The Dancing Disc

Ever since coins have existed, they have been spun and made to dance. Hardly anyone can escape the fascination of their magical whirring and whirling. Flat round discs, e.g. stones, and smooth hard surfaces to spin them on can be found everywhere in nature. They have been part of the playful cultural treasure of mankind since time immemorial. The same is true of spinning tops, to which their motion is closely related.

The scientific work of Leonhard Euler (1707–1783) is the most extensive ever created by a mathematician.

What makes a dancing disc so fascinating? It starts its dance standing upright and not particularly fast. The more it leans over, however, the faster its tumbling movement becomes: first slowly, then faster and faster, until after a frenzied finale that gets louder and louder it suddenly comes to a halt. In this sudden silence the question arises: How can that be? How can something that initially rotates so slowly and quietly become so fast and so loud without any discernible external intervention?

Physics provides the answer. It was found by Leonhard Euler, one of the most brilliant and productive mathematicians of all time. Born in Basel in 1707, he spent most of his life in Berlin and St. Petersburg, where he died in 1783. To put it simply, the disc gains the energy it needs for the ever faster dance from the approach of its centre of gravity to the base: At the beginning the disc is erect and potential energy ("positional energy") is stored in the disc. This energy is released when the disc tilts and it is converted into rotational motion energy. Leonhard Euler found the mathematical equations with which this conversion can be calculated exactly.

In 1770, when he was almost completely blind but still scientifically highly productive, he was walking with his son through a street in St. Petersburg. He stopped when he heard a familiar noise from an exchange office: the whirring sound of a coin as it rotates its pirouettes on a polished stone slab – a method, already used in Renaissance Italy to check the authenticity of a coin by observing its movement and sound. He took this as an opportunity to give a lecture the next day at the Academy of Sciences on the physical processes involved and their mathematical description. This lecture was completely unrehearsed and without a written concept, which he could not have read anyway. It was a special application of the equations of motion for an ideal top that he had found some twenty years earlier.

This construction kit for a dancing disc is dedicated to the memory of the brilliant mathematician Leonhard Euler. It is significantly larger and heavier than a coin and therefore rotates all the longer and more impressively. Since a smooth stone surface is not always available, the kit includes a round mirror. It is slightly curved inwards and thus makes sure that the disc does not move too far from the centre during its dance.

This kit contains:

- **1 stainless steel disc, 75 x 13 mm**
- **2 stickers made of metal foil**
- **1 concave mirror, Ø 20 cm**
- **1 printed die cut sheet made from 0.4 mm construction cardboard**
- **These instructions**

Also needed for assembly:

- A firm, level work surface.
- If necessary: A fine brush to remove glue residues from the stickers, e.g. a toothbrush.
- A good solvent-based all-purpose adhesive, e.g. UHU all-purpose glue or Evo-Stik Impact. Solvent-free, water-based adhesives do not adhere well to the protective coating of the cardboard and can soften it. Tip: Solvent-based all-purpose glue sets much faster if it is briefly blown on several times after spreading it on both surfaces.
- A sharp knife (craft knife*) to cut through the retaining tabs in the punched cardboard sheet.
- A pair of scissors to cut the stand parts to length if necessary.
- A little bit of methylated spirit to clean the stainless steel disc and the mirror.

* e.g. the AstroMedia Craft Knife 401.MES

Please read before commencing:

1 Each part is marked with a part number consisting of a letter and a number in a rectangular frame, e.g. **[A3]**. The letter stands for the component and the number for the order of assembly.

2 Areas to be glued are marked in light grey.

3 Before starting a step, remove the required parts from the punched cardboard sheet. If necessary, cut through the small retaining tabs with the knife.

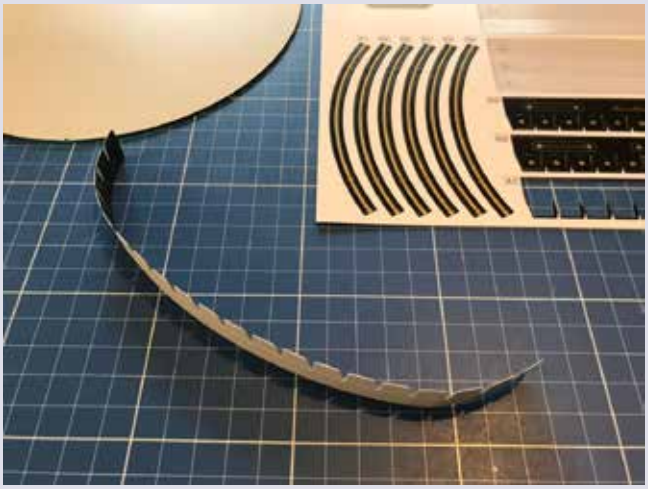
Building Instructions

Please read each step completely before commencing.

