Design of a Hot Glue Pot for First Year Engineering Lab

Gerald Recktenwald
gerry@pdx.edu
February 2018

Problem/opportunity: Design a device to keep hot glue in a molten state for dipping

Project Objective Statement

Buy or design, fabricate and test a small (8-12 oz.) pot for melting hot glue (~121°F) for a prototyping cost of $300 by 8 June 2018.

Client/Market Requirements

Primary requirements

1. Safe
2. Melts glue quickly
3. Auto startup/shutdown
4. Cleanable
5. Adjustable temperature, but not by ordinary user
6. User controls: On/Off, light(s) to indicate activity
7. Economical

External Search

Darice 115-62 40W
$7.30
one temperature
shallow

Surebonder 805 4” dia
$9.41
one temperature
shallow

External Search

Brentwood 6" Electric Skillet
Adjustable, large footprint
$11.68

Hold Heet Electric glue pot
One temperature
$135

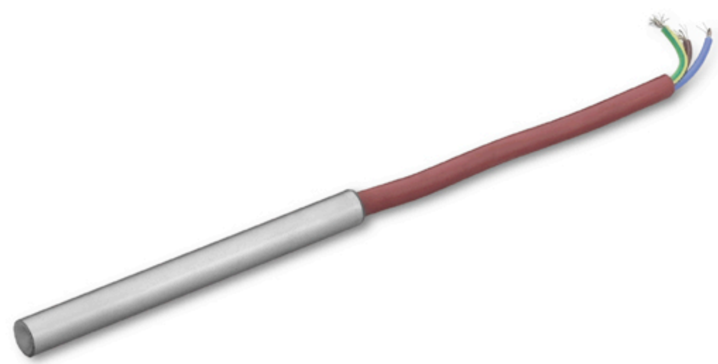
External Search

Hamilton Beach 33101 Party Dipper
Fixed temperature, doesn’t melt glue
$17.99

Summary of benchmarking

Product	Source	Price	Pro/con	Features	Amazon ratiı	N rating
Darice 115-62 40W	Amazon	$ 7.30	small, shallow	one temperature	3.3/5	57
Surebonder 805 4" dia. Glue skillet	Amazon	$ 9.41	small, shallow	Fixed temperature	3.6/5	31
Surebonder 802 7" dia electric glue skillet	Amazon	$ 35.99	too large? shallow	Temperature control 40W 380F max temperature	4.1/5	61
Brentwood 6" Electric Skillet Model SK-45	Amazon	$ 11.68	too large? shallow	Ajustable temperature	3.2/5	174
Hold Heet Electric Glue Pot (1 Quart)	Amazon	$ 134.99	too large?	Fixed thermostat Removable glue pot Designed for woodworking	5/5	1
Hamilton Beach 33101 Party Dipper Food Warmer	Amazon	$ 17.99	Doesn't melt	Fixed temperature	4.1/5	333

External Search: Cartridge Heaters



Next Thermal Cartridge heaters

National Plastic Heater, Sensor & Control inc.

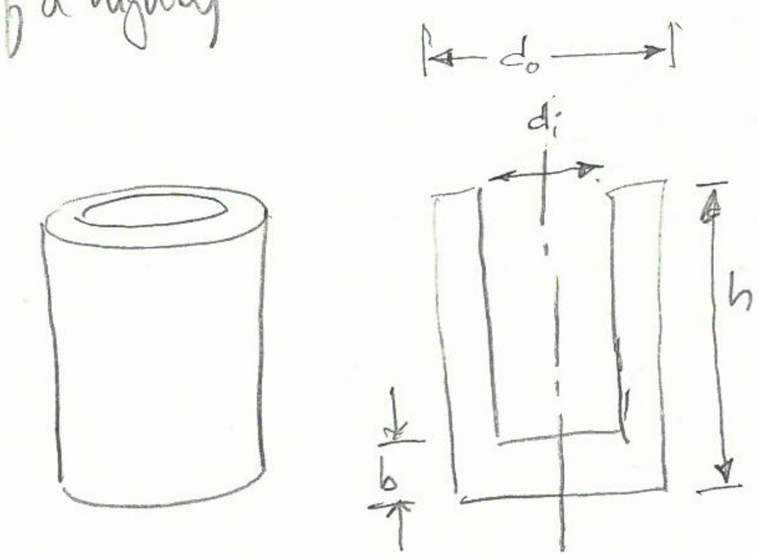
Preliminary Engineering Model:

How fast can it heat up?

Sizing of Heater for Hot Glue Pot

Assume that the glue pot is made of a highly conductive metal

Goal is to heat the metal from T_i to T_f in a desired time interval Δt. The average heating rate is



$$Q = \frac{mc(T_f - T_i)}{\Delta t} \qquad (1)$$

$m = \rho V$ = mass of metal

V = volume of metal

c = specific heat of metal

T_f = final temperature = steady operating T

T_i = initial temperature

Δt = time it takes glue pot to heat up

$$V = \frac{\pi}{4}(d_o^2 - d_i^2)(h-b) + \frac{\pi}{4}d_o^2 b$$

$$= \frac{\pi}{4}d_o^2 h - \frac{\pi}{4}d_i^2(h-b)$$

Preliminary Engineering Model:

How fast can it heat up?

