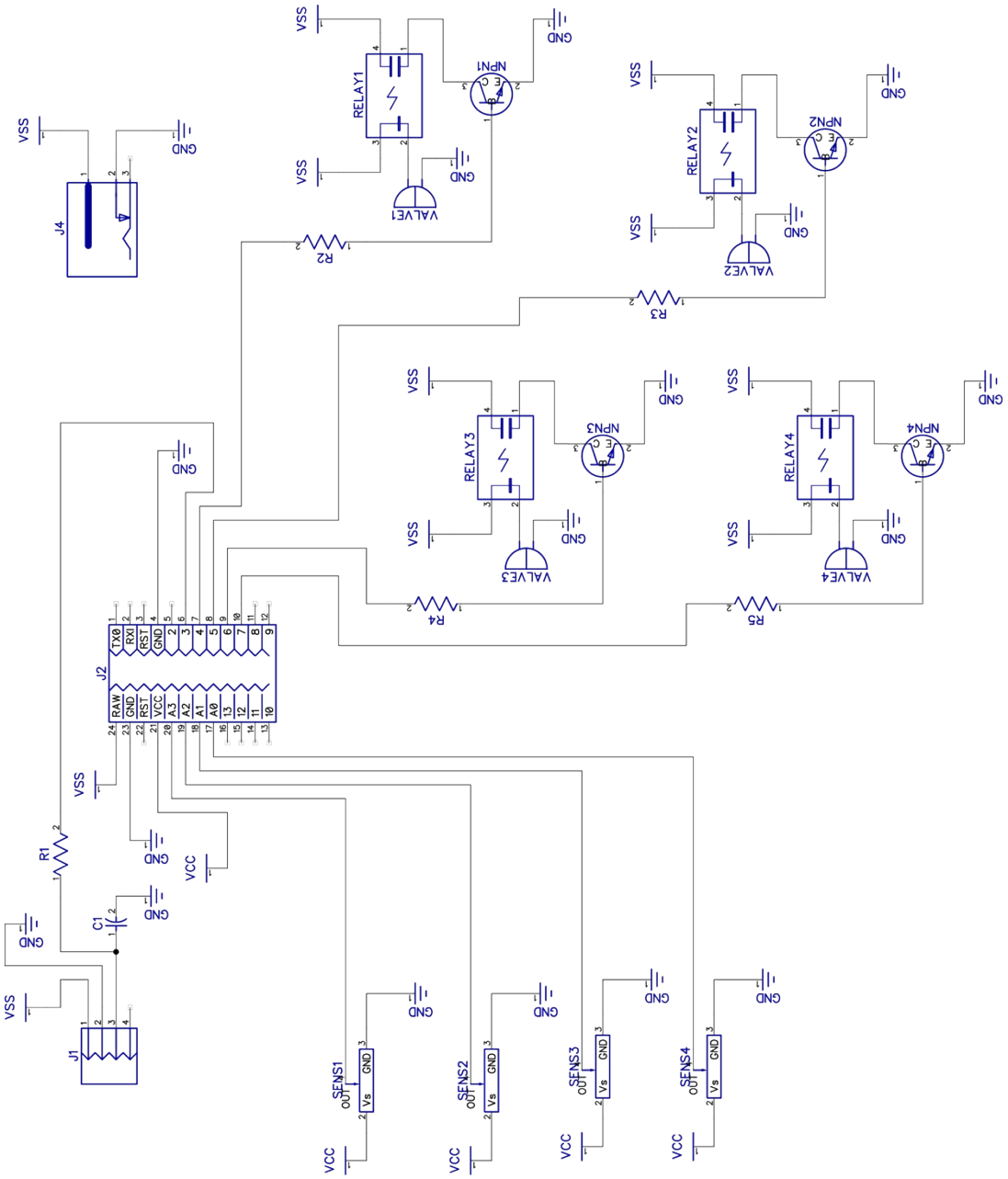
Electronic Supplementary Material (ESI) for Lab on a Chip.