A. The Mirror Stand, Layer 1

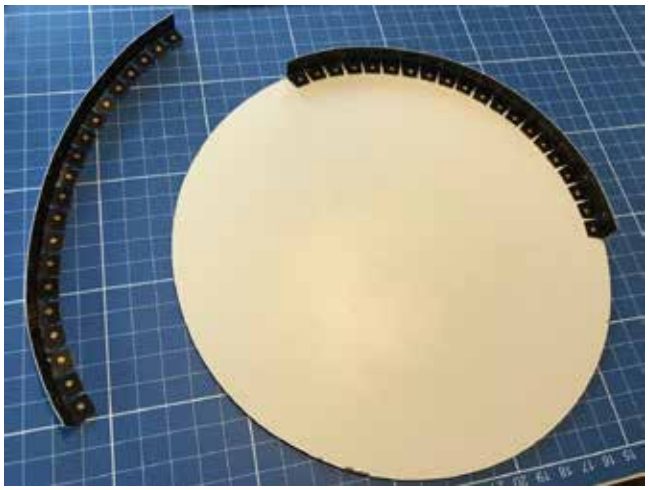
Step 1 If present, remove the protective film from the mirror and lay it with the back facing upwards on your work surface.

Step 2 Detach stand part **[A1]** from the cardboard sheet and carefully pull it with the printed side down over the edge of a table or similar so that it arches a little. The two ends should curve a bit more than the middle.



Then fold all glue tabs forwards with a sharp crease, i.e. fold them towards you when looking at the black printed side.

Step 3 Glue the tabs onto the edge of the back of the mirror so that the folded edge on the back of the stand part is exactly flush with the edge of the mirror, i.e. it neither protrudes over the mirror nor lies further inside than the mirror edge.



Step 4 Curve and fold the stand part **[A2]** in the same way and then glue it onto the edge of the mirror without gap.

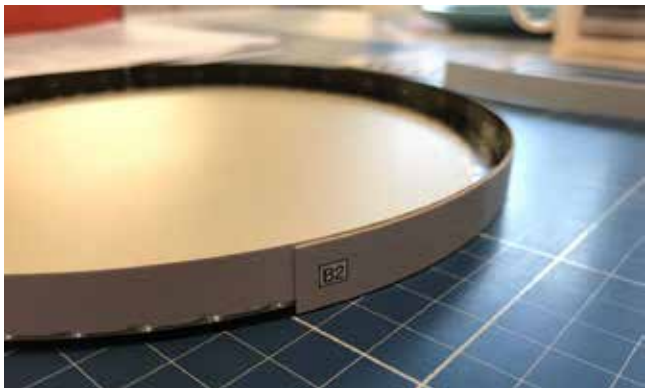
Step 5 Do the same with part **[A3]**, but before the glue dries, check that the end of part **[A3]** is exactly edge-to-edge with part **[A1]**. If it overlaps, cut off the excess. It doesn't matter if a small gap remains.

B. The Mirror Stand, Layer 2

Step 6 Detach the strip-shaped stand parts **[B1]**, **[B2]**, and **[B3]** from the cardboard sheet and also bend them by pulling them over an edge.

Step 7 Now glue one of the strips onto the outside of the first layer of the stand. It should touch the work surface right next to the mirror, so that it is flush with the top of the first layer of the mirror stand. Then glue the other two strips on as well, so that their edges are flush with the edges of the previous one. If the last strip overlaps, cut off the excess.

It doesn't matter if a small gap remains. If you are a perfectionist though, you can fill it with a narrow cardboard strip.



