DOWNLOAD PDF DRAWING AS DESIGN PROCESS

Chapter 1 : Technical drawing - Wikipedia

For design/engineering drawings, it is always best to start drawing your ideas as thumbnails, small, doodle-like sketches of your ideas. During the ideation and brainstorm phase, you will have tons of ideas that you will want to sketch, so perfection is not important.

Five hypotheses, focused on the types of drawings, their necessity in mechanical problem solving, and their relation to the external representation medium, are presented and supported. Support is through referenced studies in other domains and the results of protocol studies performed on five mechanical designers. Videotapes of all the marks-on-paper made by designers in representative sections of the design process were studied in detail for their type and purpose. The resulting data is supportive of the hypotheses. These results also give requirements for future computer aided design tools and graphics education, and goals for further studies. This goal can be extended to state that we intend to show the necessity of drawing during all the developmental stages of a mechanical design. Through the information presented here, the requirements for future computer aided design tools, graphics education, and further studies will be developed. All mechanical engineers are taught drafting. Thus, most engineers are skilled at making and interpreting these formal mechanical drawings. These drawings are representations of a final design the end product of the design process and they are intended to archive the completed design and communicate it to other designers and manufacturing personnel. Additionally, engineers are notorious for not being able to think without making "back-of-the-envelope" sketches of rough ideas. Sometimes these informal sketches serve to communicate a concept to a colleague, but more often they just help the idea take shape on paper. Understanding the use of both drafting and sketching in design is important to help formulate the future development of Computer Aided Design or Drafting CAD systems. As CAD evolves and becomes more "intelligent," the question of what attributes these systems must have becomes more important. In the past CAD system attributes have primarily been driven from developments in the computer industry. This paper is organized by first, in Section II, clarifying the types of drawings used in mechanical design. The hypotheses to be addressed in this paper are given in Section III. A discussion of research on the understanding of visual imagery to be used as a basis for arguments in support of the hypotheses is in Section IV. In Section V is a discussion of the results of data taken on how mechanical engineers use drawings during design. Lastly, in Section VI, is a discussion of how well the hypotheses have been supported and the implications of our findings on CAD development, educational requirements and future research directions. In research, to be described in Section V, we have broken down these marks into two main groupings: Support notation includes textual notes, lists, dimensions including leaders and arrows and calculations. Graphic representations include drawings of objects and their functions, and plots and charts. Mechanical design graphic representations are often scale drawings made with mechanical instruments or CAD computer systems. These drawings, made in accordance with a set of widely accepted rules, are defined as having been drafted. Sketches, on the other hand, are defined as "free hand" drawings. They are usually not to scale and may use shorthand notations to represent both objects and their function. A differentiation must be made between the act of graphic representation and the medium on which it occurs. The medium, whether it be paper and pencil, a computer stylus on a tablet, chalk on a blackboard or other medium may put interface restrictions on the representation. The following discussions are concerned with what is being represented, not with how the representation is made. Another aspect of drawings to be considered is the level of abstraction of the information to be represented. During the design process, the design is refined from an abstract concept to a final, detailed, drafted design. This can be clearly seen in an example taken from one of our studies described in Section V. Figure 1 is a compilation of all the sketches and drawings one subject made during the development of a battery contact in this design. The number under each graphic image is the percentage of the way through the design when the representation was made. The component is refined from a sketch that contains primarily functional information to a refined, scale drawing of the final form. The first sketch in Fig. The symbology here is clearly functional. The evolution of a battery contact - total protocol time of 8 hours and 34 minutes. On the other hand, most engineers receive no formal

