Magnolia PaperWeight

V2.0 - IOS 14

An iPhone and iPad app for hand papermakers and paper conservators

Magnolia Paperweight is available for iPad and iPhone at the Apple App Store

Retted and shredded linen rag in an alkali cook, (soda ash)

Pulp on a knife edge

The hiss and snap of the su being lifted as a washi is couched

Lifting the deckle – an even sheet edge to edge, corner to corner

Our visceral, Dionysian feelings regarding this process do survive when we apply some Apollonian control to the process of charting a path for a specific paper we have in mind.

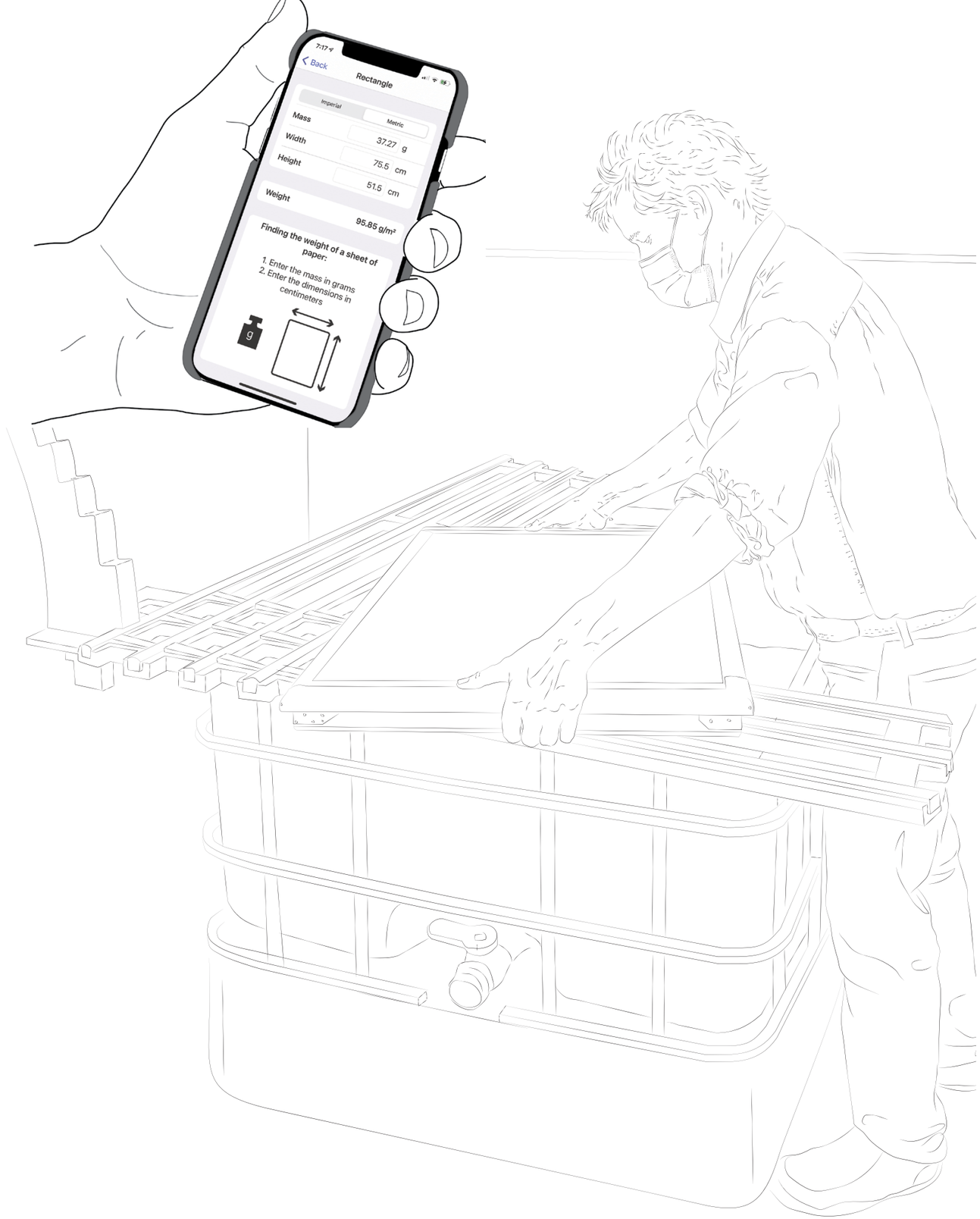
Paper is versatile and made in a density that harmonizes with its intended purpose. Might the resulting leaves be the repository of important literature? Great art? Bound and later burned for heresy? Are they to be hoarded at the outbreak of a plague for later use in our water closets?

Introduction

Where making paper by hand is concerned, sensation and perception play the lead roles. Given time, these feelings and judgments soon become second nature. We smell the earthy fragrance of retting linen before selecting and ripping the cloth to assess the right moment to cook and wash the decomposing rag. The scent of an alkali cook (linen, hemp, kozo, gampi) lets us know *the game is afoot*.

At the Hollander, we find meaning as the beater sings —we assess the fly-bars' percussion on rags and make subtle adjustments, feeling the pulp slipping between our fingers, determining its freeness. We catch fibers on a knife-edge and to ascertain their length. A visual clue might alter our shake in the last half-second of forming a Western sheet. Our senses find all four corners of the flowing furnish within the mould's deckle, assigning muscle memory responsibility for the fibrous mat's uniformity, catching a wave repeatedly, and throwing off the remainder at the last second in the way of nagashizuki. We throw a felt, and like those below, it lands squarely on the post, the stack of felt and paper that will soon be weeping under the tremendous pressure of the paper press.

From assessing the gentle tug on kozo still steaming hot in alkali liquor to the sheen on a well-formed sheet on the mould, the melodic hiss of the su, when lifted from a washi couch, all become instinctive, and all sensations heightened. It's an intricate ballet, the papermaker's dance – and it's the reason we fall in love with this age-old process.



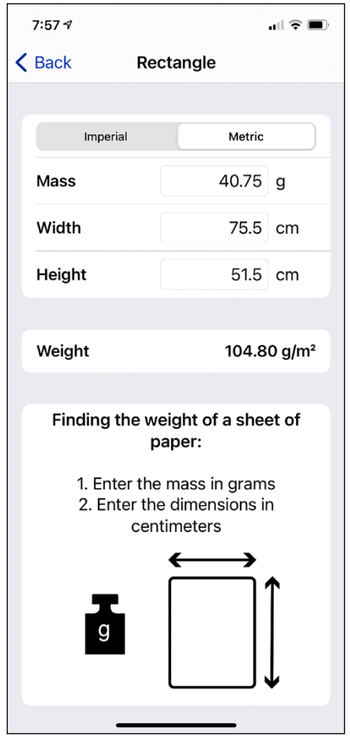
Magnolia PaperWeight

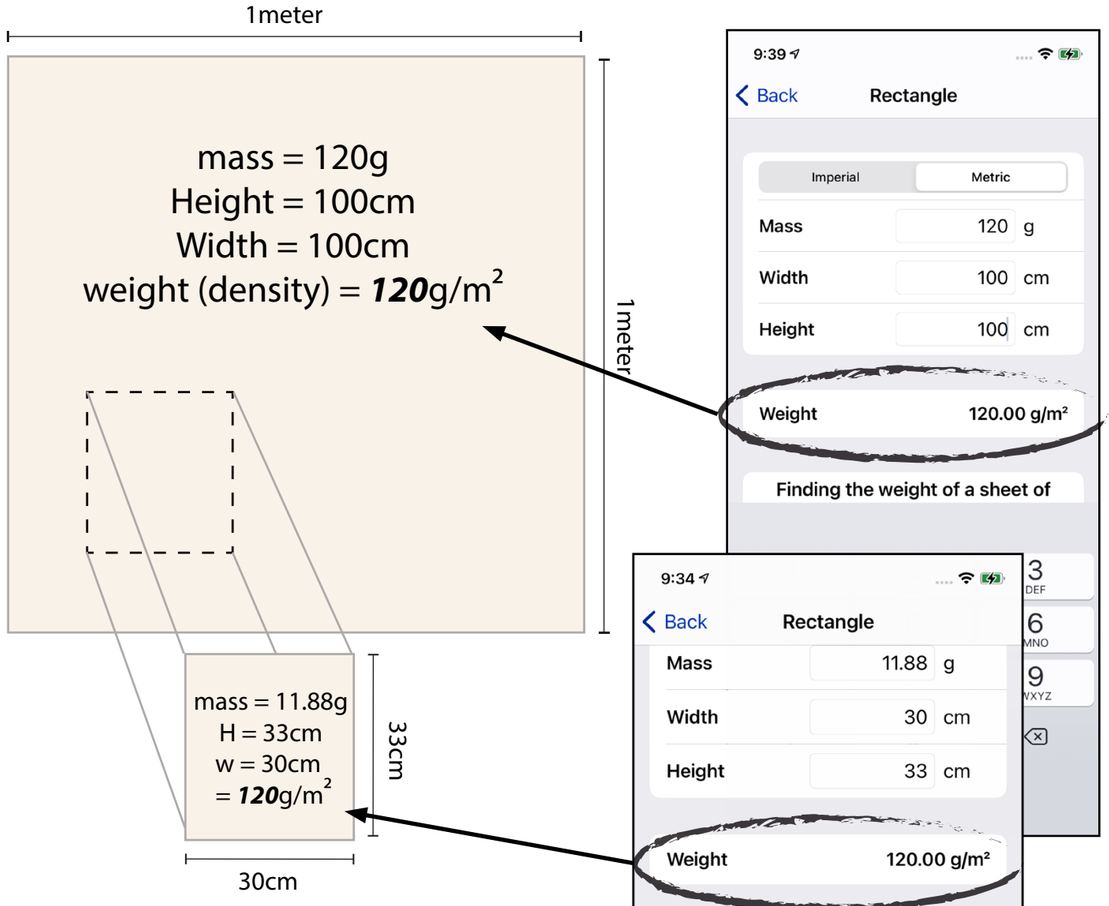
It may seem incongruous, reaching for a modern electronic device when making paper by hand, unless you are like me and see all technology as current (considering humans only just arrived on the scene). Handmade paper is, to me, a high point of man's ingenuity. Its invention was timely, significant, ecological, and allows for iterations, making all subsequent technology and stored knowledge possible. In this circumstance, an electronic device, no more or less innovative than papermaking, allows for computations that can dramatically influence a handmade process and its outcome. And this app aims to do just that; add insight into arriving at the elements necessary to create a particular sheet or set of sheets. It doesn't change how the materials behave, nor how thoroughly we revel in the process.

