

# The Jacob's Staff

Hands-on Science Series (106.JAK)

The ingenious angle measuring instrument used by captains, astronomers, and land surveyors. Columbus used it to determine the heights and angular distances of stars and landmarks. The Jacob's Staff was first described in 1342 as *baculus Jacob*. Until 1731, when John Hadley invented the mirror sextant, it was the most important instrument to measure angular distances in astronomy, navigation, and land surveying. Its outstanding importance is also shown by the fact that the three belt stars in the constellation Orion were named after it. With the Jacob's Staff you can measure the angular distance between two points. This is the angle between the two straight lines between you and these points, e.g. two stars, a star (or the Sun) and the horizon below, or two points on land.

## Building instructions

### A few tips before you start:

**Tip 1:** For assembly you will need scissors, a sharp knife (e.g. the AstroMedia Craft Knife 401.MES), a ruler, a blunt knife edge or similar for grooving the dashed folding lines, and of course a good glue: a solvent-containing all-purpose glue, e.g. UHU, Evo-Stik Impact, B&Q All Purpose Glue. It dries faster than water-based glues and does not warp the cardboard.

**Tip 2:** Take care that groove lines are not cut, so that the cardboard does not break when folded. Dashed lines are folded backwards (away from you), dash-dotted lines forwards (towards you). To make a fold completely smooth, you can press it with your thumbnail or a folding bone after folding.

**Tip 3:** All parts have a letter and a number next to their name. The letter stands for the component and the number for the order of assembly. B1 is part 1 of component B (the large transom).

**Tip 4:** Areas to be glued are marked in light grey and have a symbol for the part to be glued to them. Example: **A2** → means that part [A2] is glued in this place, ↖ that the part is glued to itself.

**Tip 5:** To accelerate the setting of the glue: Apply a suitably thick layer of glue onto one of the parts. Then press parts together so that the glue spreads out on both sides. Now pull the parts apart, blow 2 or 3 times over the surfaces, and press the parts together again. Take care that they fit exactly, as the glue binds immediately.

**Tip 6:** For the assembly of the two halves of the main staff [A1] and [A2] you will need a 3 x 9 cm piece of thin paper, e.g. the kind of thin paper often used for catalogues and advertising brochures.

**Tip 7:** The assembly is done in 16 simple steps. Please read each step fully before commencing.

### A. The Main Staff

**Step 1:** Cut out the front [A1] and back [A2] parts of the main staff. Make sure that the short sides where the two parts of the staff will meet are cut exactly in line and straight by using a sharp knife and a ruler. After cutting, check that the two parts can be laid together without a gap and that the scales are continuous. The dotted lines are not yet grooved.

**Step 2:** Take the 3 x 9 cm piece of thin paper that is to connect the two parts of the main staff and cover one side with glue. First place the end of one half of the main staff with its back onto one half of the paper. Then glue the end of the other half onto it so that the cut edges of the two parts are exactly flush. The printed longitudinal lines should be flush without any offset. Let everything dry well and, if necessary, smooth the seam with your thumbnail, so that later the transoms can slide across easily.

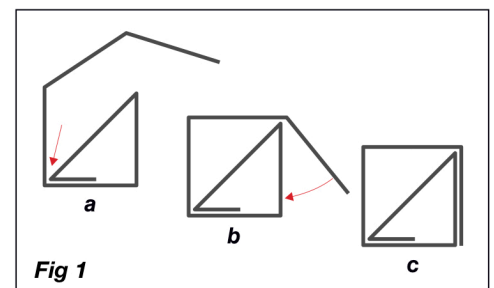
Now is a good time to fill in the fields for year of construction ("Baujahr:") and owner's name ("Dieser Jacobsstab gehört:").

**Step 3:** Groove the dashed lines on the main staff using a ruler and a blunt knife or similar. These grooving lines must be drawn with precision

so that the main staff has a uniform square cross-section. Then fold all grooves backwards.

**Step 4:** Glue the tab marked ↖111 to the glueing area on the back also marked ↖111. The fold of the glue tab is positioned in the right angle corner of the two adjacent walls of the main staff. In this way, the staff is diagonally braced inside (Fig 1a).

**Step 5:** Glue the two glueing areas marked ↖222 on top of each other and make sure that the cross-section of the main staff is square everywhere (Fig 1b and c).



**Step 6:** Glue the square front cover of the main staff [A3] to the four triangular glue tags at the front end of the main staff where the field "Baujahr" (year of construction) is printed.

**Step 7:** Fold all groove lines of the rear cover [A4] backwards, glue the tag behind to form a flat pyramid and then glue the cover onto the rear end of the main staff where the markings of the scales "C", "B" and "A" are located.

