Jan 5th, 2024: Idea 3
Flaming PJ Madness

Research question: **Does the amount of times you wash a fire resistant fabric affect how safe it is during fire?**

Notes

- the amount of time a strip is washed
- Test: how flammable a strip is, or how much time it takes to burn
- Set up: 5 strips (control, 1 wash, 5 washes, 10 washes, 20 washes)
- Count how many times you wash the strips and label them
- See how long it takes for the fire to spread through the strips once they are lighter

Materials : Fire resistant fabric (100% polyester), soap, water, lighter, hangers,tongs, (fire extinguisher), bins, water temperature thermometer

Hypotheses:

I think that the more we wash the piece of fabric, the more flammable it will be. This is because if we wash the fabric multiple times, the fire resistant chemicals will be washing off from the washer and dryer causing it to be less flame resistant. I think the chemicals wash off in the water because they are dissolving and they come off the fabric. So if we wash the fabric more, it will have more scorch area.

It is important to research about this topic because other people would use that when buying pajamas. They would look if the pajamas would stop getting fire resistant, the more we wash it. It is also important to research if the pajamas could cause harm to health because of the flame resistant chemicals.

Variables

Manipulated variable: The amount of times a sample is washed

Responding variable: What percentage of sample is scorched after burning, time taken to burn the sample

Controlled variables: The washing procedure (same temperature of 55 degrees Celsius, same time for washing and drying same detergent for all washes), all samples were burned at the right bottom corner until they caught flame

Procedure :

1. Remove the shirt from one PJ and label it with 0 washes.
2. Hand-wash all fabric with soap and warm water
    a. Measure out one load of laundry soap

    b. Add water to the bucket using bath, boiled and kettle water until temperature hits 55 degrees Celsius
    c. Add soap to bucket and let stand for one minute
    d. Add all clothing to the bucket and let stand for 10 minutes
    e. Use tongs to make sure clothing is fully in the water
3. Transfer soapy clothes using tongs to another bucket with hot tap water filled up to rinse off soap. Swirl it around with tongs (2 minutes of rinsing)
4. Rinse one more time under running hot water and set aside to cool.
5. Wait for clothing to cool down and wring out the clothing to remove as much excess water as possible
6. Dry in dryer for 40 minutes under timed settings and high heat
7. Hang until fully dry
8. Repeat washes at another time using the same procedure until all clothing has been washed the number of times needed
9. Take pictures and record observations
10. Cut fabric into 10 smaller portions for each group using a stencil roughly same size
11. Put them on a hanger above a bowl of water (for safety) and light each on fire until it burns. Recorded the start and stop time for each.
12. Repeat steps 10-11 for 5 pieces of fabric in each group (0, 1, 5, 10 and 20 washes)
13. Put the other 5 aside in case you need extra
14. Calculate how long each piece burned
15. Calculate the mean of each group (may have to remove outliers)
16. To calculate the scorch area, trace each burned piece and turn the scorch into a triangle
17. Record the dimensions of the scorch
18. Calculate the area of scorch (estimate using estimated dimensions)
19. Calculate how much fabric is left not including scorch
20. Repeat steps 16-19 for all 5 pieces of fabric in each group
21.

Dates of washes:
Jan 27 am (1 wash)
——————— remove the one wash item
Jan 28 am (1 wash)
Jan 28 pm (1 wash)
Jan 29 pm (1 wash)
Jan 30 pm (1 wash)
———————- remove the five wash item
Jan 31 pm (1 wash)
Feb 1 pm (1 wash)
Feb 2 pm (1 wash)
Feb 3 pm (1 wash)
Feb 4 pm (1 wash)
——————— remove the 10 wash item

Feb 5 pm (1 wash)
Feb 6 pm (1 wash)
Feb 7 pm (1 wash)
Feb 8 pm (1 wash)
Feb 9 pm (1 wash)
Feb 10 pm (1 wash)
Feb 11 pm (1 wash)
Feb 12 pm (1 wash)
Feb 13 pm (1 wash)
Feb 14 pm (1 wash)
————————————- remove the 20 wash item

Testing of material with fire: February 15
-See tables below

Research

Jan 7th
Fabrics that have been treated with flame retardants are usually certified for one year or for 50 washes. If you wash them in your washing machine like any other fabrics the chemicals weaken over time, which is a good argument for talking about the safety of these fabrics.

Trained professionals worry that flame retardants have chemicals that can lead to cancer, neurotoxicity and hormone disruption (hormones are disrupted from doing their task)

Laundry water washes off flame retardants and it can go into the lakes and rivers (laundry is the main source of the retardants in the water) and affect animals and fish in the water

People may be exposed directly to the flame retardants by the chemicals directly on their clothes.

Child sleepwear regulations

In 1972, for five years, rules were in place that required children's Pajamas to be flame resistant.

They used Brominated tris but then it was replaced with chlorinated tris, because children were exposed to carcinogens in their sleep through exposure in the skin.

Carcinogens are chemicals that may cause cancer.

Chlorinated tris was also bad because it was found to affect DNA.

Until 1996, natural fibres were only considered flame resistant if they were treated with flame retardants. Rules changed to allow tight fitting pajamas since they are less likely to catch fire than baggy clothing.

In Canada and the US, require pjs for children 9 months old to 14 years old must meet flammability requirements or tight fitting.

Canada laws: There should be a label on loose fitting pjs that state flame retardant with instructions with cleaning procedures.

We should not use fabric softener because it separates the fibres which makes them soft, but then it takes away the fire retardants.

January 13th

There is a common misconception that polyester is flame resistant because its plastic, unlike other fabric material polyester, doesn't burn, it melts without fire retardants.

-since polyester Melts instead of burns while its on someone's body and melts on it that would be super painful to feel and a painful surgery to get

The United States pjs with flame retardant added must be done on manufacture then fabric after 50 washes, however, in Canada after 20. This means that washing fire resistant fabric is not an effective solution to reducing exposure to fire resistants.

Of note, in the US, flammability tests on products with flame retardants added must be done on fabric after manufacture and after 50 washes, in Canada after 20 washes. Which means that washing treated PJs isn't an effective solution to reducing exposure to flame retardants.

January 19th

Loose fitting sleepwear is more likely to catch on fire than tight fitting sleepwear.

If your child wears loose fitting sleepwear make sure it is made of slower burning fabrics. Cotton-blend and rayon fabrics tend to catch fire and burn more quickly than most synthetic materials. Nylon and polyester do not catch fire as easily as cotton does and they tend to burn more slowly.

Government of Canada testing requirements: an average char length for 5 specimens that does not exceed 178 mm; and not more than one specimen with a char length equal to the full length of the specimen.

Loose-fitting sleepwear — other tests

Loose-fitting sleepwear that is treated with a flame retardant, any component that is extracted or broken down from such treated sleepwear and any flame retardant that is used to treat the sleepwear must not cause any of the following consequences:

- acute lethality as a result of oral exposure to a dose of 500 mg/kg body weight or less or as a result of dermal exposure to a dose of 1000 mg/kg body weight or less when tested

for acute oral toxicity or acute dermal toxicity in accordance with section 1 or 2, as the case may be, of Schedule 2;

- an effect graded at a mean greater than 1 for erythema formation or for edema formation measured at any specified time when tested for dermal irritation in accordance with section 3 of Schedule 2;
- when tested for dermal sensitisation in accordance with section 4 of Schedule 2, a response in greater than 15% of the test animals when using the Draize Test or the Buehler Test or in greater than 30% of the test animals when using one of the five other tests, in which an adjuvant is incorporated, that are specified in the OECD Test No. 406 that is referred to in that section;
- gene mutation or chromosomal aberration when tested for mutagenicity in accordance with section 5 of Schedule 2; or
- tumors when tested for tumorigenicity in accordance with section 6 of Schedule 2.

Labeling

Loose-fitting sleepwear that is treated with a flame retardant must have a label that is permanently affixed to it that displays in a clear and legible manner.

instructions in English and in French for the care of the sleepwear, particularly cleaning procedures, to ensure that it is not exposed to agents or treatments that could reduce its flame resistance.

Washing, drying and drycleaning

Loose-fitting sleepwear that is treated with a flame retardant must be subjected to 20 successive washing cycles in accordance with the procedure set out in section 3, followed by one drying cycle in accordance with the procedure set out in section 4.

The apparatus and washing procedure set out in sections 4.1 and 6, respectively, of Method 58, the National Standard of Canada CAN2-4.2-M77, Colour Fastness and Dimensional Change in Domestic Laundering of Textiles, published by CGSB in December 1984, must be used, with the following modifications:

The temperature of the wash water must be maintained between 58°C and 62°C; or 52 to 62 (different websites)

The hardness of the wash water must be less than 50 ppm of calcium carbonate;

for automatic washing machines, the washing cycle must be set for normal washing cycle;

A synthetic detergent that conforms to CGSB standard 2-GP-115M, Standard for Detergent, Laundry, Powder, Built, dated January 1979, must be used; and

A bleaching agent containing sodium hypochlorite that produces 0.015% of available chlorine when it is added to the washing solution must be used.

Old Procedure - too many mistakes

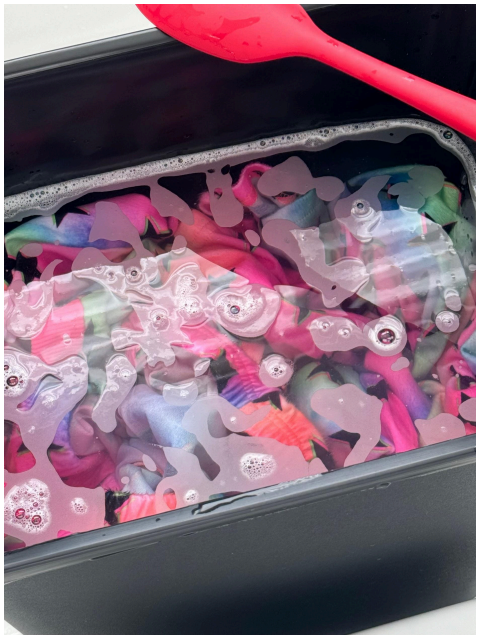
1. Count how many times you wash them. (Don't wash 3 – control)
2. Handwash 3 strips with laundry soap and warm water once
3. wash 3 strips 5 times
4. Wash 3 strips 10 times
5. Wash 3 strips 20 times
6. Use a hair dryer to dry strips between washes.
7. Make a clothesline A with a strip of each sample (no washes, 1 wash, 5 washes, 10 washes and 20 washes - 5 strips) so people can see the fabric degrading in quality – this clothesline can go on the trifold.
8. Cut up 15 pieces of fabric roughly the same size
9. (At home) line up the strips on a non-flammable surface and set them on fire one at a time. Let the samples burn for 45 seconds each before putting them out.
10. Let strips cool down and make clothesline B (shows the scorch marks that correspond to how many times a strip sample has been washed) – this goes below clothesline A on the trifold.

Jan 27 - Observations
We bought a thermometer to maintain the temperature of the water to be between 52°C and 62°C.

Bathtub water was 44 degrees Celsius, so we had to use a kettle and boiling water on a stove to get the water hotter (55 Celsius).

Photo 1. Washing tools (bins, soap, hangers and PJs)

<u>Photo 2</u>: PJs were hand washed - used kettle water, boiled water and tap water to bring the temperature up to 55 degree celsius

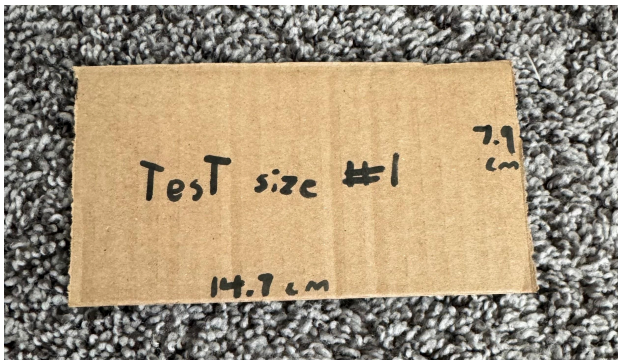


Feb 10 Observations

Practice Lighting on Fire

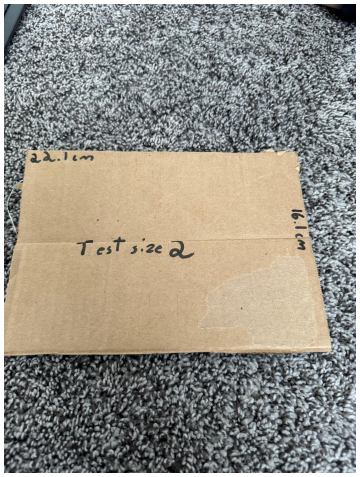
Test size 1:

- The fabric did not catch fire
- not big enough
- got bit dangerous so we extinguished it in a bowl of water
- Held fire for too long



Test size 2:

- The fabric size good
- still put too much fire
- another trial - put fabric on a hanger to light on fire above a water bowl, and we lit it on fire at the corner of the strip. Once it lights on fire, we remove the flame and stop the timer. We will measure how much area of the fabric is burnt.



