materials and think about how you might use them to meet the challenge. Sketch out your ideas as you go.

- How can you use these materials to build a tower that is tall?
- How can you make flexible materials (spaghetti and string) strong enough to build a tower that supports a marshmallow?
- What will keep the tower from tipping over?

You’ve got 18 minutes to build, test, and redesign. Go for it!

Keep in mind the design requirements:

- The tower must be freestanding.
- The entire marshmallow must be on top of the structure.
- The tower will be measured from the surface of the table to the top of the marshmallow. The **TALLEST** one wins!
- You can use all the materials in the paper bag but not the paper bag!

**Connecting to the World**

Taipei 101, with 101 stories and reaching 1,671 ft high, ranks as the world’s second tallest building. Like any tall building, it’s prone to bend and sway in strong winds. To reduce swaying, engineers came up with an innovative solution.

They designed the world’s largest and heaviest damper suspended between the 92nd and 87th floors. The ball-shaped damper is painted gold, weighs 730 tons, and measures 18 feet in diameter. Able to move 5 feet in any direction, it helps counteract the building’s movement during strong winds and even earthquakes.

*The tallest building (for now) is Dubai’s Burj Khalifa, which reaches 2,717 feet.*
Go civil!

See what Civil Engineering is all about!

Civil Engineering

BRIDGES module

asce.org/nextgeneration
Introduction

• Activity Overviews
• Planning Tips
• Master Materials List
• Resources

Activity 1: (1 meeting) Paper Bridge

• Build a bridge that holds 100 pennies using 1 sheet of paper

Activity 2: (1 meeting) West Point Bridge Design Contest

• Design, test, and optimize a truss bridge using the West Point Bridge Designer software

Activity 3: (1 or more meetings) Make It Real, Make a Difference

• Connect to real-world civil engineering through speakers, field trips, and community service projects

Activity 4: (4 meetings) Balsa Wood Bridge—Build It & Bust It!

• Build the lightest bridge capable of supporting a given load over a given span
Introduction

With over half a million bridges in the U.S., the chances are your students have crossed a bridge or two in their lives. But how much do they know about how bridges work and who designs them? Bridges are more than structures that span physical obstacles like rivers, ravines, and highways—they are an essential part of the transportation infrastructure. Civil engineers provide the creative know-how behind safe and effective bridge design. They decide which type of bridge to build based on such factors as: the distance to be spanned, the weight the bridge must support, types of materials available, how the environment will affect the bridge (such as earthquakes, strong winds, and freezing temperatures), aesthetics, and budget. In this module, students explore bridge design by building three bridge models—one using paper, another using computer design software, and a third using balsa wood. These projects can be enhanced through real world experiences such as visiting local bridges, inviting an engineer from a local firm to speak about bridge design, and more.

Activity Overviews

1 Paper Bridge (1 meeting)
   • Overview
     Introduce students to beam bridges with this quick activity. Students build simple bridges using one sheet of paper and wood abutment blocks. They’ll design and test different ways to use the paper (by folding, rolling, twisting, etc.) to make it more resistant to buckling. At the end of the activity, students will talk about different types of bridges and make connections to civil engineering.

   • Learning Objectives
     Students will be able to:
     - Explain how changing the properties of a material can improve its ability to bear loads.
     - Identify the main characteristics of different types of bridges.
     - Describe the role of civil engineers in building bridges.

2 West Point Bridge Design Contest (1 meeting, plus ongoing check-ins)
   • Overview
     This is an ongoing activity (aspects of this activity will continue at home and in following meetings). During the first meeting, students will explore the West Point Bridge Design (WPDB) contest and software in a computer lab. Students will then work outside of the club setting to design bridges and submit them to a local scoreboard. At subsequent meetings, you’ll reserve a brief amount of time to report on scoreboard standings and discuss student bridge designs. Interested club members may also compete in the national WPBD competition (ongoing from January to May) and local ASCE Section competitions.

   • Learning Objectives
     Students will be able to:
     - Explain what a truss is and its functions.
     - Explain how the engineering design process is applied to the design of a bridge.
     - Explain how engineers use computer simulations to test and redesign structures.
     - Describe how design involves decision making based on cost and the physical requirements of the structure.
**Make It Real, Make a Difference (1 or more meetings)**

- **Overview**
  Connect to real-world civil engineering through field trips, speakers, and community service projects.

**Balsa Wood Bridge—Build It & Bust It! (4 meetings)**

- **Overview**
  Students will design and build a truss bridge using balsa wood and glue. This project takes four meetings. Students will design their bridges on graph paper, and build their models over the first three meetings; then they’ll test their bridges at the fourth meeting. To test their bridges, students will attach a loading block at the load point of the bridge, suspend a 5-gallon bucket from the block, and add sand (10-minute time limit) to the bucket until failure occurs, or the maximum load of 25 kilograms is reached. The winner is determined by the largest load/mass ratio with 25 kilograms as the maximum load.

- **Learning Objectives**
  Students will be able to:
  - Explain what a truss is and how it works.
  - Describe how connections and quality of fabrication influence the ability of a structure to carry a load.
  - Identify how they use the design process to design and build a model bridge.

**Planning Tips**

- **Choose and plan activities.** Work with your Faculty Advisor and Engineer Mentors to decide which activities you’d like to do with your students and in what order. Feel free to modify activities or add other activities to match your students’ interests.

- **Decide if you will be including a speaker, field trip, or community service project.** An ideal time is after Paper Bridge and West Point Bridge Design projects (when students have gained some experience with bridge design) and before the Balsa Wood Bridge project. The *Make It Real, Make a Difference* section of the introduction suggests real-world experiences that are related to bridges. Be sure to arrange these extensions several weeks before you begin the module. For more planning and organizing ideas, see the Getting Started section of this guide. (p. 20)

- **Gather materials ahead of time.** See the Master Materials List on the next page for a summary of the materials used in this module.

- **Recruit volunteers.** It’s helpful to have a 5:1 student-adult ratio when students are building their balsa wood bridges and exploring the West Point Bridge Designer software. Recruit plenty of engineer mentors to assist you during these activities.

- **Decide if you will award prizes.** Two of the projects, West Point Bridge Design and Balsa Wood Bridge, are set up as contests. If you plan to award prizes, decide what they will be ahead of time so you can use them as motivators for students. Find out if your partners/supporters can donate prizes or provide funds.

- **Evaluate the module.** How did it go? Use student and advisor surveys to find out what worked and where you can make improvements as you continue to work with students. Work with your Faculty Advisor to determine requirements (such as consent forms) needed for student surveys.
# Master Materials List

This chart summarizes the materials used in this module. For items and quantities needed for each meeting, see the meeting’s Leader Notes.