A Microfluidic Platform for the High-throughput Study of Pathologic Cardiac Hypertrophy

Supplementary Information

Figure SF1. Control board circuit



Arduino mini control was selected as the control board.

```
/*
  INPUT: pressure
  OUTPUT: pressure set (analog), solenoid valve (digital)

  Pressure sensor:
  MPX5100DP, 0 to 100 kPa range
  Vout = Vsource * (0.009 * P + 0.04)

  Pressure regulator:
  ITV0011-2BL, 1 to 100 kPa range, 12DC power
  PWM out for analog out, ~0.4 kPa increments from 0 to 255  (need to verify)

 */

 // Control constants
const float frequency1 = 1.0;      // pressure output frequency in Hz
const float frequency2 = 1.0;      // pressure output frequency in Hz
const float frequency3 = 1.0;      // pressure output frequency in Hz
const float frequency4 = 1.0;      // pressure output frequency in Hz

const float DutyCycle=0.5;        //default to 50% duty cycle

int InitialPressure = 10;

// Constants
const int prSensePin1 = A3;    // Analog input pin that the pressure sensor is attached to
const int prSensePin2 = A2;    // Analog input pin that the pressure sensor is attached to
const int prSensePin3 = A1;    // Analog input pin that the pressure sensor is attached to
const int prSensePin4 = A0;    // Analog input pin that the pressure sensor is attached to

const int prControlPin = 3;   // Analog output pin that the pressure regulator is attached to

const int prWavePin1 = 4;      // Digital output to relay1 / solenoid valve control pressure
output to bioreactor
const int prWavePin2 = 5;      // Digital output to relay2 / solenoid valve control pressure
output to bioreactor
const int prWavePin3 = 6;      // Digital output to relay3 / solenoid valve control pressure
output to bioreactor
const int prWavePin4 = 7;      // Digital output to relay4 / solenoid valve control pressure
output to bioreactor
```

```
// Variables
float setPressure = 0.0;   // value in kPa  (range 1 to 100 kPa)  3psi = 20kPa

int prSensor1 = 0;          // value read from the pressure sensor
int prSensor2 = 0;          // value read from the pressure sensor
int prSensor3 = 0;          // value read from the pressure sensor
int prSensor4 = 0;          // value read from the pressure sensor

int prControl = 0;          // value output to the pressure regulator

boolean prDeform1 = false;    // value to control pressure state of bioreactor
boolean prDeform2 = false;    // value to control pressure state of bioreactor
boolean prDeform3 = false;    // value to control pressure state of bioreactor
boolean prDeform4 = false;    // value to control pressure state of bioreactor

boolean prLeak1 = true;

float prRead1 = 0.0;         // pressure value converted to kPa
float prRead2 = 0.0;         // pressure value converted to kPa
float prRead3 = 0.0;         // pressure value converted to kPa
float prRead4 = 0.0;         // pressure value converted to kPa

float prSetRef = 0.0;        // reference value of set pressure

unsigned long time = 0;          // tracking variable for time
unsigned long timeStart = 0;     // when the program began

unsigned long timeSwitch1 = 0;    // when the last state change occurred
unsigned long timeSwitch2 = 0;    // when the last state change occurred
unsigned long timeSwitch3 = 0;    // when the last state change occurred
unsigned long timeSwitch4 = 0;    // when the last state change occurred

unsigned long timeDiff1 = 0;      // time difference
unsigned long timeDiff2 = 0;      // time difference
unsigned long timeDiff3 = 0;      // time difference
unsigned long timeDiff4 = 0;      // time difference