When doing the experiment, we will hold lighter until it starts burning. Have to be careful with lighting fire on corners and holding fire until it ignites. Then stopping the timer when it stops having a flame.

Observations

- We had to test different sizes of fabric before finding the right one for burning.
- There were a few outliers that we accidentally burned more than others.
- It seemed if the fabric was washed more, it burns more
- A few signs that show chemical change are difference in color, difference in smell and difference in temperature.

Table 1: Table recording the time taken to start and top burning on the fabric with 0 washes
**Did not catch on fire well and had to redo it. So more burned than what we expected*

0 washes	Time taken to start burning	Time taken to stop burning	Burn time (seconds)
Trial 1	00:02.65	00:14.60	00:11.95 (outlier)
Trial 2	00:01.95	00:23.65	00:21.07 (outlier *)
Trial 3	00:02.71	00:06.06	00:03.35
Trial 4	00:01.90	00:04.38	00:02.48
Trial 5	00:01:66	00:03.96	00:02.30
Mean burn time (seconds)	8.23 average (including outliers) 2.71 average (removing outliers)		

Diagram 1: Pictures of Trial 1 to Trial 5 with 0 washes

Table 2: Table recording the time taken to start and top burning on the fabric with 1 wash

1 wash	Time taken to start	Time taken to stop	Burn time (seconds)

	burning	burning	
Trial 1	00:03.06	00:04.72	00:01.66
Trial 2	00:8.13	00:08.52	00:00.39 (outlier)
Trial 3	00:02.16	00:04.25	00:02.09
Trial 4	00:02.15	00:03.38	00:01.23
Trial 5	00:01.90	00:03.93	00:02.03
Mean burn time (seconds)	1.48 average (with outliers) 1.75 average (removing outliers)		

Diagram 2: Pictures of Trial 1 to Trial 5 with 1 washes

Table 3: Table recording the time taken to start and top burning on the fabric with 5 washes

5 washes	Time taken to start burning	Time taken to stop burning	Burn time (seconds)
Trial 1	00:02.06	00:03.18	00.01.12
Trial 2	00:01.91	00:04.70	00.02.79
Trial 3	00:02.25	00:03.56	00.01.31
Trial 4	00:01.56	00:02.53	00.00.97
Trial 5	00:03.50	00:09.52	00.06.02 (outlier)

Mean burn time (seconds)	2.44 average (with outliers) 1.55 average (removing outliers)

Diagram 3: Pictures of Trial 1 to Trial 5 with 5 washes

Table 4: Table recording the time taken to start and top burning on the fabric with 10 washes

10 washes	Time taken to start burning	Time taken to stop burning	Burn time (seconds)
Trial 1	00:06.33	00:07.71	00.01.38
Trial 2	00:02.75	00:05.26	00.02.15
Trial 3	00:06.41	00:06.81	00.00.40
Trial 4	00:01.21	00:04.51	00.02.94
Trial 5	00:05.60	00:06.21	00.00.61
Mean burn time (seconds)	1.50 average		

Diagram 4: Pictures of Trial 1 to Trial 5 with 10 washes

Table 5: Table recording the time taken to start and top burning on the fabric with 20 washes

20 washes	Time taken to start burning	Time taken to stop burning	Burn time (seconds)
Trial 1	00:05.36	00:09.81	00.04.45
Trial 2	00:06.30	00:7.77	00.01.47
Trial 3	00:04.15	00:5.63	00.01.48
Trial 4	00:06.41	00:06.88	00.00.47
Trial 5	00:03.05	00:21.67	00.18.62 (outlier)
Mean burn time (seconds)	5.30 average (with outliers) 1.97 average (removing outliers)		

Diagram 5: Pictures of Trial 1 to Trial 5 with 20 washes

Table 6: Approximate scorch area of fabrics using triangles with average scorch area for each wash

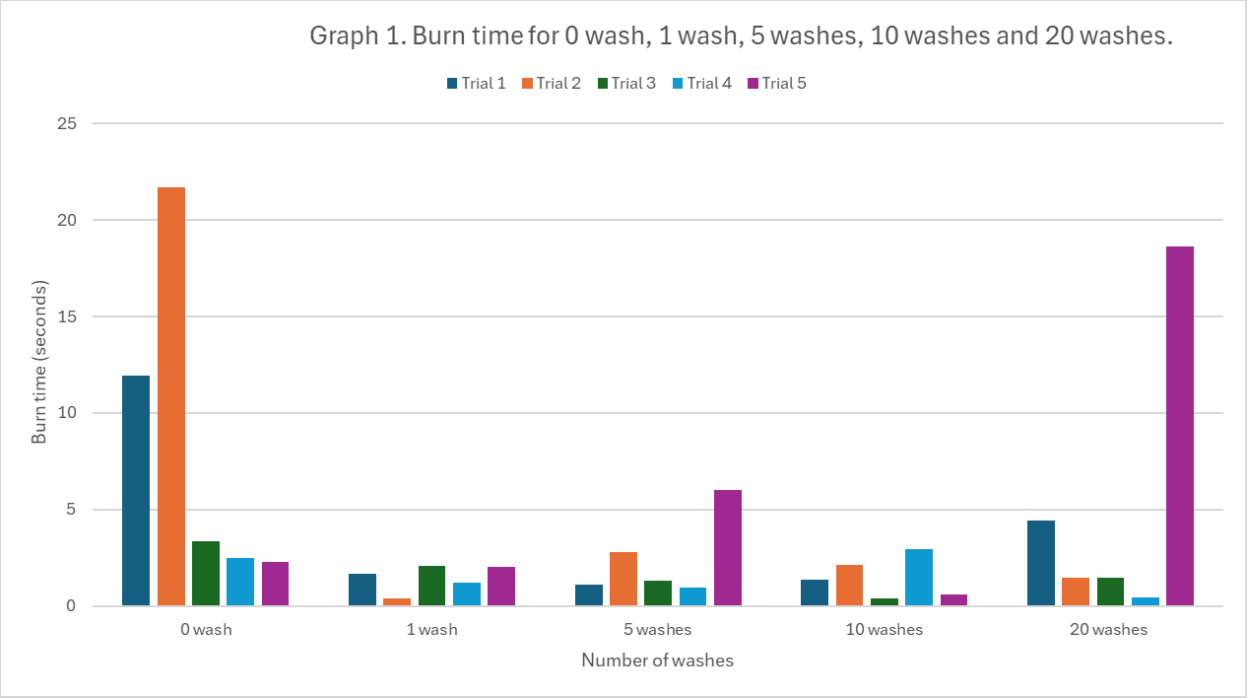
Approx	0 wash	1 wash	5 wash	10 wash	20 wash

Scorch Area Using Triangles					
Control	0 cm^2	0 cm^2	0 cm^2	0 cm^2	0 cm^2
Tral 1	13.75 cm^2	4.8 cm^2	8.2 cm^2	30.195 cm^2	21.8 cm^2
Trial 2	96.875 cm^2 Outlier	11.05 cm^2	6 cm^2	9.9 cm^2	9.5 cm^2
Trial 3	4.56 cm^2	16.2 cm^2	5.5 cm^2	8.845 cm^2	4.2 cm^2
Trial 4	17.235 cm^2	5.95 cm^2	4.875 cm^2	7.215 cm^2	9.5 cm^2
Trial 5	3.74 cm^2	10.725 cm^2	6.48 cm^2	4.48 cm^2	22.525 cm^2
Average scorch area	27.232 cm^2 (with outlier) 9.82 cm^2 (without outlier)	9.745 cm^2	6.211 cm^2	12.127 cm^2	13.505 cm^2

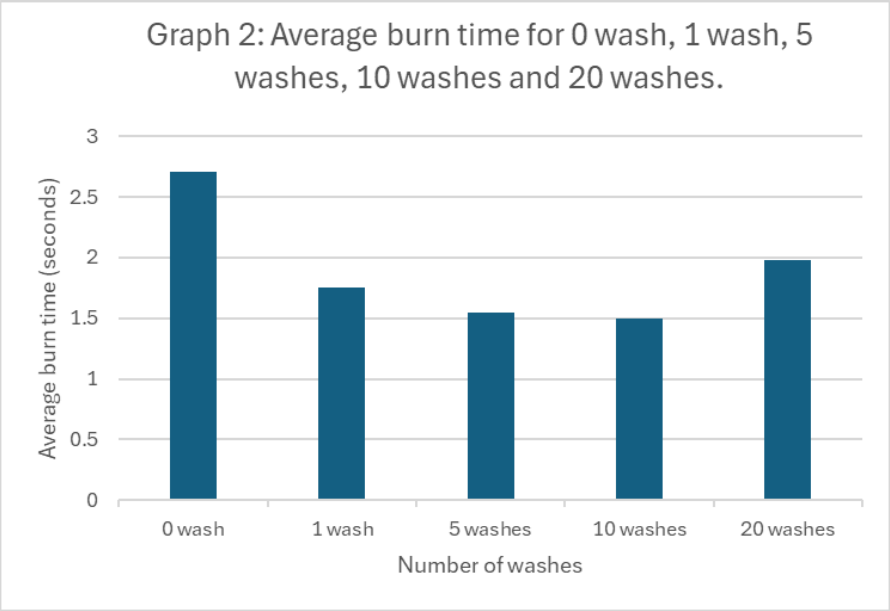
Table 7: Approximate area of fabric left over after burning with average area of fabric leftover for each wash

Approx Area of Fabric Left over	0 wash	1 wash	5 wash	10 wash	20 wash
Control	355.81 cm^2	355.81 cm^2	355.81 cm^2	355.81 cm^2	355.81 cm^2
Tral 1	348.935 cm^2	351.01 cm^2	347.61 cm^2	325.615 cm^2	334.01 cm^2
Trial 2	258.935 cm^2	344.76 cm^2	349.81 cm^2	345.91 cm^2	346.31 cm^2
Trial 3	351.25 cm^2	339.61 cm^2	350.31 cm^2	346.965 cm^2	351.61 cm^2
Trial 4	338.485 cm^2	349.86 cm^2	351.025 cm^2	348.595 cm^2	346.31 cm^2
Trial 5	352.07 cm^2	345.085 cm^2	349.33 cm^2	351.33 cm^2	333.285 cm^2
Average area	329.935 cm^2	346.065 cm^2	349.617 cm^2	343.683 cm^2	342.305 cm^2

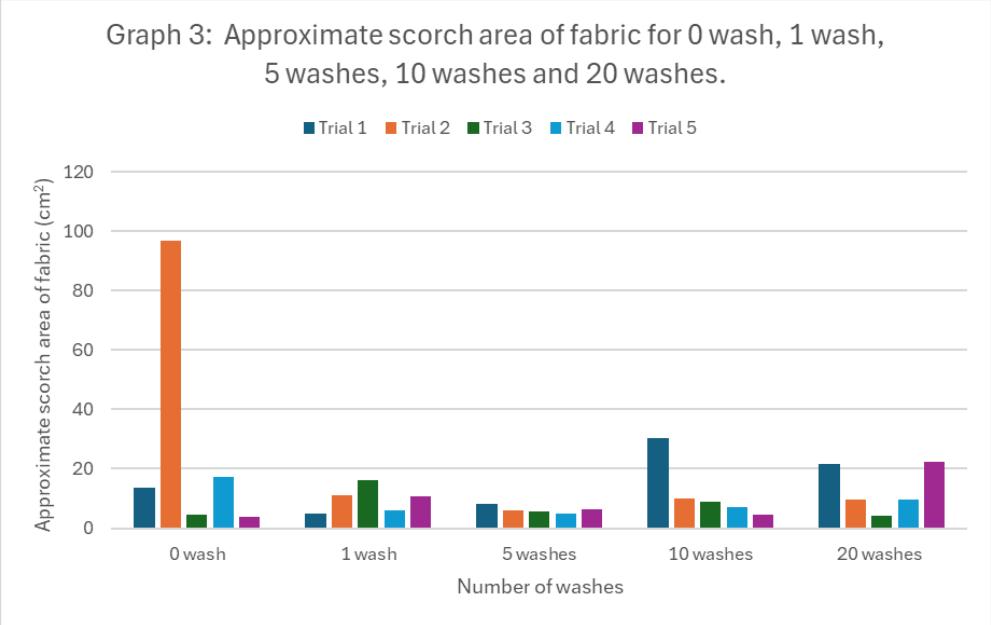
of fabric leftover					



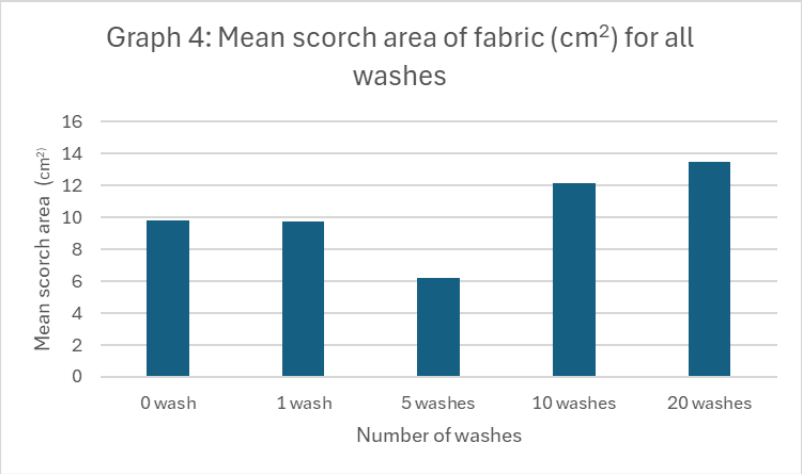
- The trend increases and decreases
- The 5 wash (trial 5) had the highest burn time (without outliers)
- The 10 wash (trial 3) had the lowest burn time
- Outliers: I notice that 0 wash (trial 2 and 1) and 20 wash (trial 5) are outliers because the burn time is too high compared to the other values



- The trend for average burn time seems to be decreasing until it gets to the 20 wash
- 0 wash had the highest burn time
- 10 wash had the lowest burn time
- I notice that if you look at the bars you see a stretched out U shape because the bars go high-low- high just like the letter 'U'.



