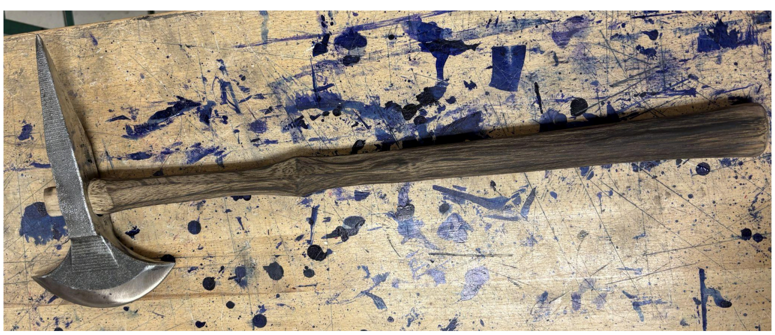
SFSA Cast In Steel 2026 – Horseman's Axe
Technical Report

Colorado School of Mines – Oops, all Freshmen



Team Members:

Austin Arvidson, Annebelle Good, Ani Palacios-Wilhelm, John-Austin Little

Advisor(s) Name: Sarah Harling

Foundry Partner: Western Foundry

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II. Introduction

Want to hear a joke?

A Chemical Engineer, Mechanical Engineer, Engineering Physicist, and Materials engineer walk into a room, that room was attached to a foundry and they are making an Axe.

That's us, we're the joke.

As a team of four freshmen, 3 of us have career plans that have nothing to do with foundry, the fourth is a Materials and Metallurgical Engineer. We already commit ourselves to one or two research labs a piece and time-consuming extracurriculars, so, why on earth are we making an axe you might ask? Well, the first thing is that we're nerds, and most of us grew up on Forged in Fire. The second thing is that we were excited to learn about a whole new world of professions and skills. And thus, our mission statement:

We seek to learn as much as possible about a new craft, and to broaden our horizons with insight into different industries and professions, as well as to make a half-decent axe.

In the same spirit, we would like to acknowledge the reason we are able to compete in the first place:

SFSA has created this competition to encourage students to learn about making steel products using the casting process and applying the latest technology available

It is with great thanks to the SFSA, whose generosity and love for foundry education that we present the following technical report on our Horseman's Axe.

III. Historical Background & Authenticity

Late into the 14th century, European armor quality had outpaced the cutting capacity of many swords and purely concussive weapons. Hardened steel plate increasingly resisted edge-based slashing and dispersed blunt trauma across curved surfaces. This created a tactical demand for weapons capable of both concentrating force and retaining cutting capacity. The mounted war-axe re-emerged as the answer.

By the late 15th century, the horseman's axe had evolved into a compact, one-handed cavalry sidearm. A German horseman's axe dated c. 1490–1535 in the collection of the Art Institute of Chicago demonstrates a compact head, the blade semicircular, and proportions suited for use from horseback rather than in pike formations.[1] A Spanish/Flemish example dated c. 1500–1533 further confirms this typology, illustrating regional variation while retaining the defining structural features of a mounted combat axe.[2]

A mid-16th-century Spanish horseman's axe preserved in the Real Armeria in Madrid, and reproduced by Arms & Armor, exemplifies the matured form: a curved cutting blade paired with a substantial rear spike designed for armor penetration.[4]

Our casting intentionally recreates these structural and tactical characteristics.

The semicircular blade in our design mirrors the late medieval crescent forms seen in both the German and Spanish examples.[1 2] In addition, the head remains compact and appropriate for one-handed mounted use, consistent with the surviving Art Institute examples.[1 2] On the backend the pronounced spike in the piece reflects the 15th-century adaptation toward armor defeat. Overall the weapons head is well situated within the documented evolution of cavalry axes responding to armored warfare.

Though the wooden handle reflects earlier 15th century axes the overall length of ___ and mild weight of ___ contribute to a representative historical synthesis.

Our design was made in this way so that we could capture the no-nonsense core of what a Horseman's Axe was meant to be and do. A simple semi-circular blade and square spike are at the center of most designs, and their sum is the vast majority of the implements utility, so those two features comprised our entire design. Although additional decorative features were not uncommon on the spike and blade, and some axes even included a top pike, these features were mostly ancillary and only complicated the production process. In conclusion, our design was selected to ensure that we captured the weapons purpose in a way that made production practical for a novice team.

IV. Design Process & Engineering

Our process started with 3D modeling. Annabelle Good, our mechanical engineer, had the pleasure of learning SolidWorks by figuring out how to make our first axe pattern, a fact that the rest of us were incredibly grateful for. We negotiated with the school to let us 3D print an axe despite the traditional “No Weapons” rule, and we were off to the races… to make a rising and gating system. A lecture and some discussion later, one came into existence for our first pour.

The test pour utilized 1045 steel doped to 4140 to produce a blade that would be appropriately hard. Molds were rammed in green sand using our 3D printed pattern board, and set outside for pouring. Austin Arvidson was our star for this pour, working as a backup for the dead end of the active pour, and getting pulled in without issue multiple times. This pour produced a good axe head, but the rising and gating system needed improvement, and it received as much before the next pour.

To test the aforementioned new system, a test pour was done in Aluminum. Green sand molds were rammed once more with the new 3D printed pattern, and were set in the foundries sand pit for pouring. John-Austin Little, the physics major, was placed on skimming and managed to toss slag onto someone's shielded foundry boots after knocking the skimmer rod clean with too much vigor, nobody was injured. At the end of the pour, which went on without further incident, the aluminum prototype demonstrated a need for the gating to further restrict the flow rate into the mold to avoid washout.