Example: Schedule 40 Aluminum pipe, nominal 1.25 inch

the operating temperature

$d_o = 1.66$ inch $= 4.216$ cm

$d_i = 1.38$ inch $= 3.505$ cm

choose $b = 0.25$ inch $= 0.635$ cm, $h = 2.5$ inch $= 6.35$ cm

$$V = \frac{\pi}{4}\left[\left(4.216\times10^{-2}\,m\right)^2\left(6.35\times10^{-2}\,m\right) - \left(3.505\times10^{-2}\,m\right)^2\left(6.35\times10^{-2} - 0.635\times10^{-2}\,cm\right)\right]$$

4.266×10^{-5}

$$V = 3.35\times10^{-5}\,m^3$$

$$m = \left(2700\,\frac{kg}{m^3}\right)\left(3.35\times10^{-5}\,m^3\right) = 0.0905\,kg \quad (91\,g)$$

↖ density 6061-T6 Al

Preliminary Engineering Model:

How fast can it heat up?

2/

Sizing of Heater for Hot Glue Pot (continued)

Δt = 10 min = 600 s

T_i = 20 °C

T_f = 135 °C (low temperature hot glue melts at 121 °C)

$$Q = (0.0905\ \mathrm{kg})\left(896\ \frac{\mathrm{J}}{\mathrm{kg\,C}}\right)\frac{(130 - 20\ °\mathrm{C})}{(600\ \mathrm{s})}$$

$Q \approx 15\ \mathrm{W}$

instead use Δt = 5 min = 300 s $\Rightarrow$ $Q \approx 30\ \mathrm{W}$

Use DC Power

$Q = \frac{V^2}{R}$ 12 V $R = \frac{V^2}{Q} = \frac{144\ V^2}{30\ W} = 4.8\ \Omega$

Preliminary Engineering Model

Heater_sizing_hot_glue_pot.xlsx

ME 122 Design Problem
Size the heater for a new hot glue melting pot

Formulas

Heater power =	Q = m*c*(Tf - Ti)/delta_t
Mass of metal =	m = rho*V
Volume of metal =	V = (pi/4)* (h*do^2 - (h-b) * di^2)

Properties of 6061-T6 Aluminum from http://asm.matweb.com/search/SpecificMaterial.asp?bassnum=MA6061t6

rho	2.7	g/cm^3	2700	kg/m^3
c	0.896	kJ/kg/C	896	J/kg/C

Glue melting parameters

Ti	20	C	initial temperature = room temperature
Tf	130	C	operating temperature = 10C + melting point of low temp hot glue, which is approx 121 C
deltat	10	min	https://www.hotmelt.com/blog/high-temp-hot-melt-vs-low-temp-hot-melt

