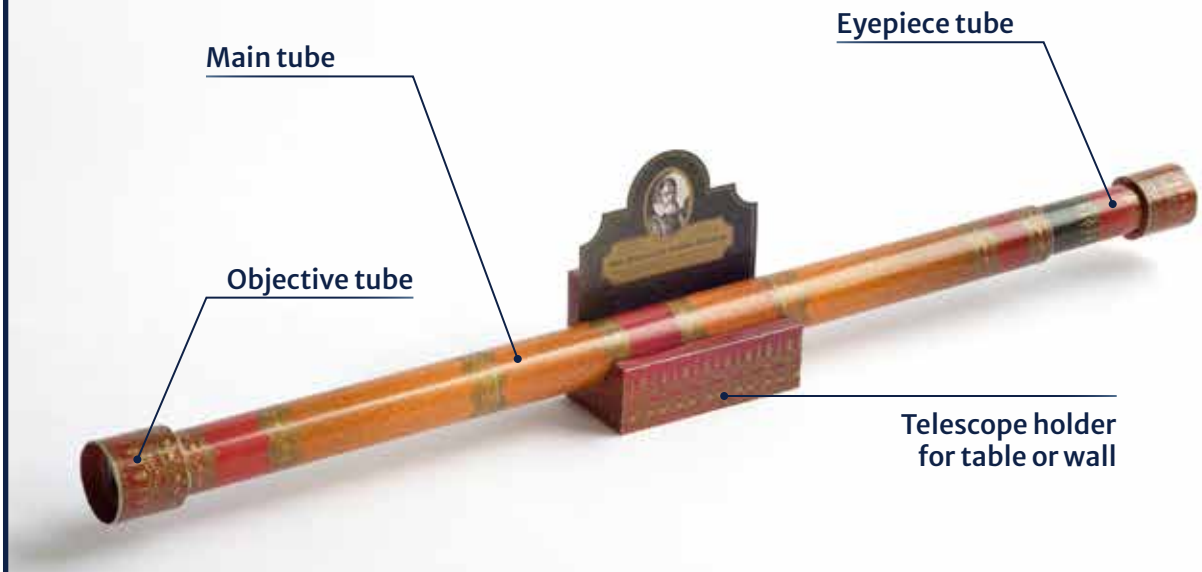
Instructions

The Historic Galileo Telescope



AstroMedia

Hands on Astronomy

The Historic Galileo Telescope

A cardboard kit for a replica of the only surviving telescope made by Galileo Galilei himself.

Hans Lippershey, a spectacle maker from Middelburg in the Netherlands, invented a telescope in 1608 that magnified approximately three times. It had a concave lens on the eye side (as used in spectacles for short-sighted people) and a convex lens towards the object (for long-sighted people). However, he was refused a patent as other spectacle makers were already offering telescopes as well when he applied for it. News about his invention spread like wildfire through the whole of Europe, but most people considered it to be just a curiosity.

Galileo Galilei (1564–1642), professor of mathematics in Padua, was immediately fascinated. Even before the first Dutch telescopes arrived in Italy, he had built his own telescope with a magnification of around 4x. He immediately began to increase the performance and subsequently built telescopes with 8x,13x and, in later years, even up to 33x magnification. He ground all lenses for the telescopes himself.

At the beginning of the 17th century, scholars were still arguing about whether the Earth was at the centre of the universe or whether it was the Sun, as Copernicus had claimed. However, they had no proof for one or the other. At that time astronomers were convinced that they knew all the planets and had catalogued all the fixed stars and that even the most precise observation would not reveal anything new, apart from the occasional comet or nova.

***Lunar surface** drawn by Galileo Galilei from Sidereus Nuncius, 1610*

It is Galileo's great achievement that he pointed his telescope at the sky. What he saw was indeed astonishing: the Moon was covered in craters, the Milky Way dissolved into millions of stars, Venus showed phases, and above all: the planet Jupiter was orbited by moons. As early as 1610, he collated his sensational discoveries from that and the previous year in his publication "Sidereus Nuncius" (Starry Messenger). This was the beginning not only of a new astronomy, but of a new world view that still shapes us today.

Even though the first telescope was invented in Holland, Galileo deserves credit for recognising it as a scientific instrument and perfecting it. In this respect, the name "Galilean telescope" is entirely justified for a telescope of this type.

The Galilean lens arrangement produces an upright image, which is a great advantage. However, its disadvantage is more serious: the higher the magnification, the smaller the visible image becomes. At 30x magnification, it is so small that an observer can hardly be sure what exactly they are looking at. Considering these restrictions, Galileo's discoveries are even more remarkable.

Galileo's contemporary Johannes Kepler, the great mathematician and astronomer, proposed a different lens arrangement: both lenses, including the smaller eye lens, should be convex (curved outwards). The fact that the image of a Kepler telescope is upside down is not a major disadvantage in celestial observations. It is more than offset by a much larger field of view and a higher magnification. With the exception of opera glasses, practically all lens telescopes today are built according to Kepler's principle. Binoculars have additional optical components to put the image the right way up.

