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Susanne Peckham susanne@techdirections.com



The *New York Times* editorial board recently addressed the need to draw more students to the science, technology, engineering, and mathematics (STEM) fields in an editorial titled “Who Says Math Has to Be Boring?” They note that the results of a recent survey of more than a million high school students indicate that nearly 90 percent show no interest in pursuing a career or further education in STEM. This, in their view, is because “the American system of teaching these subjects is broken.”

Those students who do pursue STEM fields in college “often come from families where encouragement and enrichment are fundamental.” But the system alienates and leaves behind “millions of other students, almost all of whom could benefit from real-world problem solving rather than traditional drills.” Finding ways to make STEM exciting for students who are in “the middle of the pack” could profoundly affect their futures, giving them the skills needed for good technical careers.

The editorial offers a few ideas for improvement:

- **A more flexible curriculum**—American students need better STEM skills (they rank 30th among 65 nations in math), but few need to be trained to be mathematicians or scientists. All need the fundamentals of problem solving, including algebra and geometry, but they should have greater choice between applied skills and more typical abstract courses. They should be exposed to a variety of the career-related skills needed now and in the future, which would be helped by an increase in CTE and technology education. The writers note that “the right mix of career and technical education can reduce dropout rates.” The Common Core standards now being adopted have value,

but they need “more flexibility to ensure that they do not stand in the way of non-traditional but effective ways to learn, including career-related study.”

- **Early exposure to numbers**—One in five American adults lack the basic math skills expected of 8th graders, which makes them unfit for many newly created jobs. Math education should be started at the preschool level.

- **Better teacher preparation**—All teachers should be certified in the fields they teach. The writers applaud the national campaign to add 100,000 certified STEM teachers by 2021.

- **Experience in the real world**—The editorial refers positively to “the growing number of schools helping students embrace STEM courses by linking them to potential employers and careers.” It cites P-Tech in Brooklyn, NY, which works with IBM to prepare manufacturing technicians and software specialists, and Seattle’s Raisbeck Aviation High School, which works with Boeing to mentor students in engineering and robotics.

The editorial closes with the comment that getting students excited about STEM is “the first step to improving their performance and helping them discover a career.”

*Susanne Peckham*

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## STEM

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**About the cover:** Students at the STEAM Academy at Space Coast Junior Senior High School in Cocoa, FL, use a production line to assemble and package picture frame products. Photo by Corban Young, Knight's Armament Co. Cover design by Sharon K. Miller.

**Susanne Peckham**

susanne@techdirections.com

## ACTE National Policy Seminar

The Association for Career and Technical Education (ACTE) calls on CTE educators to attend its annual National Policy Seminar (NPS), to be held this year March 3-5 just outside Washington, DC, in Arlington, VA. ACTE states, "Now, more than ever, your participation is critical at NPS. Important discussions have been launched to reauthorize the Perkins Act and shape the future of CTE. We need your voice to be heard in these important conversations!"

This year's NPS will feature:

- The latest information from Capitol Hill staff and members of Congress on the reauthorization of Perkins, as well as ongoing reauthorizations of the Elementary and Secondary Education Act, Higher Education Act and Workforce Investment Act.
- Updates on federal funding for Perkins and other key programs, with details on how educators can best influence the funding process.
- Opportunities to weigh in on the critical policy issues affecting CTE educators and their programs.
- Advocacy tips and tools educators can use to promote programs at local, state, and federal levels.

The NPS is open to both members and non-members of ACTE. For more information, go to [www.acteonline.org/nps](http://www.acteonline.org/nps).

## National Engineers Week

February 16-22 is National Engineers Week. Its goal is to call attention to the contributions to society that engineers make. It's also a time for engineers to emphasize the importance of learning math, science, and technical skills.

The celebration of National Engineers Week was started in 1951 by the National Society of Professional Engineers in conjunction with George

Washington's birthday. (Washington is viewed as the nation's first engineer, notably for his survey work.) Engineer's Week is now observed by more than 70 engineering, education, and cultural societies, and more than



50 corporations and government agencies. It is organized by the Discover E foundation, whose corporate members include Shell, Exxon Mobil, Bectel, IBM, and Raytheon.

The week is a time to:

- Celebrate how engineers make a difference in our world.
- Increase public dialogue about the need for engineers.
- Bring engineering to life for students, educators, and parents.

According to the Discover E foundation, "We help unite, mobilize, and support the engineering and technology volunteer communities. Why? They will increase their collaborative footprint in K-12 education and celebrate ... the value of engineering education and careers."

For more information on National Engineers Week, the Discover E foundation, and resources Discover E offers, visit [www.discovere.org](http://www.discovere.org).

## Call for Subject Matter Specialists

NOCTI is seeking representatives from education and industry to participate in its 2014 assessment revision/development projects. NOCTI is a provider of technical competency assessment products and services for secondary and postsecondary education.

Led by a NOCTI facilitator, teams evaluate existing standards, assessment content, and job duties to ensure that revised and new as-

sessments measure competency at the industry-standard level. Teams are made up of both secondary and postsecondary educators and industry representatives. Familiarity with NOCTI is not a requirement.

Reviewers responsibilities are to:

- Review existing national, industry, and state standards to determine critical content.
- Revise and/or rewrite tasks and competencies.
- Review tasks affiliated with each duty and assign weight by importance.
- Review/revise multiple choice items.
- Develop performance jobs according to tasks/competencies.
- Develop performance evaluation criteria.

Development and revision projects are typically conducted in an online Web-based format and are scheduled in the evening to minimize conflicts with team members' daytime work schedules. Subject matter specialist candidates must have a minimum of three years current experience in their field.

Reviews will be conducted February 17-21 in electronics technology, March 24-28 in building construction occupations, May 12-16 in small engine technology, and June 9-3 in web design. For more information, go to [www.nocti.org](http://www.nocti.org).

## Calendar

**Feb. 19-22.** Florida Technology Student Association Conference. Orlando. [www.Floridatsa.com](http://www.Floridatsa.com).

**Mar. 5-7.** New York State Technology and Engineering Educators Association Annual Conference. Hudson Valley Community College, Malta, NY. <http://nysteea.org>

**Mar. 26-28.** American Technical Education Association National Conference. Minneapolis, MN. [www.ateaonline.org](http://www.ateaonline.org).

**Mar. 27-29.** International Technology and Engineering Educators Association Annual Conference. Orlando, FL. [www.iteea.org/Conference/conferenceguide/htm](http://www.iteea.org/Conference/conferenceguide/htm)

*Susanne Peckham is managing editor of Tech Directions.*



Alan Pierce

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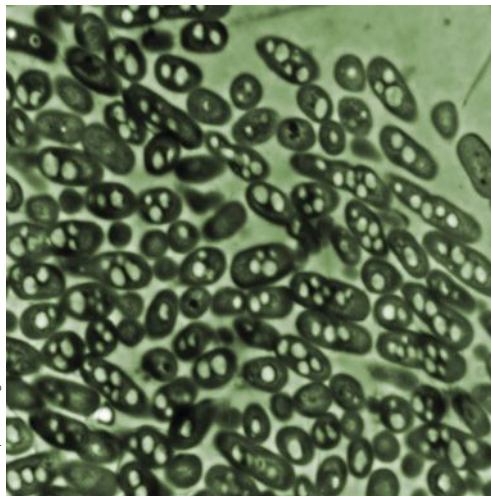
## Teaching a Bacterium to Fight Global Warming

There is no doubt that our economy is still very dependent on fossil fuels. Our continuing to burn them releases megatons of unnecessary greenhouse gases into our atmosphere. Scientists have pegged carbon dioxide (CO<sub>2</sub>) as the most troublesome greenhouse gas because of how long it will remain in our atmosphere. Atmospheric carbon dioxide is now at the highest level ever recorded. The CO<sub>2</sub> and other greenhouse gases in our atmosphere decrease the amount of heat that normally would escape our planet into space.

It is important to note that part of what makes us a Goldilocks planet is that our natural world has provided our atmosphere with just the right amount of water vapor and greenhouse gases, including CO<sub>2</sub>, to trap the right amount of solar energy. The heat that is naturally trapped is needed to keep most of our water liquid and provide the temperatures needed by the different living organisms to flourish. The problem is that our use of fossil fuels is pushing more greenhouse gases into our atmosphere and this is creating a heating blanket that is pushing temperatures globally to record highs. Scientists list many calamities that will occur if our planet really overheats—for example, mass extinctions.

Researchers at MIT might have a solution to our CO<sub>2</sub> problem. They have genetically altered a soil bacterium (see photo) so that it can eat

CO<sub>2</sub> and digest it into an isobutanol fuel. This fuel is a perfect substitute for gasoline and it could be used instead of gas in cars without any engine modifications.



Christopher Brigham

**These genetically modified bacteria eat carbon dioxide and produce a fuel that is the perfect substitute for gasoline.**

The *Ralstonia Eutropha* bacterium that MIT researchers are working with naturally converts what it eats into carbon compounds. In nature, this bacterium eats the nitrates and phosphates that are found in soil and stores what it doesn't need, for normal biological functions, as an organic polymer with properties similar to petroleum.

The MIT scientists genetically added one gene to this organism from another species and switched off some of its own genes to create a bacterium that eats CO<sub>2</sub> and poops fuel. Since it actually excretes the fuel, the bacterium doesn't need to be killed for the fuel to be harvested. Researchers are now working on building a bioreactor that can safely house the bacterium, feed it CO<sub>2</sub>, and then draw off the fuel in an ongoing manufacturing process.

Time will tell if engineers can build bioreactors that can safely hold the bacteria and feed it CO<sub>2</sub> from the smokestacks at a fossil fuel power station. If such a bioreactor can be built, we could continue to be a fossil fuel-dependent society for the foreseeable future.

The possibility exists that if these bioreactors prove viable they will become smaller and more efficient over time. Perhaps one day the ultimate Tribid car would run on electricity, have a gas engine for recharging, and also have a biological catalytic converter to convert its tailpipe gases back into more fuel to further increase its range.