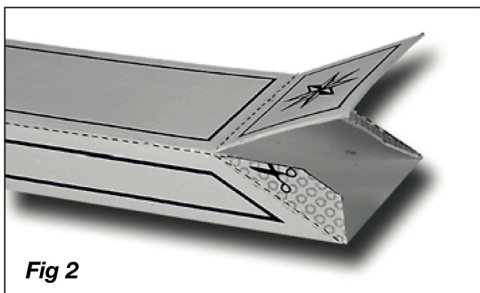
*The main staff is now complete.*

## B. The Large Transom

**Step 8:** Cut out the large transom [B1] and groove all the dashed and dash-dotted lines. In the middle, where "1/2" is written in small triangles, there is a small grey square, surrounded by a square of about 15 x 15 mm made of dashed lines. Cut out the small square and also cut along the lines that lead to the corners of the dashed square. This will create 4 trapezoidal glue tags. Next to this is a square of the same size, but this one is surrounded by dash-dotted lines. Cut along the solid lines that run diagonally to opposite corners. Thus 4 triangular glue tags are created.

**Step 9:** Fold the dotted lines backwards and the dash-dotted lines of the 4 triangular tags forwards. Glue the tag on the long edge behind the opposite side. This creates the body of the transom, which is 25 mm high and 10 mm thick.

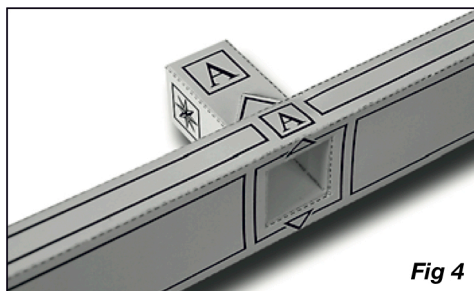
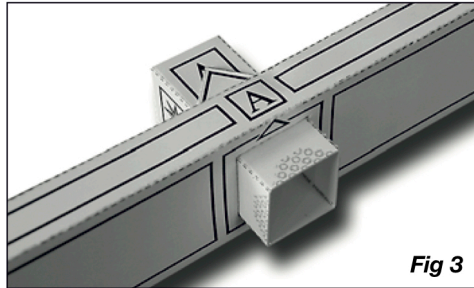
**Step 10:** The open ends of the transom are closed by two slanted flaps with a star symbol. These flaps only have glue tags on the sides but not on the outer edge (Fig 2). Glue the flaps in place and the outer edges directly to the cardboard with plenty of adhesive. These edges are particularly important because they are where the actual sighting takes place.



**Step 11:** Cut out the sliding tube of the large transom [B2]. Groove, fold, and glue it into a square tube. Before the glue sets, check that it can be pushed onto the main staff without too much resistance.

**Step 12:** Push the sliding tube with the side marked "A" first into the opening with the trapezoidal glue tags, which disappear inside the transom. On the opposite side, the sliding tube protrudes with the triangular tags nestling closely

against it. The "A" on the sliding tube must appear on the side where the "A" is located on the shorter side of the transom. First push it in only so far that it still protrudes by about 10 mm (Fig. 3). Apply glue to this end and then push it all the way in until its edges are exactly flush with the transom (Fig. 4). Allow to dry well.



**Step 13:** Now glue the 4 triangular tags on the other side of the transom to the sliding tube. Let dry thoroughly.

**Step 14:** Slide the transom onto the main staff. Its larger side points to the flat end of the main staff, the protruding sliding tube points to the end with the small pyramid. Check that it can be moved easily. If the seam between the two main staff parts is a little too thick to easily move the sliding tube across, you can carefully press the sides of the main staff together a little at this point.

## C. The Middle Transom

**Step 15:** The middle transom is assembled from parts [C1] and [C2]. Proceed in the same way as with the large transom.

## D. The Small Transom

**Step 16:** The small transom is assembled from parts [D1] and [D2]. Proceed in the same way as with the other two transoms.

*Your Jacob's staff is now finished. Congratulations!*

## This is how you determine the angle between two points:

Push a transom onto the main staff and place the staff's flat end under one eye against the cheekbone. Move the transom back and forth until the two points to be measured appear right on the outer edges of the transom. The required angle is then read off the scale on the side facing your eye. Note that each transom has its own scale on the main staff (A, B, or C). If the angle is too small or too large, use one of the other transoms. The three transoms cover different angle ranges: A for angles between 90° and 30°, B for 30° to 15°, and C for 15° to 7°30'.

The angle range is halved if one of the two points is aimed at via the middle of the transom where the little triangle marking is printed. The read off angle has then to be divided by 2.

*Tip: To measure angles with the small transom, it is sufficient to push the larger ones all the way towards your face, you do not have to remove them.*

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