With the *PaperWeight* app, you can find the density (weight) of any paper; combine that piece of information with a few other parameters, and much can be understood and accomplished, whether making a beaker of paper pulp or a beater load.

When describing a sheet of paper as lightweight, medium weight, or heavyweight, these general terms specifically refer to the sheet's density. With a gram scale and a ruler, density can be conveniently and accurately measured and expressed as "grammage," or "weight" – more accurately called "grams per square meter," GSM, or g/m²; this measurement represents the weight of one square meter of a given paper.

In this example, we make the calculations using the *PaperWeight* app: A sheet of rag paper weighs in at 40.75g (its mass). The sheets' height and width are 75.5cm x 51.5cm. I entered this data into the *Rectangle* menu within the *Paper Calculations* menu group to find the sheet has a weight (grammage) of 104.80 g/m².



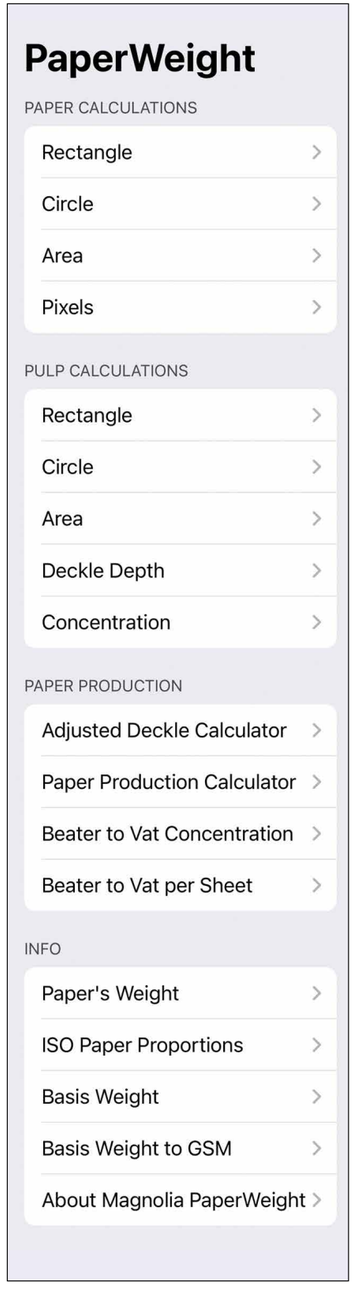


The Formula: (used in the *PaperWeight* app)
To find the grammage (g/m²) of a rectangular sheet (long-hand), we can use this formula:

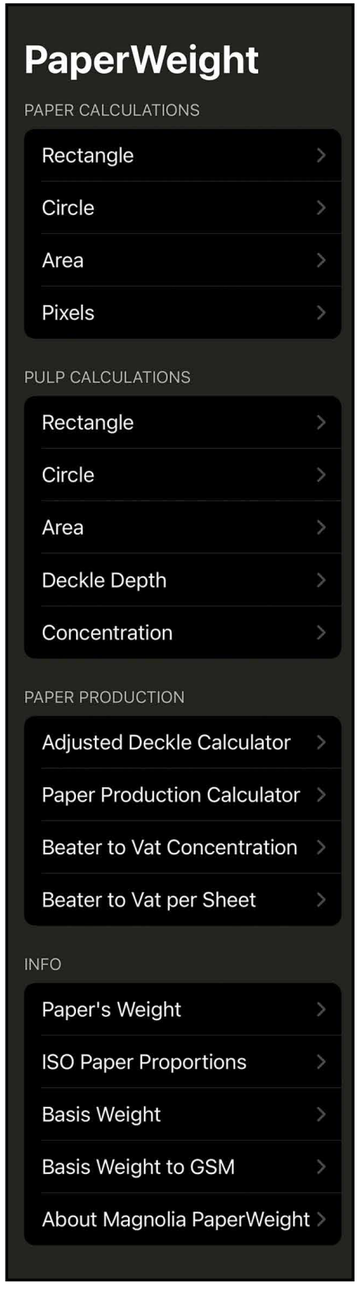
(mass (g) x 10,000) ÷ sq cm = g/m²

To calculate the weight (grammage, density) in the metric system, we theoretically enlarge the sheet to one square meter without changing other variables (such as density and moisture content), then determine its weight in those dimensions.

In the example illustration above notice the weight (mass) of one square meter of paper is 120g, and how any fragment of that paper retains the same density of 120g/m².

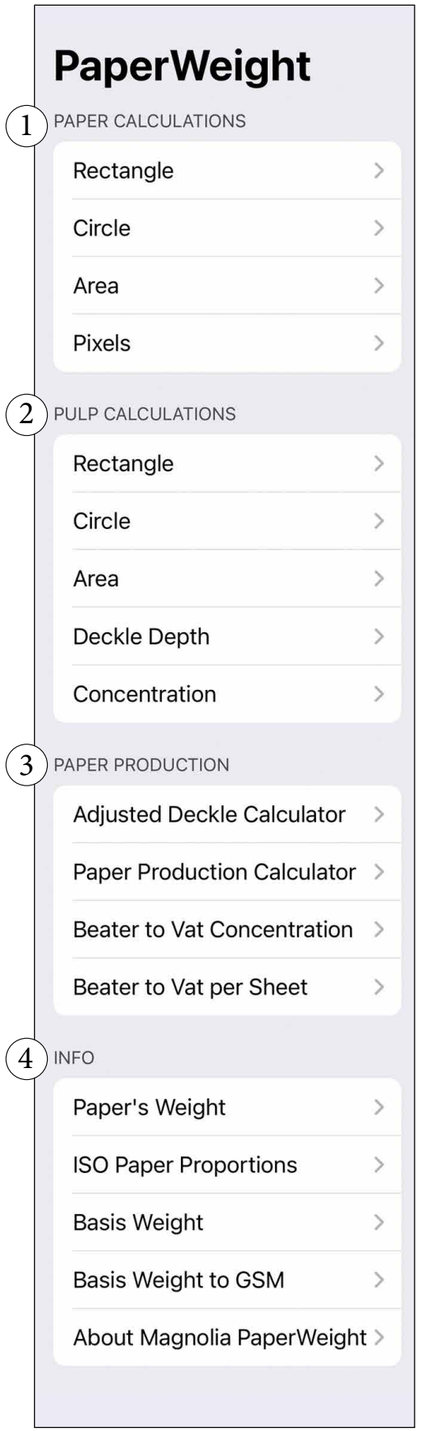


Light Mode



Dark Mode

PapertWeight **Menus** – divided into four sections:



1. Paper Calculations: Calculate a paper's density expressed as grams per square meter (g/m²) for:

- ***Rectangular*** paper
- ***Circular*** paper
- ***Pixel*** count in Photoshop for irregular and torn sheets.

2. Pulp Calculation: Determine the amount of dry fiber needed to make a sheet of specific density (g/m²) and dimensions:

- ***Rectangular*** sheet
- ***Circular*** sheet
- ***Surface area***
- ***Deckle Depth*:** Here you can find the concentration of pulp (g/L) required to make a paper of a specified density (g/m²) by entering the height of a paper mould's deckle. This is ideal for a deckle box papermakeing setup.
- ***Concentration*:** (g/L): Enter the mass of dry fiber in any amout of water to find the concentration in grams per liter.