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity for 12 students for all meetings</th>
<th>Meeting(s)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photocopy paper</td>
<td>1 ream</td>
<td>Paper Bridge</td>
<td>Office supply store</td>
</tr>
<tr>
<td>Ruler</td>
<td>6</td>
<td>Paper Bridge</td>
<td>Office supply store or borrow from school</td>
</tr>
<tr>
<td>Pennies (exchange bills at bank)</td>
<td>1200 (24 rolls at 50 pennies per roll)</td>
<td>Paper Bridge</td>
<td>Collect for free</td>
</tr>
<tr>
<td>Abutment blocks or books</td>
<td>12</td>
<td>Paper Bridge</td>
<td>Pre-build from school</td>
</tr>
<tr>
<td>Craft sticks</td>
<td>6</td>
<td>WPBD</td>
<td>Craft store</td>
</tr>
<tr>
<td>Brads</td>
<td>5</td>
<td>Balsa Bridge</td>
<td>Office supply store</td>
</tr>
<tr>
<td>String</td>
<td>3 six-inch pieces</td>
<td>Balsa Bridge</td>
<td>Office supply store</td>
</tr>
<tr>
<td>Hole puncher (high capacity to punch through craft stick)</td>
<td>1</td>
<td></td>
<td>Office supply store or borrow from school</td>
</tr>
<tr>
<td>Balsa wood (1/8 in. x 1/8 in. x 36 in.)</td>
<td>60 pieces</td>
<td>Balsa Bridge</td>
<td>Craft store</td>
</tr>
<tr>
<td>Balsa wood flat piece (1/16 in. x 1/2 in. x 12 in.)</td>
<td>6</td>
<td></td>
<td>Craft store</td>
</tr>
<tr>
<td>Elmer’s Glue, 4 oz. bottle</td>
<td>6</td>
<td></td>
<td>Craft store</td>
</tr>
<tr>
<td>Scissors</td>
<td>6</td>
<td></td>
<td>Craft store or borrow from school</td>
</tr>
<tr>
<td>Pencil</td>
<td>12</td>
<td></td>
<td>Craft store or borrow from school</td>
</tr>
<tr>
<td>11 in. x 17 in. graph paper</td>
<td>1 pad (at least 25 pages)</td>
<td></td>
<td>Office supply store or use ASCE graph paper (tape 2 pieces together)</td>
</tr>
<tr>
<td>Material</td>
<td>Quantity for 12 students for all meetings</td>
<td>Meeting(s)</td>
<td>Source</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>------------------------------------------</td>
<td>--------------</td>
<td>---------------------------------------</td>
</tr>
<tr>
<td>11 in. x 17 in. stiff paper (construction, manila, cardboard)</td>
<td>6</td>
<td>Balsa Bridge</td>
<td>Office supply store</td>
</tr>
<tr>
<td>Safety Goggles</td>
<td>12</td>
<td></td>
<td>Borrow from school</td>
</tr>
<tr>
<td>5-gallon Bucket</td>
<td>1</td>
<td></td>
<td>Hardware store</td>
</tr>
<tr>
<td>Sand</td>
<td>30 kg</td>
<td></td>
<td>Hardware store</td>
</tr>
<tr>
<td>Zipperlock bags (quart size)</td>
<td>50</td>
<td></td>
<td>Grocery store</td>
</tr>
<tr>
<td>Stopwatch</td>
<td>1</td>
<td></td>
<td>Office supply store or borrow from school</td>
</tr>
<tr>
<td>Postal scale</td>
<td>1</td>
<td></td>
<td>Office supply store or borrow from school</td>
</tr>
<tr>
<td>2 in. long x 3 in. wide x ¾ in. thick loading block</td>
<td>1</td>
<td></td>
<td>Hardware store</td>
</tr>
<tr>
<td>¼ in. eyebolt</td>
<td>1</td>
<td></td>
<td>Hardware store</td>
</tr>
<tr>
<td>Washer</td>
<td>1</td>
<td></td>
<td>Hardware store</td>
</tr>
<tr>
<td>Wing nut</td>
<td>1</td>
<td></td>
<td>Hardware store</td>
</tr>
</tbody>
</table>
Resources

Explains how tents, houses, stadiums, and bridges are built and how to build models of such structures using household materials. Offers simple demonstrations to help students understand concepts.

**Building Big: Bridges**
Includes information about different types of bridges, an interactive forces lab, databank of world bridges, and links to online bridge resources. Students may find this site useful when designing bridges for the West Point Bridge Design contest.
http://www.pbs.org/wgbh/buildingbig/bridge/index.html

**Building Big: Educator’s Guide**
Contains hands-on activities for bridges and other structures. The Hands-On Glossary is particularly useful for helping students get a feel for the physical science of bridges.
http://www.pbs.org/wgbh/buildingbig/educator/index.html

**Designing and Building File-Folder Bridges: A Problem-Based Introduction to Engineering by Stephen J. Ressler**
This online book contains in-depth information about truss bridges and activities to help students use the West Point Bridge Designer in conjunction with a hands-on model bridge building activity that incorporates math and science.
http://bridgecontest.usma.edu/manual.html

**The Gallery of Truss Bridges**
This collection of photographs shows thirty truss bridges from all over the United States.
http://bridgecontest.usma.edu/pdfs/appenda.pdf
Activity 1: (1 meeting) Paper Bridge

The Challenge:
Build a bridge that holds 100 pennies using 1 sheet of paper.
Time: 1 meeting

Overview: Introduce students to beam bridges with this quick activity.* Students build simple bridges using one sheet of paper and wood abutment blocks. They’ll design and test different ways to use the paper (by folding, rolling, twisting, etc.) to make it more resistant to buckling. At the end of the activity, students will talk about different types of bridges and make connections to civil engineering.

*Activity adapted from: Building Big Activity Guide, WGBH Educational Foundation

Learning Objectives:
Students will be able to:
• Explain how changing the properties of a material can improve its ability to bear loads.
• Identify the main characteristics of different types of bridges
• Describe the role of civil engineers in building bridges

Preparation:
• Review the leader notes and try out the activity.
• Gather materials (per group of two)
  - copy of student handout (1 per student)
  - sheet of plain photocopy paper
  - ruler
  - 2 books or blocks (abutments)
  - at least 100 pennies, washers, or other small weights
  - extra paper for students to build a second bridge

• Download the Bridges PowerPoint (See Appendix). You can use this presentation to introduce students to different types of bridges and how they stand up. If bridges are not your specialty, invite a mentor engineer who is familiar with bridge design to run the presentation. Feel free to modify the presentation as needed. For the meeting, you’ll need a computer with the downloaded presentation plus a projector for showing the presentation.

Activity: (1 hour)

Icebreaker (5 minutes)
• Hold up a single piece of paper. Ask: How many pennies do you think a bridge made out of this paper can hold? After students make some guesses, lay the sheet of paper flat across two books placed 20 cm (about 8 in.) apart. With the students keeping count, place pennies on the bridge, near the middle, until the bridge fails. (It will hold only a few.)
2. Introduce the Challenge (5 minutes)
   • Distribute copies of the student handout to each student.
   • Tell students their challenge is to build a bridge that can support 100 pennies using 1 sheet of paper.
   • Explain the design requirements/constraints:
     - The bridge must support its own weight (dead load) and the pennies (live load). If students are unfamiliar with the terms live and dead load, explain that a live load is the weight of a structure’s nonpermanent, moveable parts and “users” (such as the cars on a bridge) and a dead load is the weight of the permanent, non-moveable parts of a structure (such as the roadway of a bridge).
     - It must span 20 cm (about 8 in.)
     - The sides must rest on the two blocks and cannot be taped or attached to the blocks or table.

3. Brainstorm, Design, Build, and Test (10 minutes)
   • Divide students into teams of two. Distribute materials to each team.
   • As teams work, ask questions:
     - What can you do to the paper to make it stronger? (accordion pleat the paper, roll it, cut it into strips and weave them together)
     - Think about bridges you’ve seen. What ideas can you apply to your paper bridge?
     - Is there a difference in the load your bridge can hold if you put the load in the center, compared to spreading it out along the bridge? Make a prediction, and test it.

4. Club Check-in (10 minutes)
   • Bring teams together to discuss their bridge designs and report the number of pennies each held.
     - How did you come up with your design?
     - Was the bridge as strong as you thought it would be? Where did it fail?
     - How well did your bridge support its dead load and the live load you placed on it?
     - What are some things the bridges have in common?
     - How is it useful to see other team’s designs?

5. Redesign and Test (10 minutes)
   • Tell students they can redesign their bridge and test it again using a new sheet of paper.

6. Share Results (5 minutes)
   • How does the second design compare?
   • How did you learn from your testing results to redesign and make improvements?
   • If you had more time, how could you improve your bridge?
   • If you could use one more material to build your bridge, what would it be?
   • How were you using the design process to create your bridge?

7. Wrap Up (15 minutes)
   • Talk about bridges: Ask students to think about places they’ve visited in the past few weeks. Did they have to cross a bridge to get to these places? What do bridges do for society?
   • Show the PowerPoint and connect to civil engineering. Show students the Bridges PowerPoint presentation to introduce different types of bridges. Talk about the roles of civil engineers in bridge design. Ask students to identify the type of bridge they built in the activity (beam bridge). See if students can identify different types of bridges in their own community.
• Preview the next meetings. Let students know that at the next meeting they’ll continue building bridges. They’ll design and test truss bridges using computer software as a design tool—similar to the way engineers use structural analysis software. (If you have time, give students a quick glimpse of the West Point Bridge Designer software on a computer.) They’ll also build model bridges using balsa wood and glue. Each of these activities will be set up as fun club competitions, both online and in the club.

