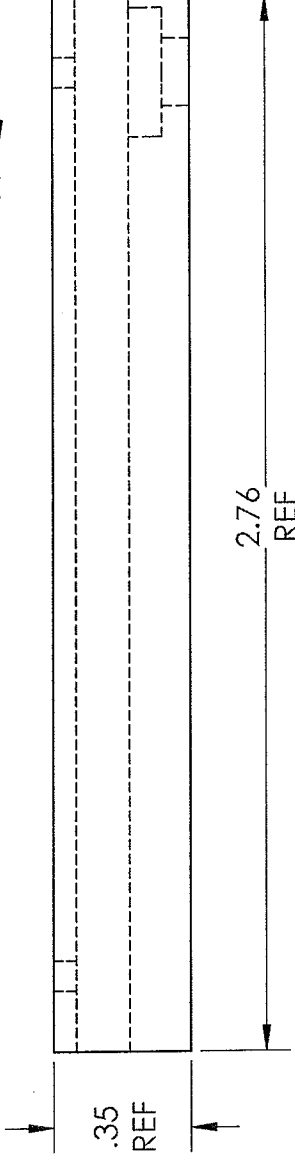
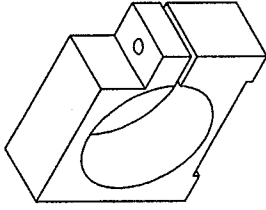
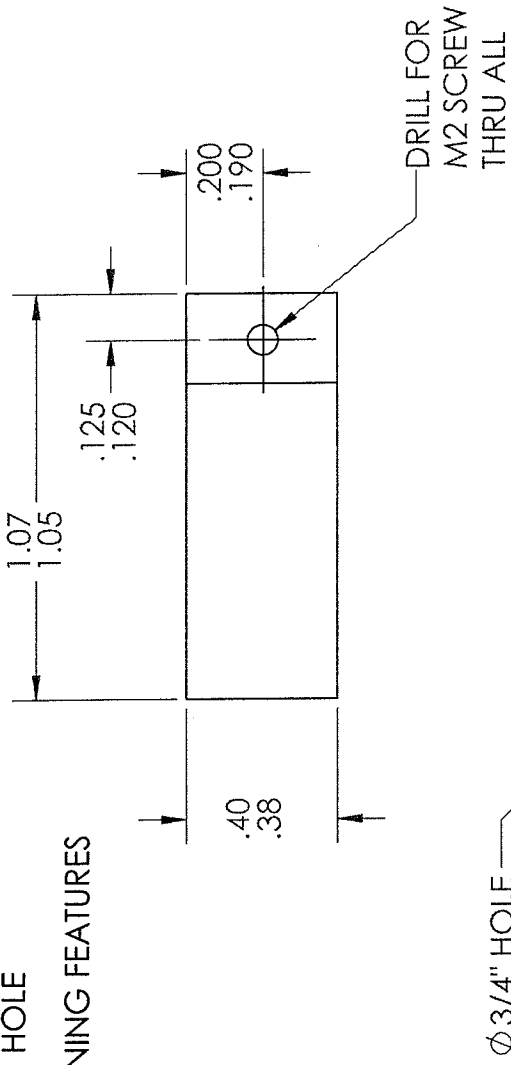


SECTION A-A  
SCALE 2:1

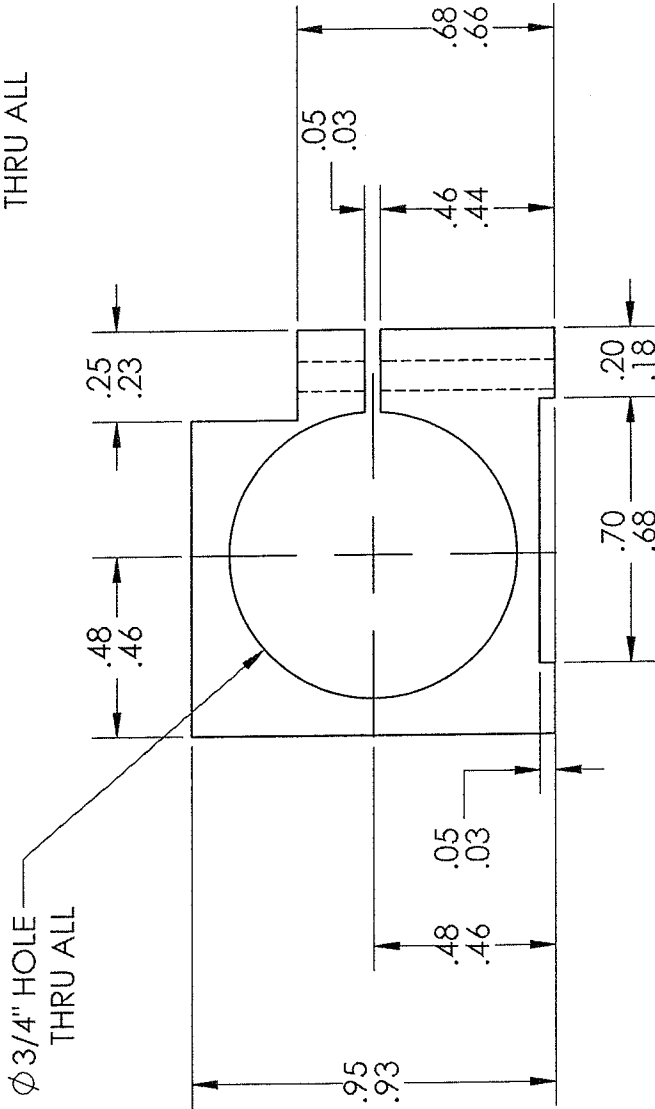


UNLESS OTHERWISE STATED DIMENSIONS ARE IN INCHES		NAME	DATE
TOLERANCES: TWO PLACE DECIMAL ± .01		BJO	2/16/12
THREE PLACE DECIMAL ± .005		RWH	2/17/12
MATERIAL STEEL		COMMENTS:	
PART NAME: MANIPULATOR RAIL GUIDE DRILL HOLES		SCALE: 2:1	

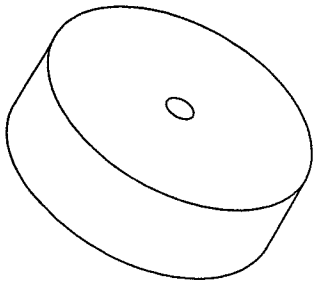
- NOTE:  
 1. MACHINE 1.06 X .39 X .94 BLOCK  
 2. DRILL M2 SCREW HOLE  
 3. DRILL 3/4" HOLE  
 4. MACHINE REMAINING FEATURES



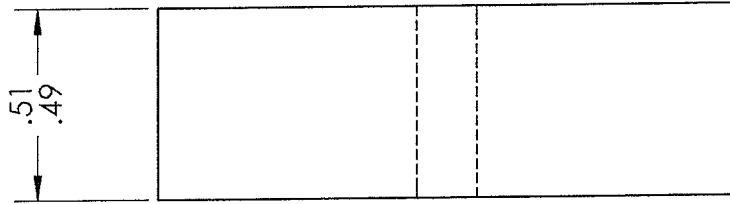
SCALE  
1:1



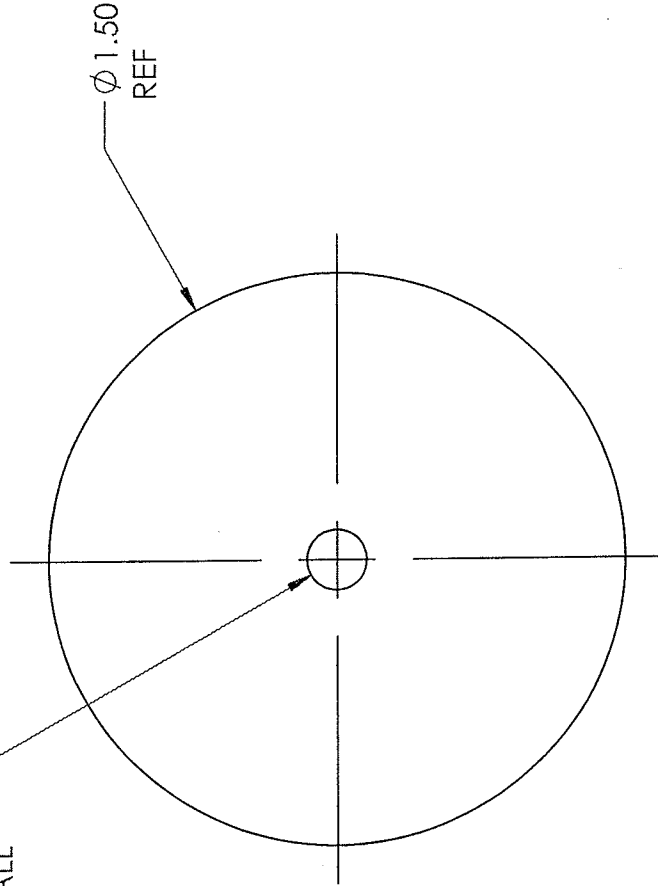
UNLESS OTHERWISE STATED DIMENSIONS ARE IN INCHES		NAME	DATE
TOLERANCES: TWO PLACE DECIMAL $\pm .01$ THREE PLACE DECIMAL $\pm .005$		BJO	2/16/12
MATERIAL ABS PLASTIC		RWH	2/17/12
COMMENTS:		PART NAME: MANIPULATOR PISTON CYLINDER MOUNT	
		SCALE: 2:1	



SCALE  
1:1

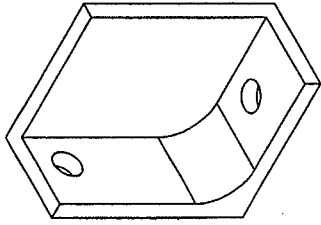


DRILL AND TAP  
FOR M4 SCREW  
THRU ALL

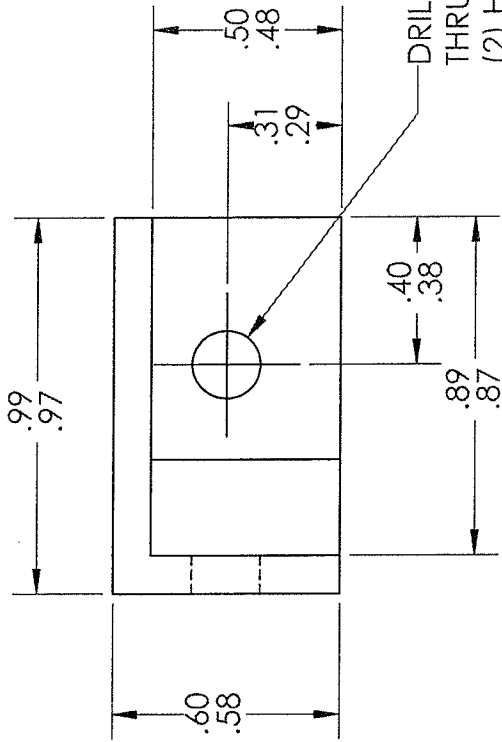


UNLESS OTHERWISE STATED DIMENSIONS ARE IN INCHES		NAME	DATE	PART NAME:	
TOLERANCES: TWO PLACE DECIMAL $\pm .01$ THREE PLACE DECIMAL $\pm .005$		BJO	2/18/12	MANIPULATOR MOUNTING BLOCK	
MATERIAL $\phi$ 1.5" ALUMINUM STOCK		RWH	2/19/12	COMMENTS:	
				SCALE: 2:1	