About this historic replica:

Galileo built well over a hundred telescopes, but only two have survived. These can be viewed today in the Museo Galileo (Museo di Storia della Scienza) in Florence and online: www.museogalileo.it One of them is a rather simple working telescope with 14x magnification, but the other is covered in precious gold-embossed leather, which is certainly Galileo's own work. It was probably built towards the end of 1609 and was intended for Cosimo II in Florence. This telescope served as the template for this kit. The total length and the focal length of the cardboard replica are 78 cm, 20 cm shorter than the original. This deviation does not affect the authenticity of the cardboard replica, however, as no two of Galileo's telescopes were the same in terms of length and optical performance. The smaller length makes the telescope a little easier to handle, and the reduced magnification of 12x expands the still quite small field of view considerably. Since the eyepiece lens of the original was replaced in the 19th century, the original magnification can only be estimated. It was probably around 20 times. With this historic Galileo telescope, you have the unique opportunity to look over the shoulder of the great researcher and to understand his discoveries using similar means, which, although modest by today's perspective, became the key to a new world view in the hands of Galileo.

This kit contains:

- 6 punched cardboard sheets, 0.3 mm
- 1 glass objective lens, Ø 42 mm, focal length 780 mm, plano-convex (one side flat, the other curved outwards)
- 1 glass ocular lens, Ø 25 mm, focal length -65 mm, plano-concave (one side flat, the other curved inwards)
- 1 sheet of A4 black velours paper to reduce stray light inside the telescope

This is what you need for assembly:

- A standard **solvent-based all-purpose glue**, e.g. UHU all-purpose glue, ideally in a bottle with a thin dosing tip. It can be used for all parts. Do not use solvent-free water-based all-purpose glue. It will soften the cardboard and lead to warping of the curved surfaces. Solvent-based all-purpose glue also sets much faster and adheres better to the surfaces protected with printing varnish.
- A **sharp craft knife** (e.g. the AstroMedia craft knife) or a scalpel with a slim tip to cut through the retaining bars.
- Some **masking tape** to hold the round outer casing in position until the glue has set. If you don't have any, you can use about a dozen rubber bands instead.
- A small **pair of scissors** to cut the velours paper and nail scissors to cut off any round excess.
- A **cutting mat**, e.g. solid cardboard (without corrugation) or plastic or wood. Self-healing cutting mats are ideal, as cuts close up again automatically.
- A **round piece of wood**, approx. 20 cm long and 1.5 to 2 cm thick, e.g. a thick felt-tip pen, a long handled wooden spoon, a thin broom handle, or similar. You can also wrap a thinner piece of wood (or a round pencil) with paper until it has the desired thickness. The outer covers are shaped into a tube by wrapping them around this winding core.
- Some **fine sandpaper** (or the AstroMedia sandpaper craft file) to sand off protruding cardboard edges.
- Some **methylated spirit** or similar to clean the glass lenses.
- A **piece of very thin paper**, approx. 3 x 10 cm, e.g. from an advertising brochure, to connect the two inner parts of the main tube.
- A **ruler** for measuring and cutting the velours paper.

The word ***'Option'*** is used in the assembly instructions to indicate steps that perfect the telescope, but are not absolutely necessary. For those you will need:

- a gold **touch-up pen** and **regular red, brown, and black felt-tip pens** to colour the white edges of the cardboard that would otherwise still be visible after assembly.
- Two **metal or plastic washers** with an inner diameter of approx. 8 mm, if you want to hang the telescope holder on the wall. You can also make washers out of plywood or strong cardboard. They are used to reinforce the hanging holes at the back of the holder.

Please read through before starting:

Tips for successful assembly

1 The assembly instructions are divided into 44 small steps with detailed descriptions. At first glance, this looks like a lot of text, but it makes successful assembly much easier because it makes it very clear. Please read each step carefully beforehand and give yourself enough time.

2 Most of the steps are repeated several times in a similar form. You will notice that the assembly is almost self-explanatory after the first few steps.

3 On the back, each part is marked with its name and a part number consisting of a letter and a number, e.g. A2 . The letters on the part denote the assembly section, the number relates to the order of assembly. It is best to only remove the parts from the sheets as you need them.

4 Don't tear the pieces out of the cardboard, but cut through the small holding bars with a craft knife. This will keep the edges completely smooth.

5 All fold lines are prepared by grooves. They are folded either "forwards", i.e. towards you when you look at the front of the die-cut sheet, or "backwards", i.e. away from you.

Main tube

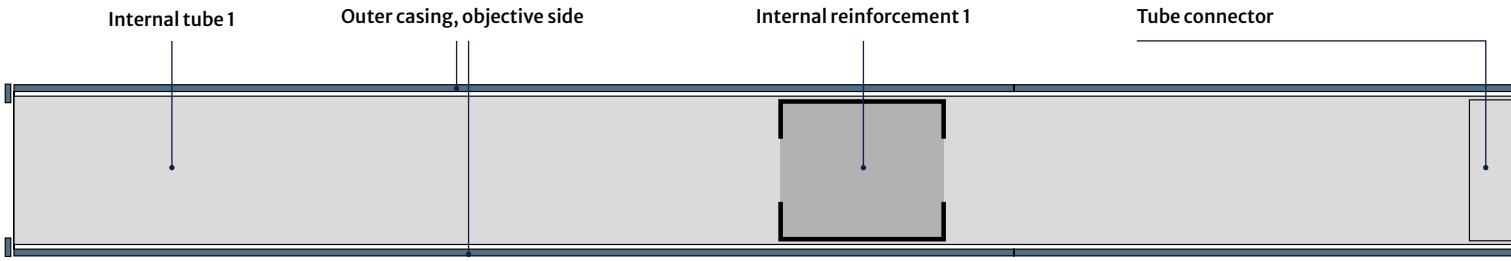


Fig. 1

6 The areas onto which something is to be glued are printed in grey. They have a symbol that identifies the part that is glued there. Example: A2 means that part A2 should be glued onto this surface. The symbol means that the part is glued to itself at this point.

