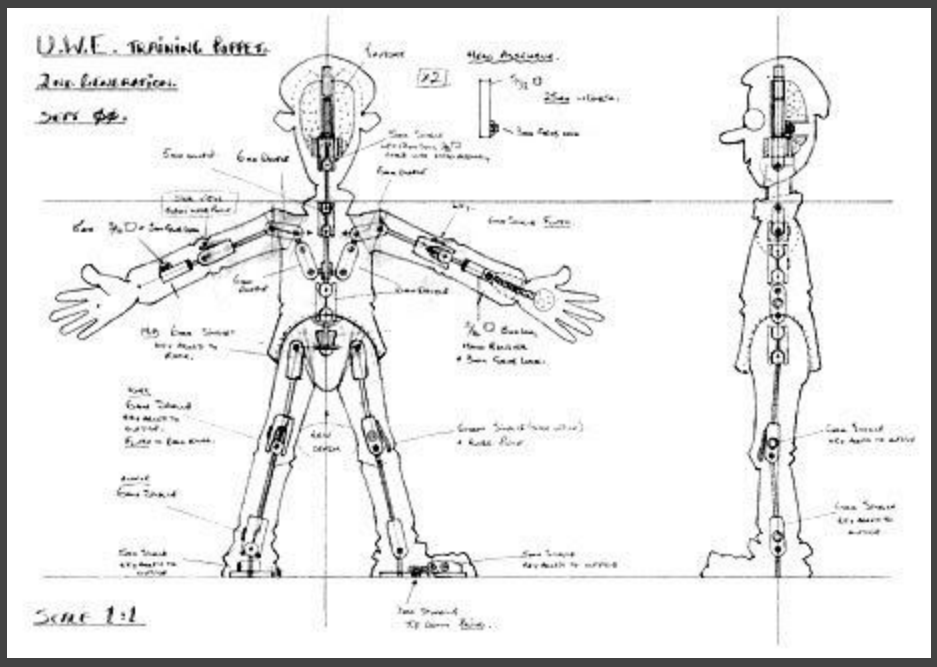
PUPPETMAKING

Destined for Bennington animation students who might want to get into stop motion puppet making, this guide lists a few techniques, with a range of difficulty, picked up over time through independent study, internship and personal research and experimenting. There is enough information to make a puppet from start to finish with varying methods, though it is far from an exhaustive list, but rather a few things picked up over time. So take it with a grain of salt from a student who is still learning.

PLANNING

When planning for your puppet, be careful to not expedite the process and to make sure you are accounting for each part of the fabrication. Without proper planning, it is easy to find yourself stuck or having to remake or rethink parts (that will likely happen anyways since a lot of the process is trial and error, or new ideas will come and make you want to change a few things, but planning carefully can save a lot of time and money).

- If you don't already have sketches of the character, make some, you need a clear idea of your goals from the start. Once you do, making a scale drawing with a front and profile view of your puppet will help you plan, and you can regularly refer to it throughout the process to make sure you are working in the right size. When making this, know that you will likely be drawing armature inside of it, and annotating. Precise outlines of the puppet is the most important, no need to have too many details, unless those are relevant to how you are planning your armature, etc...



Scale drawing and armature planning by John Parsons.

- Figure out how you intend to make each part of the puppet. Will the head be hard or soft? Will the body be full silicone or foam? Think of what you want your puppet to achieve and on how to make that work early on. If you want your puppet to be able to lip sync, for example, figuring out how and with what materials should happen now.

- Draft your armature referring to this scale drawing, adjust some things if you need to. Think on how all your parts connect. If you are casting your hands separately from the body, how will you connect them to the body? Brass tubing is a great way of fitting different parts together.

Silicone or latex:

If you decide to cast a soft body, and have to make the decision between latex and silicone here are a few things to consider:

- Latex is much softer, and lightweight which is always good when thinking of how you are going to rig your character since the heavier it is, the harder it will be to rig. If you are working with a rather bulky puppet, silicone might prevent a full range of motion

- Foam latex is however less convenient for 2 reasons: the mixing ratio isn't as easy as most silicones (a lot of silicones are 1:1 ratio). It also requires an oven specifically made for this purpose (toxic, please don't put this in your kitchen oven) which we don't have access to in Bennington as of now.

- If you are going for a bulkier puppet and don't want to lose the range of motion, using foam under the clothes of your puppet and using silicone only for specific parts (such as the hands) is a great option. If you do not want that much clothing, you could also use silicone only for an outer "skin" layer.