**Extension Ideas:**

• Have students build another paper bridge using 2 pieces of paper. What designs do they come up with? How much weight can these bridges support compared to the bridge made from one sheet of paper?

• Have students explore the Building Big: Bridges website [http://www.pbs.org/wgbh/buildingbig/bridge/index.html](http://www.pbs.org/wgbh/buildingbig/bridge/index.html) to learn more about different types of bridges and how they work.
Brainstorm and Design

Plan and sketch ideas for constructing the bridge so that it will support its dead load plus the live load of the pennies. What can you do to make the paper hold more weight?

Keep in mind the design requirements:
- Your bridge must span 20 cm.
- The bridge must support its own weight (dead load) and the pennies (live load).
- The sides of your bridge will rest on two blocks and cannot be taped or attached to the blocks or table.

Build, Test, and Redesign

Build your design.
- Test it by placing it across the supports that are 20 cm across. Load pennies one at a time, until it collapses. How many pennies did your bridge support? Where did it fail?
- Redesign your bridge and test it again, using a second sheet of paper. How does your second design compare? How can you change the design so your bridge supports more pennies?

Materials:
- sheet of paper
- at least 100 pennies or other small weights
- 2 wood blocks (abutments)
- ruler

As an advertising stunt for International Paper Company, civil engineering firm Lev Zetlin Associates (now called Thornton Tomasetti) designed a full-sized paper bridge that was strong enough to support a truck. The bridge design included long span triangular beams, pyramid “waffle” bracing between beams, and paper tube deck for spreading wheel loads. The engineers conducted tests to establish the strength of paper piles, glue lines, and the fact that paper glue must be fully dry to have strength. Unfortunately, the schedule didn’t allow ample time for drying. Luckily the bridge spanned a chasm in Utah’s Flaming Gorge National Recreation Area, where desert-like conditions helped the glue dry fast enough to work.
Activity 2: (1 meeting)
West Point Bridge Design Contest

The Challenge:
Design, test, and optimize a truss bridge using the West Point Bridge Designer software.

Time: 1 meeting, plus 10 minutes at subsequent meetings to review designs and scoreboard standings.

Overview: This is an ongoing activity* (aspects of this activity will continue at home and in following meetings). During the first meeting, students will explore the West Point Bridge Design (WPDB) contest and software in a computer lab. Students will then work outside of the club setting to design bridges and submit them to a local scoreboard. At subsequent meetings, you’ll reserve a brief amount of time to report on scoreboard standings and discuss student bridge designs. Interested club members may also compete in the national WPBD competition (ongoing from January to May) and local ASCE Section/Branch competitions.

*Activity adapted from: Designing and Building File-Folder Bridges: A Problem-Based Introduction to Engineering. By Stephen J. Ressler, P.E., Ph.D.

Learning Objectives:
Students will be able to:
• Explain how a truss functions.
• Explain how the engineering design process is applied to the design of a bridge.
• Explain how engineers use computer simulations to test and redesign structures.
• Describe how design involves decision making based on cost and the physical requirements of the structure.

West Point Bridge Designer software enables students to design, test, and optimize a structural model of a truss bridge. Through structural modeling students can explore many design alternatives. This is similar to the way engineers use structural analysis software to draw, model, analyze, and evaluate engineered systems. By using structural analysis software as a design tool, engineers can:
• Create accurate two-dimensional drawings and three-dimensional models of a structure which can be easily updated.
• Visualize a completed structure, long before construction begins.
• Create a structural model; then analyze the structure to determine its internal forces and automatically select steel or concrete members strong enough to carry these forces. By expediting the analysis-design cycle, software makes it possible for the engineer to explore a wider variety of design alternatives and thus achieve greater efficiency and lower cost.
• Share design information via computer networks and the Internet.

As powerful as structural analysis software is, it is only a tool. Like any tool, it can improve human efficiency, but it can never substitute for human creativity and good judgment. It can also be misused. An in-depth understanding of the engineering principles on which the tool is based is essential for knowing how to effectively and safely use a tool.
Preparation:

• **Review the leader notes and become familiar with the WPBD contest and software:**
  http://bridgecontest.usma.edu. If you are new to the software, take the tutorial available at:
  http://bridgecontest.usma.edu/tutorial.htm

YouTube WPBD Tutorial

- http://www.youtube.com/watch?v=4Cb7Alttt8s
  For an 11-minute overview of the software and ideas about how to present it to students, view this video tutorial created by a high school teacher. Share the link with students, too, so they can refer to it while designing their bridges.

• **Gather materials.** (per 2 students)
  - Copy of student handout (1 per student)
  - Computer with WPBD software

• **Build the Ice Breaker demo.** This demo helps students understand the stability of a triangle. Materials needed: 4 jumbo craft sticks, 4 brads, 2 six-inch pieces of string, something to drill holes in the sticks (high-capacity hole punch or drill). Drill holes in the end of each craft stick. Use brads to attach crafts sticks into a square. During the demonstration, you will attach each piece of string diagonally from a brad at one corner of the square to a brad at the other, making cross braces.

• **Gather equipment to demonstrate software.** It’s essential to run this meeting in a computer lab so students can explore software on individual computers. Work with the Faculty Advisor to download the WPBD software on each computer. Use an LCD projector and screen to demonstrate to the group how to use the software.

  Test Computers before the meeting

  Note that filters in the school and differences in java/flash can sometimes deny access. Have the Faculty Advisor ask the school tech department to test the access and programs before the meeting. You can be extra prepared by bringing your own demo laptop with loaded software.
• **Determine how students will access computers for designing outside of the club.** The West Point Bridge Design software is available in two formats for Windows (Windows XP or newer) and Macintosh (Mac OS 10.5.7 Leopard or newer). Each team will need computer access to develop their designs and Internet access to submit their designs and view the scoreboard. Work with your Faculty Advisor to determine how to ensure students will have equal access to computers when designing bridges outside of club meetings (at home or through the school computer lab).

• **Recruit volunteers to assist with software demo.** Invite engineer mentors to help guide students and answer questions as they try out the program. An ideal ratio is 1 adult to 5 students.

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• **Recruit volunteers to assist with software demo.** Invite engineer mentors to help guide students and answer questions as they try out the program. An ideal ratio is 1 adult to 5 students.

• **Decide what type of contest you’ll run:**
  - **Single Bridge Design Project.** In this format, participants are assigned one specific bridge length, height, support configuration, and load case. Single-project local contests can only be used during the period from September, to December (when the national West Point Bridge Design test is not underway). This format is useful for small school-based competitions because all contestants begin their designs from the same starting point.
  - **All-Possible Bridge Design Projects.** In this format, participants are permitted to use any bridge length, height, support configuration, and load case offered by the West Point Bridge Designer software. All-possible contests can be run anytime (except for the period from December, to January, when the national contest is setting up.) This format allows for a truly open-ended design experience and permits students to participate in both the local contest and the national West Point Bridge Design Contest simultaneously. The national competition runs from January to June. Check with your local Section/Branches to see if there is a local competition going on in the same timeframe.

• **Set up your local contest and scoreboard.** By establishing your own web-based Local Contest Scoreboard, you’ll be able to monitor the level of participation and the performance of your students on a daily basis. For step-by-step instructions, visit: [http://bridgecontest.usma.edu/local.htm](http://bridgecontest.usma.edu/local.htm). You’ll also need to decide contest logistics such as how long the contest will last, how many rounds you’ll have, what prizes you’ll offer, etc.