A. The Objective Tube

The telescope consists of the objective tube, which holds the objective lens for the incident light, the eyepiece tube, which holds the lens into which the eye looks, and the 574 mm long main tube, which has a slightly larger diameter so that the other two tubes can be inserted into its ends. All three are constructed according to the same principle: First, a hexagonal inner cardboard tube is folded and glued together. Then a piece of cardboard is bent round and glued around the internal tube to form an outer casing. In combination with further internal and external support elements, this results in a stable construction with a honeycomb-like cross-section (see Figs. 1 – 3 showing the longitudinal and the cross-sections). The hexagonal internal tube with the round outer casing of the objective tube is completed first, the lens holder is attached later in section E.

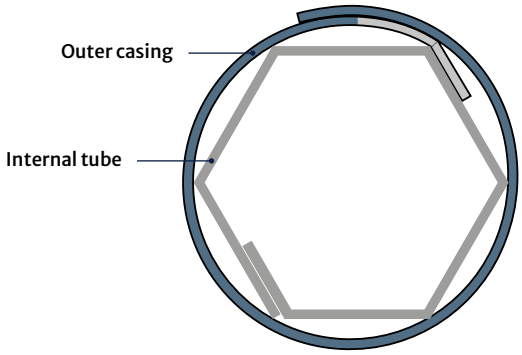
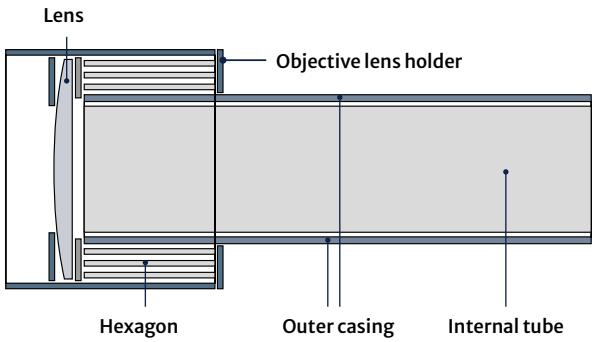


Fig. 2

Step 1 Fold all groove lines of the internal tube of the objective tube [A1, sheet 1] forwards to create a hexagonal tube with a black inner surface. Glue the back of the narrow black glue tab onto the grey glue marking on the opposite side so that it is inside the tube. ***Tip:*** *Press the tube flat onto the work surface several times, with the glue joint at the bottom. Allow it to dry thoroughly and remove any glue threads.*

Objective tube



Step 2 Remove the internal reinforcements 1 and 2 of the eyepiece tube [B2 + B3, sheet 5] from the cardboard sheet and remove the discs in the middle.

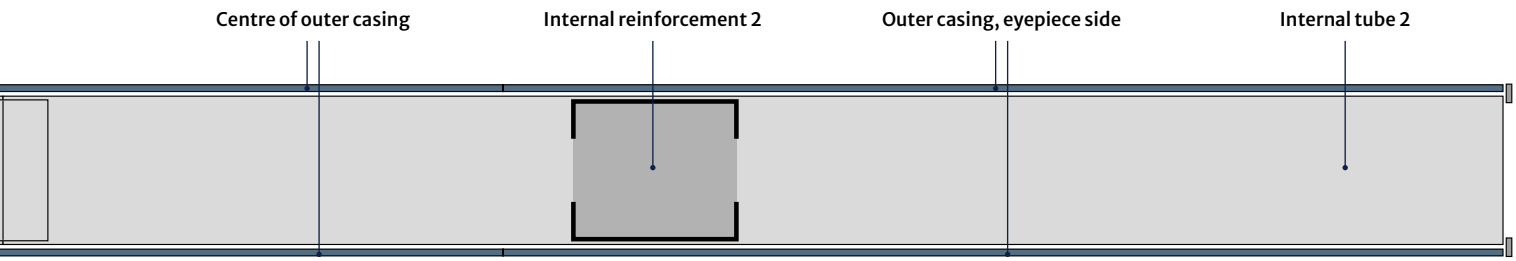
Option: *Blacken the white edges of the hole.*

The objective tube has only an external reinforcement, no internal one. To ensure that the inner tube retains its hexagonal shape when the outer casing is fitted, the two internal reinforcements of the eyepiece tube [B2] and [B3] are used as a template and temporarily inserted into it.

