GRIT FOUNDATION

GRIT Camp Guide

For Hosts, Mentors, and Volunteers

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WHAT IS A GRIT CAMP?

GRIT Camp is a hands-on, adventure-style experience designed for youth ages 12–17 to explore the basics of the skilled trades—from carpentry and pipefitting to electrical work and component disassembly. Each Student gets a blueprint (their adventure map) and works step by step to fill in the missing pieces, learning and applying new skills along the way to bring their project to life. By the end of camp, they'll add their own creative touch with craft materials and take home something they built themselves.

Our goal is to spark curiosity and give young people a positive, real-world glimpse into the skilled trades—all in an approachable, bite-sized way. GRIT Camps are guided by experienced tradespeople and technicians who are background-checked and trained in safety, creating an encouraging space where kids can build confidence, skills, and maybe even foster a desire for a future in the trades.

THE CHALLENGE/STORY OF GRIT CAMP

For too long, the skilled trades have taken a back seat to the traditional college path. College can be the right fit for some, but it's a significant investment of time and money, and it simply isn't the best choice for everyone. The trades open doors for people who like to work with their hands, build things that matter, and avoid the weight of student loan debt. Our communities rely on these hands-on problem solvers to keep us sheltered, safe, and healthy.

GRIT Camp is built on this idea. The camp challenge places students in a “what-if” world where skills like carpentry, electrical work, pipefitting, air conditioning, and plumbing have been forgotten, and the science behind them has also been lost. With blueprints full of missing pieces and clues, students team up with mentors to figure things out step by step, learning how to measure, cut, connect, and build as they bring the project back to life. Our mentors are there to guide, encourage, and keep it safe for the students—but they won’t do the work for them. That’s the heart of GRIT: letting young people tackle real problems with their own hands, building confidence, curiosity, and practical skills that last a lifetime.

About the GRIT Foundation

The GRIT Foundation is a registered 501 (c) (3) nonprofit organization.
EIN: 33-1405549
Contributions are tax-deductible to the extent permitted by law.

Effective Date of Exemption: October 9, 2024
Public charity status: 170(b)(1)(A)(vi)
Organization Name: The GRIT Foundation

GRIT CAMP ROLES & SPACES

HOST
Definition: The individual or company organizing and supporting the GRIT Camp event.

Responsibilities:

- Coordinate the camp date, time, and location
- Provide the facility and space for hands-on modules
- Act as the main point of contact with the GRIT Foundation
  - Alternatively, the Host can delegate another individual to act as the lead and manage responsibilities and communication
- Recruit Mentors **(skilled tradespeople or field techs)**; plan for 1 Mentor per 2 Students plus a floater/back-up Mentor
- Recruit Students **(up to 15 Students max per GRIT Camp)**
- Recruit at least one Volunteer (in addition to the Mentors) to help support event-day logistics (sign-in, waivers, Station and Staging Area setup)
- Ensure tools, materials, and PPE are purchased, ready, and available

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MENTOR
Definition: A tradesperson guiding **Students** through the hands-on modules.

Responsibilities:

- Guide 1–2 Students through the modules at each Station (i.e., a space/table where 2 Students work and build with 1 Mentor)
- Use the GRIT Camp Guide and Socratic Method to teach (ask thought-provoking questions rather than give direct answers or prescriptive direction)
- Model curiosity, problem-solving, and hands-on engagement
- Review the GRIT Camp modules in advance
- Complete a background check with Checkr prior to GRIT Camp participation
  - Checkr sends a link to the email address entered into the GRIT signup form
- Support a positive, safe, and encouraging learning environment

Note: Mentors should NOT be alone with a Student out of view at any point.

STUDENT
Definition: A youth participant exploring the trades through hands-on learning.

Responsibilities:

- Actively participate in each module and discussion
- Follow all safety protocols and wear PPE at all times
- Ask questions and work collaboratively with their Mentor
- Show respect for tools, materials, and peers
- Embrace hands-on learning and give their best effort

ADMIN/VOLUNTEER ASSISTANT
Definition: An individual supporting the Host with event-day logistics and general assistance.

Responsibilities may include:

- Helping with camp setup and cleanup
- Photography
- Managing sign-in/sign-out
- Assisting with food, water, and supplies
- Providing general support to the Mentors and Students as needed

Note: Admin/Volunteers are **NOT** Mentors and **do not guide Students through modules**. They also do not need to complete a background check. They should also NOT be alone with a Student out of view at any point.

STATION
Definition: A small workspace where 2 Students are paired with 1 Mentor to build their project together. Each Station should have the basic tools and materials needed for the module that the Students are working on.

Plan to have 1 Station for every 2 Students who sign up (e.g., 10 Students = 5 Stations, etc.).

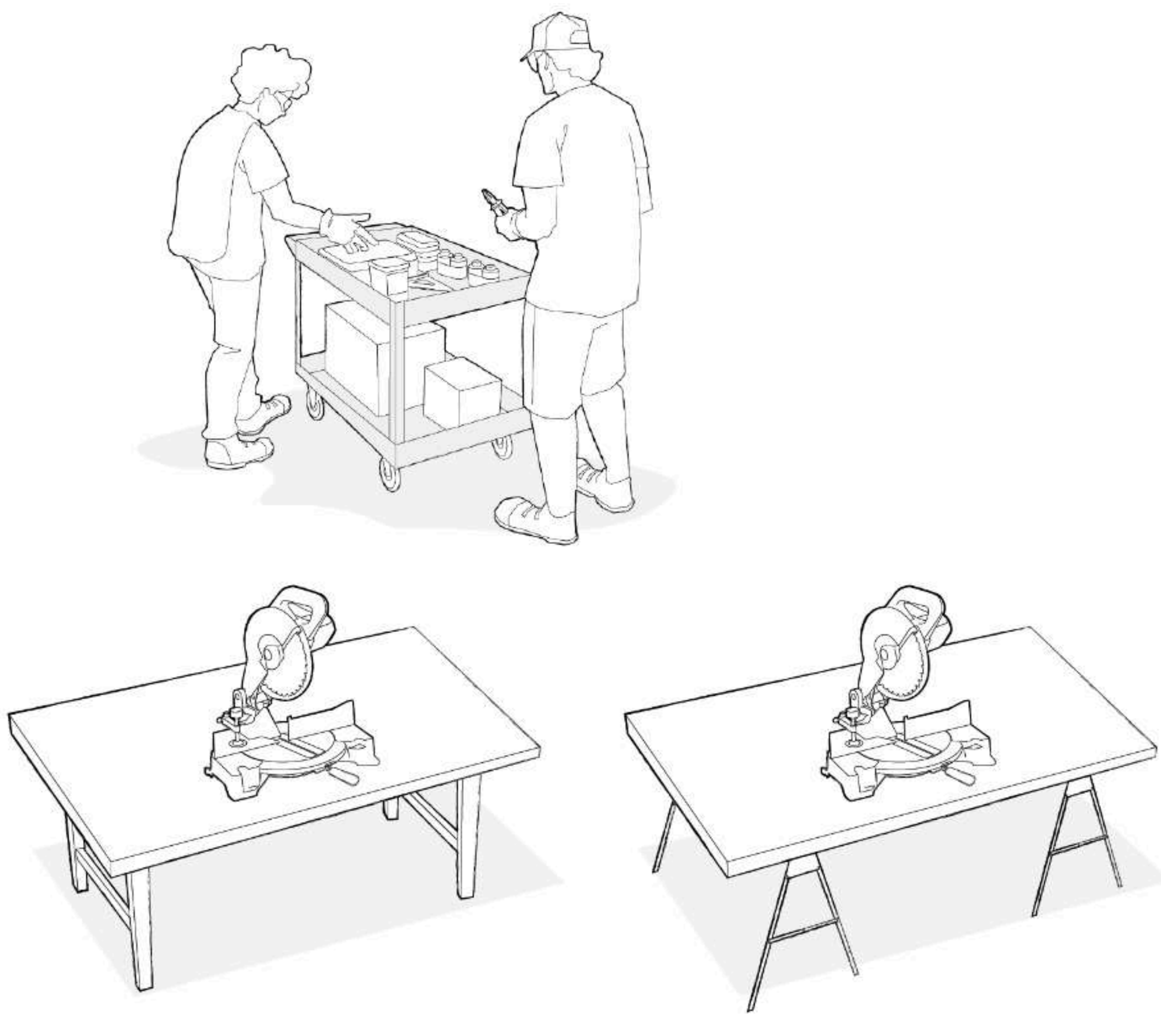
STAGING AREA(S)

Definition: Shared spaces within the camp that hold larger tools/materials (e.g., table saws, lumber, copper, PVC, sealants, hand tools, fittings, etc.) for all Students and Mentors to share and gather as needed.

The area(s) will include:

- Table saws or miter saws (shared by all Students, supervised by Mentors)
- Larger pieces of lumber, copper, or PVC
- Extra hand tools and supplies

Students and Mentors will move between their Stations and the **Staging Area(s)** as needed during each module.



MASTER MATERIALS LIST

This materials list is a comprehensive list of all the tools that will be provided by GRIT and the Host. It categorizes materials by purpose so that you can source them more easily. Feel free to copy this list and use it as a checklist. Setup and preparation by module will be covered in the **Mentor and Host Preparation** section starting on page 13, along with a checklist for each module starting on page 64 in **Appendix B**.

GRIT provides all Student safety PPE, blueprints, some personalized tools, and electrical kits. These specific items—as well as other items that GRIT may be able to loan upon request—are listed below the host contractor's material list.

Host Contractor Provides:

Safety Items

- ☐ Hair ties (in case the Student missed safety rules on the signed waiver form)
- ☐ Fire extinguishers (1–2x throughout the facility/space)
- ☐ Fire blankets (at LEAST 1–2x throughout the facility/space; ideally 1x at each torch Station)
- ☐ Bucket(s) of water (1x per Station)
- ☐ Cloth rags (4x rags per Station)
- ☐ First aid kit
- ☐ Low-level carbon monoxide (CO) monitor (at least 1x wall-mounted or personal if torch work must be done indoors)

General Setup Items

- ☐ Tables (1x folding or sturdy work tables per Station and Staging Area)
- ☐ Chairs (minimum 1x per Student, include extras for lunch and Volunteers)
- ☐ Facility to handle the camp in the event of rain or sun (e.g., warehouse or large tents)
- ☐ Outdoor heaters or fans (**optional**; depends on the weather and season)
- ☐ Signage for restrooms & the event (clearly labeled signs or banners)
- ☐ Rolling whiteboard w/ dry-erase markers & erasers for Host to use as signage throughout the camp area (**optional**; depends on Host's preferences)
- ☐ Extension cords & power strips
- ☐ Trash cans (highly suggest 2–4x large cans spread out in the event area)
- ☐ Cleanup supplies (brooms and dustpans, garbage bags, paper towels, wet wipes)

Photography for Final Customization Module

- ☐ Polaroid/Fujifilm-type instant mini camera
- ☐ Instant mini film (minimum of 70x sheets/exposures for at least 5x pictures per Student)

Administration & Documentation

- ☐ Digital photography/videography by designated photographer/volunteer (**optional**; depends on Host's preferences)
- ☐ Markers for labeling (for writing signage on whiteboards or posters throughout camp space, etc)

Large or Hazardous Machine Power Tools and Torches

- ☐ Miter saws or table saws w/guards (**1x table or miter saw for every 4x Students; 3x for camps with 12+ Students**)
  - ☐ Sawhorses or another cutting platform (at least 2x platforms for wood cutting Stations)
- ☐ Bar clamps (for holding down 2x4s—2x clamps per saw table)
- ☐ Drill with ½" chuck (1x per Station; Mentors may bring their own if they choose)
  - ☐ T25 bit (1x per Station)
- ☐ ⅞" Forstner bit (1x per Station)
- ☐ 1 ⅛" Forstner bit (1x per Station)
- ☐ Air-acetylene torch rigs w/ proper tips (1x per Station; Mentors may bring their own)
  - ☐ Tips for torch rigs: Brazing copper - TurboTorch A-8 (1x per Station)
  - ☐ Tips for torch rigs: Soldering aluminum - TurboTorch A-3 (1x per Station)
  - ☐ Optional alternative: Propane torch (1x per Station; Mentors may bring their own)
- ☐ Igniters or strikers (friction or push-button spark; 1x per Station)

Building Materials

- ☐ 2x4 lumber cut down to 5 ft lengths (1x per Student)
  - ☐ Drops or unused pieces can be used for discovery
- ☐ Various sizes and shapes of lumber samples for discovery (**optional**; Host's preference)
  - ☐ Short off-cuts in different lengths (1/2 ft, 1 ft, etc.)
  - ☐ Pieces of 2x6 or 1x4 in softwood and hardwood
  - ☐ Scrap plywood squares or triangles
  - ☐ Blocks or dowels in different diameters
  - ☐ Rough-cut vs. finished/sanded pieces
- ☐ 17.5" x 12.5" luan backing or pegboard (**pre-cut prior to camp day**; 1x per Student)

- ☐ ¾” Schedule 40 PVC pipes (**do not pre-cut**; 1x 12–13” segment per Student)
- ☐ ¾” Schedule 40 PVC adapter, slip socket FPT, coupling (1x per Student)
- ☐ ¾” Schedule 40 PVC slip socket coupling (x1 per Student)
- ☐ ¾” Schedule 40 PVC cap (1x per Student)
- ☐ ⅞” OD soft copper tubing (**do not pre-cut; scrap or rolled copper is best**; 1x 12–13” segment per Student)
- ☐ Other pipe sizes and types for discovery (**optional**; depends on Host’s preferences)
  - ☐ ⅝” OD soft copper tubing
  - ☐ Scrap copper tubing
  - ☐ Galvanized steel
- ☐ ¾” copper sweat x ¾” NPT adapter (1x per Student)
- ☐ Pre-brazed copper ⅞” caps (1x per Student)
  - ☐ Caps with Schrader are **optional**; can be used for pressure testing (1x per Student)
- ☐ 0%, 5%, or 15% phos copper brazing rods
- ☐ Cored bricks or fire bricks (3x per Station)
  - ☐ Optional alternative: Tristand pipe chain vise
- ☐ Aluminum cans or thin aluminum sheets (at least 4x per Student, add more for discovery)
- ☐ Aluminum repair kit/rods (1x per Station)

Fasteners

- ☐ 3” T-25 torx head screws (10x per Student)
- ☐ 1 ¼” finish nails (10x per Student)
- ☐ Other fastener types and sizes for discovery/discussion (**optional**; will depend on Host’s preference)
  - ☐ Self-tapping screws
  - ☐ Drill point screws
  - ☐ Concrete screws
  - ☐ Roofing nails
  - ☐ Framing nails

Chemicals & Sealants

- ☐ PVC glue and primer cans taped together (1x set per Station)
- ☐ Teflon tape or pipe dope (multiple rolls in Staging Area)
- ☐ Penetrating oil spray (**only needed if doing disassembly**; 1–3x in Staging Area)

Hand Tools

- [ ] Speed squares (**optional**; for drawing straight lines and depends on Host; 1x per Station)
- [ ] Hammer (1x per Station)
- [ ] Emery cloth sandpaper (1x roll in Staging Area)
- [ ] PVC cutters (1x per Station)
- [ ] Copper tubing cutters (1x per Station)
- [ ] Copper deburring tools (1x per Station)
- [ ] Sharp awl (1x per Station)
- [ ] Swaging tools (**optional**; used if the Host chooses not to use caps; 1x per Station)
- [ ] Stainless steel wire brush (1x per Station)
- [ ] Pliers (1x per Station)
- [ ] Adjustable wrench (1x per Station)
- [ ] Needle-nose pliers (**optional**; may help with holding small items like nails in place)

Electrical Circuit Components & Tools

- [ ] AA batteries (2x for each Student's circuit kit)
- [ ] Extra batteries for discovery (mix of AA, AAA, and 9V, including dead and corroded)
- [ ] Electrical meters (at least 1x meters per Station, preferably 1x per Student)
- [ ] Extra circuit kits (**optional;** GRIT provides enough electrical circuit kits; 1x per Student)
- [ ] Extra light bulbs for discovery (small 3V DC bulbs, assorted good and defective)
- [ ] Scrap copper wire (**optional**; recommended for discovery)
- [ ] Toggle-style light switches (**optional**; recommended for discovery)
- [ ] Breakers (**optional**; recommended for discovery)

HVAC System Components

- [ ] Aluminum evaporator coil (**optional**; varies by availability but is highly recommended)
- [ ] HVAC blower wheel assemblies (**only needed if doing disassembly**; ideally 1x per Station but can also be done in groups of 4 Students)
- [ ] Condenser fan motor assemblies (**only needed if doing disassembly**; ideally 1x per Station, but can also be done in groups of 4 Students)

Craft items for Module 7 (Final Customization)—items listed as "optional" can be anything the Host prefers. Here are some ideas we've used before, but feel free to get creative and choose your own:

- [ ] Scissors
- [ ] Hot glue guns and sticks
- [ ] Paint markers (assorted colors)

- ☐ Scrap pieces of wire of varying gauges
  - ☐ #12 solid wire
  - ☐ #12 stranded wire
  - ☐ Thermostat wire (stripped and unstripped)
- ☐ Mounting or double-sided tape
- ☐ Decorative tape (**optional**; duct tape, masking tape, painter's tape, gaffer tape)
- ☐ Decorative items (**optional**; colored paper, stickers, etc.)
- ☐ Fairy lights (**optional**)
- ☐ Pipe cleaners/chenille stems (craft type) (**optional**)
- ☐ 65–80lb card stock sheets or purchased cardboard sheets (**optional—for use with ChompSaws**; regular cardboard boxes do not work)
- ☐ ChompSaws (**optional**; they are safe and a lot of fun for customizing the completed box frames—1–2x ChompSaws per GRIT Camp)

Lunchtime Activities - These items enhance the lunch module—the more you have, the better, but not every item is necessary:

- ☐ Food warming mat/hot plate
- ☐ Heat lamp
- ☐ HVAC School Fun Physics kit (items may also be bought separately):
  - ☐ Air cannons w/ paper cups
  - ☐ Hand boiler
  - ☐ Drinking bird w/ drinking cup
- ☐ Bernoulli bags
- ☐ Thermal imaging camera (**required**; infrared thermometer at minimum)
- ☐ Thermometer
- ☐ Tungsten, aluminum, and/or copper cubes of the same volume

Refreshments

- ☐ Lunch for Students/Mentors/Volunteers
- ☐ Disposable plates, cups, utensils, and napkins
- ☐ Bottled water and snacks
- ☐ Coffee and/or juice, donuts, etc.

GRIT Provides:

- ☐ Waivers

- ☐ Safety acknowledgement
- ☐ Background check (via Checkr for Mentors upon sign-up)

Student Kits—1x per Student (GRIT ships these kits to the Host prior to camp.)

- ☐ GRIT-branded tape measure
- ☐ Pre-sharpened carpenter pencil (with sharpeners)
- ☐ Permanent marker
- ☐ 11"x 17" GRIT Blueprint
- ☐ Student/safety badge
- ☐ High-visibility vest
- ☐ GRIT-branded tool belt
- ☐ Safety glasses
- ☐ Safety gloves
- ☐ Electrical circuit kit (with extras in case of out-of-the-box defects)
- ☐ GRIT-branded 6-in-1 screwdriver
- ☐ Earplugs

GRIT may also be able to loan some hand tools to Hosts, which would be shipped with the Student kits. These tools will be subject to availability, so please call to check whether GRIT has the tools; if they are readily available and ready for shipment, we will send them.

ADMINISTRATION & DOCUMENTATION (FOR THE HOST)

Since safety is our top priority, we require all Mentors who will be working with Students to undergo background checks and training to make sure they are trustworthy and have the knowledge and resources to Mentor the Students during the GRIT Camp event. **The Host or Host's point of contact is responsible for sharing the GRIT guide and online resources with any Mentors they recruit.**

GRIT Foundation requires all Mentors to complete a background check through Checkr. After a Mentor submits our registration form with their email, we'll send them a Checkr link to complete the process. Mentors will also upload a photo when they register, which we use to create their safety badge to be handed out at check-in on the day of the event.

This written guide contains useful information for Hosts, Mentors, and Volunteers regarding GRIT Camp preparation, procedures, and using the Socratic method as a teaching tool. **Hosts, share this guide with all Mentors and Volunteers to ensure a smooth and fun experience.**

HOST AND MENTOR PREPARATION

GRIT Camp is supposed to be a fun and thought-provoking educational camp. There are several modules and lessons covered in a short amount of time, so **at least 10–12 weeks of preparation is recommended**. This preparation time will mainly allow Mentors & Hosts to familiarize themselves with educational topics, learn how to use the Socratic method, and recruit Students to the camp. Mentors & Hosts will take an online course through SkillCat that prepares them for the procedures, concepts, and Socratic approach of the GRIT Camp.

There will also be some preparation required in relation to the execution of the GRIT Camp, such as gathering tools, materials, and setting up Stations and Staging Areas.

