CRAFTY CONNIE'S HOT GLUE GUN EXPERIENCE

LESLEY SCHORPP AND MATTHEW RHODES
University of Virginia, Charlottesville, VA 22903 USA

Crafty Connie was sitting quietly in the shade of a large oak on the University of Virginia's lawn reading over her anthropology notes. Cool Craig walked smoothly up to Connie and took a seat on the soft grass. Connie could hardly breathe. Here was the boy she had a crush on for two semesters sitting next to her! Craig coolly introduced himself and then asked if she would like to attend a spring benefit dance with him the following Saturday night. Connie barely managed to gasp out a yes, with an emphatic nod. "Wear something springy," he suggested as he walked towards Cabell Hall.

In the next few days, Connie could think of nothing else except her impending date, and the problem of what to wear in order to impress Cool Craig. Her roommate, Stylish Selena, had lent her a beautiful silk flowered spring dress, but Crafty Connie had no idea what to do with her hair. While she was sitting in her room one night, staring at a set of small silk butterflies she had taped to her wall, she had an idea. If there was some way to attach the butterflies to bobby pins, she could put them around a bun in her hair. That would surely do the trick. Cool Craig would think she was the belle of the ball. But how could she get them to stay? Elmers glue would never hold the butterflies and super glue was too risky for something that was going in her hair. What she needed was a hot glue gun.

She hopped in her sporty sedan and drove to Wal Mart. At Wal Mart her eyes were assaulted with all different types of glue guns. She finally settled on a Black and Decker trigger feed hot glue gun. As she settled down in her dorm room to assemble her hair clips, she wondered, "How does such a large, plastic-like rod turn into a thin melted line of glue?" She took the problem to her RA, Phyllis the Physics major, who began to outline the inner workings of the hot glue gun.

Together the two women sat down and began to disassemble the trigger feed glue gun. They realized the hard blue plastic shell of the gun was actually two pieces that could be separated by prying apart the tabs connecting the two pieces. Crafty Connie inserted a small screwdriver in between the two tabs. By using the screwdriver as a lever, she was able to pop the shell of the glue gun open. Phyllis the Physics major decided the easiest way to describe the workings of the glue gun would be to describe the individual pieces before describing the components' relationship to one another.

The first thing they examined was the blue plastic shell. The inside of the shell revealed that it had been molded to hold all the other pieces in their proper positions. The whole gun fit together like the pieces of a jigsaw puzzle. Attached to the whole gun, was a small wire prop that held the glue gun upright while it was warming up. Inside the gun, was a small wire spring connected to a large, orange plastic trigger. A metal pulley was attached to the plastic trigger. This pulley system connected the trigger with a plastic "O" ring that Crafty Connie believed pushed the glue stick into the gun. Another "O" ring was found at the back of the gun, through which the glue stick was initially slipped and held in place.

Directly across from the second "O" ring, Connie and Phyllis found an orange plastic cylinder, which stabilized the glue as it passed into the cast aluminum "oven".

"Connie, from the looks of the glue gun, everything is put together to work off the previous piece. I think you are ready to discuss how this glue gun really works,"

explained Phyllis. She pointed to the prop that held the glue gun up while it warmed up. "In terms of physics, Connie, this can be seen as a seesaw of sorts."

"How is that?" questioned Connie.

"Well, the weight of the handle is greater than that of the nose of the gun. The prop acts as a metal pivot. The greater weight of the handle forces the handle down, while the nose remains upright. This is the same thing that happens when a heavier child sits on one end of a typical seesaw, while a lighter child sits on the opposite end. In physics, weight is defined as the object's mass multiplied by the acceleration due to gravity. For any object falling near the earth's surface, the downward acceleration is 9.8 m/s^2, no matter what the mass of the object is."

"Okay, I understand how the prop works, but how does the trigger work?" questioned Crafty Connie.

"The plastic trigger of the glue gun is attached to the metal pulley we have already looked at. As your finger does work on the trigger…"

"What do you mean, 'does work'?"

"To "do work" on an object in physics means to exert a force on an object and have that object move in the same direction of that force. When you depress the trigger, the trigger moves down, the same direction as the force you exerted. Since the pulley system is connected to the back of the trigger, when the front of the trigger goes down, the back of the trigger (where the pulley is connected) goes up. The pulley connects the trigger to the "O" ring that advances the glue stick forward. As the trigger goes down, the pulley pulls the "O" ring forward and advances the glue stick into the heating oven. We will exam the oven in a minute."