For now, the MIT research team has been concentrating on developing a bacterium that can eat CO<sub>2</sub>. They indicate that the same approach could be used to develop bacteria that can digest any organic compound and turn it into a fuel.

## Recalling the Facts

1. How does this bioengineered bacterium differ from its relatives that still live in the soil of our planet?
2. Internet research: Besides mass animal extinctions, what are some of the other disasters scientists indicate will happen to our planet if global warming isn't brought under control? @

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Alan Pierce, Ed.D., CSIT, is a technology education consultant. Visit [www.technologytoday.us](http://www.technologytoday.us) for past columns and teacher resources.

**Dennis Karwatka**

dkarwatka@moreheadstate.edu

## Arthur Collins—Radio Communication Pioneer

In 1925, the U.S. Navy could not maintain radio contact with an Arctic expedition.

A teenager in Iowa used his homemade radio to get through to the people on the expedition and telegraphed messages to and from Washington, DC. It was an improbable but true story that starred Arthur Collins. He went on to establish the Collins Radio Company in 1931.

Collins was born in Oklahoma in 1909, but his family moved to Cedar Rapids, IA, when he was young. His father had an idea about coordinating farming methods to

improve agricultural production. It was a successful venture and Col-

lins was raised in a well-to-do family environment.

He became interested in radio communication when he was nine. His father had hoped Collins would take over the family business and did not approve of this emerging technology. Collins later said his first radio receiver used a tuning coil wrapped around an oatmeal box, pieces of coal for rectifiers, and glass towel racks

for insulators. He calibrated his equipment using Morse code signals from the U.S. Navy in Arlington, VA.

Collins passed his Federal Communications Commission test at 14 and became licensed to operate transmitters. At this point, his father relented and supported his son by purchasing some commercial equipment aimed at hobbyists. Collins was soon communicating with people in such faraway places as Australia and England.

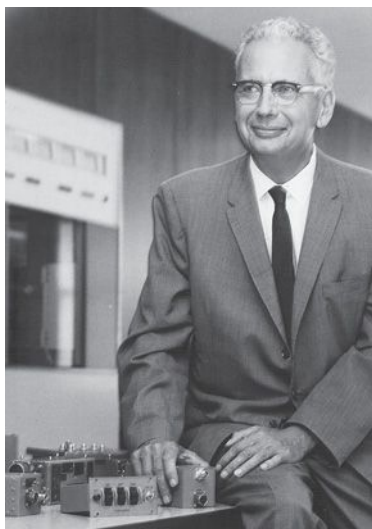
In early 1925, Navy Lieutenant Richard Byrd (later an Admiral) and others headed out from Maine toward the Arctic Circle with the Macmillan Expedition. Atmospheric conditions prevented them from consistently sending to and receiving messages from their home station in Washington, DC. Throughout the summer of 1925, Collins used a radio he built to communicate with the expedition party using Morse code. He became a nationwide sensation. The experience gave Collins recognition

he later used to establish his radio equipment company in Cedar Rapids.

Collins attended several different colleges but never graduated. He constructed radio equipment in his basement and formed a company in 1931. He incorporated it two years later with borrowed money and hired eight employees. His early units were aimed at hobbyists, government agencies, and smaller radio broadcasting stations.

But he was also designing a radio specifically for Navy use. Most transmitters at the time were constructed on open breadboards. Collins' 150 Series Transmitter was a powerful, fully enclosed, rack-mounted unit that had instant appeal to all who saw it. Rated at 150 W of transmitting power, the radio sold for \$290. The Navy successfully used two of them on its second Arctic Expedition in 1934. Collins married Margaret Van Dyke at about that time. He remarried following her death in 1955. He had a total of four children.

The Collins Radio Company re-



**Arthur Collins**



**Collins' earliest transmitter, the 4A, was aimed at hobbyists.**



Images courtesy Rockwell Collins Corp.

## Transmitter used in 1934 Arctic Expedition

maintained in production during the Great Depression with about 200 employees. They manufactured 30 models of transmitters, receivers, and other support items. With America's entry into World War II in

*Dennis Karwatka is professor emeritus, Department of Applied Engineering and Technology, Morehead (KY) State University.*



1941, employment at the company eventually soared to over 4,000. The company built 22 different models of electronic equipment for military use.


After the war ended in 1945, Collins became a leader in designing and manufacturing electronic equipment for airplanes and spacecraft. The company built guidance systems that allowed hands-off aircraft landing during poor visibility conditions.

Collins was a licensed pilot and a well-respected head of a large company who met with United States presidents. He held or shared more than two dozen patents for inventions such as multi-channel, automatically tuned radio transmitters and receivers. Still, he was an uncommonly shy person.

His company manufactured voice communication equipment used on the 1969 Apollo mission that landed Americans on the moon. Journalist



**Collins (right) signing legislation in 1962 with President Lyndon Johnson**

Walter Cronkite invited him to explain his company's part in the project on a CBS television broadcast. He politely turned down the invitation. Collins died in 1987. 

#### References

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 Kueter, Dale. (1987, February 26). Collins legacy lives on. *The Cedar Rapids Gazette*.  
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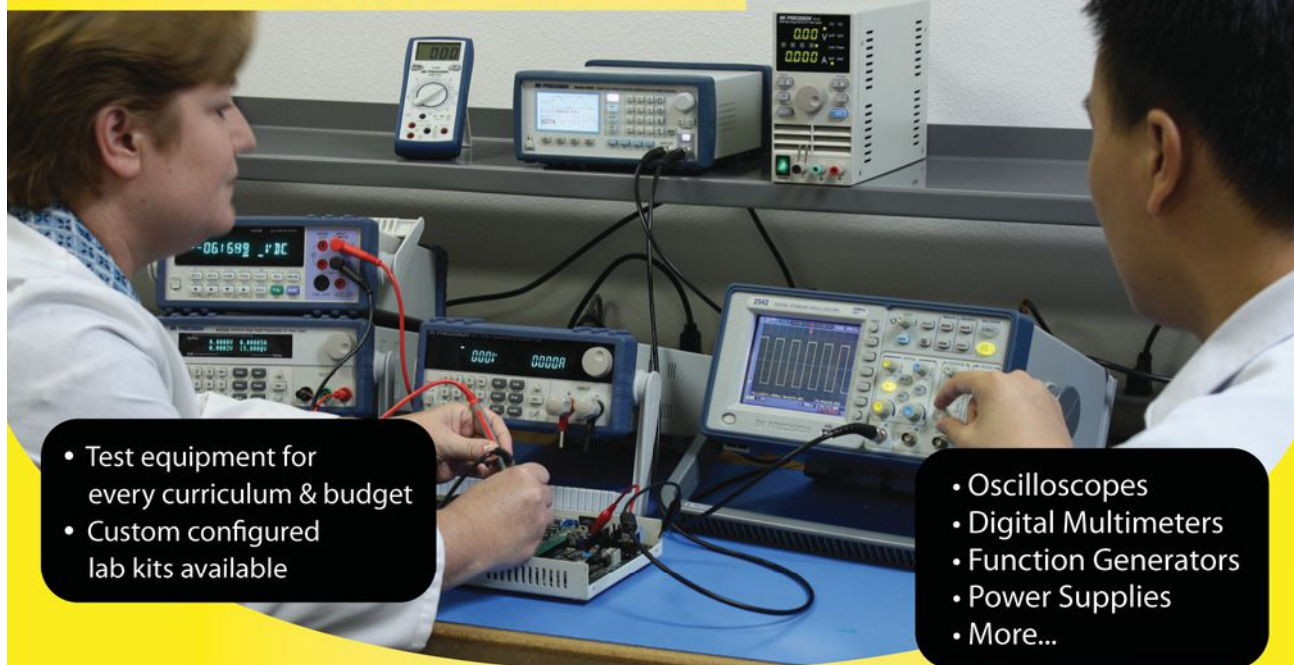


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## Reading User Reviews Critically

One of the best qualities of the Internet, and one of the worst, is the evaluations of products and services you can read on it. It's a concern for educators and students alike.

In the past, to make an informed buying decision you could check with the Better Business Bureau; read *Consumer Reports'* articles and surveys, as well as reviews in professional or trade publications and newspapers; ask around among colleagues, friends, and family; rely on your own previous experience; and use the information from ads.

Today, you can still do these things. But you can also read on the Internet about the experiences and impressions of other consumers. Still, you have to be careful.

Critical thinking is a skill that has been taught in educational institutions since the time of Socrates in ancient Greece. Trying to determine the validity of information today, especially information available over the Internet, is more important than ever.

It's as easy for a user of a product or service to put up a legitimate review on the Web as it is for the company behind that product, or the public relations company it has hired, to put up a fake review extolling it or condemning a competitor's product.

A lot of people get snowed by fake reviews. Not long ago I almost got snowed myself by fake reviews of an apartment complex, which I was able to conclude were planted only after careful scrutiny. The planted reviews nearly stopped me from moving in. A later discussion with the apartment house's manager revealed that a nearby apartment complex was likely planting these scathing reviews, and that the apartment complex I moved into was likely doing the same with the other complex.

Fortunately, large sites such as Amazon.com ([www.amazon.com](http://www.amazon.com)), Yelp ([www.yelp.com](http://www.yelp.com)), and Angie's List ([www.angieslist.com](http://www.angieslist.com)) do a good job of weeding out the most blatant of these planted reviews and of making more prominent the reviews that can be trusted, those that others find most useful.

Still, fake reviews do make it through, and based on anecdotal evi-

**You can help with the online review process yourself by writing informative, comparative reviews that describe benefits in easy-to-understand language.**

dence and on the attention this issue gets in the media and in academia, the problem of fake reviews remains serious.