training in sketching. It is often assumed to be some natural ability. Three typical texts used in teaching undergraduate "mechanical" drawing were reviewed [1, 2, 3]. Each of these presented only a few pages of information on sketching. Additionally, CAD systems do not support sketching in any meaningful way. For the purposes of this paper, the term CAD is defined as the use of interactive computer graphics to help solve a mechanical design problem. Current CAD tools aid the mechanical design process in four ways: For all these uses, the "design" must be refined to the point that a scale drawing of it can be made. Thus, for current systems, the "D" in CAD means drafting. To archive the geometric form of the design. To communicate ideas between designers and between the designers and manufacturing personnel. To act as an analysis tool. Often, missing dimensions and tolerances are calculated on the drawing as it is developed. To simulate the design. To serve as a completeness checker. As sketches or other drawings are being made, the details left to be designed become apparent to the designer. This, in effect, helps establish an agenda of design tasks left to accomplish. Designers often unconsciously make sketches to help them remember ideas that they might otherwise forget. It was realized that these observations were both overlapping and incomplete. In particular, based on the data and readings in the cognitive psychology literature, we felt that the last item was potentially much richer than stated. Thus these observations have fostered five hypotheses. Each hypothesis is presented below followed by support from the literature. The mechanical design data in support of these hypotheses is in Section V. Drawing is the preferred method of external data representation by mechanical engineering designers. Designers represent data both internally, in their minds, and externally on paper, a computer screen or other media. It is fairly obvious that designers like to draw in these mediums and prefer a picture to a written description of an object. It is important to understand why drawing representations are preferred over other forms such as text or propositions if-then rules. Here a "diagram" is a drafted, schematic drawing representing the objects in a physics problem. In comparing these the authors conclude that: Diagrams can group all information that is used together thus avoiding large amounts of search for needed elements. Text only indexes to the next element in the sentence list the adjacent piece of information while diagrams have many adjacent elements. Diagrams explicitly preserve information about geometry and topology, whereas text is only serial in nature. This feature of diagrams allows for easy indexing of information to support computation processes. However, text preserves the temporal or logical sequence of information. This is lost in diagrams. Diagrams use location to group information about a single element, avoiding the need to match symbolic labels. Diagrams automatically support a large number of perceptual inferences; the information can be indexed in a variety of manners. It seems reasonable that these conclusions, made about diagrammatic representations, can be extended to all graphical representations. Sketching is an important form of graphical representation serving needs not supported by drafting. Later in this paper we will analyze all the marks-on-paper made by a small group of engineering designers. Their drawing marks will be classified as either free hand sketching or drafting marks. The hypothesis above states that the sketches have a role that more formal drafting cannot fill. Applications for CAD Systems [7] considers the use of sketches study drawings in the solution of architectural design problems. He defines "study drawings" as "informal, private drawings that architectural designers use as a medium for graphic thinking in the exploratory stages of their work. In his paper Herbert conjectures about the properties of sketches that affect the design process. These properties form the basis for his theory of the use of sketches in design. Since sketches can be made more rapidly than formal drawings, they allow for more facile manipulation of ideas. Furthermore sketches allow the information to be represented in various forms such as differing views or levels of abstraction. Thus he calls sketches graphic metaphors for both the real object and the formally drafted object under development. In fact Herbert claims that sketches are a principal medium of external thinking. Drawing is a necessary extension of visual imagery used in mechanical design. It is a necessary extension of a designer cognitive capability for all but the most trivial data representation, constraint propagation, and mental simulation. This hypothesis states that without data representation on media external to the designer there can be no design of substantive problems. In the next section of this paper we will discuss a model of information processing in human problem solving that gives some scientific support to these anecdotal observations and to the hypothesis. The limitation of cognitive ability leads to the forth hypothesis. The nature of the transformation is

dependent on the characteristics of the medium. The manner in which humans represent information in their memory is still a subject of much debate and research. Whatever the form of this internal representation, it is potentially different from the representation made externally on paper, in a CAD system, or through some other media. The transformation between these two media is one of both correspondence and implementation. Correspondence is the transformation between the internal and the external vocabularies.

Chapter 2 : The Importance of Drawing

The digital creation and production of images in all the design professions has led today to fundamental changes in the design processes. Nevertheless, or exactly therefore, drawing as the basic design tool has gained a new importance.