You may want to have two rounds: a preliminary and a final round. Choose the All-Possible Bridge Designs Projects for preliminary round so students can explore many design options AND be automatically entered into the national contest. For the final round, choose a Single Bridge Design Project and give students a set amount of time to design (such as 1 hour).
Activity: (1 hour, 5 minutes)

Icebreaker (10 minutes)

- Show students an image of local truss bridges and/or famous truss bridge (see Gallery of Truss Bridges at http://bridgecontest.usma.edu/pdfs/appenda.pdf). Have students point out the shapes they see (mostly triangles).
- Explain that a truss is a structure made up of triangles. The triangular shape makes a truss very strong to support its weight. Compare the stability of a square and a triangle. Show students the square you made from craft sticks and brads collapses easily. Next attach a piece of string diagonally from a brad at one corner of the square to a brad at the other, making cross braces. Demonstrate how the structure is now stable and won’t collapse when square is deformed in one direction. Show how the square will collapse in the other direction unless another cross-string is added to make an X. Have students notice which pieces are in tension and compression. Dividing the square into triangles gives stability to the structure without adding significantly to the dead weight of the structure.

Note how strings (cables) can only take tension forces. Sometimes as a truck moves across a bridge (or wind blows on a building), members can switch from tension to compression members and vice-versa. Engineers have developed certain types of truss bridges to reduce that effect and confirm that certain members will remain in tension (e.g., a Pratt style truss has diagonals in tension, whereas a Howe style truss has diagonals in compression). (Note that the level of discussion will vary based on students’ different learning levels.)

What Is a Truss?

- A structure composed of members pin-connected together to form a rigid framework
- Usually composed of interconnected triangles made of steel.
- Members carry load in tension or compression. Steel is especially designed to resist these forces.
- Point out that members of the truss are pinned together, allowing rotation at intersections. Although this may seem counterintuitive when seeing large gusset plate connections, that is the design assumption used by engineers and the WPBD software.

Let students feel tension & compression

To feel compression, have pairs of students face each other with palms touching and slowly lean into each other. How do their arms feel?
2 Introduce the Challenge (5 minutes)
• Tell students they will be designing a truss bridge that:
  - Can carry its own weight plus the weight of a standard trucking load
  - Costs as little as possible
• Explain they will be designing their bridges on computers using the West Point Bridge Designer software. This software enables them to design, test, and optimize a structural model of a truss bridge without having to worry about mathematical calculations. That way they can focus on the creative part of the design process—structural modeling—and explore more design alternatives than they could do otherwise. They’ll use computers as a design tool—similar to the way engineers use structural analysis programs.

3 Brainstorm (45 minutes)
• Distribute copies of the student handout to each student so they can follow the flowchart as you walk them through a demonstration of the software.
• Demonstrate how to use the software. The talking points below outline basic information to cover in your demo. Remember: less is more. Your game plan is to demonstrate how to design a bridge using one of the basic templates (such as the Pratt or Howe). Then let students explore independently as you circulate the room to answer questions. The level of assistance needed by students will vary based on their computer backgrounds.
• After your demonstration, have students open up the same template (such as the Pratt or Howe) and begin designing. Encourage students to help each other. Some will get it quickly and be able to explain to their peers better than adults.

Software Demo

Select a design project
• Provide local contest code to students and explain how to enter the code when registering. (Note on student handout.)
• If this is a single bridge design contest, the bridge design will automatically configure when you enter the Local Contest Code.
• If this is an all-possible bridge designs contest, you choose the amount of excavation and the substrate (foundation) elements.

Decide on a truss configuration
• Explain that students can create virtually any truss configuration as long as the resulting structural model is stable.
• Start with a simple, standard configuration template—like the Pratt, Howe, or Warren truss.
• If you use a template, the locations of all joints and members for the standard truss you selected will be displayed with light gray lines on the Drawing Board.
• Once you select a configuration, enter your name in the “Designed By” box and, if you like, add a Project ID. (Note on student handout.) The Project ID is a name or number you assign to your design for future reference. If you are planning to try a variety of different design alternatives, the Project ID is a good way to keep track of them.
• Draw joints and members
• Demonstrate how to draw joints
• Connect joints with members.
• Review the Drawing Board/Bridge Design Window and point out these major elements:
  - Menu bar and Toolbars – Commands for creating, modifying, testing, recording, and reporting a bridge design.
- **Drawing Board** – The portion of the screen on which you will draw joints and members to create a structural model.
- **Design Tools Palette** – Special toolbar containing tools that are used to create and modify a structural model on the Drawing Board.
- **Rulers** – Guides that show the vertical and horizontal dimensions of the structural model.
- **Title Block** – Portion of the Drawing Board displaying the designer’s name and Project ID.
- **Member List** – List of all members in the current structural model, normally hidden on the right-hand side of the Drawing Board. (The Member List can be displayed by dragging it to the left with your mouse).
- **Design Tools Palette has four available tools** — the Joint Tool, the Member Tool, the Select Tool, and the Eraser Tool.

### Load test your design

- Run the Load Test to check the strength of your design. (Start with a design that will collapse so you’ll be able to demonstrate how to analyze and correct the problem.)
- Explain the bridge is first subjected to its own weight and the weight of the concrete deck and asphalt road surface (dead weight). Then a 360 kilonewton vehicle (representing the largest loading that this bridge is expected to experience in its lifetime) crosses the bridge to validate the structure’s ability to carry a vehicular load safely (live weight).
- As the Load Test runs, point out the colors of the members.
  - **Blue** – Members in tension.
  - **Red** – Members in compression.
  - The intensity of the color depends on the force-to-strength ratio.
  - If the color is pale, it means that the internal force in that member is much less than its strength.
  - The goal here is to get bright **colored members** — that means the internal force is nearly equal to the strength.
- Point out the Load Test Results Table (to the right of the drawing board) which shows force/strength ratios for each member. Members with ratios above 1 failed. To optimize the bridge, the goal is to get each member as close to 1 without going over. Demonstrate how to highlight and change members directly from the table. Both on the truss and in the table, if you hold “control” as you click, you can individually select multiple members.

### Strengthen unsafe members

- Are any members unsafe?
- Demonstrate how to identify and strengthen unsafe members.
- Run the load test again to show the bridge passes the load test.

### Optimize the design

- Congratulations! You now have a successful design that spans the required distance and carries all of the specified loads safely.
- But don’t relax yet! Now you must determine if the cost can be reduced, without compromising the safety of the structure. This process is called optimizing the design.
- Demonstrate how to optimize the design in three distinct phases.
  - **Are member properties/selections optimum?**
  - Select a material, cross-section, and size for each member, such that the total cost of the truss is minimized.
- Is the shape optimum?
  Explore a range of different shapes and select the one that costs the least.
- Is the configuration optimum?
  Explore new truss configurations and pick the least expensive one.

Choose the Optimum design
• Compare costs of alternative designs to determine which is least.
• Point out that selecting a “best” alternative is usually far more complicated than simply picking
  the design that costs the least. Cost is certainly important, but other factors like aesthetics, ease of
  construction, availability of materials and labor, type of traffic, soil conditions, environmental impact,
  and safety might be equally important in determining which design alternative actually gets built.

Record Your Design
• Explain that engineers prepare a detailed set of plans and specifications that will be used by the
  Constructor who will actually build the structure, as well as serve as a valuable reference for future
  projects of a similar nature.
• Explain the West Point Bridge Designer provides three different ways to record a design:
  - To save a design in a specially formatted file, click the Save button on the main tool bar, enter
    a file name, and click OK. This bridge design file can be opened and modified later.
  - To print a drawing of a design, click the Print button on the main toolbar. A drawing showing the
    configuration and dimensions of the truss and a table listing the assigned member properties will
    be printed to your default printer.
  - To print a detailed report of most recent load test results, click the Report Load Test Results
    button on the main toolbar, then click the Print button at the top of the report window.

4. Build, Test, and Redesign (outside of club, time based on length of
   contest) Students will build and test their bridge designs outside of the club. To help them get started:
   • Explain they can work individually or in teams of two.
   • Explain the Local Contest Rules (e.g., how long contest will last, prizes, opportunity to enter national contest, how to check standings on local scoreboard).
   • Explain that at subsequent club meetings, you’ll report on scoreboard standings and discuss student’s designs and questions that arise. (See step 6 below.)
   • Invite students to email you if they have questions as they design. Note that your email will show up when students click on the scoreboard.