int freq1 = 0;               // integer value for frequency in milliseconds
int freq2 = 0;               // integer value for frequency in milliseconds
int freq3 = 0;               // integer value for frequency in milliseconds
int freq4 = 0;               // integer value for frequency in milliseconds
```

```
float tempFloat1 = 0.0;
float tempFloat2 = 0.0;
float tempFloat3 = 0.0;
float tempFloat4 = 0.0;

void setup() {
  // initialize serial communications at 9600 bps
  Serial.begin(9600);


  pinMode(prWavePin1, OUTPUT);
  pinMode(prWavePin2, OUTPUT);
  pinMode(prWavePin3, OUTPUT);
  pinMode(prWavePin4, OUTPUT);

  // set the start time
  timeStart = millis();

  time = timeStart;

  timeSwitch1 = timeStart;
  timeSwitch2 = timeStart;
  timeSwitch3 = timeStart;
  timeSwitch4 = timeStart;

  tempFloat1 = 1000.0 / frequency1 * DutyCycle;  // millisecond value for frequency factor
by duty cycle for state change
  tempFloat2 = 1000.0 / frequency2 * DutyCycle;  // millisecond value for frequency factor
by duty cycle for state change
  tempFloat3 = 1000.0 / frequency3 * DutyCycle;  // millisecond value for frequency factor
by duty cycle for state change
  tempFloat4 = 1000.0 / frequency4 * DutyCycle;  // millisecond value for frequency factor
by duty cycle for state change

  freq1 = (int)tempFloat1;
  freq2 = (int)tempFloat2;
  freq3 = (int)tempFloat3;
  freq4 = (int)tempFloat4;

}

void loop() {

  setPressure =min((InitialPressure + 0.001*(time-timeStart)/(1000)),40) ;
```

```
Serial.print(setPressure);
Serial.print("\n");
  // rescale set pressure to 0 to 255 from 1 to 100, adapt to crazy formula
prSetRef = (setPressure+.3)/0.7 * 2.55;

// output setting for analog out
prControl = (int)prSetRef;

// record setting for reporting
prSetRef = (float)prControl*.7 / 2.55-.3;

// set the pressure regulator
analogWrite(prControlPin, prControl);


// time tracking for frequency switching

timeDiff1 = time - timeSwitch1;
timeDiff2 = time - timeSwitch2;
timeDiff3 = time - timeSwitch3;
timeDiff4 = time - timeSwitch4;

// read and convert the pressure value
prSensor1 = analogRead(prSensePin1);
prSensor2 = analogRead(prSensePin2);
prSensor3 = analogRead(prSensePin3);
prSensor4 = analogRead(prSensePin4);

prRead1 = (float) prSensor1 * 111.11 / 1024.0 - 0.04 * 111.11 + .5;
prRead2 = (float) prSensor2 * 111.11 / 1024.0 - 0.04 * 111.11 + .5;
prRead3 = (float) prSensor3 * 111.11 / 1024.0 - 0.04 * 111.11 + .5;
prRead4 = (float) prSensor4 * 111.11 / 1024.0 - 0.04 * 111.11 + .5;


// print the results to the serial monitor
/*
Serial.print("pressure reading = " );
Serial.print(prRead);
Serial.print("kPa \t control = ");
Serial.print(prSetRef);
Serial.println("kPa");
*/
// pressure actuation loop - time to switch?
if (timeDiff1 > freq1)
```

```
  {
    if (prDeform1)
    {
      digitalWrite(prWavePin1, LOW);   // turn the pressure off
      prDeform1 = false;
    }
    if (prLeak1 && !prDeform1)
    {
      digitalWrite(prWavePin1, HIGH);   // turn the pressure on
      prDeform1 = true;
      if (timeDiff1 > (1.2*freq1) && timeDiff1 < (1.3*freq1) && prRead1 < (0.8*prSetRef))
      {
        prLeak1 = false;
      }
    }
    timeSwitch1 = millis();
  }
}
```

Figure SF2. Design considerations. A) Finite element simulation: the bottom of the well touches the μ-tissue in each pulse. B) As a result, the μ-tissue adheres to bottom of the well. C) The design was this modified to increase the step height and elevate the tissue to avoid contact. D) Pillar cross-section design was optimized to a teardrop shape to avoid stress concentration.