The altercations were made by Sarah Harling’s husband, who we owe a great thanks too. Those molds were poured with the same kind of doped steel as before, although the process occurred inside. This was a great fortune, as we managed to set off the fire alarm inside the foundry (no small feat) and gave a poor group of fire fighters a great fright when they arrived at the scene to find 10 college students and three adults in silvers. There was nothing truly wrong, just some fumes in places they shouldn’t be, and we got most of the pouring and ensuing events on camera.

For that last pour, and for our tour of a foundry to understand the practice, we worked with Western Foundries, and a former employee of theirs, Juan. During the tour we got to see how industrial pours take place, and the kind of equipment they operate to maintain production.

V. Materials & Metallurgical Decisions

For the axe head, we chose AISI 4140 low-alloy steel over a standard plain-carbon steel like AISI 1045. 4140 is a chromium-molybdenum steel containing roughly 0.40% carbon, 1% chromium, and 0.20% molybdenum. We selected this specific grade because it provides the baseline strength and impact resistance required for a heavy-duty tool.

Metallurgical Justification

The primary engineering challenge for an axe is surviving the kinetic shock of impact. If the steel is too hard, the blade will chip or the head will shatter. If it is too soft, the edge will roll and dull. Alloying from 1045 to 4140 solves this hardness-toughness compromise through its specific composition:

- Carbon (0.40%): Provides enough carbon to heat-treat the edge to a functional hardness (typically 50–54 HRC). This ensures good edge retention while avoiding the brittleness found in higher-carbon steels.]

- Chromium (1%): Increases the steel's hardenability compared to 1045. This ensures deeper, more uniform hardening during the quenching process, which is necessary given the thick geometry of an axe head.

- Molybdenum (0.20%): Increases the overall toughness of the steel. This improves the axe head's ability to absorb shock and prevents the weapon from shattering upon heavy impact.

- Differential Hardening: 4140 responds well to differential heat treatment. The cutting edge can be hardened for wear resistance, while the main body and eye can be left softer and more ductile to act as a shock absorber.

In conclusion, our material selection prioritizes utility. By using 4140, we captured the core purpose of the weapon, ensuring it holds a sharp edge while maintaining the high durability and shatter-resistance required of a working axe.

VI. Manufacturing & Casting Process

Process Selection:

Our team selected sand casting for the production of the axe head. This method was chosen primarily for its practicality and suitability for a novice team. Sand casting provided a direct approach that easily accommodated the thick geometry of an axe head. Because a working axe requires significant post-cast grinding to establish a sharp edge and a functional spike regardless of the casting method used, the ultra-fine surface finish of more advanced techniques was unnecessary for our project goals.

Mold Making and Gating Design:

The execution phase began with pattern creation. We used a 3D printer to fabricate a solid plastic replica of our axe design, as well as the rising and gating, to serve as the master pattern. We placed this 3D printed pattern inside a two-part metal frame and packed molding sand tightly around it to capture the negative impression. We created a sprue and runners to direct the flow of molten steel smoothly into the cavity. We also placed risers near the thickest sections of the axe head, such as the eye. These risers act as reservoirs of liquid metal that feed back into the casting as it cools and shrinks, preventing internal voids and structural weakness.

Pouring, Shakeout, and Finishing:

Once the mold was sealed, the 4140 steel alloy was melted in a furnace until it reached the proper pouring temperature and was poured into the sand mold. After allowing the metal to completely cool and solidify, we moved to the shakeout phase, breaking apart the sand to reveal the rough casting. The final step was finishing. Sarah Harling and members of the Senior team used cutoff wheels to remove the solidified gates and risers from the main body of the axe. They then used grinders to clean off the rough surface finish from the sand, refine the final profile of the weapon, and establish the primary bevels for the cutting edge and rear spike before final heat treatment.

VII. Inspection, NDT, & Quality Assurance

Due to the tight deadline, and how our schedules worked out, we were not able to perform any kind of testing. We are, however, faithful in the soul of the axe.

VIII. Final Results & Submission Eligibility

The following requirements are laid out by the SFSA:

a. Axes must not weigh more than 1.5 kg (3.3lbs).

b. Axes cannot be longer than 800 mm (31.5 in.)

We meet these requirements with the following measurements:

- Final Specifications Table:
    - Final Length: ~ 30 inches
    - Final Weight: 2.8 lbs
    - Final Materials: 4140 steel head, Burned wood handle

IX. Conclusion

In summary, though deeply constrained by tight schedules and novice expertise, we succeeded in our core mission: learning about a new craft, gaining exposure to a new industry, and making what we hope is a half-decent axe.

Throughout this experience, we learned a multitude of relevant facts about both industrial casting and small-scale production. Whether it was understanding draft angles, realizing the need to restrict flow rates to avoid sand washout after our aluminum test pour , or learning exactly how not to throw slag onto someone's boots, we have been exposed to a whole new world. At the industrial scale, touring Western Foundries gave us an understanding of how industrial pours take place and when casting is preferred to machining in a manufacturing setting, which will serve us well in our future careers. At the smaller, college-level scale, we learned a lot about designing for castability, utilizing SolidWorks and 3D printed patterns to create our green sand molds.

Ultimately, this project represents a successful marriage of historical accuracy and modern foundry technology. We managed to practically recreate the no-nonsense core of a 15th-century horseman's axe—featuring a simple semi-circular blade and square spike —while using modern AISI 4140 steel to perfectly balance hardness and toughness. We conclude this project as four proud freshmen , incredibly thankful to the SFSA for the opportunity , and grateful that we didn't give the local fire department too much of a scare