- The trend mostly is a mix between increasing and decreasing
- Biggest scorch area was 10 wash (trial 1) (without outlier)
- 20 wash (trial 3) had the lowest scorch area
- The 0 wash (trial 2) sticks out because it is so huge



- The general pattern was lowest to highest but 5 washes does not fit the pattern.
- General pattern: As the number of washes increases, the mean scorch area tends to rise as well
- 20 washes had the highest mean scorch area
- The lowest mean scorch area was 5 washes
- Bar for 5 washes looks like it doesn't fit because it's too small

Sources of Error:

- During the washes some pajamas may have had excess soap than others. This might affect the results because there could be more chemicals reacting in one pair than in another and make it an unfair experiment. We could have changed our washing procedure to remove this error by using a washing machine. In the washing and drying machine every fabric gets an equal amount of soap.
- It was difficult to use our stencil to cut the pajamas into equal pieces. Sometimes we may have stretched the fabric more than others when we were cutting. This might affect the results because there could be an uneven area of fabric and we will have wrong measurements for the scorch area. We could have resolved this by using a ruler to measure and a marker to mark how we are going to cut the fabric. We label the dimensions then cut along the guidelines.
- It was difficult to burn them evenly because the fabric was crinkling up at the corner and it was hard to see if there was a flame already started or not. This is a source of error because we may have recorded the time wrong. We could have stopped this by holding and keeping the fabric straight by using an object such as a clothespin.
- It was also difficult to watch the time and watch the flame at the same time and be accurate with the timer. We know this happened because there were outliers in the data. We might be able to reduce this by having a third person - 1 for the timer, 1 to light the flame, and 1 to record when it started and when it stopped burning.
- We cannot time it exactly because it might be 5-10 milliseconds late. This is a source of error because we might have the wrong burn time measurements. We could fix this by having multiple trials so if 1 fails we have more and we could use the most accurate ones.

Conclusion

When looking at all the trials, the highest scorch area was for the 10 wash fabric (trial 1). In the average scorch area (graph 4) the 20 washes fabric had the highest scorch area because it had the most fire resistant chemicals washed off.

The common flame retardant chemicals are called Organophosphate flame retardants (OPFR) and perfluoroalkyl substances (PFAS). These chemicals have both hydrophobic and hydrophilic structures. Hydrophobic substances are substances that do not mix well with water. Hydrophilic substances that mix well with water.

The OFPRs and PFAs are chemicals that have hydrophilic structures which means that it will mix easier with water. This explains the results of my experiment because the water dissolves the flame resistant chemicals in the PJs. Since the flame resistant chemicals mix with water and come off the pajamas, it would burn more because the chemicals stop the fire and that is what is getting dissolved and washes away in water.

Sodium hydroxide is the main ingredient in the laundry detergent and is also a base. The organophosphates (the flame resistant chemicals) are acids because they have phosphate groups which are acidic. When acids and bases mix they form a new neutral substance through a neutralization reaction which means it is not an acid or a base. When organophosphates and the laundry soap react it neutralizes the organophosphates and the structure of the chemicals change. If the chemical structure of the organophosphates changes, the clothes will burn more when they are washed with soap.

This explains why the 20 wash had the most burn area on average. When we washed the pajamas more, the water mixed with the chemicals and washed it away. When we wash the pajamas with more soap, it combines with the fire resistant chemicals and makes it neutral. The 20 wash fabric now has a smaller amount of fire protective chemicals causing the pjs to burn more.

Applications

I learned that the 20 wash fabric burned more because I washed it more (Graph 3). This affects people wearing flame resistant clothes because they might wash it more and it will become less fire resistant. This is a safety hazard.

Research says that flame retardants like OFPRS and PFAs are not chemically bound to the PJs. They can flush into the external environment and people could consume these chemicals through dust or through hand to mouth contact. This is a problem because we could consume these chemicals and it could be a health hazard.

The flame retardants are a health hazard because trained professionals worry that flame retardants have chemicals that can lead to cancer, neurotoxicity and hormone disruption (hormones are disrupted from doing their task). In 1972, for five years, rules were in place that

required children's pajamas to be flame resistant. They used Brominated tris but then it was replaced with chlorinated tris, because children were exposed to carcinogens in their sleep through exposure in the skin. Chlorinated tris was also bad because it was found to affect DNA. People may be exposed directly to the flame retardants by the chemicals directly on their clothes.

The chemicals are an environmental hazard because laundry water washes off flame retardants and it can go into the lakes and rivers and affect animals and fish in the water. In a study from South Korea, scientists found out that it had a high concentration of flame retardant chemicals

References

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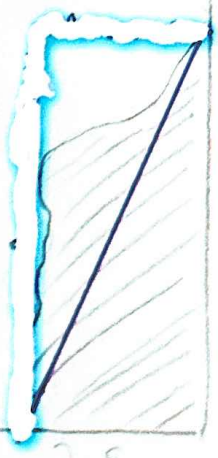
0 wash trial 1