Here are some ways to make the best use of the reviews posted on the Internet:

- Discount reviews that are gushingly positive. Be wary also of stellar reviews that include only a minor negative or a minor feature that's missing. These could be legit, or they could be planted by a clever paid reviewer.

- Likewise, discount reviews that are scathingly negative. Some reviews like this are so over the top that you could only conclude they were planted by a competitor or were otherwise written by someone with an agenda.

- Lean toward products or services that have received a lot of reviews. Conversely, be more careful with products that have only one or two reviews.

- Ignore reviews that describe the reviewer in too much detail. This could be a tip-off that a public relations firm is trying to target the demographic group represented by the reviewer's self-description.

- Discount reviews that are merely a list of features. The best reviews, whether written by an ordinary user or a professional, indicate the benefits you can derive from using the product. Consider those core features you'll actually use rather than fancy features you probably won't.

- Similarly, pay more attention to reviews that compare the product or service to similar ones. The best reviews put a product or service into context rather than just talking about it as if in a vacuum. Comparative reviews also indicate that the reviewer likely has more experience with the area and can be more relied upon.

- Don't be swayed by reviews that include a lot of impressive-sounding jargon. This may indicate the reviewer is just trying to impress others, though depending on the product or service, some jargon may be necessary for a full evaluation.

- Look for commonalities. If a number of reviewers offer the same opinion about a quality of a particular product, this gives the opinion more validity.

- Ignore reviews that sound too much like other reviews of the same product. This could indicate that they were written by the same person.

You can help with the online review process yourself by writing informative, comparative reviews that describe benefits in easy-to-understand language. You can also participate in whatever system the particular website uses to rank or legitimize the reviews of others, such as "Helpful" votes with Amazon.com. ®

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*Reid Goldsborough is a syndicated columnist and author of the book *Straight Talk About the Information Superhighway*.*

# Project-Based Learning + Real-World Manufacturing + Industrial Partnerships = Powerful STEM Education

By Stephen M. Portz  
Sportz.einsteinfellow@gmail.com

**S**TUDENTS enrolled in the STEAM Academy at Space Coast Junior Senior High School (SCHS) in Cocoa, FL, had an opportunity to participate with a local industry partner in a compelling, real-world manufacturing learning activity. The project involved having students design, prototype, create molding for, and mass produce a school spirit item following the process a real-world company would use. It grew out of the realization that students crave activities that are meaningful and exciting, and that they can associate with career fields of interest to them.

Our business partner wanted to join the effort because it would fill the talent pipeline with students who have a straight-from-education, out-of-the box awareness of manufacturing skills and processes. As all these elements converged, the project developed into an authentic, real-world manufacturing experience with a powerful impact on student learning.

The engineering career academy was created in 2007 as a small learning community with an emphasis in science, technology, engineering, aerospace, and manufacturing, hence the acronym “STEAM.” As its name would imply, SCHS is close to the

Kennedy Space Center and the aerospace and manufacturing industries prevalent in the northern section of Brevard County. From the beginning, the STEAM Advisory Board has included many key industry leaders who have generously given time, equipment, and money to support the academy’s objectives. Earlier, the barriers between education and industry made it challenging to fully implement authentic industrial processes at the high school level.

## A Dedicated Industry Partner

It was surprising to me to discover that many of the barriers to true education-industry partnerships have more to do with the inflexibilities in education than with corporate rules and regulations. In education, there are constant challenges with curriculum, standards, and time constraints, which, depending on their interpretation, can discourage in-depth, project-based learning.

Having the notion that forging a valuable collaboration with an industry partner would justify all the additional effort, the staff at SCHS persevered. Fortunately, many challenges were mitigated by finding a business partner with a lot of patience, along with a tenacious desire to make a difference in the lives of young people.

And the company holds a belief worthy of emulation—that if industry wants to grow talent, it has a responsibility to support the effort.

Knight’s Armament Co. was the perfect industry partner for us. As an armament provider for military and



A STEAM Academy-produced picture frame with a photo of students in zero G at Kennedy Space Center

law enforcement, Knight’s maintains a state-of-the-art, 400,000-square-foot manufacturing facility in Titusville, FL. Perceiving a void in the manufacturing talent stream, they took up the challenge of partnering with the STEAM Academy.

## The Project

With the help of a Motorola STEM Grant, a Brevard Schools Foundation Grant, and donations of expertise, equipment, and supplies from Knight’s Armament and many of their supporting vendors, the idea to create a true manufacturing activity for our students began to take shape. ►

---

*Stephen M. Portz is an Albert Einstein Distinguished Educator Fellow who is placed with the National Science Foundation. Before this appointment, he taught engineering and technology at Brevard Public Schools in Florida for 25 years.*





**Sylvain Roberge gives students an overview of the injection molding process.**

The basic grant objective was to use a project-based learning approach to simulate a manufacturing activity. Students would design, prototype, make, market, and sell a school spirit item that could double as a fundraiser for the academy and assist with its sustainability measures. Through this project, students would become very familiar with the entire process of product development, seeing their idea go from a concept to production.

Good instructors try to anticipate and provide for the challenges that a project will encounter, but in this case, there was no way to envision the scope and synergy that ultimately emerged as this project evolved. For example, since our lab had computers with SolidWorks 3D modeling software, a rapid prototyping machine, milling equipment, and an injection molding press, my thoughts were that the students would come up with an idea for a small project, like a school keychain or something of that nature. In the process, they would generate a variety of design ideas, decide on a favorite, prototype it with the 3D printer, do some market analysis, use the milling equipment to create a mold out of aluminum block, and then injection mold the part to produce it.

Giving imaginative, youthful talent an opportunity to take part in creating

“real things” is an extremely powerful activity, but when we started collaborating with industry experts, the “big kids” started getting excited about it too. The rush of ideas, possibilities, and enthusiasm were hard to contain. Since a major goal of the project was to create an opportunity for recurring fundraising, C. Reed Knight Jr., the owner of Knight's Armament, suggested creating a picture frame and the students agreed with him. The product went from an idea for a simple keychain, coarsely machined and molded one at a time in the school, to a commercially

marketable product, professionally tooled and mass produced in a state-of-the-art manufacturing facility.

## Bringing in the Experts

A former SCHS student, Josh Auriemma, now a graduate in Industrial Design from Georgia Tech, donated his time to come in and train the students on principles of product ideation. He walked them through the process of product modeling and refinement—using many of his own designs as examples. As an assignment, each student had to design and pitch his or her ideas about what the picture frame should look like to the class.

A critical aspect of manufactur-



**Completed frame assembly in SolidWorks**

Stephen Portz



Corban Young, Knight's Armament Co.

**STEAM students inspect picture frame tooling.**

ing is the concept of design for manufacturability. Often, if designers do not understand how a product can be made efficiently, they will require processes or designs with unnecessary and expensive features. To avoid these problems, Knight's assigned two employees, Sylvain Roberge and Richard Wade, who are expert toolmakers with experience in plastics injection molding, to work with the students.

After a student design was agreed on, Art Hoelke, Knight's vice president and general manager, taught students how to work up a product business plan. Students learned how to calculate equipment, labor, and materials costs. For example, after calculating the cost to create the initial molds, which is usually expensive (in this case, \$35,000), and the raw plastics materials (about 6¢

per frame), in addition to equipment and labor, students had to determine what the product would have to sell for and how many parts would have to be run before they would reach a breakeven point and start making a profit.

To provide students with a better understanding of manufacturing from start to finish, they were also invited to tour Knight's to see industrial injection molding taking place and learn industry specific concepts like draft angle, parting lines, back cuts, shrink factor, gates, runners, sprue holes, shot pressure, cooling systems, lead, and injection pins.

## Student Work and Learning Benefits

We talk much of the benefits of collaborative learning, and I personally have given my share of lip service to the concept without ever really letting it loose in my class the way I did for this project. As a result the experience, I have a much greater appreciation and respect for the abilities of my students than ever before. The project provided so many unique and serendipitous learning outcomes.

For example, students created and chose the "Viper Fang" picture frame idea because we are the Space Coast Vipers. They also wanted to give purchasers the option to display the frame in many different ways. As a result, the back of the frame has both horizontal and vertical sawtooth openings for hanging on the wall. Students also added horizontal and vertical grooves to accommodate a stand for desktop display. Yet another idea provided for magnets to be installed on each corner of the frame to allow for hanging it on a refrigerator or locker.

## Talking Tolerances

If students design something on a computer that they are not required to build from a project in a book, they get a very unrealistic perception of how things are made and put together. Without training, students commonly design parts with a zero tolerance: "this pin has a diameter of 0.375" so the hole for it is 0.375".

I have had many discussions with my students about tolerances, but until you have Student A design something that will fit in Student B's assembly, and the students share the files in a virtual model—or better yet build it—they really struggle to appreciate what you are talking about. This project greatly helped to reinforce the realities involved.

A good example of this arose when the back didn't fit in the frame—even though the students working on each part were sitting

right next to each other. They were obviously not sharing information about the project. This made for a great segue into a lesson on the challenges that contractors have when building parts to fit into assemblies from other companies across the country and around the world.

## Putting It All Together

The advanced STEAM Academy students, mostly members of the senior class, did most of the heavy lifting with respect to 3D modeling



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**STEAM students assemble flat patterns for packaging frames.**

design of the frame assembly. Since they had the most experience with SolidWorks, this was a logical staffing decision. Just as in industry, there is a skills strata that parallels a job description strata. So, to include the younger, less-experienced STEAM students beyond just taking a tour of a manufacturing facility, they were given the responsibility of assembling the frames and packaging them in boxes. Once again, Knight's employees lent a hand in teaching about bills of materials, packaging, quality control, and marketing.

## Observations

It would be easy to spin a project like this one with all of its benefits—its potential for STEM student learning impacts, a high profile in the community, and real industry tie-ins—as the perfect lesson plan, but the truth is a little more elusive than that. All lesson plans are improved as we refine them over time and evaluate the outcomes.