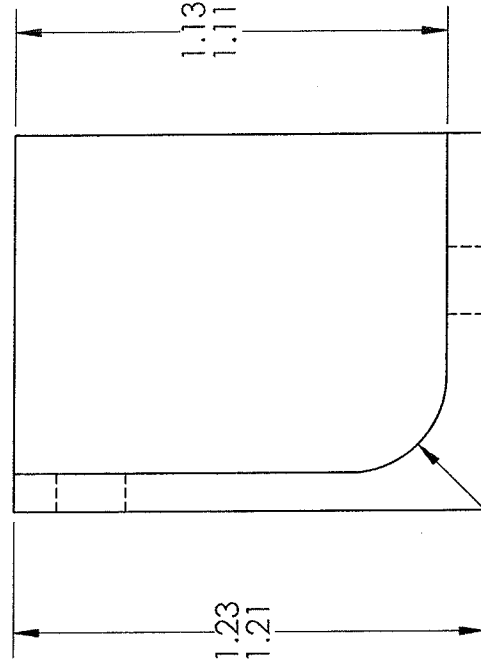
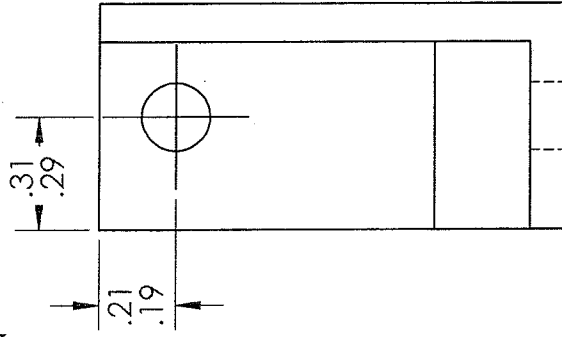
- NOTE:  
 1. MACHINE .98 X .59 X 1.22 BLOCK  
 2. MACHINE SLOT  
 3. DRILL AND TAP M4 SCREW HOLES



SCALE  
1:1



DRILL FOR M4 SCREW  
THRU ALL  
(2) HOLE LOC AS SHOWN

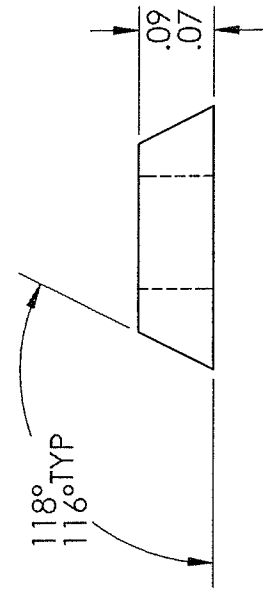
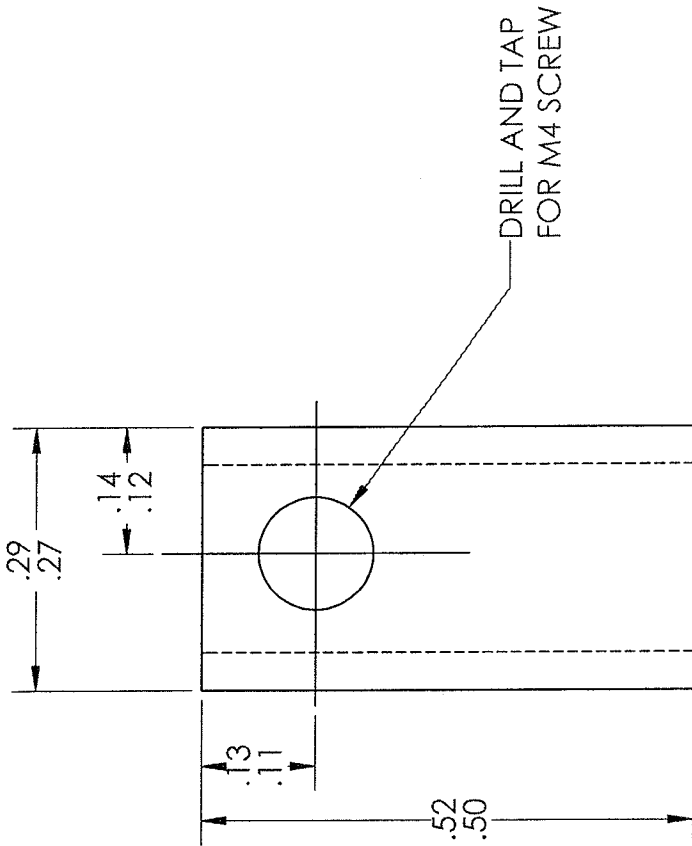


R.25

UNLESS OTHERWISE STATED DIMENSIONS ARE IN INCHES		NAME	DATE	PART NAME:	
TOLERANCES: TWO PLACE DECIMAL ± .01 THREE PLACE DECIMAL ± .005		BJO	2/18/12	MANIPULATOR ELBOW BRACKET	
MATERIAL ALUMINUM		CHECKED RWH	2/19/12	COMMENTS:	
				SCALE: 2:1	

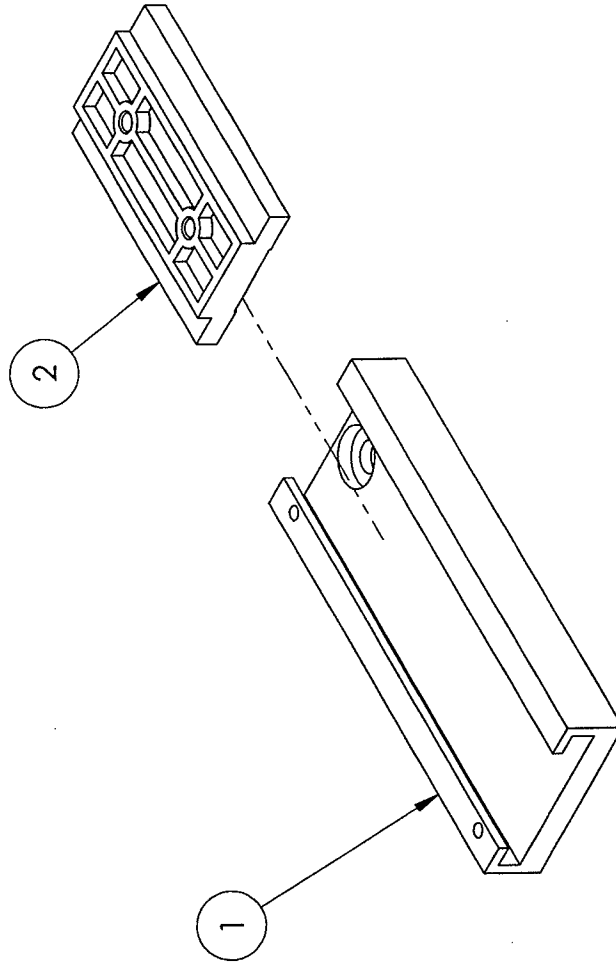


SCALE  
1:1



UNLESS OTHERWISE STATED DIMENSIONS ARE IN INCHES TOLERANCES: TWO PLACE DECIMAL ± .01 THREE PLACE DECIMAL ± .005		NAME	DATE	PART NAME:	
DRAWN	BJO	2/18/12	MANIPULATOR PIPETTE MOUNT SLIDE		
CHECKED	RWH	2/19/12			
MATERIAL ALUMINIUM		COMMENTS:		SCALE: 5:1	

NOTE:  
 1. SLIDE CARRIAGE INTO RAIL  
 FOR EACH AXIS (X3)