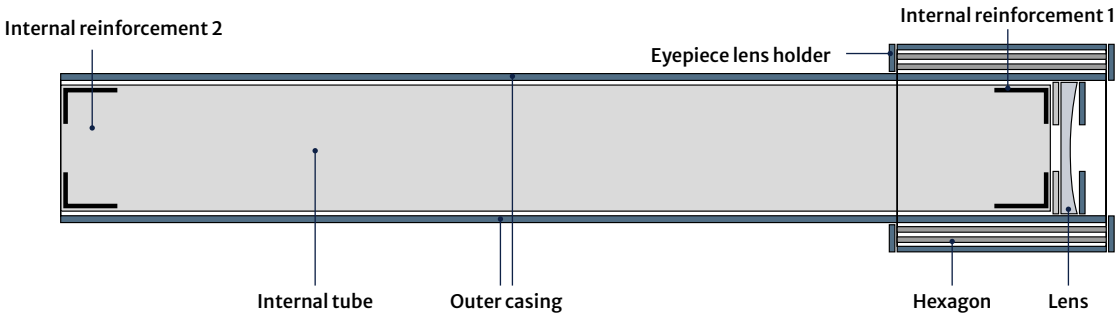
Fold the six tabs forwards and insert the internal reinforcements temporarily and without glue. Push them about 1 cm deep into the two ends of the objective tube, hexagon first, so that the tabs are flush with the edge. They will be removed again after the next step.

Step 3 Remove the outer casing of the objective tube [A2, sheet 5] from the cardboard.

Option: *Paint the cut edges of the coloured printed areas with felt-tip pens matching the colours.* First pull the outer casing with the coloured side facing upwards over the edge of a table so that it begins to curl. Then roll it carefully and without creases onto the winding core (the round piece of wood, the thickened pencil, etc., see above) to turn it into a round tube, of course with the printed side facing outwards.



Eyepiece tube



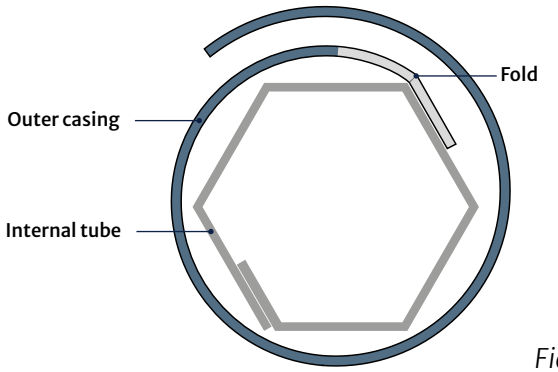


Fig. 3

***Tip**: If you have several winding cores with different diameters, start with the one with the largest diameter and then move on to smaller diameters. This will make it easier to create a uniform tube without kinks. Start with the glue tab marked with a groove on the winding core and then wind again, this time with the opposite edge on the inside.*

First fold the glue tab of the outer casing back and forth to make it more flexible, then fold it backwards. Glue it onto the marked spot so that the fold is exactly on the edge (see Fig. 3) and the cover does not protrude on any side of the inner tube. Allow it to dry well and then wrap it around the inner tube to test it (see Fig. 2). Check that the end overlaps the other side by about 1 cm.

Step 4

If necessary, roll the cover again to ensure that the end in particular is well curved and sits snugly. Then coat the five exposed edges of the internal tube generously with glue and carefully wrap the casing around the internal tube so that no glue gets on the outside. The casing forms a cylinder that rests on the edges of the inner tube, making it completely disappear; only the end is not yet glued on. Make sure that the edges of the internal tube and the edges of the cover are exactly flush at the ends of the tube. Secure the casing in place with some masking tape or pull rubber bands over it so that it rests on the edges on all sides while drying and at the same time remains completely round. Allow to dry thoroughly, then remove the masking tape or rubber bands.

***Tip**: The masking tape comes off the printed cardboard surface easily, but you have to be careful at the edges to make sure the surface does not tear.*

Step 5

Carefully bend the end of the casing upwards, spread glue on the last edge of the inner tube (which is already covered by the glue tab) and under the edge of the casing and secure it again in place. The outer casing is now completely glued in place. After drying, remove the two internal reinforcements from the inner tube. The lens barrel will now retain its round shape without them.

B. The Eyepiece Tube

Of the eyepiece tube, only the internal tube with the outer casing is completed at first. It is needed as a temporary inner support during the subsequent assembly of the main tube. The lens holder is attached later in section F. Unlike on the objective tube, the round outer casing is slightly longer than the hexagonal internal tube: the outer casing protrudes about 10 mm at one end.

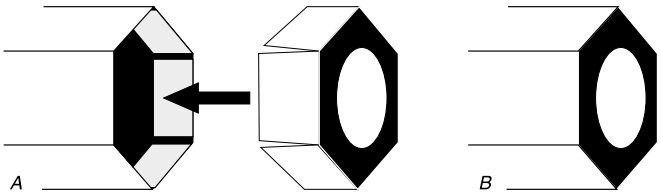


Fig. 4

Step 6 Glue the hexagonal internal tube of the eyepiece tube [B1, sheet 1] together in the same way as the one of the objective tube. Then glue the two internal reinforcements [B2] and [B3], which previously served as temporary supports for the objective tube, into the ends of the eyepiece tube. The glue tabs with their grey backs are placed inside the tube and the blackened hexagon should be flush with the outside edge of the tube (see Fig. 4). Press the tabs firmly against the tube wall, e.g. with a pencil that you insert through the holes in the hexagons.

