UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
Escola d'Enginyeria de Barcelona Est

BACHELOR PROJECT DEGREE

Mechanical Engineering Degree

MECHANICAL BENCH CHARACTERIZATION FOR THE STUDY OF HYPODERMIC NEEDLE'S BEHAVIOR IN A SOFT-TISSUE

Annex A

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Convocation: 01-2021

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A1. Calibrations Data

In this chapter of Annex A are gathered the data used in the Calibrations chapter, some of the tables displayed are a resume of the real table, as those were too much large. All decimals will be marked with a ","

1.1. Linear Actuator Feed Velocities

distance (mm)	98.1							
	Time 1 (s)	V1(mm/s)	Deviation	Error	Time 2 (s)	V2(mm/s)	Deviation	Error
	6,420	15,280	0,218	0,223	8,350	11,749	0,182	-0,111
	6,320	15,522		-0,018	8,510	11,528		0,109
	6,360	15,425		0,079	8,570	11,447		0,190
	6,210	15,797		-0,293	8,290	11,834		-0,197
Average	6,328	15,504			8,430	11,637		

	Time 3 (s)	**V3(mm/s)**	**Deviation**	**Error**	**Time 4 (s)**	**V4 (mm/s)**	**Deviation**	**Error**
	12,490	7,854	0,109	-0,054	24,700	3,972	0,020	-0,022
	12,460	7,873		-0,073	24,940	3,933		0,016
	12,780	7,676		0,124	24,870	3,945		0,005
Average	12,577	7,800			24,837	3,950		

Velocities (pps)	**Velocities (rev/s)**	**Feed (mm/rev)**	**Desviation**
200	1	3,95	0,049
400	2	3,9	-0,001
600	3	3,879	-0,022
800	4	3,876	-0,025
	Average	3,901	

1.2. Linear Actuator Vibrations

25 first acceleration values out of 1805 form the 15,5 mm/s feed velocity

Time (s)	**Linear Acceleration x (m/s^2)**	**Linear Acceleration y (m/s^2)**	**Linear Acceleration z (m/s^2)**	**Absolute acceleration (m/s^2)**
2,809566	0,039	0,158	-0,077	0,180039

2,814629	-0,001	0,117	0,059	0,131038
2,819691	-0,04	0,185	-0,02	0,190329
2,824753	-0,066	0,185	0,115	0,227609
2,829815	-0,012	0,062	-0,047	0,078721
2,834878	0,014	0,103	-0,02	0,105854
2,83994	-0,024	0,09	0,057	0,109202
2,845002	7,507	-1,176	10,83	13,22977
2,850065	5,641	4,407	9,51	11,90305
2,855127	-5,867	7,377	-10,717	14,27221
2,860189	-3,905	-4,499	-9,763	11,43705
2,865251	0,929	-4,241	7,125	8,343545
2,870314	1,8	4,094	2,713	5,230794
2,875376	-0,937	6,26	-5,881	8,640123
2,880438	0,438	4,993	0,683	5,058496
2,885501	3,638	-1,448	10,341	11,05749
2,890563	2,317	-0,563	5,233	5,75063
2,895625	-0,243	2,923	-4,804	5,628623
2,900687	0,696	4,394	-1,303	4,635673
2,90575	2,644	2,01	6,05	6,901691
2,910812	1,064	0,512	5,465	5,591106
2,915874	-0,882	1,302	-0,486	1,646002
2,920937	-0,16	2,936	-0,8	3,047244
2,925999	0,874	3,018	2,809	4,21458

25 first acceleration values out of 1805 form the 3,95 mm/s feed velocity

Time (s)	Linear Acceleration x (m/s^2)	Linear Acceleration y (m/s^2)	Linear Acceleration z (m/s^2)	Absolute acceleration (m/s^2)
0	-1,535	0,208	-0,899	1,791002
0,005062	-0,019	0,274	-0,025	0,275793
0,010124	-0,009	0,166	-0,016	0,167012
0,015187	-0,023	0,171	0,005	0,172612
0,020249	-0,03	0,237	0,023	0,239996
0,025311	-0,005	0,078	0,019	0,080436
0,030373	-0,013	0,1	-0,015	0,101951
0,035435	0,002	0,062	-0,008	0,062546
0,040497	-0,023	0,122	-0,003	0,124185
0,045559	0	0,038	0,006	0,038471
0,050621	-0,025	0,157	0,008	0,159179
0,055683	-0,017	0,174	0,017	0,175653
0,060746	-0,005	0,156	0,015	0,156799
0,065808	-0,039	0,142	-0,089	0,172064
0,07087	-0,04	0,142	-0,184	0,235839
0,075932	0,014	0,128	-0,238	0,270599
0,080994	0,014	0,169	-0,293	0,338535
0,086056	0,014	0,074	-0,184	0,198816
0,091118	-0,012	0,074	-0,089	0,116366

0,09618	-0,012	0,128	-0,116	0,173159
0,101242	0	0,183	-0,17	0,249778
0,106305	-0,026	0,155	-0,429	0,456883
0,111367	0,014	0,101	-0,238	0,258923
0,116429	-0,04	0,142	-0,211	0,257459

1.3. Load Cell Calibration

25 first lecture values:

Lectura del valor del ADC:t-46762 No ponga ningún objeto sobre la balanza Destarando... Coloque un peso conocido:	
Valor de lectura:	-10
Valor de lectura:	18
Valor de lectura:	23
Valor de lectura:	7
Valor de lectura:	24
Valor de lectura:	13
Valor de lectura:	-1811
Valor de lectura:	-214537
Valor de lectura:	-283245
Valor de lectura:	-283235
Valor de lectura:	-283266
Valor de lectura:	-283261
Valor de lectura:	-283261
Valor de lectura:	-283260
Valor de lectura:	-283257
Valor de lectura:	-283270
Valor de lectura:	-283259
Valor de lectura:	-283273
Valor de lectura:	-283255
Valor de lectura:	-283254
Valor de lectura:	-283260

Average deformations	**Tare**
-283262.14	1913.9334

1.4. Load Cell Sensibility

25 first values of the 100, 50, 5g control weights.

100g				
Absolute Time (us)	**Relative Time (s)**	**WEIGHT(g-3)**	**WEIGHT(g)**	**DESVIATION**
13718428	0	-1,8	-0,018	-100,018
13819604	0,101176	-2,6	-0,026	-100,026

13920776	0,202348	-0,9	-0,009	-100,009
14021940	0,303512	-0,7	-0,007	-100,007
14123104	0,404676	13,9	0,139	-99,861
14224272	0,505844	3502	3,502	-96,498
14325448	0,60702	17184	17,184	-82,816
14426668	0,70824	52943	52,943	-47,057
14527888	0,80946	92342	92,342	-7,658
14629108	0,91068	100060	100,06	0,06
14730364	1,011936	100074	100,074	0,074
14831628	1,1132	100098	100,098	0,098
14932888	1,21446	100090	100,09	0,09
15034148	1,31572	100080	100,08	0,08
15135412	1,416984	100075	100,075	0,075
15236668	1,51824	100097	100,097	0,097
15337928	1,6195	100069	100,069	0,069
15439188	1,72076	100043	100,043	0,043
15540444	1,822016	100055	100,055	0,055
15641700	1,923272	100076	100,076	0,076
15742956	2,024528	100088	100,088	0,088
15844220	2,125792	100075	100,075	0,075
15945488	2,22706	100075	100,075	0,075

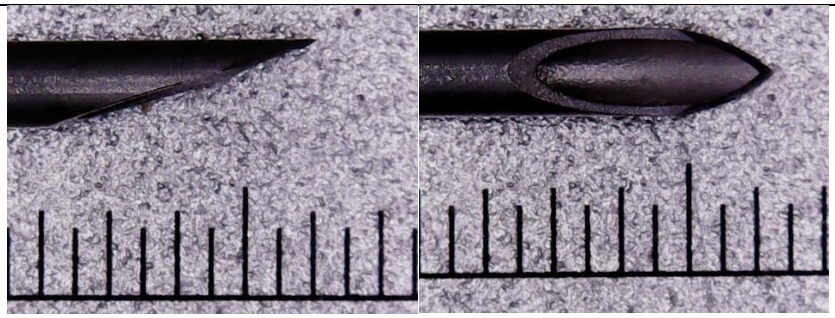
50g				
TIME (us) abs	**TIME (s) rel**	**WEIGHT(g-3)**	**WEIGHT(g)**	**DESVIATION**
646136992	0	11,4	0,114	-49,886
646238216	0,101224	12,9	0,129	-49,871
646339428	0,202436	11,5	0,115	-49,885
646440652	0,30366	13,3	0,133	-49,867
646541868	0,404876	14,2	0,142	-49,858
646643092	0,5061	2113	2,113	-47,887
646744320	0,607328	6800	6,8	-43,2
646845532	0,70854	45745	45,745	-4,255
646946800	0,809808	49996	49,996	-0,004
647048072	0,91108	50224	50,224	0,224
647149348	1,012356	50245	50,245	0,245
647250624	1,113632	50247	50,247	0,247
647351888	1,214896	50226	50,226	0,226
647453160	1,316168	50196	50,196	0,196
647554424	1,417432	50182	50,182	0,182
647655692	1,5187	50218	50,218	0,218
647756964	1,619972	50209	50,209	0,209
647858220	1,721228	50218	50,218	0,218
647959492	1,8225	50232	50,232	0,232

648060768	1,923776	50207	50,207	0,207
648162036	2,025044	50195	50,195	0,195
648263308	2,126316	50174	50,174	0,174
648364572	2,22758	50205	50,205	0,205

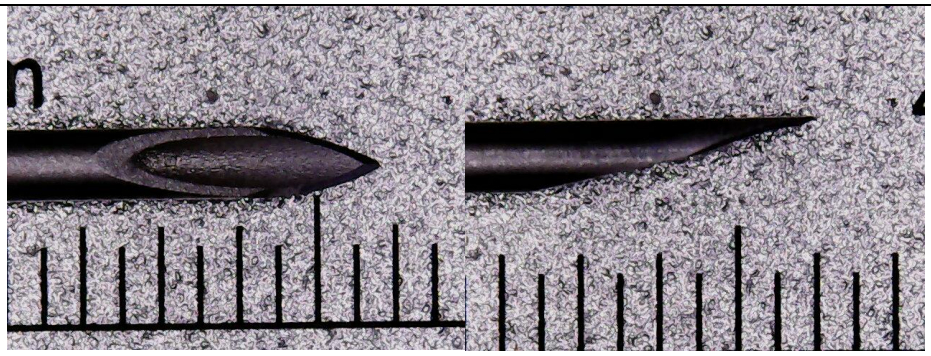
5g				
TIME (us) abs	**TIME (s) rel**	**WEIGHT(g-3)**	**WEIGHT (g)**	**DESVIATION**
1225718344	0	28,1	0,281	-4,719
1225819608	0,101264	27,5	0,275	-4,725
1225920872	0,202528	27,1	0,271	-4,729
1226022140	0,303796	28	0,28	-4,72
1226123396	0,405052	27	0,27	-4,73
1226224652	0,506308	25,1	0,251	-4,749
1226325920	0,607576	6521	6,521	1,521
1226427196	0,708852	4855	4,855	-0,145
1226528476	0,810132	4251	4,251	-0,749
1226629748	0,911404	5350	5,35	0,35
1226731012	1,012668	5394	5,394	0,394
1226832284	1,11394	5387	5,387	0,387
1226933552	1,215208	5381	5,381	0,381
1227034824	1,31648	5362	5,362	0,362
1227136096	1,417752	5377	5,377	0,377
1227237368	1,519024	5385	5,385	0,385
1227338640	1,620296	5394	5,394	0,394
1227439916	1,721572	5392	5,392	0,392
1227541196	1,822852	5376	5,376	0,376
1227642468	1,924124	5349	5,349	0,349
1227743736	2,025392	5369	5,369	0,369
1227845008	2,126664	5389	5,389	0,389
1227946276	2,227932	5402	5,402	0,402