This project was very different though, because it contained industry perspectives as well as education-perspective observations.

The most obvious observation was how much time and effort was needed—from both industry and ed-

ucation participants—to execute the project. It really takes a dedicated team. The picture frame idea would probably never have made it to professional commercial production without the technical expertise of Richard Wade and the unfailing support of Art Hoelke. This speaks to the necessity of having great industry support, as it otherwise would have been impossible for high school students to participate in a project of this caliber.

Being a STEM/CTE educator has given me the confidence to believe that I understand many industrial processes, but there are many nuances in the manufacturing world that defy cursory understanding. Observing this, I think we need to provide more industrial exchange programs for teachers—per-



Corban Young, Knight's Armament Co.

**Space Coast student holding the finished frame product**

Coast STEM Council, in the hope that other schools in our district might find a way to inspire their students though the model that we forged.

By leveraging the resources of industrial advisory committees and business partners to create authentic projects that mirror what companies do, our students connect what they learn in school with real workplace relevance. Teachers benefit by having a way to integrate the STEM curriculum in a focused thematic manner. Industry gets a seat at the education table through investing the preparation of the future workforce. The convergence created by having teachers, students, and industry work together addresses many of the challenges we share in achieving successful STEM education. ©



Corban Young, Knight's Armament Co.

**Picture frame assembly and packaging**

haps by way of summer internships and fellowships with local companies that would help a teacher's industrial skills remain viable.



# Use YouTube to Promote Your Program—Here's How

By Mark S. Schwendau  
schwendau@aol.com

**T**HOSE of us teaching in the STEM (science, technology, engineering, and mathematics) education areas have known about the shortage of students entering our programs for years. Policymakers and the national media now also seem to be getting the message of too few graduates for too many jobs. Still, the editorials and the usual political posturing, while well intentioned, are not adequately filling the seats in our programs.

In my CAD technology program at Kishwaukee College in Malta, IL, we decided to look beyond the usual promotional methods that we had been using. I offer this article in hope that our experience will be helpful to other STEM educators.

## Getting Started

Our Advisory Committee analyzed the age group we serve and their responses to specific public relations efforts. We conducted focus group studies as well as marketing surveys and quickly found that newspaper advertisements did not work well for reaching the prospective students. Radio advertisements on local country radio stations had a somewhat better impact. But, social media video seemed to be where our nation's youth really are going!

We realized that we needed to quickly get educated in all phases of movie making: writing a script,

shooting a video, editing shots into scenes and a plot, and posting a promotional video for our CAD program to social media. Our initial research revealed that the phases were more formally called *pre-production*, *production*, *post-production*, and *delivery*. Our next step was to outline the important steps involved in each phase so that we could be organized to

meet our goal. A summary of details on activities and equipment we used in all phases appears in Table 1.

## Pre-Production

In our pre-production phase, we determined that the current average student in our CAD program was a 28-year-old white male of lower income status. We decided to go with

**Table 1—The Four Phases of Making and Posting a Video**

<b>Pre-Production</b>	<ul style="list-style-type: none"> <li>• Define audience in terms of age, gender, race, status</li> <li>• Approach—introductory, product, informative, or personal</li> <li>• Research YouTube, equipment, scripting, videography</li> <li>• Acquire camera, microphones, lighting, software</li> <li>• Scripting and storyboarding—prepare plot, scenes, video, audio</li> <li>• Scenes—determine indoors, interview, outdoors, action</li> </ul> <p>NOTE: Commit to using an HD camera.</p>
<b>Production</b>	<ul style="list-style-type: none"> <li>• Camera shots—Kodak Zi8® 720P at 60FPS, pan in WVGA</li> <li>• Lenses—AmeriMax Advance, LLC, wide angle and fisheye</li> <li>• Microphones—Audio-Technica wireless microphone</li> <li>• Lighting—Cowboy Studio 2275 W digital video Softbox light kit</li> <li>• Plan lighting and camera shots</li> <li>• Computer microphone—Logitech USB desktop microphone for recording narration voiceovers</li> </ul>
<b>Post-Production</b>	<ul style="list-style-type: none"> <li>• Understand fair use doctrine and obey copyrights laws</li> <li>• Download audio background music and sound effects</li> <li>• Upload videos to editing software timeline</li> <li>• Upload audios to editing software timeline</li> <li>• Create graphics—still images, text pages, captions, animated text and graphics, illustrations, and characters</li> <li>• Do multiple previews to check synchronization and timing</li> </ul>
<b>Delivery</b>	<ul style="list-style-type: none"> <li>• File Format—MPEG 4 (preferred standard of YouTube)</li> <li>• Aspect ratio—16:9 (HD screen size since 2009)</li> <li>• Pixels—640 × 480</li> <li>• Write description for video</li> <li>• Identify keyword tags for video</li> <li>• Synchronize—audio and video tracks on timeline</li> <li>• Length—keep promotional videos to a 3-minute target length; one minute of video equals about 100 Mb of data</li> </ul>

*Mark S. Schwendau is a technology instructor at Kishwaukee College, Malta, IL, and sits on Tech Directions Editorial and Peer Review Boards.*



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an introductory approach to our program with just enough information to serve as a teaser to get people to access the CAD program website. There, they can find all the information they need.

We asked some current students to serve as our video cast. We wanted them to speak about their own experiences with the CAD program in a testimonial format that would add a personal aspect to the video. In the interest of "truth in advertising," testimonials were not scripted or rehearsed. What the students said was later written into the final script after we got a shot that both student and instructor viewed as a good take.

We conducted many hours of research on YouTube, the social media outlet we opted to post to, before we began doing anything else. We also did extensive research on what equipment to use since, at the time, online videos were transitioning from SD (standard definition) to HD (high definition). We decided to film indoors because of the muffled sound we'd get from the wind if we recorded outdoors. We also decided to go with a minimum of action shots to cut down on the need to rehearse scene takes.

The single most difficult task was developing the script. We selected two-column scripting over storyboarding because of time constraints and a desire for control. Fig. 1 shows an example of our script.

We bought two, very good (though now obsolete—how quickly technology evolves!) cameras: Kodak Zi8 pocket HD digital (also referred to as "flip"-type cameras). We had wanted to do a two-camera shoot but this proved

difficult to synchronize in our editing software program, ArcSoft Media Impressions for Kodak cameras. We also made use of Tech-Smith's Camtasia open source Cam Studio screen recorder for recording a CAD session in progress without having to do an over-the-shoulder screen shot.

## Production

We worked very hard on getting camera shots with proper lighting. We learned a lot! One thing was that our particular model of camera did not like motion at 720P at 60FPS; shots were blurry and out of focus. We learned pan shots had to be made in WVGA (wide video graphics array). We also found that a wireless lapel microphone worked better than the camera microphone for producing high-quality audio (Photo 1).

## Post-Production

In the post-production phase, we concerned ourselves early on with copyright issues, knowing that YouTube pulls videos that violate copyrights. We made certain we held copyrights to the materials we used and got signed model releases from all student cast volunteers.

VIDEO		AUDIO or TEXT	
	SCENE 1		SCENE 1
1 CLOSE UP SHOT - Karen	0:03	SCRIPT	"I wonder what the best college is for CAD?"
Over the Shoulder screen shot of Google search of "CAD college".			
2 SCREEN RECORDER SHOT	0:03	NO SOUND	
Digital Screen Capture Google search			
3 SCREEN CAPTURE	0:05	VOICEOVER SCRIPT	"Oh Wow! Kishwaukee College is right in my backyard!"
Results of Google Search for CAD college. ( Still Slide Highlighted Showing Kish )		Music Fade in "Think Tank" By Jason Shaw	
4 GRAPHIC SLIDE	0:04	GRAPHIC CAPTION	"A Top Ranked College CAD Program"
Title Screen White on black screen.			
5 WIDE ANGLE SHOTS	0:07 0:12	VOICEOVER NARRATOR	Are you looking for a college Computer-Aided Design program with an outstanding reputation?
Aerial view pan of A-415 CAD Lab. Aerial view pan of A-407 Board Lab.		Are you looking for a fast return on tuition dollars spent today, with employment compensation dollars of tomorrow?	
6 CLOSE UP SHOT - Brent	0:04	SCRIPT	"Today we are solid modeling this UNC thread bolt."
Brent posed at his CAD workstation with a wireframe model on screen in the background.			

**Fig. 1—A page from the video script. To view the entire script, visit [www.kishwaukeecollege.edu/cad/pdfs/Video\\_Script.pdf](http://www.kishwaukeecollege.edu/cad/pdfs/Video_Script.pdf)**

In this phase, editing and previewing the video that we had shot took a lot of time. There were times when the output of videos from the editing software did not go as expected, causing us a number of do-overs. Sometimes the software glitch would show up as a video hiccup in the finished movie and at other times it would be an audio issue. The most common issue was voices out of sync with the screen images of people speaking.

## Delivery

In the delivery phase, we refer-



**Photo 1—A student readies herself with a wireless lavalier microphone as her instructor checks lighting.**

enced all the things we made note of in the pre-production phase relative to posting a video online. We constantly asked, "Will attention to this detail give us the desired results when posted online and viewable by the public?" We uploaded the video

twice to YouTube before we found a thumbnail we desired in the three YouTube randomly offers after a video is uploaded. Each upload took almost an hour for our 300 MB file to become a three-minute YouTube video.

Our finished Facebook video can be seen at [www.youtube.com/watch?feature=player\\_embedded&v=f5gLUhiQpZw](http://www.youtube.com/watch?feature=player_embedded&v=f5gLUhiQpZw). ©

## Resources

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# Bits, Bytes, and Binary: The Mathematics of Computers

By David Hua, Austin Weiland,  
and Scott Drummond

**T**HE purpose of the activities presented in this article is to help students understand the role of binary in technologies such as computers, smartphones, and the Internet. Students will learn how bits, bytes, and binary are used to make these technologies function. They will learn how to convert numbers from decimal format to binary and from binary to decimal.

