Drawing a foot:

Step 1 is to draw a kidney bean:

Now apply some rigid motions. We'll begin with reflections so we can use the **Miras**. The Mira works best with the light behind you, the object you want to reflect between you and the mira, and the "notched" end of the mira up and facing you. To draw the reflection, put your pencil behind the mira and draw right on top of what you see.

Reflect the printed foot over the diagonal line using the mira. Then **rotate your paper 180** and reflect the foot you drew over the horizontal line using the mira.



Your final foot should be close to the original foot, but rotated about twice the angle in between the two lines. You might sketch center lines of your feet to see.

Now we do parallel reflections. This time you kee the paper right-side around the whole time. As you move the mira from the lower to the upper line, watch how fast the reflection moves. Perhaps twice as fast as you move the mira?



When you are done, the final foot should be moved up and to the right with no rotation or reflection. Measure the distance to make sure it is twice the distance between the two lines.

Draw a line between the tips of the original and final big toes. At what angle does that line meet the reflecting lines?

Notice how the intermediate foot is at a funny angle, but somehow it gets straightened out at the end. How do you affect the funny angle? Will it always get straightened out?

Now we try it without miras. (Unless you are very clever!) We'll do rotations around the same point. Rotate the printed foot 180 degrees around the center point. Now rotate your drawn foot another 90 degrees clockwise around the center point.



The final foot should be on the left side of the paper, toes up, a left foot. How could you have more simply done this double-rotation as a single rotation?

Notice how the foot had to walk a long way around, because it was far from the center. If it was closer to the center, it would not move as far. You might remember a game from elementary school: 7 people line up holding hands, the left half facing one way, and the right half facing the other. The center person spins while everyone else walks forward around the circle. The inside people take baby steps, while the outside people have to run. Now we rotate about two different centers. Frieze groups only have 180 degree rotations, so we'll focus on those. Rotate the printed foot 180 degrees around the first point, and then rotate your drawn foot 180 degrees around the second point.



You might recognize this as a very silly walk. Place your right toe at the rotocenter and pirouette, then step your right toe back onto the second rotocenter, and pirouette again. I recommend reversing rotation directions to avoid getting too dizzy.

Notice though that if we ignore the first drawn foot, and only use the printed and final foot, then we simply have a normal walk (for the left foot at least).

What would happen if we took the final foot and did both rotations again? This requires more flexibility, but I think you'll find the final effect is that the left foot takes another step forward. These two rotations force the translation!