Area of fabric = 355.81 cm^2

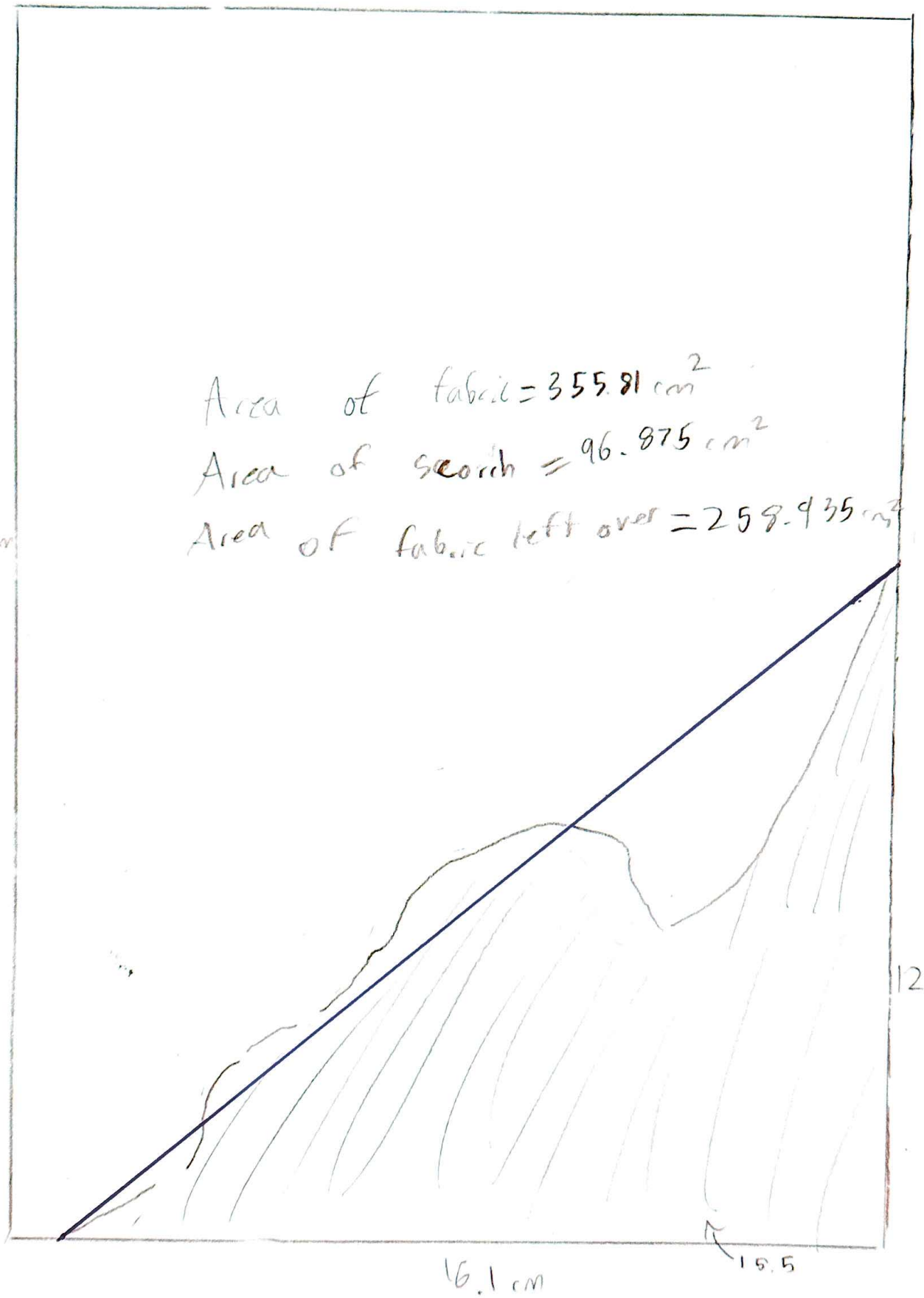
Area of scorch = 6.875 cm^2

Area of fabric leftover = 348.935 cm^2



16.1 cm

0 wash trial 2



Owasi trial 3

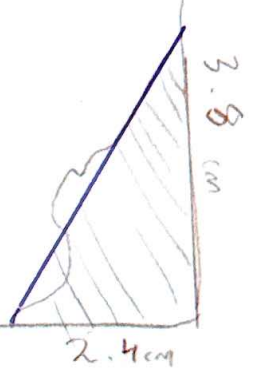
16.1 cm

Area of fabric = 355.91 cm^2

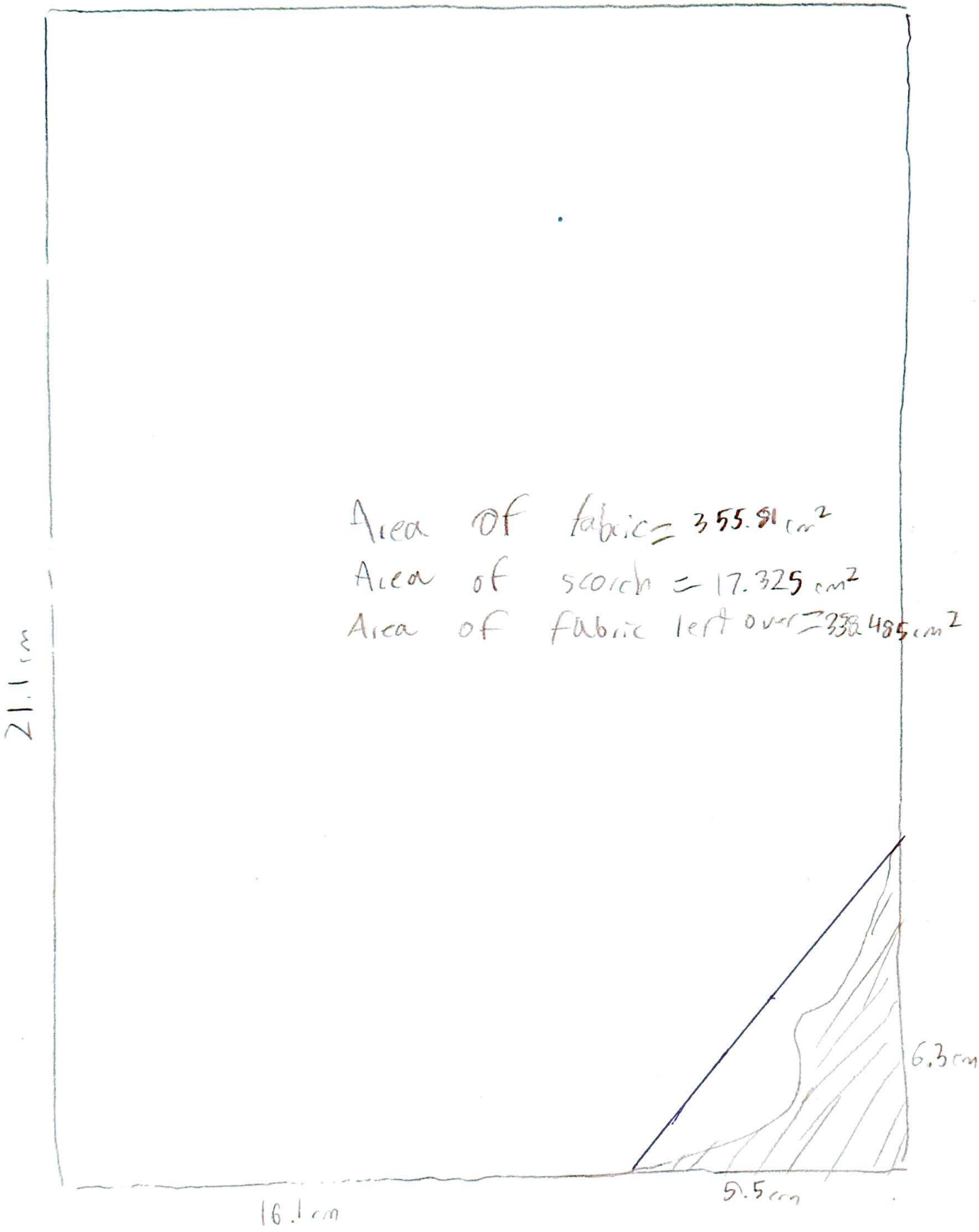
Area of search = 4.56 cm^2

Area of fabric left over = 351.25 cm^2

22.1 cm



0 wash trial 4



0 wash trial 5

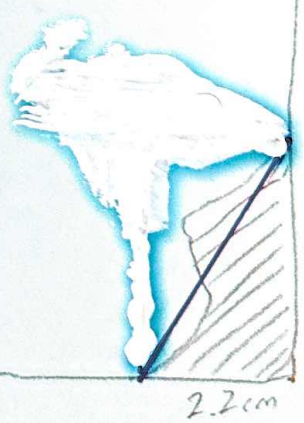
16.1

Area of fabric = 355.81 cm^2

Area of scorch = 3.74 cm^2

area of fabric left over = 352.07 cm^2

21.1



Wash trial 1

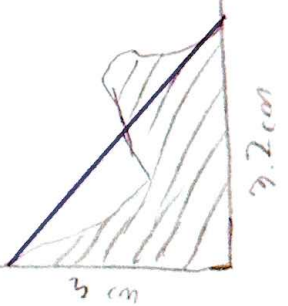
Area of fabric = 355.81 cm^2

Area of scorch = 4.8 cm^2

Area of fabric left over = 351.01 cm^2

21.1 cm