Students will be shown how to access advanced features in a computer's calculator application to verify the accuracy of the number conversions. They will also be shown how to use a free online binary game to support mastery of the mathematics and conversion process.

## Background

Binary is the foundation of almost all forms of modern communication (Bogomolny, n.d.). Whether you are talking about smartphones, computers, or mobile devices like iPads and other tablets, all rely on binary to operate and communicate with each other. Anthes (2007) noted that all data is built from binary. Everything from a cell phone to a supercomputer uses 0's and 1's to create, manipulate, and store information. Even a picture taken with a digital camera is created and stored using binary values.

*David Hua is an assistant professor, and Austin Weiland and Scott Drummond are undergraduate students in the Computer Technology program, Department of Technology, Ball State University, Muncie, IN.*

As Feaster, Ali, and Hallstrom (2012) stated, the binary number system is a very important part of building interest in the computer

science field. It is the most basic level to which any code eventually is converted. The National Council of Teachers of Mathematics (2011) has

**Table 1—Standards Met**

### ITEEA Standards for Technological Literacy Content Standards (International Technology and Engineering Educators Association, 2012)

<b>Standard 2</b>	Students will develop an understanding of the core concepts of technology.	Students will discover how binary is the foundation of all computing technologies (e.g., computers, smart phones, Internet) work.
<b>Standard 3</b>	Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.	Students will integrate math with computing in a direct manner as well as understand the concept behind binary with reference to computers.
<b>Standard 17</b>	Students will develop an understanding of and be able to select and use information and communication technologies.	Students will use a variety of technologies to accomplish the activities.

### NCTM Principles and Standards for School Mathematics (National Council of Teachers of Mathematics, 2011)

<b>4.6</b>	Developing Estimation Strategies by Making Connections among Number, Geometry, Measurement, and Data Concepts	Students will develop connections between different numbering systems.
<b>5.1</b>	Communicating about Mathematics Using Games	Students will reinforce the math skills through the use of an online game. The game can be used individually or competitively between multiple students.
<b>5.4</b>	Accessing and Investigating Data Using the World Wide Web	Students will be engaged in online research.

### NCTE Standards for the English Language (National Council of Teachers of English, 2012)

<b>Standard 8</b>	Students use a variety of technological and information resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge.	Students will use a variety of information resources to develop an understanding of binary and its role in technology.
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identified the need for students to learn about numbering systems like binary in their educational standards.

Forms of binary are used in many things. Data is transferred over telephone lines and radio lines by using high- and low-pitched tones to represent the ones and zeros (National Center for Women in Information Technology, 2008). On hard drives, binary is represented by magnetic fields.

Optical storage such as CDs, DVDs, and Blu-ray discs use reflected light to represent binary values. A reflective bit of the disc that reflects the laser in the drive represents a one and a nonreflective bit represents a zero (Alford, 1993). Bits are usually represented together to provide more information. These groups are called bytes.

The activities provided here will give students an opportunity to investigate the impact of binary on their lives, the binary number system, the conversion process between binary and decimal number systems, and strategies for reinforcing the initial learning.

Binary is also used to signify the computing capabilities of a computer's central processing unit (CPU). The CPU has evolved from 8-bit and 16-bit processing to the current 32-bit and 64-bit processing. These varying bit sizes refer to the amount of information that a CPU can process in a single clock cycle. This is then multiplied by the number of clock cycles per second a CPU can process. Current processors typically operate in the range of 3.0 to 4.0 MHz per second.

The bit size of the CPU is also an indication of the theoretical amount of RAM memory the computer is able to utilize. A 64-bit processor can use up to 2048 petabytes of RAM. Unfortunately, computer users will not see that level of performance. The actual RAM capacity is limited by other hardware components such as the motherboard.

## Materials

- A computer with a Windows operating system, including the default calculator application
- A computer with Internet access
- Student worksheets

## Learning Objectives

After conducting online research and completing the worksheets, students will be able to

1. Define binary.
2. Identify why computers use binary.
3. Identify three ways in which computers use binary.
4. Accurately convert decimal numbers to binary numbers.
5. Accurately convert binary numbers to decimal numbers.
6. Use the calculator on a Windows computer to verify decimal-to-binary and binary-to-decimal conversions.
7. Use the Cisco Binary Game to reinforce the learning of the binary conversion processes.

For a list of standards met, see Table 1.

## Activity 1: What Is Binary and Why Should I Care?

In this activity, students will investigate the role of binary numbers in computing technologies. They will use an Internet search engine to answer the questions on the Binary Research Worksheet.

The teacher can use the items below as suggestions for guiding student research.

- Binary is a base 2 numbering system that uses a series of 1's and 0's.
- Binary is used by computers because it is relatively simple to use the presence of an electric charge to represent a 1 and the absence of an electrical charge to represent a 0.
- The transistors found in a microprocessor (found in everything from computers and tablets to smartphones) act as a switch to create binary values. Like a light switch, when the transistor is "turned on" it allows electricity to flow, which represents a 1. When the transistor is "turned off" it is registered as a 0.
- Electronic documents (e.g., word-processing documents, spreadsheets, pictures, music) are stored in a binary format.
- Electronic communications (e.g., email, Twitter, social networking, online gaming, Web surfing) use binary to route information from source to destination.
- The capacity of storage media (e.g., hard drives, flash drives, DVDs, Blu-ray discs, SD cards) is based on binary. Capacity is indicated by the number of bytes the storage media can hold. ►

### Binary Research Worksheet

The purpose of this activity is for you to learn more about binary numbers and their purpose in technology. You should use an Internet search engine to research each of the three questions below.

- a. What is the binary numbering system?
- b. Why is binary used by computers?
- c. Describe ways that computers use binary.

	2 <sup>7</sup>	2 <sup>6</sup>	2 <sup>5</sup>	2 <sup>4</sup>	2 <sup>3</sup>	2 <sup>2</sup>	2 <sup>1</sup>	2 <sup>0</sup>
Decimal	128	64	32	16	8	4	2	1
Binary								

Fig. 1

	2 <sup>7</sup>	2 <sup>6</sup>	2 <sup>5</sup>	2 <sup>4</sup>	2 <sup>3</sup>	2 <sup>2</sup>	2 <sup>1</sup>	2 <sup>0</sup>
Decimal	128	64	32	16	8	4	2	1
Binary	1	1	1	0	1	0	1	0

Fig. 2

	2 <sup>7</sup>	2 <sup>6</sup>	2 <sup>5</sup>	2 <sup>4</sup>	2 <sup>3</sup>	2 <sup>2</sup>	2 <sup>1</sup>	2 <sup>0</sup>
Decimal	128	64	32	16	8	4	2	1
Binary	1	1	1	0	1	0	1	0

128 64 32 0 8 0 1 0

Fig. 3

	2 <sup>7</sup>	2 <sup>6</sup>	2 <sup>5</sup>	2 <sup>4</sup>	2 <sup>3</sup>	2 <sup>2</sup>	2 <sup>1</sup>	2 <sup>0</sup>
Decimal	128	64	32	16	8	4	2	1
Binary	1	1	1	0	1	0	1	0

128 + 64 + 32 + 0 + 8 + 0 + 2 + 0 = 234

Fig. 4

• Each 0 or 1 represents 1 bit. Eight bits make a byte, 1024 bytes make a kilobyte (KB). 1024 KB make a megabyte (MB), 1024 MB make a gigabyte (GB).

After an appropriate period of time, the teacher will ask the students to share their findings.

Students should watch the video at <http://www.youtube.com/user/MyWhyU?v=5sS7w-CMHkU&feature=pyv> (Why U, 2011). Developed by the University of Central Florida and intended for students studying pre-algebra, the video covers decimal, binary, octal, and hexadecimal numbering systems.

## Activity 2: Binary-to-Decimal Conversions

In this activity, the student works through binary-to-decimal and decimal-to-binary conversion processes without using a calculator.

### Binary-to-Decimal Conversion Example:

Convert 11101010 to a decimal number.

1. Write out the conversion sheet (Fig. 1).
2. Write the binary values in the available boxes from right to left (Fig. 2).
3. Drop down the decimal value in any column that contains a 1 (Fig. 3).
4. Add the dropped decimal values to find that the binary value of 11101010

converts to the decimal value of 234 (Fig. 4).

### Decimal-to-Binary Conversion Example

Convert 115 to binary format.

1. Write out the conversion sheet (Fig. 1).
2. Find the largest decimal value in the conversion sheet that does not exceed the number being converted. In this example, 64 is the largest number that is smaller than 115. Write a 1 in the binary box under the 64 (Fig. 5).
3. Subtract 64 from 115. This leaves a remainder of 51 (Fig. 5).
4. Repeat the process with the remainder from Step 3. Place a 1 in the binary box under 32 and then subtract that from 51. This will leave a remainder of 19 as seen in Fig. 6.
5. Repeat the process, placing a 1 in the binary box under 16 and then subtract 16 from 19 (Fig. 7).
6. Since 2 is the next number closest to the remainder of 3 from Step 5, a 1 should be placed in the binary box under the decimal value of 2. Subtracting 2 from 3 will leave a remainder of 1 (Fig. 8).
7. Place the last 1 in the binary box of the 1 column. Subtracting the 1 from 1 leaves a remainder of 0 (Fig. 9).
8. Place 0's in the remaining binary boxes (Fig. 10). The binary equivalent of the decimal

	2 <sup>7</sup>	2 <sup>6</sup>	2 <sup>5</sup>	2 <sup>4</sup>	2 <sup>3</sup>	2 <sup>2</sup>	2 <sup>1</sup>	2 <sup>0</sup>	115
Decimal	128	64	32	16	8	4	2	1	-64
Binary		1							51