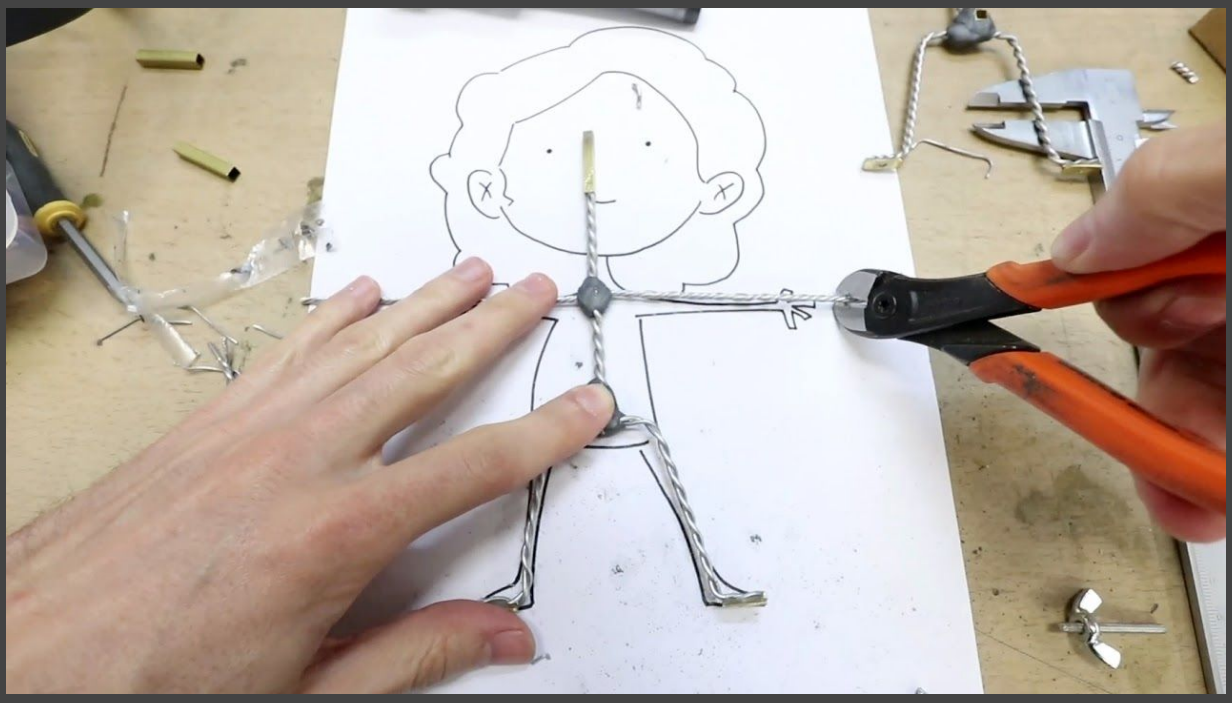
Highly recommend Smooth-on Dragonskin. It is a platinum cure silicone so you need to be careful to wear latex free gloves and generally keep it away from latex because it will prevent it from curing properly. But other than that, the silicone is easy to mix (1:1 ratio), easy to find online, and soft enough to get the job done.

ARMATURES

Wire armature

Wire armatures are the cheapest and easiest way to make the skeleton of your character, and are rather straightforward. They are also relatively lightweight, which makes rigging easier. Their main flaw is that they will break much easier than a ball and socket, which in turn could potentially last forever.

Best wire to work with is 1/16 of an inch, though you should always double it and work with two strands of wire for your armatures. You can either wrap the two strands of wire together with string, or twist the strands of wire together. However, if you are twisting, don't twist too tight or it may fragilise the wires. Aluminium will almost always be the best choice to make armatures for stop motion, because it stays in place very well, but if you are using other metals such as copper, going over it with your soldering torch may allow it to behave better when bending.