1.5. Needle Microscopic Photos

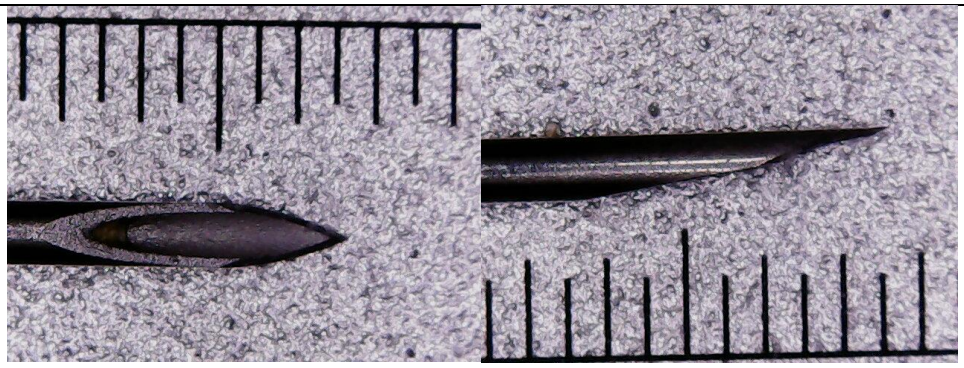
18G



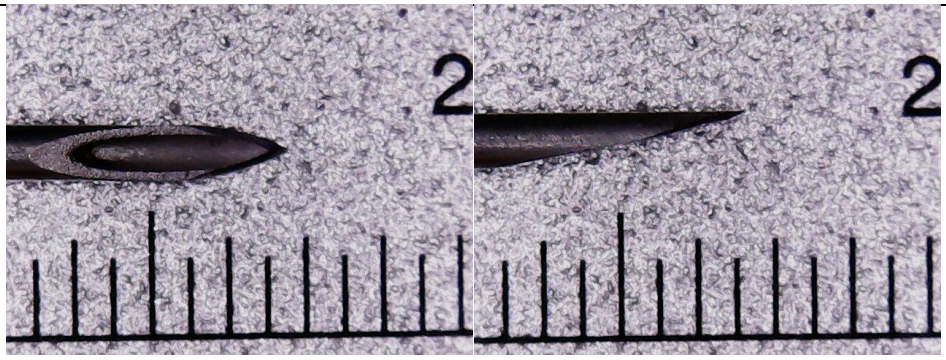
20G



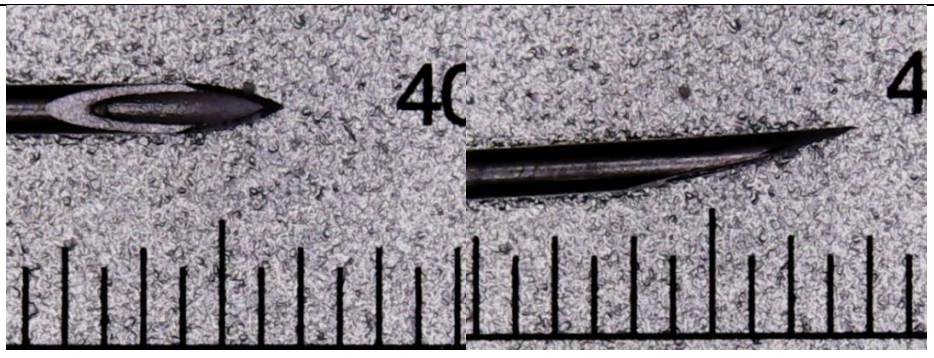
21G



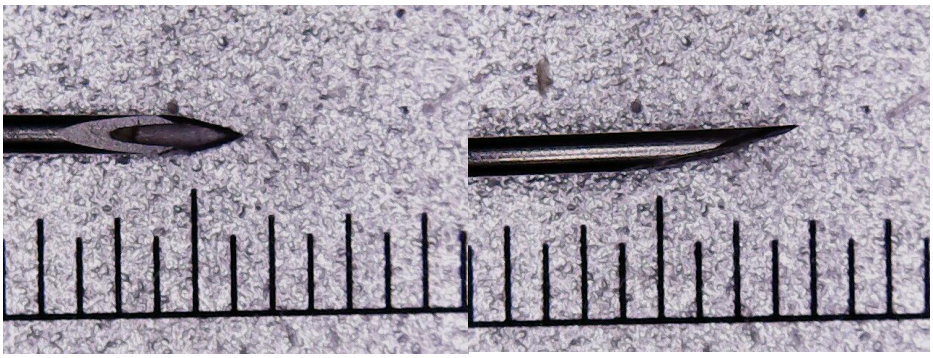
22G



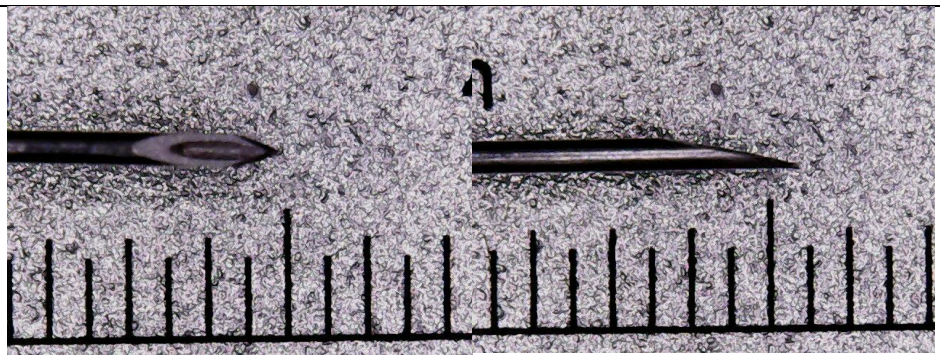
23G



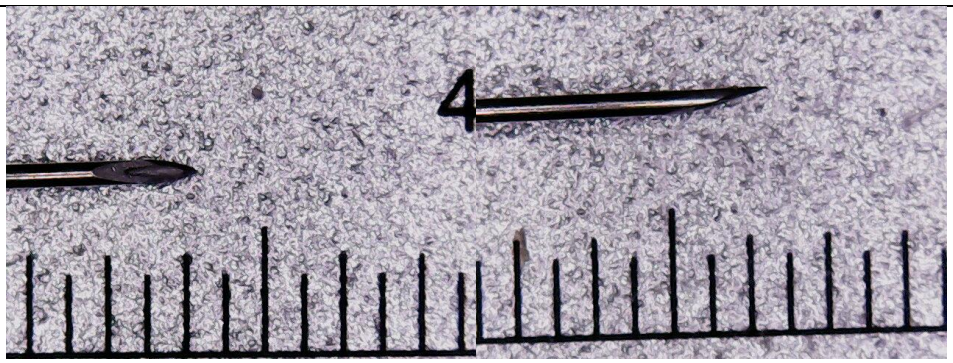
25G



27G



30G



A2. Tests Results

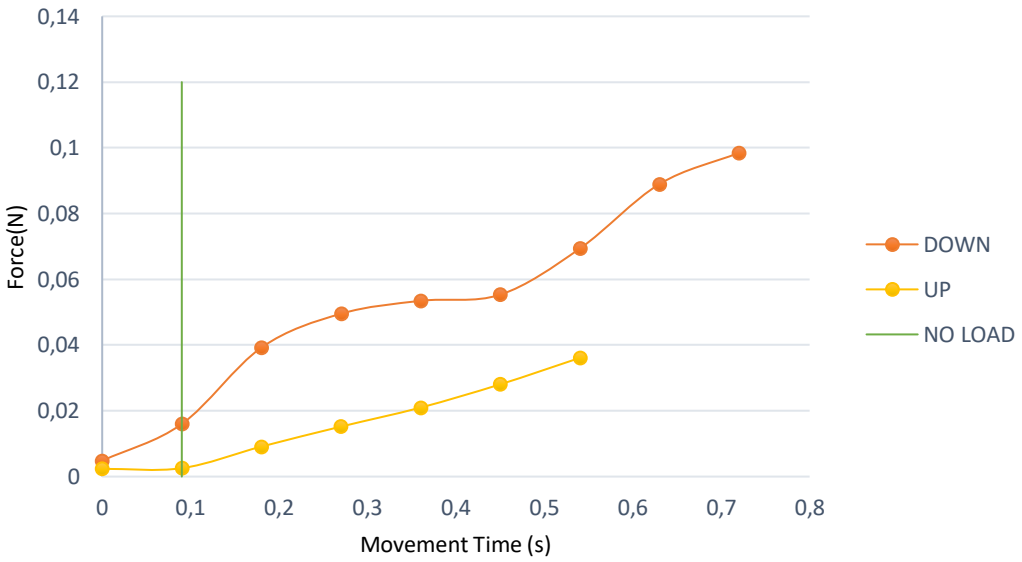
In this chapter of Annex A are gathered the 32 tests data collected with the force and relative positions calculated in the Data Analysis Chapter. All decimals will be marked with a ",".

2.1. 0.3 mm diameter for 15.5mm/s feed velocity

DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,21	0,0020601	1,73	0,0169713	0,81036
0,090056	1,395868	0,49	0,0048069	3,05	0,0299205	0,720316
0,180096	2,791488	2,41	0,0236421	4,93	0,0483633	0,63028
0,27014	4,18717	4,88	0,0478728	4,46	0,0437526	0,540236
0,360184	5,582852	5,9	0,057879	3,53	0,0346293	0,4502
0,450228	6,978534	6,72	0,0659232	2,81	0,0275661	0,360164
0,540268	8,374154	8,11	0,0795591	1,73	0,0169713	0,270116
0,630304	9,769712	9,18	0,0900558	0,38	0,0037278	0,180072
0,72034	11,16527	8,53	0,0836793	0,17	0,0016677	0,090032
0,81038	12,56089	1,73	0,0169713	0,23	0,0022563	0

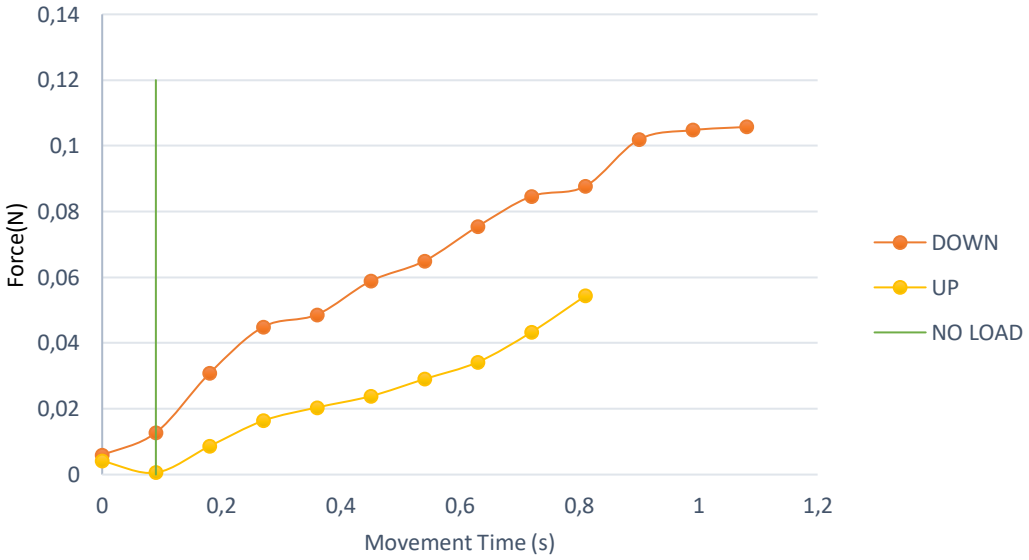
2.2. 0.3 mm diameter for 11.6 mm/s feed velocity

DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,49	0,0048069	3,58	0,0351198	0,810216
0,090028	1,0443248	1,63	0,0159903	1,16	0,0113796	0,720192
0,180052	2,0886032	4	0,03924	3,48	0,0341388	0,630156
0,270076	3,1328816	5,05	0,0495405	3,68	0,0361008	0,540124
0,360096	4,1771136	5,45	0,0534645	2,86	0,0280566	0,450108
0,450112	5,2212992	5,64	0,0553284	2,14	0,0209934	0,360088
0,540136	6,2655776	7,07	0,0693567	1,55	0,0152055	0,270064
0,630168	7,3099488	9,07	0,0889767	0,93	0,0091233	0,180044
0,720192	8,3542272	10,04	0,0984924	0,26	0,0025506	0,090028
0,810224	9,3985984	8,79	0,0862299	0,24	0,0023544	0
0,90024	10,442784	3,58	0,0351198			



2.3. 0.3 mm diameter for 7.8 mm/s feed velocity

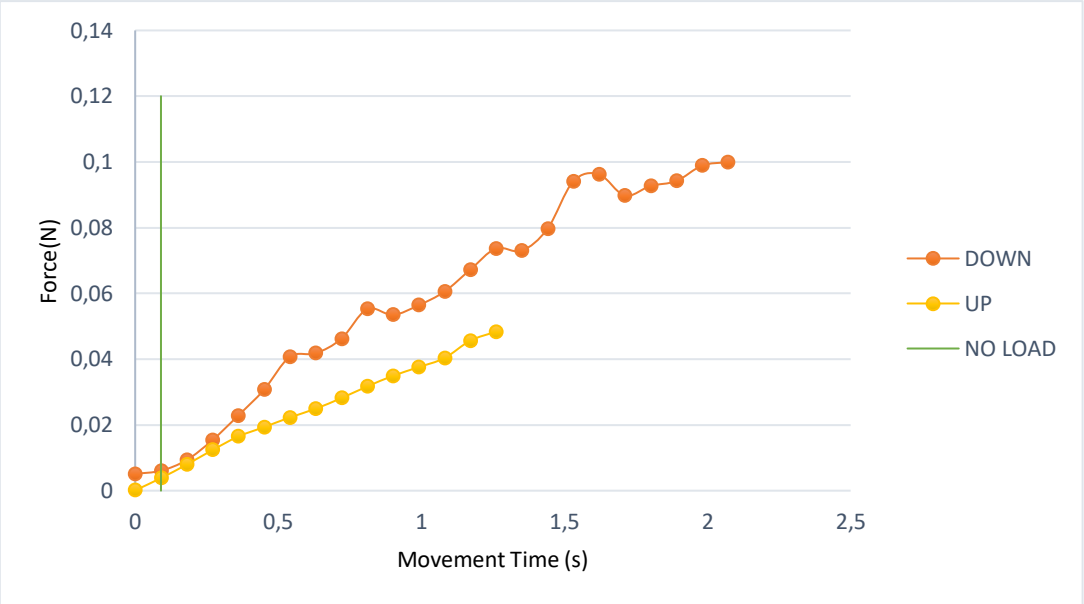
DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,6	0,005886	2,25	0,0220725	1,170496
0,090044	0,7023432	1,3	0,012753	0,94	0,0092214	1,080452
0,180076	1,4045928	3,14	0,0308034	2,62	0,0257022	0,990416
0,27012	2,106936	4,58	0,0449298	4,81	0,0471861	0,900376
0,360164	2,8092792	4,96	0,0486576	5,54	0,0543474	0,810332
0,450192	3,5114976	6	0,05886	4,42	0,0433602	0,7203
0,540236	4,2138408	6,62	0,0649422	3,49	0,0342369	0,630264
0,63028	4,916184	7,7	0,075537	2,96	0,0290376	0,540228
0,720312	5,6184336	8,63	0,0846603	2,43	0,0238383	0,450192
0,810356	6,3207768	8,94	0,0877014	2,08	0,0204048	0,360156
0,900396	7,0230888	10,39	0,1019259	1,67	0,0163827	0,27012
0,990428	7,7253384	10,68	0,1047708	0,88	0,0086328	0,180084
1,080468	8,4276504	10,78	0,1057518	0,06	0,0005886	0,090048
1,17052	9,130056	9,16	0,0898596	0,42	0,0041202	0
1,260552	9,8323056	2,25	0,0220725			



2.4. 0.3 mm diameter for 3.95 mm/s feed velocity

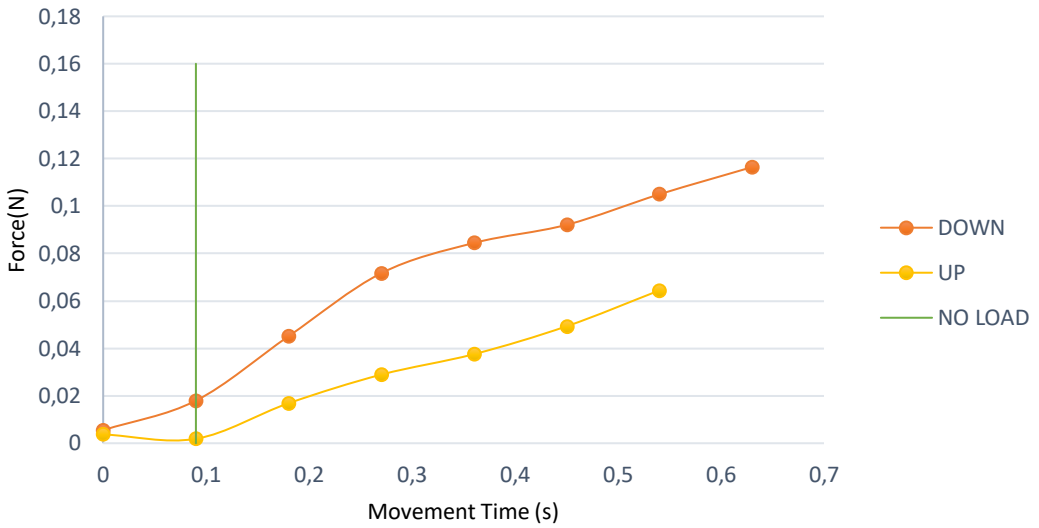
DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,52	0,0051012	0,86	0,0084366	1,890928
0,09004	0,355658	0,62	0,0060822	0,28	0,0027468	1,800884
0,180084	0,7113318	0,95	0,0093195	0,85	0,0083385	1,710848
0,270124	1,0669898	1,57	0,0154017	1,58	0,0154998	1,620804
0,360176	1,4226952	2,33	0,0228573	2,53	0,0248193	1,530756
0,450212	1,7783374	3,13	0,0307053	3,61	0,0354141	1,440712
0,54026	2,134027	4,15	0,0407115	4,47	0,0438507	1,350664
0,630292	2,4896534	4,26	0,0417906	4,93	0,0483633	1,260624
0,72034	2,845343	4,71	0,0462051	4,65	0,0456165	1,170576
0,810384	3,2010168	5,63	0,0552303	4,11	0,0403191	1,080532
0,900428	3,5566906	5,45	0,0534645	3,83	0,0375723	0,990496
0,990468	3,9123486	5,75	0,0564075	3,56	0,0349236	0,900456
1,080512	4,2680224	6,17	0,0605277	3,23	0,0316863	0,810408
1,170556	4,6236962	6,85	0,0671985	2,87	0,0281547	0,720372
1,260588	4,9793226	7,51	0,0736731	2,54	0,0249174	0,630328
1,350632	5,3349964	7,44	0,0729864	2,27	0,0222687	0,540284
1,44068	5,690686	8,12	0,0796572	1,97	0,0193257	0,450244
1,53072	6,046344	9,59	0,0940779	1,68	0,0164808	0,3602
1,620768	6,4020336	9,81	0,0962361	1,26	0,0123606	0,270156
1,710812	6,7577074	9,15	0,0897615	0,81	0,0079461	0,180108
1,800856	7,1133812	9,45	0,0927045	0,39	0,0038259	0,090052
1,890892	7,4690234	9,6	0,094176	0,01	0,0000981	0
1,980948	7,8247446	10,08	0,0988848			

2,070988	8,1804026	10,19	0,0999639			
2,161032	8,5360764	9,15	0,0897615			
2,251076	8,8917502	7,67	0,0752427			
2,34112	9,247424	4,25	0,0416925			
2,431164	9,6030978	0,86	0,0084366			



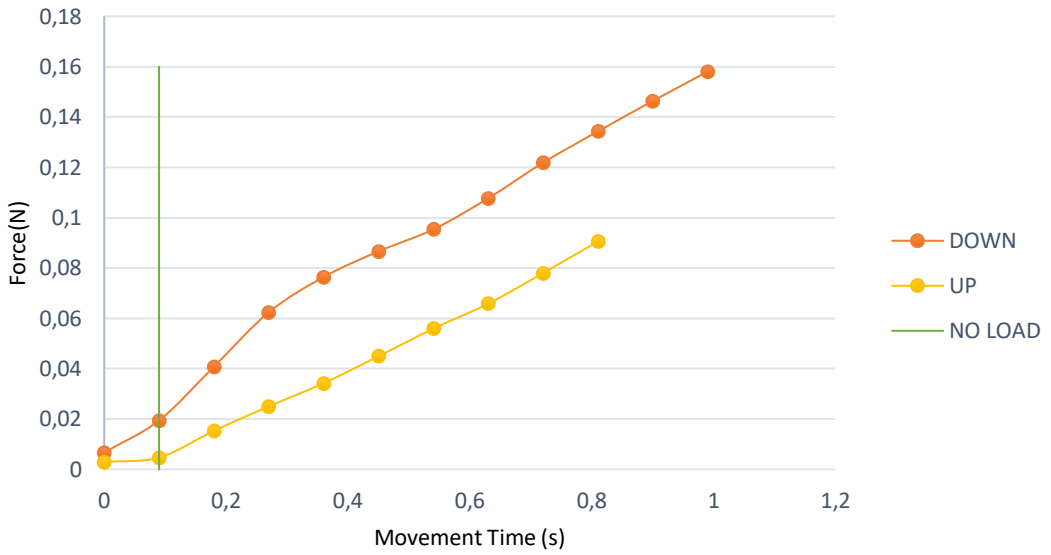
2.5. 0.4 mm diameter for 15,5 mm/s feed velocity

DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,56	0,0054936	2,06	0,0202086	0,810408
0,090044	1,395682	1,83	0,0179523	3,54	0,0347274	0,720352
0,180068	2,791054	4,6	0,045126	6,22	0,0610182	0,630316
0,270112	4,186736	7,31	0,0717111	6,57	0,0644517	0,54028
0,360156	5,582418	8,61	0,0844641	5,03	0,0493443	0,450236
0,450196	6,978038	9,39	0,0921159	3,83	0,0375723	0,360188
0,540244	8,373782	10,7	0,104967	2,95	0,0289395	0,27014
0,630272	9,769216	11,87	0,1164447	1,72	0,0168732	0,180096
0,720312	11,164836	10,42	0,1022202	0,19	0,0018639	0,090048
0,81036	12,56058	2,06	0,0202086	0,38	0,0037278	0



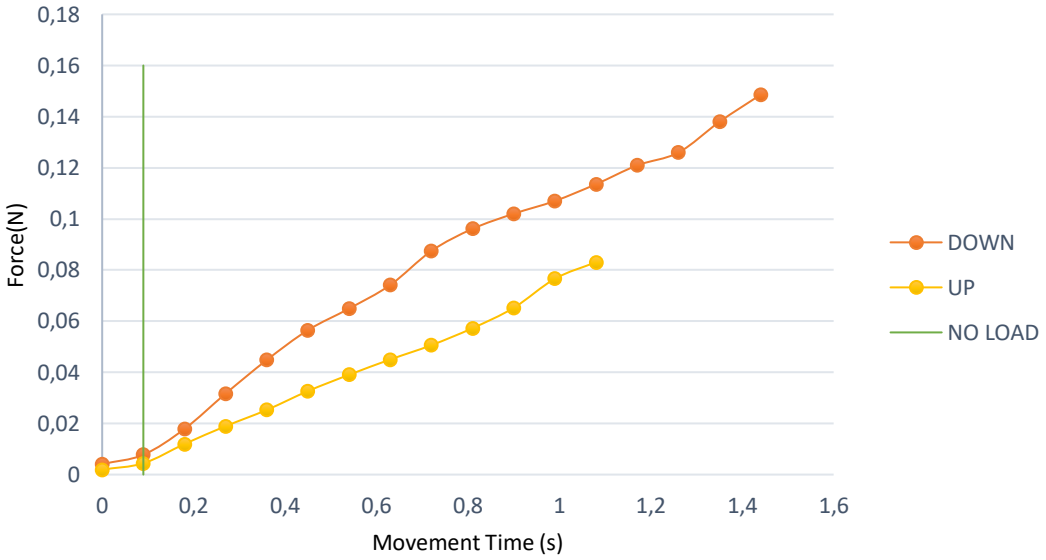
2.6. 0.4 mm diameter for 11,6 mm/s feed velocity

DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,68	0,0066708	3,55	0,0348255	0,990476
0,09004	1,044464	1,98	0,0194238	7,23	0,0709263	0,900432
0,180084	2,0889744	4,16	0,0408096	9,23	0,0905463	0,810396
0,270136	3,1335776	6,36	0,0623916	7,95	0,0779895	0,720328
0,360172	4,1779952	7,79	0,0764199	6,71	0,0658251	0,630292
0,450216	5,2225056	8,83	0,0866223	5,7	0,055917	0,540244
0,54026	6,267016	9,72	0,0953532	4,58	0,0449298	0,450208
0,630308	7,3115728	10,98	0,1077138	3,49	0,0342369	0,36016
0,720348	8,3560368	12,42	0,1218402	2,55	0,0250155	0,270124
0,8104	9,40064	13,69	0,1342989	1,56	0,0153036	0,180084
0,900452	10,4452432	14,92	0,1463652	0,48	0,0047088	0,09004
0,990496	11,4897536	16,11	0,1580391	0,3	0,002943	0
1,080548	12,5343568	12,05	0,1182105			
1,170604	13,5790064	1,56	0,0153036			



2.7. 0.4 mm diameter for 7,8 mm/s feed velocity

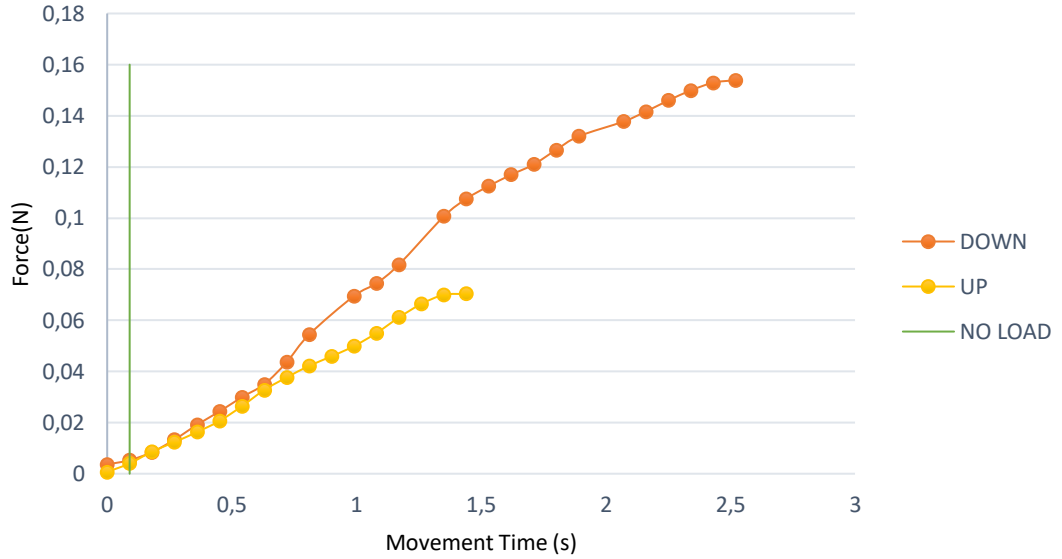
DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,42	0,0041202	6,07	0,0595467	1,620776
0,09004	0,702312	0,79	0,0077499	0,28	0,0027468	1,530732
0,180084	1,4046552	1,82	0,0178542	2,01	0,0197181	1,440684
0,270128	2,1069984	3,23	0,0316863	3,48	0,0341388	1,350636
0,360172	2,8093416	4,57	0,0448317	5,37	0,0526797	1,260592
0,450216	3,5116848	5,76	0,0565056	7,3	0,071613	1,170552
0,540268	4,2140904	6,62	0,0649422	8,47	0,0830907	1,080504
0,630312	4,9164336	7,56	0,0741636	7,81	0,0766161	0,990472
0,720364	5,6188392	8,92	0,0875052	6,65	0,0652365	0,900424
0,810408	6,3211824	9,8	0,096138	5,84	0,0572904	0,810392
0,900448	7,0234944	10,4	0,102024	5,16	0,0506196	0,720356
0,990492	7,7258376	10,91	0,1070271	4,59	0,0450279	0,630308
1,080528	8,4281184	11,58	0,1135998	3,98	0,0390438	0,540272
1,17058	9,130524	12,33	0,1209573	3,33	0,0326673	0,45022
1,260612	9,8327736	12,84	0,1259604	2,58	0,0253098	0,360184
1,350664	10,5351792	14,07	0,1380267	1,93	0,0189333	0,27014
1,440704	11,2374912	15,15	0,1486215	1,22	0,0119682	0,180092
1,530748	11,9398344	13,79	0,1352799	0,45	0,0044145	0,090056
1,620792	12,6421776	6,07	0,0595467	0,2	0,001962	0



2.8. 0.4 mm diameter for 3.95 mm/s feed velocity

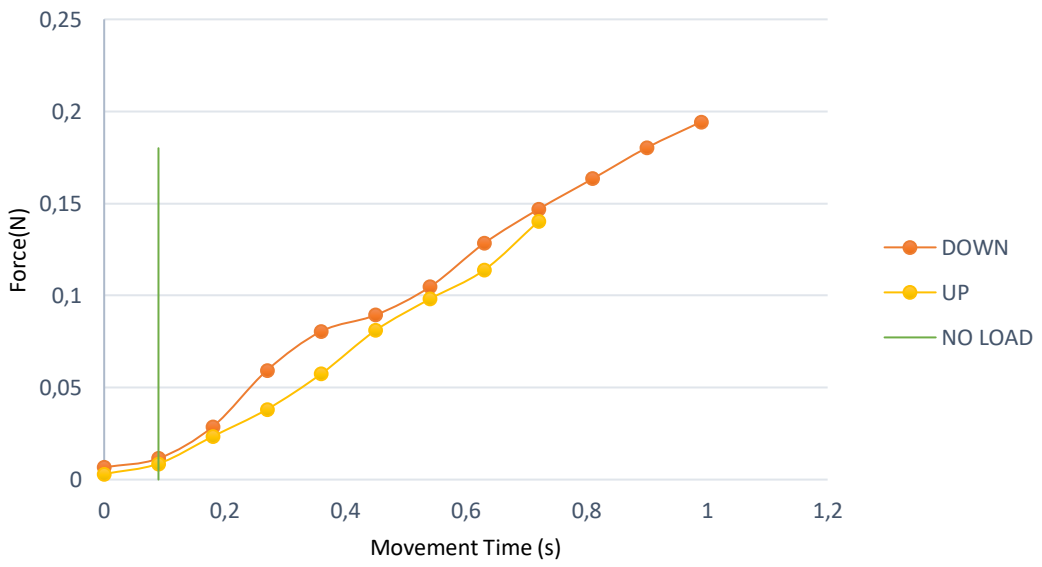
DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,37	0,0036297	0,75	0,0073575	2,611176
0,090048	0,3556896	0,54	0,0052974	0,29	0,0028449	2,521124
0,18008	0,711316	0,86	0,0084366	0,77	0,0075537	2,431088
0,270112	1,0669424	1,36	0,0133416	1,18	0,0115758	2,34104
0,360148	1,4225846	1,95	0,0191295	1,61	0,0157941	2,251004
0,450188	1,7782426	2,48	0,0243288	2,18	0,0213858	2,160956
0,540232	2,1339164	3,05	0,0299205	2,88	0,0282528	2,070916
0,630268	2,4895586	3,57	0,0350217	3,64	0,0357084	1,980896
0,720304	2,8452008	4,45	0,0436545	4,36	0,0427716	1,890852
0,810348	3,2008746	5,55	0,0544455	5,02	0,0492462	1,800812
0,99042	3,912159	7,09	0,0695529	5,62	0,0551322	1,710768
1,080448	4,2677696	7,59	0,0744579	6,14	0,0602334	1,620732
1,170492	4,6234434	8,34	0,0818154	6,72	0,0659232	1,530684
1,350568	5,3347436	10,26	0,1006506	7,17	0,0703377	1,440644
1,440612	5,6904174	10,96	0,1075176	7,13	0,0699453	1,3506
1,530648	6,0460596	11,47	0,1125207	6,77	0,0664137	1,260552
1,62068	6,401686	11,92	0,1169352	6,23	0,0611163	1,170512
1,710724	6,7573598	12,33	0,1209573	5,61	0,0550341	1,080468
1,800768	7,1130336	12,91	0,1266471	5,09	0,0499329	0,990428
1,8908	7,46866	13,45	0,1319445	4,68	0,0459108	0,90038
2,070876	8,1799602	14,04	0,1377324	4,3	0,042183	0,81034
2,160908	8,5355866	14,44	0,1416564	3,84	0,0376704	0,720292
2,25094	8,891213	14,88	0,1459728	3,34	0,0327654	0,63026