Step 7 Remove the outer casing of the eyepiece tube [B4, sheet 4] from the cardboard sheet.

Option: *Colour the cut edges to match.*

Please note that on one side of the glue tab, a 10 mm wide grey piece is cut off from the glue tab and is not folded over. The outer casing will extend over the internal tube by these 10 mm on one side. Bend the outer casing into a round tube like in Step 3. Fold the glue tab first back and forth and then backwards and glue it onto the marked area on the internal tube so that the fold lies exactly on one of the edges and the end of the outer casing printed with black leather is exactly flush with the end of the internal tube. The 10 mm wide grey edge protrudes at the opposite end.

Step 8 Now proceed with the outer casing of the eyepiece tube in exactly the same way as you did with the objective tube in Step 4: Apply glue to the edges of the internal tube and wrap the casing around the internal tube so that it sticks to the edges while remaining round on the outside. Make sure that the edges of the internal tube and the casing line up exactly on one side and on the other, the casing protrudes by 10 mm. Fix the casing in place while it dries. Finally, glue the edge of the casing in place as well and allow it to dry.

C. The Internal Tube of the Main Tube

The main tube is also made up of a hexagonal internal tube and a round casing. However, it has a slightly larger diameter and is made up of two parts because of its length.

Step 9 Remove the two internal tubes of the main tube [C1, sheet 1] and [C2, sheet 2] from the cardboard sheets. Place them next to each other with the black side facing up so that the short ends with the grey glue areas touch without gap and with the edges exactly aligned. Make sure that the groove lines run from one part to the other without any offset. To connect them, stick either adhesive tape or a piece of very thin paper measuring approx. 3 x 10 cm onto the marked area. It does not have to be blackened because it will be covered by black velours paper later.

Step 10 Fold this assembled internal tube along the groove lines and glue it together to form a 57.4 cm long hexagonal tube.

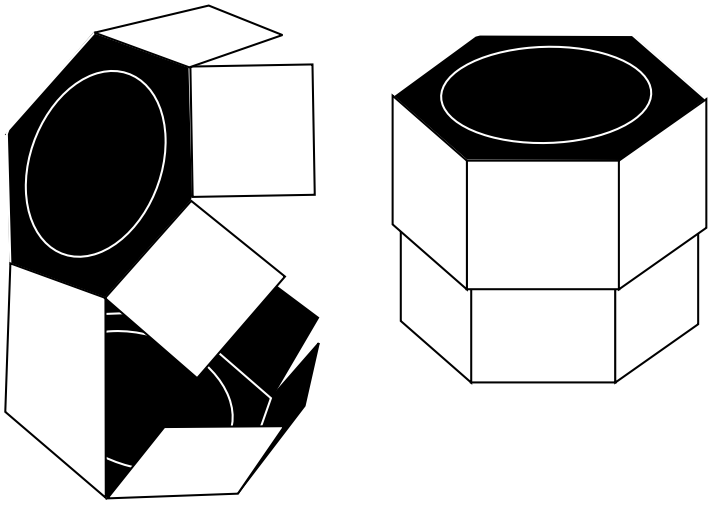


Fig. 5

Step 11 Remove the two round cutouts from the internal reinforcement 1 [C3, sheet 5] of the main tube and fold all the tabs forwards. Glue the five completely black tabs with their backs onto the grey glue surfaces of the other five tabs so that a small hexagonal block is created (see Fig. 5). Its inner surface and the two hexagons on the outside are black. Then do the same with internal reinforcement 2 [C4, sheet 5] of the main tube. Allow to dry thoroughly.

Step 12 Without using glue, push one of the internal reinforcements about 15 cm deep into the internal tube of the main tube, e.g. with the aid of a ruler or the eyepiece tube.

Tip: *To ensure that the internal reinforcement is firmly clamped inside the internal tube and will not slide back and forth, bend its six side walls slightly outwards.*

Step 13 Cut off a piece of velours paper about 11 cm wide, which then measures 21 x 11 cm, and roll it into a kink-free tube with the black side inside.

Tip: *The tube is not glued together so that it can expand again in the inner tube and rest against its walls. Insert this tube into the other end of the internal tube and push it in until it is approximately in the middle. Then push the other internal reinforcement behind. The velours paper tube now sits loosely in the middle of the tube, between the two internal reinforcements, and will greatly reduce scattered light inside the tube.*

D. The Outer Casing of the Main Tube

The outer casing of the main tube consists of 3 parts of equal width, which are printed similarly but not identically. The middle part covers the seam between the two halves of the internal tube.

Step 14 Remove the outer casing of the objective side of the main tube [C5, sheet 3] from the cardboard, round it using the winding core and fold the glue tab first back and forth and then backwards.

Option: *Colour the cut edges to match.*

As a test, fit the outer casing around the internal tube without any glue so that the glue tab is in the marked place and the red leather is exactly flush with the end of the inner tube: This is how the casing should be fitted. If the hexagonal end of the inner tube does not seem stable enough, simply insert the grey end of the eyepiece tube a little. Then glue the glue tab to the internal tube as you did with the outer casing of the objective and eyepiece tubes. Make sure that the edge of the outer casing is exactly flush with the edge of the internal tube.

