Context and Background

Assignment Context

Within the field of engineering and design, various factors must be considered when creating a useable product. Despite its simple composition, soap still contains many factors which have to be balanced, such as cost, effectiveness, environmental impact, etc. Designing and creating a unique soap highlights the rigors of the engineering process, and is an excellent tool to expose aspiring engineers to the critical thinking necessary to succeed.

Objective

This design was formed with the intention of creating a soft, conditioning soap which would be gentle enough for all skin types. Paired alongside functionality, this soap would also generate a reasonable profit margin. Through multiple iterations, this soap design was created to highlight these desired properties while simultaneously maintaining a competitive cost.

Saponification

During the formation of soap, triglycerides react with bases to liberate glycerol and form salts in its stead. Polar carboxyl groups within fatty acids attract loose metal ions from dissociated lye in a reaction referred to as saponification. These product salts give soap their characteristic “cleansing” properties.

Design Constraints

Product Quality Constraints

- The designed soap should aim to be a common household soap which meets the standards of the modern market
- The appealing properties of soap should be optimized by choosing a mixture of oils which provide the soap with different characteristics
- These characteristics include hardness, cleansing, conditioning, bubbly lather, and creamy lather of the soap. Additional fragrances and essential oils can also be added to the soap to augment and add to the appeal.

Other Considerations

- Soap must be made through cold process
- The design of the soap must be considered economically feasible where the components of the soap are fairly priced and can be manufactured at a reasonable cost.

Process Selection

- We chose to use the cold-process method to create our soaps in order to use our own oil combinations
- This process is the most simple way to create soap without having to manage high temperature

Ingredients

Distilled Water
Lye must be dissolved in distilled water in order to be combined with the oils.

Sodium Hydroxide
We chose to use sodium hydroxide rather than potassium hydroxide as our base to add additional hardness.

Olive Oil	49% of our oil mixture olive oil for its balanced properties and high conditioning score. Olive oil also has a low cost of $0.6 per mL.
Canola Oil	15% of the oil mixture Canola Oil for its exceptional conditioning rating and the lowest cost of only $0.21 per mL.
Coconut Oil	24% Coconut oil for its high ratings of hardness, cleansing, and bubbly lather.
Ghee Oil	12% of the oil is Ghee for its high creamy lather rating

Other Features

Rose Mould

- Fits the theme of our company (Flowers!)
- Makes rose shaped soap bars
- 6 bars of soap can be placed into the mould in a single batch

Fragrances and Colourants

- We experimented with fragrances to add scent to our soap and settled with “Peach and Mango”
- We also added Red colourant to make our soap more visually appealing

Packaging

Gift Box

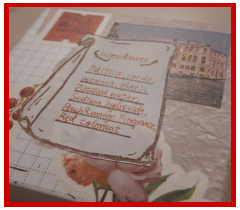
This soap is contained in a sturdy paper gift box. It protects the contents from external damage to preserve it's quality and form.

Cotton Bedding

The cotton bedding is laid underneath the soap bar inside the gift box. This bedding keeps the soap bar in place and prevents any excess oils from the soap bar from staining the bottom of the gift box.

Ingredients List

To list the ingredients of our soap, we used paper stickers with handwritten lists. The design of the stickers help create a rustic aesthetic.



Sustainable and Green Design

Choice of Container

- Container can be reused and repurposed
- Our paper boxes are **biodegradable**

Labels and Stickers

- We chose to use paper stickers to decorate our packaging because they are **biodegradable**

Raw Data Affiliated with Components

Oil	Hardness	Cleansing	Conditioning	Bubbly Lather	Creamy Lather	Density(g/L)	Cost ($/mL)
Coconut Oil	79	67	10	67	12	0.92	1.63
Ghee	55	15	22	15	40	1.01	1.67
Avocado Oil	26	0	70	0	26	0.81	0.42
Olive Oil	22	0	70	0	22	0.92	1.86
Canola Oil	17	0	82	0	17	0.92	0.6

Soap Optimizer

Oils	Percentage	Quantity(g)	Density(g/mL)	SAP(NaOH)	SAP (KOH)	Hardness	Cleansing	Conditioning	Bubbly Lather	Creamy Lather	Cost ($/mL)
Coconut Oil, 76 deg	24%	120.00	0.92	0.183	0.257	79	67	10	67	12	1.63
Ghee, any bovine	12%	60.00	1.01	0.162	0.227	55	15	22	15	40	1.67
Crisco, old	0%	0.00	0.81	0.137	0.192	26	0	70	0	26	0.42
Avocado Oil	0%	0.00	0.92	0.133	0.186	22	0	70	0	22	1.86
Olive Oil	49%	245.00	0.92	0.135	0.19	17	0	82	0	17	0.6
Sesame Oil	0%	0.00	0.92	0.134	0.188	15	0	83	0	15	1.77
Corn Oil	0%	0.00	0.92	0.137	0.192	14	0	84	0	14	0.27
Grapeseed Oil	0%	0.00	0.92	0.129	0.181	12	0	88	0	12	0.86
Sunflower Oil	0%	0.00	0.92	0.135	0.189	11	0	87	0	11	0.28
Canola Oil	15%	75.00	0.92	0.133	0.186	6	0	91	0	6	0.21
Total	100%	500									
Total Volume											