2,340976	9,2468552	15,28	0,1498968	2,69	0,0263889	0,54022
2,431012	9,6024974	15,59	0,1529379	2,1	0,020601	0,450184
2,521056	9,9581712	15,69	0,1539189	1,66	0,0162846	0,360144
2,6111	10,313845	13,92	0,1365552	1,26	0,0123606	0,270108
2,70114	10,669503	11,78	0,1155618	0,88	0,0086328	0,180072
2,791176	11,0251452	9,17	0,0899577	0,41	0,0040221	0,090036
2,88122	11,380819	3,78	0,0370818	0,07	0,0006867	0
2,971256	11,7364612	0,75	0,0073575			



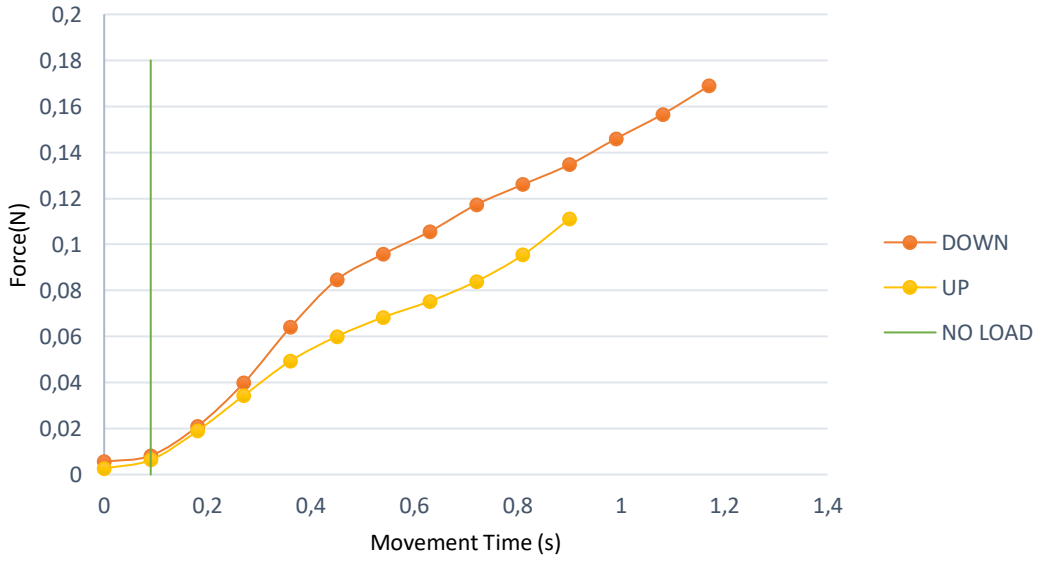
2.9. 0.5 mm diameter for 15,5 mm/s feed velocity

DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,68	0,0066708	0,87	0,0085347	0,990464
0,09004	1,39562	1,17	0,0114777	7,2	0,070632	0,900424
0,180084	2,791302	2,93	0,0287433	12,87	0,1262547	0,810364
0,270116	4,186798	6,05	0,0593505	14,3	0,140283	0,720332
0,36016	5,58248	8,21	0,0805401	11,6	0,113796	0,630284
0,450204	6,978162	9,11	0,0893691	10	0,0981	0,540248
0,540236	8,373658	10,67	0,1046727	8,26	0,0810306	0,450204
0,630268	9,769154	13,08	0,1283148	5,86	0,0574866	0,360168
0,720312	11,164836	14,97	0,1468557	3,89	0,0381609	0,270128
0,810352	12,560456	16,66	0,1634346	2,39	0,0234459	0,18008
0,900384	13,955952	18,38	0,1803078	0,88	0,0086328	0,090044
0,990428	15,351634	19,81	0,1943361	0,31	0,0030411	0
1,08046	16,74713	14,79	0,1450899			
1,170504	18,142812	0,87	0,0085347			



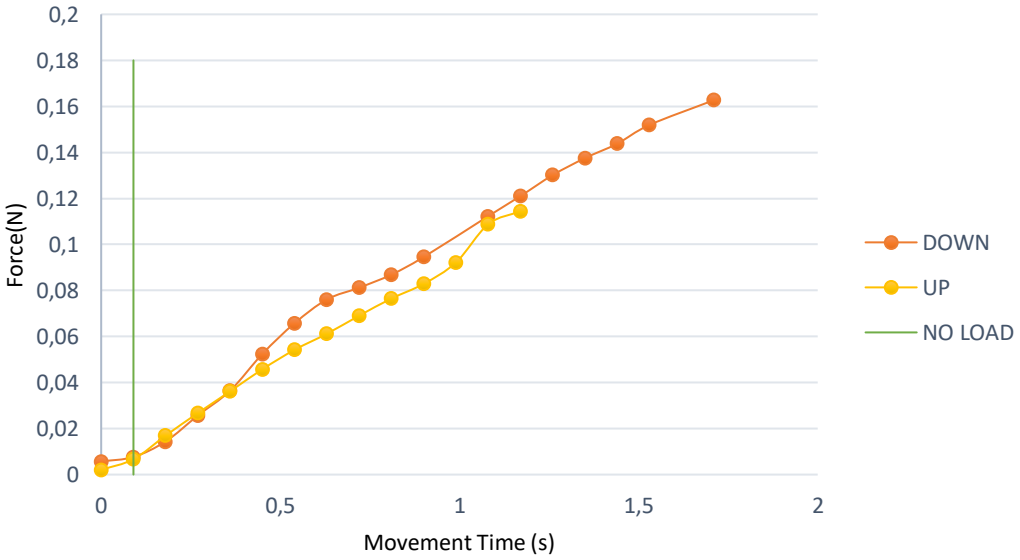
2.10. 0.5 mm diameter for 11,6 mm/s feed velocity

DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,57	0,0055917	3,73	0,0365913	1,260636
0,090044	1,0445104	0,84	0,0082404	3,5	0,034335	1,170596
0,180096	2,0891136	2,13	0,0208953	7,45	0,0730845	1,080548
0,27014	3,133624	4,06	0,0398286	10,83	0,1062423	0,990504
0,360192	4,1782272	6,52	0,0639612	11,33	0,1111473	0,90046
0,450244	5,2228304	8,63	0,0846603	9,73	0,0954513	0,810412
0,540288	6,2673408	9,77	0,0958437	8,56	0,0839736	0,720356
0,630344	7,3119904	10,77	0,1056537	7,68	0,0753408	0,630312
0,720384	8,3564544	11,96	0,1173276	6,97	0,0683757	0,540264
0,810436	9,4010576	12,85	0,1260585	6,12	0,0600372	0,450216
0,900488	10,4456608	13,73	0,1346913	5,03	0,0493443	0,360172
0,990532	11,4901712	14,88	0,1459728	3,5	0,034335	0,270124
1,08058	12,534728	15,96	0,1565676	1,93	0,0189333	0,180084
1,170624	13,5792384	17,22	0,1689282	0,65	0,0063765	0,090048
1,260664	14,6237024	15,03	0,1474443	0,27	0,0026487	0
1,35072	15,668352	3,73	0,0365913			



2.11. 0.5 mm diameter for 7,8 mm/s feed velocity

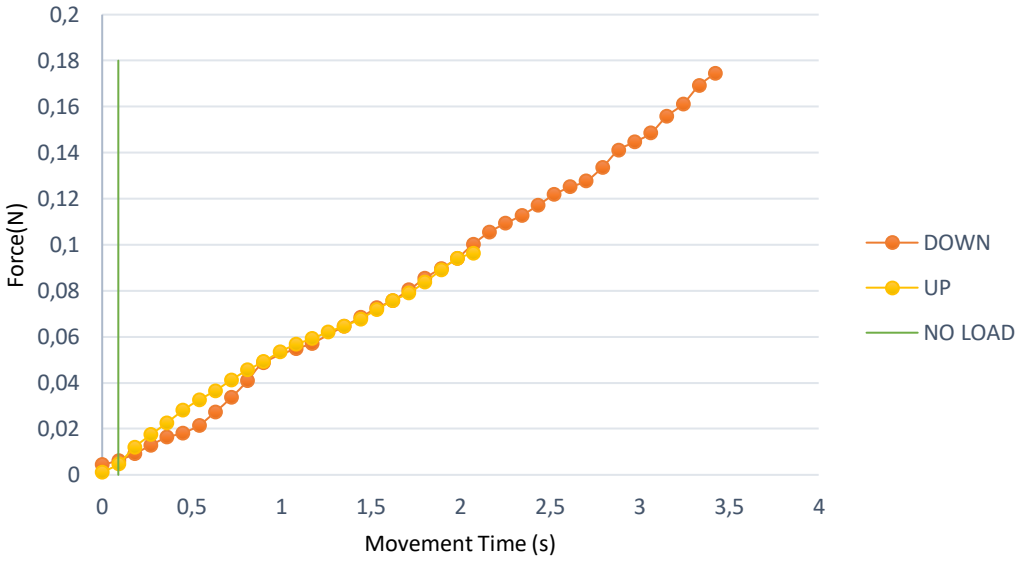
DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,58	0,0056898	2,37	0,0232497	1,710844
0,090044	0,7023432	0,78	0,0076518	1,48	0,0145188	1,6208
0,180084	1,4046552	1,47	0,0144207	3,49	0,0342369	1,530752
0,270136	2,1070608	2,62	0,0257022	5,83	0,0571923	1,440716
0,36018	2,809404	3,72	0,0364932	8,22	0,0806382	1,350656
0,450216	3,5116848	5,35	0,0524835	10,36	0,1016316	1,260612
0,540268	4,2140904	6,71	0,0658251	11,67	0,1144827	1,170568
0,630312	4,9164336	7,76	0,0761256	11,09	0,1087929	1,080524
0,720356	5,6187768	8,28	0,0812268	9,4	0,092214	0,990476
0,8104	6,32112	8,86	0,0869166	8,45	0,0828945	0,900428
0,90044	7,023432	9,64	0,0945684	7,8	0,076518	0,81038
1,080536	8,4281808	11,45	0,1123245	7,04	0,0690624	0,72034
1,170576	9,1304928	12,34	0,1210554	6,24	0,0612144	0,630292
1,260632	9,8329296	13,27	0,1301787	5,53	0,0542493	0,540248
1,350672	10,5352416	14,02	0,1375362	4,67	0,0458127	0,4502
1,440724	11,2376472	14,66	0,1438146	3,69	0,0361989	0,360168
1,530776	11,9400528	15,49	0,1519569	2,73	0,0267813	0,270132
1,710864	13,3447392	16,59	0,1627479	1,73	0,0169713	0,180096
1,8009	14,04702	12,05	0,1182105	0,68	0,0066708	0,090048
1,890952	14,7494256	2,37	0,0232497	0,21	0,0020601	0