Important: *Make sure that the gaps of the second layer are not in the same places as the gaps of the first one.*

C. The Mirror Stand, Layer 3

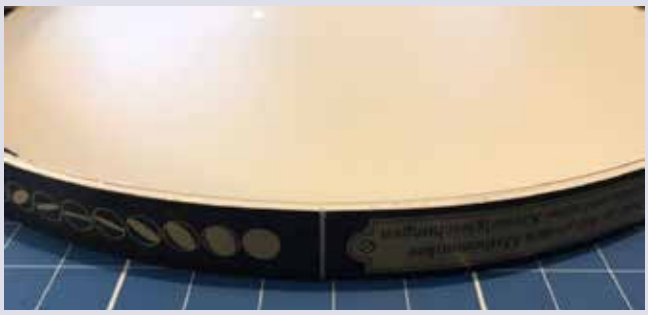
Step 8 Remove the strip-shaped stand parts **[C1]**, **[C2]**, and **[C3]** from the cardboard sheet and proceed with them in the same way as with the parts of layer 2.

D. The Mirror Stand, Outer Layer 4

Step 9 Detach the last stand parts **[D1]**, **[D2]**, and **[D3]** from the cardboard sheet and bend them like the others by pulling them over an edge, but this time with the unprinted side downwards so that the printed side is on the outside of the curved strip.

Important: *Strip **[D3]** is slightly longer than the others and is the last to be glued in place.*

Step 10 First glue parts **[D1]** and **[D2]** in place. The printed text must be upside down so that it is the right way up when the mirror is put on its stand.

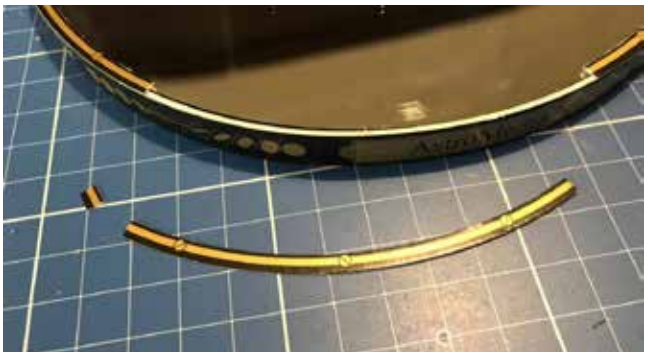


The last strip **[D3]** is deliberately longer to make sure that it will definitely overlap a bit. It must therefore be cut to size before glueing. First place it in the gap it will be glued into and cut off the excess. After that glue the strip in place.

Note: *The mirror stand is now ready. Turn the mirror over and check that it stands firmly on a level surface.*

E. The Rim Cover

Step 11 Carefully detach the narrow strips of the edge cover **[E1 to E6]** from the cardboard sheet and glue them directly abutting to each other onto the white edge of the mirror stand, formed by the three outer layers. The edge of the mirror is also covered. Cut off the overlapping end of the last strip so that it fits exactly into the remaining gap.



F. The Label

Step 12 Fill in the octagonal label and glue it in the middle of the bottom of the mirror.

Note: *Now the mirror is ready to be the perfect dance floor for the disc. If you want, you can already try it out, even if the disc has not yet got its shiny gold finish.*

G. The Disc

Step 13 Clean the stainless steel disc on both sides with methylated spirit to remove fingerprints and any oily residue and fit one of the stickers to each side. First remove the protective foil from the adhesive side and press the metal foil firmly onto the disc. Then peel off the backing foil from the golden side. Any adhesive residue next to the gold foil parts is best removed carefully with a fine, firm brush (toothbrush).

Now the disc has been transformed into a magnificent commemorative medal. The assembly is finished and the dance can begin!

Tips for use:

Make sure the mirror is standing on a firm surface and doesn't wobble. Carefully place the disc near the centre of the mirror and gently spin it so that it begins to dance. Hold it at a slight angle, otherwise it will remain upright after a few turns instead of dancing. Once it starts moving on its own everything else will happen by itself.

Interesting observations to be made:

- What happens if the disc is not started in the middle of the mirror, but towards the edge? Does it dance for a longer or a shorter time?
- Does your disc rotate a little better on one side and therefore longer than on the other? Which one is it, the one with the star or the one with Euler's portrait?
- What about the actual rotation of the disc in the course of its dance, which can be read from the rotation of the star or portrait? Is it speeding up or slowing down?
- And then, of course, the question of questions: Who will manage to make the disc dance the longest? What trick can you use to beat the record?

We would love to hear about your experiences with the disc. If you have a record-breaking video, please send us a link to ***service@astromedia.de.***

We are looking forward to seeing it!