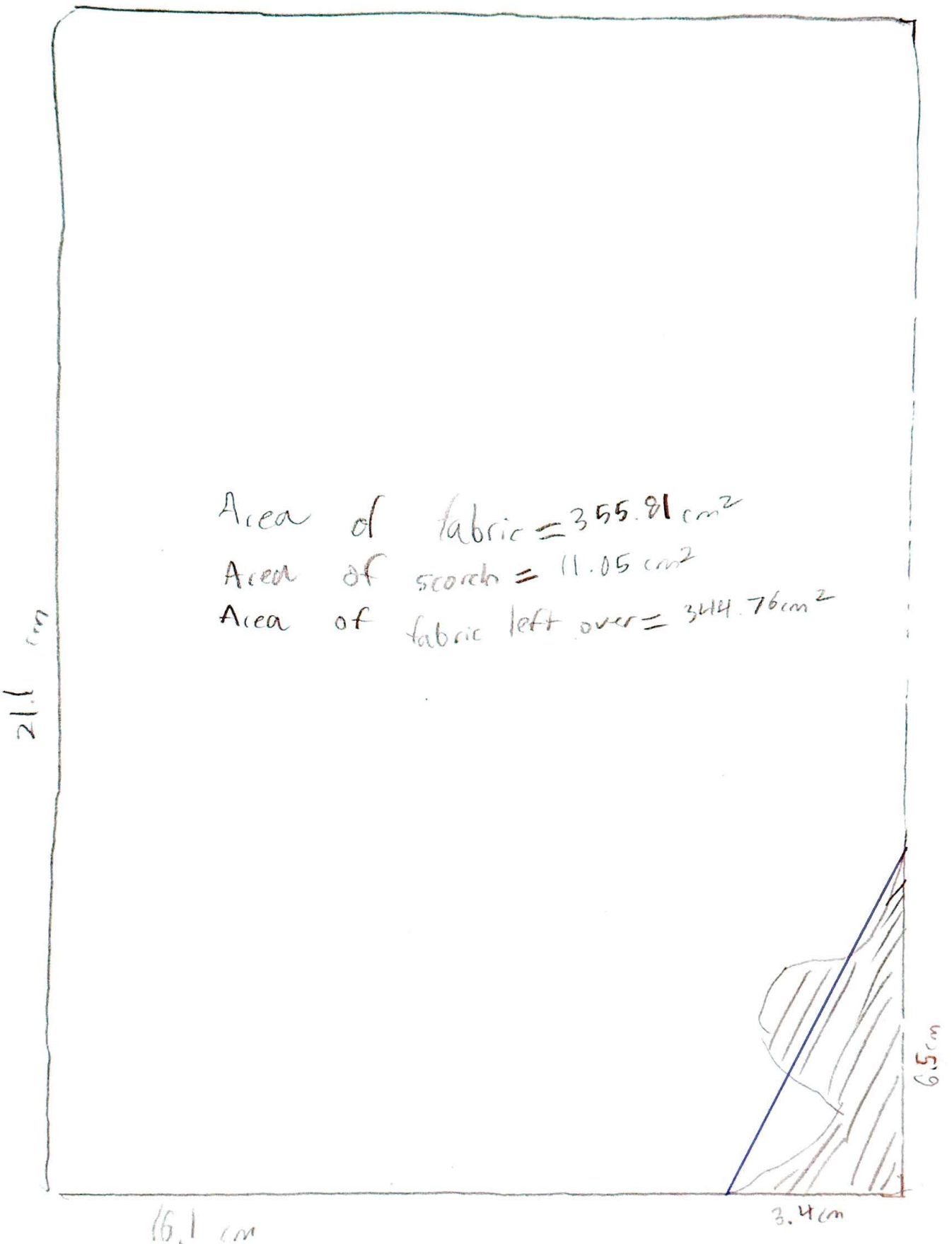
16.1 cm



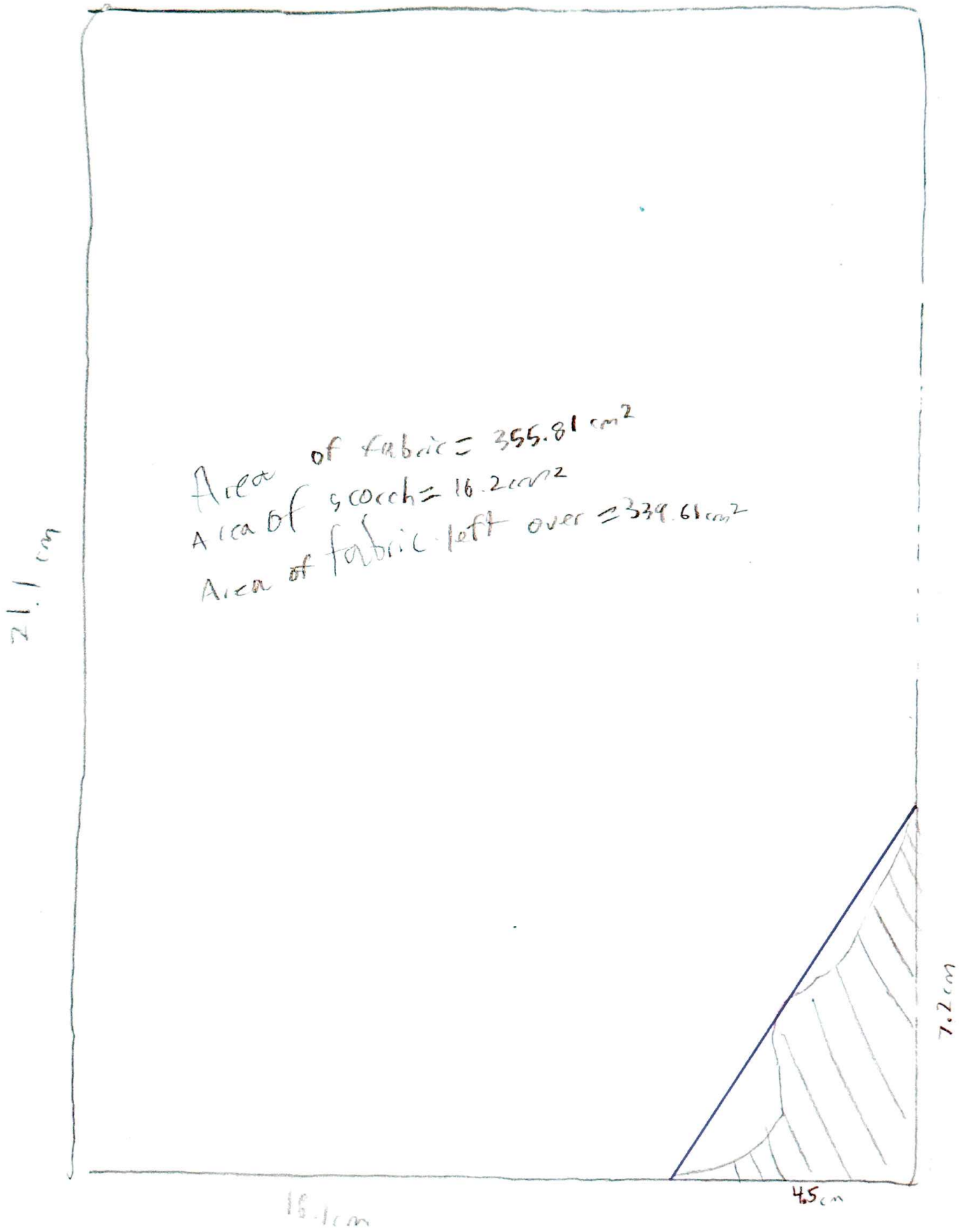
9.2 cm

3 cm

1 wash trial 2



Wash 1 Trial 3

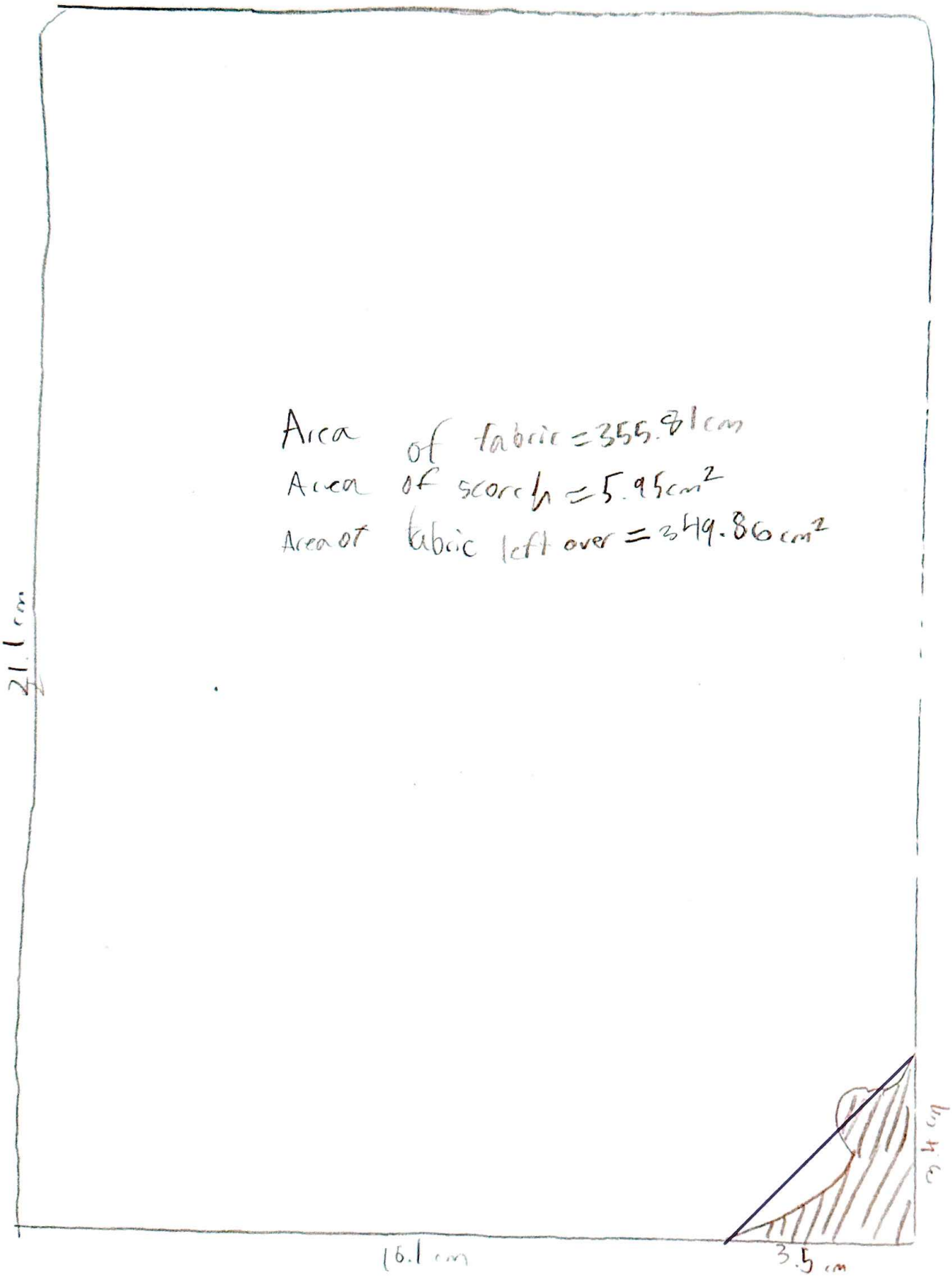


Wash trial 4

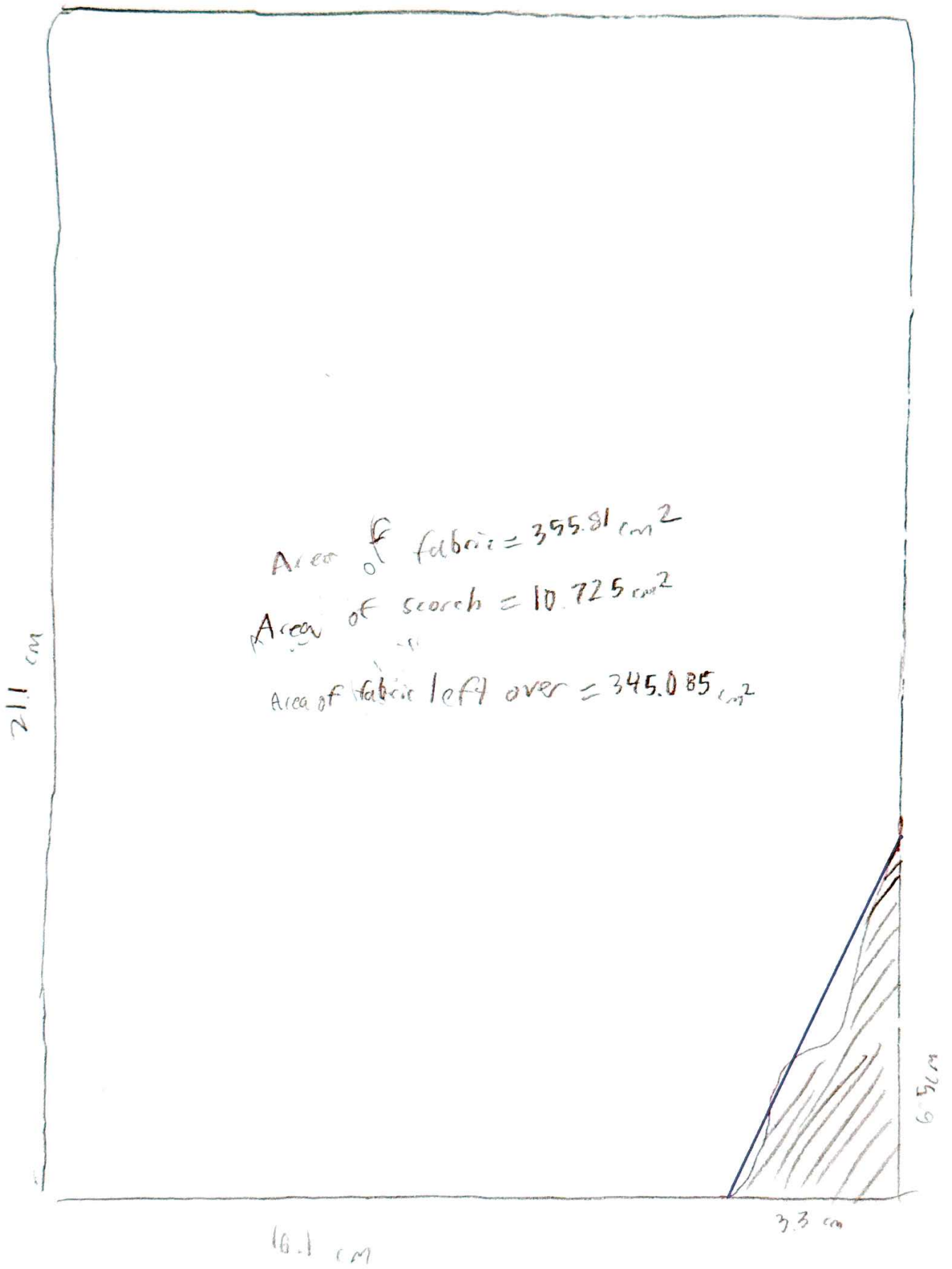
Area of fabric = 355.81 cm

Area of scorch = 5.95 cm^2

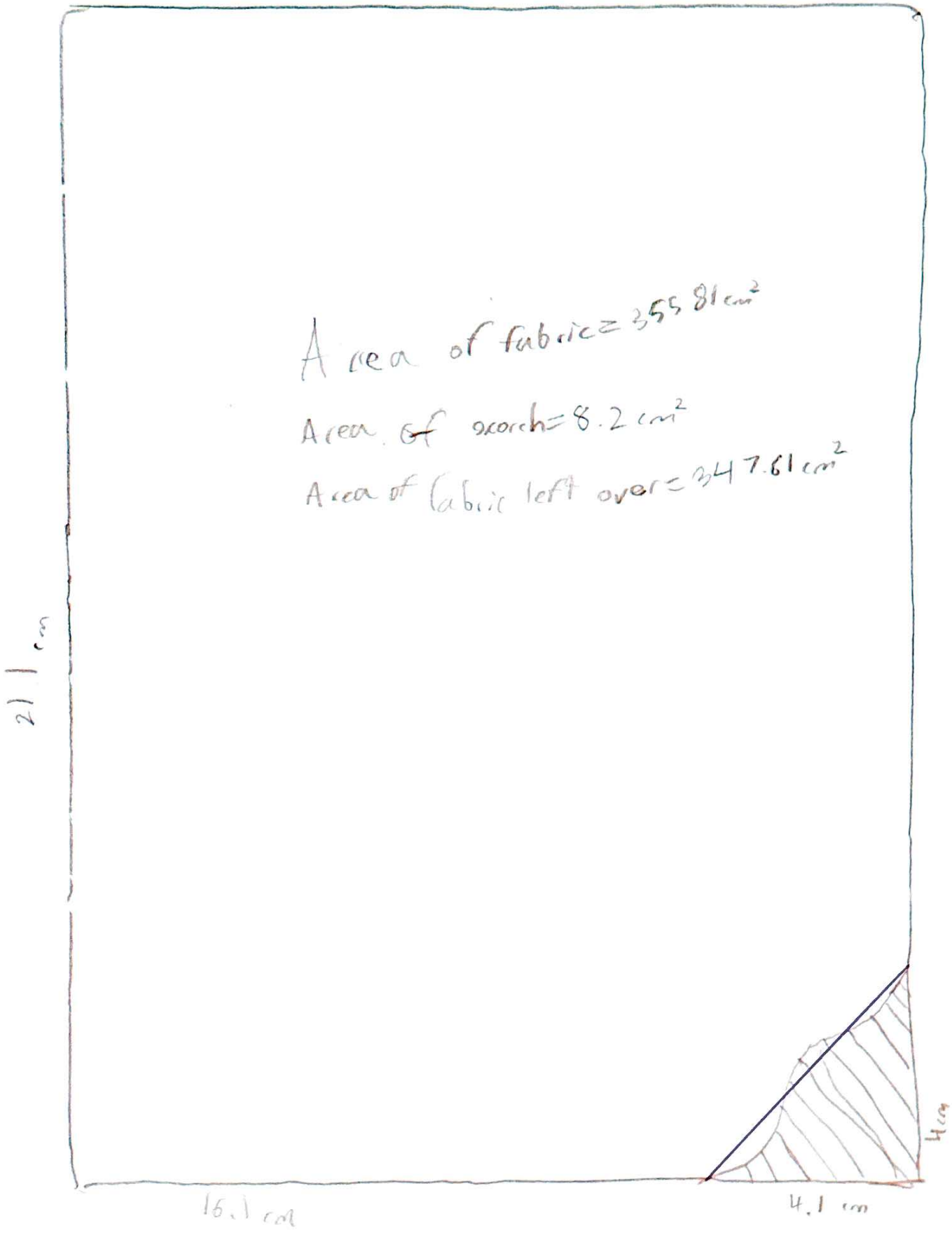
Area of fabric left over = 349.86 cm^2



1 wash trial 5



5 wash trial 1



5 wash trial 2

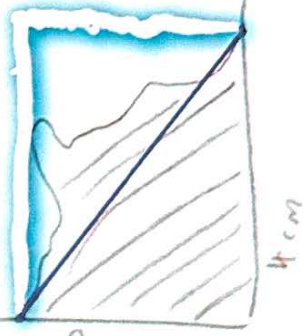
Area of fabric = 355.81 cm^2

Area of mouth = 6 cm^2

Area of fabric left over = 349.81 cm^2

21.1 cm

16.1 cm

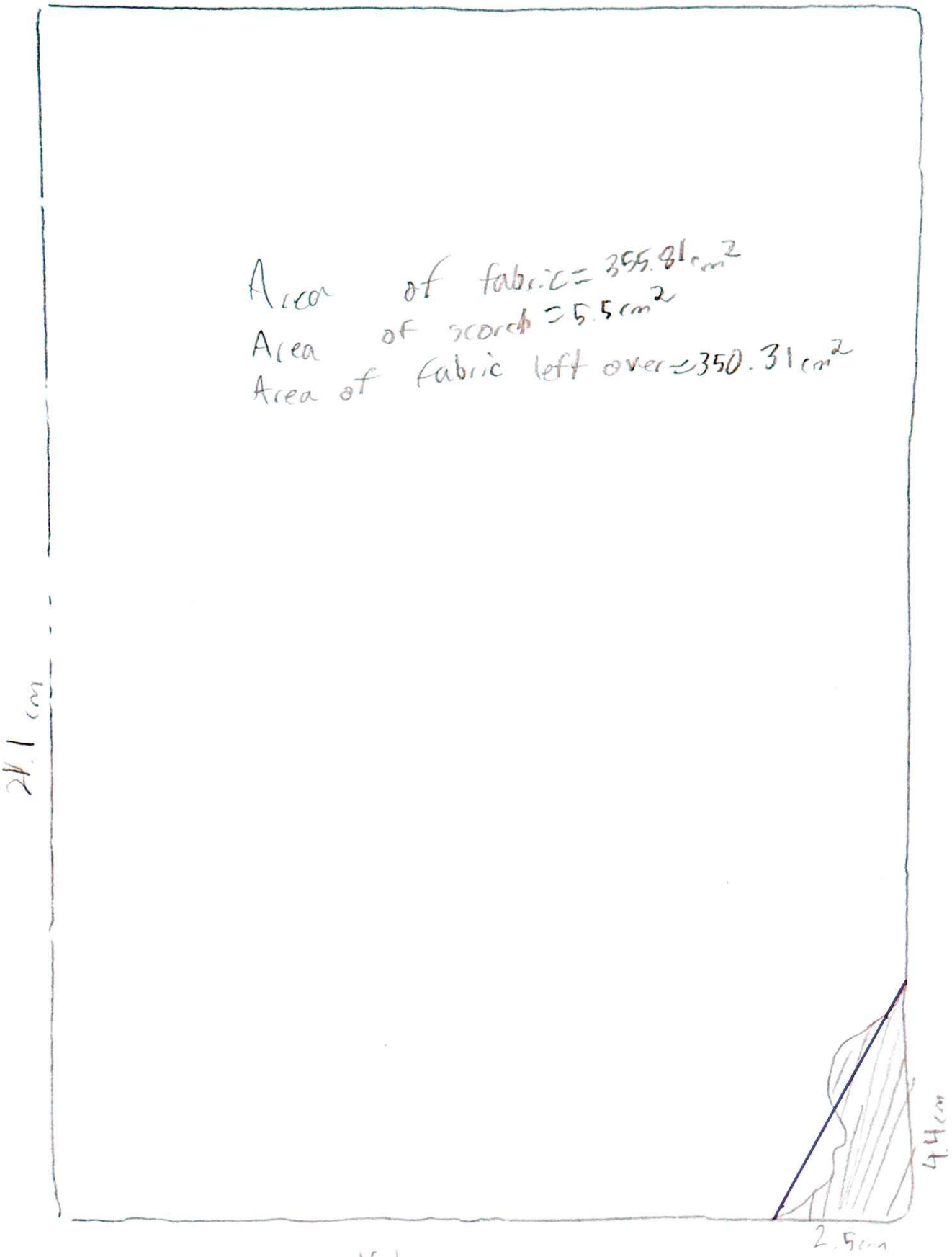


3 cm

4 cm

5 wash trial 3

Area of fabric = 355.81 cm^2
Area of scorch = 5.5 cm^2
Area of fabric left over = 350.31 cm^2