2.12. 0.5 mm diameter for 3.95 mm/s feed velocity

DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,46	0,0045126	0,07	0,0006867	3,421512
0,090052	0,3557054	0,63	0,0061803	0,84	0,0082404	3,331472
0,180108	0,7114266	0,93	0,0091233	1,51	0,0148131	3,241424
0,270148	1,0670846	1,31	0,0128511	2,17	0,0212877	3,151388
0,360188	1,4227426	1,66	0,0162846	2,88	0,0282528	3,061332
0,450232	1,7784164	1,85	0,0181485	3,65	0,0358065	2,971296
0,540272	2,1340744	2,19	0,0214839	4,43	0,0434583	2,881256
0,630324	2,4897798	2,78	0,0272718	5,13	0,0503253	2,791224
0,720364	2,8454378	3,42	0,0335502	5,84	0,0572904	2,701176
0,810404	3,2010958	4,16	0,0408096	6,59	0,0646479	2,61114
0,900452	3,5567854	4,96	0,0486576	7,19	0,0705339	2,521096
1,080536	4,2681172	5,59	0,0548379	7,84	0,0769104	2,43106
1,17058	4,623791	5,82	0,0570942	8,53	0,0836793	2,341024
1,35068	5,335186	6,59	0,0646479	9,13	0,0895653	2,250984
1,44072	5,690844	6,96	0,0682776	9,58	0,0939798	2,160936
1,530764	6,0465178	7,39	0,0724959	9,81	0,0962361	2,0709
1,620808	6,4021916	7,72	0,0757332	9,58	0,0939798	1,98086
1,710852	6,7578654	8,18	0,0802458	9,07	0,0889767	1,890816
1,800888	7,1135076	8,71	0,0854451	8,53	0,0836793	1,800768
1,890932	7,4691814	9,14	0,0896634	8,05	0,0789705	1,710728
1,980976	7,8248552	9,58	0,0939798	7,71	0,0756351	1,620684
2,071012	8,1804974	10,22	0,1002582	7,32	0,0718092	1,530648
2,161056	8,5361712	10,75	0,1054575	6,9	0,067689	1,4406

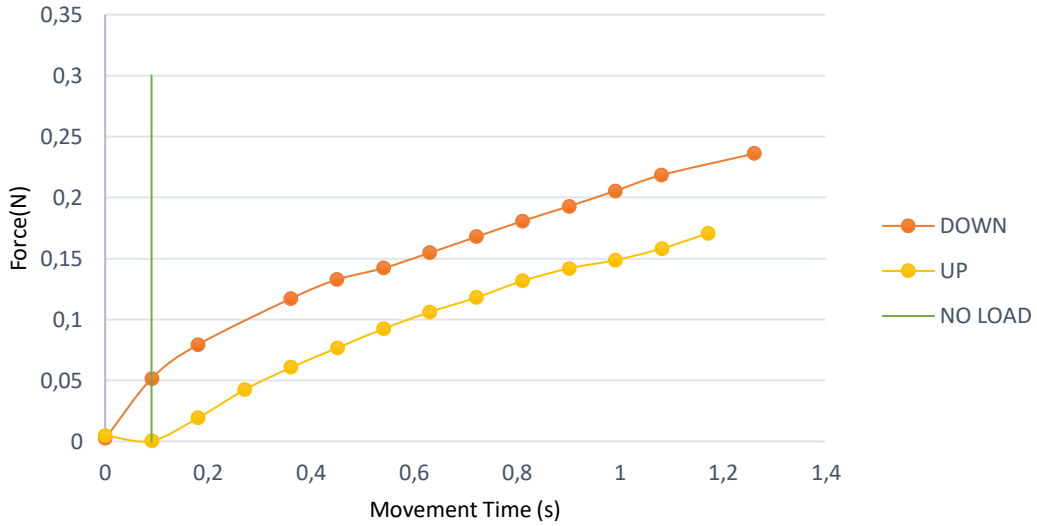
2,251096	8,8918292	11,14	0,1092834	6,59	0,0646479	1,350556
2,34114	9,247503	11,49	0,1127169	6,33	0,0620973	1,260524
2,431184	9,6031768	11,93	0,1170333	6,03	0,0591543	1,17048
2,521224	9,9588348	12,41	0,1217421	5,78	0,0567018	1,080432
2,611268	10,3145086	12,75	0,1250775	5,44	0,0533664	0,990396
2,701308	10,6701666	13,01	0,1276281	5,01	0,0491481	0,90036
2,79136	11,025872	13,61	0,1335141	4,64	0,0455184	0,810312
2,881404	11,3815458	14,38	0,1410678	4,2	0,041202	0,720276
2,971444	11,7372038	14,74	0,1445994	3,72	0,0364932	0,630236
3,061488	12,0928776	15,13	0,1484253	3,32	0,0325692	0,5402
3,151532	12,4485514	15,88	0,1557828	2,85	0,0279585	0,450164
3,241568	12,8041936	16,42	0,1610802	2,3	0,022563	0,360136
3,331604	13,1598358	17,24	0,1691244	1,77	0,0173637	0,270104
3,421648	13,5155096	17,79	0,1745199	1,22	0,0119682	0,180068
3,511688	13,8711676	1,45	0,0142245	0,49	0,0048069	0,090028
3,601724	14,2268098	0,71	0,0069651	0,11	0,0010791	0
3,781808	14,9381416	0,07	0,0006867			



2.13. 0.6 mm diameter for 15,5 mm/s feed velocity

DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,23	0,0022563	12,66	0,1241946	1,530904
0,090044	1,395682	5,25	0,0515025	4,57	0,0448317	1,44086
0,180084	2,791302	8,08	0,0792648	11,54	0,1132074	1,350804
0,360172	5,582666	11,93	0,1170333	15,04	0,1475424	1,26074
0,450204	6,978162	13,52	0,1326312	17,4	0,170694	1,170684

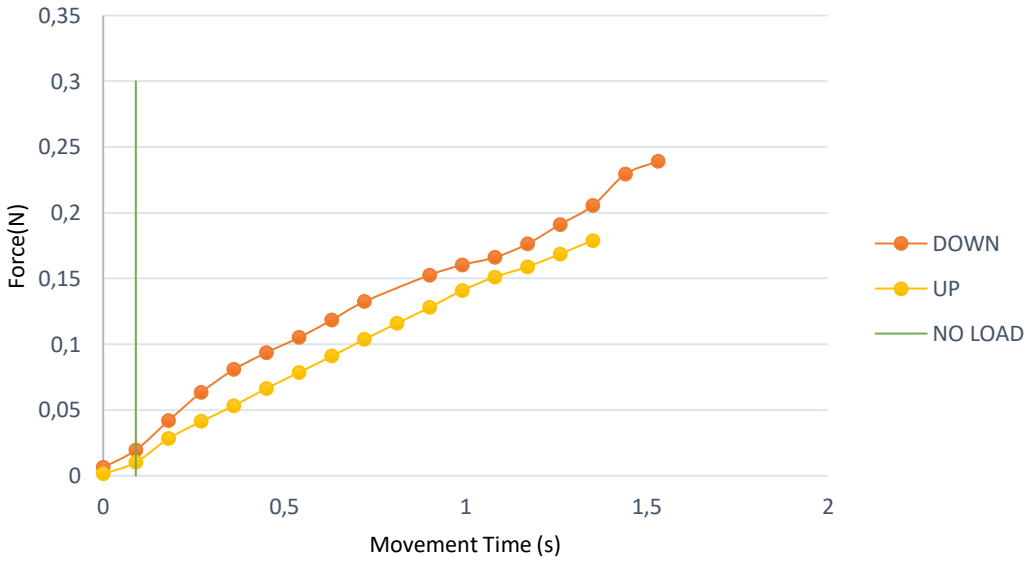
0,540248	8,373844	14,48	0,1420488	16,11	0,1580391	1,08064
0,63028	9,76934	15,76	0,1546056	15,15	0,1486215	0,990584
0,72032	11,16496	17,09	0,1676529	14,46	0,1418526	0,900536
0,810356	12,560518	18,42	0,1807002	13,41	0,1315521	0,810484
0,900392	13,956076	19,65	0,1927665	12,02	0,1179162	0,720428
0,990432	15,351696	20,93	0,2053233	10,81	0,1060461	0,630376
1,08046	16,74713	22,26	0,2183706	9,41	0,0923121	0,54032
1,260556	19,538618	24,05	0,2359305	7,8	0,076518	0,450264
1,3506	20,9343	12,66	0,1241946	6,17	0,0605277	0,360216
				4,3	0,042183	0,270168
				1,96	0,0192276	0,180112
				0,05	0,0004905	0,090056
				0,49	0,0048069	0



2.14. 0.6 mm diameter for 11,6 mm/s feed velocity

DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,63	0,0061803	5,02	0,0492462	1,62074
0,090044	1,0445104	1,99	0,0195219	11,9	0,116739	1,530692
0,180084	2,0889744	4,26	0,0417906	16,58	0,1626498	1,440656
0,27012	3,133392	6,45	0,0632745	18,23	0,1788363	1,35062
0,360156	4,1778096	8,22	0,0806382	17,19	0,1686339	1,260572
0,450192	5,2222272	9,54	0,0935874	16,19	0,1588239	1,170536
0,540232	6,2666912	10,71	0,1050651	15,4	0,151074	1,080492
0,630268	7,3111088	12,06	0,1183086	14,35	0,1407735	0,990452
0,720312	8,3556192	13,48	0,1322388	13,04	0,1279224	0,900408
0,900384	10,4444544	15,55	0,1525455	11,8	0,115758	0,81036

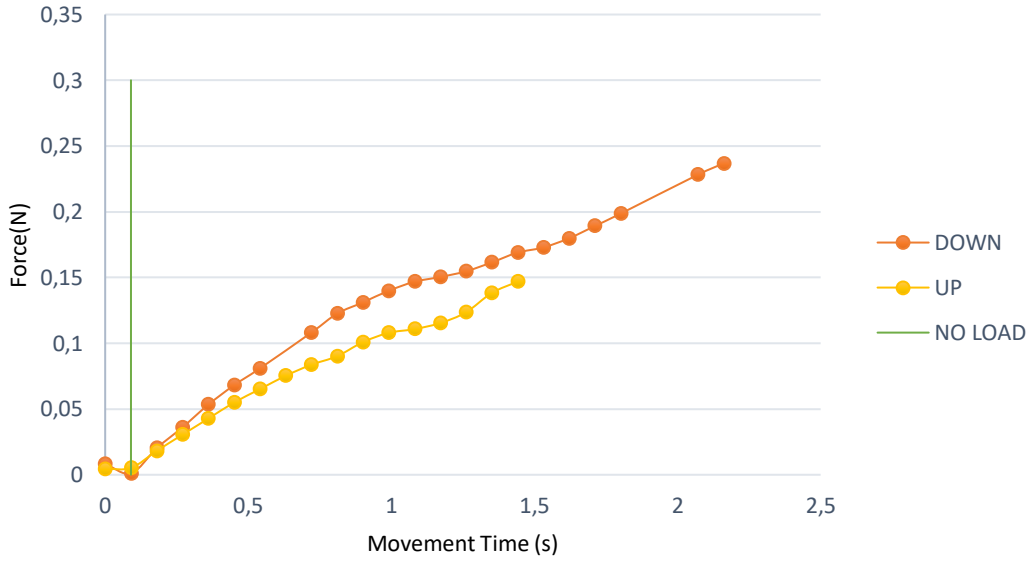
0,990428	11,4889648	16,34	0,1602954	10,56	0,1035936	0,720328
1,080468	12,5334288	16,92	0,1659852	9,25	0,0907425	0,63028
1,170512	13,5779392	17,96	0,1761876	8	0,07848	0,540248
1,260544	14,6223104	19,47	0,1910007	6,76	0,0663156	0,450212
1,350584	15,6667744	20,92	0,2052252	5,42	0,0531702	0,360164
1,440616	16,7111456	23,36	0,2291616	4,19	0,0411039	0,270128
1,53066	17,755656	24,37	0,2390697	2,88	0,0282528	0,18008
1,620704	18,8001664	21,46	0,2105226	1,04	0,0102024	0,090044
1,71074	19,844584	7,36	0,0722016	0,12	0,0011772	0