"Wow Phyllis, I think I understand this. What next?" Crafty Connie questioned.

"Well, as the glue stick is advanced by the "O" ring and the trigger, it moves through the long, orange plastic cylinder I showed you earlier. This cylinder is connected to the cast aluminum oven, and guides the glue stick into the heating chamber. Let's look at that piece next."

Phyllis removed the double-barreled cast aluminum-heating chamber that had been fit into the plastic molded shell of the glue gun.

"The heating element of the glue gun, which we will see is a resistor, is placed in the lower barrel of the chamber that is provided with heat from the electricity provided from the wall socket. In the upper barrel, as the glue stick advances, it passes over this heating element and is melted."

"But how does electricity turn into heat?" questioned Crafty Connie.

"Well, to answer this question, we must first start with the wall plug. The wall plug is made up of two electricity-conducting metal prongs covered in a thick plastic coating. Each prong is attached to a wire, which allows alternating current to flow from the electric company into the glue gun. This alternating current brings positive electrical charges carrying energy through one wire, and deposits the energy on these two metal rods," explained Phyllis, as she pointed to two aluminum rods which she withdrew from the bottom chamber of the heating oven. Between these two aluminum rods, was a flat piece of heat conducting ceramic.

"What does this do?" asked Crafty Connie.

"This piece of ceramic, which acts as a resistor, is sandwiched between the two aluminum rods carrying the positive charges to and from the electrical company. As positive charge and energy is deposited onto the piece of ceramic, the ceramic begins to get warm. Positive charges without energy flow out of the heating system and return to the electrical supply. It is a well-known law in physics that energy can be

converted into many different forms, but can never be lost. Do you know how this energy is converted into heat?"

"Well, I don't know, but I'm sure there are equations and explanations for this conversion. Do you know them?"

Phyllis smiled. "Let me see if this helps, Connie. First, you should know that the function of a resistor, which this piece of ceramic is, is to hinder the flow of the electric current and convert some or all of the energy into heat energy. As current flows through a resistor, it loses energy and the resistor becomes warm. More simply put, when a big current loses a lot of voltage, something will get hot."

"What do you mean 'when the current loses a lot of voltage?" asked a puzzled Crafty Connie.

" A resistor is basically two wires that are connected by a poor conductor of electricity, in this case, the sandwiched piece of ceramic. Current flows through the ceramic, a poor conductor, only if there's an electric field moving it forward. The larger the resistance of the ceramic, the less current that flows through it, resulting in a voltage drop. Therefore, the voltage drop equals the voltage before the resistor minus the voltage after the current flows through the resistor. The actual resistance of this ceramic piece, which we cannot measure without the proper equipment right now, would be found by dividing the voltage drop by the current flowing through it. This would be measured in ohms."

"I get it, so for the voltage drop in my glue gun, not much current is carried and this results in heat that melts the plastic, right?"

"Exactly, now you're catching on. There's one more piece here in the lower barrel that we haven't looked at though. It's this hard, plastic cylindrical casing surrounding the two aluminum rods and ceramic resistor. Why don't you try and burn the plastic before I explain its function.

Phyllis handed Connie a lighter and the plastic encasement. Connie held the plastic over the flame for several seconds, but could not get the plastic to flame.

"Why won't it burn Phyllis?"

"Well, just think what would happen if it did, the whole gun could catch on fire. The plastic encasement is a heat conductor. It can withstand high temperatures in order to conduct the heat created in the bottom chamber into the upper chamber. It also protects the heating element from scraping against the inside of the cast aluminum-heating chamber.

Connie picked up the double-barreled heating oven and inserted the two aluminum rods with the ceramic sandwiched between back into the plastic encasement and back into the lower barrel.

"So the electricity is carried from the wires into the two rods where energy is deposited and converted into heat because of the voltage drop caused by the ceramic resistor. This heat is then transferred to the upper chamber by the plastic conductor, and that melts the glue in the upper chamber, right?"

"That's correct. Now can you tell me what this material surrounding the entire heating unit would be for?" quizzed Phyllis the Physics major.

"Well, I guess it protects the plastic shell from the heat. Since the oven is made out of a metal that would conduct the heat, wouldn't it melt the shell if there was nothing between the oven and the plastic shell?"