Step 15 Round off the outer casing centre section of the main tube [C6, sheet 3], fold the glue tab and place it around the internal tube, first without glue to test the fit.

Option: *Colour the cut edges to match.*

Then proceed with this centre section part in the same way as with the first part. Make sure that the two parts butt up against each other seamlessly.

Step 16 Round and fold the third segment, the outer casing for the eyepiece side of the main tube [C7, sheet 4].

Option: *Colour the cut edges to match.*

First test fit the casing, then use glue to fix it in place. If the hexagonal end of the internal tube feels too unstable, temporarily insert the eyepiece tube again. Allow the glue to dry thoroughly.

Step 17 To finish the tube, ring-shaped covers are glued onto the two ends where the cardboard construction is still visible. Remove the two main tube edge covers 1 [C8, sheet 5] and 2 [C9, sheet 6] from the cardboard. Place them on the ends of the main tube as a test: they initially protrude a few millimetres on the outside so they can cover an irregularly shaped tube. At one end of the main tube, apply a fair amount of glue to the visible cardboard edges of the internal tube and the outer cover and place one of the ring-shaped covers flush on top of it.

Tip: *To make centring easier, you can first push the ring onto the grey end of the eyepiece or objective tube as an auxiliary tool, then insert it a little way into the main tube end and push the cardboard ring onto the edges coated with glue. Caution: Of course, only the edge cover should be glued, not the auxiliary tool!*

After drying, the excess of the edge cover is cut off with a small pair of scissors.

Option: *Colour the cut edges to match.*

Do the same with the other edge cover at the other end of the main tube.

The main tube is now complete.

E. The Objective Tube Lens Holder

The main purpose of the lens holder is to increase the diameter of the objective tube so that the objective lens with its 42 mm diameter can be mounted inside. This is achieved by three hexagonal tube sections of different sizes that are pushed onto one another in an offset position and glued together. From the front it looks like Fig. 6. Finally, a round outer casing is glued around them. To protect the objective lens, the outer casing protrudes slightly, which is why it is wider than the hexagonal parts. Following Galileo's design, only the inner part of the lens is used optically.

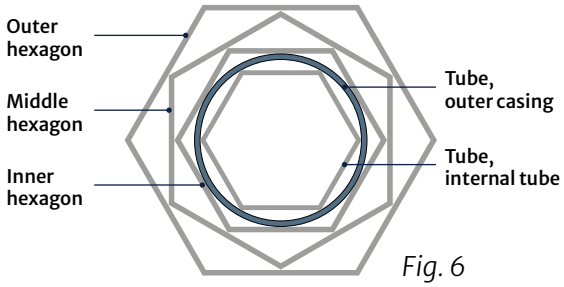


Fig. 6

Step 18 Remove the inner hexagon of the lens holder [A3, sheet 2] from the cardboard, fold all grooved lines backwards and glue the grey glue tab behind the opposite end. This creates a hexagonal tube section. Do the same with the middle hexagon [A4, sheet 2] and the outer hexagon [A5, sheet 2].

Step 19 First without glue, slide the inner hexagon [A3] onto the grey glue area on the end of the objective tube so that the end of the tube and the hexagon are flush.

Tip: *Do not mix up the 97 mm long objective tube with the eyepiece tube, which is more than twice as long and will be assembled in the next section.*

Each middle part of the hexagon surfaces now rests on the tube and touches it along a line. The hexagon will be glued in place along these contact lines.

Step 20 To do this, first push it further onto the tube until the grey marked area is fully exposed. Then apply not too thin strips of glue to the grey area in extension of the contact lines. Rotate the hexagon by 30° so that the contact lines are now in between the glue strips. Push the hexagon back onto the grey area until it is flush with the tube, with the glue not yet (or only barely) coming into contact with it. Then rotate it back again so that the centres of the sides of the hexagon lie exactly on the glue strips. Check that the hexagon is exactly flush with the end of the tube, e.g. by pushing it against your worktop, and that it properly forms a regular hexagon when viewed from the front. If necessary, you can correct its shape by pressing and moving it.

Step 21 After drying, push the middle hexagon [A4] without glue over the inner one and twist it until its side centres lie exactly above the edges of the inner hexagon (see Fig. 6). This is the position it should be glued in. To do this, remove it again and bend its surfaces inwards so that it is very tight. Apply glue to the edges of the inner hexagon, push the middle one over it and twist it until the centres of its surfaces sit on the edges of the inner hexagon. Again, make sure that it forms a regular hexagon and that it is exactly flush with the end of the tube and the inner hexagon. Let dry well.

Step 22 Proceed in exactly the same way with the outer hexagon [A5].

Step 23 Round the outer casing of the objective tube lens holder [A6, Sheet 5] by winding it around the winding core and fold the white glue tab back and forth and then backwards.