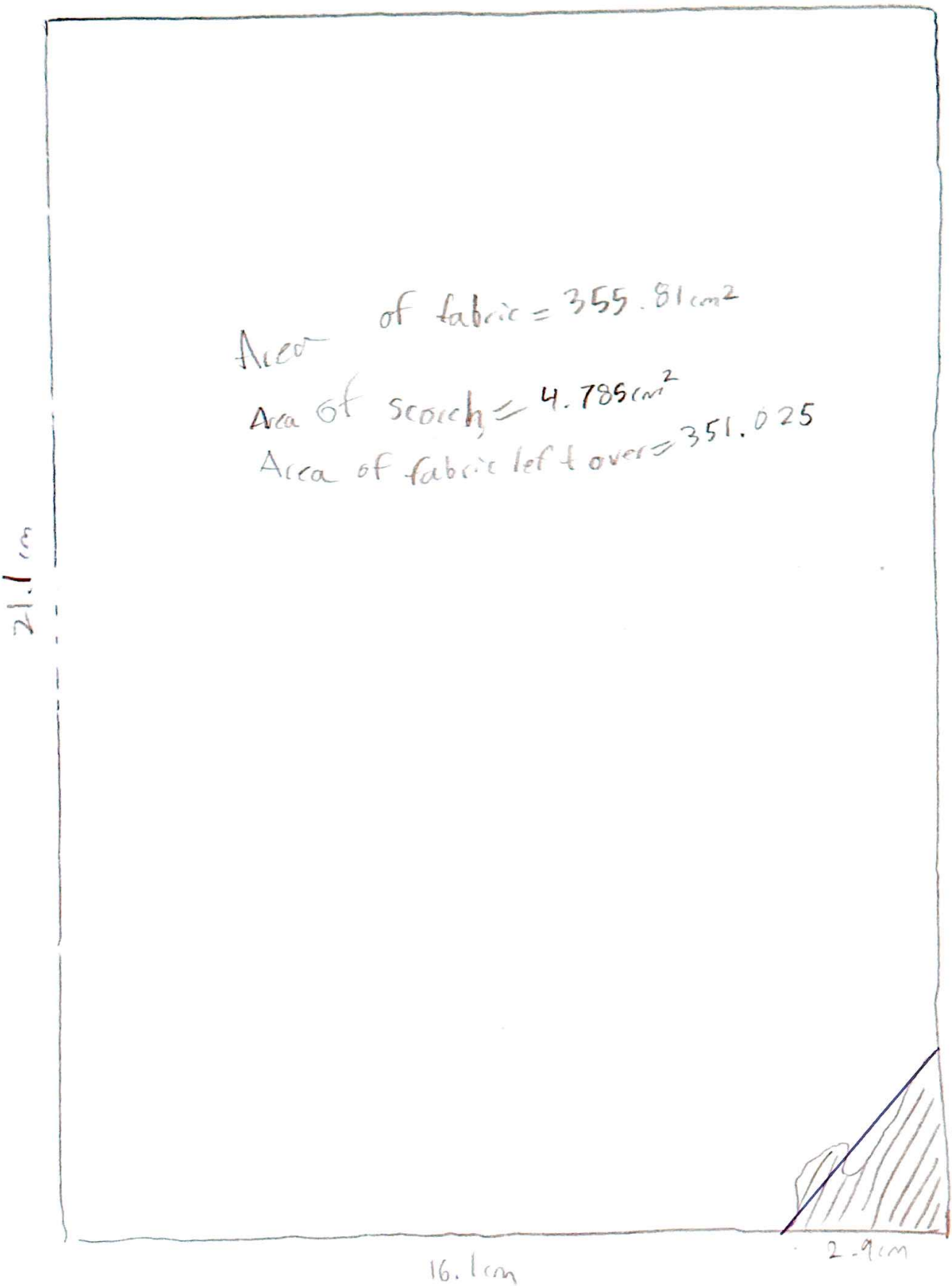


5 wash trial 4

Area of fabric = 355.81 cm²

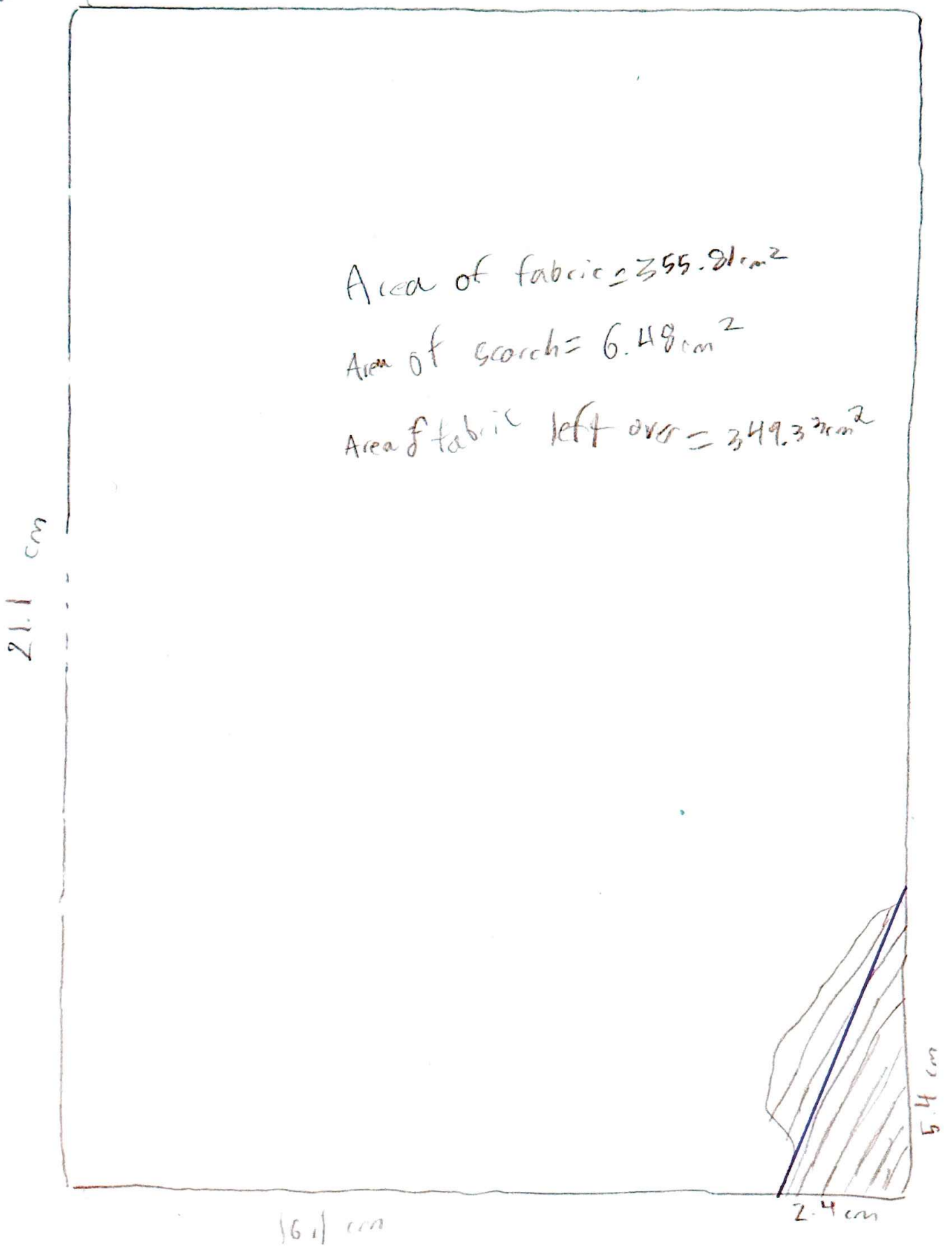
Area of scorch = 4.785 cm²

Area of fabric left over = 351.025



5 trial 5

wash



Area of fabric = 355.81 cm^2

Area of scorch = 6.48 cm^2

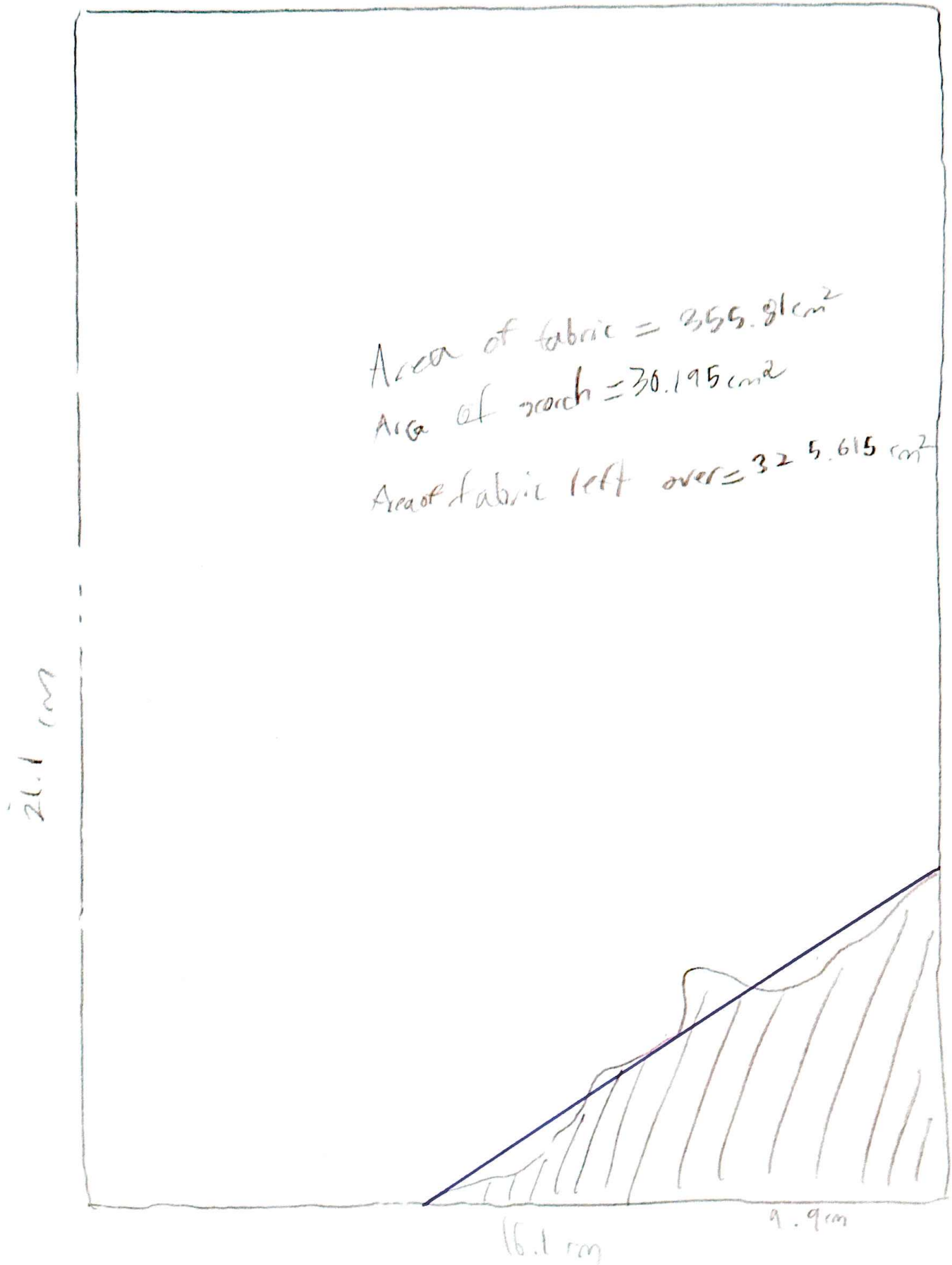
Area of fabric left over = 349.33 cm^2

10 wash trial 1

Area of fabric = 355.81 cm²

Area of scorch = 30.195 cm²

Area of fabric left over = 325.615 cm²

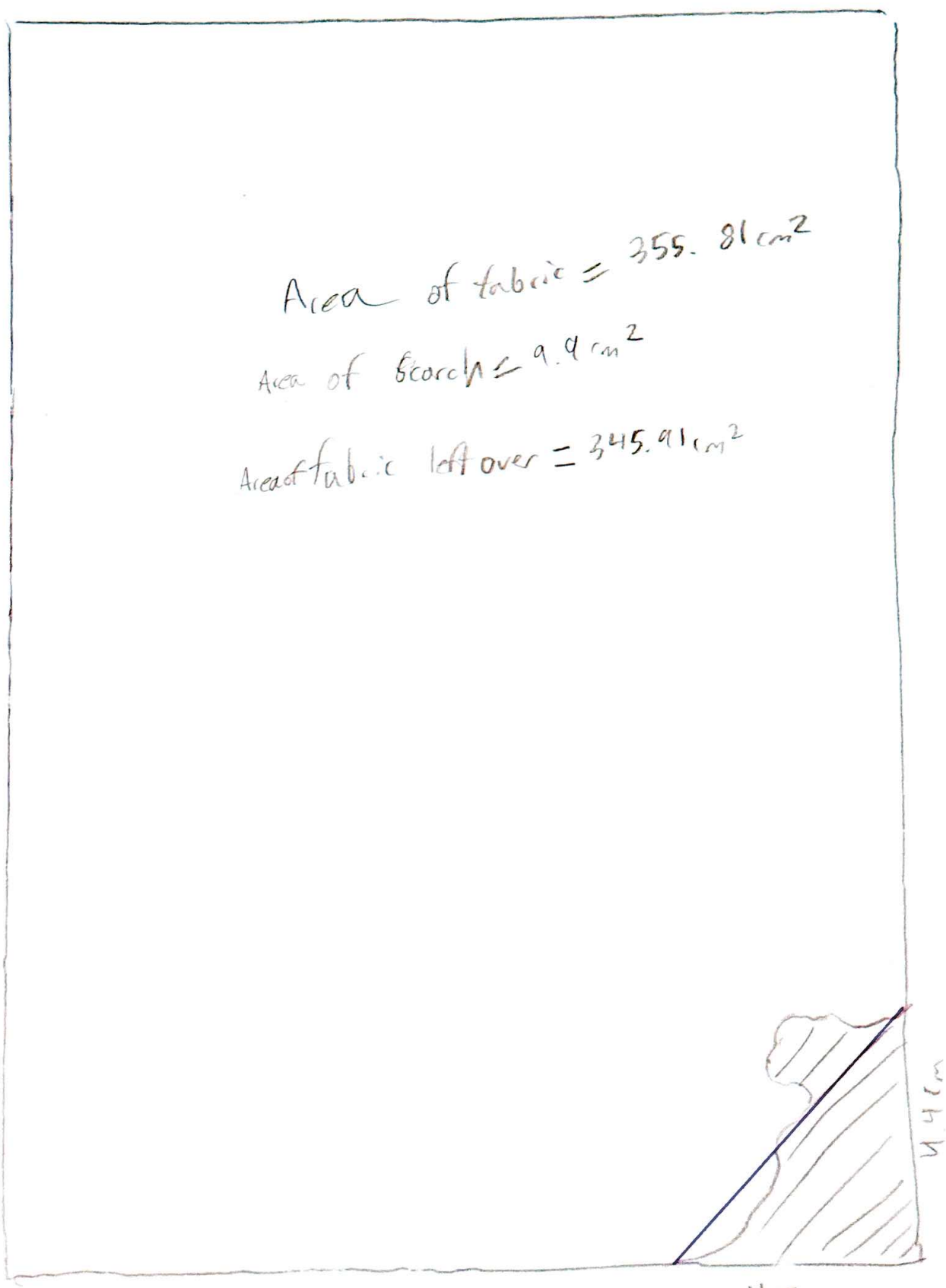


10 wash trial 2