The GRIT Camp is designed for a **maximum of 15 Students** (**less is sometimes more**) and should have up to 8 Mentors, or a 1:2 ratio of **one Mentor for every two Students**, plus **one Mentor** to act as a floater who provides extra assistance when needed. This extra Mentor can also step in if a pre-assigned Mentor backs out or can't join at the last minute.

GRIT CAMP SETUP & PLANNING (FOR THE HOST)

GRIT Camp Hosts are responsible for recruiting the Mentors, Students, and Volunteers. GRIT will be responsible for collecting emergency contact information for each one in case of a major injury or medical event.

Since each facility will be different, GRIT Camp Hosts should have a bad weather plan in case Students need to take cover during outdoor activities. In the case of severe weather, Hosts should include an emergency plan that includes a safe interior area to shelter in place. GRIT Hosts must also provide a basic shelter plan and fire safety policy for torch use.

The GRIT Camp will take place over **two main areas**:

- One designated area for the safety briefing, electrical module, and lunch (preferably **indoors**)
- One large indoor/outdoor area for carpentry, pipefitting, torchwork, disassembly, and final kit customization (torchwork requires proper ventilation if done indoors; **if your facility does not have proper ventilation, you must set up the Stations outdoors** with weather optional coverage such as a large rental tent or multiple pop-up tents)

Within those larger areas, there will be "Stations" set up to accommodate small groups consisting of **one Mentor and two Students**. These Stations may be set up either on tables or on the floor with kneeling pads and "Staging Areas" for placing larger tools, supplies, and general items shared amongst the entire group.

General Setup and Weather Considerations

There are seven modules in the GRIT Camp, with one of them being optional (**Module 6, Disassembly**). Stations and Staging Area setup are detailed below, but here are some general setup considerations, including items for inclement weather:

- ☐ Chairs (1x per Student, including extras for lunch and Volunteers)
- ☐ Pop-up tents/rental tents/canopies (if hosting a camp outdoors and for weather proofing any Staging Areas or Stations being set up outside)
- ☐ Outdoor heaters or fans (depending on the weather)
- ☐ Signage for the event (clearly labeled signs or banners for check-in and restrooms)
- ☐ Extension cords & power strips (please ensure there is extension cord management for safety)
- ☐ Trash cans (minimum 2–4x large cans distributed about the entire camp area)
- ☐ Cleanup supplies (brooms, dustpans, garbage bags, paper towels, wet wipes)

Signage and Walkthrough

On the day of the GRIT Camp, signage should be posted to show where the check-in table and restrooms are located.

Have a pre-camp (an hour or two before it starts) on-site walkthrough for all Mentors, and a role delegation should be completed so that everyone understands their responsibilities. We will provide a sample role delegation checklist on pages 78–79 in **Appendix B**.

Station Setup

"Station" is a table (or area) designated for 1 Mentor and 2 Students to complete each module. Each Station should be pre-set with:

- ☐ Torch rig (strapped safely to table legs if possible)
- ☐ Bucket of water
- ☐ Cloth rags (4x)
- ☐ Drill (impact drills are ideal) and T-25 bit
- ☐ Hammer
- ☐ Speed square (optional)

Mentors may bring their own drills if they wish to do so.

Staging Area(s) Setup

Each GRIT Camp site should have at least two separate Staging Areas: one for materials and one for saws.

STAGING AREA #1: MATERIALS

Materials for Students/Mentors to gather from one Staging Area will include items such as:

- ☐ 2x4 lumber cut down to 5 ft length (1x per Student)
    - ☐ Include drops or unused and extra pieces
- ☐ Non-2x4 lumber samples for discovery (optional but recommended)
- ☐ 17.5" x 12.5” pegboard or luan backing (1x per Student)
- ☐ 3” T-25 wood screws (10x per Student)
- ☐ 1.25” finish nails (10x per Student)
- ☐ ¾” Schedule 40 PVC pipes (do not pre-cut; 1x 12–13” segment per Student)
- ☐ ⅞” OD soft copper tubing (do not pre-cut; 1x 12–13” segment per Student)
- ☐ All shared materials listed in the master materials list, such as sealants, glues, hand tools, fittings, etc., should be placed on easy-to-access tables or carts with enough quantities as listed below.
    - ☐ Emery cloth sandpaper (x1 per Student)
    - ☐ PVC glue and primer cans taped together (1x set per Station)
    - ☐ Teflon tape or pipe dope
    - ☐ PVC cutters (1x per Station)
    - ☐ Copper tubing cutters (1x per Station)
    - ☐ Copper deburring tools (1x per Station)
    - ☐ Sharp awl (1x per Station)
    - ☐ Swaging tools (**optional**; 1x per Station)
    - ☐ Stainless steel wire brush (1x per Station)
    - ☐ Pliers (1x per Station)
    - ☐ Adjustable wrench (1x per Station)
    - ☐ Needle-nose pliers (optional)
    - ☐ ¾” Schedule 40 PVC adapter, slip socket FPT, coupling (1x per Student)
    - ☐ ¾” Schedule 40 PVC slip socket coupling (x1 per Student)
    - ☐ ¾” Schedule 40 PVC cap (1x per Student)
    - ☐ ¾” copper sweat x ¾” NPT adapter (1x per Student)
    - ☐ Pre-brazed copper ⅞” caps (1x per Student)
    - ☐ 0%, 5%, or 15% phos copper brazing rods

- ☐ Aluminum cans or thin aluminum sheets (at least 4x per Student, add more for discovery)
- ☐ Aluminum repair kit/rods (1x per Station)

STAGING AREA #2: SAW TABLES

The second Staging Area should just be used for the miter or table saws:

- Miter or table saw
- Sawhorses or another cutting platform (at least 2x pairs)
- Wood clamps (bar clamps; at least 2x)
- Extension cords left undone (if needed; **be sure to avoid creating a trip hazard**)

This second Staging Area may also be designated for torch use if the Host does not have enough torch rigs for each individual Station.

CHECK-IN

Hosts should plan to set up a check-in table near the entrance of the facility or close to the challenge/introduction and safety briefing area. A volunteer should be at this table to check in Students and Mentors and hand out their custom safety name badges. This should feel like a special moment, as each person receives their official safety badge.

*The Host should plan for **Mentors** to arrive at least an hour before the start of GRIT Camp to walk through the facility and help with setup.*

Suggested time for a GRIT Camp is 9:30 am–3:30 pm, with Mentors arriving no later than 8:30 am.

Provide light refreshments, including snacks, juice, and/or coffee. Ideally, the table would also have small items or tools to generate interest in the GRIT Camp, such as a hand boiler or a drinking bird **(which is also used during the lunch module**), while Students await late arrivals.

The Host should have a clear plan for pairing Students with Mentors ahead of the GRIT Camp Event (1:2 ratio of 1 Mentor to 2 Students). Once everyone has arrived and received their safety name badges, the Host (or a designated volunteer) should gather the group, do quick introductions, and move to the Challenge Introduction, where they explain the role of the Mentor and pair them with the designated Students.

SETUP BY MODULE

Challenge Introduction

There are no materials associated with the challenge introduction, so no pre-staging is required. It should be approximately 10–15 minutes long and could take place in the same room where you introduce PPE and safety, or even in the check-in area. This space will be where Mentors and Students get paired and can begin asking icebreaker questions after the intro and get to know each other before moving to the Safety Module.

Module 1: Safety (GRIT provides these items and ships prior to camp)

Identify a location for the safety briefing, which is often the same area as lunch. For each Student, create a bundle at each Student's chair that includes the following, 1x per Student:

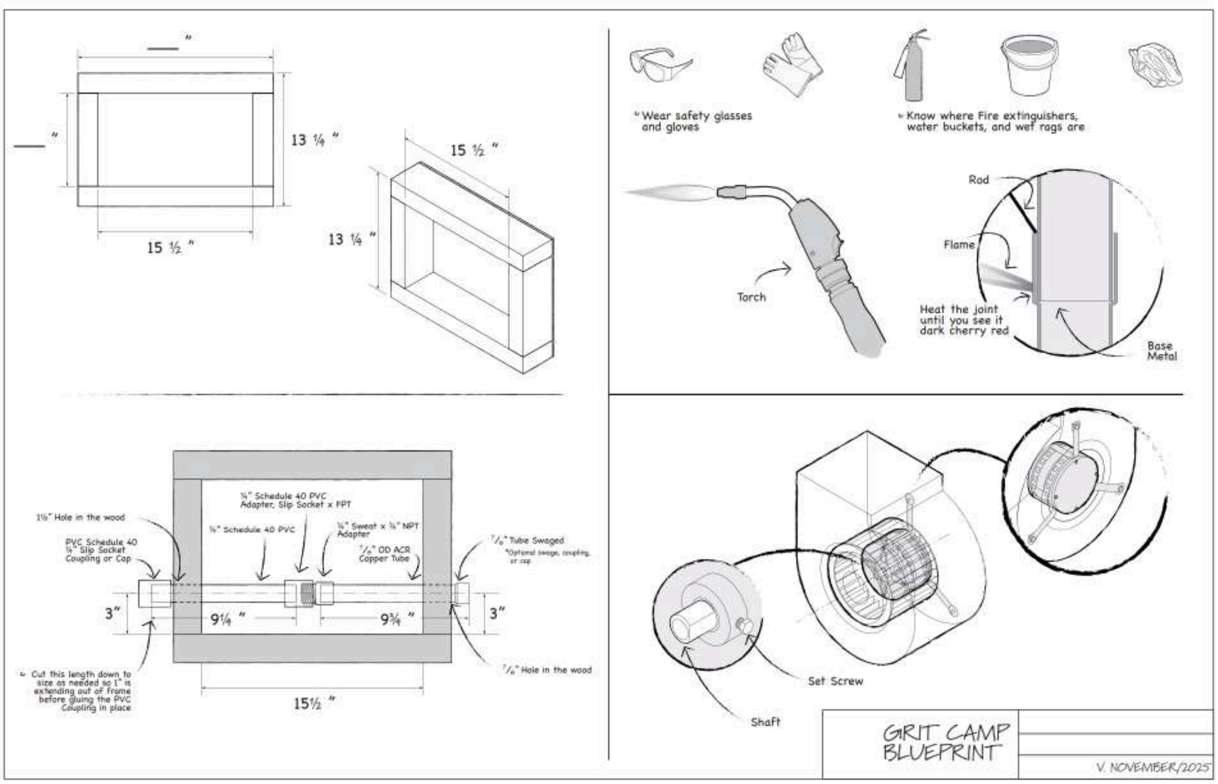
Safety Items

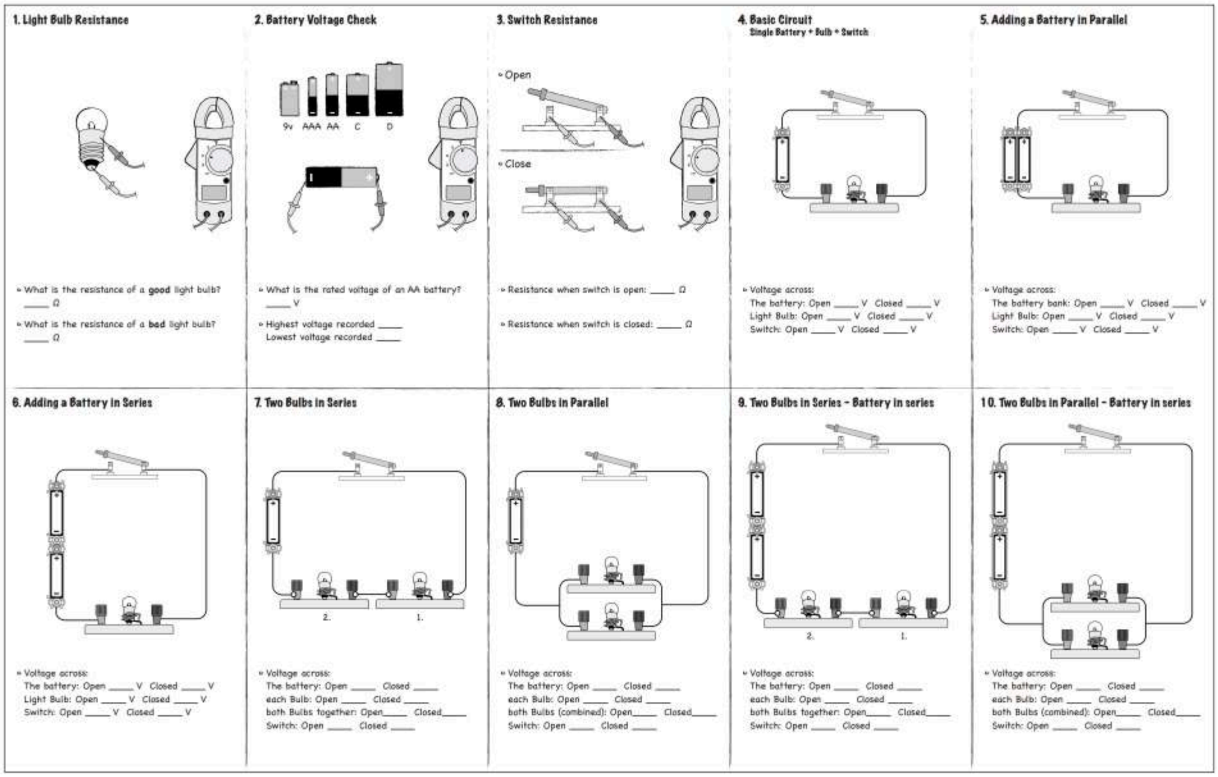
- [ ] Safety gloves
- [ ] Safety glasses
- [ ] High-vis safety vests
- [ ] Earplugs

Set aside the blueprints for distribution **after** the safety briefing:

Blueprint

- ☐ 11” x 17” GRIT Camp blueprint (**recommendation:** roll and secure with rubber bands)





Create tool bundles for distribution **after** all safety information has been covered and blueprints have been distributed:

Tools

- ☐ GRIT-branded tool belt
- ☐ GRIT-branded tape measure
- ☐ Pre-sharpened carpenter pencil
- ☐ Permanent marker
- ☐ GRIT-branded 6-in-1 screwdriver

Optional Setup Tip:

The tool belts can hold all items, but if desired, you can use small cardboard boxes (or a similar method) to organize each Student's GRIT personal items. These can be placed at each Student's chair with their safety bundles after they've completed the safety briefing, and each Student can move their box to their Station for easy access once they have received their PPE and completed their safety acknowledgment. If you use boxes, have each Student write their name on their own. The box will serve as their personal spot to keep tools during the camp.

Throughout the day, the Volunteer taking Polaroid photos can place each Student's mini Polaroid pictures in their box. This method keeps everything together and makes it easy for Students to use the photos during the final customization module**. If the Volunteer doesn't know all the Students by name, the photos can be sorted by face and set out on a table; Students can pick them up before the final customization module.**

At the end of the safety briefing, each Student will pick up their personal blueprint/adventure map and head to their assigned Station with their Mentor. From there, they'll move into Module 2: Carpentry, where Mentors will walk them through the blueprint.

Module 2: Carpentry

Several of the materials in Module 2 should be in the Staging Area(s), including:

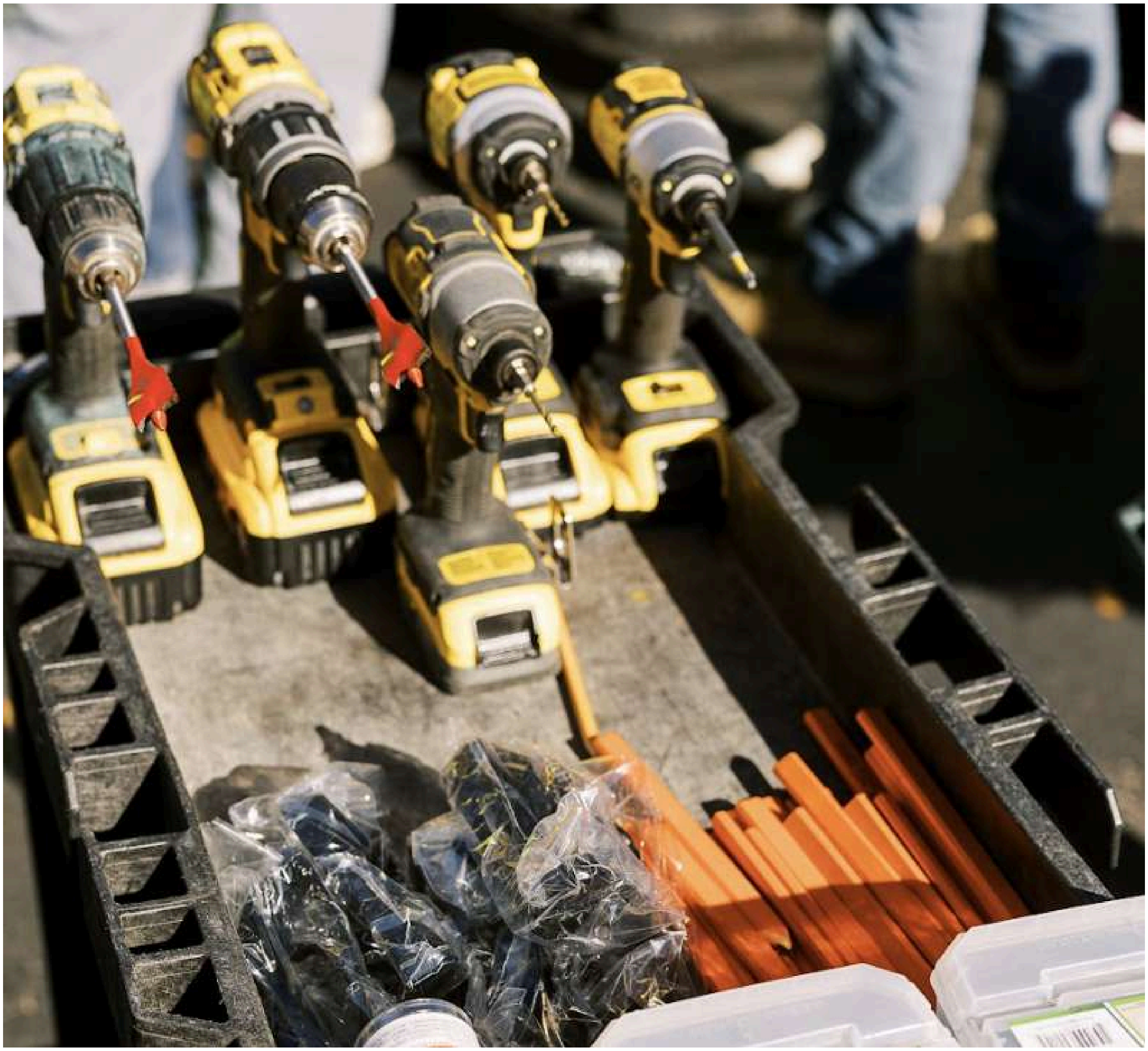
- ☐ 2x4 lumber cut down to 5 ft length (1x per Student; should be in Staging Area #1)
- ☐ Non-2x4 lumber samples for discovery (**optional**; should be in Staging Area #1)
    - ☐ Short off-cuts in different lengths (1 ft, 2 ft, etc.)
    - ☐ Pieces of 2x6, or 1x4 in softwood and hardwood
    - ☐ Scrap plywood squares or triangles
    - ☐ Blocks or dowels in different diameters, and rough-cut vs. finished/sanded pieces.
- ☐ 17.5" x 12.5" pegboard or luan backing (1x per Student and pre-cut by Hosts or Mentors before camp)
- ☐ 3" T-25 wood screws (10x per Student)

- ☐ 1.25” finish nails (10x per Student)

Stations should ideally have the following (if there isn’t enough for 1x per Station and Students will need to share, these items can also be placed in the Staging Area with the lumber):

- ☐ Drill (1x per Station)
- ☐ T-25 bit (1x per Station w/ drill)
- ☐ Hammer (1x per Station)

- [ ] Speed square (optional; 1x per Station)



Please note that the Student GRIT kits that are distributed during the safety briefing come with sharpened carpenter pencils and markers that they will use during Modules 2 and 3. These should be stored in the Students' tool belts or boxes.

Identify an outlet for the saw and place it on a table in a Staging Area with the guard on. The clamps should stay in this location as well. Plan to use a power strip if needed, and ensure that the saw is unplugged **EXCEPT** when in use with Mentor supervision; a Mentor or adult Volunteer should be present at this part of the Staging Area at all times.

Module 3: PVC, Copper, and Aluminum Fitting & Repair

Outside or in an open shop/warehouse-type environment, set up the **Stations** (with tables or kneeling pads) with the following:

- ☐ Buckets of water (1x per Station)
- ☐ Disposable rags (4x per Station)
- ☐ Drill (1x per Station)
- ☐ ⅞” wood-drilling Forstner bit (x1 per Station w/ drill)
- ☐ 1 ⅛” wood-drilling Forstner bit (x1 per Station w/ drill)

Please have fire extinguishers and fire blanket(s) available and nearby Stations. Fire blankets would ideally be <u>ON</u> the tables or ground—underneath the project—where brazing or soldering is happening.