2.15. 0.6 mm diameter for 7,8 mm/s feed velocity

DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,85	0,0083385	2,01	0,0197181	2,070992
0,090044	0,7023432	0,11	0,0010791	3,76	0,0368856	1,980944
0,180084	1,4046552	2,06	0,0202086	5,5	0,053955	1,8909
0,270128	2,1069984	3,68	0,0361008	7,7	0,075537	1,800852
0,36016	2,809248	5,43	0,0532683	10,28	0,1008468	1,71082
0,450204	3,5115912	6,94	0,0680814	12,47	0,1223307	1,620776
0,540252	4,2139656	8,24	0,0808344	14,02	0,1375362	1,530728
0,720324	5,6185272	11,02	0,1081062	14,97	0,1468557	1,44068
0,810376	6,3209328	12,49	0,1225269	14,09	0,1382229	1,350636
0,900408	7,0231824	13,36	0,1310616	12,59	0,1235079	1,260592
0,990448	7,7254944	14,26	0,1398906	11,76	0,1153656	1,170544
1,080492	8,4278376	14,96	0,1467576	11,29	0,1107549	1,080488
1,170548	9,1302744	15,33	0,1503873	11	0,10791	0,99044

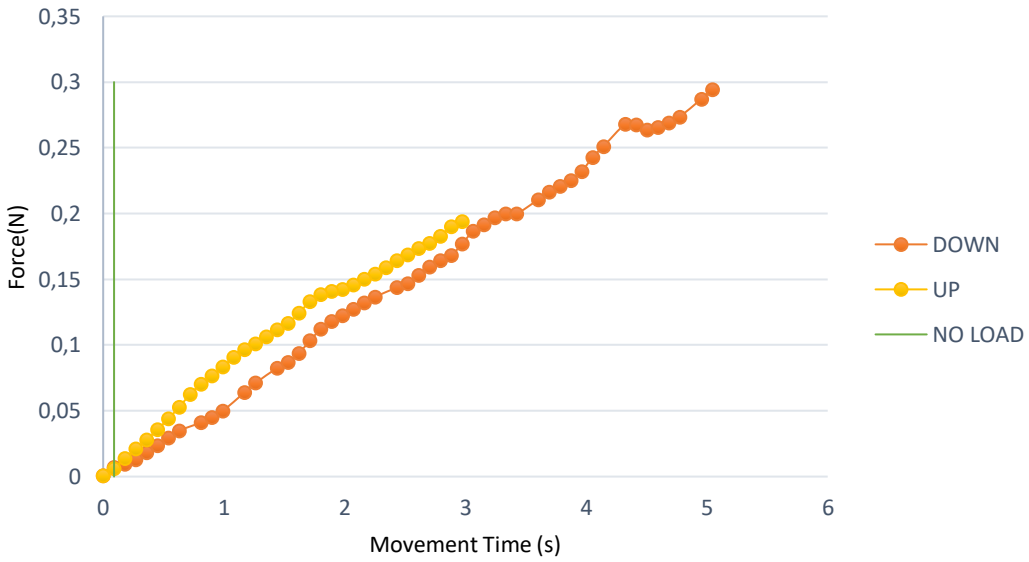
1,260588	9,8325864	15,77	0,1547037	10,28	0,1008468	0,900404
1,350628	10,5348984	16,46	0,1614726	9,19	0,0901539	0,810368
1,44068	11,237304	17,22	0,1689282	8,53	0,0836793	0,720328
1,53072	11,939616	17,62	0,1728522	7,67	0,0752427	0,630284
1,620764	12,6419592	18,33	0,1798173	6,63	0,0650403	0,54024
1,710808	13,3443024	19,28	0,1891368	5,6	0,054936	0,450192
1,80086	14,046708	20,24	0,1985544	4,35	0,0426735	0,36016
2,070996	16,1537688	23,26	0,2281806	3,11	0,0305091	0,270124
2,161048	16,8561744	24,14	0,2368134	1,85	0,0181485	0,180088
2,251092	17,5585176	14,33	0,1405773	0,53	0,0051993	0,090048
2,341144	18,2609232	2,03	0,0199143	0,46	0,0045126	0



2.16. 0.6 mm diameter for 3.95 mm/s feed velocity

DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,06	0,0005886	1,21	0,0118701	4,772536
0,09004	0,355658	0,71	0,0069651	2	0,01962	4,682492
0,180084	0,7113318	0,95	0,0093195	2,52	0,0247212	4,592448
0,270128	1,0670056	1,33	0,0130473	2,97	0,0291357	4,5024
0,360188	1,4227426	1,84	0,0180504	3,64	0,0357084	4,412344
0,450232	1,7784164	2,39	0,0234459	4,46	0,0437526	4,322292
0,540276	2,1340902	2,98	0,0292338	5,34	0,0523854	4,232248
0,630328	2,4897956	3,56	0,0349236	6,2	0,060822	4,1422
0,810416	3,2011432	4,19	0,0411039	7,23	0,0709263	4,052156
0,900456	3,5568012	4,57	0,0448317	8,45	0,0828945	3,962096
0,990504	3,9124908	5,08	0,0498348	9,84	0,0965304	3,872048

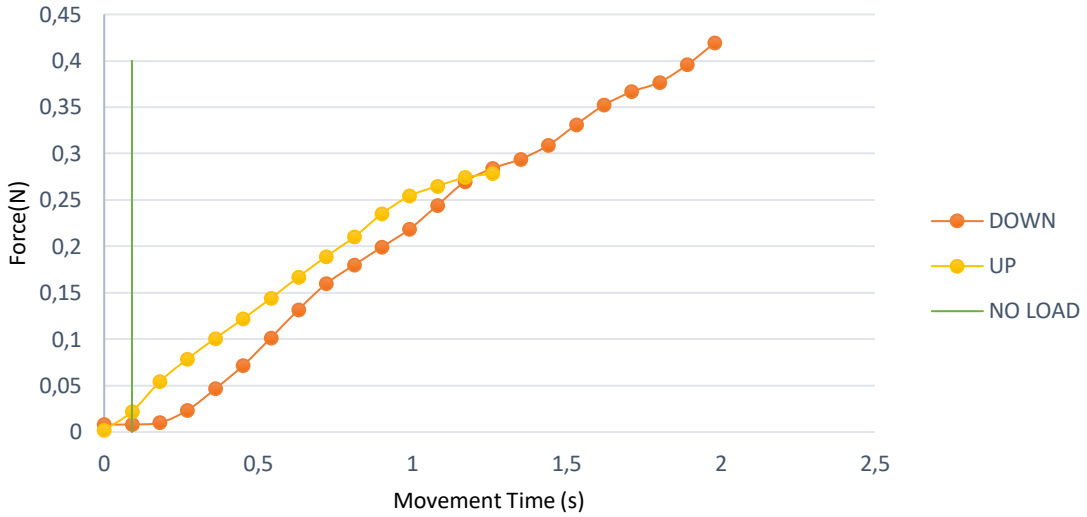
1,1706	4,62387	6,53	0,0640593	11,15	0,1093815	3,782
1,260644	4,9795438	7,24	0,0710244	12,4	0,121644	3,691956
1,440744	5,6909388	8,42	0,0826002	13,57	0,1331217	3,601908
1,530796	6,0466442	8,85	0,0868185	14,58	0,1430298	3,51186
1,620852	6,4023654	9,57	0,0938817	15,63	0,1533303	3,421812
1,710904	6,7580708	10,52	0,1032012	16,79	0,1647099	3,331772
1,80096	7,113792	11,43	0,1121283	18,01	0,1766781	3,241724
1,891024	7,4695448	12,02	0,1179162	18,99	0,1862919	3,151676
1,981076	7,8252502	12,49	0,1225269	19,58	0,1920798	3,061628
2,071132	8,1809714	12,97	0,1272357	19,78	0,1940418	2,97158
2,161176	8,5366452	13,48	0,1322388	19,37	0,1900197	2,881532
2,251228	8,8923506	13,93	0,1366533	18,62	0,1826622	2,791476
2,431316	9,6036982	14,65	0,1437165	18,08	0,1773648	2,701428
2,521372	9,9594194	14,94	0,1465614	17,69	0,1735389	2,61138
2,611412	10,3150774	15,58	0,1528398	17,2	0,168732	2,521336
2,701468	10,6707986	16,27	0,1596087	16,73	0,1641213	2,43128
2,79152	11,026504	16,72	0,1640232	16,22	0,1591182	2,34124
2,881564	11,3821778	17,13	0,1680453	15,72	0,1542132	2,251196
2,971616	11,7378832	18,03	0,1768743	15,32	0,1502892	2,161148
3,061668	12,0935886	19,02	0,1865862	14,87	0,1458747	2,0711
3,151712	12,4492624	19,54	0,1916874	14,51	0,1423431	1,981056
3,241764	12,8049678	20,08	0,1969848	14,36	0,1408716	1,891016
3,331828	13,1607206	20,36	0,1997316	14,09	0,1382229	1,800968
3,42188	13,516426	20,37	0,1998297	13,57	0,1331217	1,710924
3,601996	14,2278842	21,47	0,2106207	12,67	0,1242927	1,620876
3,692048	14,5835896	22,08	0,2166048	11,88	0,1165428	1,530832
3,7821	14,939295	22,51	0,2208231	11,37	0,1115397	1,440784
3,872156	15,2950162	22,95	0,2251395	10,83	0,1062423	1,35074
3,962208	15,6507216	23,66	0,2321046	10,3	0,101043	1,260696
4,052256	16,0064112	24,73	0,2426013	9,83	0,0964323	1,170636
4,142308	16,3621166	25,59	0,2510379	9,25	0,0907425	1,080592
4,322424	17,0735748	27,31	0,2679111	8,49	0,0832869	0,990544
4,41248	17,429296	27,26	0,2674206	7,81	0,0766161	0,900484
4,50252	17,784954	26,88	0,2636928	7,19	0,0705339	0,81044
4,592576	18,1406752	27,05	0,2653605	6,39	0,0626859	0,720392
4,682628	18,4963806	27,41	0,2688921	5,39	0,0528759	0,630344
4,77268	18,852086	27,88	0,2735028	4,5	0,044145	0,540292
4,952784	19,5634968	29,27	0,2871387	3,65	0,0358065	0,450252
5,04284	19,919218	30,02	0,2944962	2,85	0,0279585	0,360216
5,132896	20,2749392	28,93	0,2838033	2,17	0,0212877	0,270168
5,222948	20,6306446	20,08	0,1969848	1,42	0,0139302	0,180112
5,313	20,98635	8,73	0,0856413	0,61	0,0059841	0,090052
5,403048	21,3420396	2,99	0,0293319	0,08	0,0007848	0
5,493112	21,6977924	0,19	0,0018639			



2.17. 0.7 mm diameter for 15,5 mm/s feed velocity

DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,83	0,0081423	5,33	0,0522873	1,890928
0,090044	1,395682	0,84	0,0082404	5,63	0,0552303	1,800884
0,180096	2,791488	1,03	0,0101043	11,44	0,1122264	1,71084
0,270132	4,187046	2,4	0,023544	17,94	0,1759914	1,620784
0,360184	5,582852	4,74	0,0464994	24,56	0,2409336	1,530748
0,450228	6,978534	7,3	0,071613	28,36	0,2782116	1,440704
0,540272	8,374216	10,33	0,1013373	28,3	0,277623	1,35066
0,630324	9,770022	13,45	0,1319445	28,4	0,278604	1,260624
0,720356	11,165518	16,29	0,1598049	27,95	0,2741895	1,17058
0,810408	12,561324	18,34	0,1799154	27,01	0,2649681	1,08054
0,900448	13,956944	20,31	0,1992411	25,92	0,2542752	0,990496
0,990488	15,352564	22,29	0,2186649	23,96	0,2350476	0,90046
1,08054	16,74837	24,89	0,2441709	21,41	0,2100321	0,810412
1,17058	18,14399	27,5	0,269775	19,28	0,1891368	0,720372
1,260624	19,539672	28,97	0,2841957	17,04	0,1671624	0,630328
1,350664	20,935292	29,98	0,2941038	14,69	0,1441089	0,54028
1,440708	22,330974	31,5	0,309015	12,43	0,1219383	0,450232
1,530752	23,726656	33,76	0,3311856	10,29	0,1009449	0,360196
1,62078	25,12209	35,89	0,3520809	8,04	0,0788724	0,27014
1,710824	26,517772	37,37	0,3665997	5,53	0,0542493	0,180096
1,800868	27,913454	38,41	0,3768021	2,24	0,0219744	0,090048
1,890912	29,309136	40,33	0,3956373	0,21	0,0020601	0
1,980956	30,704818	42,76	0,4194756			