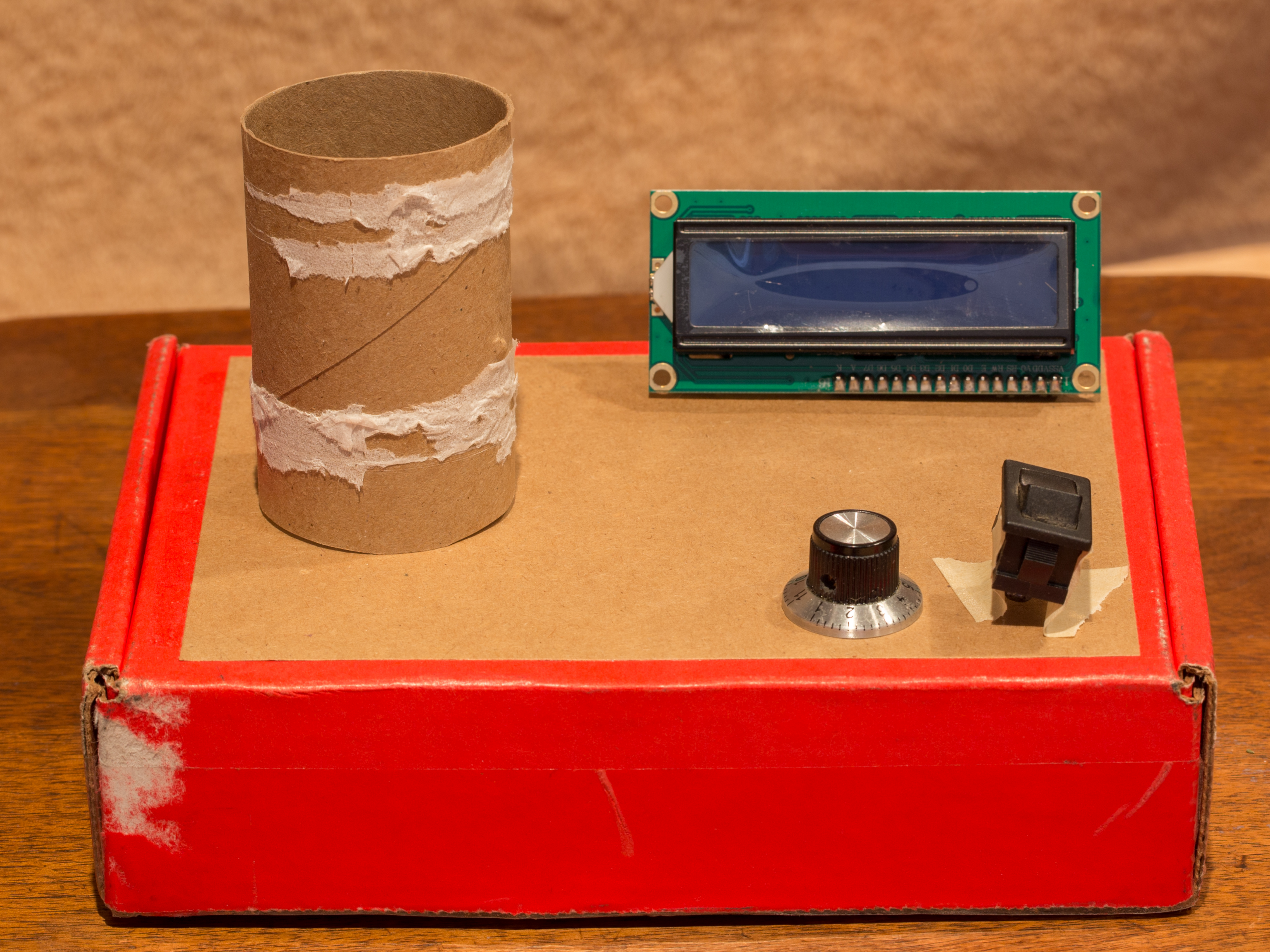
Standard sizes for Alum https://www.onlinemetals.com/merchant.cfm?id=73&step=2

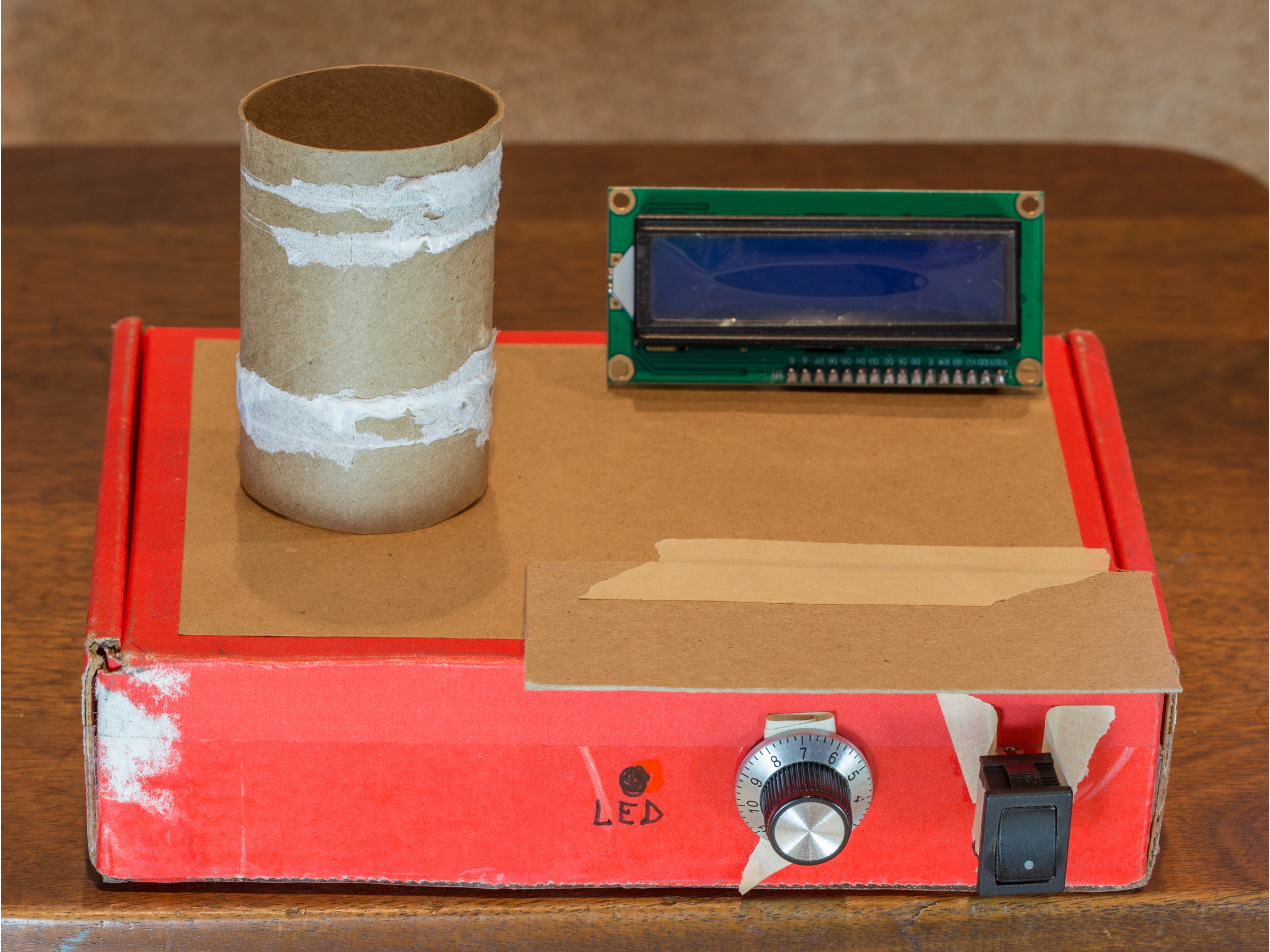
Schedule 40:

Nomin	do	di
1.25"	1.66	1.38
1.5 incl	1.9	1.61

do (in)	di (in)	h (in)	b (in)	V (in^3)	V (m^3)	m (kg)	Q (W)
1.66	1.38	2.5	0.25	2.04525536	3.35157E-05	0.0904924	14.9

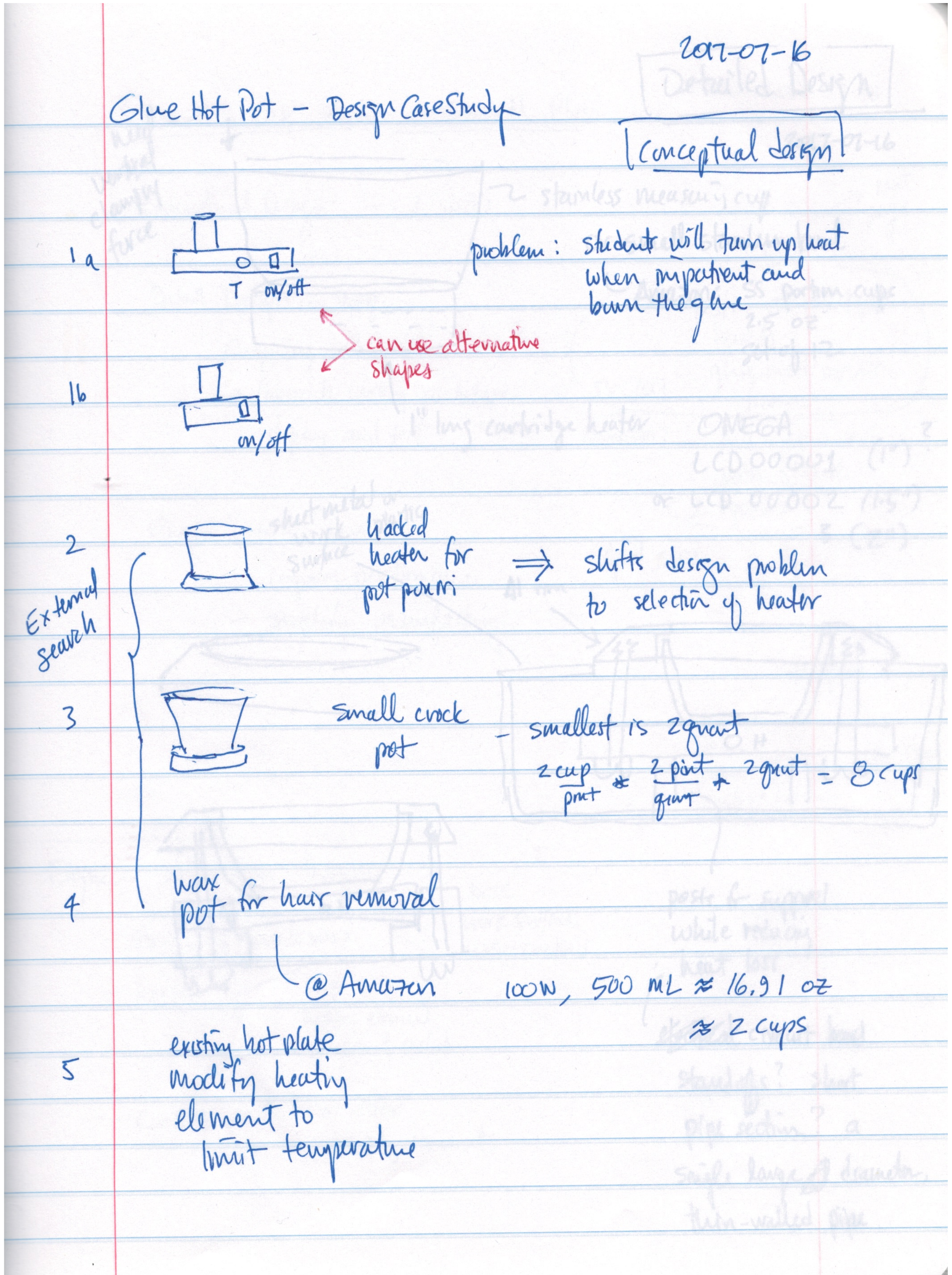
Conceptual Prototypes

