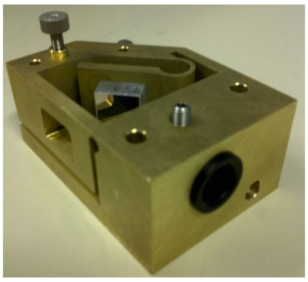
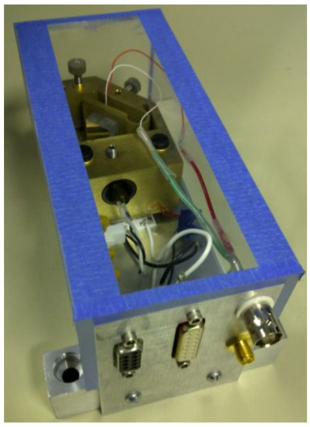
Grating-Stabilized Diode Laser (for 1064nm)

Chris Gerig , July 2011

This documentation describes the assembly of a tunable laser under the Littrow configuration, using a diffraction grating as the wavelength-selective element in the external resonator (as the end mirror).

The grating equation is $m\lambda = d(\sin\theta_i + \sin\theta_r)$, where $m \in \mathbb{Z}$ is the diffraction order and d is the line-spacing and θ_i (θ_r) is the incident (diffracted) angle which is measured from the normal vector of the grating plane. For our considerations we have $\theta_i = \theta_r$ and $m = 1$, so the desired incidence angle of the laser beam is $\theta = \arcsin(\frac{\lambda}{2d})$. Using $\lambda = 1064nm$ and $\frac{1}{d} = 1200/mm$ we get $\theta \approx 39.67^o$ (and if our source were $\lambda = 780nm$ then we would use $\frac{1}{d} = 1800/mm$ to get $\theta \approx 44.59^o$). Note that the angle of the grating plane with respect to the laser beam is $\theta_{gr} \equiv \frac{\pi}{2} - \theta$.

The bulk parts of this laser are the laser box (consisting of an aluminum base, an aluminum front panel, and a plexiglass cover) and a monolithic grating block made of phosphor bronze. This block houses the laser diode, collimation tube, grating which is glued to a hinged lever, and thermistor. It rests upon a thermoelectric cooler and mounts onto the base of the box. The grating/lever is manipulated by two adjustment screws, one which pushes the grating up and down, and one which is coupled to a piezoelectric stack and changes the angle θ_{gr} (note that θ_{gr} is machined to 40^o). Both the laser box and grating block were machined, based on SolidWorks drawings.

Here is the list of all the pieces required for this laser, minus controllers and current sources:
1) 9-pin d-sub current source circuit board
2) 3-pin 9mm diode socket
3) 1064nm 9mm laser diode
4) collimation tube
5) mounted 1064nm v-coated aspheric lens
6) 1200/mm UV holographic reflective grating
7) 10K thermistor
8) thermoelectric cooler
9) piezoelectric stack (Thorlabs AE0203D04F)
10) standard BNC connector
11) standard SMA connector
12) 15-pin d-sub connector

Additionally needed:
1) two #8-32 long plastic screws to mount the grating block onto the laser box
2) one #8-32 screw to pin the collimation tube into the grating block
3) one #4-40 screw to be used as an additional adjustment screw for the grating block
4) two #6-32 screws to mount the front panel onto the laser box
5) two #$\frac{1}{4}$-20 screws to mount the laser box onto a table
6) 5-minute epoxy to glue the grating onto the lever
7) thermally conductive epoxy to glue the thermistor into the grating block
8) thermal paste to coat the thermoelectric cooler

Fill the small hole in the backside of the grating block with the thermally conductive epoxy, place in the thermistor, and let it cure (possibly requiring a hotplate). Then dab a little 5-minute epoxy on two opposing corners of the grating and place it on the lever, positioned so that the center of the laser beam will hit the center of the grating, and that the grating orientation is correct (the grating's side containing a drawn arrow should be on top).

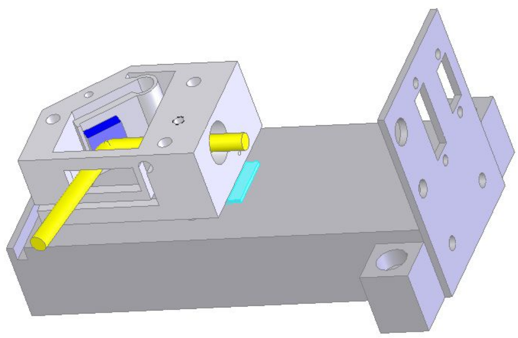
Wire the diode socket to the d-sub circuit board (only wiring the two pins corresponding to the lasing-diode), replace the lens in the collimation tube with the aspheric lens, put the laser diode in the collimation tube, connect it to the diode socket, and hook the circuit board up to a current source. Adjust the position of the diode so that the output beam is collimated (note: do not exceed the specified typical current on the diode, which is $390mA$). Once this is done, disconnect the diode socket from the diode and slide the collimation tube into the grating block, pinning it from above with the #8-32 screw.