Fig. 5

	2 <sup>7</sup>	2 <sup>6</sup>	2 <sup>5</sup>	2 <sup>4</sup>	2 <sup>3</sup>	2 <sup>2</sup>	2 <sup>1</sup>	2 <sup>0</sup>	115
Decimal	128	64	32	16	8	4	2	1	-64
Binary		1	1						51
									-32
									19

Fig. 6

	2 <sup>7</sup>	2 <sup>6</sup>	2 <sup>5</sup>	2 <sup>4</sup>	2 <sup>3</sup>	2 <sup>2</sup>	2 <sup>1</sup>	2 <sup>0</sup>	115
Decimal	128	64	32	16	8	4	2	1	-64
Binary		1	1	1					51
									-32
									19
									-16
									3

Fig. 7

	2 <sup>7</sup>	2 <sup>6</sup>	2 <sup>5</sup>	2 <sup>4</sup>	2 <sup>3</sup>	2 <sup>2</sup>	2 <sup>1</sup>	2 <sup>0</sup>	115
Decimal	128	64	32	16	8	4	2	1	-64
Binary		1	1	1			1		51
									-32
									19
									-16
									3
									-2
									1

Fig. 8



	$2^7$	$2^6$	$2^5$	$2^4$	$2^3$	$2^2$	$2^1$	$2^0$
Decimal	128	64	32	16	8	4	2	1
Binary		1	1	1			1	1

Fig. 9

	$2^7$	$2^6$	$2^5$	$2^4$	$2^3$	$2^2$	$2^1$	$2^0$
Decimal	128	64	32	16	8	4	2	1
Binary	0	1	1	1	0	0	1	1

Fig. 10

value of 115 is 01110011. Any 0's to the left of the leftmost 1 in a binary value are typically dropped. Therefore, the conversion would typically be represented as 1110011.

The student should now complete the conversions on the Binary Conversions Worksheet independently.

### Activity 3: Advanced Calculator

In this activity, students will learn how to use the advanced features in a computer's calculator to verify the conversions they completed on the Binary Conversions Worksheet. ►

$$\begin{array}{r}
 115 \\
 -64 \\
 \hline
 51 \\
 -32 \\
 \hline
 19 \\
 -16 \\
 \hline
 3 \\
 -2 \\
 \hline
 1 \\
 -1 \\
 \hline
 0
 \end{array}$$

#### Binary Conversions Worksheet

1. Convert the following numbers to binary  
a. 255

b. 31

c. 27

d. 156

e. 243

2. Convert the following numbers to decimal format

a. 11011001

b. 00110101

c. 11001010

d. 10101010

e. 11100101



## Don't miss all the great features in the December Issue:

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◀ Fig. 11

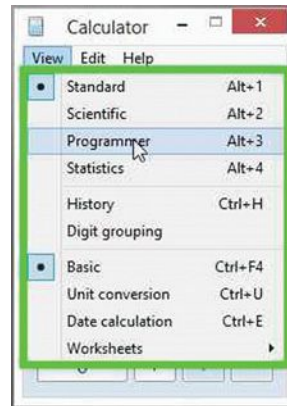


Fig. 12 ▶

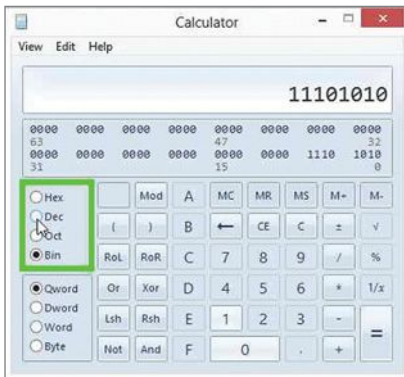


Fig. 13

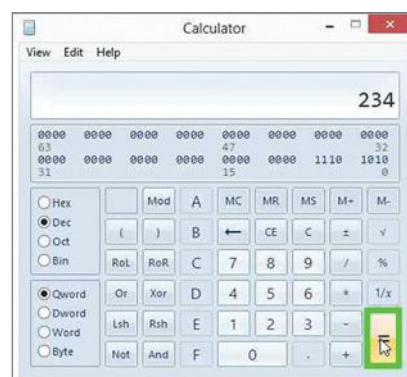


Fig. 14

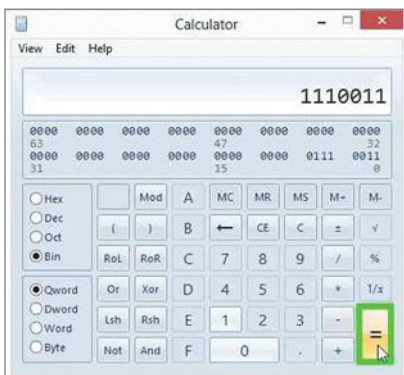


Fig. 15

### Student Instructions

1. Open the calculator on the computer. This should open the calculator in its Standard Mode (Fig. 11).
2. Put the calculator into one of its advanced modes. To do this, click on the View menu and click on the Programmer option (Fig. 12). This will show a box with four options highlighted (Fig. 13). These represent the numbering systems that the calculator can use. The options include Hex (hexadecimal), Dec (decimal), Oct (octal), and Bin

(binary). (The student should be familiar with each of these numbering systems from the video viewed in Activity 1.)

3. To verify the binary-to-decimal conversion from Activity 2, select the Bin option on the calculator and then enter the binary value of 11101010. (Fig. 13).

4. Select the Dec option. The output of the calculator should change to show the decimal equivalent of 234 (Fig. 14).

5. The calculator should still be set to the Dec option. To verify the decimal-to-binary conversion from Activity 2, enter 115 and choose the Bin option. The output should then display the binary value of 1110011. (Fig. 15).

As an alternative, the student may search for online binary/decimal converters. Students should use the calculator to check the conversions completed on the Binary Conversions Worksheet.

## Activity 4: Online Binary Game

To reinforce the concepts introduced in the Binary Conversions Worksheet, students should play the Cisco Binary Game. In the game, students score points by successfully performing both types of conversions. If there are multiple students, the game can be used as a competition to see who can earn the highest score within a specified period of time.

### Student Instructions

1. Go to [http://forums.cisco.com/CertCom/game/binary\\_game\\_page.htm](http://forums.cisco.com/CertCom/game/binary_game_page.htm) (Cisco Systems Inc., 2011). The game is also available as a free iPod/iPad app or an Android app.
2. Click "Start."
3. The game will present rows of 0's and 1's (Fig. 16). At the end of the row is a box that will either contain a number or be blank. If the box is blank, you must enter the decimal equivalent for the binary value of that row. For example, in the first row in Fig. 16, type 64 in the box and press the "Enter" key since there is a 1 in the 64 column.
4. If the row has a number in the

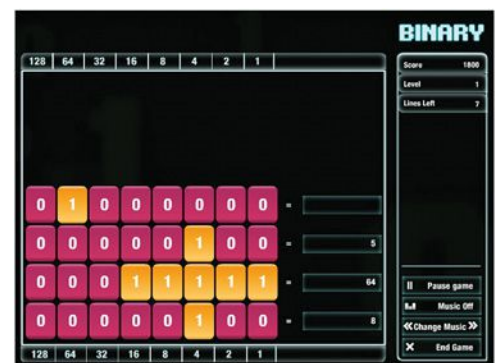


Fig. 16



Fig. 17



### Worksheet Answer Key

- |                             |                             |
|-----------------------------|-----------------------------|
| <b>1. Decimal to binary</b> | <b>2. Binary to decimal</b> |
| a. 11111111                 | a. 217                      |
| b. 00011111                 | b. 53                       |
| c. 00011011                 | c. 202                      |
| d. 10011100                 | d. 170                      |
| e. 11110011                 | e. 229                      |

box, you need to arrange that row's 1's and 0's to the binary equivalent of the value in that row's box. When you click on any of the binary values in the row, it will change a 1 to a 0 or a 0 to a 1. For example, the second row in Fig. 16 has a 5 in the box. The student would need to click on the 0 in the 1's column to create the binary equivalent of 101.

5. Once you have entered the correct decimal or binary value, the row will disappear. The game will add rows periodically. The game will add rows more frequently as the student successfully progresses through the game. The game ends when it can no longer add rows to the game screen. (Fig. 17). ©

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## ROBOTICS TECHNICIAN

Robots have an impressive range of applications, from “pick and place” for packaging, to welding, painting, or inspecting parts immediately after a process. However, robots are not foolproof; they require effective preventive maintenance to ensure they operate at full capacity. If a robot malfunctions, an experienced maintenance professional must know how to troubleshoot the exact cause.

Robotics technicians install, service, maintain, troubleshoot, and repair robots and automated production systems. They must understand computers, electrical and electronic systems, sensor and feedback principles, and how robots work as machines.

Robots are utilized in a diverse range of industries including the appliance, automotive, aerospace, consumer goods, logistics, food, pharmaceutical, medical, foundry, and plastics industries as well as multiple applications including material handling, machine loading, assembly, packaging, palletizing, welding, bending, joining, and surface finishing.

### The Job

Robotics technicians employed by manufacturers work closely with designers, engineers, and technologists. They might be involved in the developing, testing, programming, and actual on-site installation of new robots. Some technicians work as robotics trainers and train others to install, use, and maintain robots.

Robotics technicians have another important role—they are the people who help keep the robots “working.” Employed by robot manufacturers, suppliers, distributors, or by the companies that use and depend on robots, they maintain and troubleshoot all aspects of robots and automated systems—mechanical as well as electrical.

Robotics technicians are employed either by the manufacturers and distributors of robots or by the robot users, and are often responsible for the initial installation of the robot. Technicians may establish an in-house maintenance and repair program. If employed by a robot manufacturer or distributor, maintenance technicians usually respond to service calls. Members of the robotics team work closely with engineers and other technical workers. Robotics technicians who are trained in computer programming sometimes perform low-, mid-, and even high-level programming and reprogramming of the robots. In many cases, the robotics technician acts as the liaison between robotics engineers and the customers who purchase the machines. They may also install the robots at the manufacturing plant or other site where they will be used.