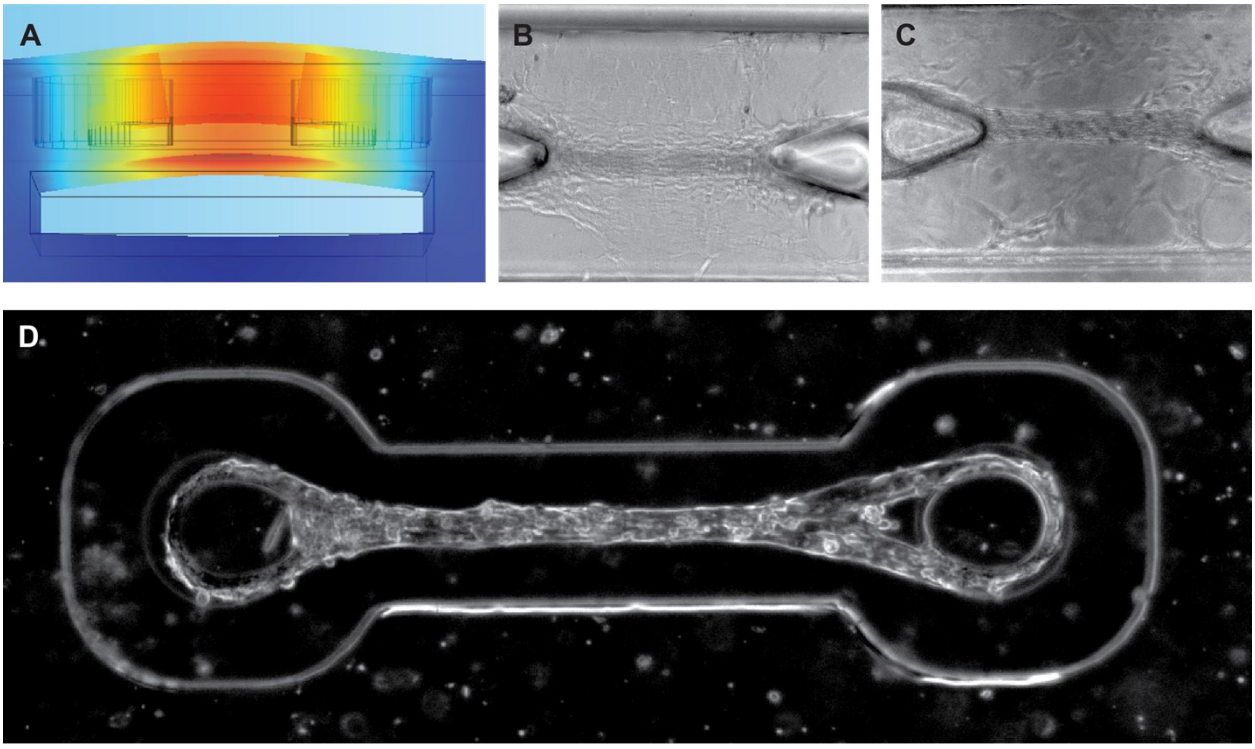


Figure SF3. Alignment device. A) Assembly B) Bottom stage B) Top slider

