Lesson 2:
Cross-halved joints

Subject: Design

Age(s): 11 and up

Duration: 45 minutes

Difficulty: low to medium

Objectives

By the end of class, students will be able to:

- Understand the principles and applications of cross-halved joints.
- Do mental-spatial transformations to apply this principle to given 3D-bodies to prepare them for laser-cutting and assembly.
- Design own 3D-objects using cross-halved joints.

Overview

In this lesson, students will learn about a common type of joinery called cross-halved joints. After discussing the applications, they will design and fabricate their own smartphone stand with the help of CAD tools and an xTool laser cutter. Together the class will discuss the outcome of the activity and the possibilities to extend the lesson.

Key Focus

- Use of digital tools like construction- and design software.
- Use of digital production machines like laser cutters.
- Using intersections of 2D shapes to build 3D structures.

Pre-lesson Checklist

For the teacher:

- Computer with XCS (xTool Creative Space) installed
- 2D Vector Design/Illustration software (e.g., Inkscape) (optional)
- xTool P2 connected to the Smoke Purifier
- 3mm basswood sheet or equivalent material to create a smartphone stand

For the students:

- Computer with XCS (xTool Creative Space) installed
- 2D Vector Design/Illustration software (e.g., Inkscape) (optional)
- 3mm basswood sheet or equivalent material to create their smartphone stands

Content Standards

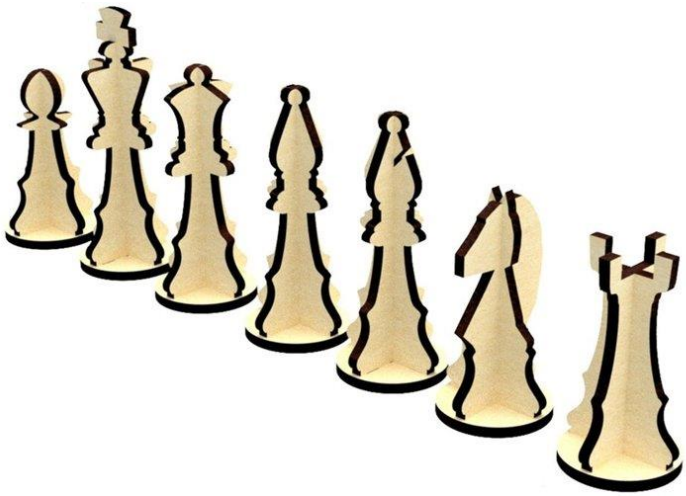
Type	Indicator	Standard
ISTE	1.1d	Students understand the fundamental concepts of technology operations, demonstrate the ability to choose, use and troubleshoot current technologies and are able to transfer their knowledge to explore emerging technologies.
	1.2c	Students demonstrate an understanding of and respect for the rights and obligations of using and sharing intellectual property.
	1.3a	Students plan and employ effective research strategies to locate information and other resources for their intellectual or creative pursuits.
	1.3c	Students curate information from digital resources using a variety of tools and methods to create collections of artifacts that demonstrate meaningful connections or conclusions.
	1.3d	Students build knowledge by actively exploring real-world issues and problems, developing ideas and theories and pursuing answers and solutions.
	1.4a	Students know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems.
	1.4c	Students develop, test and refine prototypes as part of a cyclical design process.
	1.6b	Students create original works or responsibly repurpose or remix digital resources into new creations.
	1.6c	Students communicate complex ideas clearly and effectively by creating or using a variety of digital objects such as visualizations, models or simulations.

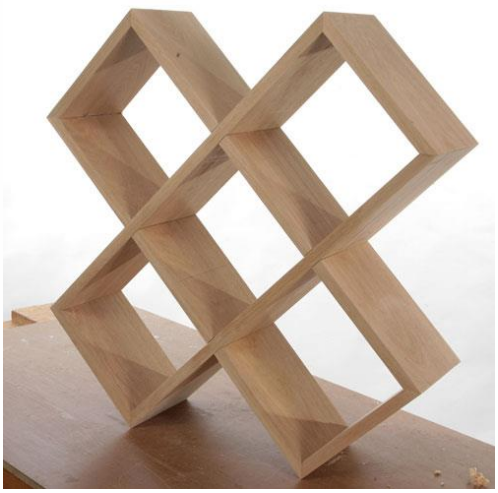
Agenda (45 minutes)