Option: *Colour the edges to match.*

The outer casing is wider than the three hexagon parts; it protrudes at the front. The glue tab does not cover the entire width, but is separated from the rest by a cut that is not folded over, similar to the outer casing of the eyepiece tube. As before, glue the glue tab to the outer hexagon, making sure that it is exactly flush with the three hexagonal parts towards the centre of the tube and protrudes towards the front. Then glue the outer casing in place.

Step 24 Round the interior lining of the outer casing [A7, sheet 4] using the winding core, so that the printed side is on the inside. Glue it flush onto the inside of the outer casing.

Option: *Colour the edges to match.*

Durch den Überstand ist ein vertiefter Raum entThe overhang has created a recessed space that will receive the objective lens in the next step. Use plenty of glue to glue the edge cover of the objective lens holder [A8, sheet 5] to the cardboard edges on the other end. This edge cover is also larger on the outside than needed. Cut off the excess after the glue has dried.

Option: *Colour the edges to match after cutting off the excess.*

Step 25 Clean both sides of the 42 mm objective lens. Note: Always use a soft cloth, never tissue paper to clean lenses! Look at the lens surfaces from the edge so that you can see reflections on the surfaces. One side is flat (even, reflected images appear normal), the other is convex (curved outwards, reflected images appear slightly smaller). First without glue, place the objective lens with its flat side downwards in the centre on the lens base [A9, sheet 2]. Then glue it in this position. Make sure that no glue gets into the field of view of the lens.

Once dry, glue the lens, base first, into the recess of the lens holder using a generous amount of glue on the edges of the cardboard hexagons. If necessary, carefully move the lens to make sure its centre is exactly in the middle of the tube. Allow the glue to dry thoroughly.

Step 26 Finally, glue the outer lens diaphragm [A10, sheet 5] onto the lens. Before applying glue, check that it fits into the overhang of the outer casing. If necessary, cut off a strip around the outer edge.

The main tube has already been lined with velours paper to reduce stray light. This is also necessary for the objective tube (and in the next section for the eyepiece tube).

Step 27 Cut the remaining piece of velours paper into two equal pieces, each measuring 21 x 9.2 cm. Then shorten one of them to 17 x 9.2 cm, round it with the black side inside to form a 17 cm long tube and insert it into the objective tube. It will protrude about 7 cm from its opening.

Step 28 Insert the objective tube with the protruding velours paper tube first into the end of the main tube that shows a little more red leather between the gold ornaments. It should be inserted deep enough so that only about 1 cm of the black leather of the tube is visible. You can glue it into the main tube if you want. Focusing will be achieved using the eyepiece tube. If the fit is too loose, you can glue a strip of paper around the concealed end of the tube.

F. The Eyepiece Tube Lens Holder

The lens holder of the eyepiece tube has a smaller diameter than the one of the objective tube. Therefore two hexagon support parts are sufficient.

Step 29 Remove the inner and outer hexagons of the eyepiece lens holder [B5, Sheet 2] and [B6, Sheet 2] from the cardboard, fold and glue them into hexagonal tube sections as in the previous section.

Step 30 Glue the inner hexagon [B5] onto the grey area at end of the eyepiece tube, using the same method as for the objective tube. Once dry, glue the outer hexagon [B6] on top.

Step 31 Round the outer casing of the eyepiece tube lens holder [B7, sheet 5] using the winding core and fold the adhesive tab.

Option: *Colour the edges to match.*

Glue the tab to the outer hexagon and then glue the outer casing in place, the same way as before.

Step 32 Slide the ring-shaped rear edge cover of the eyepiece tube lens holder [B8, sheet 5] onto the eyepiece tube and glue it to the exposed cardboard edges at the back of the eyepiece holder using a fair amount of of glue. Cut off the excess after drying.

Option: *Colour the edges to match.*

Step 33 Round the inner lining of the eyepiece lens holder [B9, sheet 5] with the winding core, with the printed side facing inwards, and glue it inside the protruding outer casing of the eyepiece tube. Check that the edges are flush at the front.

Step 34 Clean the eyepiece lens and place it with the flat side down onto the centre of the eyepiece tube lens base [B10, Sheet 2]. The concave side is then facing up. Glue it in this position to the lens base. When dry, glue the lens with the lens base to the edges of the cardboard hexagons in the recess. Carefully move the lens if necessary so that its centre is exactly in the middle of the tube opening. Allow to dry thoroughly.

Step 35 Check that the lens diaphragm of the eyepiece tube [B12, Sheet 6] fits nicely on the lens. Otherwise trim off some of the outer edge.

Option: *Colour the edges to match.*

Then carefully glue it to the outer edge of the lens with a few small drops of glue.

Step 36 Glue the lens holder front edge cover of the eyepiece tube [B11, sheet 5] to the front of the lens holder and cut off the excess after drying.

Option: *Colour the edges to match.*

Step 37 Roll the remaining piece of velours paper into a 21 cm long tube and push it into the eyepiece tube as far as it will go.

With the eyepiece tube finished, the telescope is now complete and you can take a first look through it.

To focus, the eyepiece tube is moved back and forth in very small steps by carefully rotating it. Don't be disappointed that the field of view is so small. This is an unavoidable characteristic of telescopes with this lens arrangement!