How to create the perfect design process How to create the perfect design process T We explain the basics of how to get ideas from conception to completion. But to harness your creativity and imagination, you need a solid design process to get your ideas from inception to production. Otherwise all your talents will go to waste and lesser - but more organised - mortals will steal your spot. So where do you start? Research Research will help you get inside the minds of your clients and their audience For a successful outcome, you need to begin the project by reviewing and further researching: These introductory research stages are vital for every designer. Research can throw up some unexpected results. It may show you, for example, that the problem you need to solve is not the one the client was initially focused on. You may have to carry out further research to justify why your time is better spent on a more critical issue they may have overlooked. Far from upsetting your client, this should demonstrate an engagement in the project and attentive service. This is the fun bit Sometimes a very large brief can be quite intimidating. In this case, think about dividing things up into a series of smaller tasks and objects. This can be a good way of making seemingly insurmountable problems or a terrifying workload seem less daunting. Visual concepts As designers, we think visually. Collect images relating to the aims of the project - Pinterest is a good tool for this. Also consider using mood boards. The idea-generating stage will often move very quickly. If it all moves too fast, then take a breath, stand back, and refer again to the initial brief and research; this should steer you back on track. Presenting ideas As a creative, using your professional judgement, you should begin filtering your various ideas and designs, retaining the strongest relevant material. Present your work to the client in their preferred method of communication. Justify each design with the research you have previously gathered. This is the important stage of selling your idea to the client, so make sure to communicate well. Getting feedback The quicker you receive the client feedback, the better to keep the momentum and creative juices flowing. I like to make sure the feedback is always in writing. If you get it face-to-face, send a follow-up email stating what occurred in the meeting and ask them to approve Gradually, all the pieces should start to fall into place. One thing that can help you refine your design to perfection is testing. Upload a snapshot of your work in progress and get comments from the Behance community; this gives you the ability to get instant feedback. Private sharing is also an option. There are plenty of resources to help you assemble a great presentation, but the most important thing is being so comfortable with your content that every pause, every reaction, is natural. Roll your own These four stages are the bare bones around which you should develop a design process that is personal to you and adapts flexibly to the different clients, projects and briefs you take on. Developing a solid design process may seem like a pain but will help you evolve throughout your creative career. Technology, as a tool, is constantly changing and there will always be new platforms for various stages of the creative process. Aaron Kitney is a freelance graphic designer and art director based in London and Vancouver. He specialises in branding, identity, web design, publication design, album covers, packaging and book design.

Chapter 3 : The Drawbackwards Design Thinking Process - calendrierdelascience.com

A characteristic of the design process in all areas of design is the use of a number of different types of drawings. The different types of drawings are associated with different stages of the process with one type, the relatively unstructured and ambiguous sketch, occurring early in the process.

So why is it the exception not the norm in design today? Now that computers can create just about any virtual and real-looking environment, drawing is perceived as old-fashioned and slow. Contemporary culture pushes us to celebrate the newest approaches and the latest and greatest gadgets, devices and software. Early stages of the design process can and should be messy. During a client visioning session, as ideas are discussed I draw them for the group. In these dynamic sessions, the real-time reaction and input moves the conversation and creative process at speeds not possible with computer drawings. Away from our offices and their sophisticated rendering software, with just a black felt-tip pen, I can demonstrate multiple design options to clients. Hand-drawn concepts engage the group and spark discussion. When I talk about a concept using a sketch, the passion, mood and feeling communicated by the image complements the emotion of my voice. This builds a stronger connection between the design and the audience. That connection always trumps technology. Drawing connects with people at an emotional level. This series of sketches quickly traveled from my mind, to my hand, to the paper, and now you are seeing the journey through my eyes. The same views generated by the computer would not impart the same emotional responses or convey my particular point of view as effectively. Even the simple act of tracing holds tangible value. The above picture might make you want to laugh, but using trace paper over a screen lets me iterate options at lightning speed. Especially in the early design stages, time is of the essence. Only my hand can keep pace with the thought process. Consider these studies, which help explain the massing evolution. Rational drawings like these, with precise measurements, have a short-lived use, but complement looser drawings and studies. While a pen sketch effectively communicates my design solution, in some cases I turn to pencil and watercolors. The soft and appealing nature of this medium pulls the audience into the process. Its painterly style evokes emotion. They can complete the picture in their own way. This leaves certain pieces up to the imagination. As humans we all yearn for authenticity. A design process that starts with the hand, akin to the first brush strokes on a canvas, humanizes the process and establishes a strong foundation for the later stages where computer generated precision takes precedence. So while drawing is paramount to my process, technology also plays a leading role. But starting at a computer would be like putting the cart before the horse.

Chapter 4 : Design Process - HARRISON architects

Many different types of drawing can be used during the process of designing and constructing buildings. Some of the more commonly-used types of drawing are listed below, with links to articles providing further information. See also: Video overview of different types of drawings.