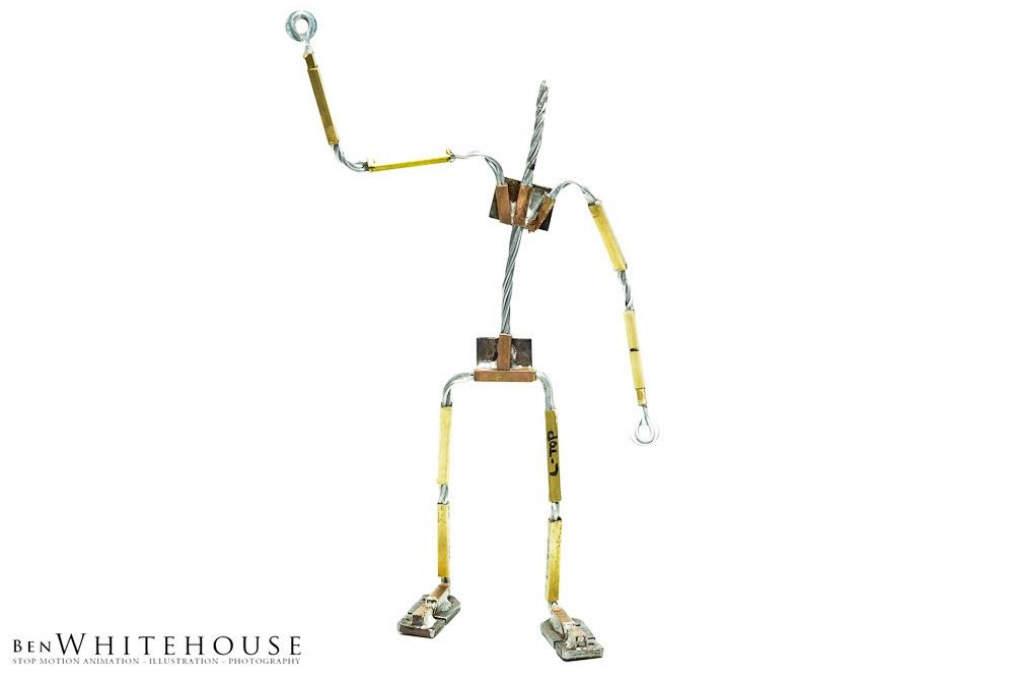
A wire armature by Eduard Puertas Anfruns (Citoplasmas studio). Eduard Puertas posts animation content on this youtube account, and this is a frame taken from an explanatory video on wire armatures, watch it here.

To connect the different limbs/pieces together, you can use epoxy clay (a 2 part self hardening clay) or brass tubing. Brass tubing is especially useful when you want to make a spare pair of hands, or if you want to be able to take off the head for example, since they can be telescopic and fit together.

When cutting wire, or bending them as you are constructing the armature, be careful not to leave dents. Dents will fragilise the wire and make it break faster. Pliers and other tools can leave dents in the wire, so it is important to protect the wire. Covering your tools with something like electrical tape will preserve your wire from some of the dents that the metal tools could inflict on them.

I would recommend crafting hands separately. They tend to be used a lot and break easily, on top of being crafted with smaller, more fragile wire. Working with an extra pair of hands is always helpful, in case a hand breaks halfway through your project.

Unless you are looking for the noodle arms aesthetic, forming "bones" with epoxy or brass tubing is a good way to make sure your arm or knee always bends in the same place, rather than forming an arc instead of a clean elbow. Though, as always, be aware that bending in the same place will weaken the wire over time and it might eventually break.

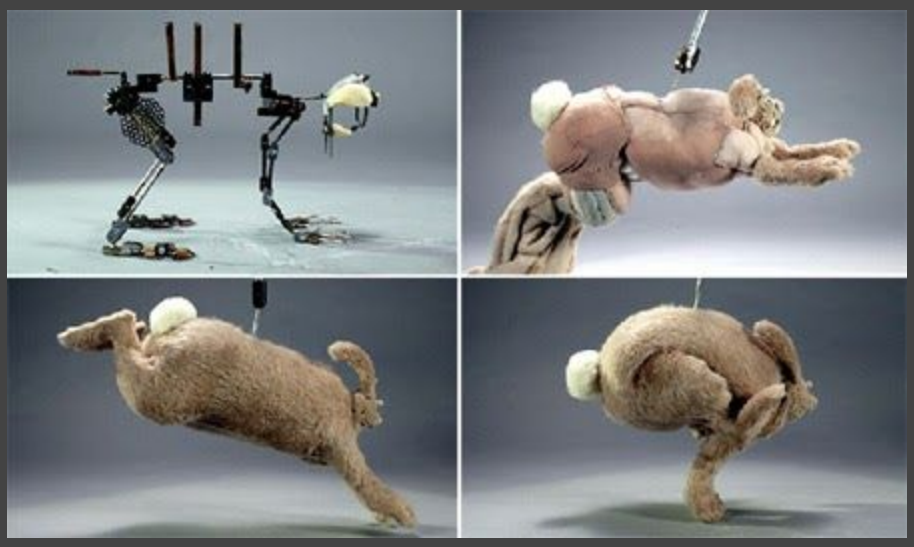


A wire armature by Ben Whitehouse using brass tubing as connectors and "bones". Ben Whitehouse's blog here.

As a rule of thumb, and though it is incredibly tempting to play with your puppet once it is finished before shooting with it, avoid bending the armature when you are not recording. Of course a bit of testing never hurts, but resist the urge to bend and pose your puppet when you are not shooting, or it will weaken your armature over time.