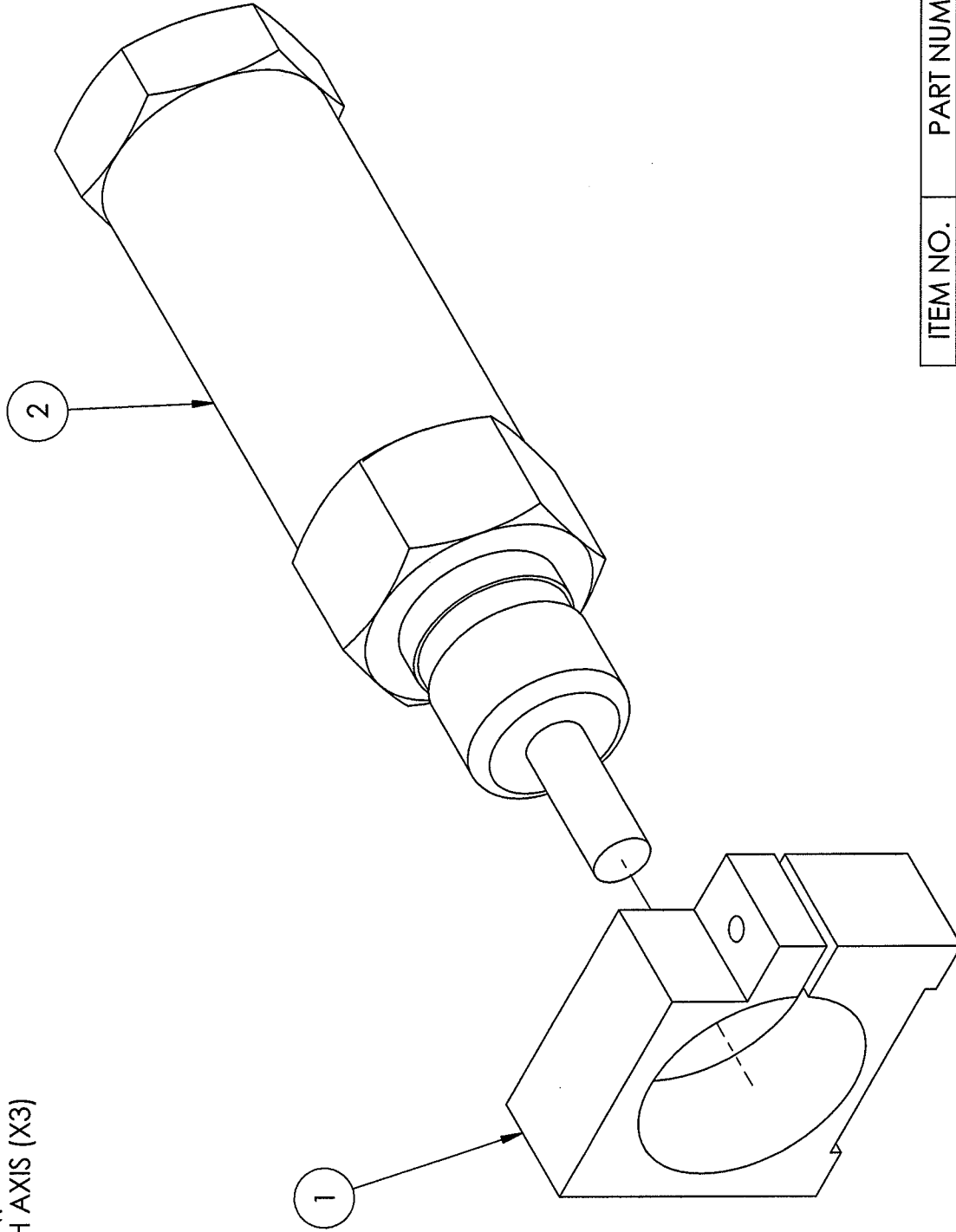


ITEM NO.	PART NUMBER	QTY.
1	LPM27R_0075_Y_10m m RAIL	1
2	MODIFIED.SLDASM LPM27C CARRIAGE	1

NAME	DATE	ASSEMBLY NAME:
DRAWN BJO	2/18/12	CARRIAGE INTO RAIL
CHECKED RWH	2/19/12	

COMMENTS:  
 SCALE: 1:1

1. INSERT PISTON CYLINDER INTO PISTON  
 2. DO FOR EACH AXIS (X3)

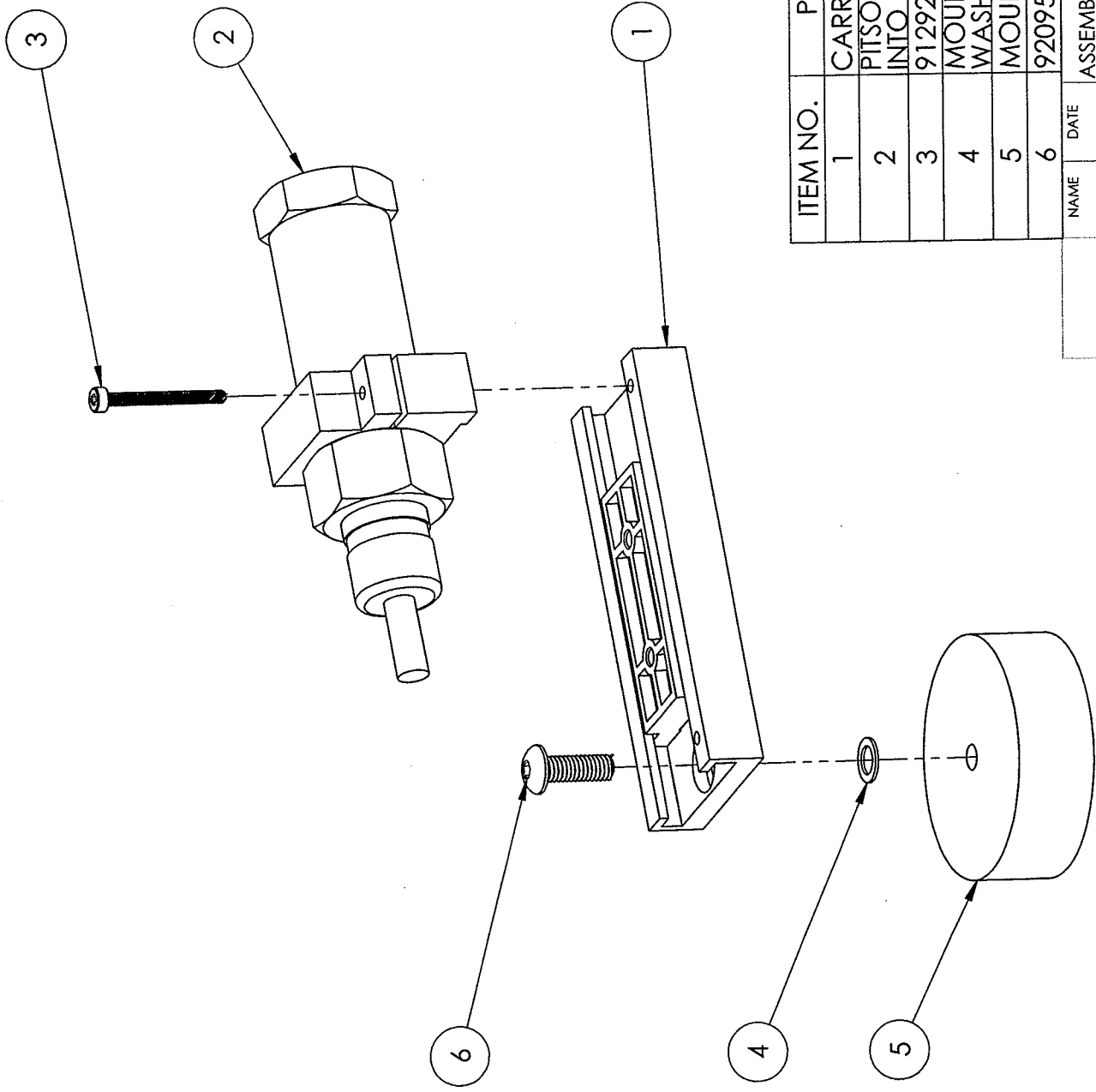


ITEM NO.	PART NUMBER	QTY.
1	PISTON CYLINDER MOUNT	1
2	PISTON CYLINDER	1

NAME	DATE	ASSEMBLY NAME:
BJO	2/18/12	PISTON CYLINDER INTO MOUNT
RWH	2/19/12	

COMMENTS:

SCALE: 1:1



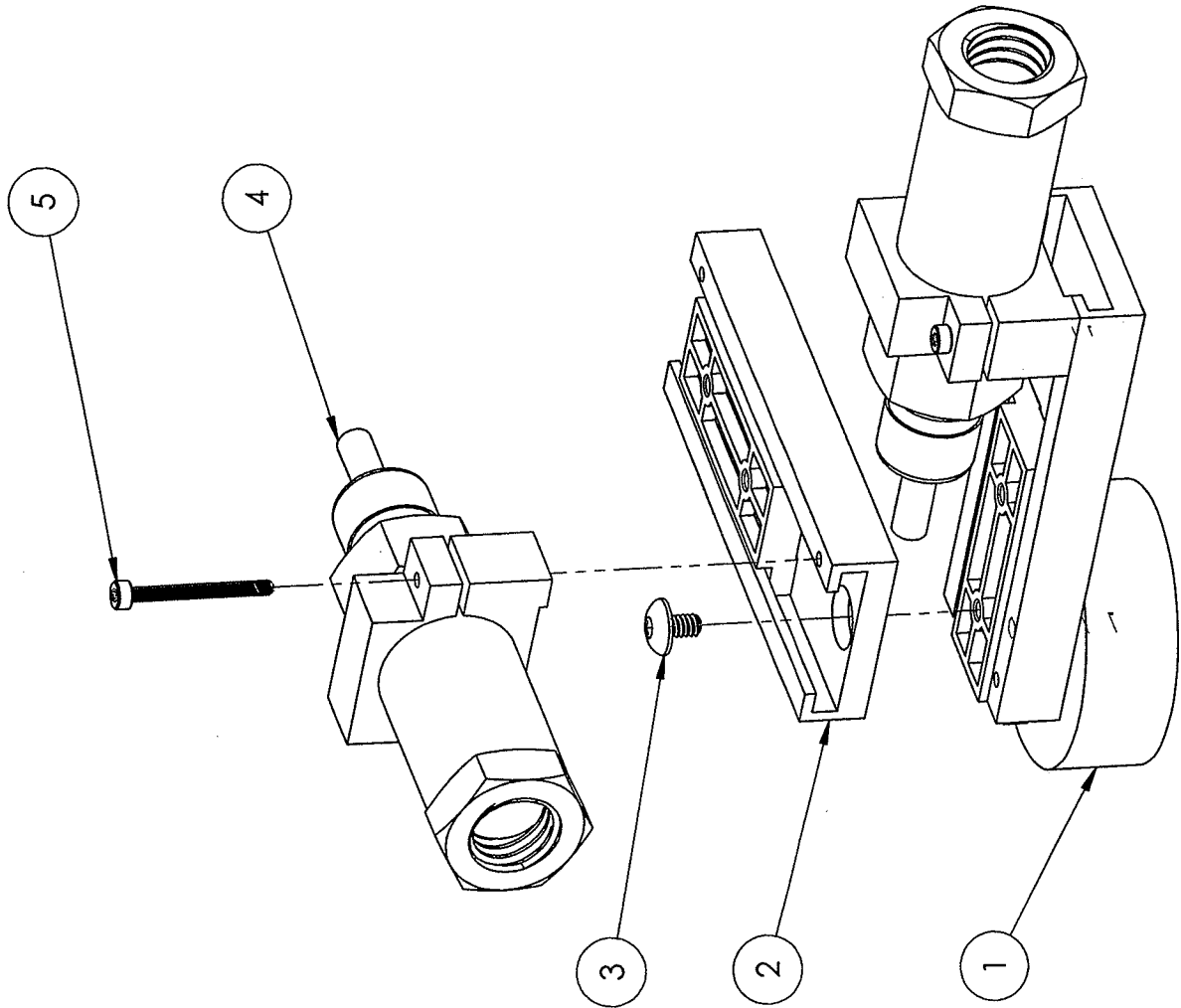
ITEM NO.	PART NUMBER	QTY.
1	CARRIAGE INTO RAIL	1
2	PITSON CYLINDER INTO MOUNT	1
3	91292A013 M2 20 MM	1
4	MOUNT BLOCK	1
5	MOUNTING BLOCK	1
6	92095A192 M4 12 MM	1

NAME		DATE	
BJO		2/19/12	
RWH		2/19/12	
ASSEMBLY NAME: X-AXIS			

DRAWN  
 CHECKED  
 COMMENTS:

SCALE: 1:1





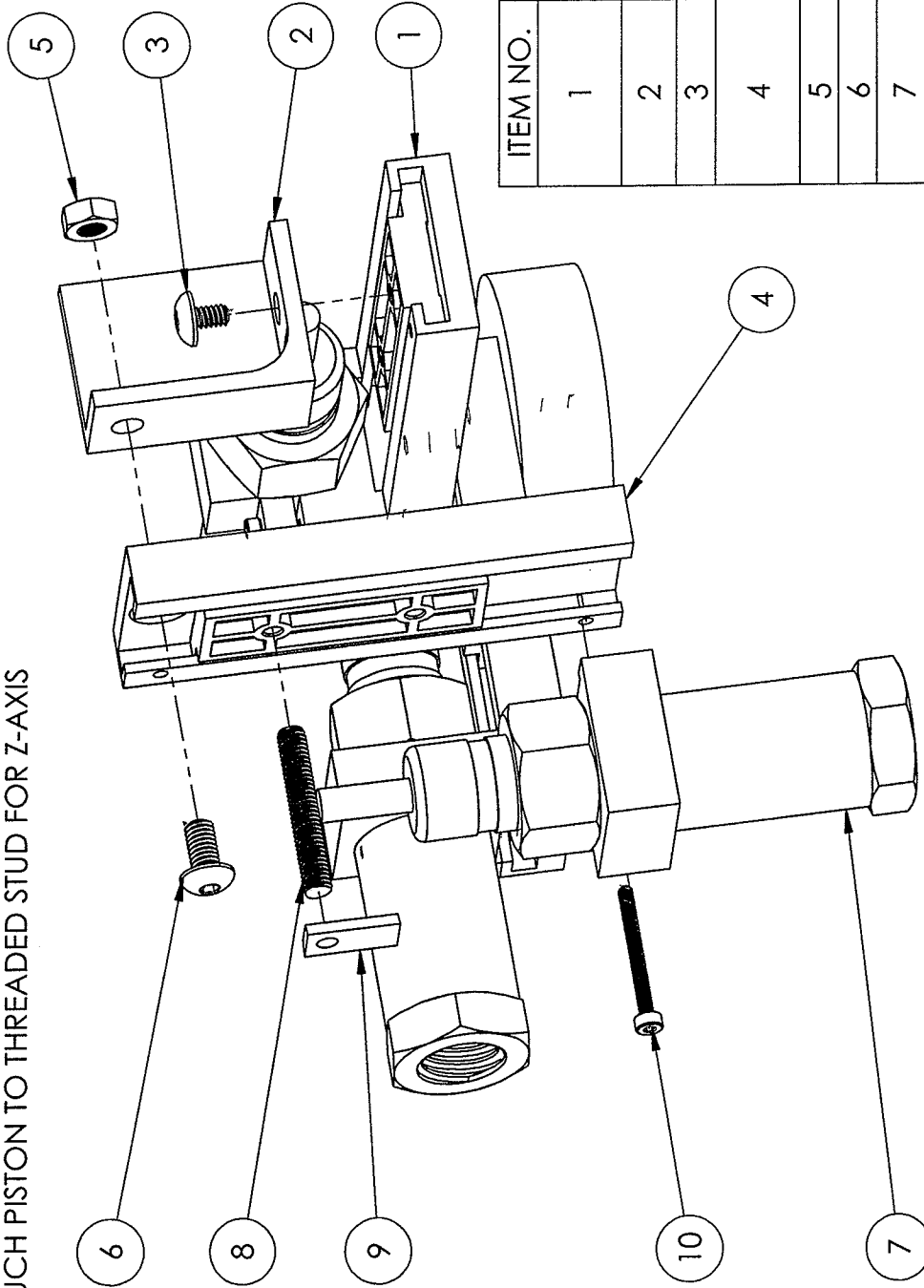
ITEM NO.	PART NUMBER	QTY.
1	PREVIOUSLY ASSEMBLED X-AXIS	1
2	CARRIAGE INTO RAIL	1
3	91239A136 M4 5 MM	1
4	PISTON CYLINDER INTO MOUNT	1
5	91292A013 M2 20 MM	1

