Paper making: a craft and a chemical engineering major

What is paper? Essentially it's a thin flat sheet of rearranged, cleaned cellulose chains.

What's involved in paper making?

- You need a fiber source.
- You need to separate the fibers.
- You need to cut the fibers.
- You need to make the fibers into an even sheet.
- You need to prepare the paper to meet your needs.

Fiber sources

Recycled paper is an excellent fiber source. Other possibilities are rags, wood pulp, flax, hemp, weeds, seaweed, okra, kenaf, sugar cane, bamboo, onion, wheat straw — try anything once.

Cleaning the fibers

Plants are made of cellulose chains held together by adhesives such as lingen and pectin. In order to rearrange the fibers into paper, you've got to unglue them1 . This has already been done for you if you're recycling paper! However, if you're using something besides paper as your source fiber, you're probably going to have to deal with plant adhesives.

Wood makes a great building material because the cellulose is tightly bound together2 . Chemicals that can dissolve lingen, though, usually dissolve cellulose. Mechanical pulping leaves the lingen in, and lingen will oxidize over time, producing yellow, brittle paper3 . Most paper mills use a combination of mechanical and chemical pulping. The chemicals used to separate the lingen out are most commonly strong bases.

Hemp, with less lingen than wood pulp, can be made into paper using fewer chemicals. If specific sections of the plant are used, no-chemical paper can be produced.

Craft papermakers generally rely on mechanical processing (beating pulp to a pulp) and/or cooking the fibers with a strong base to break them apart4 .

This step is important. Any oils left in the fibers will oxidize over time to form brown spots called "foxing," which weaken the paper.

Cutting the fibers

Tearing, blending, beating, or any combination of those three work pretty well so long as the cellulose is roughed up enough to fray microscopically. Those frayed ends catch other cellulose fibers and hold the finished sheet of paper together.

Making the fibers into an even sheet

Paper-making requires water. After the fiber is pulped, floating it in water allows you to control the thickness and consistency of the paper being formed5 ; if you control the water, you control the pulp6 .

Making paper to meet your needs

You may want different absorbencies: for example, toilet paper should absorb more liquids than writing paper which should absorb more than magazine paper7 . You may also want to control the smoothness8 and color9 of your paper. These procedures usually involve chemicals.

How to make paper

You'll need a mold
deckle
vat
cloth squares or felt squares
newspaper (lots)
a dedicated blender10
a water source
sponges
a strainer

Equipment FAQs

What are molds and deckles? A mold is a frame with a screen (usually wire mesh) stretched across it. The paper is formed on this screen. A deckle is a frame the same size as the mold but without the mesh. It gives your paper clear edges.

How do you get a mold and deckle? You can buy them at papermaking supply houses11 or you can make them.

How do you make a mold and deckle? Buy stretcher bars, which are available for pretty cheap at art supply stores in lots of different sizes. For a deckle, just assemble four bars together. For am old, put four bars the same size as the deckle bars together. Then buy

some mesh (screen material, fine mesh) at a hardware store, but to fit over the mold, staple or somehow affix (nail? super glue?). The mesh needs to be as taut as possible. You now have a mold and deckle.

Making the paper

You need fiber. Recycling office paper or card stock is easiest, but you can use almost anything provided the fibers are strong enough and you like experimenting. Keep a note book.

For making recycled paper, tear up or shred your paper (never use cardboard or newspaper12 ), and soak over night in a pot of water. Most other fibers require soaking and beating, or cooking with soda ash and lye (sodium hydroxide).

When the fibers are soaked, you next have to fill your vat. Put a handful of soaked fibers into a blender 2/3 full of water, blend to a slurry, then pour into the vat. For every blender of pulp mix, add 1-2 blenders worth of water. Fill the vat to higher than the mold and deckle edges combined. Stir the pulp with your hand (this is the best way to figure out if a vat has enough or too much pulp).

Now make a sandwich with the mold on the bottom, the screen in the middle, and the deckle on top. Holding them firmly together, scoop the whole thing into the vat below a layer of floating pulp. Wiggle and shift the mold and deckle unit to get more or less pulp over it, then gently lift it up out of the vat. You should have a nice coating of paper pulp on the screen13.