Since Module 3 is large and consists of three different skills, we will divide the Staging Area prep into 3A (PVC), 3B (copper), 3C (joining PVC and copper), and 3D (aluminum repair). Have the following items in the Staging Area for the Mentors and their two Students each to grab and take back to their respective Stations (grouped by module segment):

3A - PVC

- ☐ ¾” Schedule 40 PVC pipes (not pre-cut; 1x 12–13” segment per Student)
- ☐ ¾” Schedule 40 PVC adapter, slip socket FPT, coupling (1x per Student)
- ☐ ¾” Schedule 40 PVC slip socket coupling (x1 per Student)
- ☐ ¾” Schedule 40 PVC cap (1x per Student)

3B - Copper

- ☐ ⅞” OD soft copper tubing (not pre-cut; 1x 12–13” segment per Student)
- ☐ ¾” copper sweat x ¾” NPT adapter (1x per Student)
- ☐ Pre-brazed copper ⅞” caps (1x per Student)
    - ☐ Optional: Caps with Schrader (if pressure test is being performed; 1x per Student)
- ☐ Scrap copper and other tubing types for discovery

3C - Joining PVC and Copper

- ☐ Teflon tape or pipe dope
- ☐ 0%, 5%, or 15% phos copper brazing rods

3D - Aluminum Repair

- ☐ Aluminum cans (approx. 6 per Student)
- ☐ Aluminum repair kit/rods

The Staging Area should also contain the following **tools** (grouped by module segment):

3A - PVC

- ☐ PVC cutters (1x per Station)

3B - Copper

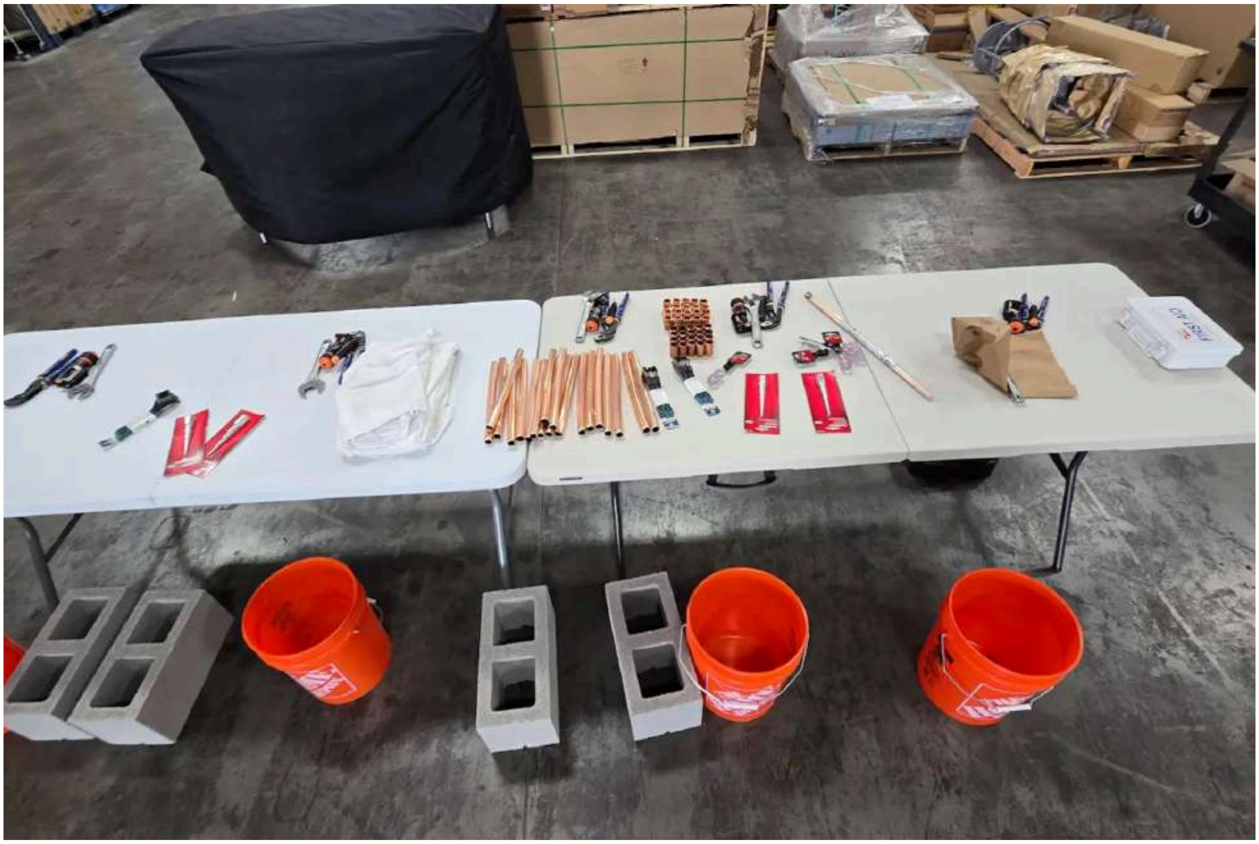
- ☐ Copper tubing cutters (1x per Station)
- ☐ Copper deburring tools (1x per Station)
- ☐ Swaging tool (**optional**; in place of copper caps)

3C - Joining PVC and Copper

- ☐ PVC glue and primer cans taped together (1x set per Station)
- ☐ Adjustable wrench

3D - Aluminum Repair

- ☐ Sharp awl (for making coil and can holes)
- ☐ Pliers
- ☐ Stainless steel wire brush



Set up torch rigs at each Station (or have a few in the Staging Area if you don't have enough rigs for each Station), secure them properly, and place them in an area that a Mentor can closely supervise. Here are the requirements for the torch rigs:

- ☐ Acetylene torch rigs or propane torches (including any fuel and lighters/strikers); **make sure to tie down torch rigs to the Station to prevent tipping them over**
  - ☐ Brazing copper: TurboTorch A-8 tip
    - ■ If there are no air-acetylene rigs, use oxy-acetylene
  - ☐ Soldering aluminum: TurboTorch A-3 tip
    - ■ If there are no air-acetylene rigs, use a propane torch

Mentors MUST demonstrate safe torch practices prior to starting the GRIT Camp. They may also bring their own torches if they wish to do so.

Optional: If the facility has HVAC components or access to another local HVAC shop, have an aluminum evaporator coil ready to demonstrate aluminum soldering.

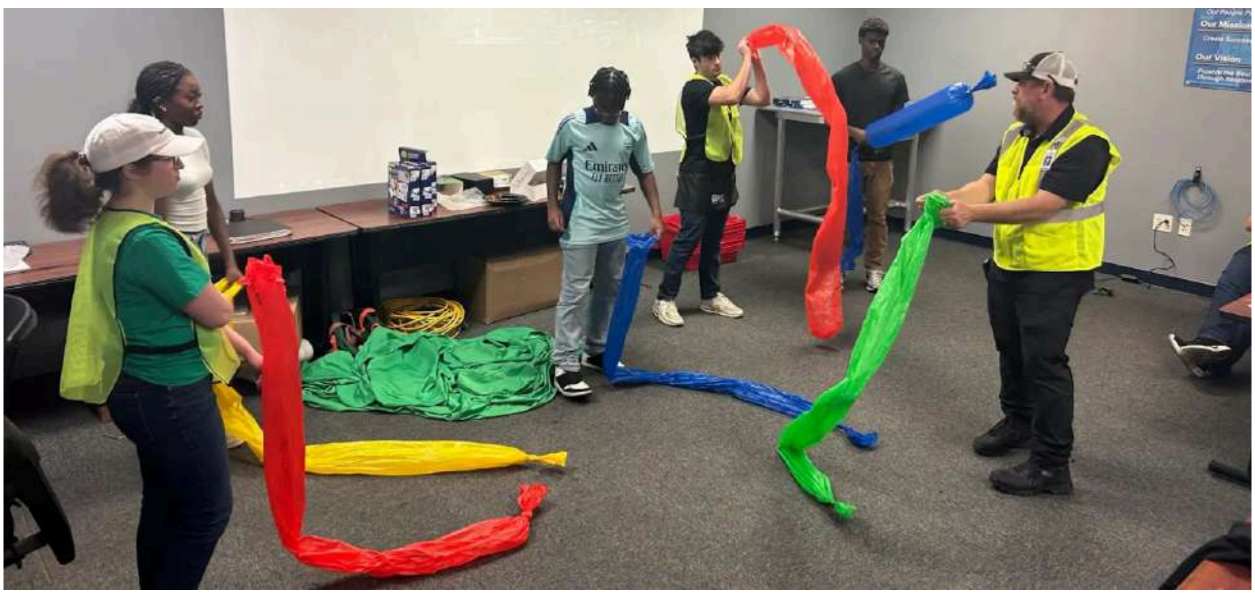
Module 4: Lunch Lessons

There is a lot of freedom here, but there should be a plan to feed the Students and possibly use the food, alongside some standard supplies like cubes made of various elements, to generate discussion about scientific principles at work in the skilled trades.

Coordinate the meals with a local catering company or an in-house Volunteer ahead of time to ensure a smooth transition to lunchtime. Ensure that there is at least one **thermal imaging camera** present in the lunch area that the Students can use on the food and nearby objects.

For optional and added discovery, have a hot plate or heat mat, a lamp, and an electric heater in the space to demonstrate the three forms of heat transfer: conduction, radiation, and convection, respectively. We can use tungsten, aluminum, and copper cubes with these lamps to demonstrate the concept of heat transfer.

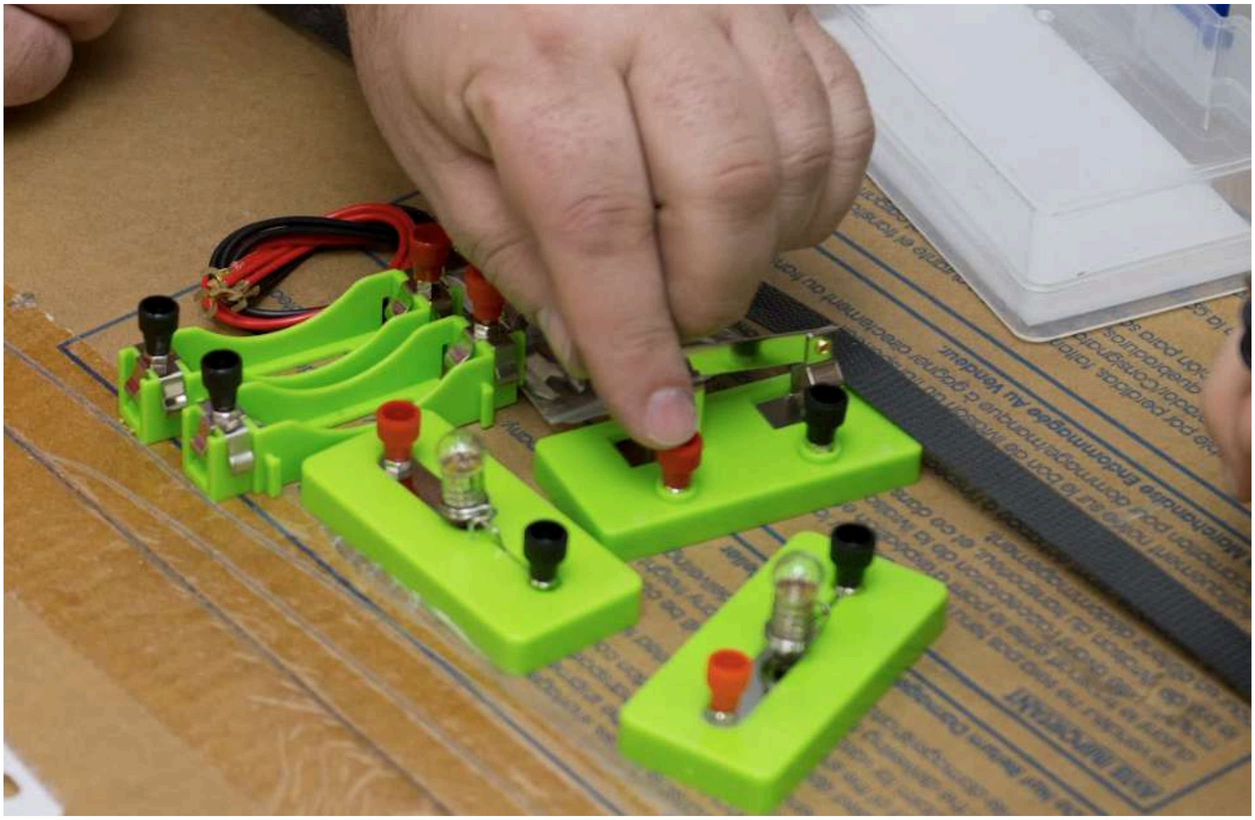
Since this break still has educational value, feel free to bring in other educational kits for the Students, like the HVAC School Fun Physics Kit, which includes **an air cannon, cups, a drinking bird, and a hand boiler.** Set up a location with air cannons (1–3x per camp) and stacks of 10 paper drinking cups that Students can set up in a triangular formation. Include some Bernoulli bags in this location so that the Students can play with them at will to reinforce the lesson.



Module 5: Basic Electrical

Module 5 often takes place at a group table, usually indoors. Set up the electrical circuit kits that GRIT shipped to the Host for each Student. **Each small circuit kit provided by GRIT includes:**

- Color-coded wires
- Battery holders (2x)
- Lighting fixtures and bulbs
- Switch



The Host must provide:

- ☐ AA batteries (2x good batteries per Student for circuit kits)
- ☐ Other battery types and dead batteries (AAA, 9V, dead/corroded AAs for discovery)
- ☐ Electrical meters (at least 3x meters for the group)
- ☐ A mixture of bad/good bulbs (small, 3V bulbs) for Students to find and test
- ☐ Scrap copper wire (for discovery)
- ☐ Extra switches (for discovery)
- ☐ Breakers (for discovery)

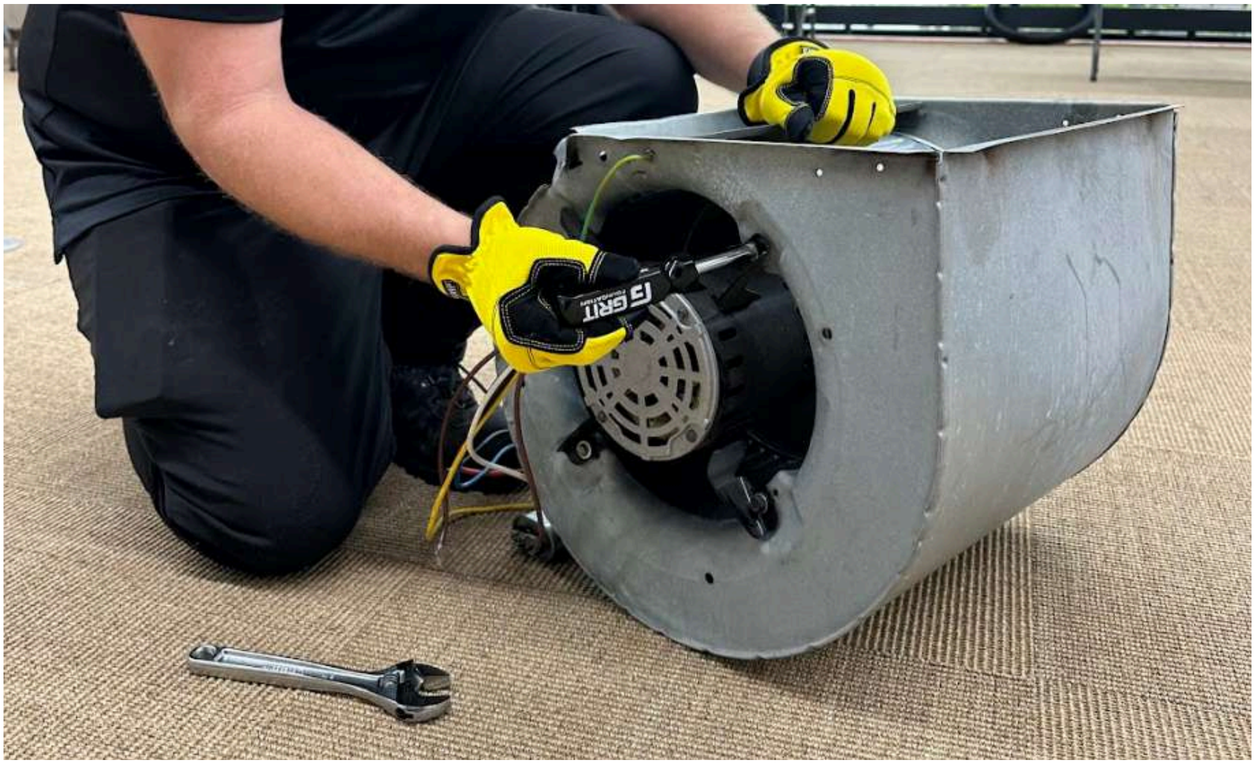
If you only have access to good AA batteries, you can directly short a few of them by connecting the terminals with a short copper wire. Place **all** batteries—regardless of type or status—in cups or on plates in a few spots on the group table. Set aside one good battery (of any type) so that Mentors can show how to measure voltage, if needed.

You can also burn out light bulbs during prep by wiring them in circuits with a higher-voltage power supply than their rating. The bulbs in our circuit kits are 3V, so you can connect them to a 9V battery to make them go bad.

Note that this Station may run long; if possible, plan to leave a 15-minute cushion for the faster Students to continue discovering with the switches, breaker, and scrap copper wire.

Module 6: Disassembly (optional)

Ensure that we have access to a few different HVAC condensing fan assemblies or blower wheels for disassembly. Ideally, there will be one disassembly per two Students, but two groupings may share a single assembly if needed. The only setup required for this Station is arranging the equipment in an orderly fashion so that each group can work on one, as well as setting up penetrating oil and sandpaper in a nearby Staging Area to help unstick components.



The blower and fan motors have sharp edges, so safety is critical during setup. Mentors MUST communicate the importance of wearing gloves during disassembly and assembly. **Any Students who handle blowers or fans must wear gloves**.

Module 7: Final Customization

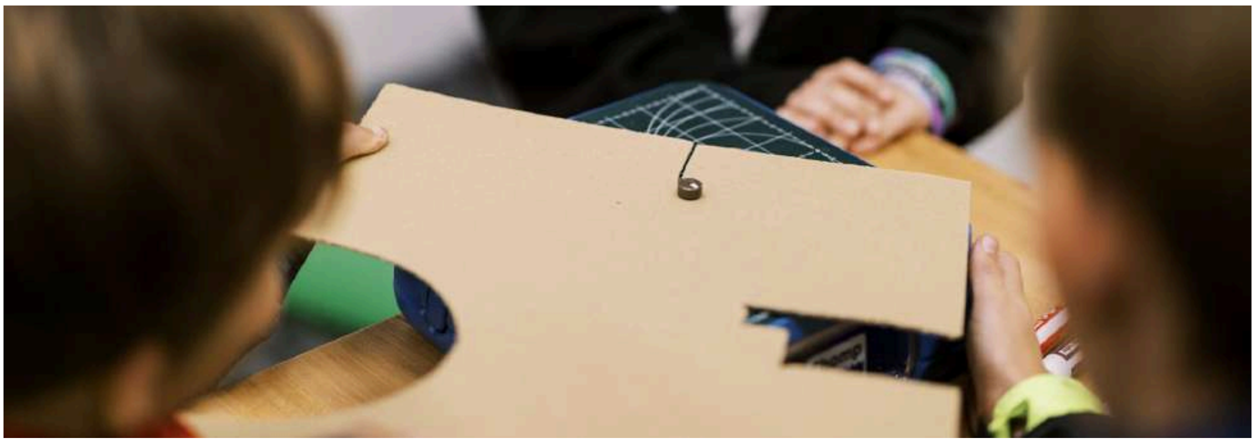
The final module gives the Students some time to customize their kits, including adding photos taken throughout the day, their electrical assemblies, and adding drawings or wire designs. There will be a central table that should have the following (these items can vary by Host preferences):

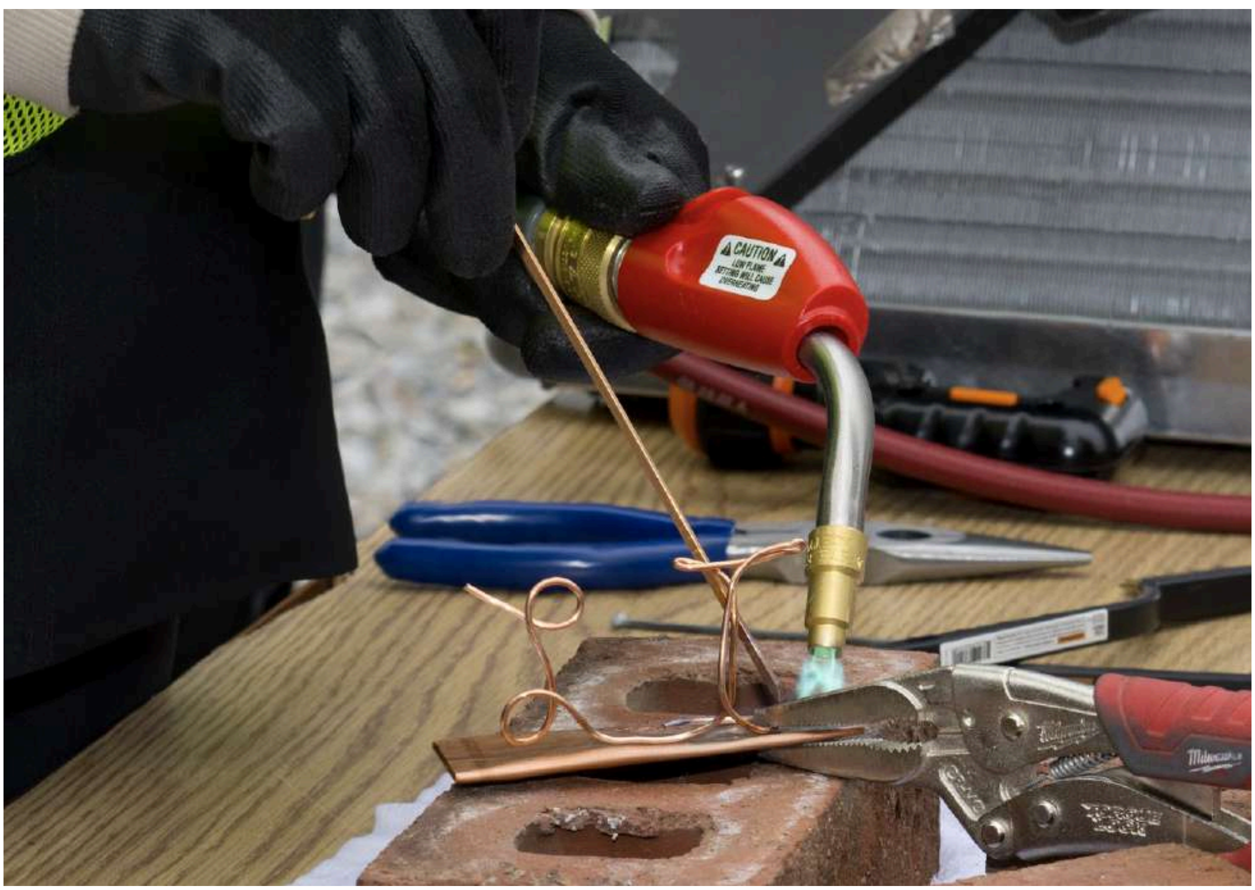
- [ ] Scissors
- [ ] Hot glue guns and sticks
- [ ] Paint markers (assorted colors)
- [ ] #10 or #12 scrap bare solid wire
- [ ] Mounting or double-sided tape
- [ ] Decorative tape (duct tape, masking tape, painter's tape, Gaffers Tape)
- [ ] Decorative items (markers, colored paper, stickers, etc.)
- [ ] Fairy lights
- [ ] 65–80lb card stock sheets or cardboard sheets (for use with ChompSaws)
- [ ] Other arts and craft supplies

The Students may also use the following tools (with supervision and guidance from their Mentors) to put their initials on the box:

- ☐ ChompSaw (for cutting **cardboard sheets/card stock**)
- ☐ Air-acetylene or propane torch with scrap copper/wire

Safe usage for each of these will be detailed in the Module 7 procedure.