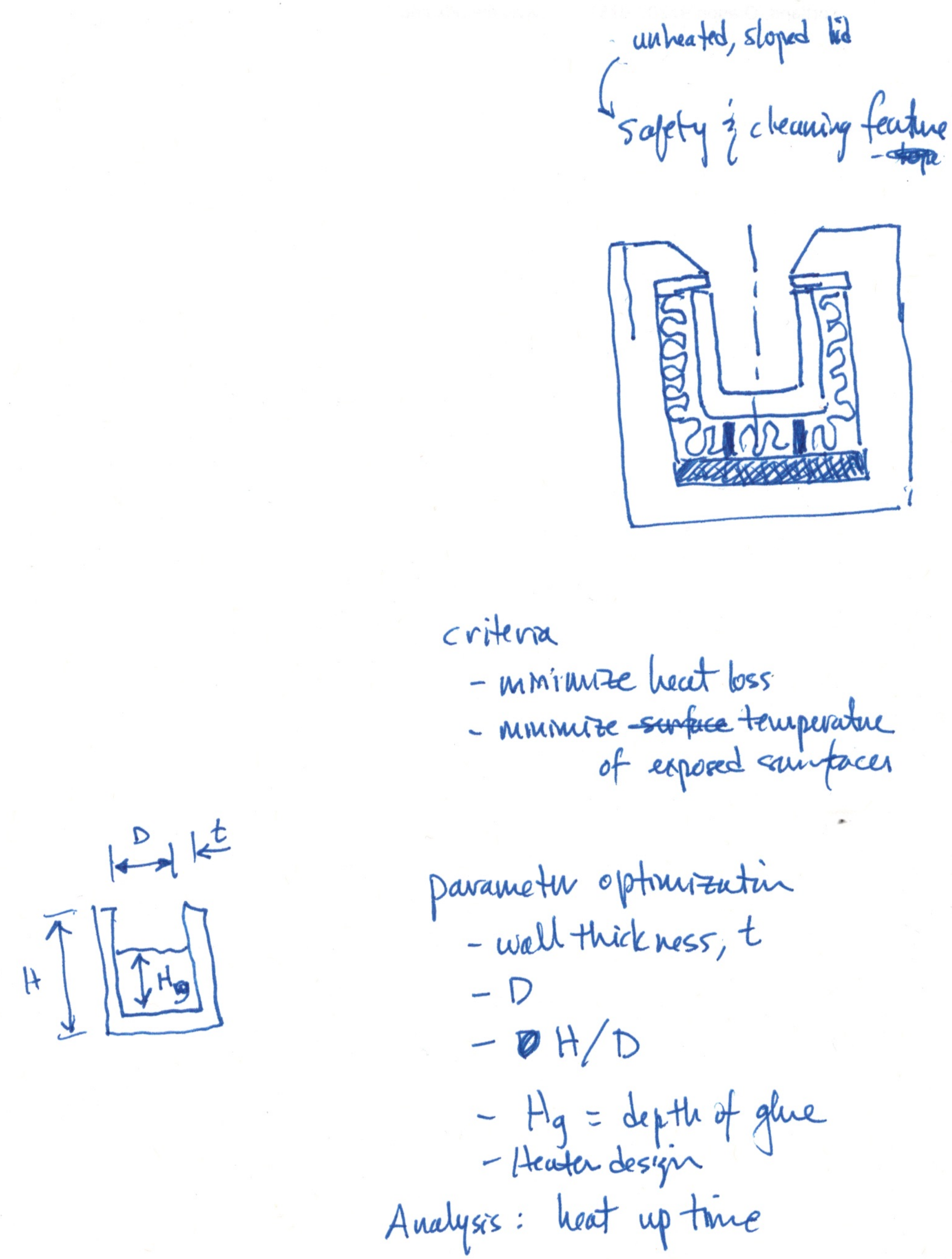



LED

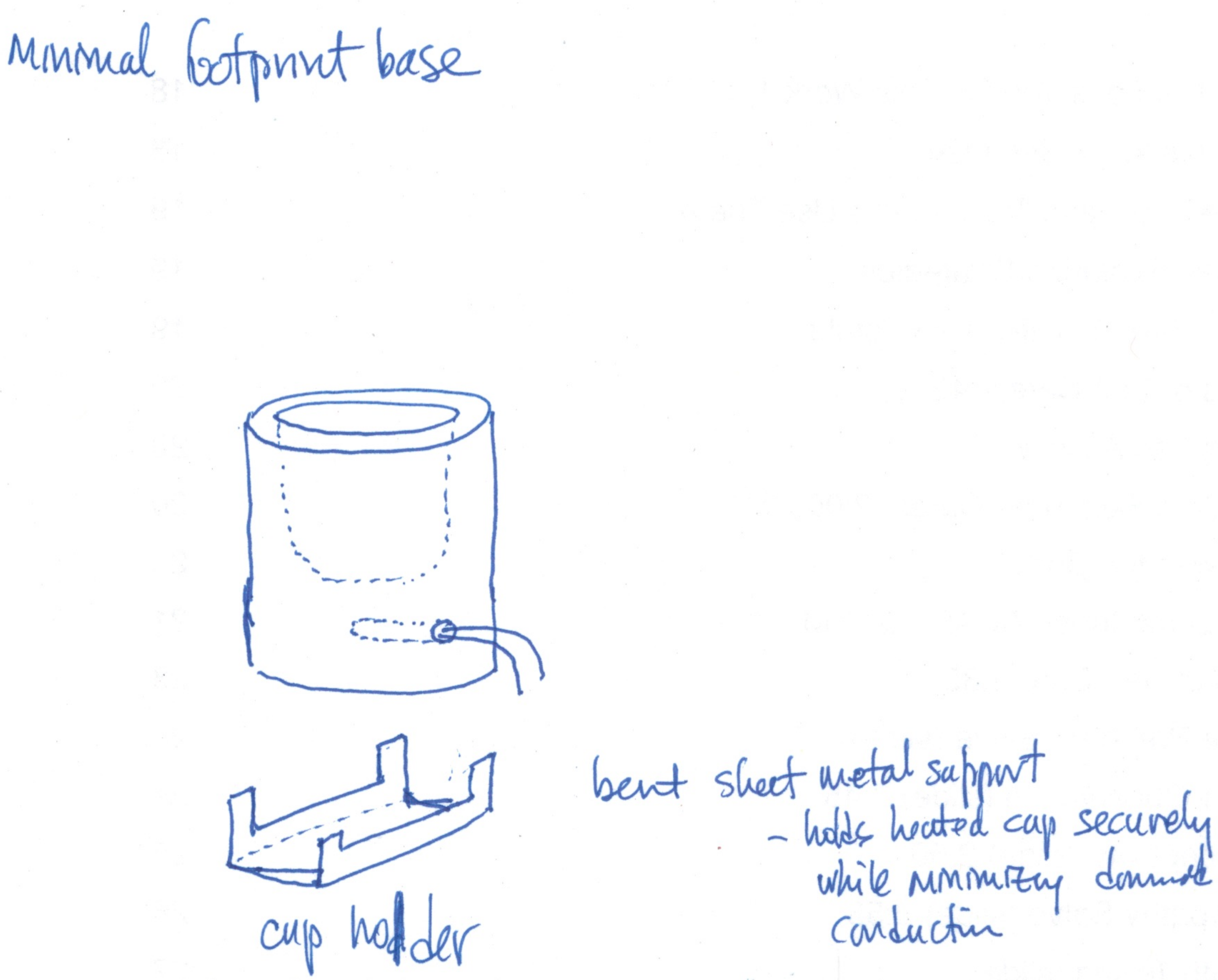
Concept Sketches