ASSEMBLY NAME:	
Y-AXIS ATTACHMENT	
NAME	DATE
BJO	2/19/12
RWH	2/19/12
DRAWN	
CHECKED	
COMMENTS:	

SCALE: 1:1

**NOTE:**

1. ATTACH Z-AXIS AS SHOWN
2. APPLY EPOXY TO TIP OF PISTONS (X3)
3. TOUCH PISTON TO OPPOSING PISTON CYLINDER MOUNTING BLOCK FOR X AND Y AXIS
4. TOUCH PISTON TO THREADED STUD FOR Z-AXIS

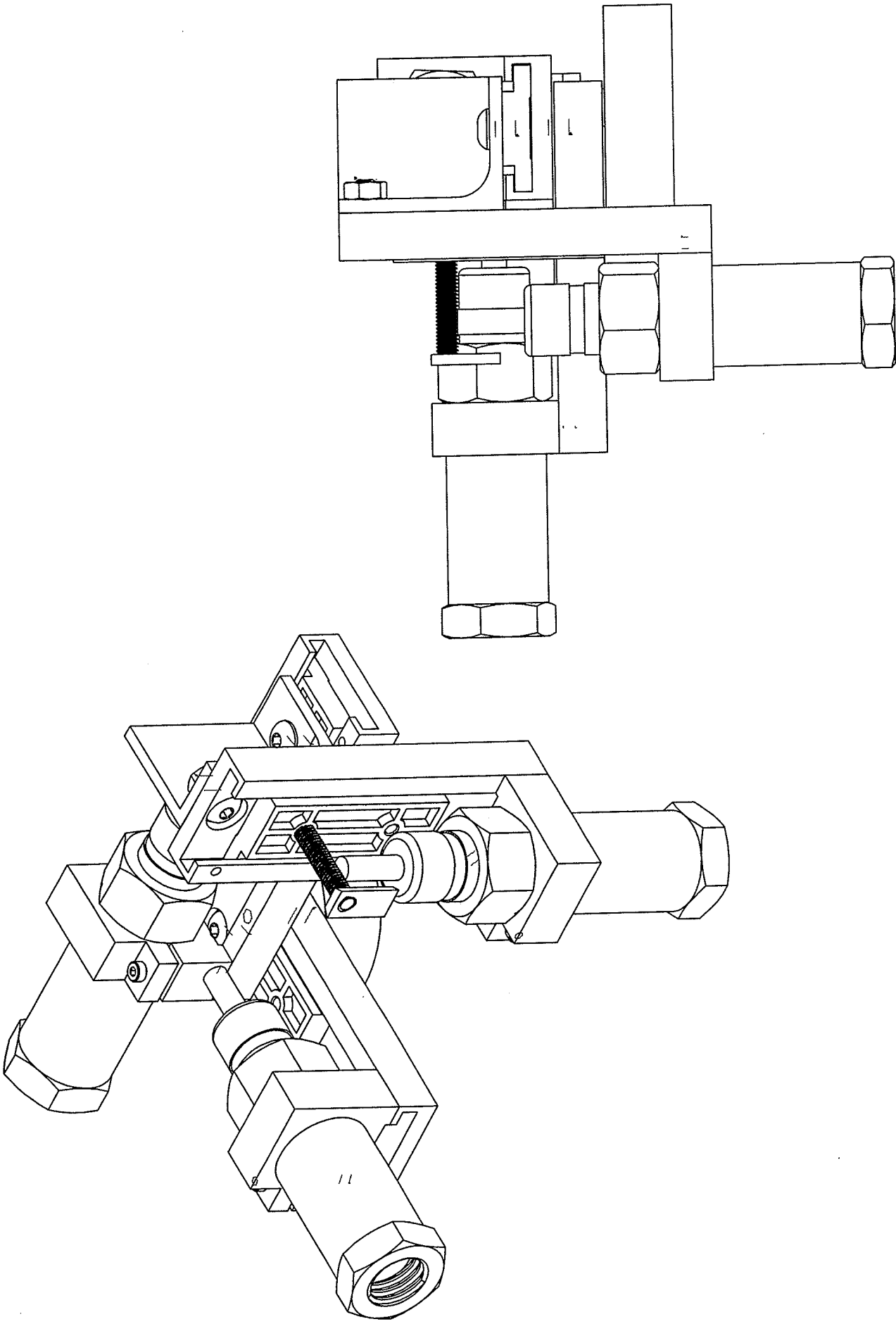


ITEM NO.	PART NUMBER	QTY.
1	PREVIOUSLY ASSEMBLED X AND Y AXIS	1
2	LPM27 ELBOW BRACKET	1
3	91239A136 M4 5 MM	1
4	CARIAGE INTO RAIL	1
5	92497A250 M4 NUT	1
6	92095A189 M4 8 MM	1
7	PISTON CYLINDER INTO MOUNT	1
8	92855A419 M4 25 MM THREADED STUD	1
9	PIPETTE MOUNT SLIDE	1
10	91292A013 M2 20 MM	1

NAME	DATE
DRAWN BJO	2/19/11
CHECKED RWH	2/19/11
COMMENTS:	

ASSEMBLY NAME:  
MANIPULATOR FINAL ASSEMBLY

SCALE: 1:1



ASSEMBLY NAME:  
MANIPULATOR

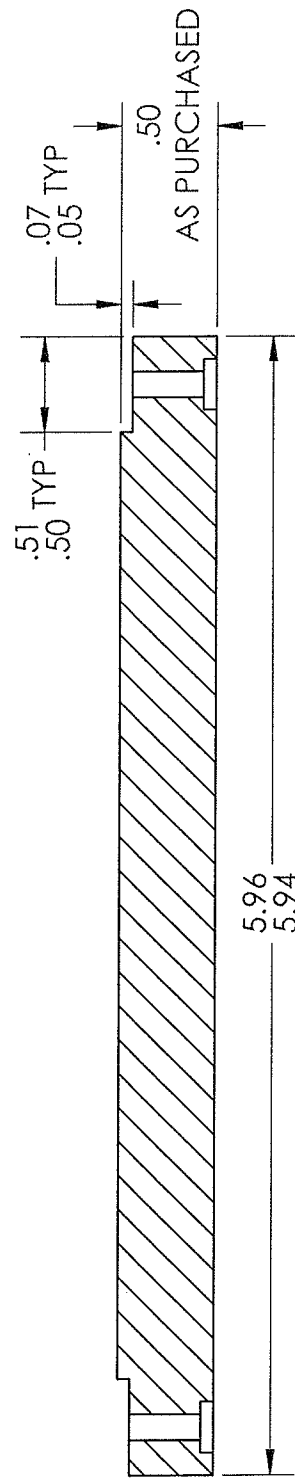
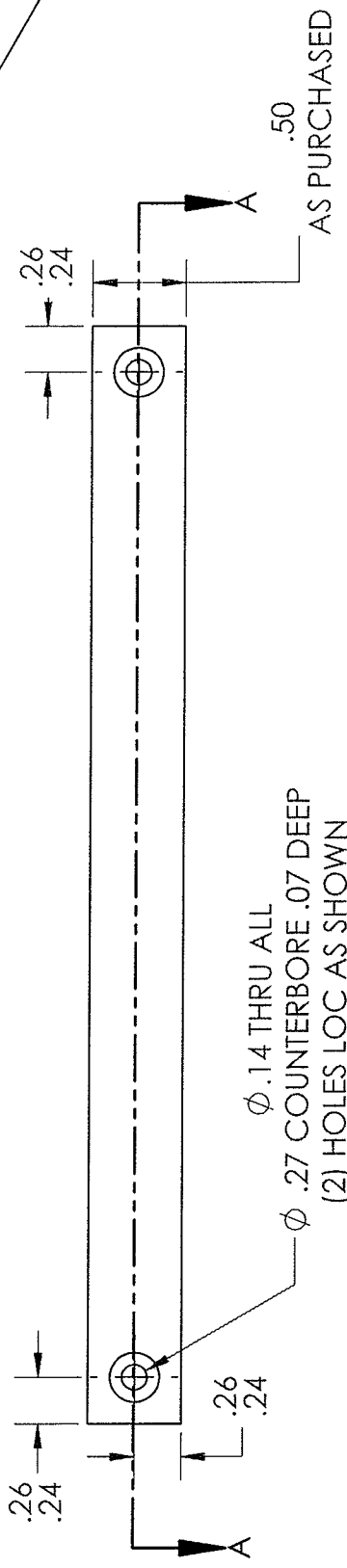
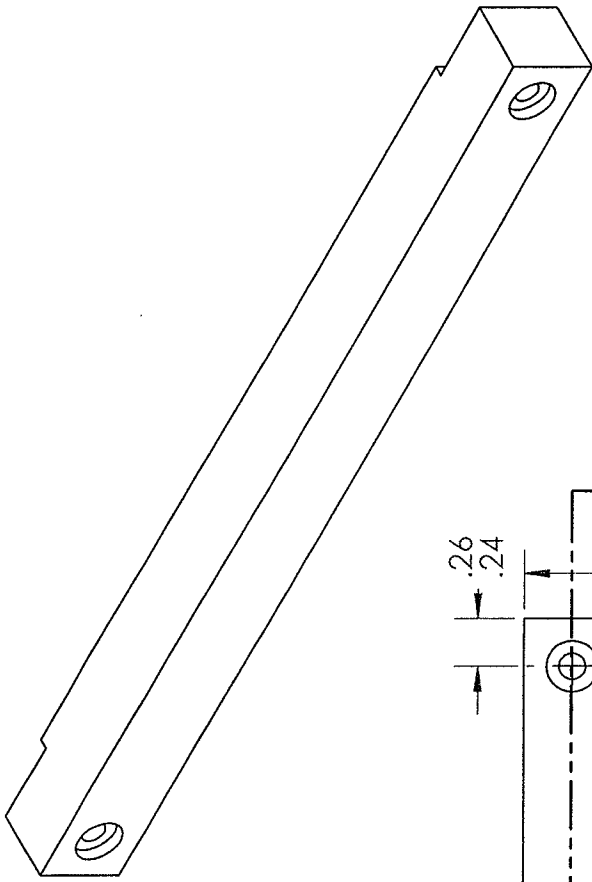
NAME	DATE
BJO	2/19/12
RWH	2/19/12