DISCOVERY VIA THE SOCRATIC METHOD (FOR MENTORS)

The goal of the GRIT Camp is to spark curiosity in the science of skilled trades work. One of the best ways to spark that curiosity is to ask Students to explain what they think is happening during the activities, rather than telling them the answers.

Throughout the day, Mentors should ask their Students questions about what is happening. As the Students work through the concepts, Mentors will also be able to choose a few follow-up questions to encourage Students to think more deeply and challenge incorrect answers along the way to the correct answer.

Here is an example of a question, its follow-up questions, and the answer we want the Students to arrive at eventually:

> **Q:** (After the Students close the switch and turn the circuit on for the first time**)**
>
> **Why does the switch need to be closed for the bulb to turn on?**
>
> > Follow-up questions:
> >
> > - What happens to traffic when a drawbridge is down? And what happens when it is up?
> > - What happens to the current flow when a switch is closed? Open?
> >
> > **A:** When a switch is open, there is a gap in the circuit. Electricity can't flow continuously, so we need the switch to be closed to bridge that gap and create a complete path between the power supply and the light bulb (the load).

While we don't want Mentors to give the correct answer outright, we want them to affirm the correct answer and ask questions that will make Students rethink incorrect answers. The guiding follow-up questions aim to keep them on track or help them get back on the right track after an incorrect answer. There will be several Socratic-style questions per module and opportunities for Mentors to ask them. However, **Mentors should not feel pressured to fit every question into the modules.** These questions exist to foster curiosity and can be asked as opportunities arise. Socratic-style questions can also help Mentors fill time if Students move quickly—remember, it's not a race! If Students go too slow, Mentors may skip questions and help get them up to speed with the rest of the group.

Mentors can study and refer to the Socratic Question Cheat Sheets in **Appendix A** for a briefing on the principles behind the activities and the Socratic-style questions, follow-up questions, and answers to guide the Students' learning. Mentors could also potentially print these cheat sheets and have them on hand during the camp.

Handling Mistakes (FOR HOSTS AND MENTORS)

The purpose of the GRIT Camp is for Students to discover trade skills, not receive direct instructions. Mistakes are inevitable, and we do **not** want to discourage the Students.

Unless a mistake puts a Student in danger, Mentors do not need to step in and immediately correct the Student. It's okay to let the mistake happen, allow the Student to realize their mistake, and then give them another attempt. For example, if a Student puts the tubing in the box in the wrong order, simply cut out the incorrect tubing and let them retry with a coupling.

The only time a Mentor should directly intervene and correct something immediately is when a Student is doing something dangerous, such as mishandling a torch, tube cutters, or saw blades.

MENTOR ATTIRE

Mentors will be leading by example throughout the camp, so they should comply with safety measures, including wearing appropriate clothing, tying long hair back, and demonstrating professional behavior.

Mentors should arrive at the GRIT Camp site in their usual work clothes, such as a company uniform—this helps show students what real jobsite attire looks like. They should also bring their own basic PPE, including:

- High-visibility vest
- Safety glasses
- Gloves
- Ear protection

Mentors do **not** need to arrive at the GRIT Camp site with their PPE on. Students will be learning about and putting on PPE during Module 1 (Safety), so Mentors should put their own PPE on during or after that module, especially as the group moves into carpentry activities.

CHALLENGE INTRODUCTION

The Challenge Introduction follows check-in and will involve pairing of Mentors to Students as described in the GRIT Camp Setup and Planning. It may take place in the check-in area or another area away from the Stations and Staging Areas, preferably nearby but separated from the Module 1 safety briefing location.

Story/Mission:

Our world has become so dependent on cell phones and computers that many people don't know how to work with their hands anymore! The things many of us take for granted—the buildings we live in, the lighting in our homes at night, the plumbing that brings us clean water, and the machines that work tirelessly to keep us comfortable—all need people with special skills. Those skills are lost knowledge, and it's up to you to unlock those trade secrets.

YOU (Students) are the ones who have been entrusted to rediscover that lost knowledge through a series of hands-on trials. With each puzzle, you will learn a skill that you can take into the world and help make a difference. You will need to decode a set of plans; as you make progress on the structure, it will showcase the skills you discover along the way. You will keep the finished product and make it your own as proof that you have the hands-on skills that our very society is built on.

Estimated Completion Time: <15 minutes

Procedure:

1. The GRIT Camp Host or a designated Volunteer (hereby referred to as the **Leader** in this section) will stand in front of the Students near check-in or in the safety briefing room. Here, they will present the challenge based on the **Story/Mission** above.
    a. The challenge should be presented in a manner that resembles that of an escape room—Students live in a timeline where they have to figure out "lost knowledge" of the trades on their mission.
2. The Leader will clarify that the parts will be divided into phases based on different trade skills that they will have to learn and apply to complete the mission.
    a. The leader will identify the Stations and Staging Areas, where the tools and materials will come from.
3. The Leader will introduce the Mentors to the Students and explain their role.

a. Mentors perform tasks that aren't age or skill-appropriate.

b. Mentors are there to help, but they don't have all the answers! They will ask questions to get everyone to think through the tasks, not give step-by-step explanations for everything.

4. The Leader and/or Mentor(s) should emphasize the need for collaboration and sharing answers and thoughts with each other throughout.

    a. Students will finish challenges as a team and can only move on once they have finished their part.

        i. Fast finishers should share their insights with their teammate to unlock the next Station.

5. The Leader will divide the Students into pairs (planned ahead of the camp event) and assign them a Mentor.

    a. If some Students don't show up or you perceive a possible conflict of pairings, simply switch up the Students and move around as needed.

    b. Avoid pairing siblings. GRIT Camp is a good time to meet other kids and not fuel sibling competition during modules.

6. At this time, Mentors can begin asking their Students a couple of ice breaker questions and tell them what they do in the skilled trades as they comfortably proceed to the safety briefing as a team.

MODULE 1 — SAFETY

Story/Mission:

Before we can take up our tools and embark on this mission, we need to know how to be safe! Our hands and eyes are the most important tools we have, and we must protect them and the rest of our bodies at all costs.

Estimated Completion Time: <10 minutes

Materials:

- ☐ Safety gloves — **GRIT provides**
- ☐ Safety glasses — **GRIT provides**
- ☐ Branded tool belt — **GRIT provides**
- ☐ High-vis safety vests — **GRIT provides**
- ☐ Earplugs — **GRIT provides**
- ☐ Hair ties for long hair (**required for anyone with hair longer than shoulder-length**)
- ☐ Low-level carbon monoxide (CO) monitor (if any torch work takes place indoors)
- ☐ Fire extinguisher (for demonstration)

Tools (GRIT-Provided Kit; Students receive this in their individual bundles *during* safety training):

- ☐ Blueprints for creating a box frame or shelf
- ☐ GRIT-branded tape measure
- ☐ GRIT-branded 6-in-1 screwdriver
- ☐ Construction pencil and sharpener

Theory/Skill:

- Using personal protective equipment (PPE)
- Electrical safety
- Torch safety
- Sharp object safety
- Respiratory safety (around sealants/glue)

Procedure:

1. One of the Mentors or a designated safety volunteer (hereby referred to as the **Safety Speaker**) will introduce the **Story/Mission** and emphasize the importance of keeping our bodies safe. This person will take the lead in the steps that follow.

2. The Safety Speaker will introduce the PPE, asking Students what the items in front of them are, what they protect, and how to use them.

    a. This step can be fun and humorous! The Safety Speaker may attempt to put the high-vis vest on the wrong way and ask the Students to tell them how to do it the correct way, make safety puns, etc.

    b. This step will end with the Safety Speaker instructing Students to put on the PPE correctly.

3. The Safety Speaker will give Students a pep talk about activities like torch and tool use to get them excited.

    a. During the pep talk about the activities, they should ask the Students what sorts of safety precautions they think they'll need to take.

4. The Safety Speaker will quickly educate Students about the risks of working with electrical equipment, sharp objects, sealants, and torches (including carbon monoxide).
    a. While there are no predetermined Socratic-style questions for this module, the Safety Speaker may consider asking the Students the following (which are also available on page 45 in **Appendix A**):
        i. What would happen if you touched a saw blade?
        ii. What would happen if you're using a torch and get distracted by someone who's horsing around?
        iii. Why do you think you'd need to protect your eyes while sawing wood?
        iv. What do you think would happen if you inhale or ingest toxic glue?
    b. The Safety Speaker should also drive home the idea that anything involving hot or sharp objects or specialized glue should NOT be attempted at home.
5. All of the Students must acknowledge the safety concerns and pledge to be safe during the GRIT Camp.
    a. There is some variability here; the Host may opt for a verbal or written acknowledgment.
6. The Safety Speaker should call the Students' attention to the kits with basic materials and have the Students once again verbally acknowledge the safety concerns related to the activities at GRIT Camp.
    a. Upon receiving the acknowledgment, distribute kits with the blueprints, tape measures, and 6-in-1 screwdrivers and allow Students to place small items in their tool belt, pick up their blueprint, find their Mentor, and head to their designated Stations.

MODULE 2 — CARPENTRY

Story/Mission:

Our world needs builders! These days, we rely so much on technology that many people don't know how to cut and piece together wood anymore—much less make it match a blueprint. When they try, they're often surprised to find the pieces don't fit: too long, too short, or just not right. They grab any fastener that might hold it together, but the result is usually wobbly and awkward.

That's where you (Student) come in. It's up to you to figure out how to read this blueprint and turn it into something real, using your tape measure and the materials right here in front of you.

Location Requirements: Outdoors or a well-ventilated area

Estimated Completion Time: 45 minutes

Materials:

- ☐ Blueprints for creating a boxed frame
- ☐ 2x4 plywood planks (**pre-cut to 5-foot lengths for easier handling**)
- ☐ Other wood types and sizes for discovery (**optional**)
- ☐ 3" T-25 torx head screws
- ☐ 1 ¼" finish nails
- ☐ Other fastener types and sizes for discovery (**optional**)
- ☐ **Pre-cut** 17.5" by 12.5" backing board (pegboard or luan)

Tools:

- ☐ Miter saw (or table saw) with a guard and 2 bar clamps
- ☐ Tape measure
- ☐ Drill(s)
- ☐ T-25 bit
- ☐ ⅞" wood-drilling Forstner bit
- ☐ 1 ⅛" wood-drilling Forstner bit
- ☐ 6-in-1 screwdrivers
- ☐ Speed squares (**optional**)
- ☐ Hammer(s)

☐ Needle-nose pliers (**optional**)

Theory/Skill:

- Using a tape measure
- Nominal vs. actual size
- Cutting building materials (including waste and kerf)
- Fastener & sealant selection and use

Socratic Approach:

- Q1 - Where do you start measuring on the tape measure? Why is this important?
- Q2 - Measure the 2x4, why do you think a piece of 2x4 plywood isn't really 2"x4"?
- Q3 - On which side of the mark should we cut the wood? Why?
- Q4 - Does that cut look bigger or smaller than you expected? Why?
- Q5 - Which fastener do you think would do the best job of holding the frame together with the tool you have in front of you? Why?

Procedure:

1. Instruct Students NOT to touch the saw(s) without guidance from their Mentor and explain the safety risks of operating a saw (cuts, losing fingers, etc.). Keep saws unplugged and drill batteries out until ready to use, and then unplug the saws or remove the batteries immediately after use.

2. Instruct the Students to wear gloves, safety glasses, and keep their earplugs nearby.

3. Tell the Students to look at their blueprints and grab the wood they need for it.

    a. They will need to pick a 2x4, but if there are other wood types and they choose one of those, that's a great opportunity to ask them how they'll make it work with the blueprint.

4. Tell the Students to measure the width and thickness of the 2x4.

    a. Ask them where to start on the tape measure **(Q1)**.

    b. If they struggle to use the tape measure, ask them questions about why certain tick marks look longer than others and how far they appear to be between the whole numbers.

    c. The 2x4 will not be 2"x4", so ask them why they think that is **(Q2)**.

5. Instruct the Students to look at the blueprint and ask them how they are going to fill in the blank dimensions.
    a. They should subtract the thicknesses of the attached pieces of wood from the dimensions already filled in.
    b. If they don't get that answer immediately, stack the uncut 2x4s at a right angle so that they can physically see the thickness that needs to be subtracted and ask the Students again.
6. Instruct Students to use their GRIT tape measure to mark the cutting points according to the math they performed and the missing dimensions they filled in on the blueprints.
    a. If your GRIT Camp has speed squares, ask the Students how they might be able to use one of the tools nearby to help them make a straight, level line. You might also consider asking what might happen if the line is slanted when it's time to cut the wood.
    b. Let the Students discover how to use the speed square and advise them to hold the speed square tightly against the wood when it's time for them to draw the line.

7. Ask the Students which side of the wood they want to keep and which side they want to cut off **(Q3)** BEFORE anyone cuts the plywood.
8. Ensure that the Students are wearing their PPE at this time; these items will remain on for the remainder of this module.
    a. Students must use their earplugs when operating the saw.
9. The Mentor or an authorized adult helper will plug in the saw. One at a time, allow the Students to place their marked wood against the saw's fence, secure the wood with the bar clamps (if necessary), and demonstrate how to use the saw for them (with or without cutting).
    a. Let them see where the blade aligns with the wood WITHOUT turning the saw on so that they can judge the saw's kerf and determine where to make their cut.
    b. Make sure to tighten the clamps to hold the wood in place.
10. When the Student feels comfortable, they can use the saw to cut the wood at the marked points, just on the outside of the "waste" side of the lines. **Continue to pay close attention to them to ensure that their other hand is away from the saw blade.** During the cutting portion, ask whether the cut width was what the Students expected **(Q4)**.

11. Unplug the saw as soon as everybody is finished cutting their wood. This step reduces the risk of injuries.

12. Direct Students to the table with fasteners and hammer(s). Let them examine each type of fastener. Ask them which type should hold the frame together **(Q5)**.

13. Let the Students see the different types of drill bits on display. Ask them which bit they think will fit for drilling into the frame with the fastener they selected, guiding them until they arrive at the T25.

    a. Show the Students how to add or change a drill bit (perhaps starting by using the wrong bit). Then, if their gloves are on, ask the Students to remove the wrong bit and attach the right one.

14. Put batteries into the drill (if needed) and demonstrate how to use it. (Optional: You can have them pre-drill holes if you have the drill bit, OR you can use a hammer to tap a screw into the wood to hold it.)

    a. You may either step in to hold the wood at the same 90° angle shown in the blueprint or have the Students work together to hold the wood together as they take turns drilling.

    b. While supervising them closely, let the Students drill the screws. Ask them where they think the holes should be drilled and let them figure it out themselves.

15. With the main part of the frame assembled, point the Students to the backing and ask which fastener or sealant they should use for the thinner material (again, you may refer to **Q5** for guidance on the Socratic-style reasoning).

a. If the backing has different textures on each side, ask which side the Student(s) want on the inside of the box; there is no "wrong" answer.

16. When the Students decide to use the nails and hammer, make sure they have their glasses and gloves on. Ask them where they think the finished nails should go.

    a. You can use a simple demonstration to show how to use a hammer for safety purposes if a Student isn't yet confident enough to use one. You can also use pliers or needle-nose pliers to hold the nail before they start hammering. Ideally, they should be able to finish hammering a nail you start and be able to hammer in the rest of their nails.

17. OPTIONAL: If there is time left at the end of the module, the Mentor can drill the holes for the pipefitting module. **This step is only done by the Mentor; drilling holes can be hazardous and must NOT be done by Students.**

    a. First, ask the Students to mark their wooden frame where they want to drill a hole based on the blueprint.

    b. After that, show the Students the bits and give them a chance to figure out which size of Forstner bits to use based on the blueprint.

MODULE 3 — PVC, COPPER, AND ALUMINUM FITTING & REPAIR

Story/Mission:

We need piping to move vapors and liquids throughout buildings. The only problem is that joining pipes and repairing leaks is a lost skill. We have a few pipes here of different materials, but we're not sure what they're supposed to be used for—moving vapor, moving water, etc.

It's up to you to discover how to fit and repair pipes with the materials in front of you. Think about how vapors and liquids move and interact with the world around us on your journey.

Location Requirements: Outside or a well-ventilated area

Estimated Completion Time: 90 minutes (approx. 15 minutes for PVC, 15 minutes for copper, 30 minutes for brazing and joining the tubing, and 30 minutes for aluminum)

Materials:

3A - PVC

- ☐ ¾" Schedule 40 PVC pipes (not pre-cut)
- ☐ ¾" Schedule 40 PVC adapter, slip socket x FPT, couplings
- ☐ ¾" Schedule 40 PVC adapter, slip socket couplings
- ☐ ¾" Schedule 40 PVC adapter, slip socket caps
- ☐ PVC glue and primer cans taped together

3B - Copper

- ☐ ⅞" OD soft copper tubing (not pre-cut)
- ☐ ¾" copper sweat x ¾" NPT adapter
- ☐ Pre-brazed copper ⅞" caps (1x per Student)
    - ☐ Optional: Caps with Schrader (if pressure test is being performed; 1x per Student)
- ☐ Other pipe sizes and types for discovery (**optional**)
    - ☐ ⅝" OD soft copper tubing
    - ☐ Scrap copper tubing
    - ☐ Galvanized steel
- ☐ Emery cloth sandpaper

3C - Joining PVC and Copper

- ☐ 0%, 5%, or 15% phos / copper brazing rods

- ☐ Teflon tape or pipe dope
- ☐ Cored bricks or fire bricks

3D - Aluminum Repair

- ☐ Aluminum cans or thin aluminum sheets
- ☐ Aluminum repair kit/rods
- ☐ Aluminum HVAC evaporator coil (**optional**)

Tools:

General/Safety

- ☐ Permanent marker
- ☐ Drill
- ☐ ⅞" wood-drilling Forstner bit
- ☐ 1 ⅛" wood-drilling Forstner bit
- ☐ Fire extinguisher(s)
- ☐ Fire blanket(s)
- ☐ Bucket(s) of water
- ☐ Rags

3A- PVC

- ☐ PVC cutter

3B - Copper

- ☐ Copper tubing cutters
- ☐ Deburring tool
- ☐ Swaging tool (**optional**; battery-powered or hand swage if not using caps)

3C - Joining PVC and Copper

- ☐ Air-acetylene brazing/soldering torch rigs OR propane torches
    - Brazing copper (air-acetylene): TurboTorch A-8 tip
    - Soldering aluminum (air-acetylene): TurboTorch A-3 tip
- ☐ Igniter/lighter (friction or push-button spark)
- ☐ Adjustable wrench

3D - Aluminum Repair

- ☐ Pliers (large enough to grip ⅞" tubing and an aluminum can)
- ☐ Sharp awl (to punch holes in the cans)
- ☐ Stainless steel wire brushes

Theory/Skill:

- Modifying copper to make it useful in service
- Joining plastics
- Joining metals (brazing vs. soldering)
- Aluminum repair

Socratic Approach:

- Q1 - Why do you think we use PVC for some pipes and copper for others?
    - What sorts of things would we move with PVC piping, and what would we move with copper tubing?
- Q2 - Why do we need to remove the burr after we cut copper?
- Q3 - Why do we need to use soft copper for swaging?
- Q4 - Why don't we apply heat directly to the rod when we make a joint?
- Q5 - What can we do to patch a leak and make this can hold water or air as effectively as before?
- Q6 - Why do we need to apply less heat to an aluminum can than the copper pipes we brazed earlier?
- Q7 - Why do we need flux for aluminum but not copper?