Menu The Drawbackwards Design Thinking Process Shortly after World War II, a new Japanese manufacturing practice emerged that transformed one automobile company into a global leader and inspired millions of businesses ever since. Factory workers at Toyota began implementing quality circles, a system of continuous, small improvements. Facing scarce resources and high stakes after the war, the company hoped taking these minor steps would add up to major benefits, including faster delivery, less waste, cost savings, and higher customer satisfaction. It has become the cornerstone of the Toyota Production System and helped catapult the company to consistent success ever since. Kaizen has helped Toyota not only achieve a greater market capitalization than that of General Motors, Ford, and Honda combined , but also inspired an entire movement. Manufacturing no longer purely focuses on churning out widgets. Brown defines design thinking as: Instead of being focused on making something look good, the design thinking process focuses on understanding and solving a specific problem to produce positive results. The only thing we were going to do was evangelize outcomes delivered to the market that were the result of the practice. The business only cares about market outcomes. And in order to accelerate the outcomes, we use these practices. It guides people through the steps of empathizing with users and the problem first, then diverging to brainstorm numerous ideas for solutions, and converging to identify the best one. This methodology also embraces the idea of iteration. What Kaizen was for manufacturing, design thinking is for design and innovation: The Drawbackwards Design Thinking Process Typically, the design thinking process consists of 5 stages: Empathize, Define, Ideate, Prototype, and Test. Following these 5 steps alone can produce meaningful results. Before you can empathize with your users, you need to understand who your users are and the constraints that will dictate their solution business objectives, budget, timeline, etc. Are there multiple audience segments? Empathize Empathizing is a commonly skipped step in a design process, yet it often makes the biggest difference in producing positive results. Most of us think we know our users, but do our perceptions match reality? Empathizing tests the waters by answering questions like: What are they looking for? However, people actually need constraints to be creative. It combines the research and empathy gathered during steps 1 and 2 to define a design philosophy and user stories that address: Ideate When companies seek help improving their product, they often ask a designer or consultant to start with the Ideate stage, which involves diverging to brainstorm as many creative solutions as possible. The challenge is that brainstorming smart solutions is the most difficult task and rarest skill set of UX design. Prototyping allows you to test your hypothesis without spending time, money, and other resources creating the full product. It helps answer several vital questions, including: Although it may seem like skipping prototype design saves time and money, it often ends up costing more in re-work later on. While any prototype is better than none, there are multiple kinds that each serve a different purpose and have different pros and cons. No matter which kind you decide is most appropriate for your project, remember to treat prototyping as the test run before you make the final product. It may turn out perfectly and give you more confidence when you start building the real thing, or you might notice that it needs some adjustments or a completely different approach altogether. Test Usability testing is all about sharing your prototype with real users to get their feedback, then ideating, prototyping, and testing again. In fact, there are tons of lean usability tools and best practices that make it easy to moderate a test, record sessions, and analyze results. Some of our favorites include:

Chapter 5 : Why drawing remains relevant in the design process | Building Design + Construction

Summary: In the profession of architecture, drawing is essential to the process of design. From diagrammatical to highly technical, hand drawing brings value to every architectural project by allowing us to quickly explore ideas and convey intent.

Print Since the beginning of time, drawings have been a way to share ideas with others. Although it might seem intimidating, drawing is all about starting with the basics, and like anything else in lifeâ€”practice, practice, practice! They just need to get your ideas across to others through simple shapes and symbols. Start your drawing training by practicing the simplest of shapes. In your design notebook, draw lines, curves, circles, rectangles, squares, triangles, etc. You will be amazed at how much faster you get at drawing these simple shapes and symbols. Drawing of Stator winding machine by Richard M. Click image for full-screen version. As silly as it may seem to practice drawing basic shapesâ€”you are on your way to being able to draw everything that you see in your everyday life! To draw a house, you need a rectangle with a triangle above it. Draw windows and doors with more rectangles. Lines and curves allow you to add curtains, shutters, bricks, siding, etc. Basic shapes combine to make much more elaborate drawings. Take your design notebook, and go look at the objects that surround you. Try to pull out the basic shapes within each object. Draw these basic shapes and then combine them with one another as you see them in real life. You will find that you are capable of drawing more complex objects. Once you have spent time practicing simple doodles of everyday objects, you can begin trying more detailed drawings. When you add more detail, qualities like proportion become important for accurate drawings. To draw in proportion, consider how large certain aspects of your drawing are in comparison to others. During the ideation and brainstorm phase, you will have tons of ideas that you will want to sketch, so perfection is not important. You are sketching your ideas quickly and all in the same place your design notebook so that you can later go back and reference your ideas. Once you have decided on a final design concept, go back and find the related sketches from your collection of thumbnails. Draw your final concept on a larger sheet of paper that you can use to present your idea to others. Combine the thumbnails that make up your final design. Be sure to add more detail to your final drawings, such as dials and knobs, all of the separate parts, color, texture, etc. When printing this document, you may NOT modify it in any way. For any other use, please contact Science Buddies.