Galileo Galilei had to make do with an even smaller image 400 years ago, when using his telescopes with higher magnification. Nevertheless, he made groundbreaking discoveries with them, albeit with the help of a tripod so that imperceptible shaking movements of his hand were not magnified.

Tip: *If you attach the telescope to the round camera tripod adapter from AstroMedia (article no. 258.FSR) with a few rubber bands or with masking tape, you can mount it on any commercially available camera tripod.*

Never look directly at the Sun with the telescope!

Your eyes could suffer permanent damage.

G. The Telescope Holder

The holder consists of 6 parts: the rear panel [D1, sheet 6] (this part also contains the base and the lower front panel), the front part [D6, sheet 6] (with the inner rounded part that accommodates the telescope), the two reinforcement rings [D2, sheet 2] and [D3, sheet 2] that are glued between the back panel and the front panel, and the two side pieces [D4, sheet 6] and [D5, sheet 6]. The holder can stand on a table or shelf, or hang on the wall. In the latter case, the holes for suspending the holder must be reinforced on the inside before assembly so that they do not tear.

Step 38 Remove the rear panel of the holder [D1] from the cardboard and write your name in the space provided.

Option: *Colour the edges to match.*

Step 39 If you want to prepare the holder for wall mounting, remove the two pre-punched discs from the red leather to create the holes for hanging. Then glue metal washers or something similar to the back around the holes so that the cardboard will not tear. The holes in the washers should be big enough for the nails or screws in the wall and must line up exactly with the top edge of the cardboard holes. If you do not want to mount the holder on the wall, leave the cardboard discs in their holes and stick a piece of adhesive tape over them from the inside so that they cannot fall out.

Step 40 Fold all grooved lines of the rear panel backwards. This creates the actual rear panel (marked with the letter "B"), the base ("A"), the lower front panel ("C") and two narrow strips ("D" and "E").

Step 41 Remove the two rear wall reinforcement rings [D2 and D3, sheet 2] from the cardboard – these are the last parts of sheet 2. Bend the two strips into a circle and glue them together with an overlap of about 5 mm to form rings that have a diameter of just under 30 mm and are 10.5 mm wide. Apply a fair amount of glue to the edges on one side of the rings and glue them edge-on to the inside of the rear wall around the two suspension holes. The front of the holder [D6] will later be glued to their opposite edges.

Step 42 Remove the left side piece of the holder [D4, sheet 6] from the cardboard and fold all glue tabs backwards. The folds of the small tooth-shaped glue tabs should form as uniform a curve as possible.

Option: *Colour the edges of the folded tabs to match.*

First, without glue, try the fit of the side piece into the left half of part D1, matching the letter markings on the side piece and the rear panel. Then glue the tabs marked "A" and "B" onto part [D1]. Push the side panel tightly into the corner between edges "A" and "B" and make sure that it is flush with the edges.

Step 43 Fold the tabs on the right side piece of the holder [D5, sheet 6] backwards as well.

Option: *Colour the edges of the folded flaps to match.*

Glue it in place with tabs "A" and "B" in the same way on the right side of part [D1] and then glue the glue tabs marked "C" and "D" on both sides. You may have to sharply fold the tab marked "D" again to do this.

Step 44 Remove the front part of the holder [D6, sheet 6] from the cardboard. This is the last part of the kit. Fold the glue tab backwards and round off the bottom 5.5 cm of the front with the winding core (approximately 2.5 cm of the area below and above the cartouche with the words "Replica..."). This rounding of the front should match the rounded shape of the two side pieces.

Option: *Colour the edges to match.*

To test the fit, place the rounded part into the side pieces so that the upper end with the portrait of Galileo is straight and the glue tab is under the strip marked "E". Then first glue the glue tab under this strip marked "E" and let it dry. Then apply glue to all remaining glue tabs and carefully press the strip and the back panel onto them.

Congratulations!

Your historic cardboard replica of Galileo Galilei's telescope is complete, including its holder.

You can make observations with this telescope, but because of the small field of view, it is as difficult as it was in Galileo's time.

If you would like to build a modern, more powerful telescope following the designs of Kepler or Newton, you can find these kits on our website **astromediashop.co.uk**.

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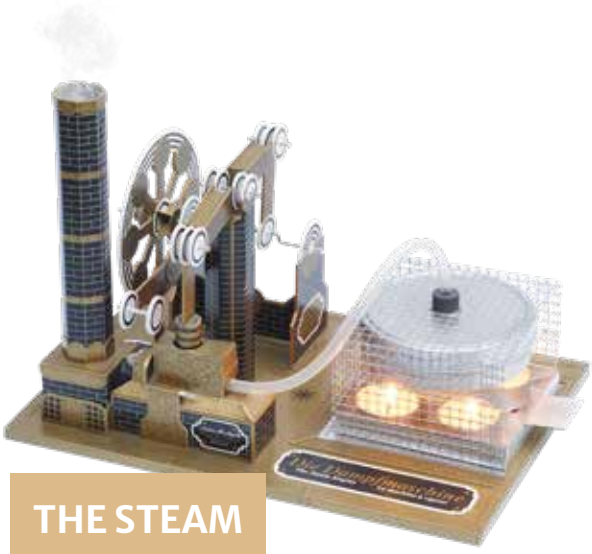

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