Procedure:

1. Cover any relevant safety information (i.e., cutter, torch, and glue safety) and ask the Students to point out the location of the fire extinguisher(s) and blanket(s). Show the Students the tools and ask them to identify the hazards that come with using PVC and copper cutters, PVC glue, and a torch rig (cuts, inhaling toxic substances, and burns or fires, respectively).

    a. Ensure that all hazards are covered, even ones that the Students don't mention when asked.

2. Ensure that Students have their glasses and gloves on before doing ANY activity in this module.

3. If holes for the tubing weren't drilled during the carpentry module, the **Mentors** should do that at this point. First, ask the Students to mark where they want the hole to be drilled based on the blueprint and mark it on their box. Then, ask the Students to figure out which size of Forstner bits they should use based on the blueprint.

a. **For safety, the Mentor should be the one who drills these holes, NOT the Students!**

3A - PVC Cutting and Fitting

4. Ask the Students to identify the ¾" schedule 40 PVC from the tubing varieties in the Staging Area, cut a 12" piece, and return it to their Station. As they explore the different materials, ask them what they think each pipe might be used to transport—cool liquids, hot vapors, etc. **(Q1)**.

5. Instruct Students to follow the blueprint and supervise/support them as they use their tape measures and a marker to mark off where they will need to cut their PVC pipes.

6. Ask the Students to identify the tool in front of them that is best for cutting the PVC. They will likely choose either the copper cutter or the PVC cutter.

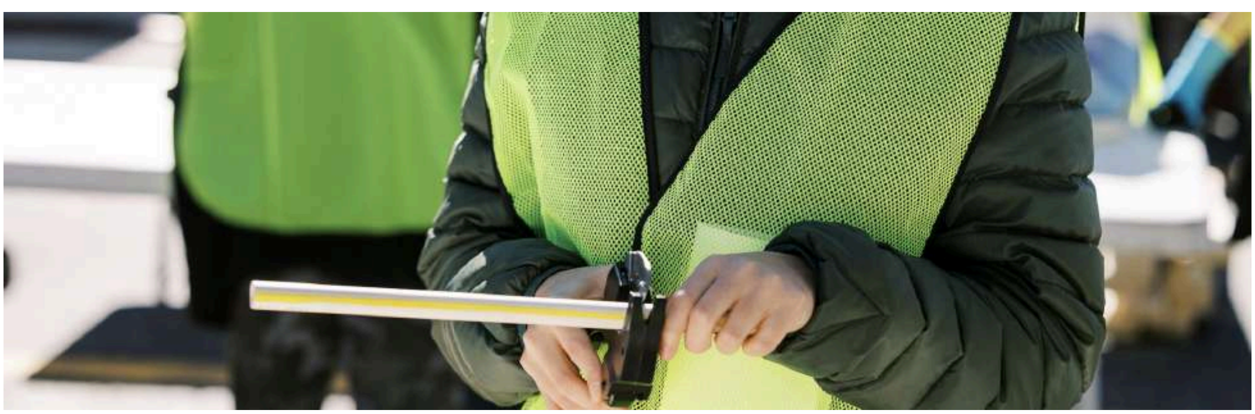
    a. If they choose the former, allow them to make that mistake and see what happens; there is always a chance to try again if it doesn't work out.

7. Let the Students figure out how to use the PVC and/or copper cutter, asking them how they think it works along the way.

    a. Ask them to identify parts of the cutters that do the cutting, like the cutting wheel, and what they need to do to make sure the pipes are cut (i.e., squeezing the handles for the PVC cutter and gradually tightening the adjustable handle on the copper cutter).

    b. Make sure to watch out for the Students' hand placement when using the PVC cutters so that they don't get cut or pinched.

    c. You might consider having the Students practice on spare PVC tubing before cutting for the blueprint.



8. Once the cutting portion is complete, make sure the PVC cutter is in the closed position. Clean up any PVC pieces off the floor to prevent a trip hazard.
9. With the PVC cut to the proper lengths, ask the Students to find the PVC fittings shown on the blueprint. Ask them what we need to use to connect the pipe to the fittings.
    a. Ask them if we can glue the pipes right away or if there needs to be any cleaning or prep work before applying the glue.
10. Direct the Students to the glued PVC primer and glue cans, asking them which comes first and what they think each one is used for. Guide them until they come to the conclusion that primer comes first.
    a. Note: The Students may glue the tubing before they slip it through the hole in the box. It's okay to let them make that mistake; we can always cut the PVC and use a coupling.

11. Allow the Students to apply PVC primer, asking them how they think they should hold the pipe to prevent the primer from running down the pipe, how far up the pipe the primer should go (relative to the fitting), which parts we need to add primer to, and what they notice as they apply the primer.

12. With the primer in place, instruct the Students to apply PVC glue. When they've applied the glue, tell them to fit the parts together, make a quarter turn, and hold the pipe and fitting firmly together for 10 seconds to connect them.

3B - Copper Cutting & Fitting

13. Ask the Students to identify the ⅞" copper from the tubing varieties in the Staging Area, cut a 12" piece, grab some sandpaper from a roll of it, and return it to their Station.

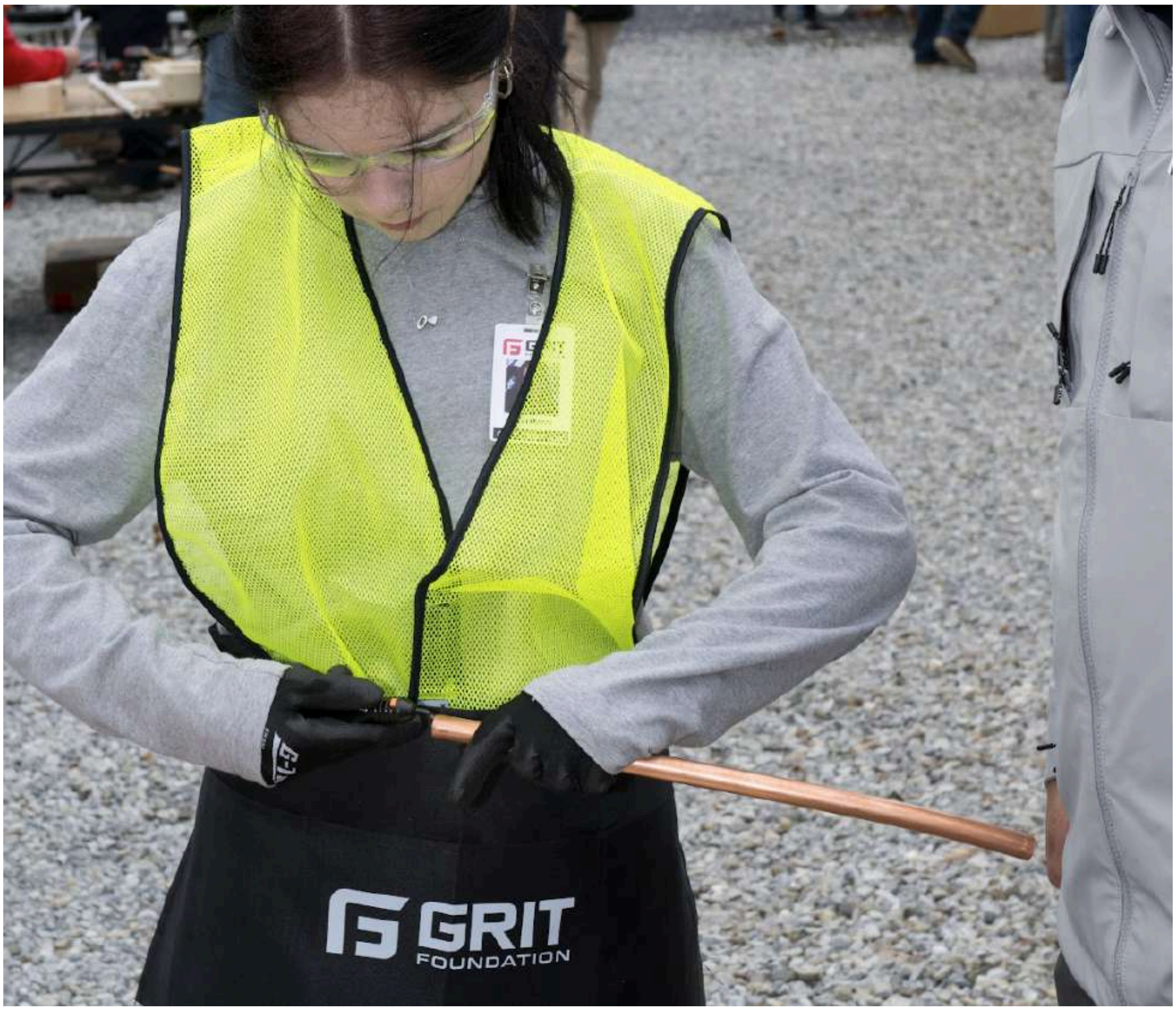
14. Instruct Students to follow the blueprint and supervise/support them as they use their tape measures and a marker to mark off where they will need to cut their copper pipes.

15. Ask the Students to identify the tool in front of them that is best for cutting the copper and what we'll use to clean the copper. Let the Students figure out how to use the sandpaper and copper cutter.

    a. Along the way, ask them how they think the copper cutter works and offer guidance about usage, like tightening the adjustable handle.

16. With the copper cut, ask them to look at the site where the cut was made and tell you what the surface looks like. Ask them what a sharp surface or burr might mean for fluids inside the tubing **(Q2)**.

17. Show the Students a deburring tool and tell them what it is. Give a brief demonstration of how it works—just enough to show how they need to operate the tool. Instruct them to remove the burr where they cut the copper.



3C - Joining PVC and Copper

18. Ask the Students to find the adapter to connect the copper to the PVC. Once they identify it, ask them what we will use to seal them together.

    a. They will probably get this one wrong; the answer is that we'll use flame and a filler metal to put them together (brazing).

19. Ask the Students what we will need to create a flame and what we'll need to extinguish fires or cool the pipes down.
    a. Ensure that a bucket of water and rags are in the work area.
    b. Grab the brazing rods from the Staging Area with the Students.
20. IF POSSIBLE, lay a fire blanket on top of tables or on the ground underneath the project to prevent damage from the torches.
21. RECOMMENDED: Spend a few minutes allowing the Students to practice brazing before attempting to fit pipes according to the blueprint.
    a. Use the cored bricks to hold the copper pipes. Let the Students figure out what works best for them while they're practicing.
    b. Show the Students how the torch works (and whether it has a push-button lighting mechanism or needs a striker).
    c. When it's time to braze, instruct the Students to heat the base material and NOT the rod. Ask them why that's the case **(Q3)**.

22. Let the Students braze the pipe and the adapter together with guidance. Give gentle reminders about not melting the rod. Be ready to step in if there is a dangerous situation.
    a. These instances MUST be captured on camera so that the Students can have the photos as keepsakes and for the final box assembly.

23. Cover the brazed joint with a wet towel to begin cooling it, instructing the Students to stay away, as the steam could burn them.
    a. If needed, after some of the cooling has started, use pliers to grab the tubing and tip it into the water bucket.
24. Ask the Students to check their joints for gaps or possible leaks; if they need to braze again, give them a little more time to fix their joints, repeating steps 22–23.
25. With the threaded adapter brazed to the piping, ask the Students how we can connect it to the PVC.

a. The coupling is threaded, but the threads can leak! Ask the Students how we might be able to stop those threads from leaking.

26. Ask the Students to apply the Teflon tape or pipe dope to create a seal around the threads.

    a. Let them figure out the right way to do it; just let them know if they make a mistake in the application's direction or thickness.

27. Stand by while the Students tighten the threaded connection with the pipe dope or Teflon tape.

    a. You may want to use pliers and an adjustable wrench to apply more leverage when tightening the connection.

28. If the copper is too long once the pipes have been joined, the Mentor will supervise the Students who need help cutting the excess copper.

29. Instruct the Students to look at the blueprint and determine whether to use a swage or cap on the copper based on the tools and materials around them. Allow them to use the swaging tool or put the cap on.

    a. OPTIONAL (if swaging instead of using a cap): Let the Students swage the end of the copper, and then ask them if we can do that with hard copper and what would happen if we did **(Q4)**.

3D - Aluminum Repair

30. Punch a hole in a can with the sharp awl tool and ask the Students how they think we should patch it **(Q5)**.

31. Tell the Students that the can has a coating that we need to remove with the help of a stainless steel wire brush. Let them clean the can with the wire brush.

32. Demonstrate the indirect heating technique with flux-cored alloys.

    a. Light the torch, heat the rod, heat the aluminum, and then apply the rod with flux.

    b. Let the filler metal and flux melt over the leak. Ask the Students if they think aluminum requires more or less heat than copper and why **(Q6)**, as well as what they think the flux is for **(Q7)**.

    c. OPTIONAL BUT RECOMMENDED: If you have an all-aluminum HVAC evaporator coil, you may want to demonstrate how to patch a leak on that first. Help the Students practice on this coil, ensuring that they have their safety glasses and gloves on. Help them handle the torch if needed.

33. Allow the Students to set up what they need to patch aluminum.

    a. They should arrange the cored bricks in a way that they feel most comfortable with so that the aluminum can will stay upright while it's being patched.

    b. Have a water bucket and rags in the work area.

34. With the assistance of a Mentor, help each Student attempt to patch their aluminum can, allowing them to hold the torch (with guidance) and/or the rod as they apply the alloy.

    a. **These instances should be captured on a camera by a Volunteer so that the Students can have the photos as keepsakes and for decorating their box during the final customization module.**

    b. This activity is exceptionally difficult, and accidentally melting cans or not being able to patch the leak completely is all part of the discovery experience.

35. When a Student finishes patching the leak, instruct them to turn off the torch and let the can cool by picking it up with the pliers and putting it in the water bucket.

36. Instruct the Students to wipe the flux with a wire brush.

37. Pour a little bit of water into the cans and see if they still leak.

MODULE 4 — LUNCH LESSONS

Story/Mission:

As we take some time to eat, let's discover some of the cool things in this room! Have you ever thought about heat and air movement or why you feel cooler when you sit underneath a fan while you're sweating? Now's a good time to explore!

Estimated Completion Time: 60 minutes

Materials/Tools:

- ☐ Food (arranged ahead of time)
- ☐ Cubes or spheres of identical size but different materials (e.g., tungsten, aluminum, and copper; **optional**)
- ☐ Thermal imaging camera
- ☐ Food warming mat or hot plate (**optional**)
- ☐ Heat lamp (**optional**)
- ☐ Spray bottle (to be filled with water)
- ☐ Plug-in or battery-powered fan (**optional**)
- ☐ HVAC School Physics Fun Kit (includes the items below, which may be purchased separately)
    - Air cannon w/ 10 paper cups
    - Hand Boiler
    - Drinking Bird
- ☐ Bernoulli bags
- ☐ Small drop cloths, tarps, or sheets **(optional)**
- ☐ Pieces of metal and small cloths **(optional)**

Theory/Skill:

- Heat & temperature
- Calories and units of energy
- Air movement

Socratic Approach:

- Q1 - How does heat move from the mat to the food or the lamp to something underneath it (like a tungsten, aluminum, or copper cube)?
- Q2 - Why do you think the thermal images look different after some time? Where did the heat come from and go, and why?
- Q3 - What does a calorie measure? How do you think we can quantify calories?
- Q4 - If you spray water on your hand and hold it in front of the fan, what do you feel? Why do you think that happens?
- Q5 - Why do you think we can knock down a bunch of cups from a distance with the air cannon? How can we knock it down from such a long distance?
- Q6 - Why does the air get sucked into the air cannon when you pull back the elastic launcher on the back side and then shoot out of it when you let go?
- Q7 - Why does the entire Bernoulli bag inflate when you blow into it?
- Q8 - Why does the fluid in the glass hand boiler rise when you close your hand around the base?

Procedure:

1. Set up the food and heating items (heat mat and lamp) if they aren't already prepared. Then invite the Students to line up and get their food buffet-style, or have a Volunteer serve it onto paper plates.

2. Once everyone has their food, conduct a roundtable-style discussion asking each Student to share the coolest thing they've created or fixed (or something they would want to create with the skills they're learning).

3. Let Students use a thermal imaging camera around the room to identify sources of heat, including the heat mat/plate, lamp, and the hot food in the original serving dish, and describe what they see. Put the cubes of various elements close enough to the heaters to absorb heat. Ask the Students about how they think heat is moving around us (and between the objects) **(Q1)**.

    a. Ask the Students to revisit the cubes and other items undergoing heat transfer a few minutes later and ask them what seems different and where the heat went **(Q2)**.

4. As the Students eat, ask them to think about what calories are **(Q3)**.

    a. Note: If food was catered and has nutritional information on the packaging, that can come in handy, but it's not required.

5. Make sure the plug-in or battery-powered fan is running or ready to run. When a few people have finished eating, bring out the spray bottle and spray a little water on their hands. Then, ask them to hold their hands out in front of the fan and ask what they feel before asking them why they think it feels cooler **(Q4)**.

6. Set up 10 (or more) paper cups in a triangular formation (4 on the bottom, 3 above, 2 above, and then 1 on top) and bring out the air cannon. Allow the Students to take turns trying to knock the formation down. Ask the Students how they think it's possible to knock down the cups from such a long distance **(Q5)** and how air gets sucked into the cannon when they pull back the elastic membrane **(Q6)**.

7. Distribute Bernoulli bags to each Student and instruct them to tie one end shut. While they play, tell them to see what happens if they get into pairs and have one person hold the tied end while the other blows into it. Ask them why they think the whole bag inflates when just one of them blows a little bit of air into it **(Q7)**.

8. Let the Students take turns holding the hand boiler. When the liquid rises, ask them why they think that is **(Q8)**.

    a. Consider having them hold an ice cube or hold their hand under a heat lamp before holding the bottom of the boiler to see if the fluid rises faster or slower.

Other possible experiments include:

- Boiling water or blowing up a balloon in a vacuum chamber
- Learning how an analog manometer works to measure pressure

NOTE: With the exception of serving food, these steps are all optional, and the sequencing of these steps is less important for this module. Feel free to add or take away steps as you please. Hosts are responsible for providing the materials for any experiments not detailed in this guide.

MODULE 5 — BASIC ELECTRICAL MEASUREMENTS & CIRCUITS

Story/Mission:

We need electricity to be able to keep our homes and other buildings lit, but many people don't know how to make circuits! When they try to make lighting circuits with the same tools you have in front of you, the light bulbs don't turn on when they flip the switch. Are there a bunch of bad bulbs? Bad batteries? Are the circuits all wrong in the first place?

It's up to you Students to discover how to wire circuits and restore light to your city. Think about how the circuit works as a whole as you embark on this journey—what a circuit needs for electricity to flow from a battery to the part that does the work.

Estimated Completion Time: 60 minutes

Materials:

- [ ] GRIT-provided electrical circuit kits
- [ ] 3V light bulbs, mix of good and bad
- [ ] AA batteries for electrical circuits
- [ ] Assortment of battery types and conditions for discovery (corroded, fully charged, dead)
- [ ] Conductive wires with extra scrap wires (**optional** but recommended for discovery)
- [ ] Switches (**optional** but recommended for discovery)
- [ ] Breakers (**optional** but recommended for discovery)

Tools:

- [ ] Electrical multimeter

Theory/Skill:

- Assembling circuit components: power supply, load, and switch
- Series vs. parallel circuits
- Measuring voltage and resistance (multimeter use)

Socratic Approach:

- Q1 - How can you test batteries with the materials at your disposal?
- Q2 - If a “dead” battery has some voltage, why doesn’t the bulb turn on if we use one?
- Q3 - Why do we measure resistance to check if a bulb is good and not volts or amps?
- Q4 - Why does every circuit need a switch, load, and power supply?
- Q5 - Why does the switch need to be closed for the bulb to turn on?
- Q6 - What do you think will happen if we use two batteries instead of one? What if we stack them from end to end? Next to each other?
- Q7 - What do you think will happen if we use two light bulbs in the circuit instead of one? Do you think it’ll be different if we stack them from end to end vs. wire them in parallel?