DRAWN

CHECKED

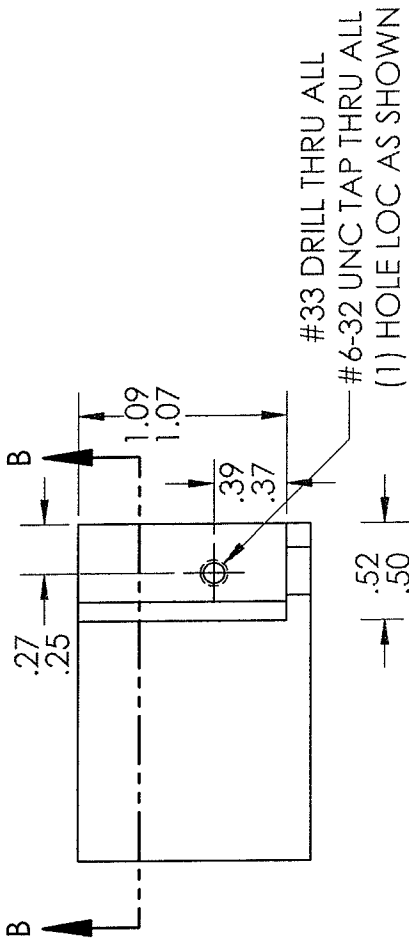
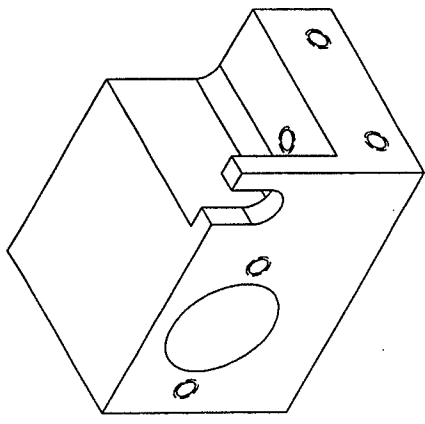
COMMENTS:

SCALE: 1:1

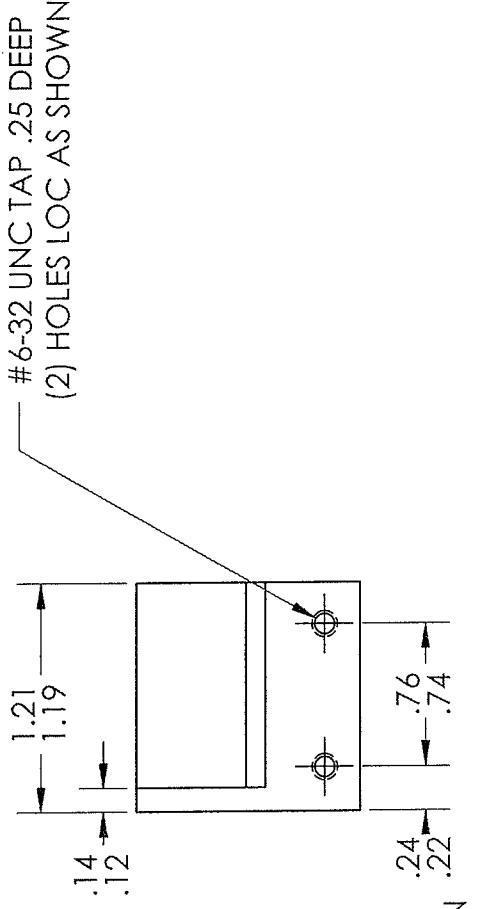
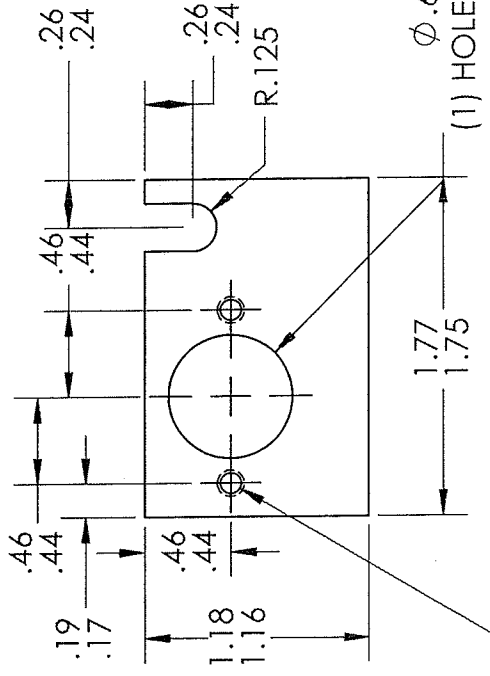


SECTION A-A  
SCALE 1 : 1

UNLESS OTHERWISE STATED DIMENSIONS ARE IN INCHES		PART NAME:	
TOLERANCES: TWO PLACE DECIMAL $\pm .01$ THREE PLACE DECIMAL $\pm .005$		NAME	DATE
DRAWN	RWH	2/19/2012	PUMP SUBSYSTEM UNDER BLOCK
CHECKED	BJO	2/19/2012	
MATERIAL: ALUMINUM		COMMENTS:	
		SCALE: 1:1	



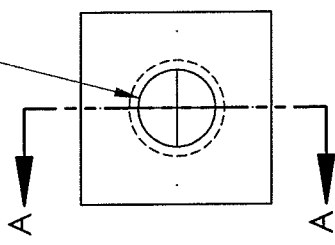
SECTION B-B



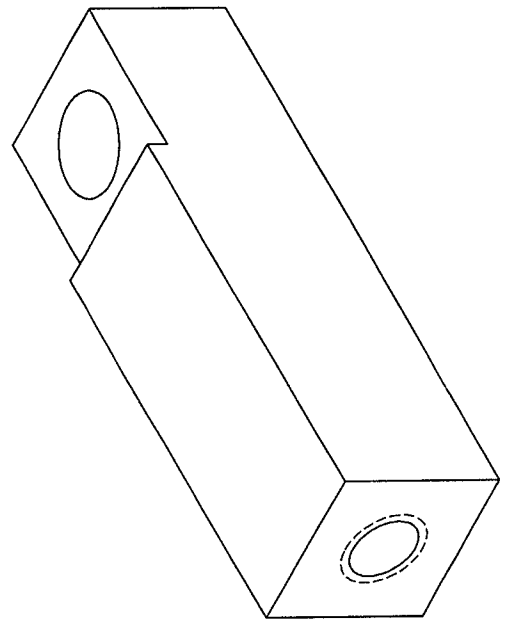
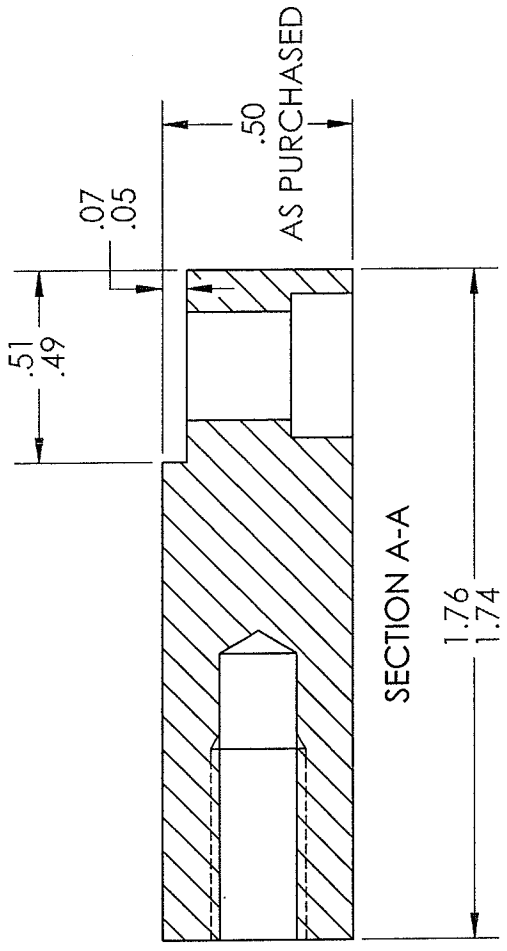
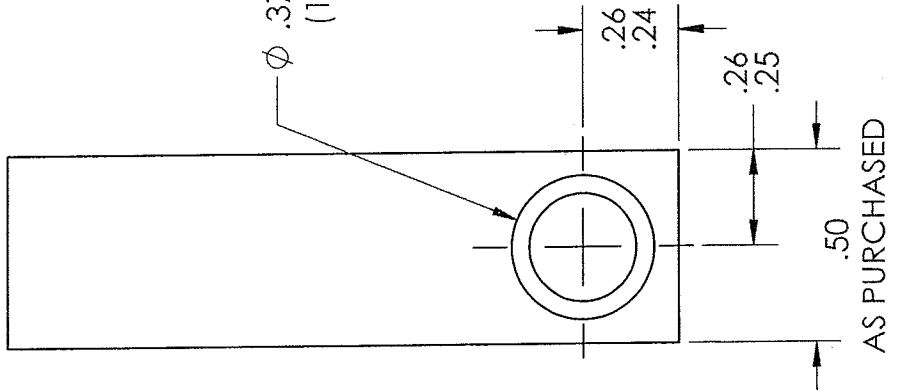
UNLESS OTHERWISE STATED DIMENSIONS ARE IN INCHES TOLERANCES: TWO PLACE DECIMAL ± .01 THREE PLACE DECIMAL ± .005		NAME	DATE	PART NAME:	
DRAWN	RWH	2/19/2012	PUMP SUBSYSTEM CONNECTING BLOCK		
CHECKED	BJO	2/19/2012	SCALE: 1:1		
MATERIAL ALUMINUM		COMMENTS:			



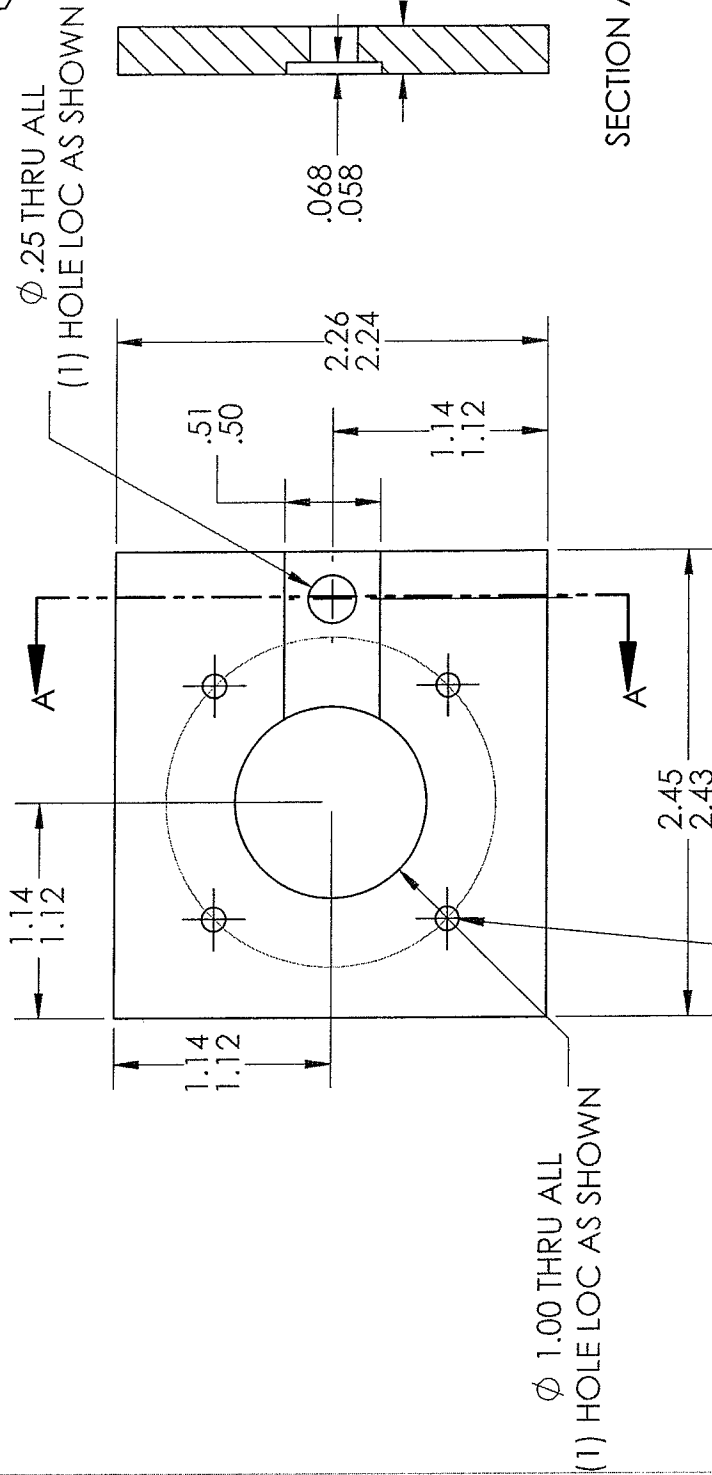
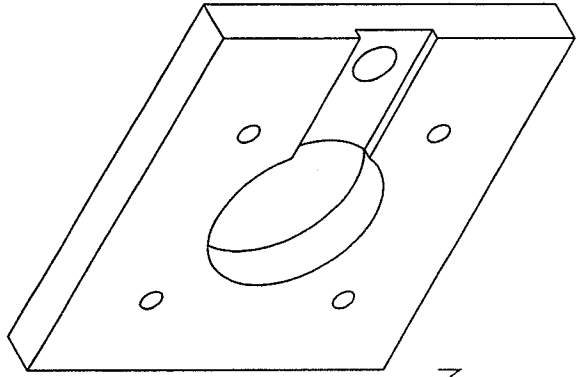
$\phi$  7/32 DRILL .75 DEEP  
 1/4-20 UNC TAP .5 DEEP  
 (1) HOLES LOC AS SHOWN