3. Paper Production:

- ***Adjusted Deckle Calculator:*** computes the Volume of furnish used per sheet formed at a vat and provides a conceptual (adjusted) deckle height corresponding to the volume of liquid passing through the mould when a sheet is formed.

- ***Paper Production Calculator:*** computes various aspects of producing a specified number of sheets of a specific density and dimensions,.

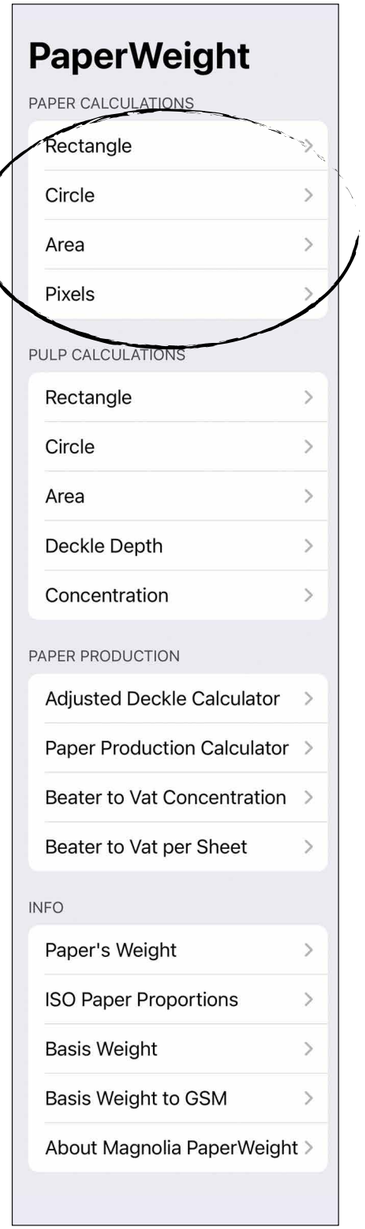
- ***Beater to Vat Concentration***: Calculate the optimum amount of additional water (±) needed to arrive at a concentration perfect for a specific paper density.

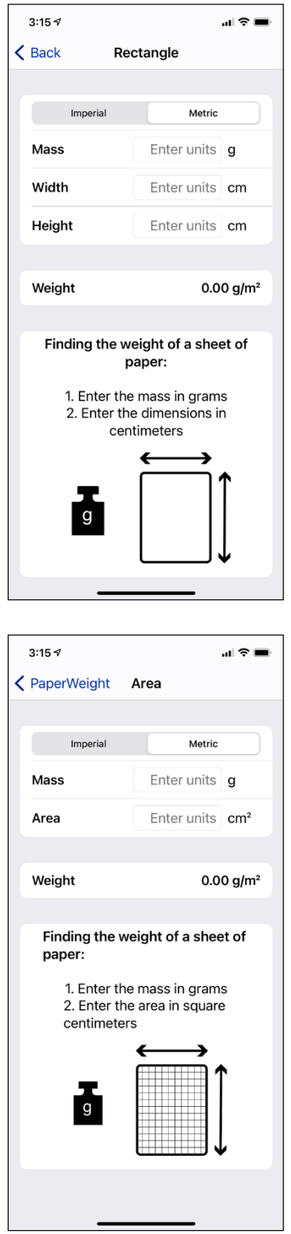
- ***Beater to Vat per Sheet***: This menu item calculates the volume of beaten pulp to be added to the vat after each sheet is formed.

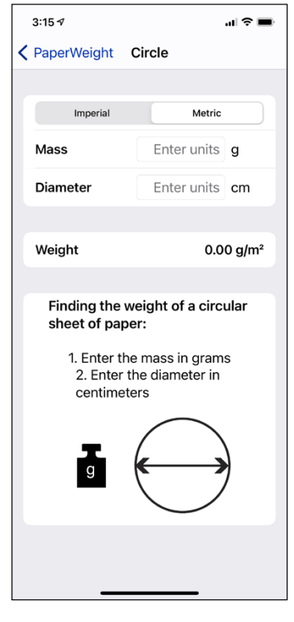
4. Info:

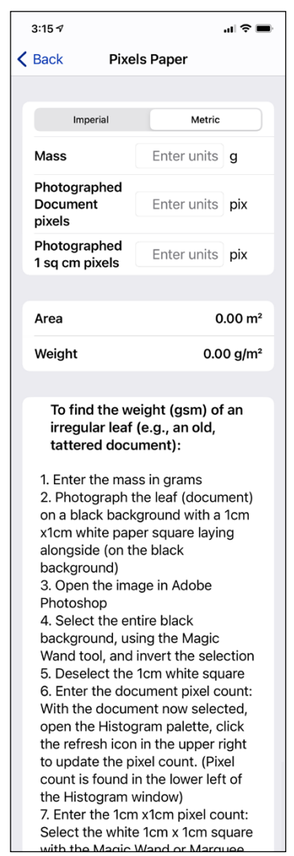
- ***Paper's Weight:*** Description of paper density (g/m²)
- ***ISO (216)*** is an international standard for paper sizes. All ISO paper sizes have the same aspect ratio, √2:1.
- ***Basis Weight*** Description
- ***Basis Weight to Grams per Square Meter*** (g/m²)
- **About *Magnolia PaperWeight***

Paper Calculations Menu group:

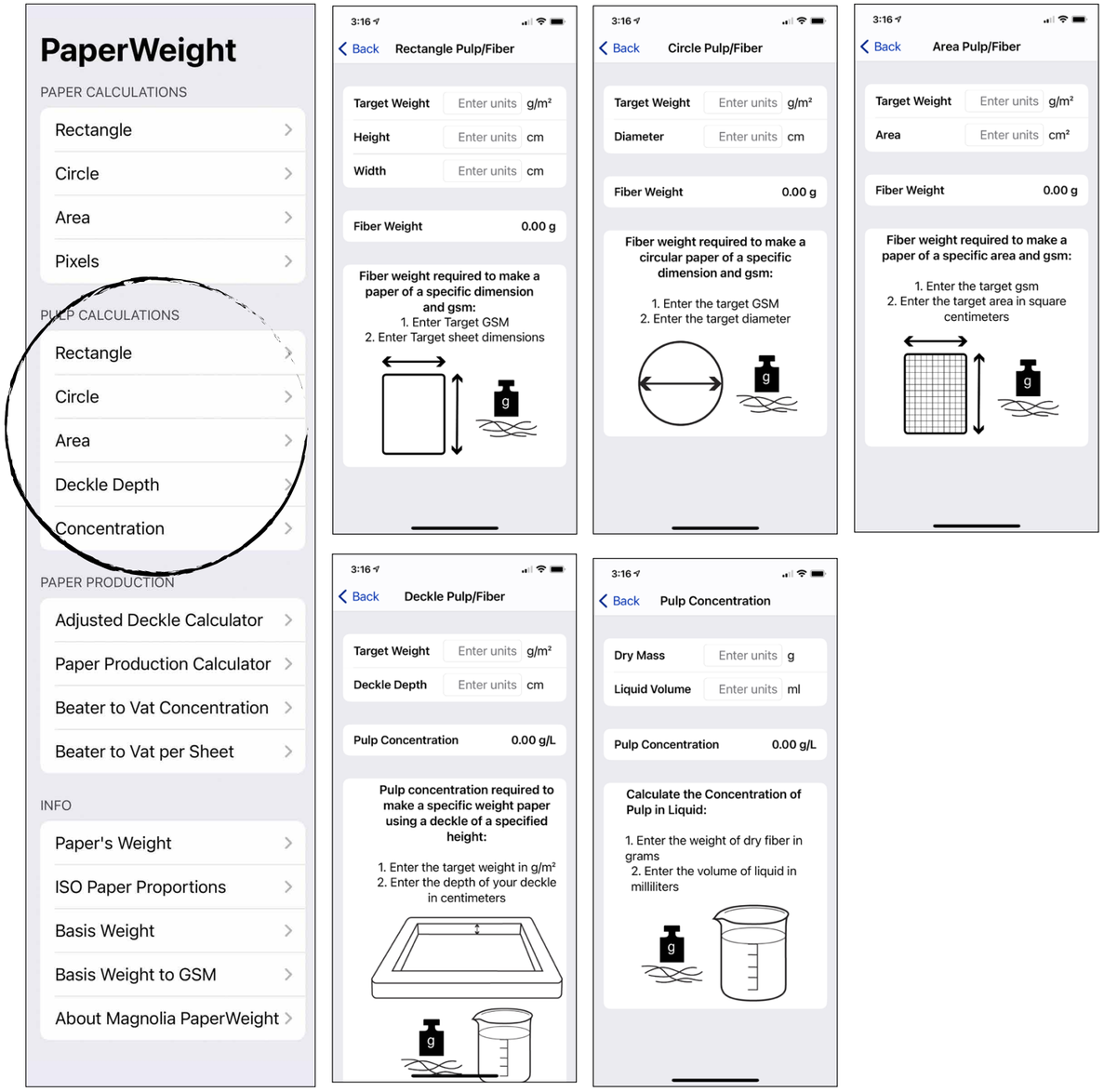






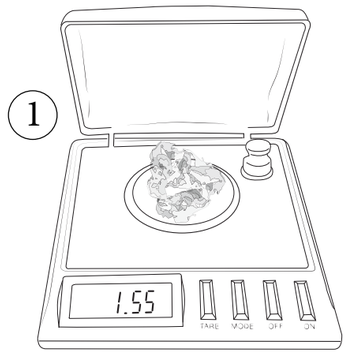


Pulp Calculations Menu group:

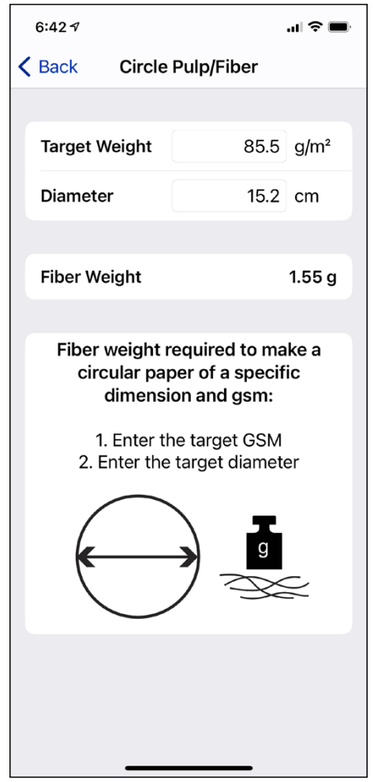


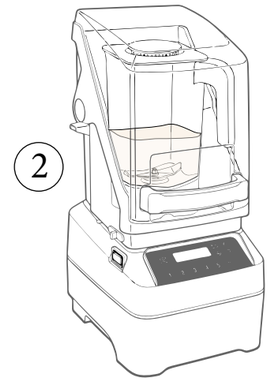
Knowing the dry weight of fiber per sheet, (round, circular or odd shaped), for a specific grammage is perfect for leaf casting, deckle box and pouring a sheet. For paper made at the vat, see the *Paper Production Calculator* menu.

Using the ***Circle Pulp/Fiber*** menu in the ***Pulp Calculations*** menu group
Step-by-step



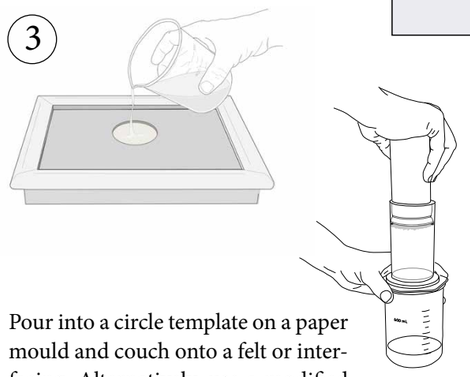
Select & weigh fiber: Use the *Paper-Weight* app to calculate the weight of fiber needed for a specific g/m² paper.



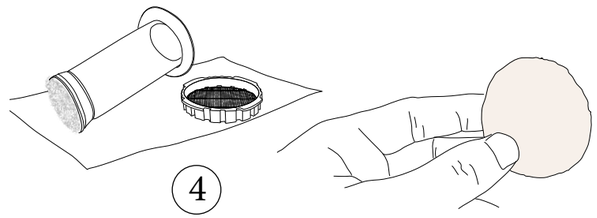


Soak the fibers for an hour (or more) before blending to increase the tear and tensile strength.

After a good soak, blend until fibers are separated and add any furnish additives (pigment, retention aid, formation aid, buffering agents, etc.), at which point, mix very gently.



Pour into a circle template on a paper mould and couch onto a felt or interfacing. Alternatively, use a modified Arrow coffee press (with a screen instead of a coffee filter), pour in your furnish, insert (a felt tipped) Plunger into Cylinder, and press slowly.

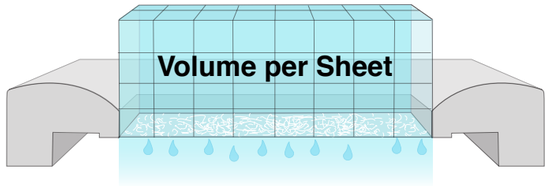


Blot and/or hot-press dry. The circular sheet will most likely be very close to your target g/m², in this example weighing 1.5g. Slightly more g/m² in high humidity and less in a dry climate. It's important to use all the furnish in the pour, using the complete weight of dry fiber required in order to achieve your target g/m².

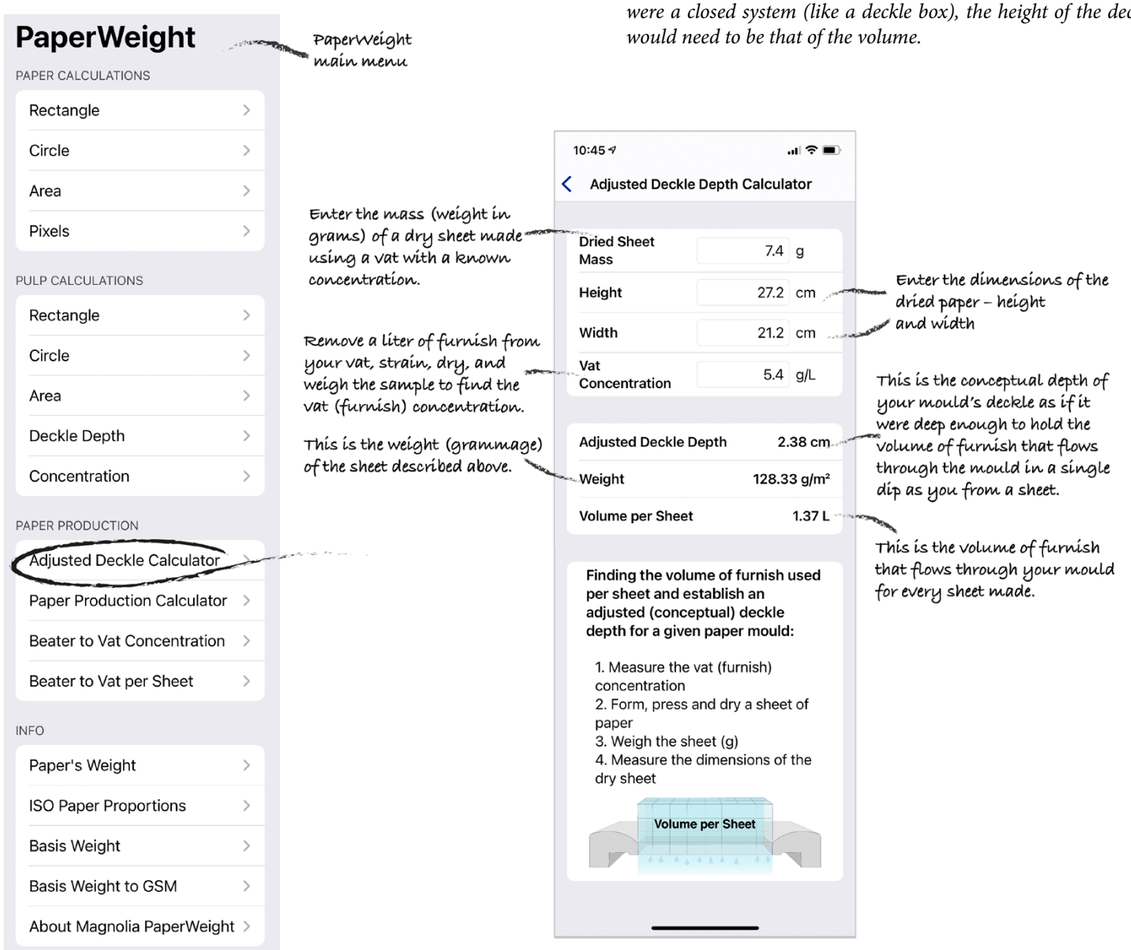
Adjusted Deckle Depth Calculator

The furnish volume required to form a given sheet can be thought of as a cube the fits nicely in the deckle. That cube's height is the conceptual "adjusted" deckle depth, describing the white water volume that passes through the mould when a sheet is formed at a vat. (It also includes the moisture in the sheet filtered out on the mould's screen surface.) Furnish characteristics, especially freeness and concentration, can dramatically affect the volume that will pass through a mould with each sheet formed. Therefore, it is advisable to recalculate *Volume per Sheet* and *Adjusted Deckle Height* for furnishes of different densities and those with longer or shorter processing time.

Knowing the volume and concentration used when forming a sheet in production is key to achieving a target grammage and understanding the quantities of pulp required to replenish the furnish while creating sheets in a production setting. This volume to sheet relationship is also used in Freeness testers and deckle box hand sheets.



The above illustration displays the furnish volume required to make a sheet and depicts a deckle's conceptual depth. i.e., if this were a closed system (like a deckle box), the height of the deckle would need to be that of the volume.