Procedure:

1. Take the Students to the table with the batteries and bulbs (including dead ones and other types for discovery).

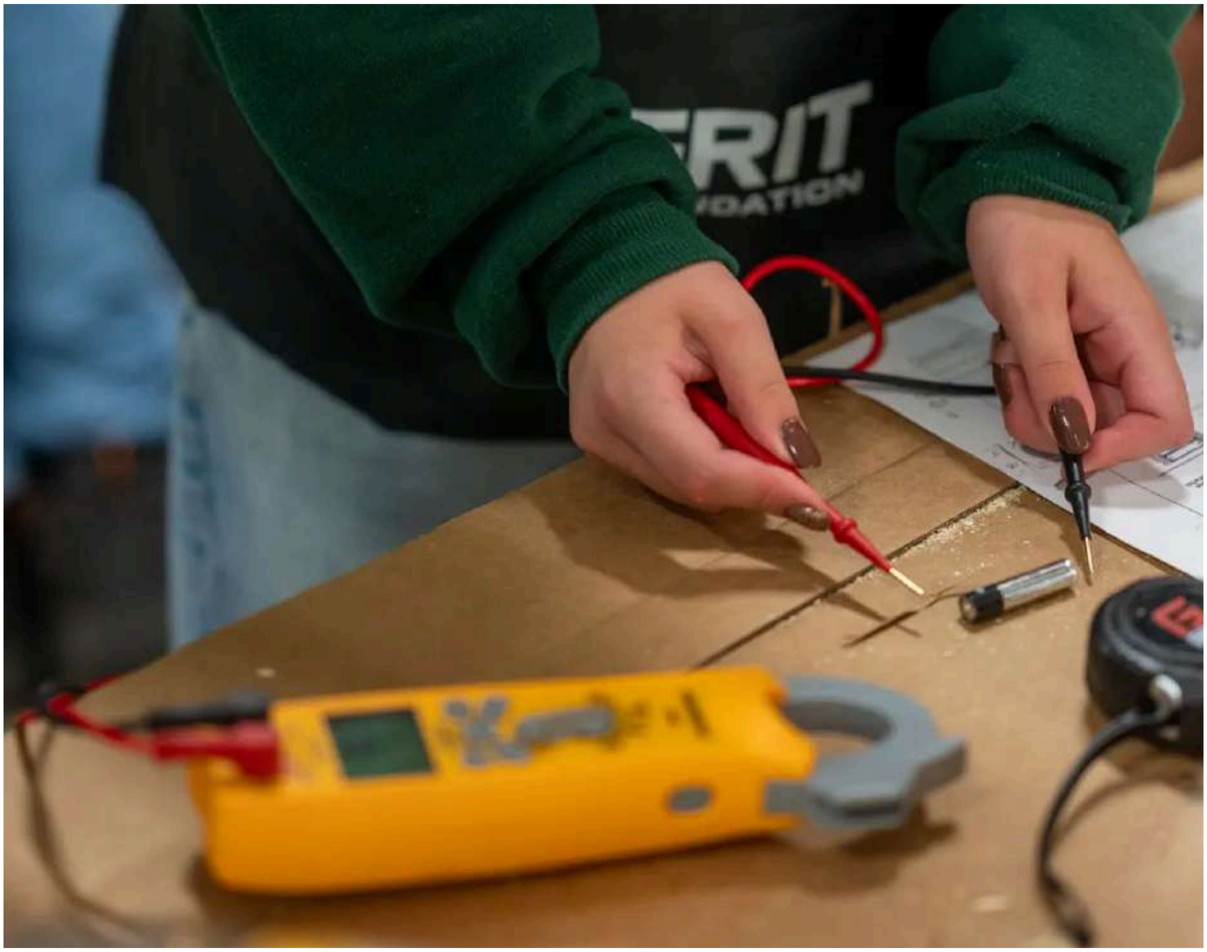
2. Mentors should get the entire group’s undivided attention and cover relevant safety information and ground rules for working with electrical circuits and proper multimeter use, including not touching live electrical components and not crossing electrical meter leads when measuring voltage.

3. Lay out the batteries on the table (or distribute them evenly in plastic cups throughout the center of the table so that multiple Students can access them at once). Ask the Students which tool they should use to figure out which batteries are good and why **(Q1)**.

4. Allow the Students to pick out batteries. Supervise them as they test the batteries’ voltage using a multimeter. Make sure they know that the red lead should go on the positive terminal and the black lead should go on the negative terminal, either by saying so outright in the safety introduction or by taking a Socratic approach (i.e., asking what they think and guiding them until they know the proper way to measure voltage).

    a. 1.6V - New; 1.5V - Good; <1.4V - Poor/Dead

5. If a Student doesn’t ask why dead batteries have voltage, ask them why they think a dead battery still has voltage **(Q2)**.



6. Once Students identify their fully charged AA batteries (two each), instruct them to test the light bulbs to find a good one.

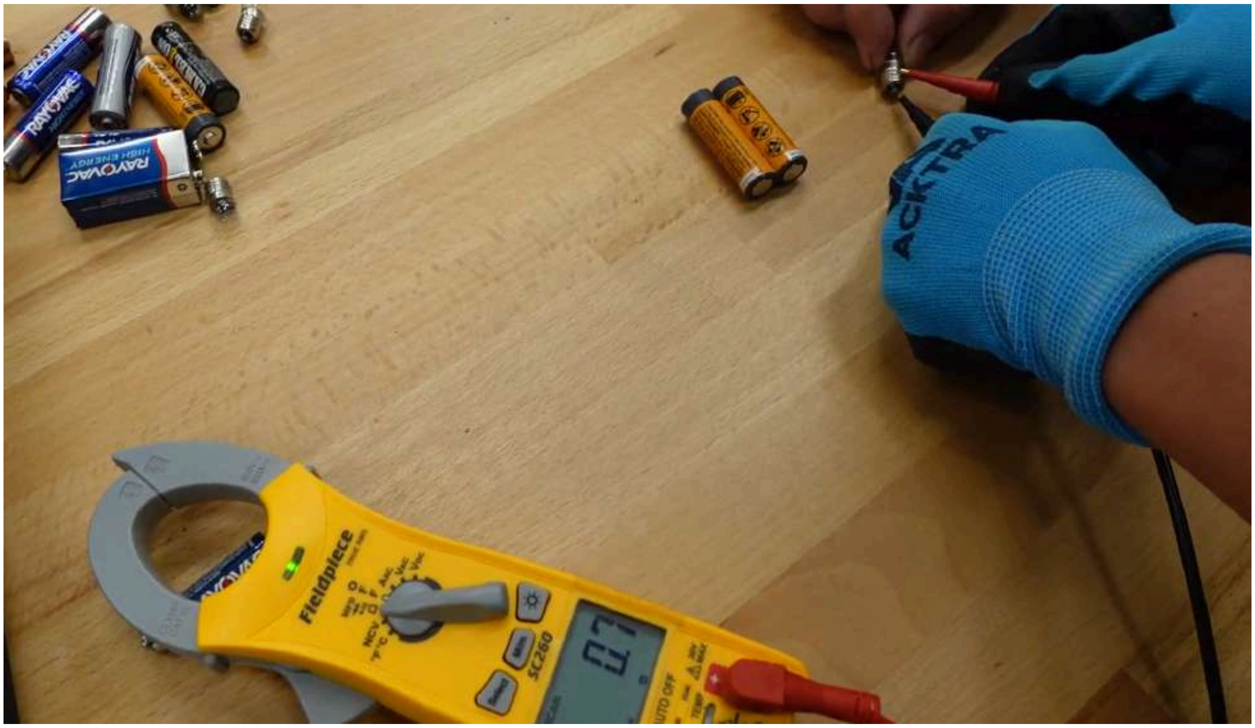
    a. Set the meter to the ohms (Ω) setting and let them know that it measures resistance in a circuit. Ask them why we measure resistance and not voltage to check if the bulbs are working **(Q3)**.

    b. Cross the meter leads and see if the meter shows a reading close to 0 to verify that the meter is working.

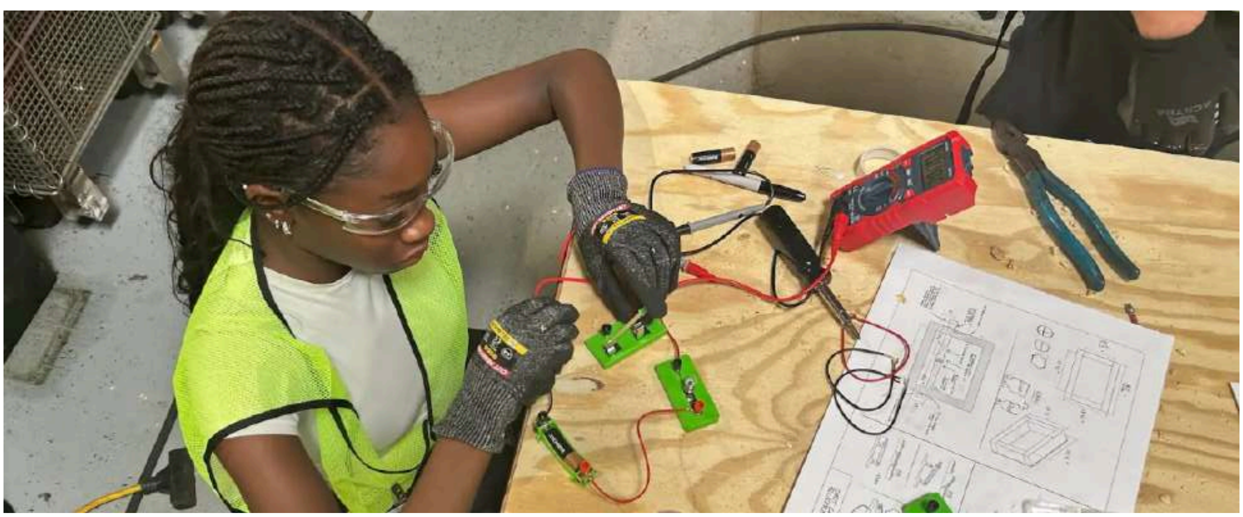
    c. Place a meter lead on the very bottom of the light bulb.

    d. Place the other meter lead on the metal threading on the sides of the bulb.

    e. A working light bulb will have resistance; a bad one will read OL, open, or dashes.



7. After the Students have successfully identified working batteries and light bulbs, give them the kits. Supervise the Students as they assemble the circuits in front of them.
    a. These circuits consist of a battery, a lighting fixture, a switch, and color-coded wires to connect the components. Ask the Students to identify the parts based on the blueprint.
    b. Ask the Students if we can make a circuit with one of the components missing (e.g., missing a switch) **(Q4)** and why they think so (or not).



8. Give Students the all-clear to add the light bulbs and then flip the switch to turn it on. As they add light bulbs and flip their switches, ask them why the switch needs to be closed for a bulb to turn on **(Q5)**.

    a. Let the Students use the multimeter to measure continuity across the switch in the open and closed positions. Make sure they write their answers down.

    b. OPTIONAL: Use disconnected switches and breakers as examples to facilitate the discussion.

9. Ask the Students what they think will happen if they use two batteries instead of one, both in the series and parallel configurations **(Q6)**.

    a. Let them measure the voltage across the bulb and the battery holders each time, and make sure they write their answers down.

10. Ask the Students what they think will happen if they wire up another light bulb in series and again in parallel **(Q7)**.

    a. Let them measure voltage and discover the series and parallel wiring. Make sure they write their answers down.

11. Once the Students have discovered a few different configurations, instruct them to wrap up by wiring the circuit in their favorite configuration and holding onto it for the final customization module, where they will arrange it in their box.

MODULE 6 — DISASSEMBLY

This module is optional; its feasibility will depend on the availability of blower assemblies, condensing fan assemblies, and time.

Story/Mission:

Now that we know how to put things together, we need to be able to apply our knowledge to take broken things apart!

It's up to you to discover how to take these broken machines apart with the tools you have and see what makes them work in the first place! Think about the way these assemblies fit together and how each part looks—our senses are the key to understanding how these things work.

Estimated Completion Time: 30 minutes

Materials:

- ☐ Scrap HVAC blower assemblies
- ☐ Scrap condenser fan assemblies
- ☐ Penetrating oil
- ☐ Emery cloth sandpaper

Tools:

- ☐ Adjustable wrench—NO hammers or pliers!
- ☐ 6-in-1 screwdriver

Theory/Skill:

- Becoming comfortable with using tools to disassemble parts
- Understanding how fasteners hold parts together
- Learning how a component works by taking it apart

Socratic Approach:

- Q1 - What fasteners are used on these blowers/fans? Why do you think the manufacturer has chosen to assemble the blower/fan this way?

- Q2 - How can penetrating oil and sandpaper make disassembling the blower/fan assemblies easier?
- Q3 - What can you assume about the way a fan or blower works based on what you've taken apart? How do you think a motor spins now that you see the inside of one?

Procedure:

1. Briefly go over any relevant safety information (i.e., sharp object safety with the tools, fasteners, and blades). Drive home the fact that each Student MUST wear gloves when touching the blowers or fans and their parts.

2. Let the Students examine their group's assembly for a few minutes, asking them questions about how they think it works.

    a. You can ask about the purposes of the brackets, set screw, and bolts that hold the assembly together.

3. Let the Students look at the fasteners. Then, ask the Students what they think they are and how we might be able to remove them **(Q1)**.

    a. Allow them to try using the adjustable wrench and screwdrivers by themselves before helping any of them.

4. Show the Students where the penetrating oil and sandpaper are if they encounter any issues taking the blades or wheel off the shaft. Ask the Students how they think those tools might be able to help separate the shaft from the wheel or blades **(Q2)**.
5. As the Students disassemble their blower and fan assemblies, ask them how they think each part works and then how all of them work together as a whole.
    a. If time allows, let the Students start to disassemble part of the motor as well, at least enough to expose the windings. Ask them what they see, what they think the purpose of those parts is, and how they think the windings work with the rest of the assembly to rotate the motor and move air **(Q3)**.

6. If Students have time and wish to do so, they may attempt to reassemble the motor (following the safety information from Step 1).
    a. If we run out of time before the Students can reassemble the blower or fan, no worries. Just leave the parts, and a Mentor/Host can go back after the camp to reassemble if necessary.

MODULE 7 — FINAL CUSTOMIZATION

Story/Mission:

You have unlocked the lost trade skills! Now is the time for you to celebrate and make your creation yours. Hang the circuits you made with hot glue, cover your box in stickers or drawings, and put your name on the box—it's yours, and you have every right to be proud of it!

Estimated Completion Time: 30 minutes

Materials:

- ☐ Students' completed box frames with piping and all related experiments:
    - Completed electrical circuit
    - Patched aluminum can
- ☐ Polaroids of Students taken throughout the camp
- ☐ #10 or #12 scrap bare solid wire
- ☐ Mounting or double-sided tape
- ☐ Decorative tape (duct tape, masking tape, painter's tape, Gaffers Tape)
- ☐ Decorative items (colored paper, stickers, etc.)
- ☐ Fairy lights
- ☐ Paint markers (assorted colors)
- ☐ Glue sticks for glue guns
- ☐ Pipe cleaners/chenille stems (craft type)
- ☐ Cardboard sheets (purchased; regular cardboard boxes do not work) or 65–80lb card stock sheets **for use with ChompSaws**
- ☐ Other art and craft supplies chosen by the Host

Tools:

- ☐ Hot glue guns
- ☐ ChompSaw(s) (**optional**; GRIT can include these with the PPE shipment if available upon request)
- ☐ Air-acetylene or propane torch and scrap copper (for use with Mentor supervision only)

Theory/Skill:

- Just for fun!

- This module is nearing the end of the GRIT Camp and provides a space for Mentors to take a breather and for Students to be independent and creative.

Procedure:

1. A central arts and crafts table with ChompSaws and card stock paper/cardboard sheets, hot glue guns, paint markers, and other supplies should be ready at the start of the module.
    a. Plug in multiple hot glue guns using a power strip
    b. Plug in ChompSaws and stack card stock paper or cardboard sheets next to each one.
    c. If necessary and to help create a smooth flow of activity, you can move the ChompSaws to a side table out of the way of the centrally located arts and crafts table.
    d. No razor blades or sharp tools should be used in this area.
2. Give Students about 30 minutes to customize their frames using their creations and photos, with hot glue, tape, or fasteners as needed.

3. Encourage them to add their own creative touch to make the box unique.
4. Students can decorate their boxes with paint markers, scrap wires, or other available materials.
5. If Students want to burn their initials into the box or braze copper wire with their initials, they can use the torch with the proper tip and PPE—**but only under Mentor supervision.**
    a. To do this, we can smash copper tubing flat to create a stand and bend wire into names or initials and solder them in place.

6. They can attach photos, circuits, aluminum cans, or other items to the luan backing as they choose.

Once everyone is finished, gather the Mentors and Students for a group photo. If possible, have a Volunteer do a few quick exit interviews to hear what Students and Mentors thought about their time at camp and what they learned. This feedback helps us share what GRIT Camps are all about and shows others the positive impact of giving kids hands-on exposure to the skilled trades.

Thank you for being part of GRIT—your time, effort, and dedication help build skills, confidence, and a brighter future for the next generation of builders.

APPENDIX A — SOCRATIC QUESTION CHEAT SHEETS

MODULE 1: SAFETY

Q: What would happen if you touch a saw blade?

A: You could cut your hand.

Q: What would happen if you're using a torch and get distracted by someone who's horsing around?

A: You could burn yourself or someone else, or you could start a fire.

Q: Why do you think you'd need to protect your eyes while sawing wood?

A: Wood shavings or splinters can fly off and into your face.

Q: What do you think would happen if you inhale or ingest toxic glue?

A: You could get sick.

MODULE 2: CARPENTRY

Main Questions

Q1: Where do you start measuring on the tape measure? Why is this important?

- What do each of those little lines represent?
- How many lines are there between one inch and the next?
- What is the starting point of positive numbers? (0 or 1?)

A: Start at the zero point, which is marked by the edge of a metal hook or tab. Starting beyond the zero point, such as the first tick for 1 mm (centimeter side) or 1/16" (inch side), will give you an inaccurate measurement.

Q2: Why do you think a piece of 2x4 plywood isn't really 2" x 4"?

- It's smaller than 2" x 4"—what do you think happened to make it smaller?
- Can we use raw wood for buildings? Why or why not?
- What do you think would happen if we used unfinished, non-uniform materials to make buildings?

A: The wood was initially cut to be two inches thick and four inches wide, but the wood has undergone sanding and preparation to make it suitable for use as a building material. For that reason, the processed wood is smaller than the first 2" x 4" cut. 2x4 is called a "nominal" size.

Q3: On which side of the mark should we cut the wood? Why?

- That saw blade is pretty thick—how do you think it'll impact the cuts we make?
- What's worse—a piece of wood that's too long or too short? Why do you think so?

A: You'll want to cut just outside the line on the "waste" side to account for the saw blade's thickness and not risk having a piece of wood that is too short.

Q4: Does that cut look bigger or smaller than you expected? Why?

- What were you expecting the cut to look like? Why that particular size?

- Look at the size and shape of the blade on the saw. What impact do you think that'll have on the shape of the cut?

A: The saw teeth make the cut happen at a slight angle, and the angle makes the cut larger than one would normally expect with a vertical cut from something with a perfectly straight blade, like a boxcutter, knife, or scissors. The total cut, including the extra due to the angle, is called the "kerf."

Q5: Which fastener do you think would do the best job of holding the frame together with the tool you have in front of you? Why?

- Let's say you want to attach something to a piece of wood and then to a concrete wall. Would you use the same fastener for both? Why or why not?
- In situations where we need a structure to withstand pulling force, would a nail or screw be more helpful? Why?
- What would be the key difference between a fastener that would work well for wood and one that would work well for concrete? Do we need one to be stronger than the other? Longer to go deeper? Grooved? Why?
- Let's say you have a hammer and a drill, and there is a screw here. Which one would you use to insert the screw into the wood and why?

A: Depends on the fasteners and tools available; since we will most likely have a drill or 6-in-1 screwdriver, then a screw makes the most sense due to the motion of the drill and the threads on the fastener. Tapcons are typically reserved for drilling into concrete. Nails can be used with a nail gun or hammer, but they are typically better for larger light framing projects.

Additional Questions

Q: What do you notice about the posted lengths in the blueprint? How can we figure out the lengths of the wood pieces we need to cut?

A: The blueprint shows how long some of the sides are, but it doesn't tell us how long the cut pieces of wood should be. We need to do some addition and subtraction.

Q: Which tool can help you draw a straight, perfectly level line where you want to cut the wood?

A: The speed square locks onto the horizontal edge and lets you draw a perfect vertical line perpendicular to the edge.