Chapter 6 : Design - Wikipedia

The product design book Design Sketching explains the entire process of sketching for product design. It offers tutorials, explanations, and examples. It offers tutorials, explanations, and examples. The example below from the book shows how a designer might investigate a problem and explore potential solutions.

That way you can gain an understanding of how we operate from the initial consultation all the way through construction administration. Ideally, we would prefer to work with you through every phase we describe below to ensure the smooth completion of your project â€" we carry out each phase with the intention of keeping your project on budget and within code. That being said, you may decide to contract with us to complete one or more phases separately, as you see fit. We can discuss your options further during an initial consultation meeting. The initial consultation will result in a proposal for our services as well as a breakdown of our fees. Once we have come to an agreement, we will document any existing conditions through field studies and gather any relevant architectural data to initiate the first phase of the architectural design process â€" Phase 1: We will generally present these options in the form of sketches, so you can visualize the different routes your project could take. We will also attach a rough cost estimate to each option to aid you in selecting a design that meets both your aesthetic preferences and budget requirements. Once you have selected a design option that best suits your needs, we will begin the process of refining the design during the Design Development phase. Design Development At this point, we will take the schematic design you selected, as well as any requested modifications, and revise the design as necessary. This phase may require additional give and take as we work with you to finalize the details of the design before moving into the next phase. Construction Documents By now, we will have settled on a final design and will begin preparing drawings, notes, and technical specifications necessary for bidding, construction, and permit application. This is the phase that many people think of when they picture the work of an architect â€" the creation of blueprints. Contractors will use these detailed drawings and specifications to prepare for the next phase in the architectural design process. Bidding Having an architect on your side during the bidding phase of home construction is of great advantage to you. At minimum, we can aid you in developing a list of qualified contractors for your bid list and submitting bid packages to bidders. But we can also review submitted bids, provide analysis, and help you compare the cost figures that you receive from your bidders. This phase will ensure the contractors you are considering for your construction project are reading the blueprints correctly and are providing an accurate bid for your project. Construction Administration Finally, once you have selected a contractor and construction is under way, we move into the fifth phase of the architectural design process â€" construction administration. During this phase, we will administer the construction process to assure conformance with design intent, visit the site during construction, and address any field conditions as they arise. This final phase, along with all the others described above, will ensure the smooth and satisfactory completion of your home construction or renovation project. Our ultimate goal as architects is to help you turn your dream of a new or renovated home into an affordable reality. Contact us and take the first step toward your new home.

Chapter 7 : Engineering Design Process - TeachEngineering

IED Study Guide Learn with flashcards, games, and more â€" for free.