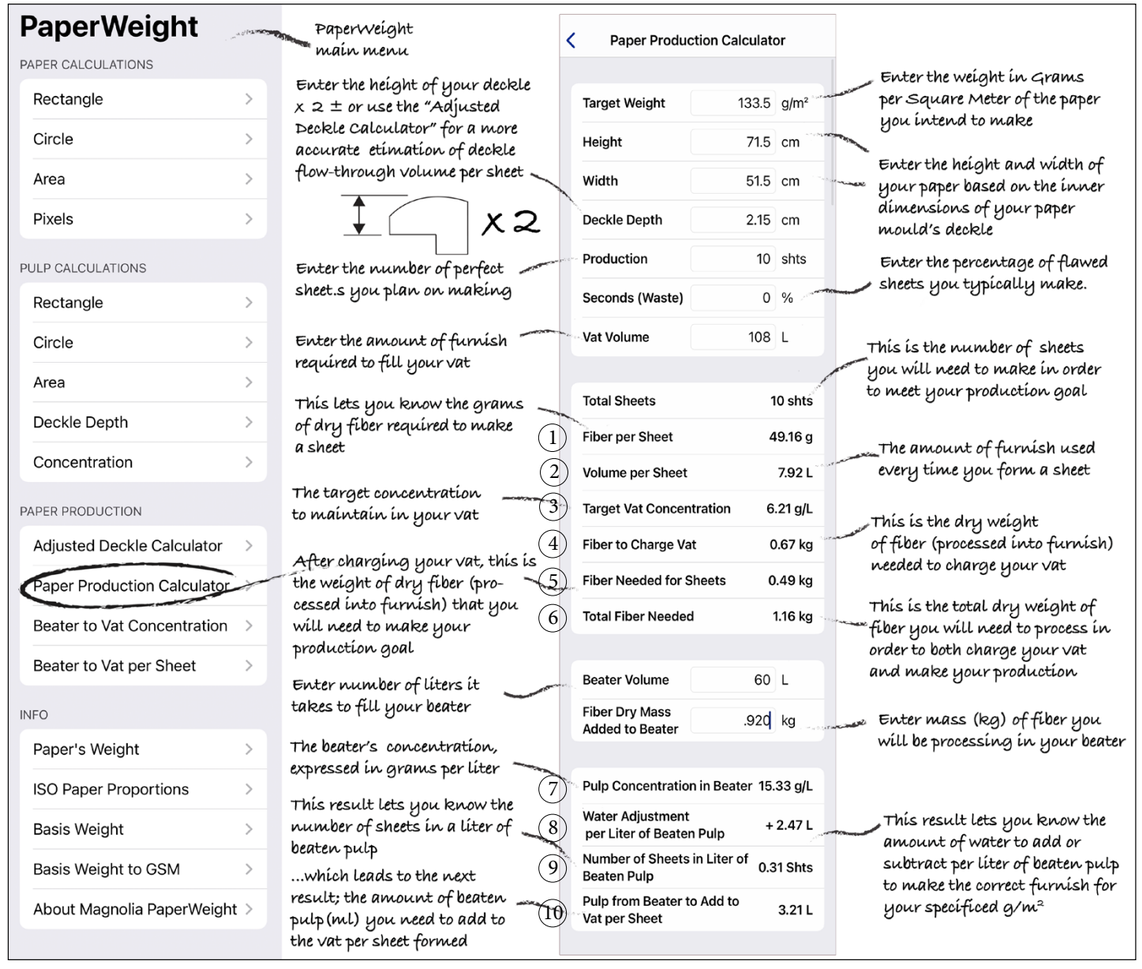


The Paper Production Calculator

The *Paper Production Calculator* computes various aspects of producing a specified number of sheets of a specific density and dimensions, for practitioners of traditional handmade paper making:

Data entry: (what you enter)
- Target weight (grammage)
- The dimension of your mould including deckle depth
- How many sheets in the production run.
- Your vat and beater volumes.
- The dry weight of fiber in each beater load

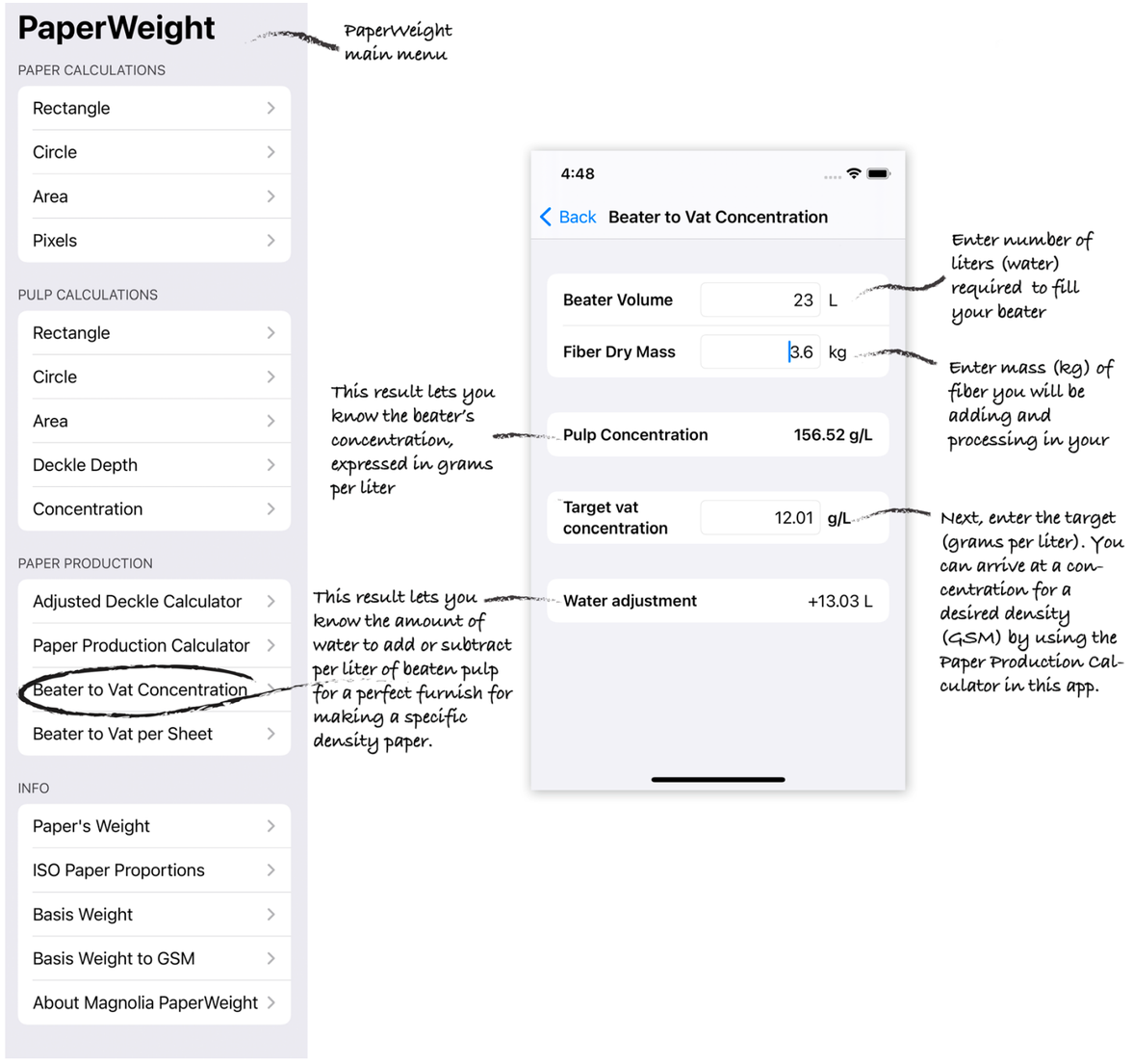
Results:
1. **The weight of dry fiber required for each sheet.**
2. The amount of furnish necessary for each sheet.
3. The weight of fiber needed to charge your vat.
4. The concentration in the vat to maintain to form sheets of your specified g/m² and dimensions.
5. The weight of dry fiber required to charge your vat.
6. **The total weight of dry fiber necessary** for this user-defined production run.
7. The pulp concentration in your beater.
8. The water adjustment to make per liter of beaten pulp to make your furnish the correct concentration to achieve a paper of your target weight.
9. the number of sheets in a liter of beaten pulp.
10. If you want to add pulp directly from beater to vat as you make each sheet this identifies **the quantity you should add to maintain vat concentration**.



The Beater to Vat Concentration Calculator

There are essential factors to consider when processing fiber in a Hollander beater; one key variable is pulp concentration (fiber to water ratios in the beater). A lower fiber ratio to water allows for more cutting action in the beater, while a higher fiber concentration produces more hydration and fibrillation. Therefore, concentrations vary depending on the desired characteristics of the finished paper.