### Skills/ Characteristics

- Manual dexterity
- Good mechanical and electrical aptitude
- Logical thinking skills, problem-solving skills, and troubleshooting skills
- Good eyesight and color vision—techs must inspect and work on small, delicate parts
- Good hearing—some malfunctions are revealed by sound
- Ability to work without close supervision
- Pleasant personality, neat appearance, and good communication skills for those who have frequent contact with customers
- A willingness to pursue additional training on an ongoing basis—technicians must attend training sessions and read manuals to keep up with design changes and revised service procedures



### Wages

Wages vary depending on geographical location, years of experience, and industry. In industrial settings, robotics technicians can expect to earn between \$30,400 and \$50,500 annually. The average wage for technicians in the automotive industry ranges from \$63,310 to \$65,291. Highly skilled industry professionals can earn as much as \$65 to \$125 per hour.

Employers offer a variety of benefits, including paid vacation and sick leave, medical and dental insurance, retirement plans, and educational assistance programs.

## Training

### High School

- Science
- Math
- Computer systems/programming
- English
- Technology education
- Blueprint and electrical schematic reading



### Postsecondary

Because changes occur rapidly within the field, it is recommended that technicians get a broad-based education that does not focus solely on robotics. Programs that provide the widest career base are in automated manufacturing, which includes robotics, electronics, and computer science.

Two-year programs are available at community colleges and technical institutes. Many robotics programs cover the major components of industrial robots, common applications for robots, axis movement, vision systems, effective preventive maintenance, and common causes of robot failure along with ways to identify those causes.

## Additional Requirements

Applicants for entry-level jobs may have to pass tests that measure mechanical aptitude, knowledge of electricity or electronics, manual dexterity, and general intelligence. Newly hired robotics technicians, even those with formal training, usually receive some training from their employer. They may study electronic and circuit theory and math, or study in detail the equipment used by a particular manufacturer or proprietor. They also get hands-on experience with equipment, doing basic maintenance and using diagnostic programs to locate malfunctions. Training offered by employers may be in a classroom or it may be self-instruction, consisting of videotapes, programmed computer software, or workbooks that allow trainees to learn at their own pace. Many technicians also take advanced training in a particular system or type of repair.

## Working Conditions

Most robotics technicians work 40 hours per week; some work overtime. Some technicians travel to customers' plants to service or install equipment. Others work in-house with engineers and scientists. Depending on the employer, robotics technicians may work in well-equipped test labs, in manufacturing operations of robot makers, and/or servicing robots in a user's plant facilities. Labs may be clean and well lit while production areas may be noisy, hot, dirty, or have high levels of dust or fumes. Attention to safety is critical as robots are capable of quick, sudden movements.

Robotics technicians may be expected to be on call in plants where robots are in 24-hour use. Operators may have to work night shifts. In some cases robotics technicians belong to labor unions.

## Duties and Responsibilities

Common tasks and assignments include:

- Assist engineers in the design and application of robot systems
- Inspect electronic components from suppliers prior to robot assembly
- Inspect and test robots for defects after manufacturer's assembly
- Install robots or robotic systems at users' sites
- Install robot safety systems
- Provide start-up assistance to users, including qualifying (fine tuning) performance and accuracy of robots and troubleshooting
- Program robot for a series of manipulator (arm-hand) moves
- Modify computer-controlled motion of robots
- Troubleshoot to determine robot malfunctions
- Disassemble robots and/or peripheral equipment to repair or replace defective circuit boards, sensors, controllers, encoders, servomotors, servovalves, or automatic lubrication systems
- Reassemble robots
- Train technicians and skilled workers to operate, program, repair, and service robots
- Keep records of test procedures and results, service schedules, and repairs

## Professional Associations

### Robotics Industries Association

734-994-6088

[www.robotics.org](http://www.robotics.org)

### IEEE Robotics and Automation Society

[www.ieee-ras.org](http://www.ieee-ras.org)

### The Student Activities Committee of the IEEE Robotics and Automation Society

[www.ieee-ras.org/member-communities/students](http://www.ieee-ras.org/member-communities/students)

### Society of Manufacturing Engineers

[www.sme.org](http://www.sme.org)

### Society of Manufacturing Engineers Education Foundation

[www.smeef.org](http://www.smeef.org)

# Table Project Teaches Woodworking and Lamination Basics

By Tim Sykes

**S**TURDY and versatile, this cutting table can be an intermediate project for junior high students with some hand tool experience or it can provide a simple introduction to basic power tools or mass production procedures. It offers the future cabinetmaker needed experience in basic lamination.

Compact, the table provides needed work space for the smaller kitchen. The shelf offers stability as well as storage space; another shelf may

laminate cutter, use that. In fact, if you plan to do much work with laminates, it is a good investment. If you use the table saw, be aware that plastic laminate may dull a sharp blade very quickly.

## Procedure

All joints are doweled-butt joints except the shelf slats, which are simply glued in place. No screws or nails are needed. Any adjustments in dimensions for TV or sound system requirements should be made in the bill of materials before proceeding.

1. Square and cut pieces A through E to exact dimensions according to the bill of materials as follows: from the first 8' x 1-1/2" x 3/4" piece of stock, cut four shelf pieces (E) and one side brace (A); from the second and third pieces, cut one shelf piece (E) and two legs (B) from each; and, from the last, cut one side brace (A), two shelf supports (D), and one shelf piece (E).



2. Sand all parts, working down to #100 paper.

3. Square the plywood top and cut to exact dimensions.

4. From the scrap plywood left in step 3, cut two pieces about 2" wide and 1' 6-1/2" long.

### Raw Materials Needed

4	8' x 1-1/2" x 3/4" pine
1	3' x 3-1/2" x 3/4" pine
1	2' x 2' x 3/4" plywood (\$15)
1	2' square Butcher block laminate (or other design)
3'	3/8" dowel

be added 6" to 8" from the top for additional storage. The table can also double as a lightweight TV stand; dimensions may be adjusted to hold a sound system or, with the added shelf, both TV and sound system.

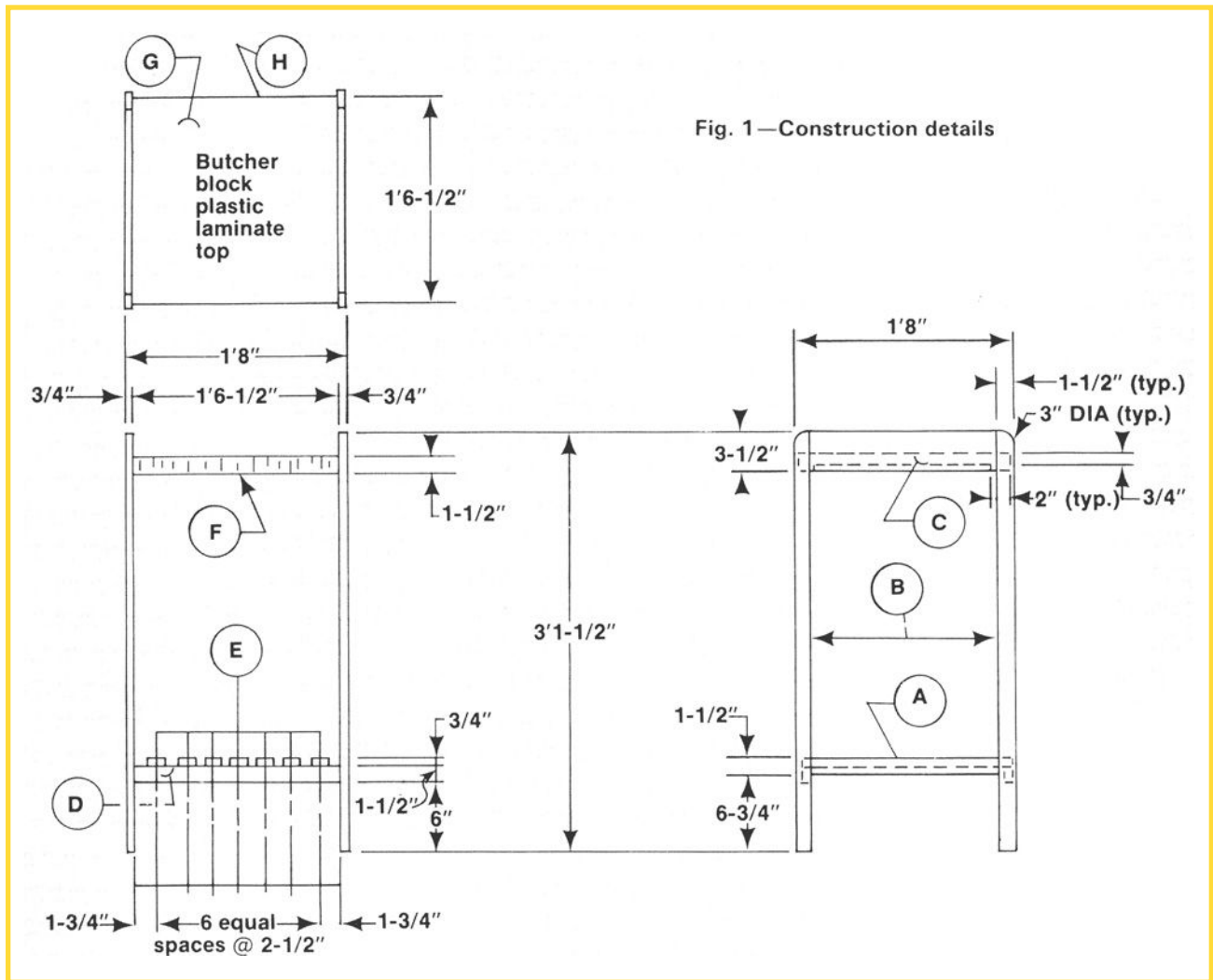
To cut the laminate to width, I used a table saw but if you have a

*This article first appeared in the September 1985 issue of this magazine. At that time, Tim Sykes, a former junior high woodshop instructor, was a designer in the oil industry and ran a part-time cabinetry and furniture design and construction business in Pasadena, TX.*

### Bill of Materials

Part	Part Name	Qty.	Size	Material
A	Side brace	2	1' 5" x 1-1/2" x 3/4"	Pine
B	Leg	4	3' 1-1/2" x 1-1/2" x 3/4"	Pine
C	Top brace	2	1' 5" x 3-1/2" x 3/4"	Pine
D	Shelf support	2	1' 6-1/2" x 1-1/2" x 3/4"	Pine
E	Shelf	7	1' 7-1/4" x 1-1/2" x 3/4"	Pine
F	Top	1	1' 6-1/2" x 1' 6-1/2" x 3/4"	Plywood
G	Laminate (top)	1	1' 6-3/4" x 1' 6-1/2" x 1/8"	Formica
H	Laminate	2	1-1/2" x 1' 6-1/2" x 1/8"	Formica
I	Joint supports	16	1-1/2" x 3/8" DIA	Dowel





5. Using carpenter's glue, glue these onto the bottom (the rough side) of the plywood cut in step 3. Position them even with the edge, on opposite sides. This gives the top a heavy look. Clamp with 2" C-clamps and set aside.