Ball and socket armature

Ball and socket armatures are much more durable, but also much more expensive and complicated.



The Wererabbit puppet and its armature by Aardman Animations.

When starting, you can buy them as kits, which are convenient especially for a simple humanoid puppet, and also teach you how to put them together. Prices for a simple humanoid kit rarely go below $80. You can also buy the plates and ball bearings separately and make your armature yourself. That however doesn't reduce the price much. You can always use ball and socket in combination with wire. For example, most of the body could be wire, except for the neck, which tends to have a lot more range with a ball and socket joint than with wire.

Given the right equipment, you could build the joints yourself. This would however require some level of machinery, and some soldering skills. This is more time consuming, but it allows more freedom in the basic structure of your puppet, and also may cost less if buying materials in bulk for several puppets.

Ball and socket armature for Opening Night by Nathan Flynn (Sculpt Double). He details some of his process, including ball and socket joints, in his blog here.

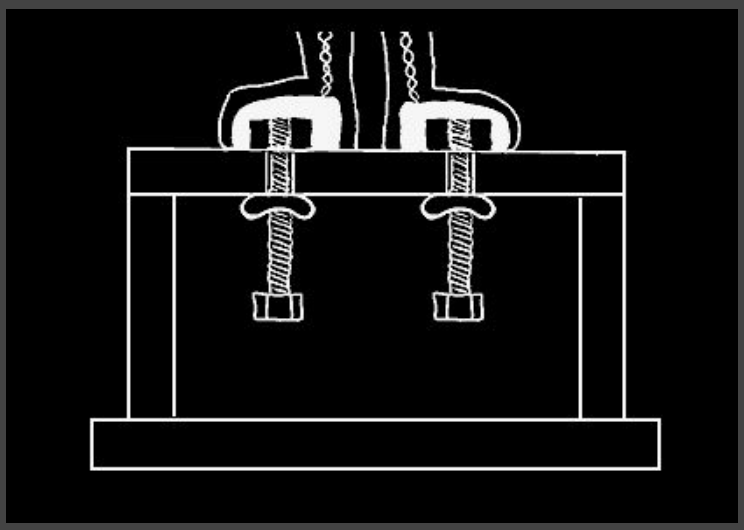
Using ball and socket armatures means you need to take some precautions if casting the body in silicone. The silicone will clog the joints if you don't protect them: before casting, fill the joint (don't just coat it, fill it) with petroleum jelly, so that they keep the silicone out. Alternatively, you can also wrap the joints with teflon tape.

Rigging

It is unlikely your puppet stands on its own, and when planning the building of your puppet, you should have decided on how you will pose it. There are 3 main methods.

The most common and reliable is to use screws to lock the feet in place on the animation table. This means that the armature of the feet must have been made with this purpose in mind. Feet armatures can be bought as a kit, but

alternatively you can place an M3 nut (or another size, depending on the size you want you puppet in, though M3 seems the most standard) inside the foot. You will then be able to secure the foot down by setting your screws into your foot nut through the holes of the animation table.



Sketch of tie down system by Anthony Scott. You can use bolts or L-shaped threaded rods, and wingnuts to secure it onto the foot nut.

Another option may be to use neodymium magnets built in your puppet, and to animate the characters either over a metal plate or with a strong magnet under the surface you are working on. This is however not the most stable, and restricts the range of motion of your puppet, since it might need to be balanced not to fall. This method is better with a rig to support it.

Puppet with neodymium magnet in the foot by Val.

You can use a rig to support your puppet. This is pretty much an arm that you can pose in a variety of ways, with a threaded rod that connects to your puppet (usually through to a block at the hips and sometimes the upper back). Though it is possible to use only a rig to animate, it is better to use a rig in supplement of another method. The rig can also (and mostly) be used for frames where the puppet is in mid air, like during a jump.