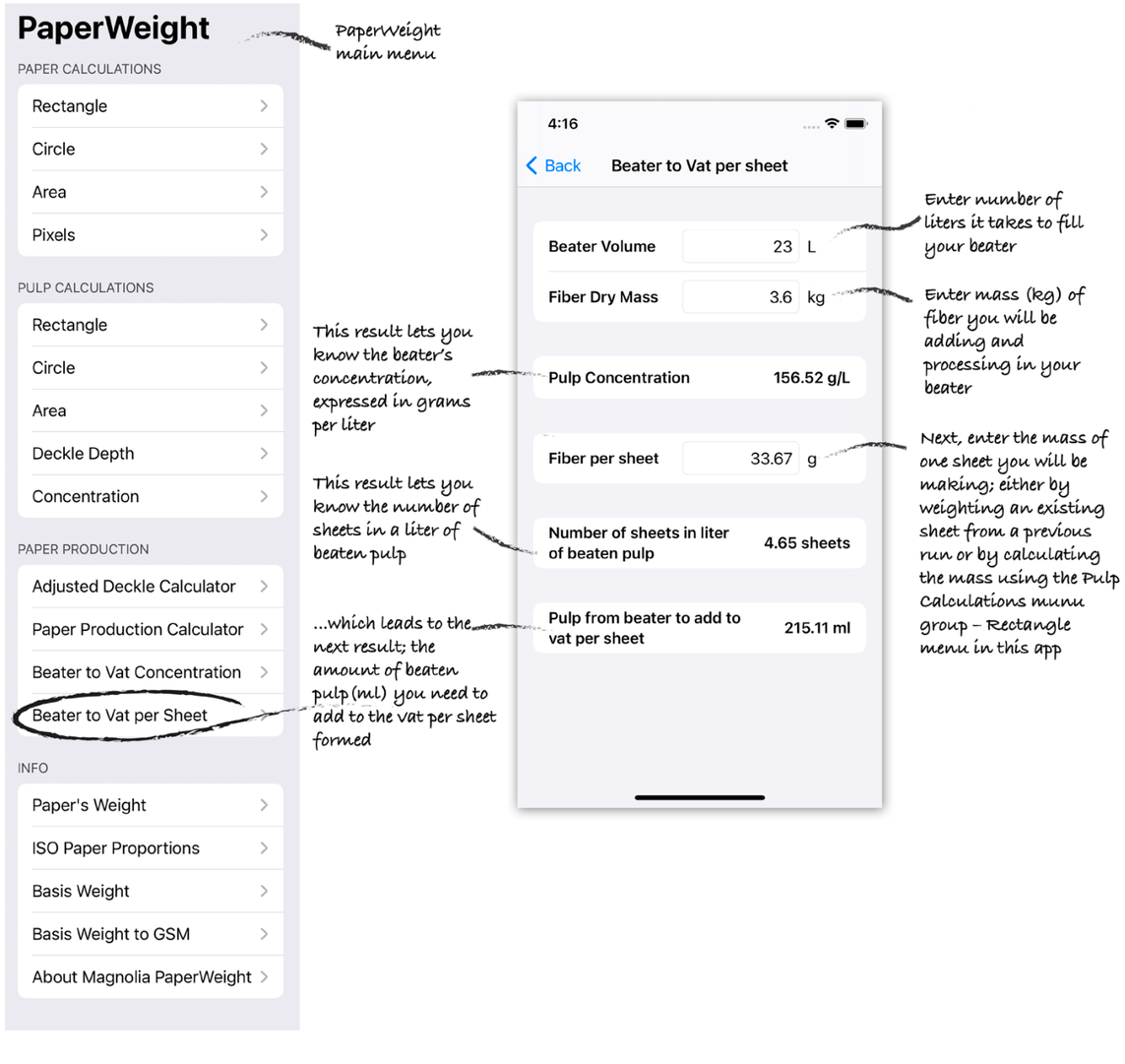
Typically a beater load of beaten pulp is not considered "furnish" ready for papermaking; typically, water, fillers, and chemicals are most often added to achieve a viable furnish. Using *Beater to Vat Concentration*, you can find the optimum amount of additional water needed to arrive at a concentration perfect for a specific paper density. Determining the optimum Target vat concentration can be calculated in the Paper Production Calculator, included in *Magnolia PaperWeight*. This data is also available in the *Paper Production Calculator*, but here it is as a stand-alone



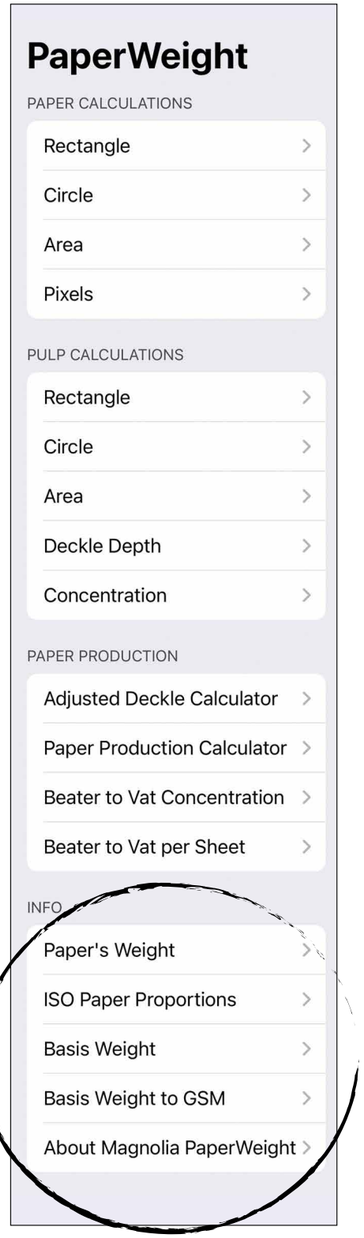
Beater to Vat per Sheet

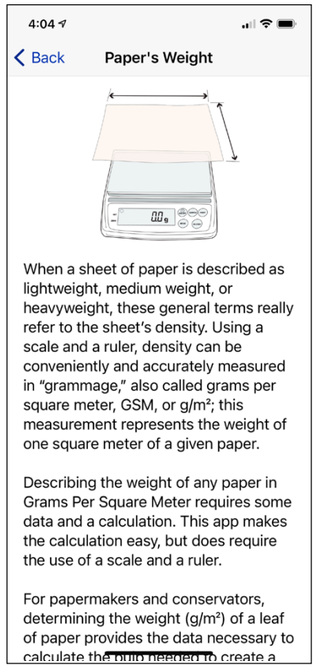
(pulp from beater necessary to replenish vat after a sheet is made made)

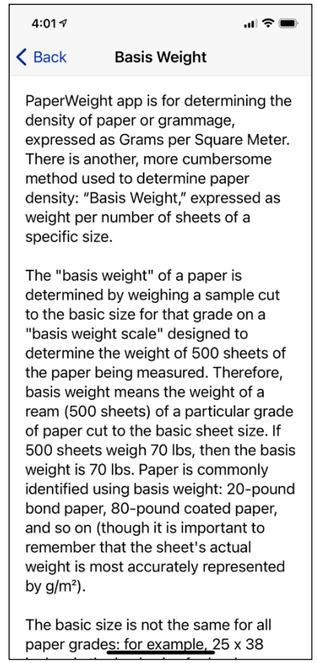
The elements in the ***Beater to Vat per Sheet*** menu can also be found as part of ***Paper Production Calculator***. The *Beater to Vat per Sheet* calculator helps determine the volume of beaten pulp to be added to the vat after each sheet is formed. Start by imputing your beater's water volume and the dry weight of fiber you will be processing (kg) to discover your beater's pulp concentration (g/L). You will need to enter the mass (g) of a target sheet in the Fiber per sheet field which can be calculated using the menu *Pulp Calculations – Rectangle*.