Measurements of a Bungalow The design process is divided into three main phases, preliminary design, construction documents, and construction administration. If the project is a renovation the initial work also includes measuring the existing building. We also review the zoning and building codes and regulations relevant to the project. These are often hand-drawn, and include a site plan, the floor plans, the most important elevations, and a section or two. The 3D virtual model of the exterior of the project allows us to look at the design from every angle, and see the path of the sun across the project. Our clients find this very helpful in understanding the design. This phase, like all of the design process, is iterative. The sketches provide talking points. They bring out the issues, and help both client and architect focus and move toward appropriate solutions. We take a first pass at specifications for materials and assemblies to be used in the work toward the end of this phase. We prepare additional drawings that explore and convey all aspects of the design, in more detail, and preliminary specifications for materials and techniques to be used in the project. We make suggestions for materials, finishes, appliances, lighting, and plumbing fixtures and fittings to be used in the work. As we move through this phase, we refine the design, modify it here and there, adjust and rationalize dimensions to fit specific components chosen by our clients, and generally flesh out what had been the rough design ideas. Ideally, by the end of this phase, our clients have made many of their choices of materials, fixtures, appliances and so on. The Permit Set typically includes a site plan, floor plans, elevations, building sections and one wall section, and the Structural Drawings and Notes, as well as information on energy use and the heating and ventilating systems of the building. These Construction Documents include exterior or interior details, interior elevations of rooms such as kitchens and bathrooms or other rooms with lots of detail, cabinet and stair details, interior materials and finishes, and specifications. The specifications describe all the materials and techniques to be used, including special materials and finishes â€" such as low-toxic paints, FSC-certified lumber, whole house ventilation fans, fly ash to be added to the concrete mix and so on â€" and suggestions to the contractor about where to get them. This includes preparing bid documents, going over the plans with contractors, analyzing and comparing bids, etc. Construction Administration Concrete Formwork During Construction Essentially, the design process is completed on site during construction, in collaboration with the owner and contractor. Almost every new building is a prototype that brings together literally hundreds of products from tens of different sources, installed by a total of perhaps thirty or forty different people employed by a dozen different companies. If architects were to try to draw and account for every interface of each of those components in the Construction Documents, their fees would be astronomical. We find a once-a-week site visit with owner, contractor and architect works really well for this.

Chapter 8 : Interior Design Process | Mitchell Wall

The engineering design process is a series of steps that engineers follow to come up with a solution to a problem. Many times the solution involves designing a product (like a machine or computer code) that meets certain criteria and/or accomplishes a certain task.

Newhouse School of Public Communications Renovation. All images courtesy Gensler Drawing. So why is it the exception not the norm in design today? Now that computers can create just about any virtual and real-looking environment, drawing is perceived as old-fashioned and slow. Contemporary culture pushes us to celebrate the newest approaches and the latest and greatest gadgets, devices and software. Early stages of the design process can and should be messy. During a client visioning session, as ideas are discussed I draw them for the group. In these dynamic sessions, the real-time reaction and input moves the conversation and creative process at speeds not possible with computer drawings. Away from our offices and their sophisticated rendering software, with just a black felt-tip pen, I can demonstrate multiple design options to clients. Hand-drawn concepts engage the group and spark discussion. When I talk about a concept using a sketch, the passion, mood and feeling communicated by the image complements the emotion of my voice. This builds a stronger connection between the design and the audience. That connection always trumps technology. Drawing connects with people at an emotional level. This series of sketches quickly traveled from my mind, to my hand, to the paper, and now you are seeing the journey through my eyes. The same views generated by the computer would not impart the same emotional responses or convey my particular point of view as effectively. Sketch over the computer screen illustrates the potential of an existing site. Even the simple act of tracing holds tangible value. The above picture might make you want to laugh, but using trace paper over a screen lets me iterate options at lightning speed. Especially in the early design stages, time is of the essence. Only my hand can keep pace with the thought process. Massing Studies for an office building. Consider these studies, which help explain the massing evolution. Rational drawings like these, with precise measurements, have a short-lived use, but complement looser drawings and studies. While a pen sketch effectively communicates my design solution, in some cases I turn to pencil and watercolors. The soft and appealing nature of this medium pulls the audience into the process. Its painterly style evokes emotion. They can complete the picture in their own way. This harkens back to the title: This leaves certain pieces up to the imagination. Sectional perspective, Greenfield Community College. As humans we all yearn for authenticity. A design process that starts with the hand, akin to the first brush strokes on a canvas, humanizes the process and establishes a strong foundation for the later stages where computer generated precision takes precedence. So while drawing is paramount to my process, technology also plays a leading role. But starting at a computer would be like putting the cart before the horse. With a relentless passion for art and design, he inspires his teams through thoughtful, well-crafted design solutions. GenslerOn Gensler Published by Gensler, a global design firm with 5, practitioners networked across five continents, GenslerOn features insights and opinions of architects and designers on how design innovation makes cities more livable, work smarter, and leisure more engaging. For more blog posts, visit:

Chapter 9 : How to create the perfect design process | Creative Bloq

The 5 Phases of the Architectural Design Process At De Biasse & Seminara Architects, PC, we make it our mission to layout the process of working with us as clearly and succinctly as possible. That way you can gain an understanding of how we operate from the initial consultation all the way through construction administration.