"Yes, it would. This white material is wrapped around the oven and is what we call an insulator. It is made of woven glass fibers that resist the propagation of heat. Glass is a poor conductor of heat anyway, but by reducing it to an entanglement of

fibers, it makes it even harder for the heat to get through. It is difficult to explain how insulators work without a firm understanding of an atom's nucleus. An atom's nucleus has a set of valence and conduction levels through which electron's move. In an insulator, the set up of the valence and conduction levels prevents the movement of electrons. Hence, in the case of the glue gun's insulator, the glass fiber material, the insulator keeps the thermal energy away from the shell."

"I think I understand what you are saying. I am glad the insulator is made of those long strings of glass to trap the heat, because the box says the gun can get up to 380 degrees Fahrenheit, and I wouldn't want to burn my hand."

" Here," said Phyllis, "try to burn it with that lighter I gave you."

Connie held the insulator up to the flame for several seconds. The insulator did not flame, but the outer layer scorched.

"Now see how the insulator did not burn, Connie. It would have melted if you left the flame on it long enough, but it will not catch on fire. It is performing its intended purpose."

"I see, so if I left the gun on for too long an extended period of time, the insulator could melt and cause the gun to malfunction, right?"

Phyllis nodded her head, and said, "That's why you have to unplug it after every time you use it. The last part we need to discuss is the nose of the glue gun."

"The shape of the nozzle reminds me of the funnel my mom uses when putting gasoline into our lawn mower."

"Very observant. The glue is melted by the heat coming from the bottom chamber and conducted by the plastic heat-conducting encasing. However, the glue is not much use as a large blob, so it needs to be made into a thin, workable line of glue. By gradually decreasing the diameter of the nozzle, it can be made to come out of the small opening at the end of the nozzle in this thin workable line of glue. This is how you can use such a large plastic rod to affix your butterflies onto the thin bobby pins. What good would a large thick blob of glue be? This way, you do not need to manipulate the blob into something usable. The glue gun does it for you. Do you understand?"

"I think so, let me see if I can briefly explain what you just told me," said Crafty Connie. " The prop attached to the outside of the plastic shell acts as a pivot. Since the side of the gun with the handle and trigger is heavier, the nozzle points up. As I do work on the trigger by pushing it down, the trigger does work on the pulley, then pulls the "O" ring forward. The "O" ring advances the glue stick into the orange plastic cylinder that stabilizes the glue stick as it enters the upper barrel of the heating unit. Alternating current from the power company flows into the plug and through the wires. The current enters with a positive charge with energy and leaves with a positive charge with no energy. The energy is deposited on to those two aluminum rods. The ceramic piece sandwiched between the two rods acts as a resistor. This resistor creates a voltage drop that results in the production of heat. The heat is then conducted by the plastic encasing into the upper chamber, melting the glue. The entire chamber is surrounded by the glass fiber insulator, which keeps the outer shell from melting. The final step is for the melted plastic to pass through the nozzle into a thin workable stream of glue. Did I get it right?"

"Yup, those are the basics of your glue gun. Now, I guess we need to put this back together, or how else are you going to glue those butterflies on?"

Satisfied with her understanding of the glue gun, Connie smiled and nodded her head. Crafty Connie and Phyllis the Physics major reassembled the glue gun.

"Thank you so much for your help Phyllis. I should probably go try and assemble my hair clips before I go to bed. The dance is tomorrow. I don't want to wait till tomorrow and have anything go wrong."

"No problem Connie. I think that is a good idea. Have a great time at the dance, and I'm sure everything will work out okay. Feel free to come back with any questions. Make sure you let the glue cool, so it sets back into the hard plastic and sets the butterflies onto the bobby pins. Good night, I'm glad I could help," concluded Phyllis

The next night, Phyllis watched from her open door, as Cool Craig walked slowly up to Crafty Connie's door and nervously knocked. Connie answered the door in Stylish Selena's flowing dress, her hair adorned with several small butterflies, successfully attached to small bobby pins. "Wow, you look beautiful. How's you get those butterflies to stay?" marveled Cool Craig.

"Oh, my RA helped me. It actually wasn't nearly as hard as I had thought," explained Crafty Connie. She winked over Cool Craig's back at Phyllis the Physics major as they walked, hand in hand, out the door. Phyllis smiled and shut the door. Later that night, she saw Craig return a smiling Connie to the dormitory, with butterflies still dancing on her head.