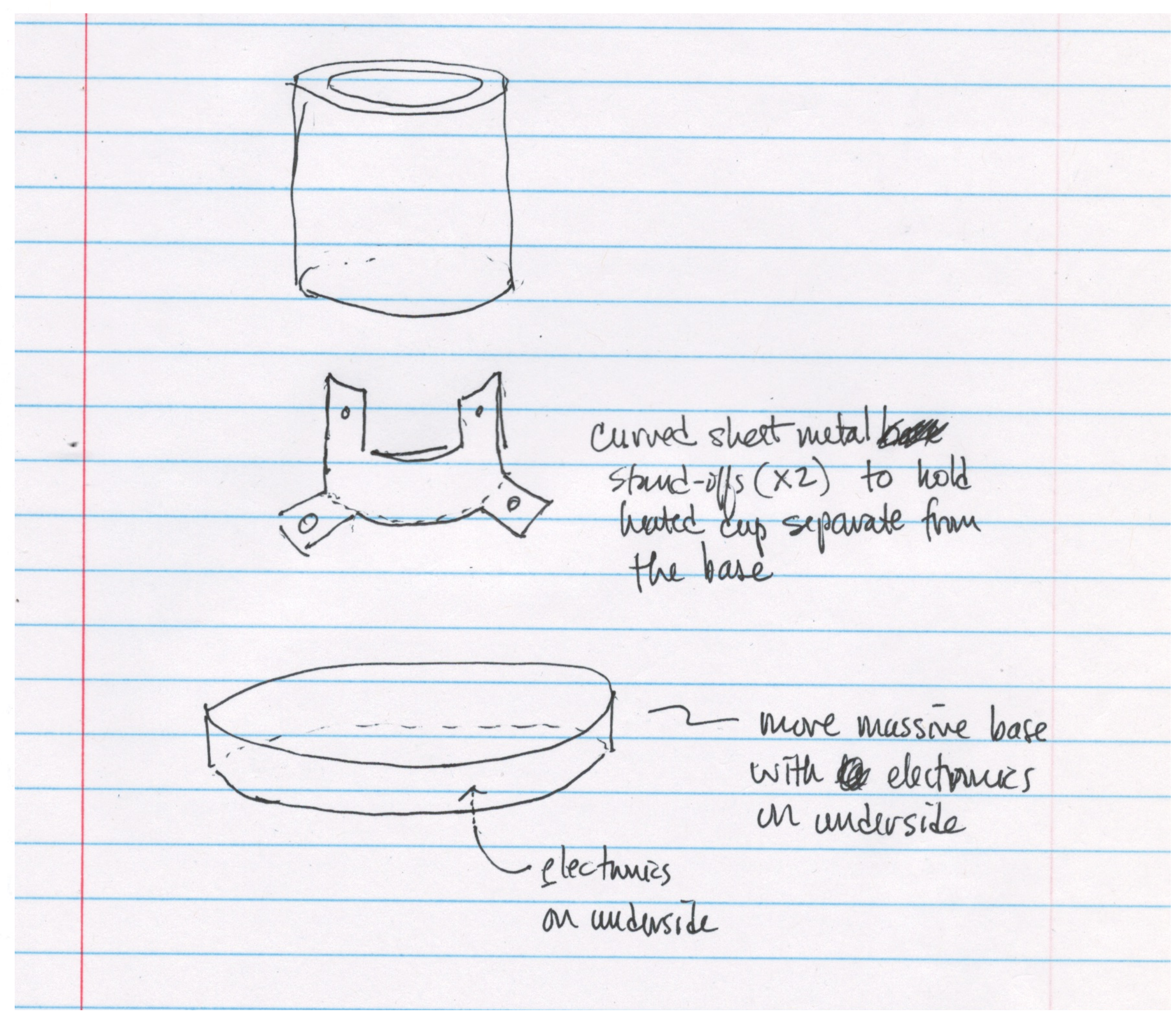
Design Concepts



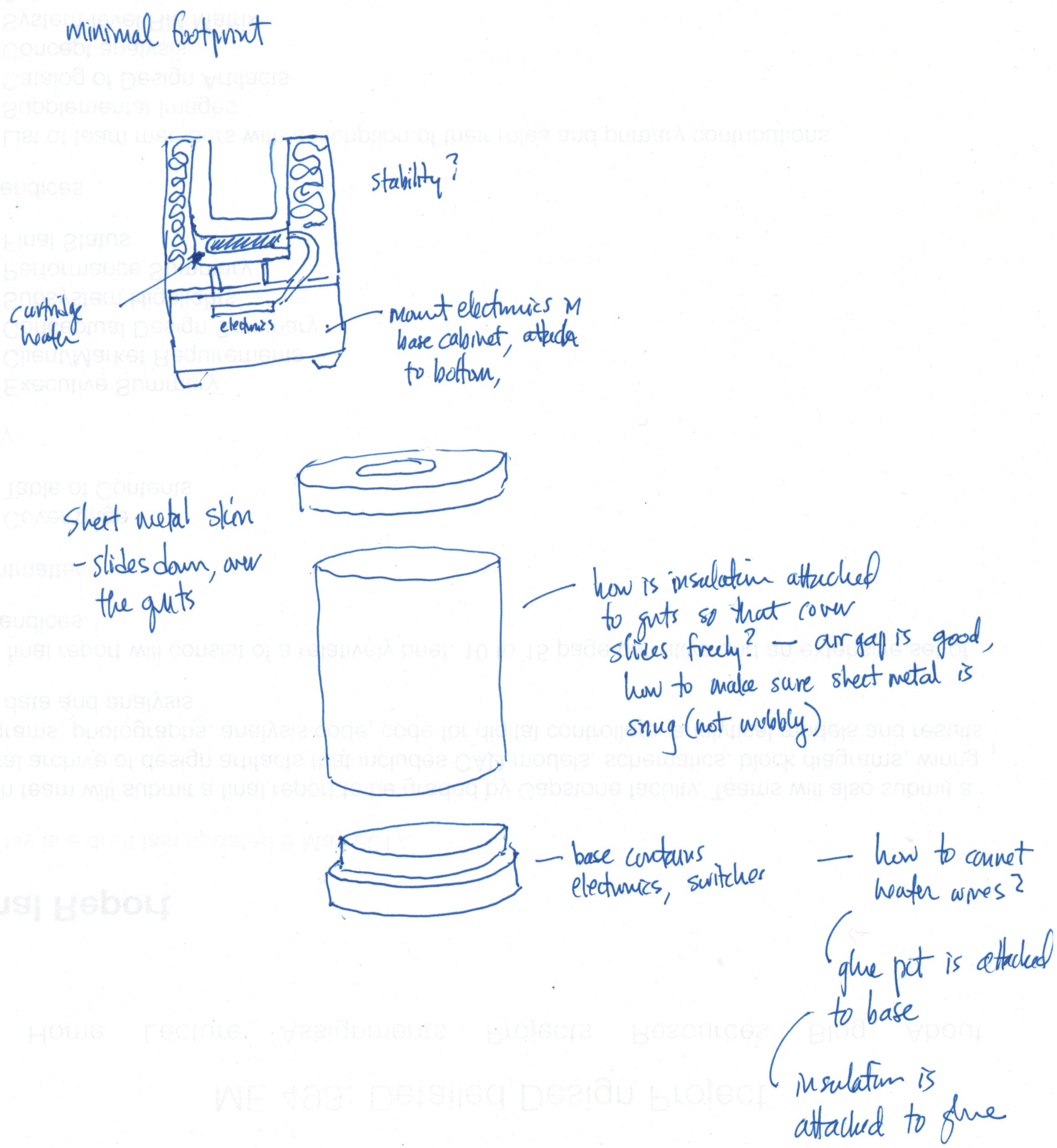