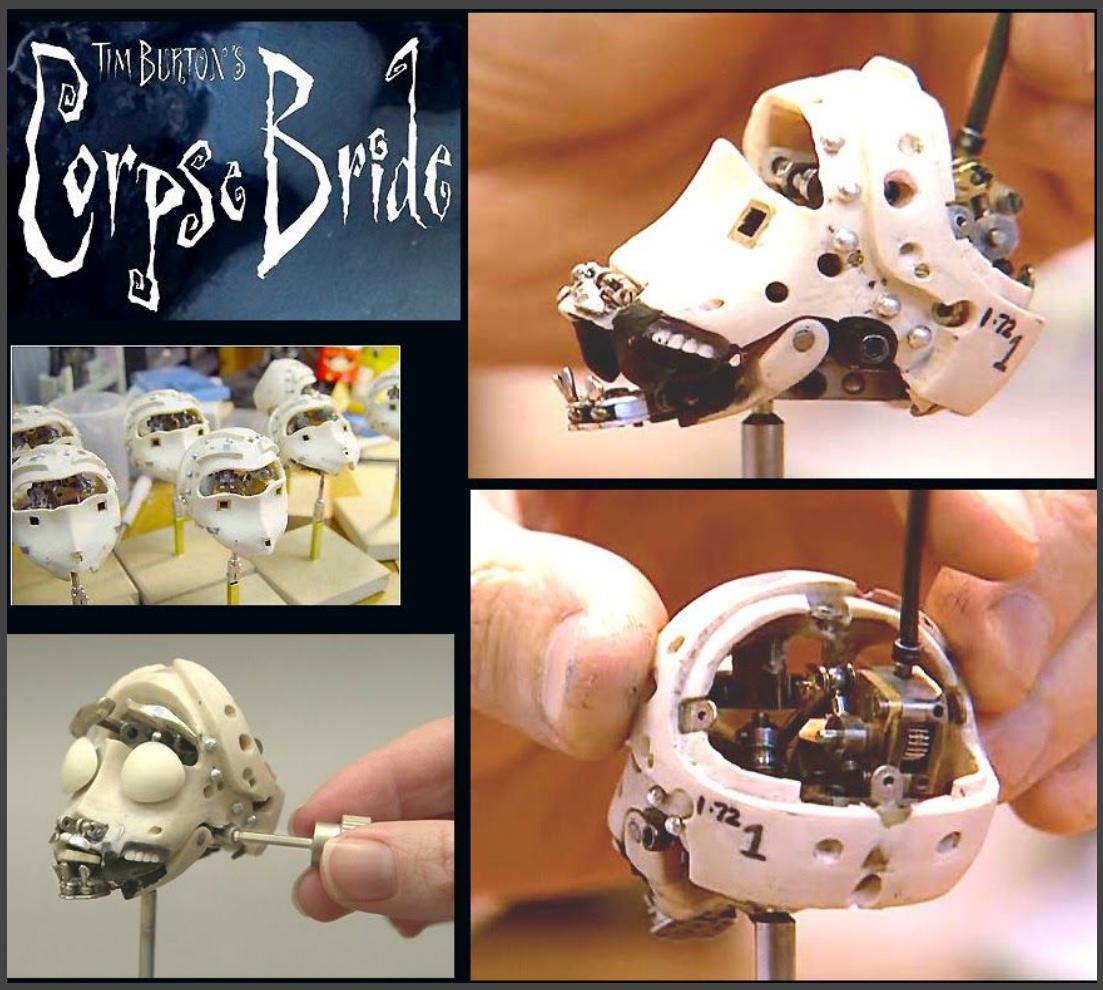
A simple rig by Anibild, easy to use especially when starting.

FACES

Mechanical heads

These are most often soft faces, cast in latex or silicone, with their own armature inside allowing to manipulate facial expressions.

These are most often simple and most often allowing for simple brow and lower jaw movement, but more complicated versions exist, such as these armatures for the Corpse Bride puppets.



The head mechanism for the puppets of Corpse Bride, created by MacKinnon & Saunders.

However, it doesn't have to be this complex. The most simple way to make a soft head with some range of motion (in closing or opening the mouth, or raising the eyebrows) would be by using wire to line your mold on the areas that will move (this wire being attached to a head core connected to your body armature) before casting silicone.

Unfortunately, unless you are able to work with mechanisms as precise and complex as the MacKinnon & Saunders puppets, this method of making heads likely restricts the range of facial expressions that your puppet could perform.

Replacement faces

The replacement method that allows for a wider range of facial expressions. It is much more time consuming, but can really be worth it. These are hard faces that attach to the core of your puppet's head, and can be replaced.

3D printing has hugely helped in developing this method, and is used for example by Laika Studios, allowing them to create endless possibilities with their characters' facial expressions.