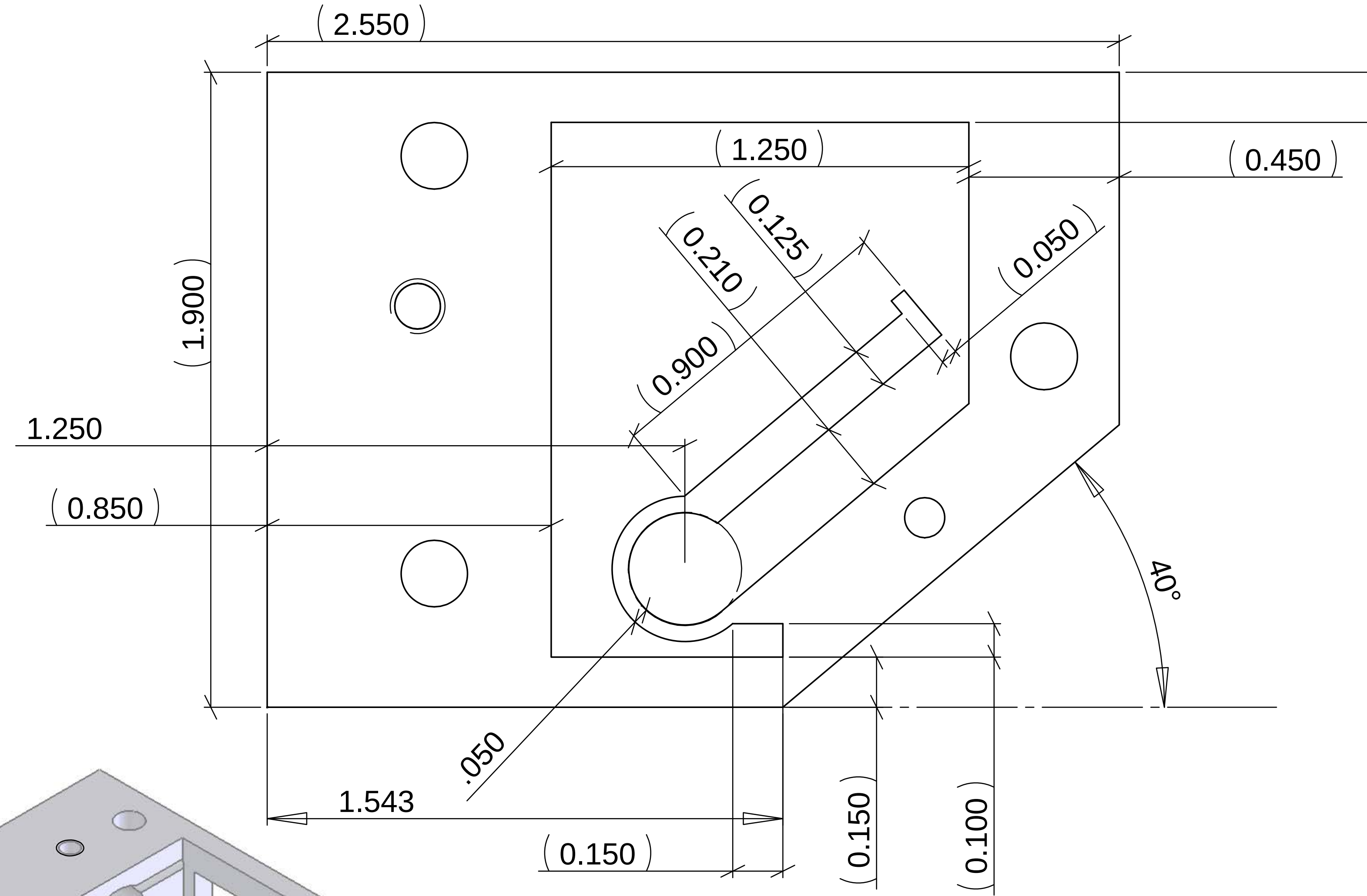
The next step is to align the S-polarization of the diode so that it is horizontal to the grating. To do this, hook the circuit board up to a current source and place the output beam through a polarizing beam-splitter. Using a power meter, rotate the collimation tube in the grating block until the output power is maximized, and then pin it down again.

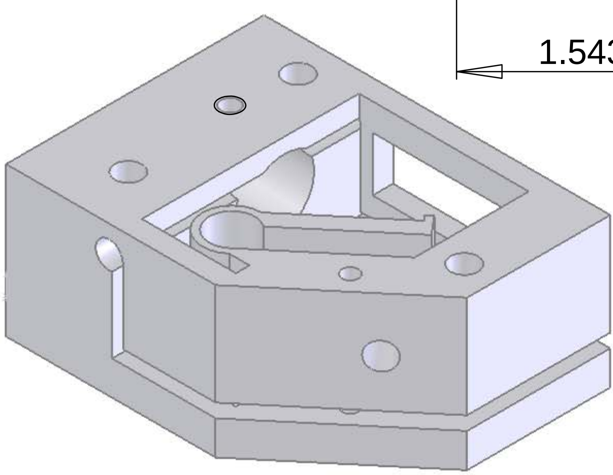
Now double check the ILX Lightwave Temperature Controller handbook for the pin-out diagram of the 15-pin d-sub connector, and wire pins 1+2 to the positive terminal of the thermoelectric cooler and pins 3+4 to the negative terminal of the thermoelectric cooler and pins 7+8 to the positive+negative terminals of the thermistor.