Duration	Content
5 minutes	Section 1- Engage (Introduction) • Introduction of cross-halved joints • Real-world examples of the use of this type of joinery
5 minutes	Section 2 – Explore • Students experiment with cardboard and scissors to intersect different 2D shapes
10 minutes	Section 3 - Explain • Discuss the findings from the previous step • Discuss the technical characteristics of cross-halved joints at a right angle
20 minutes	Section 4 - Elaborate • Students apply their knowledge by designing a smartphone stand • Students make use of the xTool laser machine to fabricate their designs • Ideas to extend the lesson
5 minutes	Section 5 – Evaluate and Exchange • Review of the lesson objectives (summary) • Couple of questions • Key vocabulary used • Reflection • Invite students to present their outcomes and ask questions to each other

Section 1 - Introduction (Engage)

A cross-halved joint is a type of joinery in which two pieces are put together by removing material from each at the point of intersection so that they overlap. This type of joinery is commonly used in wooden constructions, furniture design, temporary installations, and more.





https://nickfrearson.com/bed-frame

https://www.archiproducts.com/en/radis

https://designbundles.net/

https://www.trend-usa.com/

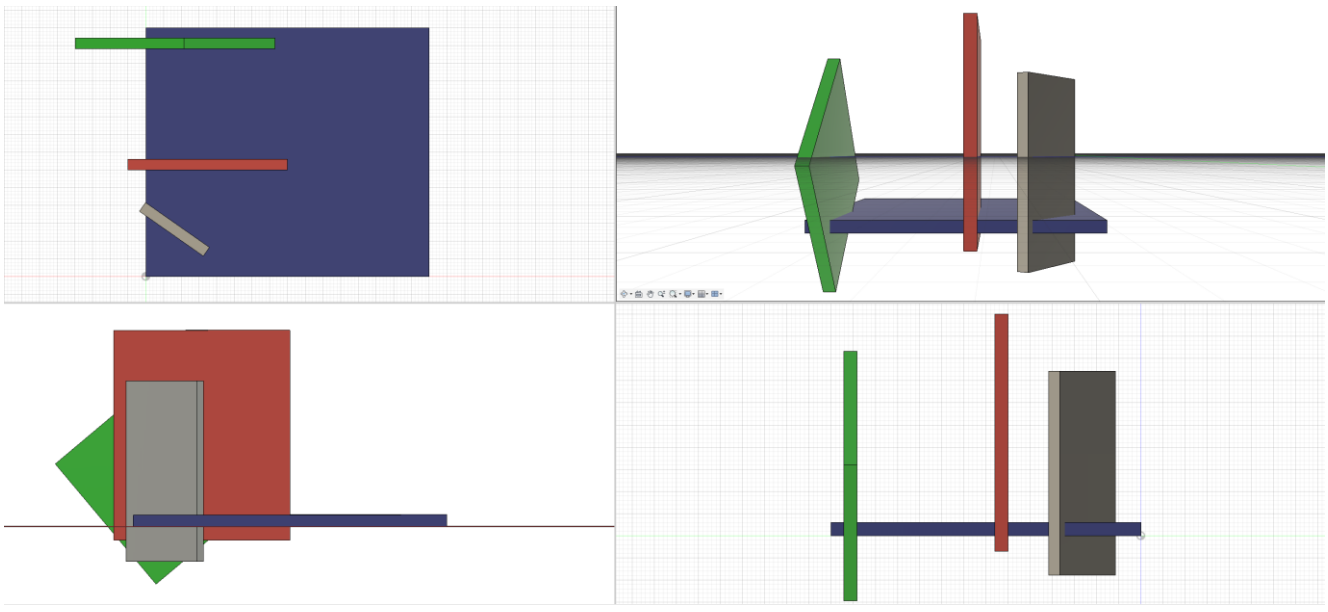
Please ask the students to think of other examples of objects using cross-halved joints.

Section 2 - Explore

As a first approach, students should experiment with cardboard and scissors to use cutouts of the material to align a shape from the same material perpendicular to the cut.
Starting with different shapes like rectangles, triangles or circles cut from cardboard, they can experiment with intersecting them.
The students should briefly document their tests and observations – e.g., regarding the cut-out sizes, the stability and the spatial alignments for building 3D shapes from 2D cutouts using the technique of cross-halved joints – all using analog media first.