The TeachEngineering hands-on activities featured here, by grade band, exemplify the engineering design process. Engineering for Efficiency Cars: Engineering for Efficiency Students learn how the aerodynamics and rolling resistance of a car affect its energy efficiency through designing and constructing model cars out of simple materials. As the little cars are raced down a tilted track powered by gravity and propelled off a ramp, students come to understand the need Invent a Backscratcher from Everyday Materials Invent a Backscratcher from Everyday Materials In this activity, students create devices to get "that pesky itch in the center of your back. Clean Enough to Drink: Making Devices to Filter Dirty Water Students act as engineers contracted by NASA to create water filtration devices that clean visible particulates from teacher-prepared "dirty water. Straw Towers to the Moon Straw Towers to the Moon Students learn about civil engineers and work through each step of the engineering design process in two mini-activities that prepare them for a culminating challenge to design and build the tallest straw tower possible, given limited time and resources. In the culminating challenge tallest straw t Grades Engineering a Mountain Rescue Litter Engineering a Mountain Rescue Litter Students build small-sized prototypes of mountain rescue littersâ€”rescue baskets for use in hard-to-get-to places, such as mountainous terrainâ€”to evacuate an injured person modeled by a potato from the backcountry. Groups design their litters within constraints: Biodomes Engineering Design Project: Lessons Biodomes Engineering Design Project: Lessons In this multi-day activity, students explore environments, ecosystems, energy flow and organism interactions by creating a scale model biodome, following the steps of the engineering design process. Water Bottle Rockets Water Bottle Rockets Students are challenged to design and build rockets from two-liter plastic soda bottles that travel as far and straight as possible or stay aloft as long as possible. Guided by the steps of the engineering design process, students first watch a video that shows rocket launch failures and then partic Grades Saving a Life: Heart Valve Replacement Saving a Life: Building on what they learned in the associated lesson about artificial heart valves, combined with the testing and scoring of Clay Boats Clay Boats Students use a small quantity of modeling clay to make boats that float in a tub of water. The object is to build boats that hold as much weight as possible without sinking. In the process of designing and testing their prototype creations, students discover some of the basic principles of boat desi Ups and Downs in Design Students design, build and test looping model roller coasters using foam pipe insulation tubing. They learn about potential and kinetic energy as they test and evaluate designs, addressing the task as if they are engineers. Winning designs have the lowest cost and best aesthetics. Creative Crash Test Cars Creative Crash Test Cars Students explore how mass affects momentum in head-on collisions and experience the engineering design process as if they are engineers working on the next big safety feature for passenger cars. They design, create and redesign impact-resistant passenger vehicle compartments for small-size model car Grades Convertible Shoes: Function, Fashion and Design Convertible Shoes: Function, Fashion and Design Student teams design and build shoe prototypes that convert between high heels and athletic shoes. They apply their knowledge about the mechanics of walking and running as well as shoe design as learned in the associated lesson to design a multifunctional shoe that is both fashionable and function Building Arduino Light Sculptures Building Arduino Light Sculptures Students gain practice in Arduino fundamentals as they design their own small-sized prototype light sculptures to light up a hypothetical courtyard. They program Arduino microcontrollers to control the lighting behavior of at least three light-emitting diodes LEDs to create imaginative light displ Students explore energy efficiency, focusing on renewable energy, by designing and building flat-plate solar water heaters. They calculate the efficiency of the solar water heaters during initial and final tests and compare the efficiencies to those of models currently sold on the market requiring Boom Construction Boom Construction Student teams design their own booms bridges and engage in a friendly competition with other teams to test their designs. Each team strives to design

a boom that is light, can hold a certain amount of weight, and is affordable to build. The engineering design process is a series of steps that guides engineering teams as we solve problems. The design process is iterative, meaning that we repeat the steps as many times as needed, making improvements along the way as we learn from failure and uncover new design possibilities to arrive at great solutions. What is the problem to solve? What do we want to design? Who is it for? What do we want to accomplish? What are the project requirements? What are the limitations? What is our goal?