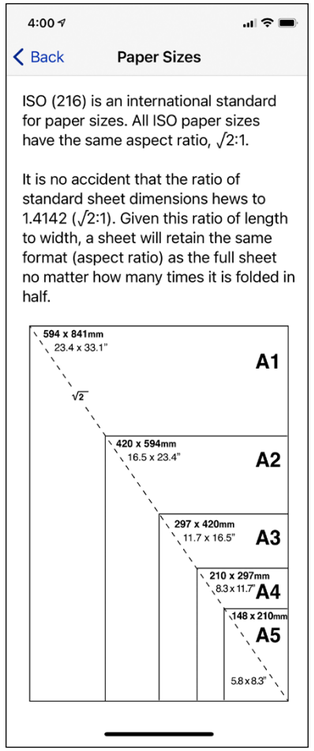


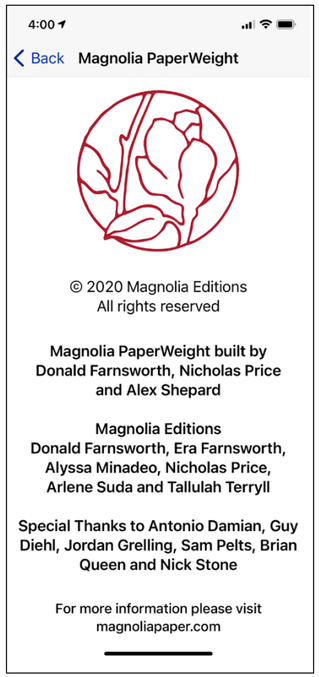
Info Menus











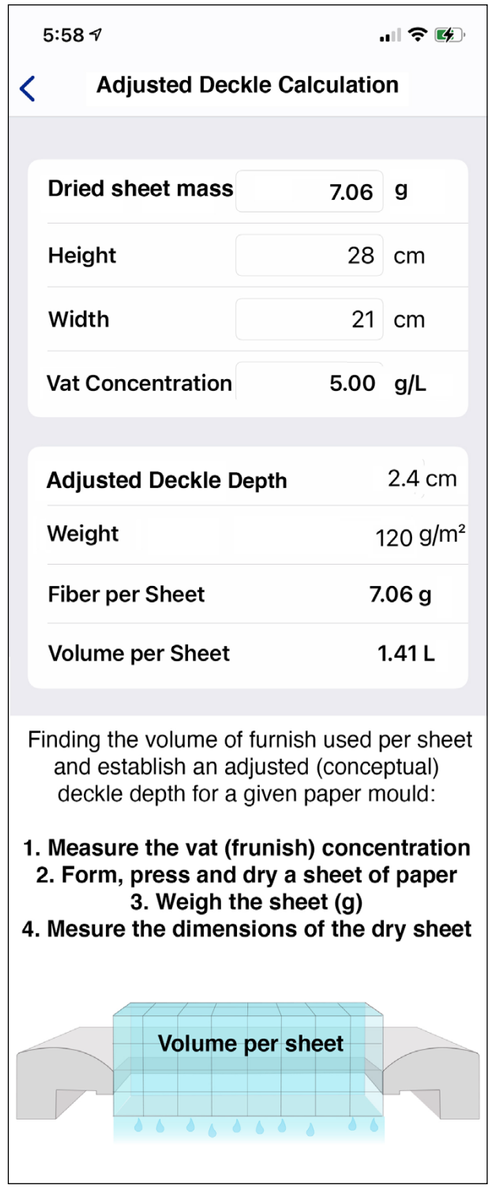
A test production run of 40 sheets

If you pour a quantity furnish containing a know amount of dry fiber into a mould and deckle, the fiber trapped on the screen forms a sheet of know weight and dimension (and therefore grammage). Whereas, if you form a sheet at a vat of known concentration you can only know the grammage, the amount of dry fiber you are removing, if you have previously determined the volume passing through and trapped by your mould and deckle.

Thanks to Nicholas Price and Alex Sheppard, our ace programmers, I have a beta version of the *PaperWeight* App with the newly added *Adjusted Deckle Calculation* and *Paper Production Calculator*. These tools (calculators) can help us find these volumes. Let's put these two menu items to the test and make a production run of paper. Is it beneficial and easy to use? Is it accurate?

I am confident the app will help with consistency and simplify the analytical approach to a production paper run. Still, nothing worthwhile is easy. Now we must make test sheets, measure volumes, concentrations, and check the grammage. There are many variables to contend with when the goal is the making of consistent sheets.

Key variables that influence g/m2 repeatability:
- Freeness
- Beater and vat (furnish) concentrations
- Vat furnish temperature
- Paper mould's screen porosity
- Deckle depth
- The vatman's skill



For this first test of the beta software, I will use the app to guide me while making 40 sheets of 8½ x 11 inch, 16th-century style rag paper, with a target weight of 120 g/m². That is to say, laid sheets couched on coarse handmade felts, air dried, made from Spanish flax half stuff, and animal-sized.

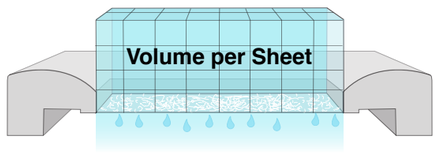
To key-in the data it is necessary for me to measure my deckle, find the Valley Iron Works beater volume and the volume at which I normally fill my small tub vat – easy enough.

- Deckle: 8.5 x 11.25 x 0.4 inches (28 x 21 x 1.2cm)
- Valley Iron Works Beater: 5 gal (18.9 liters)
- Small vat volume: 6.6 gals (360 L)

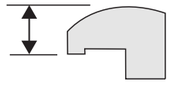
I entered the numbers above into the *Paper Production Calculator*. The app's answers describe the task ahead. I must process 0.44kg (1 lb) of dry fiber, of which 0.12kg (¼ lbs) will be used to charge the vat.

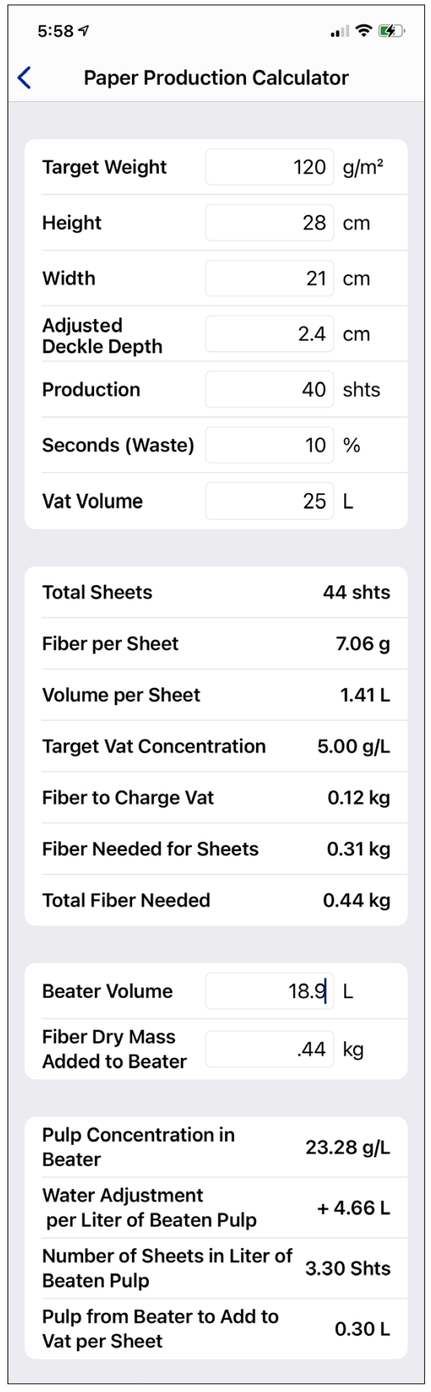
There is a relationship between the *deckle depth* and the volume of water that passes through the mould when sheet forming at a vat. Since the water flows through the mould as we dip, the volume is a moving target. In my verification tests on the following pages, I am finding that dipping and pulling up through the furnish use about 2x the deckle's volume.

On this day, I happened to have another vat with a 5g/L concentration (220CSF linen and hemp), so I formed a sheet using the same small mould we will be using in this test. Perfect results: the dry sheet's weight and vat concentration only agreed if I doubled the deckle's physical depth .



Using the ***Adjusted Deckle Depth Calculator*** in the app, I entered the *vat concentration* (5g/L), and sheet dimensions to make a 7g sheet (120 g/m²) in one normal dip. The result was approximately 2 x the deckle height. And now I know the furnish volume per sheet.





Actual

116 g/sm²

6.5 g

4.5 g/L

22 g/L

0.30L
= 6.5 g
target 7.06g

Following the *Water Adjustment* recommendation:

For every liter of pulp I transfered from the beater to the vat I added 4.66 liters of water, it this way, filling my vat to the 25 liter mark (the *Vat Volume*).

At this point, before forming any sheets and because I am verifying the app, I take a concentration measurement of the vat.

Next, I would like to know the volume of pulp I am removing for every sheet formed; So, I couch into a tray and weight the result - 192g. (7g of which is fiber) So, looks like I am leaving about 1.2L of water in the vat with each sheet I form (minus the water the drips on the floor outside the vat). Since I will be adding 0.30L of pulp per sheet formed that works out pretty well to the specifications in the app.

Volume per sheet	= 1.41 Liters
Couched volume	– 0.19
Drained outside vat	– 0.11
Water remaining in vat	= 1.11
Pulp added per sheet	+ 0.30
	= 1.41 Liters

This works out very nicely, assuming I drain 110ml of water outside the vat as I make a sheet, and replenish with .30L of pulp from beater, (as per the instructions from the app) the vat concentration remains the same.

Time to make 44 sheets, adding 0.30L (300ml) of beaten pulp per sheet.

From left to right top to bottom: Beating, Testing Freeness, taking sample from vat, Pouring sample into Arrow Press, Paper Puck at tip of Arrow Press after pressing, The paper puck, Drying puck on inverted iron, weighing puck.