Then hook up the 15-pin d-sub connector and 9-pin d-sub circuit board to the front panel of the laser box (after screwing that panel onto the base). Coat the thermoelectric cooler with thermal paste (using a razorblade to wipe the two surfaces so that only a little paste is existent), and mount the grating block onto the laser box with the thermoelectric cooler directly below the location of the collimation tube and directly between the two #8-32 mounting screws. Finally, wire the piezoelectric stack to the BNC connector and hook it up to the front panel, along with the SMA connector (which won't be used unless needed for some future purpose), and pin the piezo in the hinge slot using the adjustment screw.

All that is left to do is vary θ_{gr} until 1064nm lasing occurs, being aware of possible mode-hops. To do this, first hook up the laser to the current/thermal sources. Two output beams will be present and close to each other (the $m = 0$ and $m = 1$ orders). At the desired $\theta_i = \theta_r \approx 40^o$ the two modes will overlap, retroflecting the 1064nm wavelength back into the cavity and thus producing the necessary feedback/lasing. Use the adustment screws to course-adjust θ_{gr} until the beams overlap. Then hook up a function generator to both the current source (the current modulation port) and an oscilloscope, and hook up a photodiode to the other channel of the oscilloscope. Tune the beam's input current to where the beam starts lasing, and then shine the beam at the photodiode and put on a small AC voltage (via the function generator). In xy-mode of the oscilloscope, the threshold for lasing can be viewed, so we can fine-adjust the grating until that threshold is at a visual minimum.







Material: Phosphor Bronze

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

Chris Gerig
cgerig@berkeley.edu
Birge B123

Stamper-Kurn Group

TITLE:

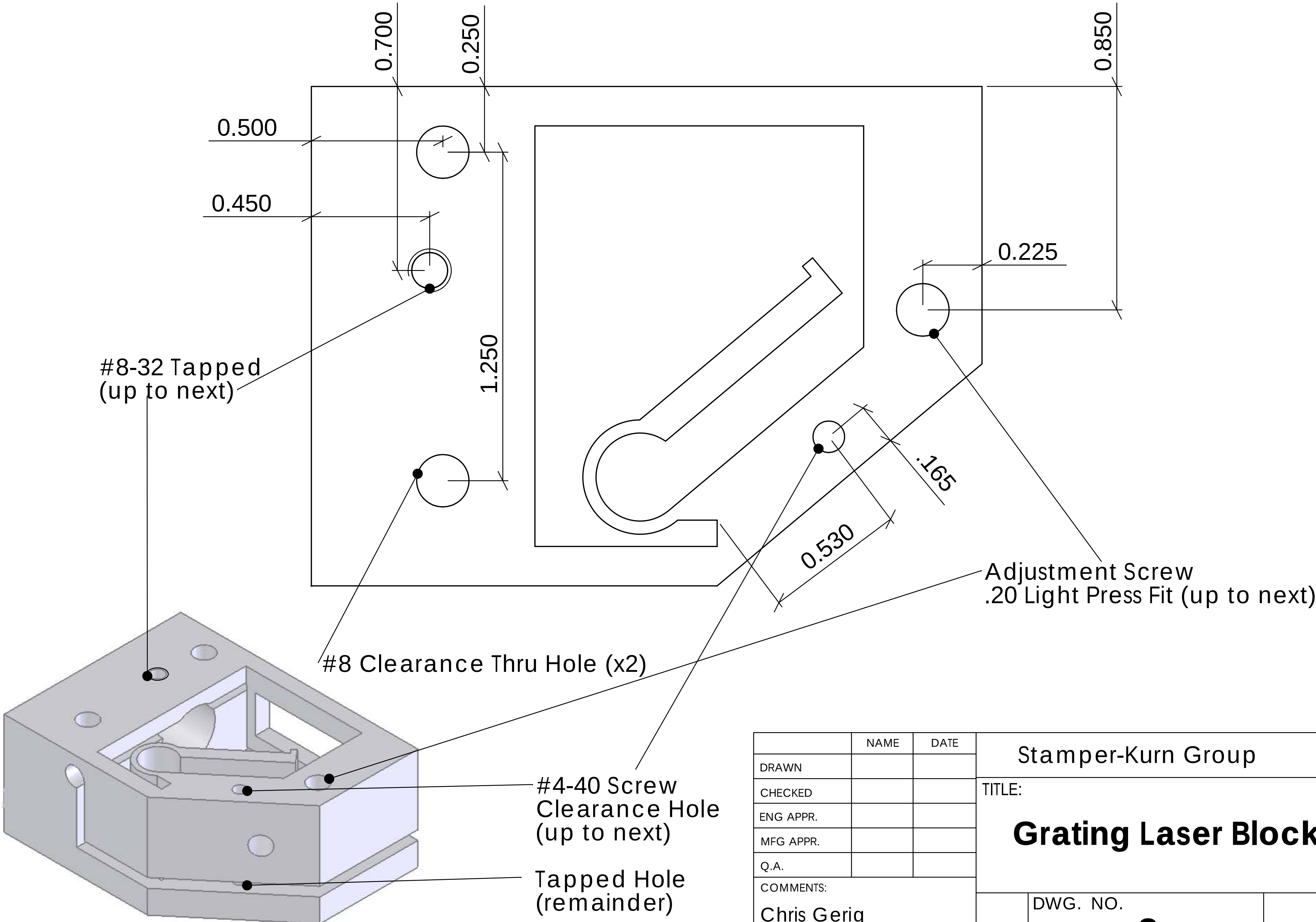
Grating Laser Block

DWG. NO.
1

SCALE: 1:1

SHEET 1 OF 1

5 4 3 2 1



	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

Chris Gerig
cgerig@berkeley.edu
Birge B123

Stamper-Kurn Group

TITLE:

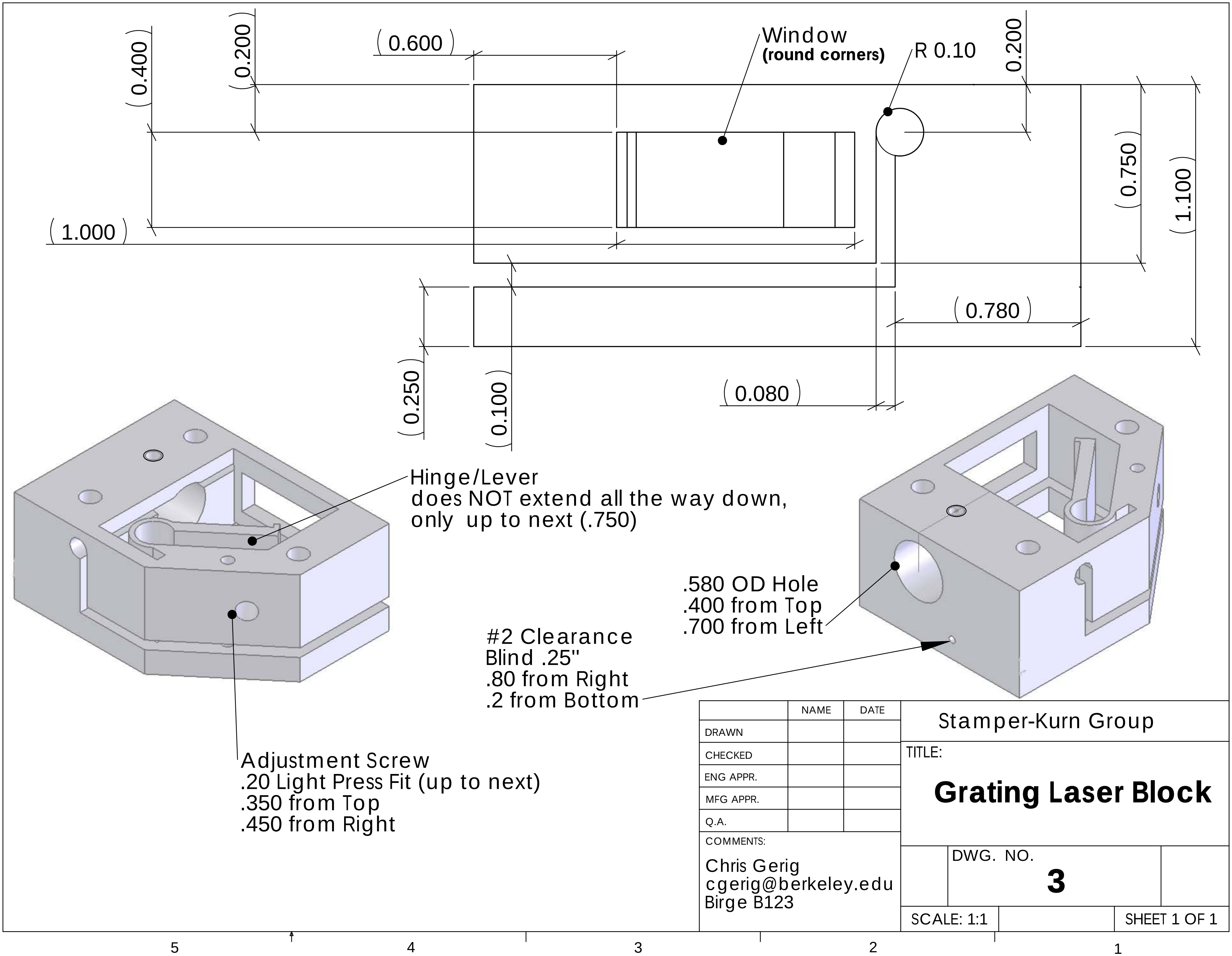
Grating Laser Block

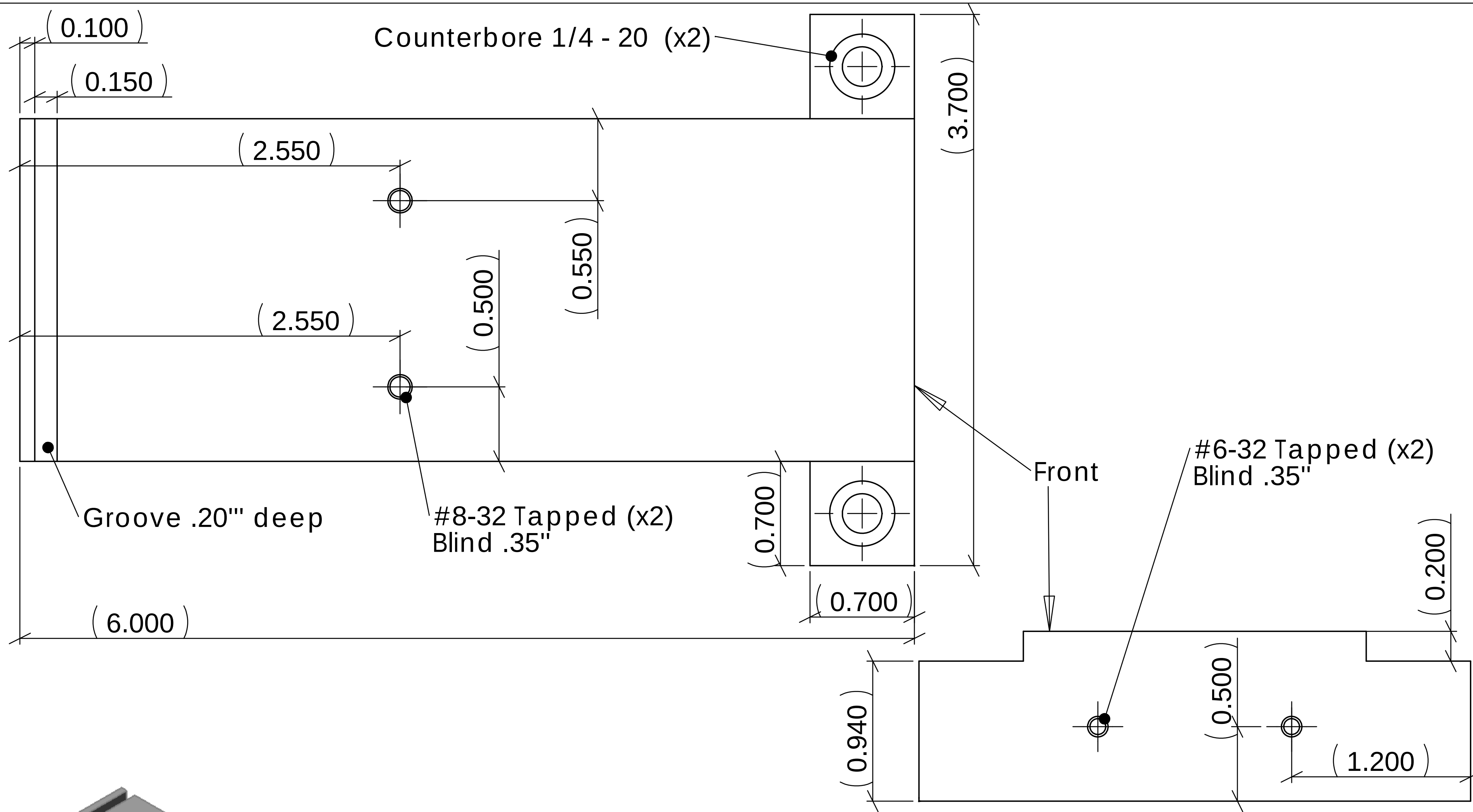
DWG. NO. **2**

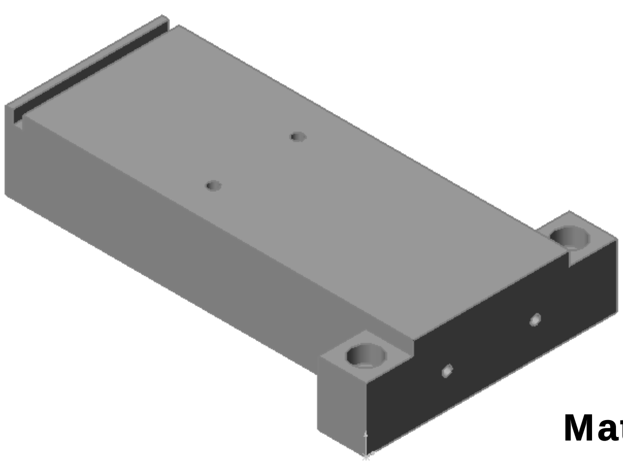
SCALE: 1:1

SHEET 1 OF 1

5 4 3 2 1


Window
(round corners)
R 0.10
0.600
0.400
0.200
0.200
1.000
0.750
1.100
0.780
0.250
0.100
0.080
Hinge/Lever
does NOT extend all the way down,
only up to next (.750)
.580 OD Hole
.400 from Top
.700 from Left
#2 Clearance
Blind .25"
.80 from Right
.2 from Bottom
Adjustment Screw
.20 Light Press Fit (up to next)
.350 from Top
.450 from Right
NAME
DATE
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
Chris Gerig
cgerig@berkeley.edu
Birge B123
Stamper-Kurn Group
TITLE:
Grating Laser Block
DWG. NO.
3
SCALE: 1:1
SHEET 1 OF 1
5
4
3
2
1