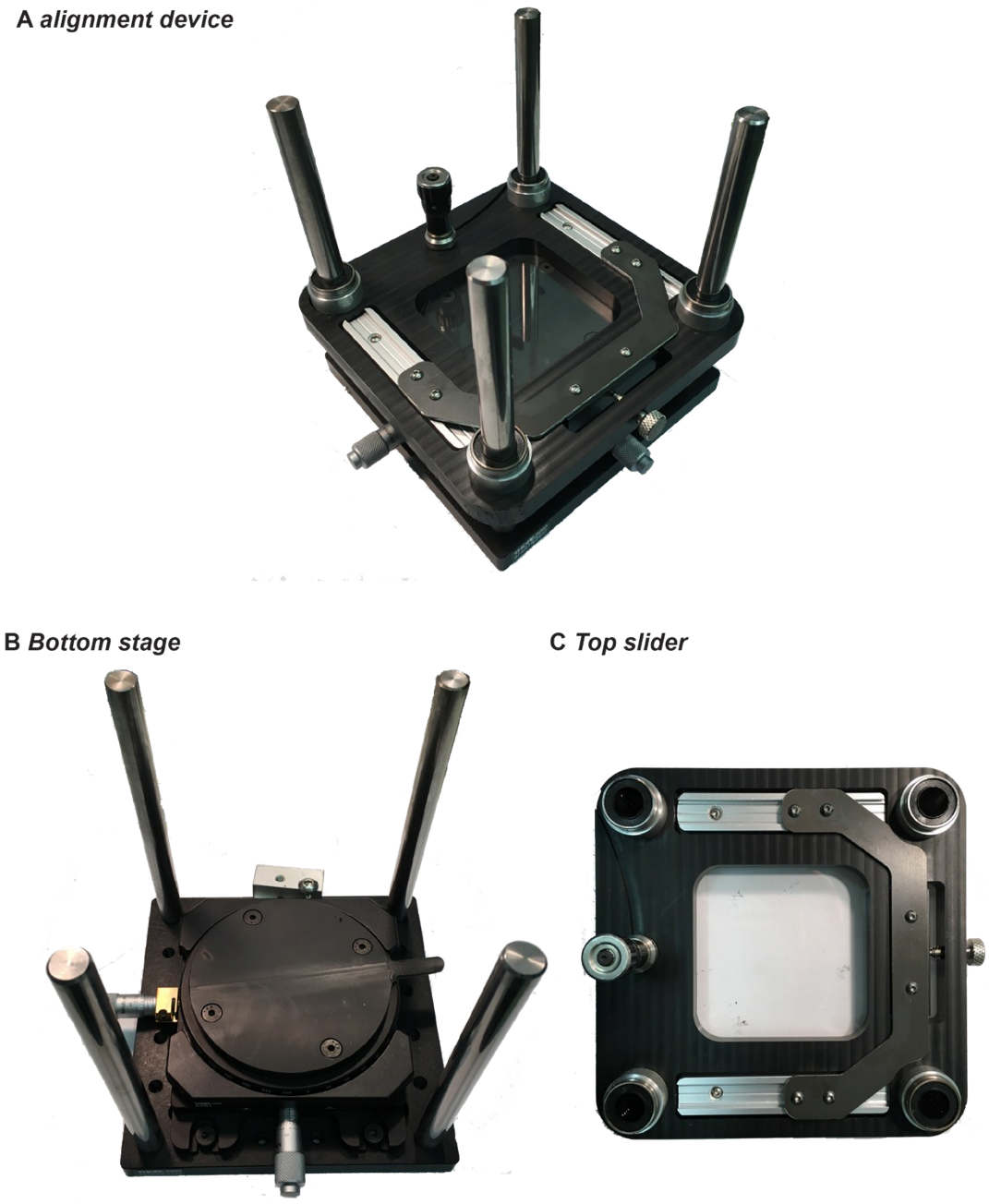
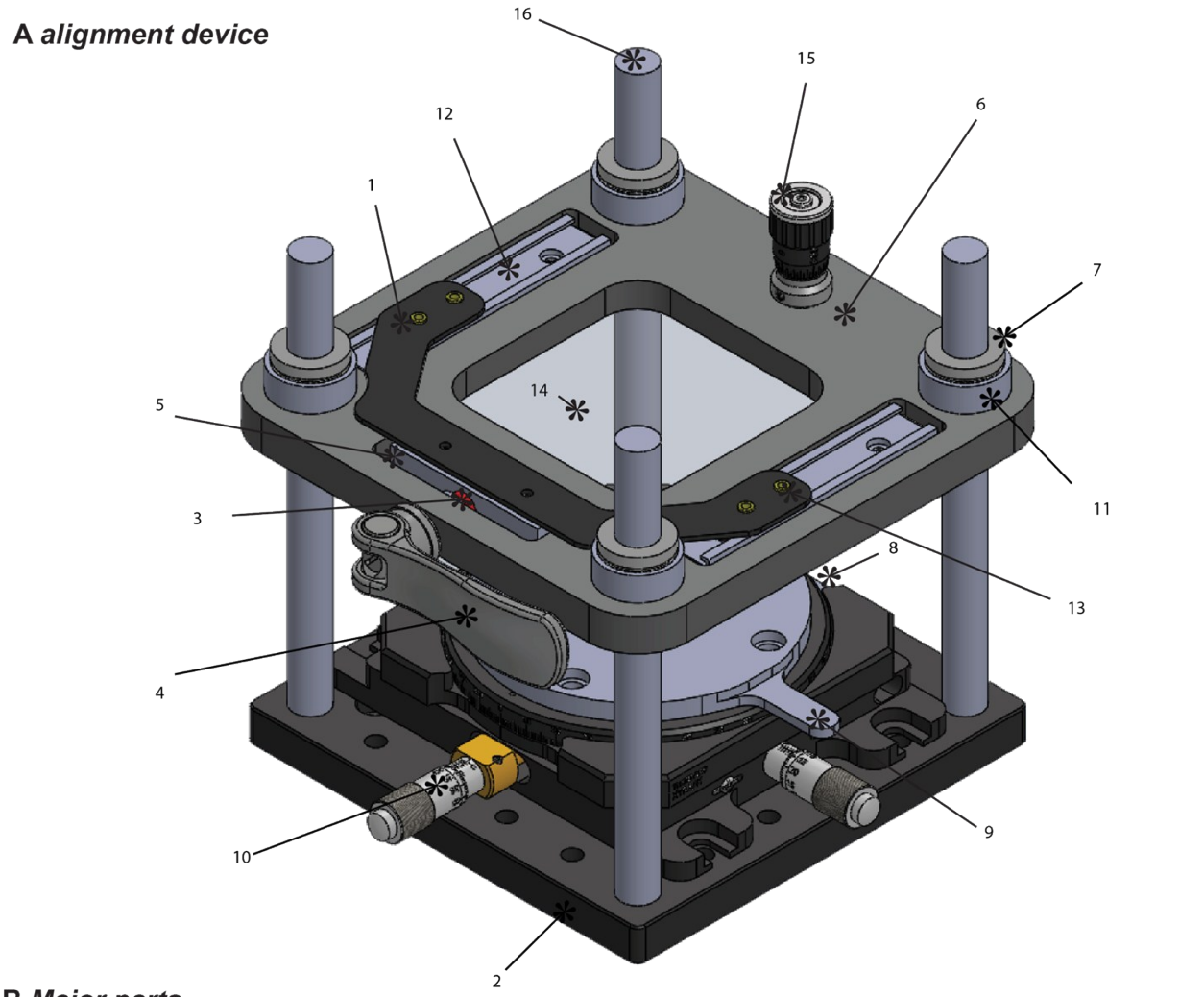


Figure SF4. Device alignment. A) Alignment device schematic B) Major parts



Extended part list for the alignment device.
We used CNC milling and turning machine to fabricate the device.