The layer of wet pulp on your screen needs to be dried before it's paper. Remove the deckle. Use the sponge to soak as much water from the bottom of the screen as possible (squeezing the water from the sponge back into the vat).

There should be a pile of newspapers next to you, with a felt or cotton14 cloth bigger than your mold on top of the pile. Gently turn your mold over, pulp side down, and lay it on the cloth. Now, with more sponging, gentle pressure, and gravity, you will convince the paper to leave the screen and stick to the cloth. This is called couching (pronounced koo-ching).

The paper is now on the cloth. Move the cloth with the paper on it to one side, flip the top layer of the newspaper pile over to the dry side, put a new cloth on top of the pile, and you're ready to pull another sheet of paper.

THE MOST IMPORTANT PART OF PAPERMAKING!!!! Do not ever pour any of the water or slurry or pulp into any drain in any place unless you are a plumber and need practice on emergency situations. Set up a funnel lined with cloth or some other fine filtering material to strain the pulp out of the leftover slurry. The pulp, once dried, can be stored and reused, or dumped into the recycling bin or thrown away (depending on what's in it). The remaining water now can safely be flushed down a toilet or non-food sink.

On destroying adhesives. Lingen is attacked chemically in most paper mills through the use of caustic soda (sodium hydroxide) and sodium sulfide. These chemicals and their reaction products (including sulfides) account for the majority of pollutants produced by this very polluting industry.

Cellulose and hemicellulose. Cellulose is mainly a crystalline carbohydrate Molecule and comprises about half of wood. Hemicellulose is an amorphous version of the same molecule and makes up about a quarter of wood. These two molecules together form wood pulp paper.

Yellowing paper. The acidic residue from alum (aluminum salts) sizing also causes paper to yellow and become brittle when exposed to light. As a result, alum has become less common as sizing.

Bettie Allen, a talented papermaker, recommended simmering fibers in hot water for approximately 1-2 hours (depending on material used) and adding soda ash to the water to help break down the fibers.

Substances added to the water to help the pulp float are called formation aids. These include starch, tararo, and even pectin.

Bettie Allen said, "Cold water always produces better paper." She didn't Know why and I have no guesses from my research as to why this might be, but based on my experiences, I believe she,s right.

Sizing seals the surfaces of the paper, preventing inks from bleeding. Some sizings used by crafters include gelatin, pectin, starch, wallpaper cellulose adhesive, and PVA. Some of these are non-archival and will cause acid formation in the paper eventually (PVA, or polyvinyl alcohol is a good example

of a commonly used non-archival size).

Fillers are used when the spaces between cellulose fibers are considered too big. Common fillers include various types of white clay, titanium dioxide, and calcium oxide. Most fillers eventually react chemically with the cellulose to form acids which damage the paper.

Color can be added to paper by experimenting with plant pigments (though you will produce a lot of foxed papers for every success) or adding water based paints or pigments. Most paper mills trying to produce bright white paper bleach the pulp. Chlorine bleach produces dioxins, a major paper manufacturing pollutant. Other bleaching options include ozone, oxygen, hydrogen peroxide, and solar.

This blender will NEVER again be used for anything except papermaking. The pulp is permanent and the chemicals from recycled paper or from your own experiments are not for eating.

Magnolia Editions in Oakland and Flax in San Francisco are good for starts.

The fibers are too short, the ink will be difficult to filter or overwhelm your paper, and many newspapers still use newsprint made with phenylformaldehyde resin - not a nice chemical to be working with lots.

If you don't, it's too thick or uneven or just not perfect, take the deckle off, turn the mold over, and lightly touch the screen to the slurry's surface. The pulp will go back into the vat and you can start over.

Bettie Allen said never polyester, though polyester blend was fine. I think it has to do with the thread sizes in polyester garments, and with polyester's poor water absorbency, but I'm not sure.

A web resource on a "Guided Tour of Handsheet Making" is at:
http://www.chem.utas.edu/au/students/finnegan/handsheet/handsheet/html