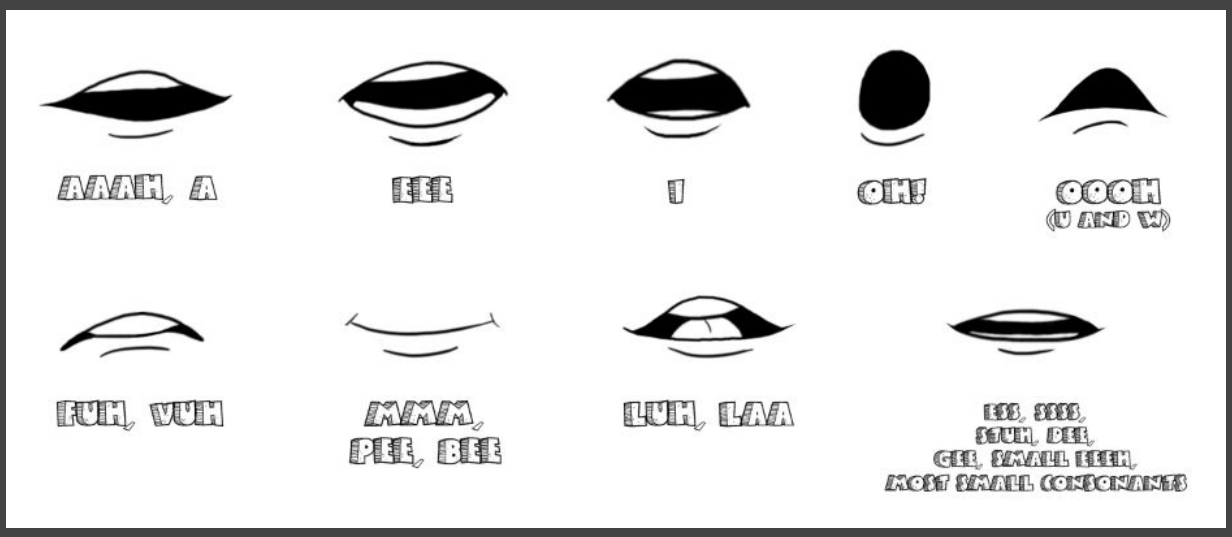
3D printed replacement heads for Paranorman by Laika Studios.

Replacement faces can also be hand sculpted. This can be as complex or simple as you make it, and depends on what different expressions you want your puppet to have. Using many faces can make this process rather time consuming, but it is also very rewarding in the final animation.

Face sculpt and resin replacements by Joshua Flynn for Opening Night (sculpt double). He details his process on his blog here.

If you are wanting to work beyond simple expressions and want your character to be able to lip sync, use mouth shape sheets to determine what mouths you will need, but don't follow it too closely: assess what the needs of your puppet are depending on what you need it to be able to perform, there isn't really a standardised system for it. Maybe you want an extra set of mouths for when the character is speaking with a smile.

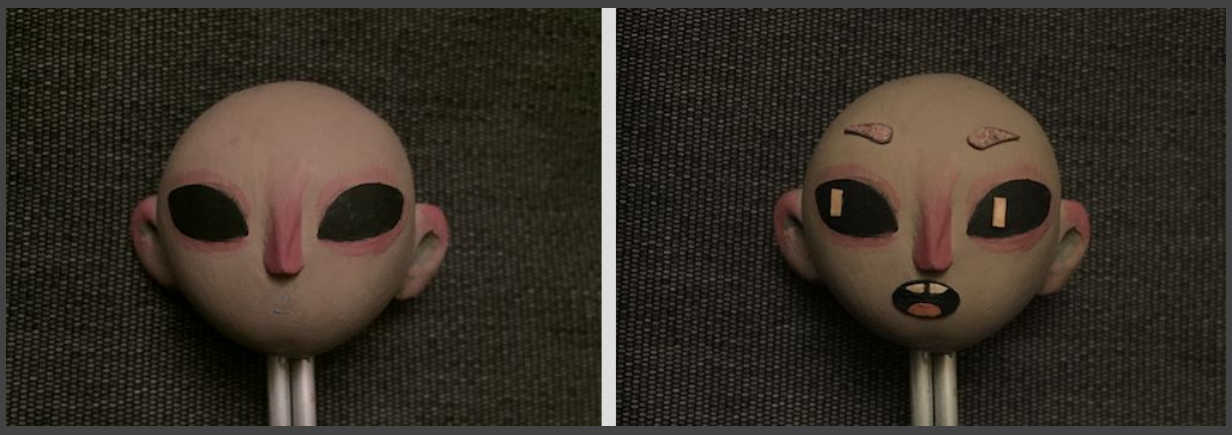
Some hand sculpted, molded and resin cast replacement heads, by Val.



Mouth chart, by Will Boyer. Many different charts exist, make sure you use something that makes sense for your puppet and what it needs to achieve.

Easier alternatives

Replacement and mechanical faces may not be the most convenient or fast ways to make a puppet, so stickers can be a great alternative while still allowing for a wide range of motion.



Puppet head with and without stickers, by Val.

These can be paper or clay, depending on how often they will be used and how sturdy they need to be. It is preferable to work with a hard head and a flat surface when doing so, like with polymer clay for example. These can be stuck on the face with sticky tack, or even with a magnet system.

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Replacement mouths for the puppets of My Life as a Zucchini.