Section 3 - Explain

Let the students report their findings and analyze and systemize them together with the groups. Here are some suggestions to pay attention to:
Since laser cutter can only do cuts at a right angle to the surface, the two layers of material that should be joined need to be aligned 90° to each other along one axis/plane (the cut itself can be at an angle – for advanced users).
In the following example all planes have a right angle between height (z axis) to the horizon (xy-Plane), but they can have different angles between the xz plane to y axis or yz plane to x axis. Only the red color plane has right angles to all planes. All these cuts can be done with a laser cutter, because one plane stays at a 90° cut – this suggestion is for advanced students.



With cross-halved joints at a right angle, special attention needs to be put at two factors at the point of intersection or slot.

The first one is the width. The width of the slot depends on the thickness of the other piece. For a tight joint, the slot needs to be no larger than the thickness of the intersecting piece. For instance, if the intersecting piece is 3mm thick, the width of the slot should be 3mm theoretically. Some materials, such as wood or cardboard, allow for tighter slots since they are made up of fibers and these can compress.

When using a laser cutting machine, the laser burns away a part of the material. This is known as the laser kerf and although minimal, it is important to consider it in the design of the slot – it should therefore be a bit smaller than the theoretical width (by 0.1 to 0.12 mm – students should to some tests to find the optimal value).

The second factor is the depth of the slot. This will determine how far the two pieces will intersect. Considering the total distance of intersection between two pieces, it is common to divide it in half so an equal amount of material is removed from both pieces.

Cross-halved joints with no right angle at all cannot be easily cut by a laser cutter, since the material would need to be inserted with an angle – and the focus of the laser point would need to change during cutting. For the purpose of this project, this type of cross-halved joints won't be covered.

Section 4 - Elaborate

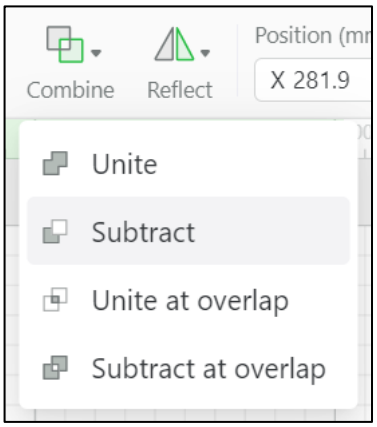
Students will now exercise the use of cross-halved joints by designing a smartphone stand.

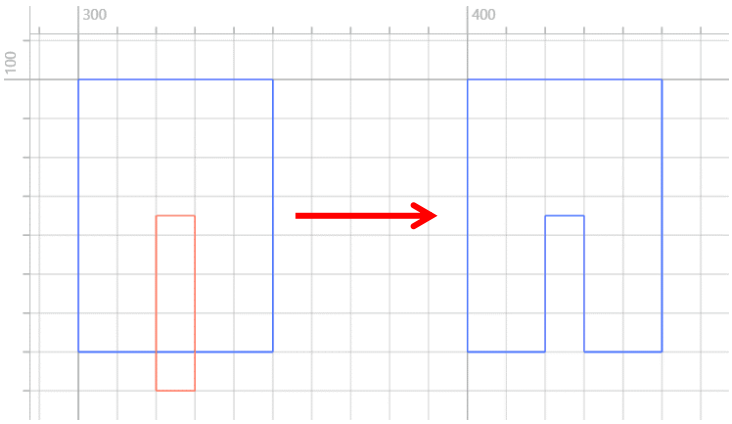
The teacher can propose some basic requirements for the project, such as:

- The stand should be able to hold the smartphone on a comfortable position when placed on a table.
- Each piece of the stand should not exceed a 10x10cm area of material.
- Other design requirements are subject to the criteria of the teacher.

When designing the pieces, they can make use of different design tools including XCS, the proprietary software for the Xtool P2 and M1.

In XCS, students can use the 'Subtract' operation under the 'Combine' menu to create the slot, making sure that the shape to subtract is drawn at the front and the piece is at the back.





The teacher can start with a demonstration using the sample project included with the lesson, and then give some free time to the students to create their own designs before fabricating them.

Extending the lesson

Ask students to modify their designs by adjusting the requirements, such as:

- The pieces of the stand should be symmetrical
- The stand should hold a tablet
- The stand can only be made of 2 pieces
- The stand should be made of cardboard or acrylic

Section 5 - Evaluate and Exchange

It is now time for a brief reflection. The students should think on their own and discuss with the group the following questions:

- What do you think turned out well?
- What could be better?
- Which parts of the lesson did you find easy, and which did you find more difficult?
- What would you like more explanation about?
- Who could help you with that?
- Could you think of improvements regarding the design of the smartphone stand?