5. Wrap Up (5 minutes)
   • Preview the next meeting: a Make It Real/Make a Difference experience or Balsa Wood Bridge

6. Club Check-Ins (10 minutes at the end of subsequent meetings)
   • At subsequent club meetings, report on scoreboard standings and discuss student’s designs and questions that arise.
Note: The scoreboard shows standings only, not design or cost. One way to review student designs is to have students save their designs on your flash drive. Then upload all designs on one computer to view during the club meeting. Check with your Faculty Advisor to see if flash drives need to be provided to students. Also keep in mind that there is no security on any file in this competition, so to avoid any accusations of copying, think about how to prevent students from having access to the work of others on your system.

- As students talk about their designs, ask:
  - What were the different steps you had to do to get your design to work the way you wanted?
  - What’s the best feature of your design? Why?
  - What can you learn by looking at other team’s designs? (It’s is okay to borrow and build on ideas—that’s what engineers do all the time.)
  - What are some problems you need to solve to further optimize your bridge?
  - When you “go back to the drawing board,” what will you modify and retest? What alternate designs might you try?
  - What are the benefits and limitations of using the computer as design tool? (If you use structural analysis software in your own work, talk about how it helps you.)
  - What have you learned about engineering and bridge design from using this software? What have you learned about how structures carry load?
- When the contest concludes, announce the winning design and award prizes (if provided). Congratulate all students on participating.

Extension Ideas:

- Compete at the national level. Encourage students to participate in the national WPBD competition.

- Explore the relative efficiency of various different truss configurations. Divide the class into teams, and assign a different truss configuration to each team. (The easiest way to do this is to have each team use one of the standard truss templates provided by the West Point Bridge Designer.) Then have each team optimize the member selections for its assigned truss configuration, without changing the shape of the truss. At the end of the project, invite each team to report its optimum cost; then compare these costs to determine which configuration is most economical.

- Model and design an actual bridge. Provide students with images of a truss bridge (take photos of a local bridge or use images from the Gallery of Truss Bridges at http://bridgecontest.usma.edu/pdfs/appenda.pdf). Have students use the Bridge Designer to model, test and optimize the bridge. (Since the software does not allow the user to change the span length of a design, students will only be able to model the shape and configuration of the actual bridge, not its specific dimensions.)
Your Challenge: Design a truss bridge that:
  • Carries its own weight plus the weight of a standard truck loading
  • Costs as little as possible

Materials:
  • Computer
  • West Point Bridge Designer software

Download Software at: http://bridgecontest.usma.edu/

Ready to move from computer designs to real steel? Check out ASCE’s annual Student Steel Bridge Competition. This competition brings together college students from around the country to showcase their knowledge and skills in designing, fabricating and constructing a scale model steel bridge.

To find the competition that is happening in your area visit: www.aisc.org/content.aspx?id=780
Activity 3: (1 or more meetings)
Make It Real, Make a Difference

The Challenge:
Extend your students’ exploration of bridges with speaker presentations, field trips, and community service projects. We suggest scheduling one or more of these real-world experiences after Paper Bridge and West Point Bridge Design projects (when students have gained some experience with bridge design) and before the Balsa Wood Bridge project (which spans several meetings).

Make It Real

Speakers

- **Invite an engineer from a local firm to speak about bridge design.** Let the engineer know the students have been designing bridge models using paper, balsa wood, and the WPBD software, and are interested in learning more about how actual bridges are designed. You might want to provide the following topics for discussion:
  - Tell us about your engineering background. What got you interested in engineering? What did you study?
  - Describe the process you go through when designing a bridge.
  - What factors do you take into consideration when choosing a bridge design?
  - What tools do you work with? (If possible please bring tools, drawings, models, or other show-and-tell objects.)
  - How do you use structural analysis software programs in your work? How are these programs helpful? What are the limitations?
  - Tell us about a favorite project. What made it special?
  - Tell us about a challenging project. What challenges arose and how did you solve them?
  - What is creative about your job?
  - What people do you collaborate with on a project?
  - How does your work make a difference?
- **Invite a volunteer from Bridges to Prosperity or Engineers without Borders to speak about community service.** Bridges to Prosperity (BTP) builds footbridges over impassable rivers to provide isolated communities with access to essential healthcare, education, and economic opportunities. To learn if BTP volunteers are in your area, visit: [http://www.bridgestoprosperity.org/](http://www.bridgestoprosperity.org/). Engineers Without Borders (EWB) brings a variety of practical engineering solutions, including bridges, to developing countries. To find a local EWB chapter, visit: [http://www.ewb-usa.org/chapters/locate-chapter](http://www.ewb-usa.org/chapters/locate-chapter).

Field Trips

- **Visit an area bridge.** Ideally try to visit a bridge in place and a bridge under construction. Many bridges along waterways have nice parks below which give excellent view of structure. You can walk through inside structure of some hollow precast segmental bridges (ask DOT). Use this experience to illustrate design principles by exploring an actual civil-engineered project.
  - Identify the bridge design (beam, truss, arch, suspension, or a combination).
  - Why do they think the civil engineers chose this particular design? Why might it work for the given location/geography?
- Identify the materials used to construct the bridge. Why do they think the engineer made these choices?
- What parts of the bridge are in tension? In compression?
- Invite students to photograph, sketch, and take notes on the bridge design so they can later build a model using balsa wood or other materials. (If it’s a truss bridge, they can use the West Point Bridge Designer.)

**Arrange a tour of a local bridge design firm.** Consider asking if the firm can help cover some or all of the transportation costs for your students. See Speakers above for questions and talking points the engineer might want to cover during the tour. You could also give the engineer the winning design ahead of time and ask him/her to model the bridge in a real design program. Review the differences in how the bridge appears. Ask the engineer what s/he would do to improve the design.

**Attend an ASCE Student Regional Steel Bridge Competition.** For the listing of Conference Student Steel Bridge Competitions (held in conjunction with the 18 ASCE conferences), please check the ASCE website or [http://www.aisc.org/content.aspx?id=780](http://www.aisc.org/content.aspx?id=780).

**Visit the office of a contractor specializing in bridge construction.** Ask them to explain how long-span bridges are built over ravines, water, etc. What actions can be taken to make a bridge design more cost-effective?

**Visit a steel fabricator and/or concrete batch plant.**

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**Community Service Projects**

- **Introduce younger students to bridge building activities.** Work with children at an afterschool program or elementary or middle school to explore basic engineering concepts with hands-on activities. You can find fun, easy-to-do activities at the Building Big Educator’s Guide ([http://www.pbs.org/wgbh/buildingbig/educator/index.html](http://www.pbs.org/wgbh/buildingbig/educator/index.html)) and ZOOM website ([http://pbskids.org/zoom/activities/sci/#engineering](http://pbskids.org/zoom/activities/sci/#engineering)). Create an Engineering Kit to leave with the younger students so they can continue building after your visit. The kit could be a box containing sets of activity sheets and simple materials (straws, paper clips, etc.) for 25 students.

- **Prepare a local report card for infrastructure.** According to the Report Card for America’s Infrastructure, one in four of the nation’s bridges is either structurally deficient or functionally obsolete ([http://www.infrastructurereportcard.org/fact-sheet/bridges](http://www.infrastructurereportcard.org/fact-sheet/bridges)). Ask students to document (take pictures, write up observations) bridges in their community that are in need of repair (i.e., rusting steel, splitting wood, posted limits on load rating, damage from trailers hitting overpass, etc.). Meet with representatives from local ASCE section and discuss a media campaign/issuance of local report card for infrastructure.

- **Plan and build a bridge in school or community property.** Find out if a simple footbridge project needs to be built or repaired.

- **Host a West Point Bridge Design competition for the entire school.** It’s a great way to introduce civil engineering to a larger group of students and possibly recruit new club members. Work with your Faculty Advisor to help club members create a plan for marketing the competition (posters, school newspaper article), introduce the software (school presentation, host mini learning labs, tutor), set up a local scoreboard, and oversee the competition.
Activity 4: Balsa Wood Bridge Competition Build it!, Bust it!

The Challenge:
Design and build the lightest truss bridge capable of supporting a given load over a given span.