Q: (If speed squares are available at the GRIT Camp) Which tool can help you draw a straight, perfectly level line where you want to cut the wood?

> **A:** The speed square locks onto the horizontal edge and lets you draw a perfect vertical line perpendicular to the edge.

MODULE 3: PVC, COPPER, AND ALUMINUM FITTING & REPAIR

Main Questions

Q1: Why do you think we use PVC for some pipes and copper for others? What sorts of things would we move with PVC piping, and what would we move with copper tubing?

Follow-up questions:

- Let's say you're moving cool water under pressure—based on these two pipes, which one do you think is better—the PVC or the copper? Why do you think so? (Show them both materials)
- Let's say you want to move some very hot liquid or air—can we use the PVC for that? Why? What are the risks we face?

A: PVC is durable and can withstand high fluid pressures. We'd use PVC to move water and other cool fluids in applications like drains or irrigation pipes. Copper can withstand higher heat and is an excellent conductor, making it a good choice for applications where we move warmer fluids or need to transfer heat as the fluid moves through the tubing, and that's why we use it for refrigerant tubing.

Q2: Why do we need to remove the burr after we cut copper?

Follow-up questions:

- Fluids can move through tubing like cars on a highway—what would happen if there were a speed bump and all the cars were moving really fast?
- In a closed space like tubing, do you think the chaos that happens whenever there is an obstacle has effects beyond just an erratic flow?

A: Leaving the burr on the copper will cause turbulence, as the fluid in the pipe will need to move around it, which disrupts the smooth flow we want in pipes. This turbulence can lead to vibration, which is a cause of leaks.

Q3: Why don't we apply heat directly to the rod when we make a joint?

Follow-up questions:

- What happens if we heat a surface and put an ice cube on that surface? Why?

- If we heat the copper and touch the rod to the copper at the joint, what will happen to that rod? Where will that liquid go? (How do you think water goes from the ground to the top of a tree?)

A: We don't just want to melt the rod; we want it to draw into the joint and create a seal. Heating the base metal (highly conductive copper, in this case) will transfer some heat to the rod, causing it to melt and draw into the joint to create the type of seal we need. The liquid can move into that small space, even against gravity, because of something called capillary action, which allows liquid molecules to cling to solid molecules in the base metal and propel themselves.

Q4: Why do we need to use soft copper for swaging?

Follow-up questions:

- Even soft copper isn't soft like a plush animal! How do you think "soft" copper is different from "hard" copper?
- If you try to squeeze a soft object and a hard one, which one can you reshape more easily?
- What happens when you take something soft, like a pool noodle, and something hard, like a plastic or glass tube, and try to bend each one? Why do you think so?

A: Soft copper is relatively malleable, and hard copper is not. We need to reshape the base metal when swaging, so we need to use a metal that will change its shape without cracking. Hard copper will crack under that kind of stress, so we need soft copper or a means of softening the hard copper (annealing).

Q5: What can we do to patch a leak and make an aluminum can hold water or air as effectively as before?

Follow-up questions:

- Why does water come out of the can?
- What was in the gap before the leak?

A: We would need to fill the gap with another metal. Thinking back to the brazing activity, we can melt an alloy to fill that gap.

Q6: Why do we need to apply less heat to an aluminum can than the copper pipes we brazed earlier?

Follow-up questions:

- What happens if we directly touch the flame to the metal?
- [If melting comes up] Do you think that'll happen faster or slower with aluminum than the copper we worked with earlier? Why do you think so?

A: Aluminum has a lower melting point, so it would melt if we used the same amount of heat as we used for the copper tubing.

Q7: Why do we need flux for aluminum but not copper?

Follow-up questions:

- What's different about aluminum and copper?
- What molecules are in the air?
- What happened to the copper when we exposed the tubing to heat and oxygen? (Answer should be related to the scale/oxides.)
- If there were a way to stop these oxides from forming and make it easier for the base metal to bond with the alloy, would we use it? How?

A: At high temperatures, the base metal molecules start to form bonds with oxygen, which produces a substance called an oxide, which the alloy doesn't want to bind to. In the case of aluminum, these oxides make it difficult for the alloy to bind to the base metal, so flux bonds with the oxide to keep them from affecting the ability of the alloy to bind to fill the gap in the base metal.

Additional Questions

Q: How might the PVC glue be dangerous? What precautions do we need to take?

A: The glue has toxic fumes. We need to keep our faces away from the open containers and make sure we have enough fresh air.

Q: What could possibly be dangerous about the tubing cutters? How can we stay safe?

A: The tubing cutters have sharp edges, and the PVC cutters also have a pinch point. We can stay safe by wearing gloves and paying attention to our hands.

Q: Based on how these tools look, which tool do you think will work best for cutting the PVC? What about the copper?

A: Ideally, they'd come to the conclusion that the PVC cutter is best for PVC, and the copper tubing cutter is best for copper. If they answer incorrectly, let them try it out anyway and see what happens.

Q: Can you find the fittings on the blueprint? Why do you think they're called couplings and caps? What about an adapter?

A: Couplings join two pieces of tubing together. Caps simply cover the end so that the piping isn't open, like a pen cap that protects a pen nib and keeps it from leaking ink. An adapter adapts a piece of tubing so that it can work with a fitting it isn't typically designed for.

Q: What is this [deburring] tool? How do you think it works?

A: A deburring tool has an edge that scrapes along the tubing edge to remove any ridges or rough spots that might cause vibrations or affect a pipe's ability to transport a fluid.

Q: Why do we need to heat the rod before we dip it into the flux?

A: Heating the rod starts to melt the metal just a little bit, which makes the surface stickier for the flux to bind to.

MODULE 4: LUNCH LESSONS

Q1: How does heat move from the mat to the food or the lamp to something underneath it (like a tungsten, aluminum, or copper cube)?

Follow-up questions:

- When your parents cook something on the stove or the grill, how do you think the heat gets from the burner or flame to the food?
- When you put your hand underneath the lamp, what do you feel? Does the air directly between your hand and the light bulb also feel warm? Why do you think it doesn't?

A: Heat moves in a few different ways. The first is by conduction, which is direct contact; it's how heat moves from the heat mat or burner to whatever is on top of it. The next one is radiation, which is heat that moves via electromagnetic waves. Heat from a lamp transmits its heat directly to the surface in its path via waves, which is why the air between your hand and the light bulb isn't hot like your hand; radiation doesn't heat the air molecules, just the solid surfaces. Heat leaves the heat source (like hot food) and travels to the air molecules, which move it around. This form of heat transfer is convection.

Q2: Why do you think thermal images look different after some time? Where did the heat come from and go, and why?

Follow-up questions:

- Hold your hand above the objects. How does the air feel compared to the air a few feet away from them?
- If we were to let these items sit for several hours in this room, what temperature do you think they would be if we were to come back?

A: Heat naturally moves from areas of higher temperatures to lower temperatures, so the heat from the hotter objects moves to the cooler ones (hot lamp to the cooler cube, hot cube to the cooler air, etc.), becoming cooler in the process. This exchange will keep happening until the objects exchanging heat are at the same temperature.

Q3: What does a calorie measure? How do you think we can quantify calories?

Follow-up questions:

- How do we get the energy we need to run, jump, play sports, etc.?

- Hypothetically speaking, if food gives you the energy to perform physical activity, what do you think that energy would do if we applied it to something like a cup of water?

A: We use calories to quantify the energy content of food, but a calorie is really a unit of heat, which is a form of energy. If we could apply calories to a small vessel of water, it would heat the water; a calorie represents the amount of energy needed to raise the temperature of a single gram of water by one degree Celsius. (The Students likely won't know the specifics, but the goal is to get them to understand that calories are energy—and most importantly, units of heat.)

Q4: If you spray water on your hand and hold it in front of the fan, what do you feel? Why do you think you feel that?

Follow-up questions:

- Does your hand feel warmer or cooler when you put it in front of the fan?
- When you're all sweaty after running around and there's no A/C, would you rather go into a room with a nice ceiling fan or one with nothing at all?
- Where does the water, sweat, etc., go if you don't dry it off with a towel?
- How does the water get into the air? What do you usually need to make water evaporate?
- (If someone asks if evaporation is the same as boiling) What about puddles on the ground? Do those need to boil to evaporate?

A: If you have water or sweat on your skin, it doesn't stay there forever; it will eventually evaporate. A breeze or other form of convection provides some heat, as does your body in direct contact with the water. Your body gives off heat as the water evaporates, which makes you feel cooler. Keep in mind that boiling is a form of evaporation, but it is not the only way evaporation happens. Puddles and splashes all eventually evaporate without boiling; it just happens at a much slower rate because there's less heat.

Q5: Why does the air get sucked into the air cannon when you pull back the elastic launcher on the back side and then shoot out of it when you let go?

Follow-up questions:

- What happens to the membrane when you pull the elastic launcher back?

- If you're in a room that's uncomfortable and packed with a bunch of people and someone opens a door to a spacious, empty room, what would you do?
- Now, what would happen if the back wall suddenly closed in towards the door? Where would everyone go? Would they get out slowly or quickly?

A: Pulling the elastic launcher increases the volume inside the air cannon, which creates an area of low pressure. Air molecules under pressure move into the cannon. When someone releases the launcher, the volume rapidly decreases as pressure increases, forcing it out at a high velocity.

Q6: Why do you think we can knock down a bunch of cups from a distance with the air cannon? How can we knock it down from such a long distance?

Follow-up questions:

- What shape do you think the air makes when it's forced out of that smaller hole (as compared to the body of the cannon)?
- What do you think slows the air down?
- How do you think the shape of the air affects how quickly or slowly it slows down (i.e., what about its shape makes it travel far)?
- What is the difference between the air we shoot out of the cannon and the air around us?

A: The cannon creates a ring-shaped vortex by sending the discharged air through a nozzle. Since the orifice is narrower than the barrel, the fast-moving air is forced out of that smaller circular opening and begins spinning. When that spinning mass of air moves through a calm, still fluid (like stationary air or calm water), the ringed nature of the vortex allows it to travel far because the spinning motion combats friction from the air it has to travel through to reach the cups. The air around us is relatively stationary and has high static pressure exerted in all directions; the air coming out of the cannon has high velocity pressure exerted in one direction, so the static pressure keeps it on a straight path. This is called Bernoulli's principle.

Q7: Why does the entire Bernoulli bag inflate when you blow into it?

Follow-up questions:

- What is the speed of the air you blow into the bag, especially compared to the air that's just hanging around us?

- If the air is moving quickly in one direction, what do you think the air around it will do?

A: When air moves really quickly in one direction, especially on a narrow trajectory into a closed space like the Bernoulli bag, the air around it gets sucked into the airstream as well.

Q8: Why does the fluid in the glass hand boiler rise when you close your hand around the base?

Follow-up questions:

- What makes water boil when you or your parents are cooking?
- Is your hand warmer or colder than the glass?
- What happens when you add heat to a substance and it boils?
- What do you think would happen if you heated your hand underneath one of the lamps and then grabbed the bottom of the boiler?

A: Adding heat makes a substance boil; when heat is added, the molecules start moving faster, which makes the substance expand and start moving up the boiler. Adding more heat, such as when a Student holds their hand under a lamp, will cause the boiling to happen at a faster rate.

MODULE 5: BASIC ELECTRICAL MEASUREMENTS & CIRCUITS

Main Questions

Q1: How can you test batteries with the materials at your disposal?

Follow-up questions:

- What are batteries? What do they do?
- Is there live power coming out of these batteries? How do you know?
- If we aren't measuring live power, can we measure the ability of the batteries to "push" the power out with the materials we have?
- How do you think the multimeter lets us test voltage when we aren't actively using the battery?

A: We could just randomly insert batteries to see which ones make the circuit work, but we can also use a voltmeter to read the voltage. Voltage is electrical potential, so we want to see a voltage value that matches that on the battery packaging (or the voltage value given by the Mentors if we don't have a pack of batteries with the voltage on the packaging). We can use a multimeter set to volts DC (VDC) and connect the red lead to the positive terminal and the black lead to the negative terminal to measure the potential difference between them. Of these leads, the red one is "hot" and provides a small amount of current, and the black one is neutral and creates a return path to the multimeter. The meter interprets the difference in voltage between the two points.

Q2: If a "dead" battery still has some voltage, why doesn't the bulb turn on if we use one?

Follow-up questions:

- If you throw something when you're full of energy, how far will it go?
- What if you were to try the same thing when you were extremely tired? You can still throw it, but would the object travel as far?

A: Voltage is electrical potential or "pressure." The current is what powers a load, not the voltage, and even though there isn't enough voltage for the battery to supply power to a load, the multimeter will still detect some voltage.

Q3: Why do we measure resistance to check if a bulb is good and not volts or amps?

Follow-up questions:

- Does the light bulb supply power and provide an electrical "pressure?"
- When you rub your hands together, what do you think causes them to get hot? (The motion of your hands? The fact that your skin is opposing itself? The strength of your arms as you move your hands?)
- What do you think causes the light bulb to get hot? (The motion of electrical current? The filament's opposition to the current? The electrical pressure driving the current?)
- What would happen if that filament were broken? Would the bulb be able to light up? Would current be able to flow through it?
- What do you think the meter is doing when we measure continuity?

A: Voltage is electrical potential or "pressure." The bulb itself doesn't supply any power, but it has a little filament inside that resists the flow of current when it's in a closed circuit. This filament's ability to resist the current flow is what creates heat (and light). It cannot resist current flow if it doesn't have a complete path for the current to flow. When we measure continuity, the meter sends a tiny current through the leads and will ring if there is a complete path.

Q4: Why does every circuit need a switch, load, and power supply?

Follow-up questions:

- What happens if we take these circuits and don't have batteries?
- What happens if we make circuits without a switch?
- What happens if we make these circuits without a light bulb or motor?

A: A power supply introduces electrical energy to the circuit; without it, we can't expect a load to do anything. A load does the work in a circuit; it can be a light bulb, a motor, a toaster, etc., but it's the part that carries out a function. Without it, the electrical energy doesn't go towards anything and doesn't perform any work. A switch can either allow the flow of electricity or interrupt it so that we can control when the circuit does work and when it does not, so a switch is necessary for a circuit that we don't want to run all the time.

Q5: Why does the switch need to be closed for the bulb to turn on?

Follow-up questions:

- What happens to traffic when a drawbridge is down? What about when it's up?
- What happens to the current flow when a switch is closed? Open?

A: When a switch is open, there is a gap in the circuit. Electricity can't flow continuously, so we need the switch to be closed to bridge the gap and create a complete path between the power supply and the light bulb (the load).

Q6: What do you think will happen if we use two batteries instead of one? What if we stack them from end to end? Next to each other?

Follow-up questions:

- Each battery has a voltage rating. Do you think it will change if we arrange the batteries in a power bank from end to end? What about next to each other?
- What do you think will happen to the bulb if we add more voltage?
- What do you think will happen to the bulb if we don't add more voltage but have another battery?
- Once you've arranged the batteries, measure the voltage across the power supply. What do you notice about the voltage of the batteries in series? In parallel?
- If the voltage doesn't change when we arrange the batteries in parallel, why do you think people might still do it anyway?

A: Arranging the batteries in series (end to end) will add the voltages together, and you can see that if you measure voltage from one end of the complete power supply to the other. When we have more voltage, the light will be brighter. Arranging the batteries in parallel will maintain the voltage, so the bulb's brightness won't change, but the extra battery will make it last longer.

Q7: What do you think will happen if we use two light bulbs in the circuit instead of one? Do you think it'll be different if we stack them from end to end vs. wire them in parallel?

Follow-up questions:

- Each bulb is designed for a specific amount of voltage as well. Based on what happened when we stacked the batteries from end to end, what do you think will happen if we do the same with light bulbs? What about when the bulbs are wired in parallel?

- How do you wire a light bulb in parallel?

A: Wiring the light bulbs in series will make both of them dimmer, as each bulb will receive less voltage than if it were the sole bulb in a circuit. Wiring these particular light bulbs in parallel will theoretically supply the same voltage to the bulbs, making them maintain the same brightness, but difficulties connecting the circuit wires may make one bulb extremely dim or produce other unexpected results.

Additional Questions

Q: Which meter setting should we use to measure voltage (which is what the blueprint asks us to find)?

A: We want something that will measure voltage (V), and a battery only "pushes" electrons in one direction, not two, so we rely on direct current (DC) rather than alternating current. We want to use the VDC setting.

Q: Which meter lead do you think needs to go on the positive (raised) terminal of the battery? What about the negative one?

A: The red lead should touch the positive terminal, and the black lead should touch the negative terminal. If a Student reverses these, they'll get a negative voltage reading because the current only flows in one direction.

MODULE 6: DISASSEMBLY

Main Questions

Q1: What fasteners are used on these motors? Why do you think the manufacturer has chosen to assemble the motor this way?

Follow-up questions:

- What shapes have you noticed as you've looked at the fasteners holding the module together?
- How do these seem to compare to the ones we saw earlier?
- Do you see that little fastener on the motor shaft? What do you think that does?

A: The housing mostly has screws, though the motor module has bolts. The screws on the housing are threaded for tight assembly, and the bolts are shaped to handle the forces associated with a functioning motor inside the blower. The fastener attached to the shaft is called a set screw and attaches to a hub, which connects the motor to the part of the blower that's supposed to rotate.

Q2: How can penetrating oil and sandpaper make disassembling motors easier?

Follow-up questions:

- What do you already know about oil? How does it feel?
- What do you already know about sandpaper? How does it feel?

A: Oil is slippery and lubricates the shaft so that it can detach from the housing more easily. Sandpaper is gritty and can sand down hard substances and even remove rust, allowing it to remove coatings that make it more difficult for the shaft to separate from the assembly.

Q3: How do you think a motor spins now that you see the inside of one? What can you assume about the way a fan or blower works based on what you've taken apart?

Follow-up questions:

- Look at the shapes of each part. What do they remind you of?
- Why is it important for the blades or wheel to mount to the motor's shaft?

- Think about the motions of a motor. How do you think those parts allow a motor to move?

A: Students should be able to identify that motors provide the ability to spin the blades. If the Students get far enough to disassemble the motors, they will learn that motors can rotate and consist of a moving part (rotor) and a stationary part (stator). (They probably won't know this vocabulary or arrive at it on their own.) Motors have magnets and require electrical energy to generate magnetism from the stator, and the interaction of that magnetism and the magnets on the rotor drives the rotation.

Additional Questions

Q: How do you think this assembly in front of you moves air?

A: A motor connects to a wheel that draws air around it inside and uses centrifugal (spinning) force to throw it out of the rectangular portion at the top. This method is how air gets pushed through ductwork.

Q: Why does the motor move a little bit if you press on the module or the shaft?

A: A motor spins extremely fast inside the housing, and there needs to be a little bit of give for the motor to work as intended without putting too much stress on the assembly.

Q: Which bit of your screwdriver is best for the current task?

A: The answer will depend on what specific part the Student is trying to disassemble. Encourage the Students to look at the fastener shape and size and compare those to the screwdriver bits to find the appropriate one.

Q: The adjustable wrench is too big (or small)! How can you make it work to disassemble the blower assembly?

A: The adjustable wrench has a screw mechanism that can open or close the jaw. Open the jaw as much as needed, put the jaw around the bolt or other fastener needing to be loosened, tighten the jaw around the fastener, and then turn it counterclockwise to remove a fastener. If reassembling, turn the wrench clockwise.

APPENDIX B — CHECKLISTS

This appendix contains checklists for delegating responsibilities on the morning of the camp before Students arrive or procuring materials by module (as opposed to using the massive material list) for quick setup.

You may find that these work well for you, or you may prefer to use a different method. Feel free to print them and use them as you please, or you may ignore them and use the method that you feel will work best for you.

Materials By Module

This list will break down the materials needed for each module and their quantities. It's another means of separating the materials in the master list and doesn't include copies of items that the Students use across modules, like their blueprints, screwdrivers, or tape measures (all of which are listed on multiple materials lists inside the individual module guides).

Responsibility Delegation Checklist

This list can help Hosts figure out which volunteers are going to perform their respective setup and supervisory tasks. It can be a helpful tool to make sure all the materials, Stations, Staging Areas, and other needs of GRIT Camp, including signage throughout the property, are ready to go before the GRIT Camp starts.