		Mass of Strawberry Oil Fragrance (g)	Cost of Fragrance ($/gram)	Total Cost of Fragrance	Mass of Red Colourant (mL)	Cost of Colourant ($/mL)	Total Cost of Colourant
Mass of Oils (g)	500	25	$0.53	$13.21	5.52	$ 0.51	$ 2.81
Percentage of Water as a Percentage of Oils	38%						
Mass of Water (g)	190						

Mass of KOH (g)	Mass of NaOH (g)	Hardness	Cleansing	Conditioning	Bubbly Lather	Creamy Lather	Price per 100mL	
104.96	74.73	34.79	17.88	58.87	17.88	16.91	$ 4.89	537.6668102

Options and Iterations

The following reflect various different soap compositions that were considered:

Final Design	
Oils	Percentage
Coconut Oil	24%
Ghee, any bovine	12%
Olive Oil	49%
Canola Oil	15%
Total	100%
Properties	Score
Hardness	34.79
Cleansing	17.88
Conditioning	58.87
Bubbly Lather	17.88
Creamy Lather	16.91
Price per Batch	$4.89

Avocado Oil	
Oils	Percentage
Coconut Oil	24%
Ghee, any bovine	12%
Avocado Oil	49%
Canola Oil	15%
Total	100%
Properties	Score
Hardness	37.24
Cleansing	17.88
Conditioning	52.99
Bubbly Lather	17.88
Creamy Lather	19.36
Price per Batch	$8.24

Corn Oil	
Oils	Percentage
Coconut Oil	24%
Ghee, any bovine	12%
Corn Oil	49%
Canola Oil	15%
Total	100%
Properties	Score
Hardness	33.32
Cleansing	17.88
Conditioning	59.85
Bubbly Lather	17.88
Creamy Lather	15.44
Price per batch	$4.01

Sesame Oil	
Oils	Percentage
Coconut Oil	24%
Ghee, any bovine	12%
Sesame Oil	49%
Canola Oil	15%
Total	100%
Properties	Score
Hardness	33.81
Cleansing	17.88
Conditioning	59.36
Bubbly Lather	17.88
Creamy Lather	15.93
Price per batch	$8.00

Soap Calculator Design Comparison

Expected Property Values from Design

Properties	Score
Hardness	34.79
Cleansing	17.88
Conditioning	58.87
Bubbly Lather	17.88
Creamy Lather	16.91

**Assuming the small bars of soap are ⅓ of the mass of a regular bar of soap*

Properties of the Experimental Soap

Properties	Score
Hardness	Lower hardness than expected
Cleansing	Cleaned well
Conditioning	Good conditioning, hands did not get dry
Bubbly Lather	Produced a fair amount of bubbles.
Creamy Lather	Hands were fairly smooth after use

Weight of 6 Rose-shaped Bars of Soap (g)	Weight of 3 Small Soap Bars Submitted (g)	Actual Yield (g)	Theoretical Mass(g)
517.8	86.3	604.1	599.01

$$Percent\ yield = \frac{Actual\ Yield}{Theoretical\ Yield}$$

$$\frac{604.1g}{599.01g} = 100.85\%$$

Cost and Economics

Component	Component Cost	Amount	Total
Coconut Oil	1.63/100mL	130.4mL	$2.13
Ghee	1.67/100mL	59.4mL	$0.99
Olive Oil	0.6/100mL	266.3mL	$1.60
Canola Oil	0.21/100mL	81.5mL	$0.17
Lye	$14.93/500g	70.99g	$2.12
Colourant	$0.51/mL	5.52mL	$2.82
Fragrance	$0.53/g	22.5g	$11.93
Packaging	$1.80/box	6 Boxes	$10.80
Price Per Batch			$32.56
Mass of Bar	Price per Packaged Batch	Price per Hardened soap	Cost per Soap Bar
86.3g	$32.56/599.01g	$0.05/g	$4.69

Production Cost : $0.0544/g

Price : $0.0579/g

Net Profit Margin

Profit Margin = (100%)(Revenue - COGS)/Revenue

Profit Margin = (100%)($5.00 - $4.25)/$5.00

Profit Margin = 15%