Design concepts

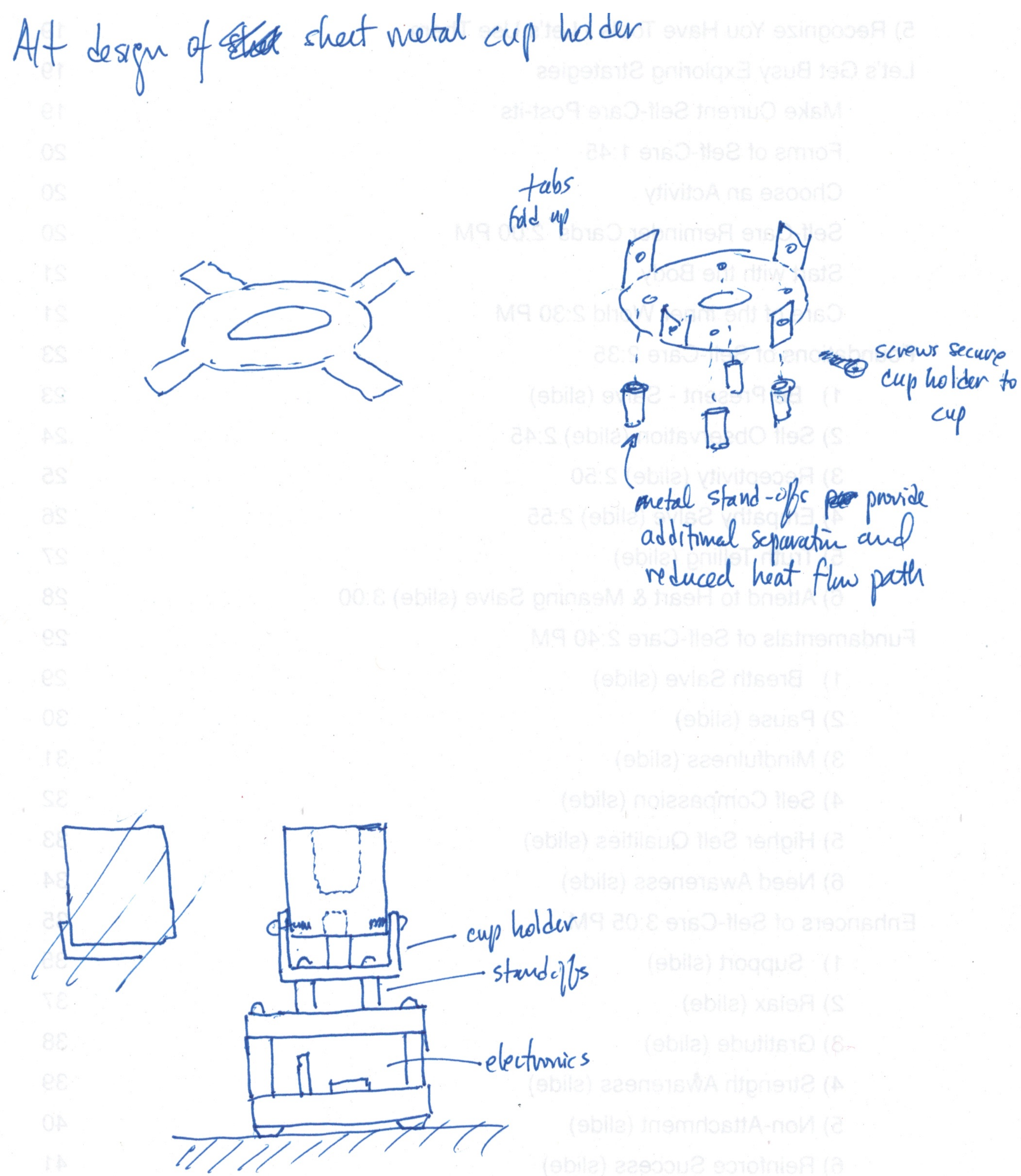




Design concepts



Design concepts



Design concepts