$\phi$  .25 THRU ALL  
 $\phi$  .375 COUNTERBORE .17 DEEP  
 (1) HOLE LOC AS SHOWN



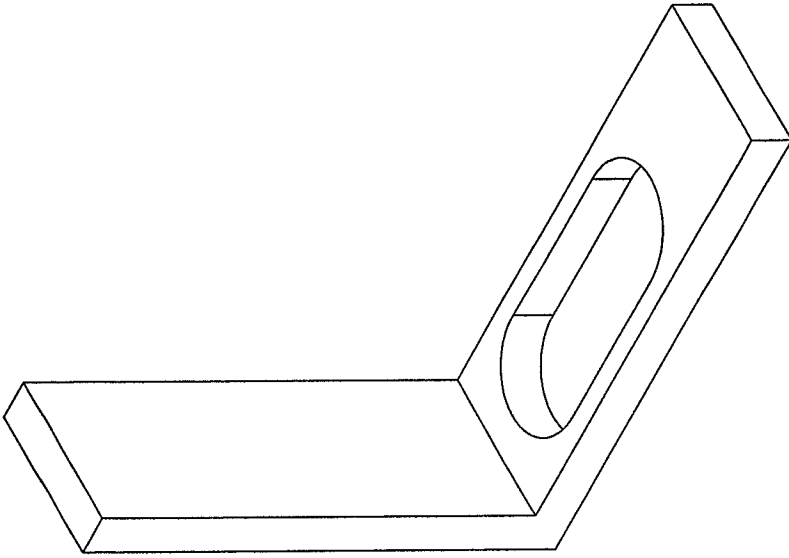
UNLESS OTHERWISE STATED DIMENSIONS ARE IN INCHES		NAME	DATE	PART NAME:	
DRAWN	RWH	2/19/2012	PUMP SUBSYSTEM		
CHECKED	BJO	2/19/2012	MOTOR SPACING BLOCK		
TOLERANCES: TWO PLACE DECIMAL $\pm$ .01 THREE PLACE DECIMAL $\pm$ .005		COMMENTS:		SCALE: 2:1	
MATERIAL: ALUMINUM					



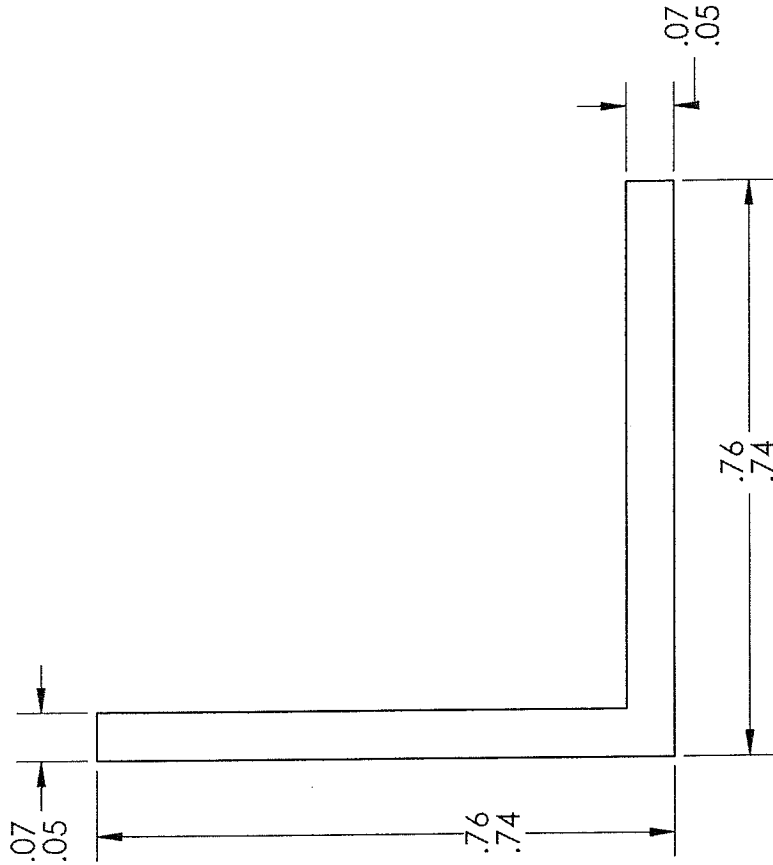
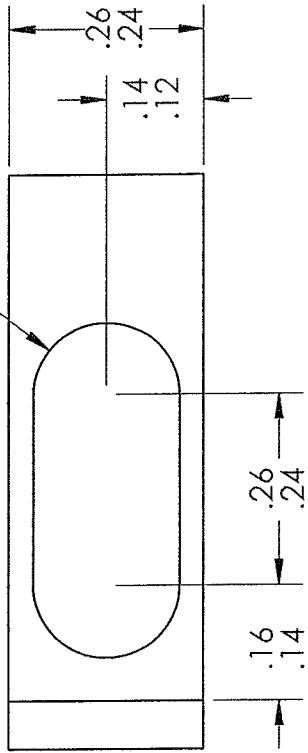
UNLESS OTHERWISE STATED DIMENSIONS ARE IN INCHES		NAME	DATE	PART NAME:	
TOLERANCES:		RWH	2/18/2012	PUMP SUBSYSTEM	
TWO PLACE DECIMAL $\pm$ .01		BJO	2/18/2012	MOTOR MOUNTING BLOCK	
THREE PLACE DECIMAL $\pm$ .005					
MATERIAL		COMMENTS:			
ALUMINUM					

SCALE: 1:1

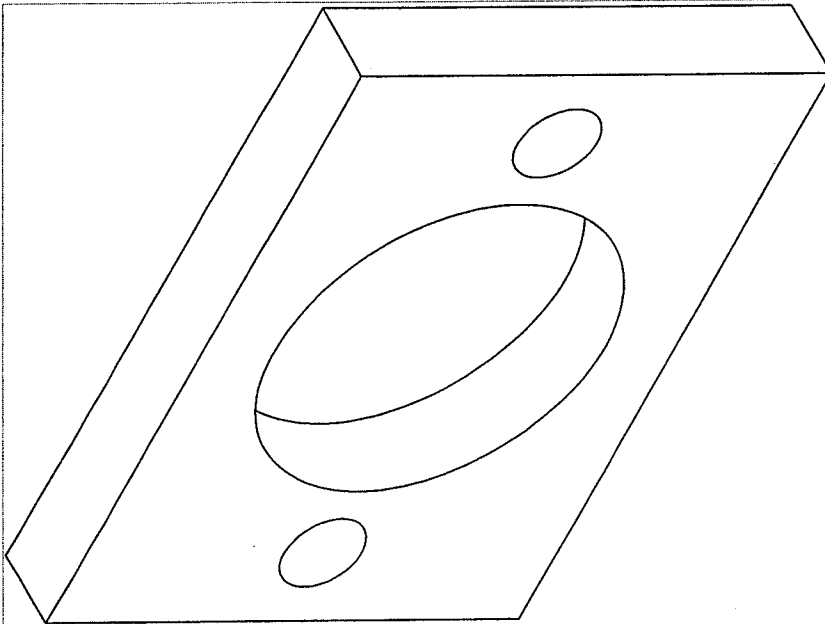




R.09 TYP

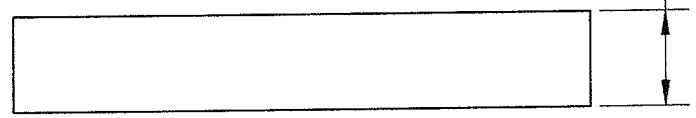
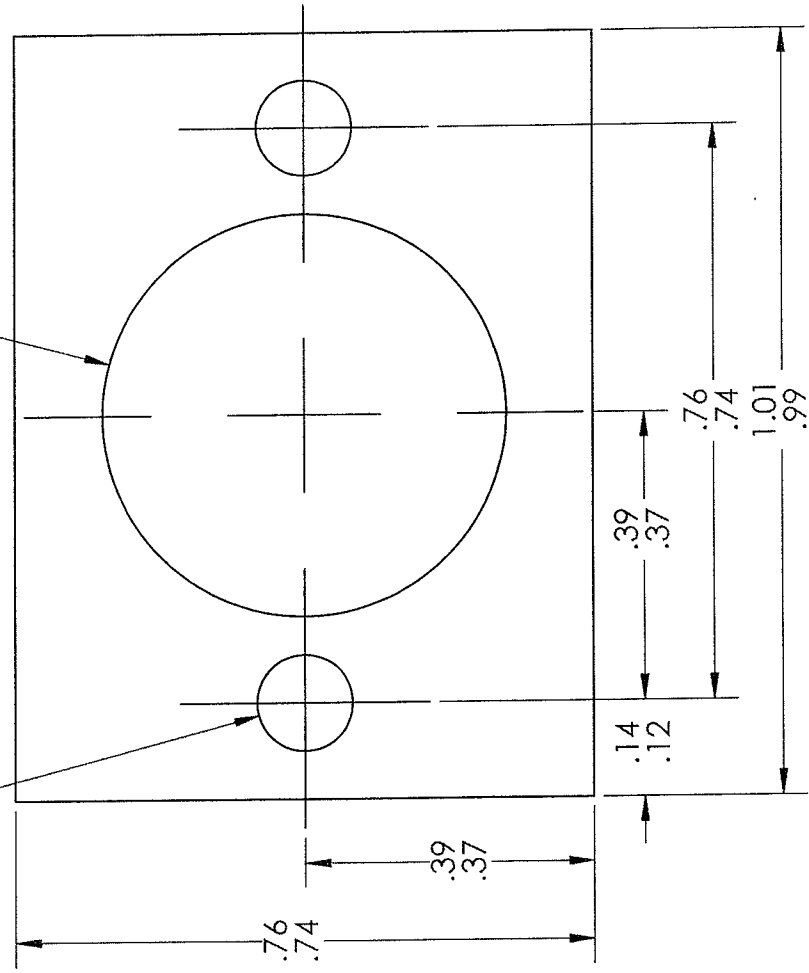