MATERIALS BY MODULE

MODULE 1: SAFETY

Materials (1x per Student) - *Provided by GRIT*:

- ☐ Safety gloves
- ☐ Safety glasses
- ☐ Safety badges
- ☐ Safety checklist
- ☐ Branded tool belt
- ☐ High-vis safety vests
- ☐ Earplugs
- ☐ Pre-sharpened carpenter pencils (with sharpeners)

Tools (1x per Student) - *Provided by GRIT*:

- ☐ Blueprints for creating a box frame or shelf
- ☐ GRIT-branded tape measure
- ☐ GRIT-branded 6-in-1 screwdriver

MODULE 2: CARPENTRY - *GRIT does not provide*

Materials:

- ☐ 2x4 lumber cut down to 5 ft length (with drops or extra pieces; 1x per Student)
- ☐ Non-2x4 lumber samples for discovery (**optional**)
- ☐ **Pre-cut** 17.5" x 12.5" pegboard or luan backing (1x per Student)
- ☐ 3” T-25 torx head screws (10x per Student)
- ☐ 1 ¼” finish nails (10x per Student)
- ☐ Other fastener types and sizes for discovery (**optional**)

Tools:

- ☐ Miter saw (or chop saw) with a guard (1x table saw per 5 Students)
- ☐ Bar clamps (2x per saw table)
- ☐ Pre-sharpened carpenter pencils (1x per Student; **provided in GRIT Student Kit**)

- ☐ Drill with ½” chuck (1x per Station, if possible, or multiple drills placed in the “Staging Area” to share; Mentors may bring their own drills if they wish)
    - ☐ Wood-drilling Forstner size ⅞”
    - ☐ Wood-drilling Forstner size 1 ⅛”
    - ☐ T25
- ☐ Speed square (**optional**; 1x per Station)
- ☐ Hammer (1x per Station)
- ☐ Emery cloth sandpaper (1x roll placed in “Staging Area”)

MODULE 3: PVC, COPPER, ALUMINUM FITTING & REPAIR - *GRIT does not provide*

Materials:

3A - PVC

- ☐ ¾” Schedule 40 PVC pipes (not pre-cut)
- ☐ ¾” Schedule 40 PVC adapter, slip socket x FPT, couplings
- ☐ ¾” Schedule 40 PVC adapter, slip socket couplings
- ☐ ¾” Schedule 40 PVC adapter, slip socket caps
- ☐ PVC glue and primer cans taped together

3B - Copper

- ☐ ⅞” OD soft copper tubing (not pre-cut)
- ☐ ¾” copper sweat x ¾” NPT adapter
- ☐ Pre-brazed copper ⅞” caps (1x per Student)
    - ☐ Optional: Caps with Schrader (if pressure test is being performed; 1x per Student)
- ☐ Other pipe sizes and types for discovery (**optional**)
    - ☐ ⅝” OD soft copper tubing
    - ☐ Scrap copper tubing
    - ☐ Galvanized steel
- ☐ Emery cloth sandpaper

3C - Joining PVC and Copper

- ☐ 0%, 5%, or 15% phos / copper brazing rods
- ☐ Teflon tape or pipe dope
- ☐ Cored bricks or fire bricks
    - ☐ Optional alternative: Tristand pipe chain vise

3D - Aluminum Repair

- ☐ Aluminum cans or thin aluminum sheets
- ☐ Aluminum repair kit/rods
- ☐ Aluminum HVAC evaporator coil (**optional**)

Tools:

General/Safety

- ☐ Permanent marker
- ☐ Drill
- ☐ ⅞" wood-drilling Forstner bit
- ☐ 1 ⅛" wood-drilling Forstner bit
- ☐ Fire extinguisher(s)
- ☐ Fire blanket(s)
- ☐ Bucket(s) of water
- ☐ Rags

3A- PVC

- ☐ PVC cutter

3B - Copper

- ☐ Copper tubing cutters
- ☐ Deburring tool
- ☐ Swaging tool (**optional**; battery-powered or hand swage if not using caps)

3C - Joining PVC and Copper

- ☐ Air-acetylene brazing/soldering torch rigs OR propane torches (Mentors may bring their own)
    - Brazing copper (air-acetylene): TurboTorch A-8 tip
    - Soldering aluminum (air-acetylene): TurboTorch A-3 tip
- ☐ Igniter/lighter (friction or push-button spark)
- ☐ Adjustable wrench

3D - Aluminum Repair

- ☐ Pliers (large enough to grip ⅞" tubing and an aluminum can)
- ☐ Sharp awl (to punch holes in the cans)
- ☐ Stainless steel wire brushes

MODULE 4: LUNCH LESSONS - *GRIT does not provide*

Materials/Tools:

The more of these items you have, the better, but the Host can purchase/gather at their own discretion:

- ☐ Food (arranged ahead of time)
- ☐ Cubes or spheres of identical size but different materials (e.g., tungsten, aluminum, and copper; **optional**)
- ☐ Thermal imaging camera
- ☐ Food warming mat or hot plate (**optional**)
- ☐ Large Marshmallows (**optional**)
- ☐ Heat lamp (**optional**)
- ☐ Spray bottle (to be filled with water)
- ☐ Plug-in or battery-powered fan (**optional**)
- ☐ HVAC School Physics Fun Kit (includes the items below, which may be purchased separately)
    - ☐ Air cannon w/ 10 paper cups
    - ☐ Hand Boiler
    - ☐ Drinking Bird
- ☐ Bernoulli bags
- ☐ Small drop cloths, tarps, or sheets
- ☐ Pieces of metal and small cloths

MODULE 5: BASIC ELECTRICAL MEASUREMENTS & CIRCUITS - *GRIT provides the main kit; GRIT does not provide the rest:*

Materials:

- ☐ Electrical circuit kits (1x per Student; GRIT provides)
- ☐ Brand new AA batteries (2x per Student)
- ☐ Extra batteries for discovery (mix of AA, AAA, and 9V, including dead and corroded)
- ☐ Light bulbs with extra for discovery (small 3V DC bulbs, assorted good and defective)
    - ☐ Working light bulbs (2x per Student; **these come with the GRIT provided kit)**
    - ☐ Burnt-out bulbs (you can connect bulbs to a 9V battery; at least 1x per kit)
- ☐ Conductive wires with extra scrap wires for discovery (rolls or pre-cut lengths; **optional**)

- ☐ Switches with extra for discovery (simple on-off, toggle type; light switches; **optional**)
- ☐ Breakers for discovery (**optional**)

Tools:

- ☐ Electrical multimeter (at least 3x, but 1x per Station is best)

MODULE 6: DISASSEMBLY - *GRIT does not provide*

Materials:

- ☐ Scrap HVAC blower assemblies (1x per Station)
- ☐ Scrap condenser fan assemblies (1x per Station)
- ☐ Penetrating oil (1x per Station; reuse from previous modules)
- ☐ Emery cloth sandpaper (reuse from previous modules)

Tools:

- ☐ Adjustable wrench (1x per Station, reused from previous modules)
- ☐ GRIT-branded 6-in-1 screwdriver (reused from previous modules)

MODULE 7: FINAL CUSTOMIZATION - *Many of these are OPTIONAL; GRIT does not provide*

Materials:

- ☐ #10 or #12 scrap bare solid wire
- ☐ Mounting or double-sided tape
- ☐ Decorative tape (duct tape, masking tape, painter's tape, Gaffers Tape)
- ☐ Decorative items (colored paper, stickers, etc.)
- ☐ Fairy lights
- ☐ Paint markers (assorted colors)
- ☐ Glue sticks for glue guns
- ☐ Pipe cleaners/chenille stems (craft type)
- ☐ Cardboard sheets (purchased; regular cardboard boxes do not work) or 65–80lb card stock sheets
- ☐ Other art and craft supplies of your choice

Tools:

- ☐ Scissors
- ☐ Hot glue guns
- ☐ ChompSaw(s) **(optional**; **GRIT can loan these, if available, upon request)**
- ☐ Air-acetylene torch with a #8 and #3 tip OR propane torch (1x)

RESPONSIBILITY DELEGATION CHECKLIST

Please refer to the GRIT Camp Setup for guidance in the placement of materials

Tasks to be Completed	Responsible Volunteer
Check-In Prep	
☐ Post directional signage around the property	______________________
☐ Set up the check-in table with the sign-in forms	______________________
☐ Arrange refreshments on the table	______________________
Module 1 — Safety Prep	
☐ Arrange safety/tool bundles for each Student (And if you decide to use small boxes for their toolbox, have these set out by the safety prep table.)	______________________
Module 2 — Carpentry Prep	
☐ Pre-cut the 2x4s into 5' lengths	______________________
☐ Pre-cut the luan backing to 17.5" x 12.5" lengths	______________________
☐ Arrange the materials for the carpentry module	______________________
☐ Arrange the hand tools for the carpentry module	______________________
☐ Set up the saw and drill (with bits) in a safe location	______________________
Module 3 — Pipefitting & Aluminum Repair Prep	
☐ Arrange PVC pipes in a Staging Area	______________________
☐ Arrange the materials for the PVC work	______________________
☐ Arrange the PVC tools in a Staging Area	______________________
☐ Arrange copper tubing in a Staging Area	______________________

- ☐ Arrange the materials for the copper work ______________________
- ☐ Arrange the copper tools in a Staging Area ______________________
- ☐ Arrange the materials for aluminum repair work ______________________
- ☐ Arrange the rest of the tools (e.g., awl) in a Staging Area ______________________
- ☐ Set up at least one water bucket with 4 rags per Station ______________________
- ☐ Place a fire extinguisher within reach of the Stations ______________________
- ☐ Place a fire blanket within reach of or at the Stations ______________________
- ☐ Set up the torch assemblies ______________________

Module 4 — Lunch

- ☐ Set up the hot plate/mat, lamp, and electric heater ______________________
- ☐ Develop a plan to serve the food in an orderly fashion ______________________
- ☐ Put out Bernoulli bags, air cannons, and misc. toys ______________________
- ☐ Adult has been made in charge of thermal camera use ______________________

Module 5 — Electrical

- ☐ Gather a mix of good, bad, and corroded batteries ______________________
- ☐ Gather a mix of good and bad light bulbs ______________________
- ☐ Arrange and test electrical multimeters ______________________
- ☐ Arrange the electrical kits for each Student ______________________

Module 6 — Disassembly

- ☐ Set up the assemblies in a safe, supervised location ______________________
- ☐ Arrange the hand tools at Stations or in a Staging Area ______________________
- ☐ Set up penetrating oil and sandpaper in a Staging Area ______________________

Module 7 — Final Customization

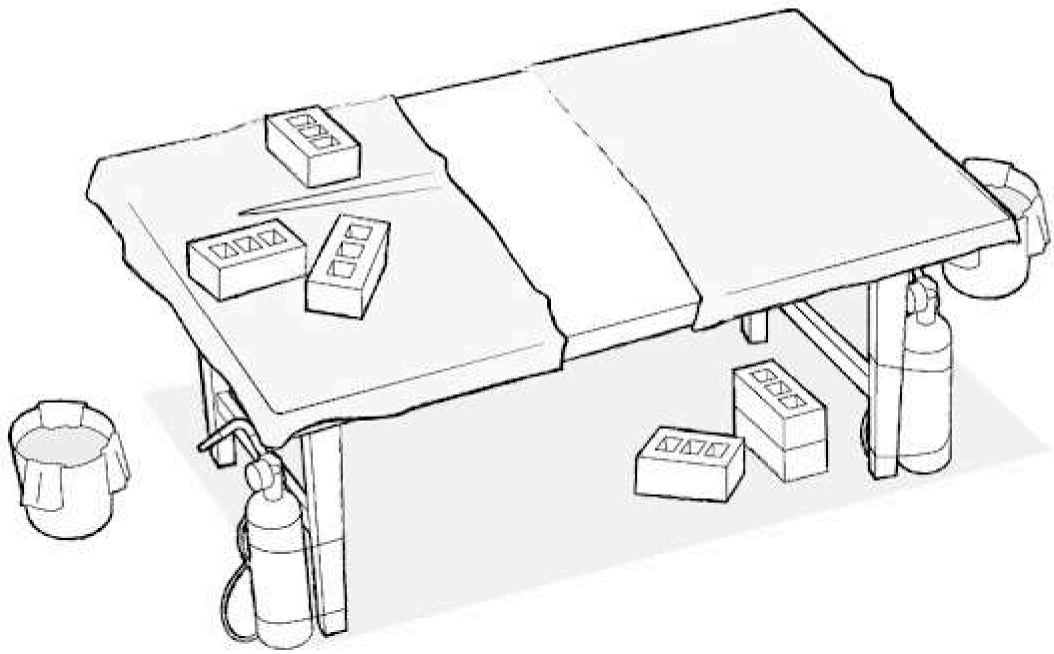
- ☐ Set up a central table with non-hazardous craft items ______________________________
- ☐ Create an area with ChompSaws (if applicable) ______________________________
- ☐ Arrange a table with a torch rig safely tied down ______________________________

APPENDIX C — STATION & STAGING AREA SETUP RECOMMENDATIONS

This appendix contains photos of Station and Staging Area setups from prior GRIT Camps. You do not need to model your GRIT Camp's Stations and Staging Areas in exactly the same way, but you may choose to use these as references.

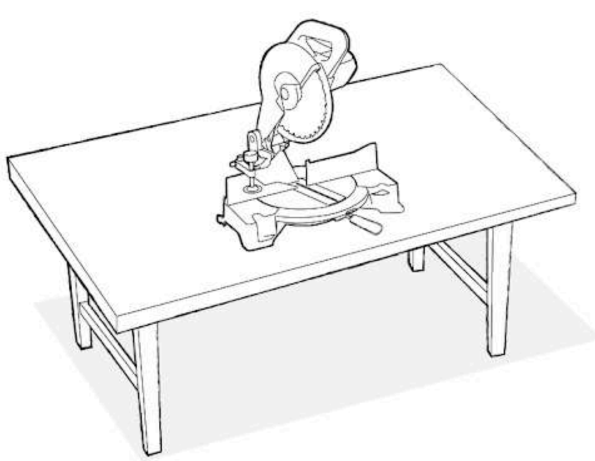
STATION LAYOUT

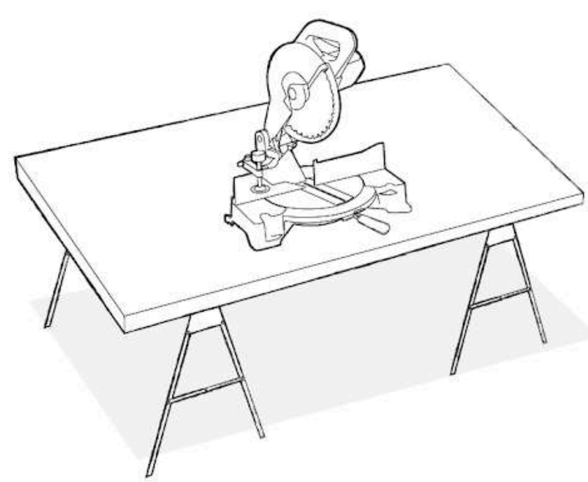
A Station is a dedicated space for each team of one Mentor and two Students to build together. You may use fold-up tables, workshop tables, or other various options to create this space.

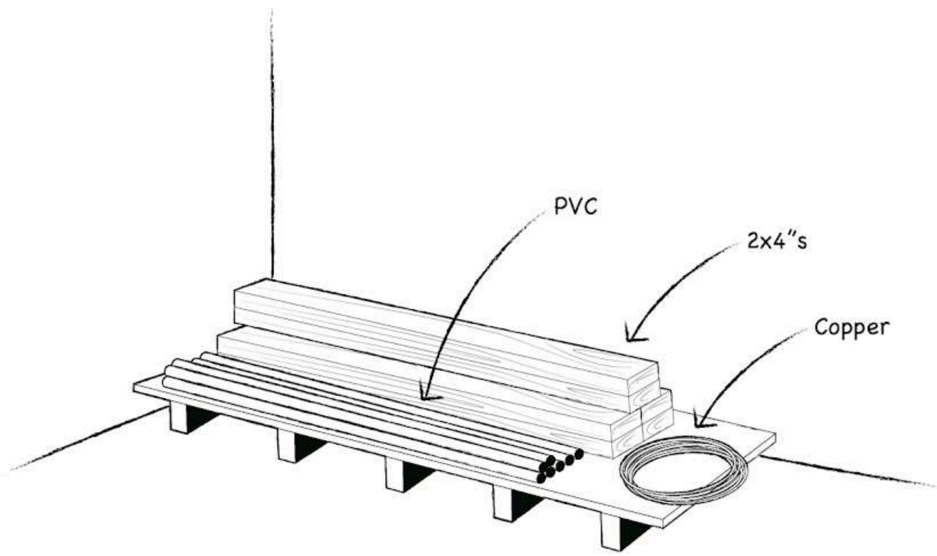


STAGING AREA LAYOUT

The Staging Areas are shared spaces for Students and Mentors to use saws and gather needed materials like lumber, PVC, copper, and various small materials and hand tools needed for each module.






PVC
2x4"s
Copper

APPENDIX D — Purchasing Links

While most of the required materials for the GRIT Camp can be found in most trades businesses and education facilities, you may be missing a few items. This list contains links to required *and* optional materials that some Hosts may not already have in their facilities or local supply houses.

REQUIRED

First Aid Kit
(Module 1: Safety)

Bar Clamps
(Module 2: Carpentry

Drill
(Module 2: Carpentry

T-25 Bits
(Module 2: Carpentry)

3” T-25 Torx Head Screws (+ 1 Bit)
(Module 2: Carpentry)

Forstner Bits (⅞” and 1 ⅛”)
(Module 2: Carpentry)

[1 ¼” Finish Nails](#)
(Module 2: Carpentry)

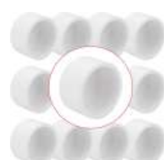
[Hammer](#)
(Module 2: Carpentry)

[¾” Schedule 40 PVC Pipes](#)
(Module 3A: PVC)

[¾” Schedule 40 PVC Adapter, Slip Socket x FPT Coupling](#)
(Module 3A: PVC)

[¾” Schedule 40 PVC Slip Socket Coupling](#)
(Module 3A: PVC)

[¾” Schedule 40 PVC Slip Socket Cap](#)
(Module 3A: PVC)



[PVC Primer and Glue](#)
(Module 3A: PVC)

[PVC Cutter](#)
(Module 3A: PVC)

[Emery Cloth Sandpaper](#)
(Module 3B: Copper,
Module 6: Disassembly)

[Copper Tubing Cutter](#)
(Module 3B: Copper)

[Copper Deburring Tool](#)
(Module 3B: Copper)

[¾” Copper Sweat x ¾” NPT Adapter](#)
(Module 3B: Copper)

[Pre-brazed Copper ⅞” Caps](#)
(Module 3B: Copper)

[Fire Extinguisher](#)
(Module 3C: Joining PVC and Copper)

[Fire Blanket](#)
(Module 3C: Joining PVC and Copper)

[Cloth Rags](#)
(Module 3C: Joining PVC and Copper)

[Spark Lighter & Flints](thegritfoundation.com)
(Module 3C: Joining PVC and Copper)

[0% Silver Phos-Copper Brazing Rods](thegritfoundation.com)
(Module 3C: Joining PVC and Copper)

[Adjustable Wrench](thegritfoundation.com)
(Module 3C: Joining PVC and Copper)

[Teflon Tape](thegritfoundation.com)
(Module 3C: Joining PVC and Copper)

[Pliers](thegritfoundation.com)
(Module 3C: Joining PVC and Copper)

[Aluxcor 78/22 Flux Cored Zinc/Aluminum Brazing Alloy](thegritfoundation.com)
(Module 3D: Aluminum Repair)

[Awl](thegritfoundation.com)
(Module 3D: Aluminum Repair)

[Stainless Steel Wire Brush](thegritfoundation.com)
(Module 3D: Aluminum Repair)

Thermal Camera
(Module 4: Lunch Lessons)

AA Batteries
(Module 5: Basic Electrical)

Electrical Meter
(Module 5: Basic Electrical)

Instant Camera & Film
(Module 7: Final Customization)

OPTIONAL

Speed Square
(Module 2: Carpentry)

Needle-Nose Pliers
(Module 2: Carpentry)

Hand Swaging Tool
(Module 3B: Copper)

[Heat Lamp](#)
(Module 4: Lunch Lessons)

[Warming Mat](#)
(Module 4: Lunch Lessons)

[Spray Bottles](#)
(Module 4: Lunch Lessons)

[Plug-In Fan](#)
(Module 4: Lunch Lessons)

[Bernoulli Bags](#)
(Module 4: Lunch Lessons)

[Element Cubes (1”)](#)
(Module 4: Lunch Lessons)

[HVAC School Physics Fun Kit](#)
(Module 4: Lunch Lessons - contains drinking bird, hand boiler, circuits, and air cannon)

[Air Cannon](#)
(Module 4: Lunch Lessons - included in HVAC School Physics Fun Kit)

Hand Boiler
(Module 4: Lunch Lessons - included in HVAC School Physics Fun Kit)

Extra Circuit Kits
(Module 5: Basic Electrical - GRIT provides enough for the camp)

Bare Wire (Rolls or Scraps for Discovery & Customization)
(Module 5: Basic Electrical)

Toggle Light Switches (Discovery)
(Module 5: Basic Electrical)

Breakers (Discovery)
(Module 5: Basic Electrical)

Penetrating Oil Spray
(Module 6: Disassembly)

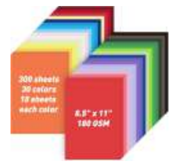
ChompSaw
(Module 7: Final Customization)

Hot Glue Guns & Sticks
(Module 7: Final Customization)

[Double-Sided Tape](#)
(Module 7: Final Customization)

[Paint Markers](#)
(Module 7: Final Customization)

[65+ lb Card Stock](#)
(Module 7: Final Customization - for use with ChompSaw)



[Cardboard Sheets](#)
(Module 7: Final Customization - for use with ChompSaw)