Vendor	Catalog No.	Description
THORLABS	MB1824	Aluminum Breadboard, 18" x 24" x 1/2", 1/4"-20 Threaded
THORLABS	BBH1	Breadboard Lifting Handles (set of 2)
THORLABS	MB6	Aluminum Breadboard 6" x 6" x 1/2", 1/4"-20 Threaded
THORLABS	146-200	146-200 - High Precision Micrometer Head, Range 0 - 10 mm, 5 mm per Division
THORLABS	XYR1/M	XY Linear Translation Plus Z Axis Rotation Stage
Mcmaster	8575K143	Black Delrin ® Acetal Resin Sheet - 1/2" Thick, 6" x 6"
Mcmaster	91251A539	Black-Oxide Alloy Steel Socket Head Cap Screw - 1/4"-20 Thread, 5/8" Length
Mcmaster	91251A540	Black-Oxide Alloy Steel Socket Head Cap Screw - 1/4"-20 Thread, 3/4" Length
Mcmaster	91251A541	Black-Oxide Alloy Steel Socket Head Cap Screw - 1/4"-20 Thread, 7/8" Length
Mcmaster	96765A140	Black-Oxide 18-8 Stainless Steel Flat Washer - 1/4" Screw Size, 5/8" OD, .04"-.06" Thick
Mcmaster	92700A960	Zinc-Plated Brass Male-Female Thread Hex Standoff - 1/2" Hex, 3" Length
Mcmaster	92700A965	Zinc-Plated Brass Male-Female Thread Hex Standoff - 1/2" Hex, 4" Length
Mcmaster	90308A861	Zinc-Plated Brass Female Threaded Hex Standoff - 1/2" Hex, 6" Length
Mcmaster	92991A540	Brass Cup Point Set Screw - 1/4"-20 Thread, 3/4" Long
Mcmaster	6023K293	Multipurpose Anodized Aluminum (Alloy 6061) - 3/8" Thick x 2" Width, 3'Length
Mcmaster	47065T142	Standard Zinc-Plated Steel End-Feed Fastener, for 1" Aluminum Inch T-Slotted Framing System
Mcmaster	86215K11	Weather-Chemical Resistant Santoprene Rubber - 1/32" Thickness, 12" x 12", 55A Durometer
Mcmaster	8477K15	Heat-Resistant Borosilicate Glass 5" Diameter, 1/8" Thick (Same as 8477K49),
Mcmaster	9968K22	External Retaining Ring for Linear Bearing for 1/2" Bearing OD (Same as 9968K11)

Mcmaster	1162K65	Miniature Hardened Precision 17-4 SS Shaft 1/4" Diameter
Mcmaster	60595K11	Steel Fixed-Alignment Linear Ball Bearing Closed
Mcmaster	6723K9	Low-Profile Sleeve Bearing Carriage, Threaded-Hole, for 17 mm Rail Width
Mcmaster	6723K5	Low-Profile Sleeve Bearing Carriage, Guide Rail, 17 mm Width, 250 mm Length
Mcmaster	5720K12	Quick-Positioning Cam Handle, Aluminum, 1/4"-20 Thread x 1-3/16" Thread Length
Mcmaster	5720K13	Quick-Positioning Cam Handle, Aluminum, 1/4"-20 Thread x 1-9/16" Thread Length
Mcmaster	91145A169	Nylon 6/6 Unthreaded Shoulder Spacer with Flange, Long Barrel, 1/4" Screw Size, .750" Length, packs of 100
Mcmaster	9435K78	302 Stainless Steel Precision Compression Spring, .813" Length, .36" OD, .038" Wire, packs of 5
Mcmaster	9435K84	302 Stainless Steel Precision Compression Spring, .813" Length, .36" OD, .045" Wire, packs of 5
Mcmaster	6649K41	Hardened Precision Steel Shaft, 1/2" Diameter, 6" Length Overall, 1/4"-20 x 1/2" Depth Tap One End
Mcmaster	9056K753	Multipurpose Aluminum (Alloy 6061) Tube, 1" OD, .870" ID, .065" Wall Thickness, 1' Length
Mcmaster	60595K73	Steel Fixed-Alignment Linear Ball Bearing, Closed, for 1/2" Shaft Diameter, 1-1/4" Overall Length
Mcmaster	9968K24	External Retaining Ring for Linear Bearing for 7/8" Bearing OD
Mcmaster	2984A11	Dovetail Cutter, High-Speed-Steel, 45 Degree Angle, 3/4" Cutter Diameter