MOLDMAKING AND CASTING

Sculpt and mold

(This is all assuming that you are using silicone for a two part plaster mold).

If you want to cast your puppet in silicone, you will first need a sculpt (or master) of your puppet. The softer clays like plastiline rather than hard ones like monster clay may make it hard to sculpt, especially the bigger the piece, but the clay softness is something you should decide for yourself, seeing what you are most comfortable sculpting with. At this point make sure that your armature would fit in the puppet, it would be sad to figure out that the armature doesn't fit once you have finished your mold.

As a rule of thumb, if you are casting something hard, your mold should be soft (use silicone if you want your final product to be resin for example) and if you are casting something soft, your mold should be hard (use plaster if you want your final product to be silicone for example).

Moldmaking by Tom and Hani. They detail their process on their website here.

You will need to plan beforehand how to make your mold. Try to think of what areas could trap bubbles, where air should escape from, where will you pour the silicone, etc. Ideally, your mold will fill up from the bottom when you are casting, and little conduits will allow the air to escape from the top as the mold fills up with silicone, plan for that as well.

Make a "box" for your mold using squares of wood clamped together. Use a soft clay like plastiline when preparing for the first half of your mold. Determine where the "seam line" of the object should be, and surround the bottom half of your master, up to the seam line, with this soft clay. It is always good to make sure the "box" will not leak, maybe bring a little extra plastiline along the corners.

As mentioned earlier, ideally your mold will fill up from the bottom when you are casting, and little conduits will allow the air to escape from the top as the mold fills up with silicone. It may be easier to carve the air conduit on the plaster once the mold is finished, but the pouring conduit should be added in plastiline now. This is a little snake of plastiline reaching from the top of the mold to the bottom of the master, that once cured will create a conduit. Using a large plastic syringe you will pour the silicone from the entrance of this conduit, filling up the mold from the bottom.

Hand mold from Zdar Sorm's workshop with keys/locators.

Also use the plastiline to create keys. Keys will allow the two parts of the mold to slot into place, create them by just pressing half a sphere into the surface of the plastiline with a marble for example. Once that is ready, you can pour your plaster mix in the mold. Especially when working with something that has lots of detail, it could be good to start by gently brushing a first coat of plaster on the master, which reduces the bubbles and captures the details better. Finish up by pouring the plaster on the side of the master, never directly on it.

When the first half of your mold has cured, you can flip it over and carefully remove the plastiline. Be careful not to move the master! Once the master/sculpt is in place, you should never move it until you have finished the mold. At this point, you should add prying points with plastiline. Add rectangles of clay on the sides. Once the mold is finished and these rectangles of plastiline removed, it will form gaps in which you will be able to slide in a screwdriver and pry the mold open. Fill in once more the gap that was left by the plastiline to create a pouring conduit, you want to make sure that the pouring conduit remains when casting the second half of the mold. This is also the occasion to refine the entrance of the conduit to better fit the size of your syringes.

Before pouring in the plaster for the second part, you need to make sure that the two parts will not stick together. Do so by brushing petroleum jelly onto the plaster, or to be ever safer, by coating the plaster with acrylic spray (be careful to do this in a well ventilated space and to protect your mouth, nose and eyes) before brushing in the petroleum jelly or spraying mold release. You can then pour your plaster the same way you did for the first half of the mold.

Once your mold has cured, remove the plastiline in your prying points and you can pry the mold open. This may require some force, but be careful to still be gentle about it, especially if your mold is rather thin. Plaster can be pretty fragile. Once open, remove the master and the plastiline from the pouring conduit. You can then carve out tiny air conduits from the top of the master, running along the surface of one mold half. These will allow the air to exit from the top when you are filling up the mold from the bottom with silicone using the pouring conduit. After that, make sure the mold is clear of dust and petroleum jelly, and coat it again with acrylic spray. It is also good to clean up the mold with isopropyl alcohol if you have been working with a clay that the silicone may react poorly to.

Casting

Moving on to casting, make sure that you are all set up to cast before you start mixing the silicone, especially if you are working with a fast curing one. Spray mold release or brush petroleum jelly on the mold, then place your armature properly and make sure that it is not touching the mold.

If you are working with ball and socket joints, you need to protect them beforehand. Otherwise silicone will enter the joint and clog it, completely blocking the joint from moving. To do so, generously fill the gaps in the joint with petroleum jelly, which will prevent the silicone from entering. You will also need to protect parts of your armature that need to stay clear such as nuts in the feet or hands. You can also use petroleum jelly for this.