Time: 4 meetings

Overview: Students will design and build a truss bridge using balsa wood and glue.* This project takes 4 meetings. Students will design their bridges on graph paper and build their models over the first three meetings; then they’ll test their bridges at the fourth meeting. To test their bridges, students will attach a loading block at the load point of the bridge, suspend a 5-gallon bucket from the block, and add sand (10-minute time limit) to the bucket until failure occurs or the maximum load of 25 kilograms is reached. The winner is determined by the largest load/mass ratio with 25 kilograms as the maximum load.

*Activity adapted from: J. Chris Carroll Ph.D., M.ASCE

Learning Objectives:
Students will be able to:
• Explain what a truss is and how it works.
• Describe how connections and quality of fabrication influence the ability of a structure to carry a load.
• Identify how they use the engineering design process to design and build a model bridge.

Applying loads to a simple 3 member truss

A truss is a framework composed of members (short straight pieces), some in compression and some in tension, joined to form a series of triangles. Materials arranged in triangles form very rigid shapes—they remain stable when a force is applied to the joints. For example, when you push down on the top joint of a triangle, the compression in the two diagonal sides of a triangle is balanced by the tension in the cross-piece at the bottom, which pulls the sides back together. This works the other way, too: If you hold two joints and pull on the top joint, the two diagonals are in tension and the cross piece stays in compression to keep the shape. This balancing of forces results in a stable structural form.

It is important for students to understand that the loads are always applied at the joints so that all members are in either tension or compression. If a load is applied at the middle of a member (rather than at a joint), the member bends like a beam. Since most truss bridge members are arranged in interconnected triangles, these bridges are very strong for their weight. Students will tend to underestimate the strength of a truss and, as a result, they’ll tend to overdesign their bridges.

Connections are used to join the structural members. Two types of connections are used in truss bridges: pinned connections (a single large metal pin used to connect members) and gusset plate connections (one or two heavy metal gusset plates attached to members with rivets, bolts, or welds). Both types of connections are typically treated the same analytically. A main issue of failure for balsa wood bridges is at the connections. Students can experiment with different ways to join members (end joint, lap joint, notch joint) and add gussets to strengthen connections. By paying attention to the use of triangles and connections in their bridge design, students will discover that a relatively light bridge can support a surprisingly heavy load.
Preparation:

• Review the leader notes and try out the activity.

• Gather materials (per team of 2 students).
  - copy of student Balsa Woodbridge student activity handout (1 per student)
  - copy of Truss Bridge Designs and Connections handout (1 per student)
  - 10 pieces of balsa wood (1/8 in. x 1/8 in. x 36 in.)
  - 1 flat piece of balsa wood (1/16 in. x 1/2 in. x 12 in.)
  - 4 ounce bottles of Elmer’s glue*
  - scissors
  - pencil
  - ruler
  - 2 sheets of 11 in. x 17 in. grid paper (if you’re using the ASCE graph pads, students can tape two 8.5 in. x 11 in. sheets together)
  - 1 sheet of 11 in. x 17 in. stiff paper (construction, manila, cardboard)
  - Safety goggles (to wear during testing)

  *To save on time, use hot glue guns and glue sticks instead of Elmer’s glue. Check with the Faculty Advisor about safety requirements for using glue guns.

• Gather the testing materials.
  - Postal scale (to weigh bridges)
  - 5-gallon bucket
  - 30 kg sand
  - 50 ziplock bags (quart size)
  - stopwatch
  - Fill each ziplock bag with ½ kg sand. Use a postal scale to measure the sand.

• Obtain storage space. Work with Faculty Advisor to identify a place to safely store students’ bridges between meetings.

• Build the Ice Breaker demo.
  - Build a small (2 ft. long x 6 in. wide) balsa wood truss bridge that you will stack books on to demonstrate the bridge’s strength. For design plans, see page 65. Materials needed: 7 pieces of 3/8” x 3/8” x 36” balsa wood, Elmer’s glue (use glue sparingly so the bridge will collapse), books for testing bridge strength (text books work well). This takes about 2 hours to build; consider assigning this task to an Engineer Mentor.
  - Build a mini truss from 2 jumbo craft sticks, 1 brad, and a piece of string.
• **Build the loading assembly.** Use the following materials to build the loading assembly (shown in photos below): 2 in. long x 3 in. wide x ¾ in. thick loading block with a hole in the center for a ¼ in. eyebolt, washer, and wing nut.

• **Build and set up the testing frame.**
Build the testing frame shown below (Figure 1.) by welding together 4 pieces of 1 in. x 1 in. steel tubing. Note that the inside dimensions should have a 12 inch span. If the school has a shop or auto mechanics department, they may be able to help build the frame. Estimated cost is $50-$100. Alternative: Set up two robust tables that are spaced so the inside dimensions of the span is 12 inches. Note that the tables might move during the load test, causing the bridges to slide.
Meeting 1 (50 minutes)

1 Icebreaker (10 minutes)
   • Show students the sample balsa bridge you constructed. Ask, What shapes do you see in this bridge? (triangles) Let them hold the bridge and feel the weight. Then ask them to hold one of the books you’ll be stacking on the bridge. Ask, How many books do you think the bridge can support? Have students stack books one at a time on the bridge until it fails. The results will be surprising—the stack of books could reach up to 7 feet high!
   • Show students the mini truss model you made from jumbo craft sticks and string. Push down on a joint to demonstrate the stability of a triangle shape. Show how the two inclined sides are in compression and horizontal bar (string) is in tension.
   • Point out that in a truss, loads are applied at the joints and all members are in either tension or compression.

2 Introduce the Challenge (10 minutes)
   • Tell students their challenge is to build the lightest bridge capable of supporting a given load over a given span.
   • Explain the design requirements:
     - Materials: The bridge can be constructed only from balsa wood and Elmer’s glue. You may NOT coat the wood in glue.
     - Span: The bridge must span a 12 in. opening. No maximum length. (Remind students that for a bridge to span a 12 in. opening, it must be bigger than 12 inches. A 12.5 in. length works well because the joints will sit on the testing frame support.)
     - Width: The bridge must be at least 3 in. wide (outside to outside). No maximum width.
     - No portion of the bridge may extend more than ½ in. below the top surface of the test supports.
     - Load Point: The load point will be at the center of the bridge. The bridge must accommodate a loading assembly made from a 2 in. long x 3 in. wide x ¾ in. thick loading block, ¼ in. eyebolt, washer, and wing nut.
   • Explain the testing procedure:
     - Show students the loading assembly and remind them that there must be a place at the center of their bridge where loading assembly can fit.
     - Explain that they’ll suspend a 5-gallon bucket from the block and have 10 minutes to add sand to the bucket until failure occurs or the maximum load of 25 kilograms is reached. The sand will be in ½ kg bags.
     - The winner is determined by the largest load/mass ratio with 25 kilograms as the maximum load.

3 Brainstorm and Design (10 minutes)
   • Divide students into teams of three and distribute the student handouts and materials.
   • Have students brainstorm and sketch truss designs. They can refer to the Truss Designs handout and the West Point Bridge Designer software (if they have already done this project) for ideas.
   • Once they settle on a design, have students draw the views (side, top, head on) of their bridge to size on grid paper. As this might be students’ first attempt at fabrication drafting, their sketches are likely to leave out important details. Encourage them to be detailed.
     - What do you need to show so that someone else could build from your drawing?
     - Do you need diagonal bracing on the horizontal planes?
     - Did you remember to draw a top view?
     - What happens if you don’t connect the two top chords of the side trusses? (Members must be braced to prevent buckling in both principle directions.)
4 Club Check-In (10 minutes)
   • Bring teams together to discuss their bridge design drawings.
     - How did you come up with your design?
     - What are some things the bridges have in common?
     - How is it useful to see other team’s designs?
     - How does your bridge meet the design requirements? (Remind students that the span is 12 inches—that means the bridge must be longer than 12 inches.)
     - What are some things you’ll need to figure out as you build your bridge?
   • If there is extra time at the end of the meeting, you can have students fill bags with sand for the competition meeting.

5 WPBD Check-in (10 minutes)

Meeting 2 (1 hour, 20 min)

4 Club Check-In (10 minutes)
   • Bring teams together to review their drawings. Ask, how will you connect the wood members?
     Distribute copies of the Connections handout. Talk together about the different joints and ways they might be used to connect members.
   • Briefly review the bridge design requirements and answer any questions.