Material: Aluminum

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

Chris Gerig
cgerig@berkeley.edu
Birge B123

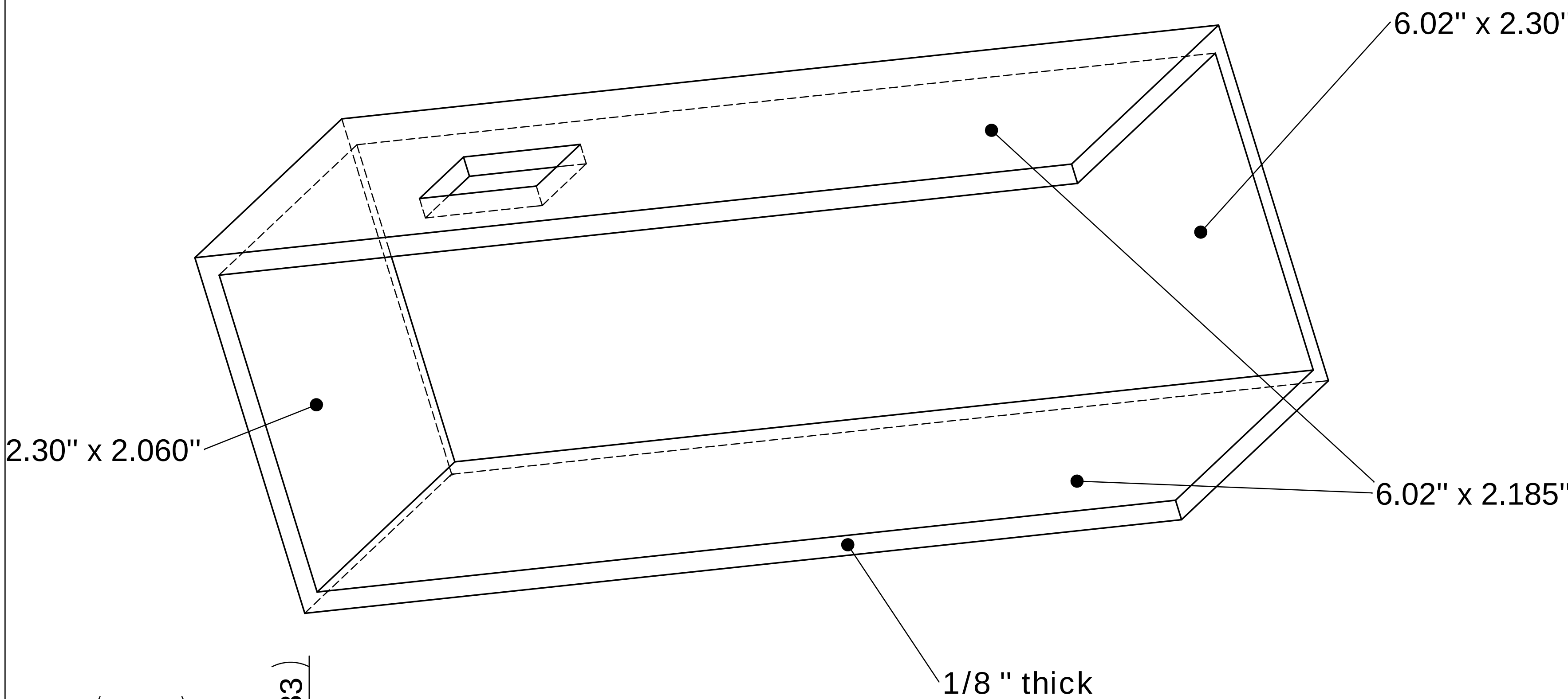
Stamper-Kurn Group

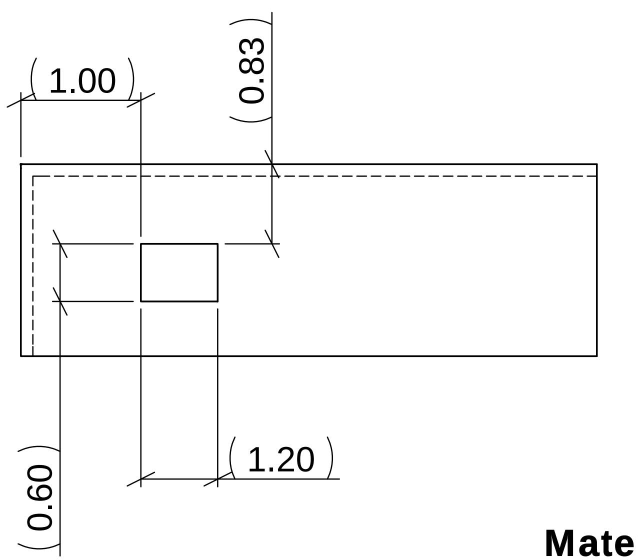
TITLE:

Laser Box

DWG. NO. **1**

SCALE: 1:1 | SHEET 1 OF 1





Material: Plexiglass
(4 pieces bonded)

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

Chris Gerig
cgerig@berkeley.edu
Birge B123

Stamper-Kurn Group

TITLE:

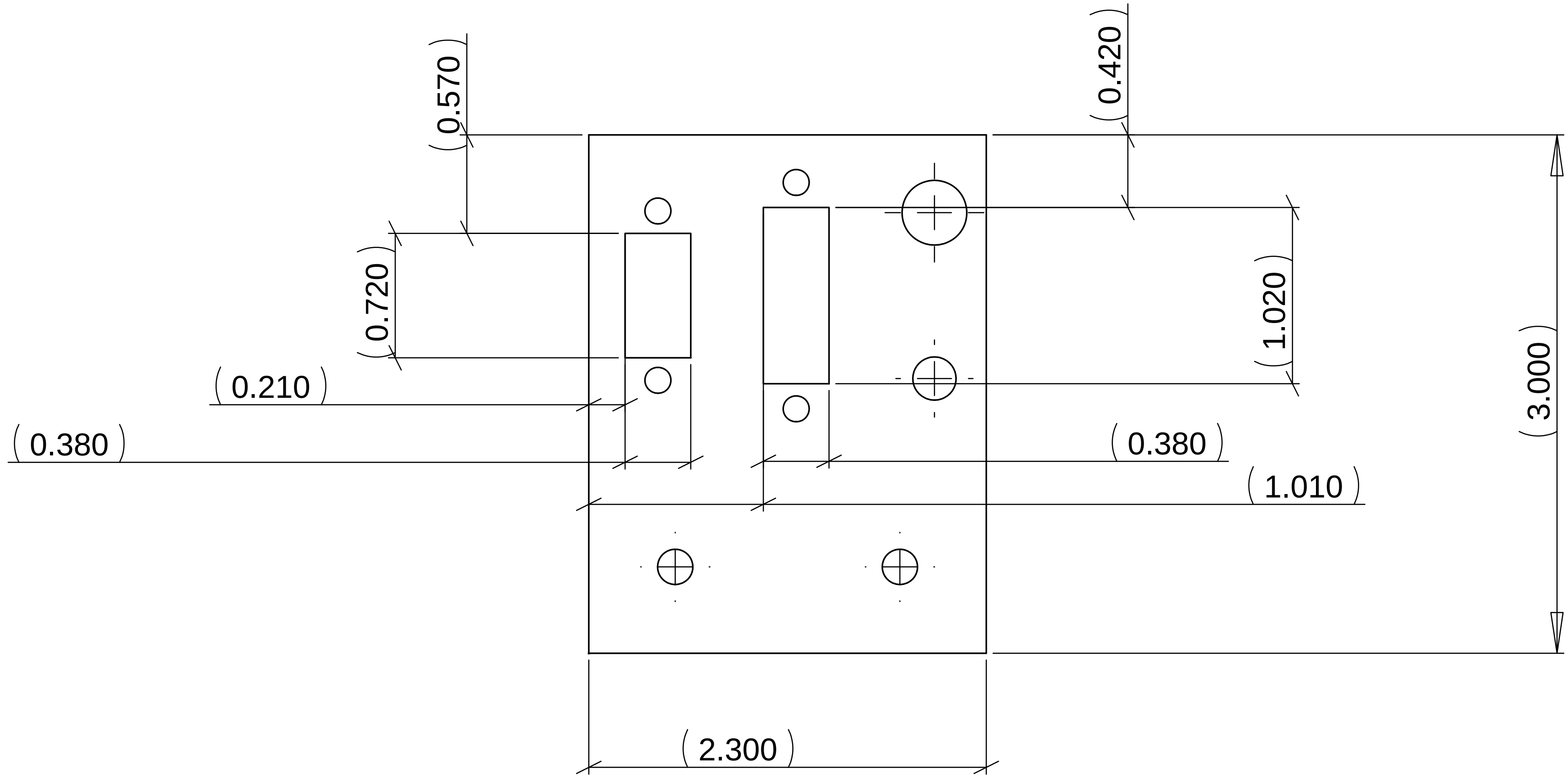
Laser Box Cover

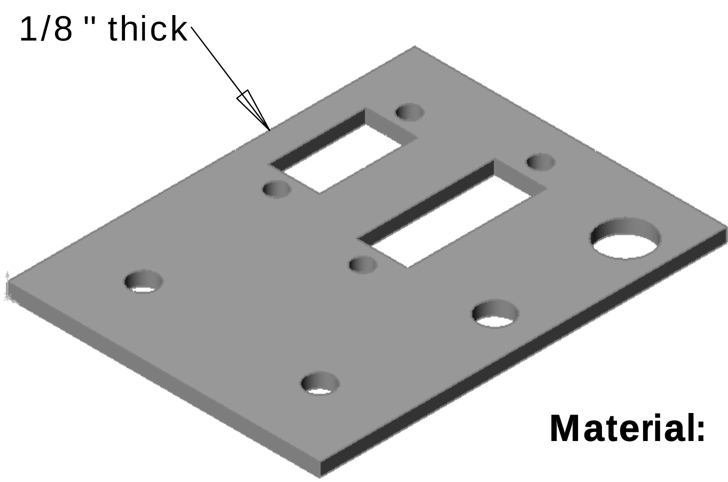
DWG. NO.
1

SCALE: 1:2

SHEET 1 OF 1

5 4 3 2 1





Material: Aluminum

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

Chris Gerig
cgerig@berkeley.edu
Birge B123

Stamper-Kurn Group

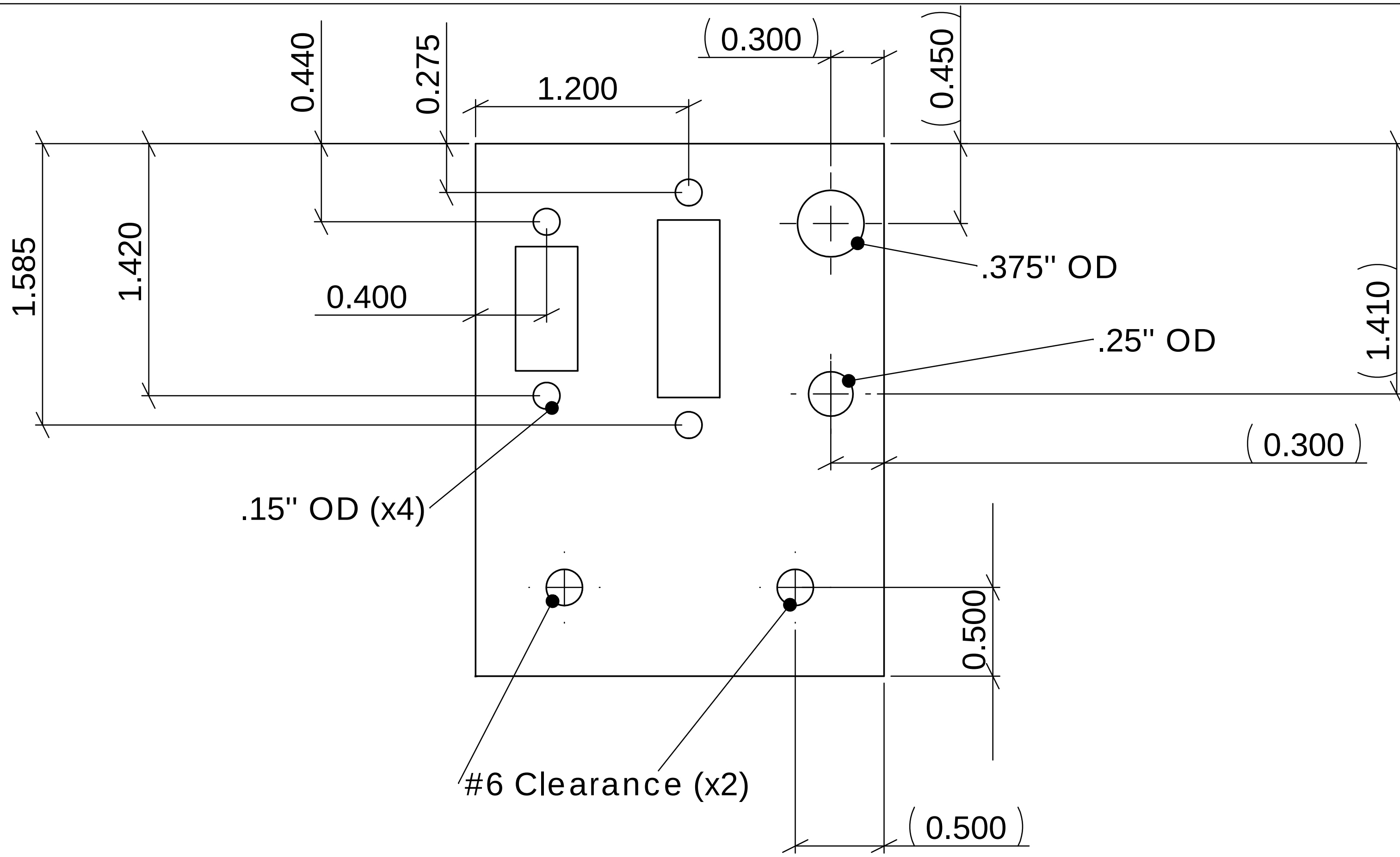