Once your armature is set in the mold, close the mold properly. The key points should make this easy. Secure it with clamps. It may be worth it to sandwich your mold with plates of wood, and clamp the wood rather than the plaster itself, especially if the mold is small. The wood will redistribute the weight of the clamps and prevent the concentration of too much pressure on one point of the mold.

Mix your color pigment before mixing the silicone. Use color other than silicone pigments at your own risk: since silicone is capricious, you are better off sticking to pigments specifically made for silicone if you don't want your piece to cure poorly. For the same reason, be sure to use latex-free gloves, since silicone reacts poorly to latex, and if you have been working with a substance that the silicone may not react well to when making your mold, make sure to clean the mold with isopropyl alcohol before casting.

For color, you should use 2% of the weight of silicone you will be mixing. You should always mix a bit more silicone than you need, and always mix the silicone parts separately before you mix them together. Mix the color with part A of your silicone, then add part B and mix thoroughly. If you have a vacuum chamber, you can get the bubbles out of the silicone easily, but if not, pouring the silicone from high up as a thin stream into your syringe will help get rid of some of the bubbles. When your syringe is ready, press the silicone into the pouring conduit, until you can see a bit of silicone overflowing from the air conduits. After a few minutes, press again on the syringe a little bit. The bubbles present in the silicone inside the mold may have travelled and gotten trapped at the top of the mold. Pressing a little more silicone in will send these bubbles out through the air conduits.

Puppet hand mold by Val. The thin lines at the tip of the fingers work as air conduits, and silicone is poured through the conduit leading to the base of the wrist.

Once your silicone has cured and is out of the mold, you can cut along the seam lines, and then smoothe the seam lines by running a dremel tool with petroleum jelly on it. Be sure to always use a generous amount of jelly on the dremel tube, as the silicone could rip it without it. Protect your eyes when doing so though, because the dremel will most definitely send vaseline into your face.

EXTRAS

Hands

Hands should be made separately from the rest of your puppet. Firstly because it will be easier to capture more detail on a smaller mold, but also because hands will get used a lot, are fragile and will need to get replaced, and because their armature can get rather complex. This method will give you hands with a good range of motion that will also allow your character to hold something in a more stable way.

A main difference with the usual way of making armatures is that in the palm, the armature will have an M3 or M2 (depending on the size of the puppet) nut, helping you to secure objects in the palm thanks to screws. You can either build the M3 nut into the hand armature, or use epoxy clay to secure it with the fingers.

Puppet hand by Val. M3 nut in the armature allows objects to be screwed in place.

Before casting, you need to fill the hole of the M3 nut with petroleum jelly, so that the silicone doesn't clog it. When the silicone has cured and after dremeling the seam line, you can make a small hole in the palm.

When making an object that will be help by the puppet, you can include another M3 nut in it, for example, if you are making a sword, include a nut or a washer in a hole on the handle (you can dremel the nut or washer to make it smaller, but these hands are pretty much designed for an M3 nut to fit well in the palm), then use a screw to secure the object in place, allowing the hand to hold onto the object without dropping it mid-shot.

Hair and costume

There are ways to make your puppet's hair and clothing poseable. You should however always keep in mind that the more flowy your hair or clothing is, the more likely becomes. Touching and moving clothing to reposition your character for each frame turns into this shaky effect when playing the shot, this is what is referred to as boiling. Unless this is a look you enjoy, it is good to build your puppet with this in mind. If you have a big skirt for example, support the skirt with foam underneath.

The first way to make fabric move would be to sew wire into the hem of the item of clothing. You could also use wire mesh between two layers of fabric. This is especially good for an item of clothing that will be particularly flowy and will need to move in many ways, like a cape for example, but not especially the best idea for something like the sleeves of a jacket.

Vokabulantis puppet with poseable hair by WiredFly.

When it comes to hair, you can also use wires inside the hair to animate it, but this is likely to only work for braids or other hairstyles that would allow you to hide the wire. However it can really help bring life to the hair. Another way could

be to use silicone or latex to make the hair, and to create an armature for it with wires. Coat the scalp of your puppet with petroleum jelly, then cover it with a thin layer of epoxy clay. You can then sculpt the hair on that epoxy "wig cap", and take it off to make a mold. The epoxy clay and petroleum jelly should make it easier to remove the sculpt from the head to mold it, but it will help hugely to not envelop the skull entirely with hair. If you have long hair falling to the side of the head, sculpt the hair as falling a few millimeters away from the head itself, so that the head isn't encapsulated in the hair when trying to remove the head. You can tehn mold and cast the hair with silicone with a wire armature allowing to move parts of the hair. A wire mesh could also be used for some hairstyles. As always, be careful to plan this out properly, and know how to make a mold that accounts for the air conduits and prevents air bubbles from getting stuck at the tips of the hair.