Area of fabric = 355.81 cm^2

Area of scorch = 9.9 cm^2

Area of fabric left over = 345.91 cm^2

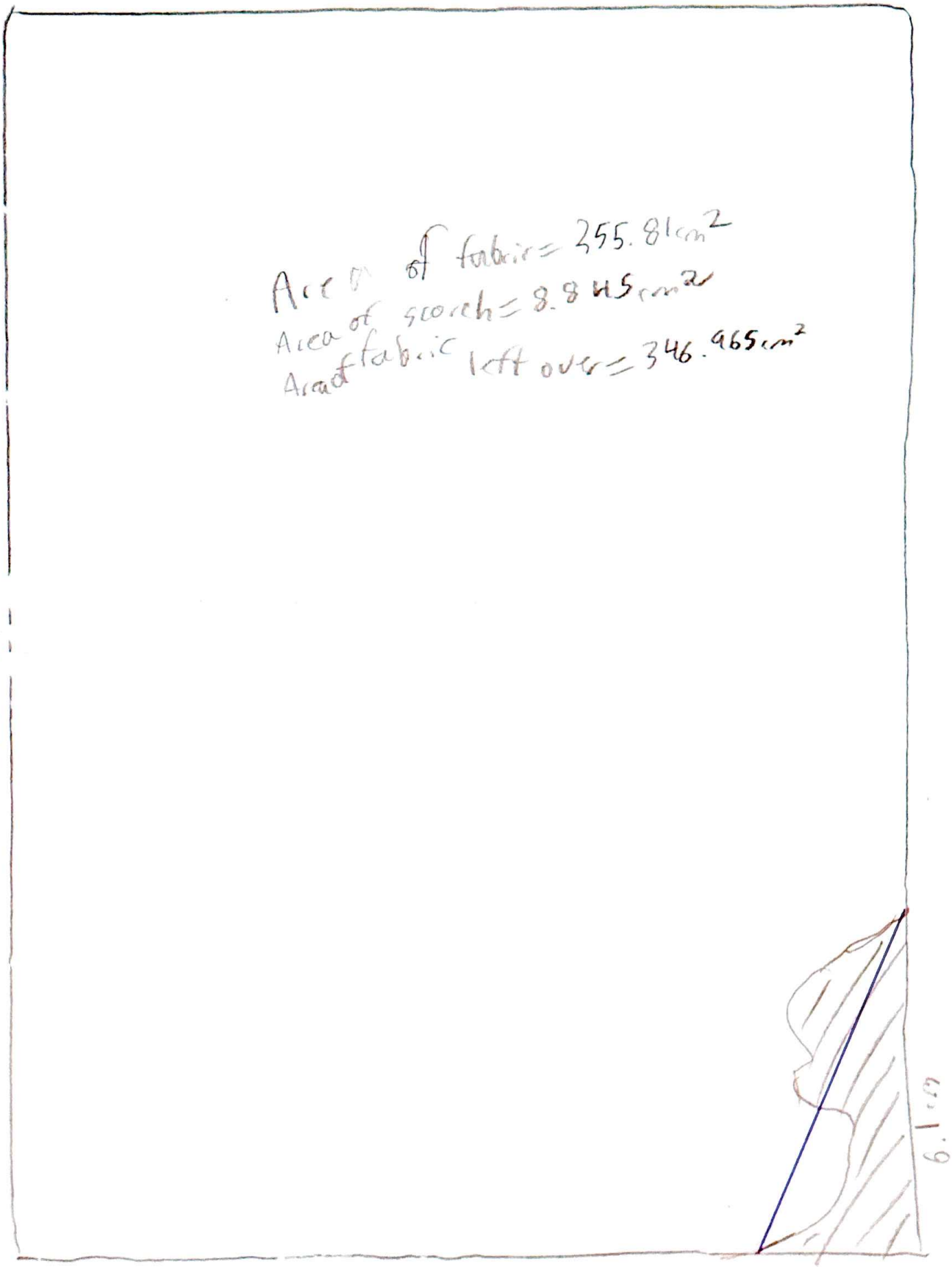


10 Wash trial 3

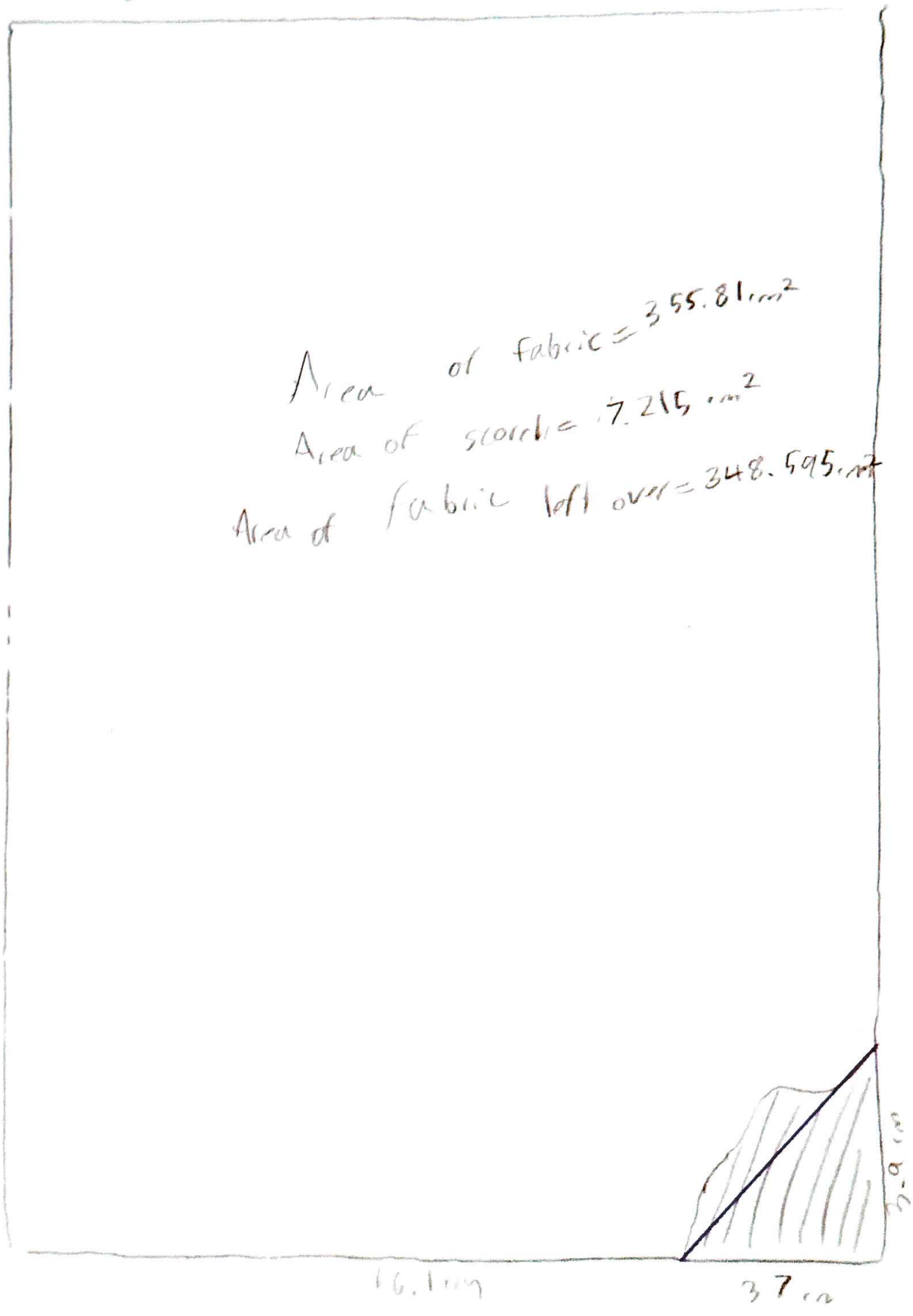
Area of fabric = 355.81 cm^2

Area of scorch = 8.845 cm^2

Area fabric left over = 346.965 cm^2



10 wash trial 4



10 Wash trial 5

Area of fabric = 355.81 cm^2

Area of scorch = 4.48 cm^2

Area of fabric left over = 351.33 cm^2

21.1 cm

16.1 cm

2.8 cm

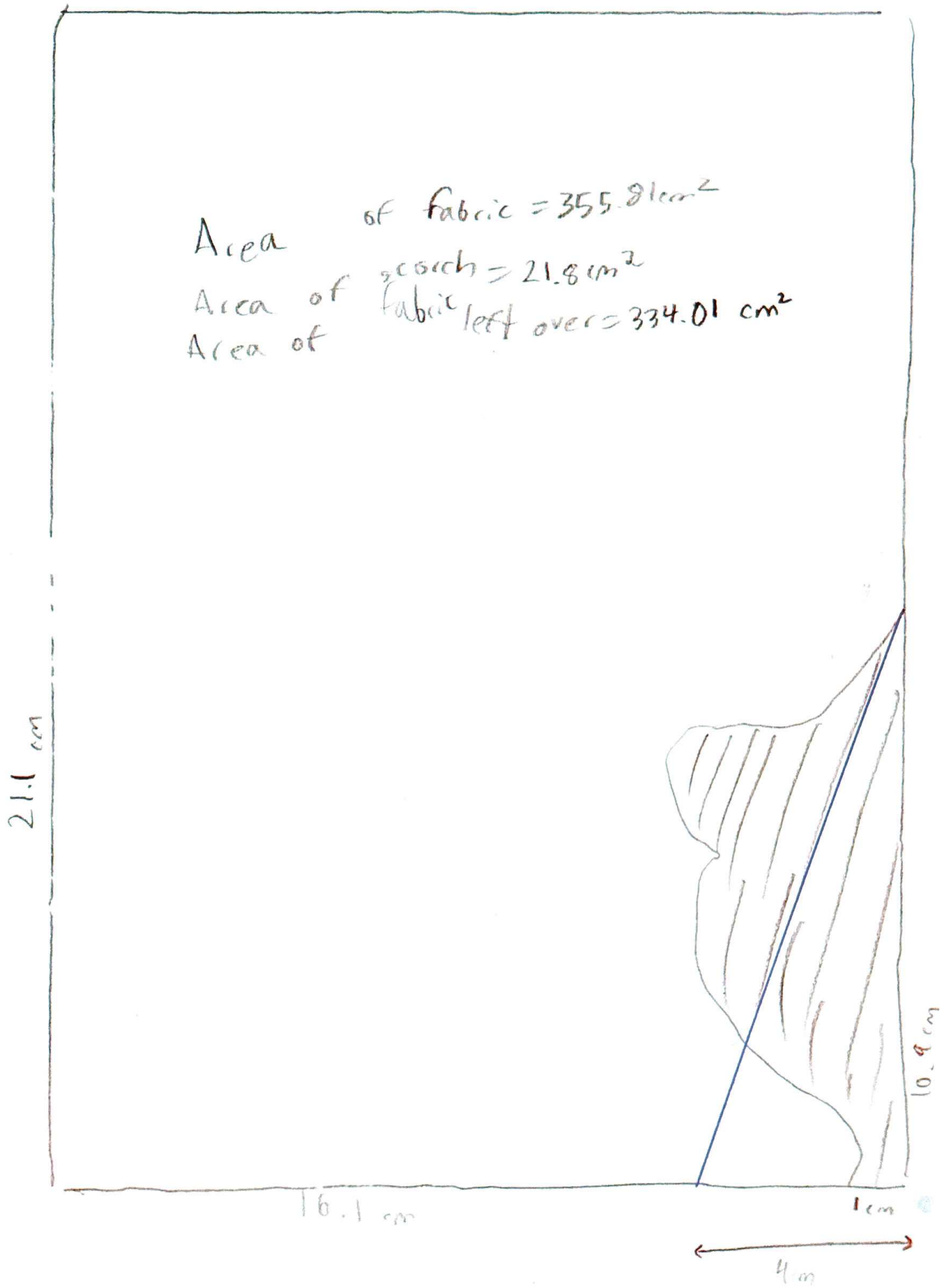
3.2 cm

20 wash trial 1

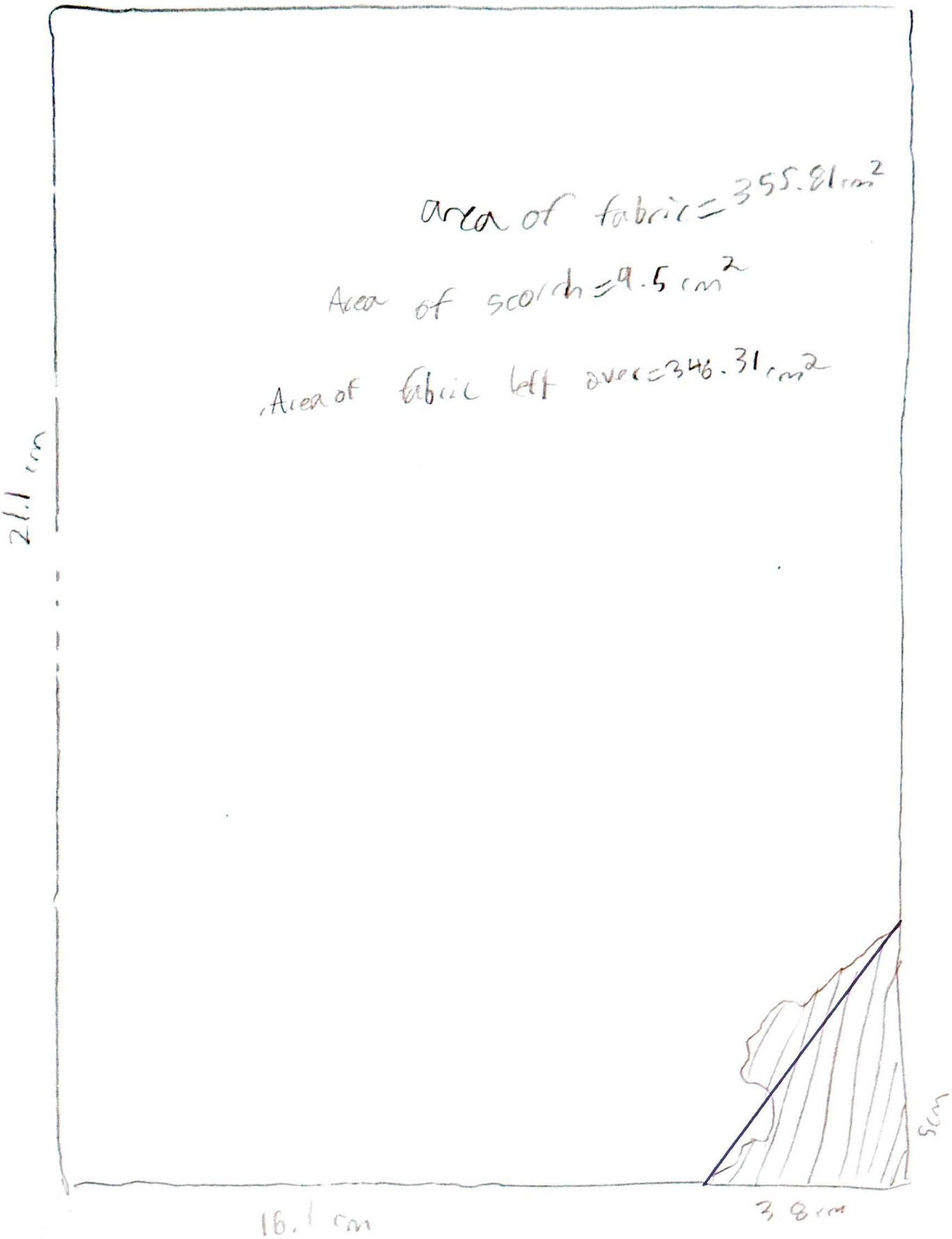