UNLESS OTHERWISE STATED DIMENSIONS ARE IN INCHES TOLERANCES: TWO PLACE DECIMAL ± .01 THREE PLACE DECIMAL ± .005		PART NAME: <b>PUMP SUBSYSTEM SYRINGE LOCK ANGLE</b>	
DRAWN	NAME	DATE	COMMENTS:
CHECKED	RWH	2/19/2012	
	BJO	2/19/2012	
MATERIAL ALUMINUM			SCALE: 4:1

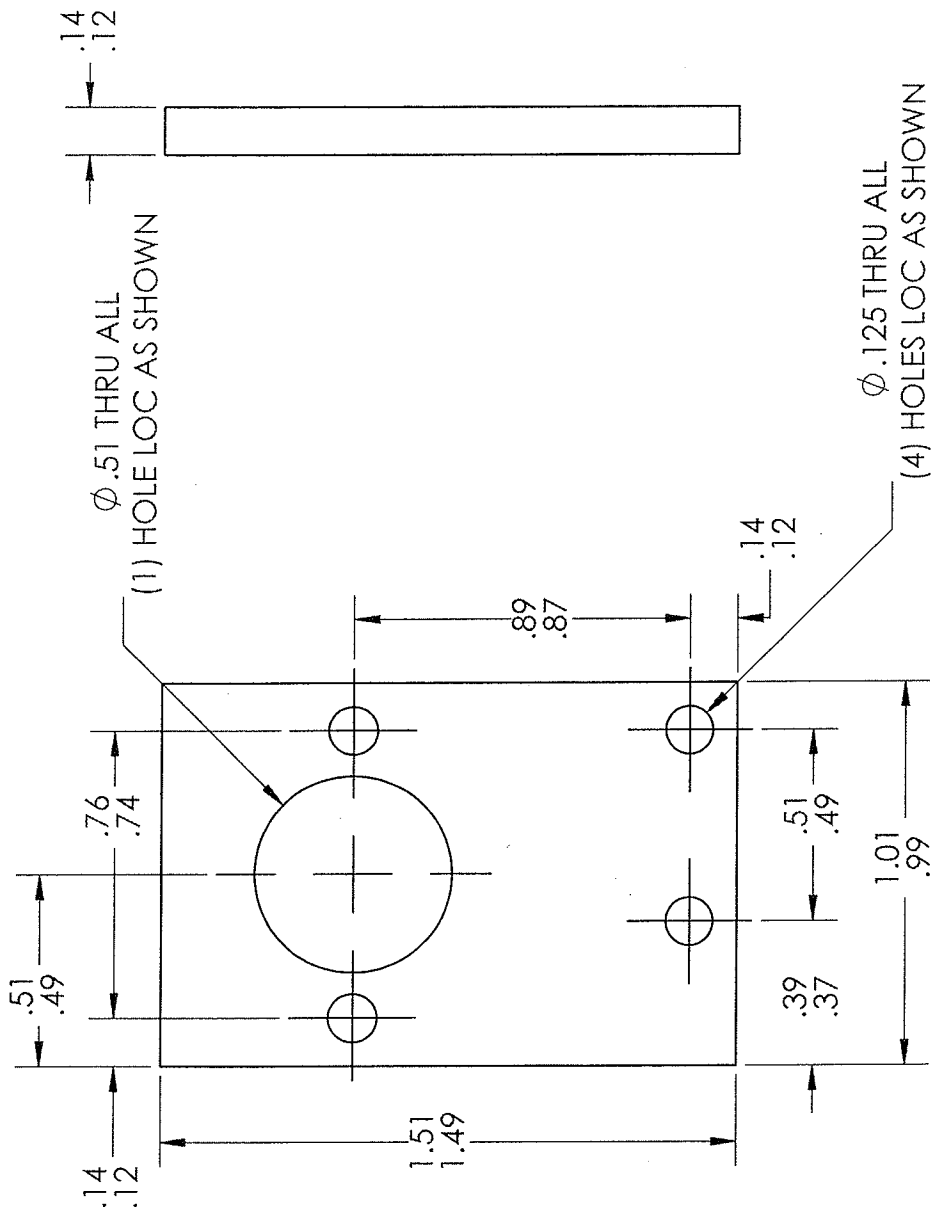
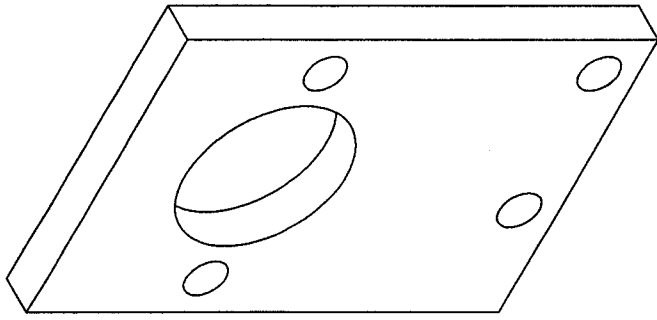


$\phi .125$  THRU ALL  
(2) HOLES LOC AS SHOWN

$\phi .09/16$  THRU ALL  
(1) HOEL LOC AS SHOWN

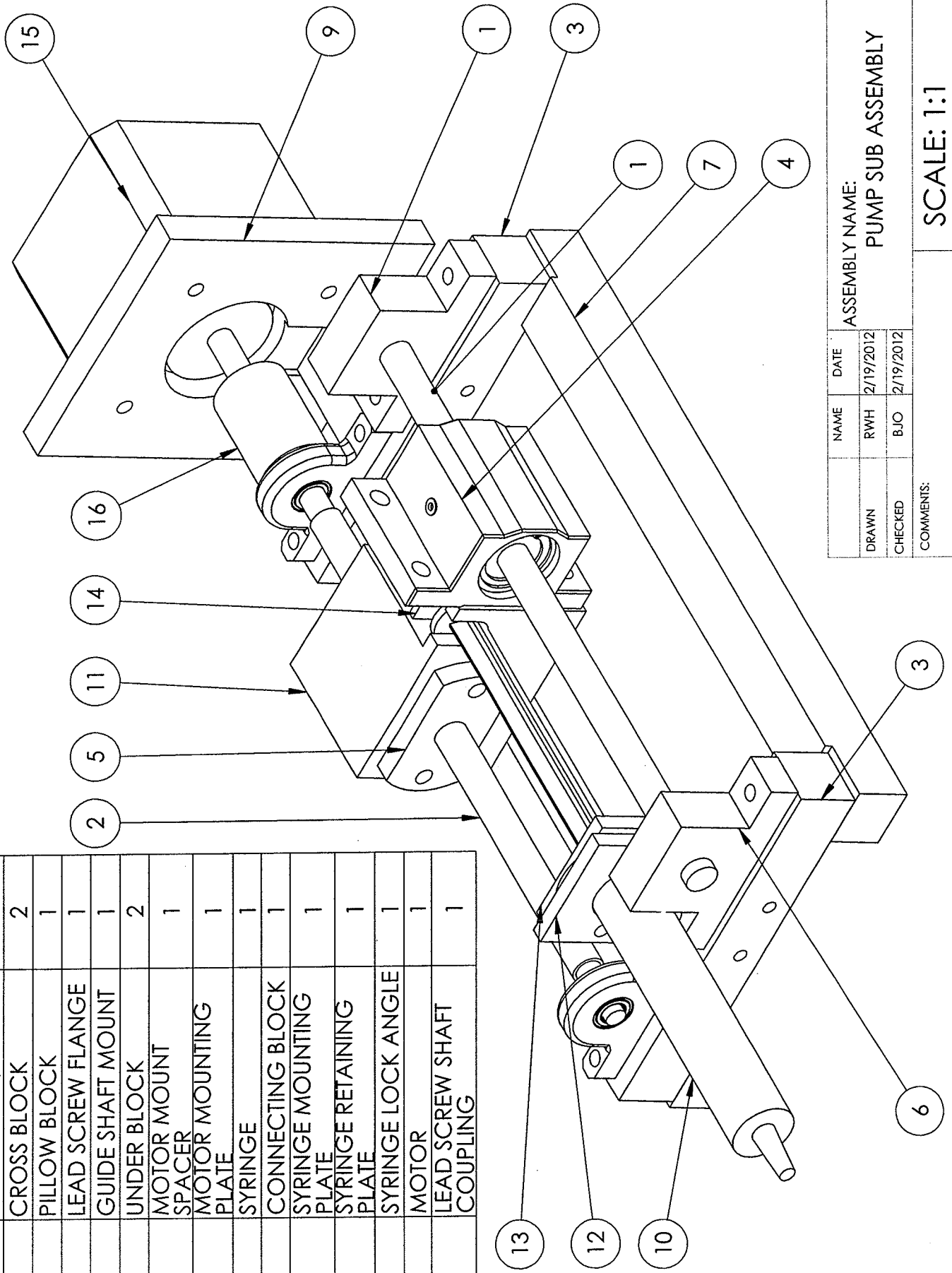


UNLESS OTHERWISE STATED DIMENSIONS ARE IN INCHES		PART NAME:	
TOLERANCES: TWO PLACE DECIMAL $\pm .01$ THREE PLACE DECIMAL $\pm .005$		NAME	DATE
MATERIAL: ALUMINUM		RWH	2/19/2012
COMMENTS:		BJO	2/19/2012
		DRAWN	CHECKED
		PUMP SUBSYSTEM SYRINGE RETAINING PLATE	
		SCALE: 4:1	



UNLESS OTHERWISE STATED DIMENSIONS ARE IN INCHES		PART NAME:	
DRAWN	RWH	NAME	DATE
CHECKED	BJO		2/19/2012
TOLERANCES: TWO PLACE DECIMAL $\pm .01$ THREE PLACE DECIMAL $\pm .005$		PUMP SUBSYSTEM SYRINGE MOUNTING PLATE	
MATERIAL ALUMINUM		COMMENTS:	
		SCALE: 2:1	

ITEM NO.	PART NUMBER	QTY.
1	GUIDE RAIL/MOUNTS	1
2	LEAD SCREW/MOUNTS	1
3	CROSS BLOCK	2
4	PILLOW BLOCK	1
5	LEAD SCREW FLANGE	1
6	GUIDE SHAFT MOUNT	1
7	UNDER BLOCK	2
8	MOTOR MOUNT SPACER	1
9	MOTOR MOUNTING PLATE	1
10	SYRINGE	1
11	CONNECTING BLOCK	1
12	SYRINGE MOUNTING PLATE	1
13	SYRINGE RETAINING PLATE	1
14	SYRINGE LOCK ANGLE	1
15	MOTOR	1
16	LEAD SCREW SHAFT COUPLING	1