2 Redesign and Build (40 minutes)
   • Have students make any revisions to their drawings. Encourage them to also sketch detailed drawings for connections.
   • Have students start building the sides of their bridges. As they build:
     - Have students lay their drawings on top of a stiff piece of paper for their work space. They’ll assemble and glue the pieces laying down on the paper. That way it will be easy to pick up and move their bridges to a storage area to dry between meetings. When dry, carefully peel the paper away and use scissors to trim any paper that sticks to edges.
     - Advise them to lay the balsa wood on their drawing; then cut the wood to length using their fingers or scissors. (The wood snaps easily using fingers; more precise edges can be made by cutting with scissors.)
     - Remind them to re-measure before gluing.
     - Tips: Hair dryers can speed up drying time. Paint scrapers and ice take glue off of tables easily.
• If some students finish early, have back-up activities prepared for them to do.

3 Club Check-In (10 minutes)
• Bring teams together to compare and discuss the bridge sides they’ve built so far.
  - What problems came up as you were building? How did you solve them?
  - What are strategies for cutting the wood? (Note that balsa wood breaks easily using fingers. To make a straight or angled edge, use scissors.)
  - What are strategies for gluing?
  - How did you create strong connections between members?
    (Balsa wood bridges tend to fail at connections. If some teams designed ways to strengthen connections, point these out and discuss their ideas. Discuss the pros and cons of strengthening joints, such as strengthens bridge but adds weight.)
• Do you have a place on bridge where the loading assembly can fit? (Have it available for kids to test as they build their bridges.)

4 Wrap-Up (10 minutes)
• Set aside bridges in a safe place to dry.

5 WPBD Check-in (10 minutes)
Redesign and Build (50 minutes)
• Before students return to building, remind them of the design requirements and contest rules. Also be
sure that they have one place on bridge where loading assembly can fit—have it available for kids to
test as they build their bridges.
• Have students connect the bridge sides and complete their bridges. Remind students to record notes
and dimensions to help them remember for their final designs.
• As they build, ask:
  - Are compression members appropriately braced out-of-plane? Test by taking similar length and
    compressing with your hands. Approximately how much force did it take before the piece buckled?
    Will that be enough? How long is the unbraced length of your top chord?
  - Are your connections strong enough? How might you reinforce the connections?
  - How does the weight of your bridge compare to other teams? Where might you be able to shave
    some weight from the design?
  - Have other teams come up with any clever ideas? Might you be able to incorporate them into
    your design?
  - How many as-built changes have you made to your original fabrication drawings? Go back and
    revise your drawings to represent the as-built condition.
  - Will the loading assembly place any stress concentrations on your design? How might you
    locally reinforce your design to support the loading assembly?

Wrap-Up (10 minutes)
• Set aside bridges in a safe place to dry.
• Explain that teams will test their bridges at the next meeting.

WPBD Check-in (10 minutes)
Meeting 4 (1 hour, 10 min-1 hour, 30 min)

Test (50 minutes)
• Bring everyone together to watch each team test their bridge. Allow for about 5-10 minutes for each test.
• Select a team to go first. Have the students put on safety goggles.
• Begin by weighing the first team’s bridge on a postal scale or science balance scale. Record the weight on a blackboard or poster for all to see. (Assign a Mentor to assist as scorekeeper.)
• Then have one team member monitor the bridge while the other adds sand bags to the bucket.
• As the sand is loaded, direct students to observe the bridge:
  - Can you see members/connections in danger of failing?
  - Do any members appear to be buckling?
  - Which member/connection do you think will fail first?
  - Can you predict how much load the bridge will take? Will it hold the entire amount?
  - Is the load swaying? What happens if it sways too much? Is that a load event that you considered during design?
  - What would you do to reinforce any failing conditions?

Model testing is most fun when there are failures, which provide rich opportunities for teaching principles. Be supportive of students whose bridges fail—remind them that failure is part of the engineering process, and they can apply the lessons they learn to the next design.

Testing Rules
• All bridges must be submitted prior to the onset of testing.
• Each bridge will be evaluated to determine if they meet the design requirements. (If not, see if students can modify their bridges to meet the requirements, rather than disqualifying them.)
• The event supervisors will provide all equipment/materials for testing.
• All students must wear safety goggles during loading and testing.
• The bridge will be centered on the testing frame, containing the 12 in. opening between the two tables.
• The loading block will be placed at the load point of the bridge. The eyebolt will be pushed up through the bridge and loading block from below and secured with a wing nut and washer on top of the loading block. A standard 5-gallon plastic bucket will be suspended from the eyebolt.
• The students will add sand to the bucket until failure occurs or the maximum load of 25 kilograms is reached. Both students will be allowed to test. One may add the sand bags while the other student steadies the bucket. Hint: There is no advantage to build a bridge that will hold more than 25 kilograms.
• Students have a time limit of 10 minutes to add the sand.
• The bridge must support a 5 kilogram load for a minimum of 5 seconds to qualify for scoring.
• The load used for scoring will be the weight of the bucket and sand only.
• Scoring: The winner will be determined by the largest load/mass ratio with 25 kilograms as the maximum load.
Howe Truss Design

1 5/16"  3 1/2"  2 1/2"

4 15/16"
2 Share Results (10 minutes)
   • Discuss the testing results. Ask:
     - Which shapes/structures seem to be the strongest while using the least material?
     - How did what you learned about trusses and triangles help you when you designed your bridge?
     - Based on the testing results, how would you improve your design next time?
     - Do you think a strength test is a good way to test our bridge designs?
     - What did you learn about engineering from this challenge?

3 Wrap-Up (10-30 minutes)
   • Award prizes and congratulate all teams for a job well done.

Extension Ideas:

• Take part in larger competitions. Identify balsa wood bridge competitions run by local universities, colleges, or ASCE branches, and encourage students to enter.
• Design and build a simplified model of the Waddell A-Truss using manila file folders. For a zipped PowerPoint presentation that includes an introduction to truss bridges, basic concepts of structural engineering, structural analysis using the Method of Joints, and step-by-step procedures for designing and building a model of the Waddell A-Truss, go to: [http://bridgecontest.usma.edu/ffb.htm](http://bridgecontest.usma.edu/ffb.htm)
• Build a bigger bridge. Use real wood, cotter pins, and twine to build a six-foot bridge that students can walk across. Use the West Point Bridge Designer software as a design tool to come up with a bridge shape; then build and test it.
• Visit a local iron workers union to learn how iron workers fit up bolted connections. How do they use a torque wrench to guarantee that bolts are adequately tightened. Get a demonstration from a certified welder. What do they do to make sure their welds are quality?
• Visit steel fabricator/detailer. Observe actual truss connections. How do professionals make connections stronger?
Your Challenge: Design and build the lightest bridge capable of supporting a given load over a given span.

Brainstorm and Design

Look at your materials and think about how you might use them to meet the challenge. Sketch out your ideas as you go.

- How can you use these materials to build a bridge that is light and strong?
- Keep in mind the design requirements:
  - Materials: The bridge can be constructed only from balsa wood and glue gun glue. You may NOT coat the wood in glue.
  - Span: The bridge must span a 12 in. opening. No maximum length.
  - Width: The bridge must be at least 3 in. wide (outside to outside). No maximum width.
  - No portion of the bridge may extend more than ½ in. below the top surface of the test supports.
  - Load Point: The load point will be at the center of the bridge. The bridge must accommodate a loading assembly made from a 2 in.
  - long x 3 in. wide x ¾ in. thick loading block, ¼ in. eyebolt, washer, and wing nut.

Build and Test

1. Sketch your design on grid paper.
2. Lay out your wood on the drawing. Use scissors or your fingers to cut members to size.
3. Glue your members together. How can you make strong connections between members?
4. Test your bridge. How much weight does it support before failure? What would you do differently to improve your bridge?

Connecting to the World

Health check for bridges!