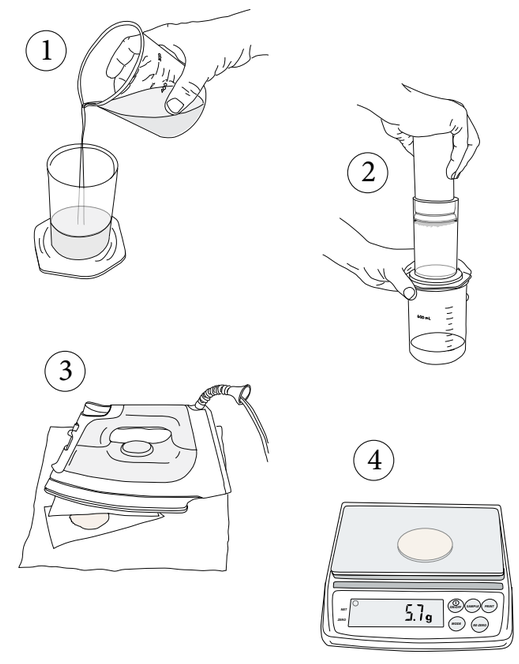
Verifying furnish concentration and furnish-per-sheet-formed volume

When making a sheet of a desired g/m², it is good to verify the concentration of furnish in the vat. After following the output provided by *PaperWeight /Paper Production Calculator* we can double check the preditions.

Find the grams of dry fiber per liter in your vat:

• Stir the vat well.
• Remove 1 liter of furnish, strain and blot.
• Dry, the strained and blotted furnish (Oven, hotplate, iron or air-dry.)
• Allow dried furnish to acclimatize then weigh.
The result is the mass of dry fiber in one liter of furnish residing in your vat (g/L).

Removing a smaller amount is more convenient and less wasteful.
1. Scoop out 250ml of furnish.
2. Pour into an Arrow (coffee) Press (with substituted screen for a filter).
3. Allow the furnish drain, then insert plunger (with felt tip) and press firmly.
4. Dry and weigh the puck. Multiply the Arrow Press results by 4 to find the grams per liter (g/L).



Because Western-style papermaking dips a paper mould once per sheet, scooping out furnish onto the mould surface, it is not difficult to find the quantity of furnish used per sheet. Knowing the volume of furnish-per-sheet-formed can prove to be valuable data:

Volume of furnish-per-sheet-formed

• From a vat of furnish with a known concentration (i.e., the above test), stir well and form a sheet using your standard style and technique.
• Couch and dry the sheet.
•Weigh the paper sheet. Note the result.

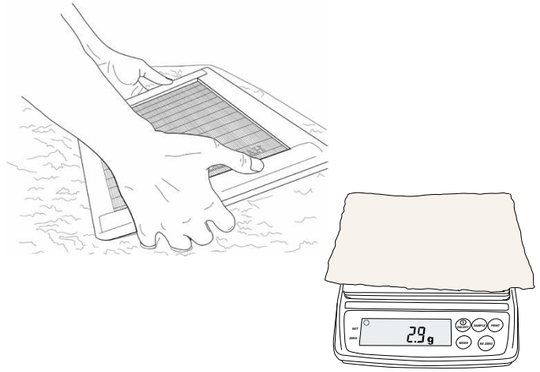
To find the volume per sheet:
Divide the mass of the dry paper by the grams per liter from the above test.

• Compare the results to the predictions in *PaperWeight/ Paper Production Calculator.*

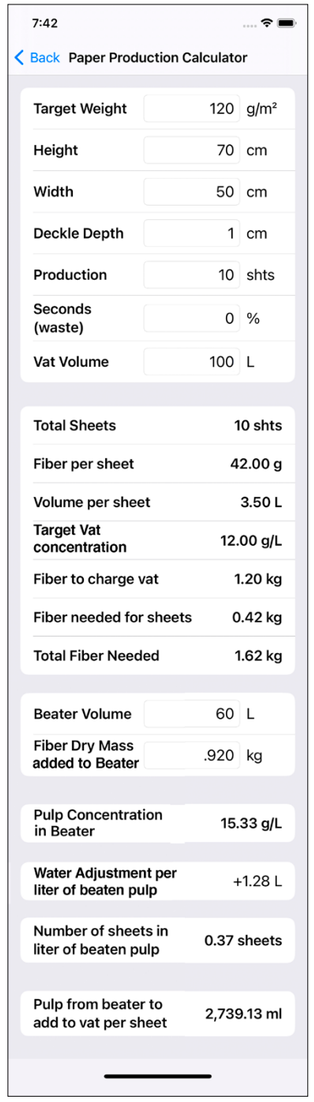
Another data point of interest is the volume of water used and water left behind in the vat after forming a sheet.

Volume of water used when forming per sheet formed

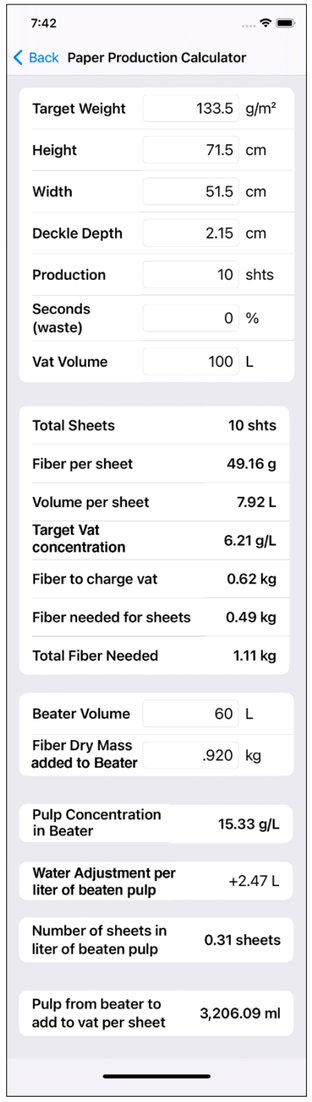
• Place a felt and plastic sheet (or a plastic tray) on a scale and press the tear button to zero out the scale.
• Form a sheet from a vat of known concentration. Couch the sheet on the felt and plastic (or into the plastic tray).
• Carefully place the plastic, felt (or tray) and wet paper onto the scale to find the weight of fiber and volume of water used per sheet.



Projected parameters
working premise



Actual empirical result
Note adjusted deckle depth



Using empirical data:

Rather than taking my input numbers for granted (my working premise data entered), I followed the guidelines on the previous page and measured the volumes, dimensions and mass of the various elements of production papermaking. I started a new *Paper Production Calculator* and entered these very real numbers. Since *Target Vat concentration* is not user entered, I adjusted the *Deckle Depth* until my *vat concentration* and grammage numbers agreed with reality.

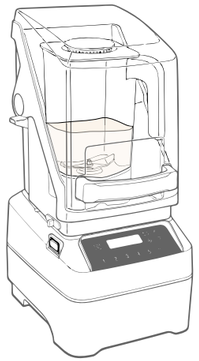
Actual Grammage = 133.5 g/m²
Actual deckle dimensions: 73 x 52 x 1.1cm = 4.18L
Felt constrained dried paper: 71.5cm x 51.5cm
Air dried paper dimensions: 70cm x 50cm
Actual dried paper mass 49.2 grams
Deckle depth adjusted = 2.15

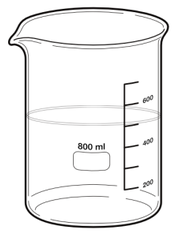
1cm deckle x 2 ±

Vat concentration measurement = 6.2g/L
Freeness of furnish measurement = 220CSF
Couched paper volume measurement = 1 liter
Approximate water draining back into vat: 6-7 liters

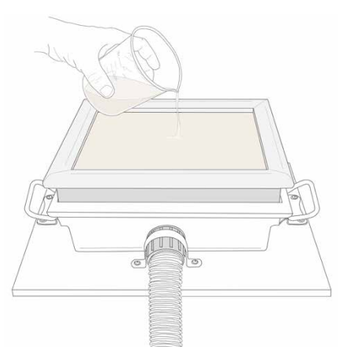
What this real-life example describes:
The volume of water draining from the furnish flowing through the mould covering (laid screen) during sheet formation is double that of the deckle volume. Deckle volume being: length x width x (height x 2)

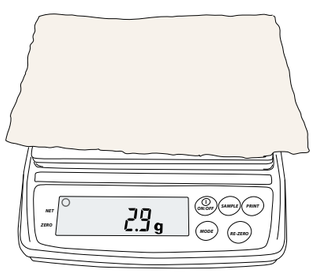
This production was done using a furnish with a freeness of 220CSF.

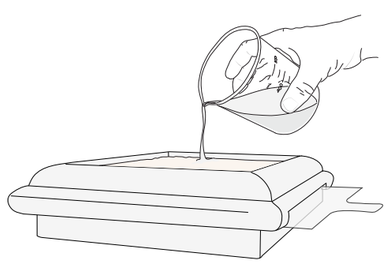




*The **Magnolia PaperWeight*** app for iPhones and iPads is available for free from the Apple App Store, thanks to the programming efforts of Nicholas Price and Alex Shepard







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