TITLE:

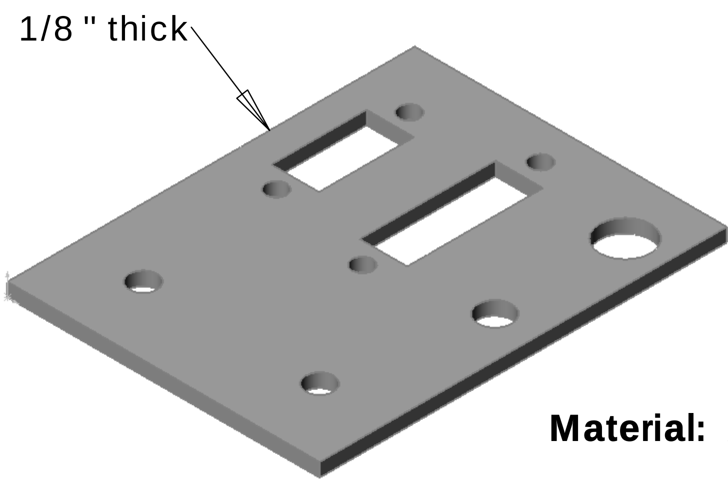
Laser Box Plate

DWG. NO.
1

SCALE: 1:1 | SHEET 1 OF 1

5 4 3 2 1





Material: Aluminum

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

Chris Gerig
cgerig@berkeley.edu
Birge B123

Stamper-Kurn Group

TITLE:

Laser Box Plate

DWG. NO. **2**

SCALE: 1:1

SHEET 1 OF 1

5 4 3 2 1