In 2009, ASCE gave the overall quality of America’s bridges a grade of “C.” To raise that grade, ongoing monitoring and repair is needed. Most bridges are evaluated by visual inspection every two years. What about the other 729 days? Civil engineer Simone Laflamme is developing a technique to continually monitor bridges using a high-tech “sensing skin”—flexible patches with electronic properties that constantly check for cracks. Sensing skin patches are glued to areas prone to cracking (like the underside of a bridge). When a crack occurs, a tiny movement in the concrete under the patch is detected and the exact location is relayed to a computer.

www.gizmag.com/sensing-skin-detects-concrete-cracks/19105/

Materials:

- 10 pieces of balsa wood (1/8 in. x 1/8 in. x 36 in.)
- 1 flat piece of balsa wood (1/16 in. x 1/2 in. x 12 in.)
- 4 ounce bottles of Elmer’s glue
- scissors
- pencil
- ruler
- 2 sheets of 11 in. x 17 in. grid paper
- 1 sheet of 11 in. x 17 in. stiff paper (construction, manila, cardboard)
- safety goggles

Wear safety goggles when testing your bridge!

At MIT, researchers tested the ‘sensing skin’ by attaching it to the underside of a concrete beam.

(Photo: Simon LaFlamme)
Truss Bridge Designs

Lap Joints
End Joint
Nocht Joint
Double Gusset Joint
Gusset Joint

Connections
Lap Joints
End Joint
Nocht Joint
Gusset Joint
Double Gusset Joint
Appendix

Introduction

1. Text for Introductory Email
2. Text for Sample Proposal
3. Image of the recruitment poster
4. Image of the Student Membership card
5. Image of the Certificate
6. Let’s Talk handout
7. Logo and Legal Guidelines
8. Credits

Bridges Module

Civil Engineering Club - Sample Introductory Email Text

Dear [SAMPLE High School ADMINISTRATOR/TEACHER]

I am writing to tell you about an exciting after school club program that will support students at [SAMPLE High School] and provide engaging experiences for students interested in science, technology, engineering and math. The program is called Civil Engineering Club.

As a member of the [local SECTION/BRANCH of the American Society of Civil Engineers (ASCE)], I am working with a group of engineer volunteers who are active in educational outreach and eager to share their enthusiasm for civil engineering with high school students. Recently, our parent society, ASCE, developed a Club program that members could use as a resource for outreach in their local communities. The Club program is designed to work within the construct of a high school’s existing club environment, making it a flexible program to introduce.

I would be interested in learning more about students at [SAMPLE High] and talking with you about the possibility of developing a partnership with your school to initiate a Club.

Would it be possible to arrange a convenient time to meet? Attached is a Club proposal that will more thoroughly explain the Club concept. Should you be interested in pursuing the idea further, we will be able to address the unique needs of your students and faculty more completely and develop a more formal proposal. Thank you for your consideration. I look forward to hearing from you.

Sincerely,

[YOUR NAME]
[CONTACT INFORMATION]
Civil Engineering Club - Sample Club Proposal

Civil Engineering Club for [SAMPLE high school]

[DATE]

Sponsors: American Society of Civil Engineers (ASCE)
[SECTION/BRANCH NAME]

Contact Information:
[YOUR NAME, PROFESSIONAL AFFILIATION, ADDRESS, PHONE NUMBER, EMAIL]

Summary: Civil Engineering Club – sponsored by ASCE is a high school outreach program of the American Society of Civil Engineers. ASCE has an active Pre-College Outreach program and an enthusiastic pool of volunteer engineers who carry out the educational outreach work of the society. ASCE is committed to increasing awareness, understanding and interest in civil engineering among students in grades pre-K – 12 to help establish a large, diverse population of future engineers and a more technologically literate population.

Program Description: ASCE Civil Engineering Clubs are a great way for students to get to know civil engineering in a way that’s up close and personal.

In small-group gatherings, students participate in activities that inspire them to explore the field of engineering, including engineering design projects, field trips to engineering agencies and sites, guest speakers, community service projects, and opportunities to connect with professional engineers and college engineering students.

Through the leadership and participation of practicing civil engineers and civil engineering students, the Civil Engineering Club will bring [SAMPLE High School] students in direct contact with tested engineering design projects and activities. In addition, students will have the opportunity to interact with engineers and students to talk about careers, career preparation, and real-world experiences that demonstrate how civil engineering involves creativity, designing things that matter and making a difference.

Club Organization: Although backed by ASCE and sponsored by [LOCAL SECTION /BRANCH], the Civil Engineering Club will function within the framework of your school’s extracurricular club construct in cooperation with a faculty advisor. The Club concept is designed to be a year-long program with regular students meetings. The club is robust enough to be held on a weekly basis but flexible enough to adapt to the unique needs of your students and faculty. During the course of the year, students may help select civil engineering topic modules that interest them most, and will work with engineers and their faculty advisor to schedule trips, speakers and outreach projects.

Benefits: The benefits of the Civil Engineering Club are many. In addition to student exposure to real-life engineering, the club comes with the added benefit of engineer volunteers who are supported by ASCE’s national headquarters, and connected to a vast array of professional resources relating to engineering in our local community. The Club model relies on a team approach, giving depth and breadth to the adult presence associated with the club and lending stability to the continuum of club activities.

Founded in 1852, the American Society of Civil Engineers (ASCE) represents more than 140,000 members of the civil engineering profession worldwide and is America’s oldest national engineering society.
Recruitment poster

See what Civil Engineering is all about!

Student ID card

STUDENT MEMBER
Civil Engineering Club

NAME: ________________________________

CLUB MEMBER SINCE: ________________________________

SUPPORTED BY:

asce.org/nextgeneration
Certificate

This is to certify that

(name)

is a member of the Civil Engineering Club sponsored by the American Society of Civil Engineers (ASCE).

(name of school)

(school year)
What Is a Civil Engineer?

Civil engineers are changing the world all the time. They are professionals who dream up creative, practical solutions and work with teams of smart, inspiring people to invent, design, and create things that matter. They are team players with independent minds who ask, “How can we develop a better recycling system to protect the environment, design a school that can withstand an earthquake, or ensure our community water supply is safe?”

Who makes a good civil engineer?

There is no one “type” of person who becomes an engineer. Civil engineers . . .

• are creative
• like collaborating with others
• are curious and persistent
• want to make a difference
• like solving problems or improving processes

Ten Reasons to Love Civil Engineering

1. Love your work, AND live your life too!
   Engineering is an exciting profession, but one of its greatest advantages is that it will leave you time for all the other things in your life that you love!

2. Be creative
   Engineering is a great outlet for the imagination—the perfect field for independent thinkers.

3. Work with great people
   Engineering takes teamwork, and you’ll work with all kinds of people inside and outside the field.

4. Solve problems that matter
   Come up with solutions no one else has thought of. Make your mark on the world.

5. Never be bored
   Creative problem solving will take you into uncharted territory, and the ideas of your colleagues will expose you to different ways of thinking.

6. Make a big salary
   Engineers not only earn lots of respect, but they’re highly paid. Even the starting salary for an entry-level job is impressive!

7. Enjoy job flexibility
   An engineering degree offers you lots of freedom in finding your dream job. It can be a launching pad for jobs in business, design, medicine, law, and government.

8. Travel
   Field work is a big part of engineering. You may end up designing a skyscraper in London or developing safe drinking-water systems in Asia. Or you may stay closer to home, working with a nearby high-tech company or hospital.

9. Make a difference
   Everywhere you look, you’ll see examples of engineering having a positive impact on everyday life.

10. Change the world
    In very real and concrete ways, engineers save lives, prevent disease, reduce poverty, and protect our planet.

*Used with permission from Engineer Your Life.
Civil Engineering CLUB

Logo and Legal Guidelines

Logos
You may photocopy these logos and use them on handouts, newsletters, etc. for Civil Engineering Club™ purposes only. Please follow the legal guidelines on the next page when using these logos.

Legal Guidelines
In addition to the posters, handouts, certificates and membership cards available through the American Society of Civil Engineers (ASCE), you may want to create some of your own printed materials to advertise and enhance your Civil Engineering Club. Please read and follow the legal guidelines below for all printed materials (brochures, fliers, handouts, etc) that you produce.

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