6. Assemble side braces, legs, and top braces (parts A, B, and C) using doweled-butt joints and carpenter's glue (see Fig. 1). Use a drill guide to center the holes for the dowels. Clamp with bar clamps and let dry. After the glue has set, round the corners as shown with a coping or sabre saw, both sides.

7. Again using doweled-butt joints, add the shelf supports and the top (parts D and F). Be sure the shelf supports are centered against the legs. Dowels in the top should be placed in the top only, not in the 1" wide scrap pieces. Scrap pieces should be to the front and back of

the top. Clamp with bar clamps.

8. Glue the shelf (parts E) to the supports, 1" apart. If your dry time is slow due to excessive humidity, you may want to use 3" C-clamps to hold them in place.

9. Sand all parts except the top, working down to #220 paper.

10. Stain and finish as desired. Allow to dry overnight.

## Lamination

1. Use a laminate cutter or table saw to cut the laminate to width.

Set the blade at its highest setting and set the fence 1' 6-1/2" from the blade. Be very careful and use the blade guard since most of the blade is exposed during this procedure. Cut with the grain of the butcher block.

2. Reset the fence at 1-9/16" from the blade and cut two pieces from the laminate against the grain. These

are the front and back of the top (H).

3. Spread contact cement along the underside of parts H and along the front and back of the top (F). Allow it to dry (follow the directions on the can), and put the laminate in place. Be sure the grain pattern matches on both sides and be careful—you only get one chance!

4. Measure the length (back to front) of the top with parts H in place and, adding about 1/16", cut the laminate (G) to length. Glue as in step 3. There should be a little overlap extending from the top. Once this is set, file the edges of the laminate smooth and even. ©

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## More Than Fun Answers

- |                    |               |
|--------------------|---------------|
| 1. BUG             | 18. MOUSE     |
| 2. MENU            | 19. BOOT      |
| 3. DRIVE           | 20. NET       |
| 4. PORT            | 21. CRASH     |
| 5. SCREEN          | 22. JAVA      |
| 6. ICON            | 23. BACKUP    |
| 7. CHIP            | 24. TOWER     |
| 8. BATCH           | 25. SURF      |
| 9. VIRUS           | 26. MONITOR   |
| 10. CODE           | 27. CARD      |
| 11. WEB            | 28. PLATFORM  |
| 12. HARDWARE       | 29. FLOPPY    |
| 13. EXECUTE        | 30. PRINTER   |
| 14. BUS            | 31. BIT       |
| 15. JUSTIFY        | 32. SCROLL    |
| 16. BULLETIN BOARD | 33. KEYBOARD  |
| 17. BETA           | 34. CHARACTER |

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## Computer Word Search

Hidden in the puzzle below are words that are used in everyday conversation but are also computer related. First, write the word suggested by the clue, then find that word in the puzzle. It may be hidden horizontally, vertically, or diagonally. Next, place, in order, the letters remaining after all the words are circled on the blanks below to spell out a message.

1. Insect \_\_\_\_\_
2. Restaurant list \_\_\_\_\_
3. Manipulate a vehicle \_\_\_\_\_
4. Sailor's stop \_\_\_\_\_
5. Check incoming phone call \_\_\_\_\_
6. Russian church treasure \_\_\_\_\_
7. Potato or tortilla \_\_\_\_\_
8. A \_\_\_\_\_ of cookies
9. Microscopic disease-causing particle \_\_\_\_\_
10. Spy's message \_\_\_\_\_
11. Spider's home \_\_\_\_\_
12. Nails, bolts, saws \_\_\_\_\_
13. Kill \_\_\_\_\_
14. Public transportation \_\_\_\_\_
15. Defend actions \_\_\_\_\_
16. Classroom place to hang papers \_\_\_\_\_
17. Greek letter \_\_\_\_\_
18. Small rodent \_\_\_\_\_
19. Slushy weather footwear \_\_\_\_\_
20. Separates tennis players \_\_\_\_\_
21. It happened in 1929 \_\_\_\_\_

E	W	I	G	N	E	E	R	C	S	H	E	D	T
A	T	E	B	N	B	I	H	T	M	S	R	A	R
C	O	X	B	D	O	A	P	B	R	A	A	E	Y
R	O	E	T	R	R	C	R	E	O	O	W	N	S
A	B	C	D	A	E	B	I	B	F	O	D	C	G
S	I	U	C	O	M	O	N	I	T	O	R	L	U
H	C	T	A	B	C	I	T	L	A	O	A	I	B
O	E	E	C	Y	T	N	E	B	L	Y	H	I	S
R	V	H	T	E	P	S	R	L	P	E	T	U	U
T	I	M	L	K	U	P	U	K	C	A	B	S	R
P	R	L	E	O	N	G	O	D	R	I	V	E	F
I	U	O	M	N	G	E	A	L	B	D	R	A	C
B	S	Y	P	J	U	S	T	I	F	Y	T	E	J

22. Coffee slang \_\_\_\_\_
23. Opposite of move forward \_\_\_\_\_
24. Rapunzel lived in one \_\_\_\_\_
25. Catch a wave \_\_\_\_\_
26. Watches over class while teacher's away \_\_\_\_\_
27. Many send one for Mother's Day \_\_\_\_\_
28. Raised stand \_\_\_\_\_
29. A rag doll is \_\_\_\_\_
30. A first grader \_\_\_\_\_
31. Applied teeth to apple \_\_\_\_\_
32. Rolled-up papyrus \_\_\_\_\_
33. Black and white instrument in band \_\_\_\_\_
34. Odd, eccentric person \_\_\_\_\_

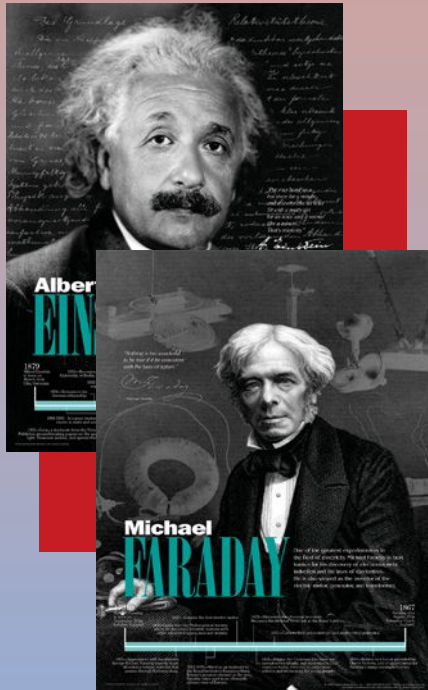
\_\_\_\_\_ = \_\_\_\_\_

\_\_\_\_\_ = \_\_\_\_\_

See answers on page 29.

We pay \$25 for brainteasers and puzzles and \$20 for cartoons used on this page. Preferable theme for all submissions is technology, engineering, and career/technical education. Send contributions to [susanne@techdirections.com](mailto:susanne@techdirections.com) or mail to "More Than Fun," PO Box 8623, Ann Arbor, MI 48107-8623.

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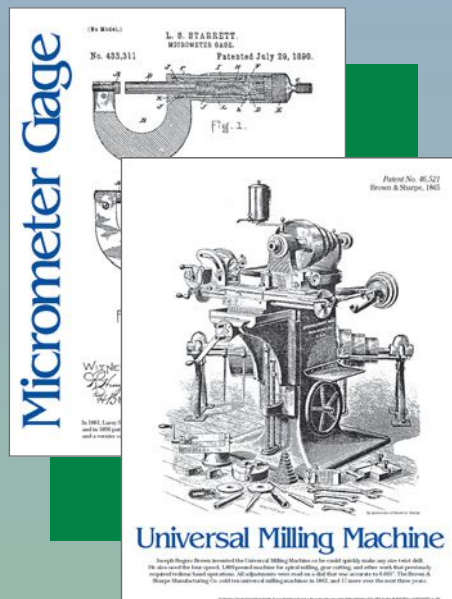
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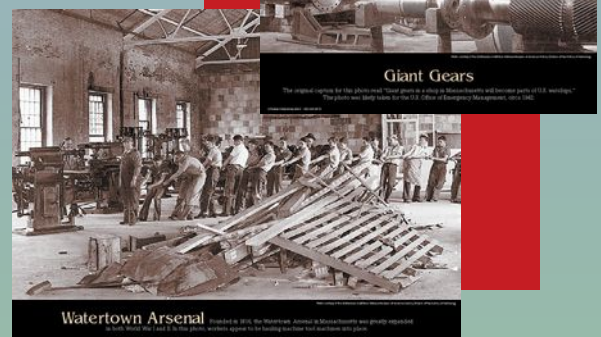


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