ASSEMBLY NAME:		PUMP SUB ASSEMBLY	
NAME	DATE	DRAWN	CHECKED
RWH	2/19/2012		
BJO	2/19/2012		
COMMENTS:			
SCALE: 1:1			

Manufacture BOM

Total cost for 50 Units		Hourly Machine Rate		Total cost for 50 Units						
\$ 55,143.52				\$ 95.00						
Part Name	Qty per Unit	Total Qty	Material Lot Size	Lots required	Per Lot price	Set Up time	Machine Time	Total Cost	Vendor	Vendor P/N
0.5x0.5x6ft Aluminium (feet)	5.1	255	6	43	\$15.36			\$ 660.48	McMaster Carr	9008K23
1.25x1.25x12in Aluminium (inches)	6	300	12	25	\$16.19			\$ 404.75	McMaster Carr	9008K151
1/2 - 20 Washer	2	100	100	1	\$2.58			\$ 2.58	McMaster Carr	91081A129
1/2-20 x .75 in bolt	2	100	100	1	\$4.03			\$ 4.03	McMaster Carr	92196A151
4-40 Nuts	10	500	100	5	\$0.87			\$ 4.35	McMaster Carr	90480A005
4-40 washer	24	1200	1450	1	\$11.05			\$ 11.05	McMaster Carr	90126A005
4-40 x .5 in Bolt	4	200	100	2	\$3.13			\$ 6.26	McMaster Carr	92196A110
4-40 x .75 in Bolt	4	200	100	2	\$3.64			\$ 7.28	McMaster Carr	92196A113
4-40 x 1.25 in Bolt	4	200	100	2	\$5.50			\$ 11.00	McMaster Carr	92196A302
6-32 Washers	5	250	765	1	\$6.63			\$ 6.63	McMaster Carr	90126A007
6-32 x .5 in Bolt	5	250	100	3	\$3.98			\$ 11.94	McMaster Carr	92196A148
91239A136 M4 5MM LENGTH BUTTON	3	150	1	150	\$0.01			\$ 1.50	McMaster Carr	
91292A013 M2 20 MM LENGTH	3	150	1	150	\$0.01			\$ 1.50	McMaster Carr	
92095A192 M4 12 MM LENGTH BUTTON	1	50	1	50	\$0.01			\$ 0.50	McMaster Carr	
Breakout board	1	50	10	5	\$15.00			\$ 75.00		
Breakout board	1	50	50	1	\$8.62			\$ 8.62	BusBoard Prototype System	PAD 3D
Cross Block(ft)	1.75	87.5	1	88	\$0.00		360	\$ 3,356.67	0.5x0.5x6ft Aluminium	
Driver Chip	3	150	50	3	\$5.92			\$ 17.76	Toshiba	THB6064AH
Guide Shafts	3	150	1	150	\$4.00			\$ 600.00	McMaster Carr	6061K413
Joystick	1	50	10	5	\$22.49			\$ 112.46	Logitech	Extreme 3D Pro
Lead Screw (inches)	18	900	1	900	\$2.00			\$ 1,800.00	Tompson BSA	SV2580
Lead Screw Bearing	6	300	1	300	\$15.00			\$ 4,500.00	McMaster Carr	8600N9
Lead Screw Nut	3	150	1	150	\$28.04			\$ 4,206.00	Tompson BSA	XCF-2580
LPM27 ELBOW BRACKET	1	50	1	50	\$0.00		360	\$ 2,153.33		
LPM27C CARRIAGE	3	150	1	150	\$0.00		240	\$ 3,230.00	PBC LINEAR	
LPM27R_0075_Y_10mm	3	150	50	3	\$32.00			\$ 96.00	PBC LINEAR	
M2 x .25 in Screws	2	100	1	100	\$0.01			\$ 1.00	Machine Shop Stock	CSMB12
Microcontroller	1	50	10	5	\$76.00			\$ 380.00	Freescala	
Motor Retaining Plate	3	150	1	150	\$0.00		240	\$ 3,230.00	Shop Scrap	
Motor Spacer Block(ft)	0.5	25	1	25	\$0.00		180	\$ 680.83	0.5x0.5x6ft Aluminium	
MOUNT BLOCK WASHER	1	50	100	1	\$2.68			\$ 2.68	MCMMASTER	
MOUNTING BLOCK	1	50	1	50	\$0.00		240	\$ 1,567.50		
PIPEPTE MOUNT SLIDE	1	50	1	50	\$0.00			\$ 6.75	MCMMASTER	
PIPEPTE SCREW	1	50	100	1	\$6.75			\$ 84.43	Cylinder & Valve Inc.	
PISTON CYLINDER	3	150	50	3	\$28.14			\$ -		
PISTON CYLINDER MOUNT	3	150	1	150	\$0.00			\$ 516.00	Automation Direct	STP-PWR-3204
Power Supply	1	50	10	5	\$103.20			\$ 250.00		
Serial Cable	1	50	1	50	\$5.00			\$ 250.00		
Shaft Clamp	6	300	1	300	\$10.93			\$ 3,279.00	McMaster Carr	1865K1
Shaft Coupling	3	150	1	150	\$39.38			\$ 5,906.25	McMaster Carr	2463K11
Shaft Pillow Blokb	3	150	1	150	\$29.60			\$ 4,440.00	McMaster Carr	6255K31
Connecting Block(inches)	2	100	1	100	\$0.00		480	\$ 5,510.00	1.25x1.25x1ft Aluminium	
Syringe Lock Angle (inches)	1	50	1	50	\$0.00		240	\$ 1,567.50	1.25x1.25x1ft Aluminium	
Stepper Motor	3	150	50	3	\$10.00			\$ 30.00	Automation Direct	STP-MTR-17040
Syringe	3	150	50	3	\$12.63			\$ 37.89	3-D printer supplies	
Syringe Lock Plate	3	150	1	150	\$0.00		180	\$ 3,135.00	Shop Scrap	

Syringe Retaining Plate	3	150	1	150	\$0.00	180	12	\$ 3,135.00	Shop Scrap
Under Block (ft)	3	150	1	150	\$0.00			\$ -	0.5x0.5x6ft. Aluminium
Wires	1	50	50	1	\$25.00			\$ 25.00	
Tubing	3	150	1	150	\$0.46			\$ 69.00	Ace Hose and Rubber Company

P12371 Bill of Materials

System Cost: \$ 1,220.89

Part Name	Qty	Unit Cost	Total Cost	Make/Buy	Vendor	Vendor P/N	Lead Time	Subsystem	Owner
0.5x0.5x6ft Aluminium	1	\$15.36	\$15.36	Buy	McMaster Carr	9008K23	Pump	Rob H	Rob H
1.25x1.25x1ft Aluminium	1	\$16.19	\$16.19	Buy	McMaster Carr	9008K151	Pump	Rob H	Rob H
1/2 - 20 Washer	2		\$-	Make	Machine Shop Stock		Pump	Rob H	Rob H
1/2-20 x .75 in bolt	2		\$-	Make	Machine Shop Stock		Pump	Rob H	Rob H
4-40 Nuts	10		\$-	Make	Machine Shop Stock		Pump	Rob H	Rob H
4-40 washer	24		\$-	Make	Machine Shop Stock		Pump	Rob H	Rob H
4-40 x .5 in Bolt	4		\$-	Make	Machine Shop Stock		Pump	Rob H	Rob H
4-40 x .75 in Bolt	4		\$-	Make	Machine Shop Stock		Pump	Rob H	Rob H
4-40 x 1.25 in Bolt	4		\$-	Make	Machine Shop Stock		Pump	Rob H	Rob H
6-32 Washers	5		\$-	Make	Machine Shop Stock		Pump	Rob H	Rob H
6-32 x .5 in Bolt	5		\$-	Make	Machine Shop Stock		Pump	Rob H	Rob H
91239A136 M4 5MM LENGTH B	3	\$0.01	\$0.03	Buy	MCMMASTER		Manipulator	Brad O	Rob H
91292A013 M2 20 MM LENGTH	3	\$0.01	\$0.03	Buy	MCMMASTER		Manipulator	Brad O	Rob H
92095A192 M4 12 MM LENGTH	1	\$0.01	\$0.01	Buy	MCMMASTER		Manipulator	Brad O	Rob H
Bread Board Peripherals	1	\$15.00	\$15.00	Buy			Control	Sabine L	Rob H
Breakout board	1	\$10.78	\$10.78	Buy	BusBoard Prototype System	PAD 3D	Control	Sabine L	Rob H
Cross Block(ft)	1.75	\$-	\$-	Make	0.5x0.5x6ft Aluminium		Pump	Rob H	Rob H
Driver Chip	9	\$7.40	\$66.60	Buy	Toshiba	THB6064AH	Control	Sabine L	Rob H
Guide Shafts	3	\$4.00	\$12.00	Buy	McMaster Carr	6061K413	Pump	Rob H	Rob H
Joystick	1	\$24.99	\$24.99	Buy	Logitech	Extreme 3D Pro	Control	Sabine L	Rob H
Lead Screw (inches)	18	\$2.00	\$36.00	Buy	Tompson BSA	SV2580	Pump	Rob H	Rob H
Lead Screw Bearing	6	\$15.00	\$90.00	Buy	McMaster Carr	8600N9	Pump	Rob H	Rob H
Lead Screw Nut	3	\$28.04	\$84.12	Buy	Tompson BSA	XCF-2580	Pump	Rob H	Rob H
LPM27 ELBOW BRACKET	1	\$-	\$-	Make			Manipulator	Brad O	Rob H
LPM27C CARRIAGE	3	\$-	\$-	Buy	PBC LINEAR		Manipulator	Brad O	Rob H
LPM27R 0075 Y_10mm	3	\$40.00	\$120.00	Buy	PBC LINEAR		Manipulator	Brad O	Rob H
M2 x .25 in Screws	2	\$95.00	\$95.00	Make	Machine Shop Stock		Pump	Rob H	Rob H
Microcontroller	1	\$95.00	\$95.00	Make	Freescall	CSMB12	Control	Sabine L	Rob H
Motor Retaining Plate	3	\$-	\$-	Make	Shop Scrap		Pump	Rob H	Brad O
Motor Spacer Block(ft)	0.5	\$-	\$-	Make	0.5x0.5x6ft Aluminium		Pump	Rob H	Brad O
MOUNTING BLOCK WASHER	1	\$0.01	\$0.01	Buy	MCMMASTER		Manipulator	Brad O	Brad O
MOUNTING BLOCK	1		\$-	Make			Manipulator	Brad O	Brad O
PIPEPETTE MOUNT SLIDE	1		\$-	Make			Manipulator	Brad O	Brad O
PIPEPETTE SCREW	1	\$0.55	\$0.55	Buy	MCMMASTER		Manipulator	Brad O	Brad O
PISTON CYLINDER	3	\$35.18	\$105.54	Buy	Cylinder & Valve Inc.		Manipulator	Brad O	Brad O
PISTON CYLINDER MOUNT	3		\$-	Make			Manipulator	Brad O	Brad O
Power Supply	1	\$129.00	\$129.00		Automation Direct	STP-PWR-3204	Electrical	Brad L	Brad O
Serial Cable	1	\$5.00	\$5.00				Control	Sabine L	Brad O
Shaft Clamp	6	\$10.93	\$65.58	Buy	McMaster Carr	1865K1	Pump	Rob H	Brad O

Shaft Coupling	3	\$52.50	\$157.50	Buy	McMaster Carr	2463K11	Pump	Rob H	Brad O
Shaft Pillow Blokk	3	\$37.00	\$111.00	Buy	McMaster Carr	6255K31	Pump	Rob H	Brad L
Connecting Block(Inches)	2	\$-	\$-	Make	1.25x1.25x1ft Aluminium		Pump	Rob H	Brad L
Syringe Lock Angle (Inches)	1	\$-	\$-	Make	1.25x1.25x1ft Aluminium		Pump	Rob H	Sabine L
Stepper Motor	3	\$17.00	\$51.00	Buy	Automation Direct	STP-MTR-17040	Electrical	Brad L	Sabine L
Syringe	3	\$-	\$-	Buy	3-D printer supplies		Pump	Rob H	Sabine L
Syringe Lock Plate	3	\$-	\$-	Make	Shop Scrap		Pump	Rob H	Sabine L
Syringe Retaining Plate	3	\$-	\$-	Make	Shop Scrap		Pump	Rob H	Sabine L
Under Block (ft)	3	\$-	\$-	Make	0.5x0.5x6ft Aluminium		Pump	Rob H	Sabine L
Wires	1	\$5.00	\$5.00				Control	Sabine L	Sabine L
Tubing	10	\$0.46	\$4.60	Buy	Ace Hose and Rubber Company				