Area of fabric = 355.81 cm²

Area of scorch = 21.8 cm²

Area of fabric left over = 334.01 cm²



20 wash trial 2

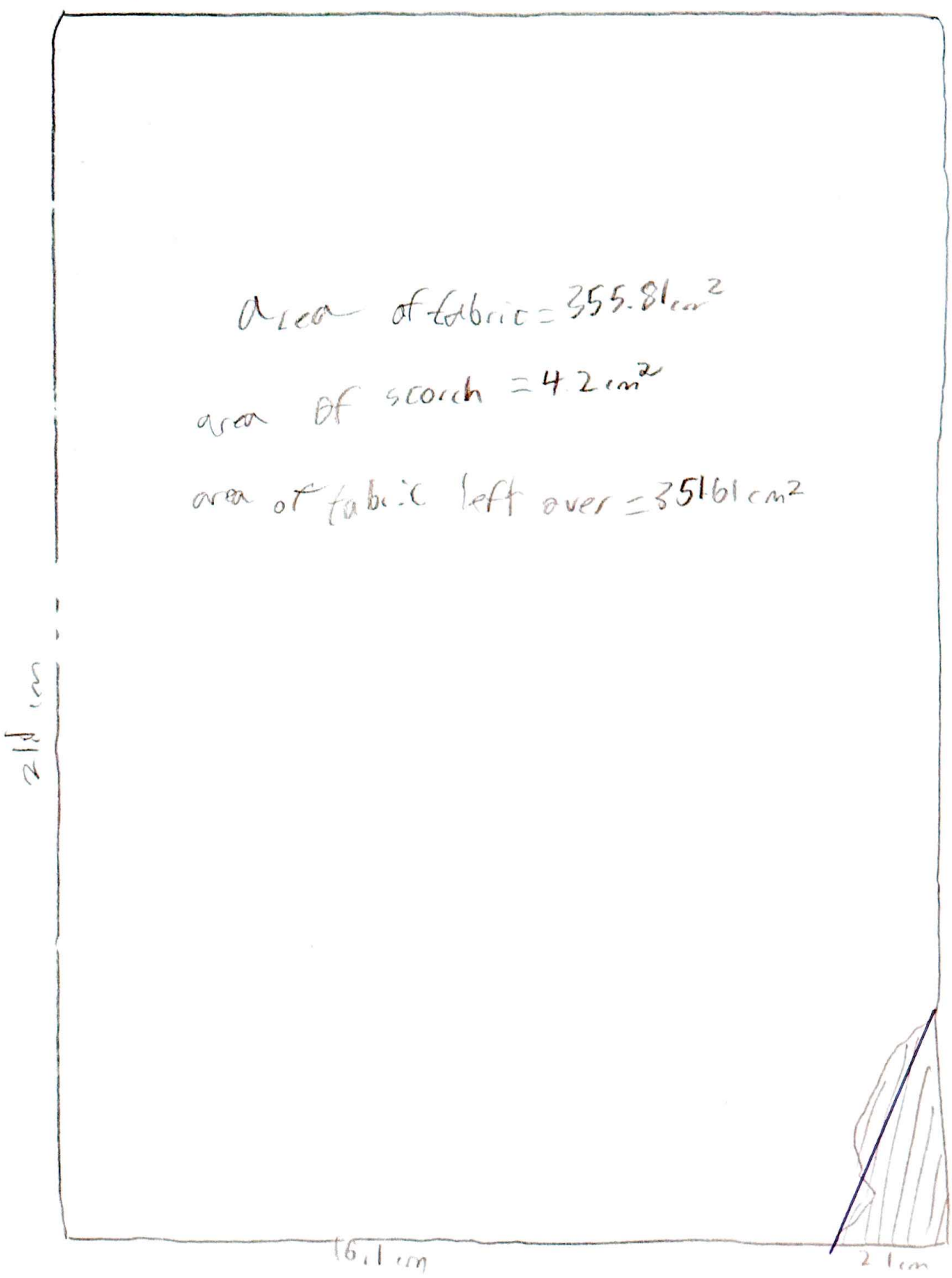


Wash 20 trial 3

Area of fabric = 355.81 cm^2

area of scorch = 4.2 cm^2

area of fabric left over = 351.61 cm^2



20 wash trial 4

Area of fabric = $355.81 cm^2$

Area of scorch = $9.5 cm^2$

Area of fabric left over = $346.31 cm^2$

21 cm

16.1 cm

5 cm

20 wash trial 5

Area of fabric = 355.81 cm^2

Area of scorch = 22.525 cm^2

area of fabric left over = 333.285 cm^2