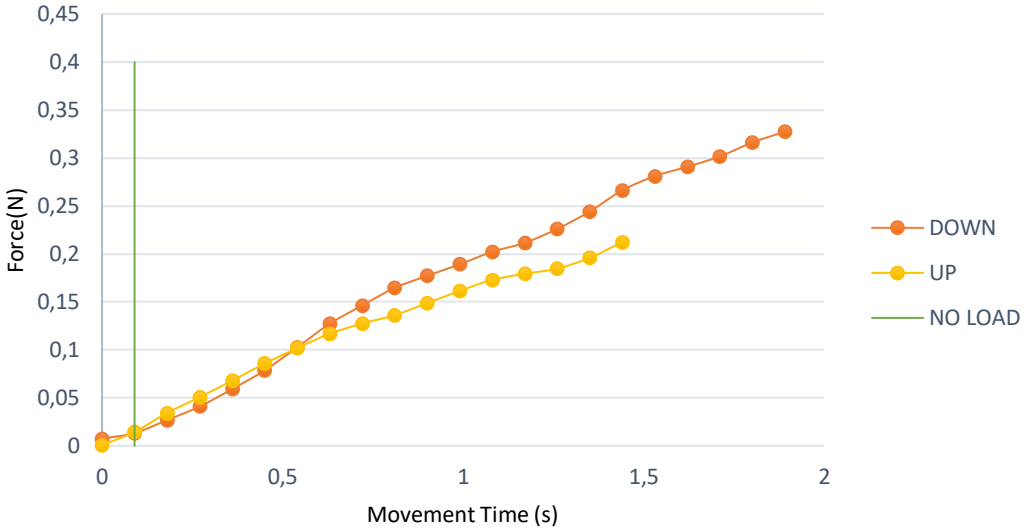
2,071004	32,100562	31,96	0,3135276			
2,161044	33,496182	5,33	0,0522873			



2.18. 0.7 mm diameter for 11,6 mm/s feed velocity

DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,75	0,0073575	9,97	0,0978057	2,070908
0,090044	1,0445104	1,36	0,0133416	1,87	0,0183447	1,98088
0,180088	2,0890208	2,73	0,0267813	4,98	0,0488538	1,890832
0,270132	3,1335312	4,17	0,0409077	8,24	0,0808344	1,800796
0,36016	4,177856	6,02	0,0590562	12,58	0,1234098	1,710752
0,450204	5,2223664	8,01	0,0785781	17,02	0,1669662	1,620712
0,540244	6,2668304	10,45	0,1025145	20,75	0,2035575	1,53068
0,630276	7,3112016	12,96	0,1271376	21,63	0,2121903	1,440636
0,72032	8,355712	14,91	0,1462671	19,97	0,1959057	1,3506
0,810352	9,4000832	16,77	0,1645137	18,82	0,1846242	1,260556
0,900392	10,4445472	18,06	0,1771686	18,28	0,1793268	1,17052
0,99042	11,488872	19,28	0,1891368	17,63	0,1729503	1,080476
1,080452	12,5332432	20,61	0,2021841	16,45	0,1613745	0,990436
1,170484	13,5776144	21,56	0,2115036	15,16	0,1487196	0,900392
1,260512	14,6219392	23,04	0,2260224	13,88	0,1361628	0,810356
1,350536	15,6662176	24,89	0,2441709	12,99	0,1274319	0,720324
1,440576	16,7106816	27,14	0,2662434	11,9	0,116739	0,630292
1,530608	17,7550528	28,64	0,2809584	10,37	0,1017297	0,540244
1,62064	18,799424	29,65	0,2908665	8,73	0,0856413	0,450208
1,710672	19,8437952	30,74	0,3015594	6,92	0,0678852	0,360168
1,800704	20,8881664	32,22	0,3160782	5,16	0,0506196	0,270124

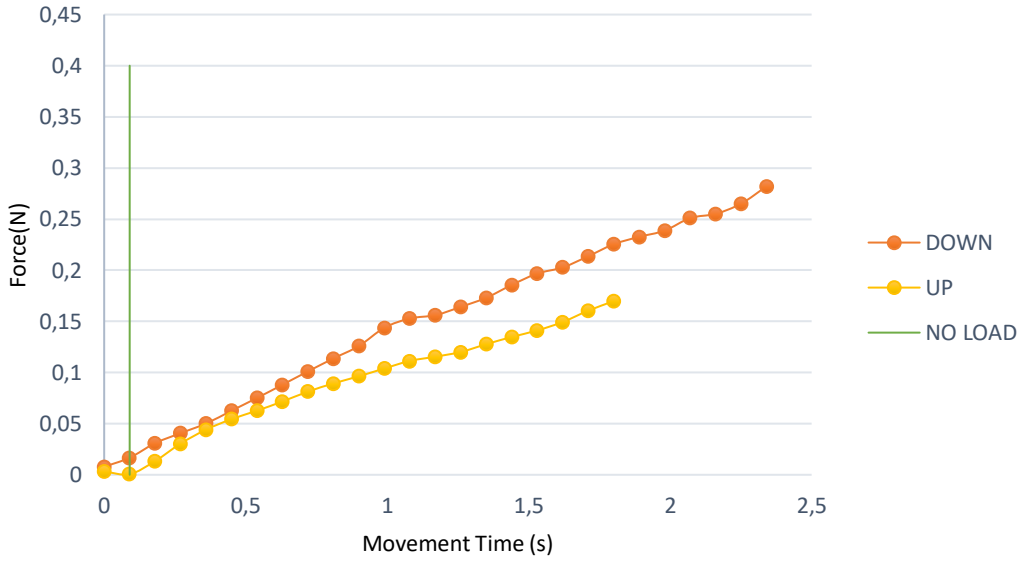
1,890736	21,9325376	33,37	0,3273597	3,48	0,0341388	0,180084
1,98078	22,977048	29	0,28449	1,48	0,0145188	0,090048
2,070812	24,0214192	9,97	0,0978057	0,06	0,0005886	0



2.19. 0.7 mm diameter for 7,8 mm/s feed velocity

DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,8	0,007848	0,2	0,001962	2,701268
0,090052	0,7024056	1,7	0,016677	2,64	0,0258984	2,611224
0,180104	1,4048112	3,15	0,0309015	3,76	0,0368856	2,521176
0,270148	2,1071544	4,15	0,0407115	4,94	0,0484614	2,43114
0,360192	2,8094976	5,11	0,0501291	6,62	0,0649422	2,341092
0,450236	3,5118408	6,39	0,0626859	8,53	0,0836793	2,251036
0,540284	4,2142152	7,66	0,0751446	10,55	0,1034955	2,160992
0,630336	4,9166208	8,98	0,0880938	12,62	0,1238022	2,070956
0,720376	5,6189328	10,31	0,1011411	14,6	0,143226	1,980908
0,810424	6,3213072	11,6	0,113796	16,47	0,1615707	1,890864
0,900464	7,0236192	12,84	0,1259604	17,31	0,1698111	1,800828
0,990516	7,7260248	14,66	0,1438146	16,36	0,1604916	1,710796
1,080556	8,4283368	15,58	0,1528398	15,23	0,1494063	1,620748
1,170612	9,1307736	15,91	0,1560771	14,39	0,1411659	1,530712
1,260656	9,8331168	16,74	0,1642194	13,74	0,1347894	1,440676
1,3507	10,53546	17,65	0,1731465	13,02	0,1277262	1,350632
1,440752	11,2378656	18,93	0,1857033	12,24	0,1200744	1,260596
1,530796	11,9402088	20,06	0,1967886	11,77	0,1154637	1,170564
1,620844	12,6425832	20,67	0,2027727	11,35	0,1113435	1,080528

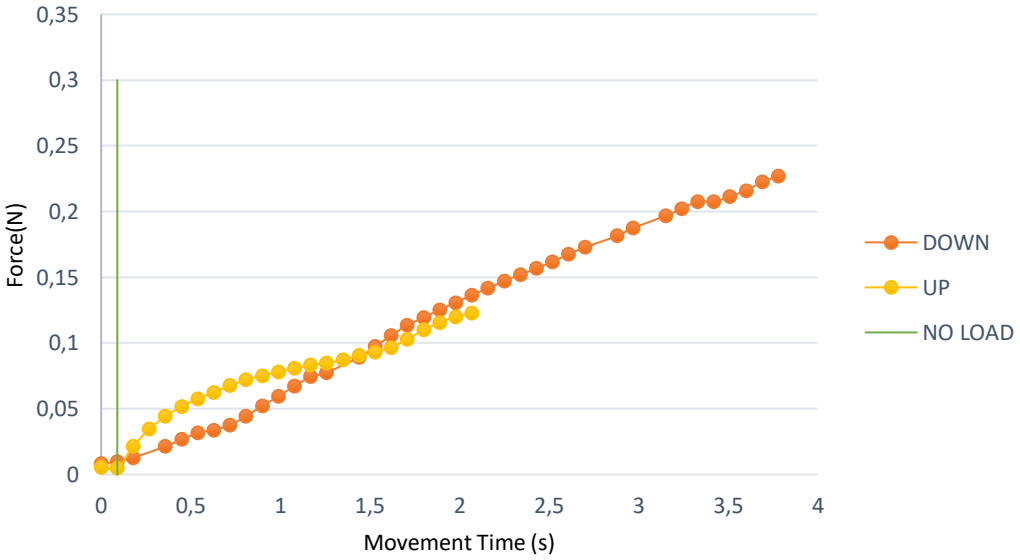
1,710884	13,3448952	21,79	0,2137599	10,6	0,103986	0,99048
1,800936	14,0473008	22,98	0,2254338	9,82	0,0963342	0,900444
1,89098	14,749644	23,72	0,2326932	9,11	0,0893691	0,810392
1,981032	15,4520496	24,34	0,2387754	8,29	0,0813249	0,720344
2,071076	16,1543928	25,59	0,2510379	7,31	0,0717111	0,6303
2,161112	16,8566736	26,01	0,2551581	6,39	0,0626859	0,540264
2,251164	17,5590792	27,03	0,2651643	5,55	0,0544455	0,450224
2,341204	18,2613912	28,76	0,2821356	4,5	0,044145	0,360176
2,431256	18,9637968	26,43	0,2592783	3,11	0,0305091	0,27014
2,521296	19,6661088	11,27	0,1105587	1,37	0,0134397	0,180096
2,611352	20,3685456	0,2	0,001962	0,06	0,0005886	0,090048
				0,32	0,0031392	0



2.20. 0.7 mm diameter for 3.95 mm/s feed velocity

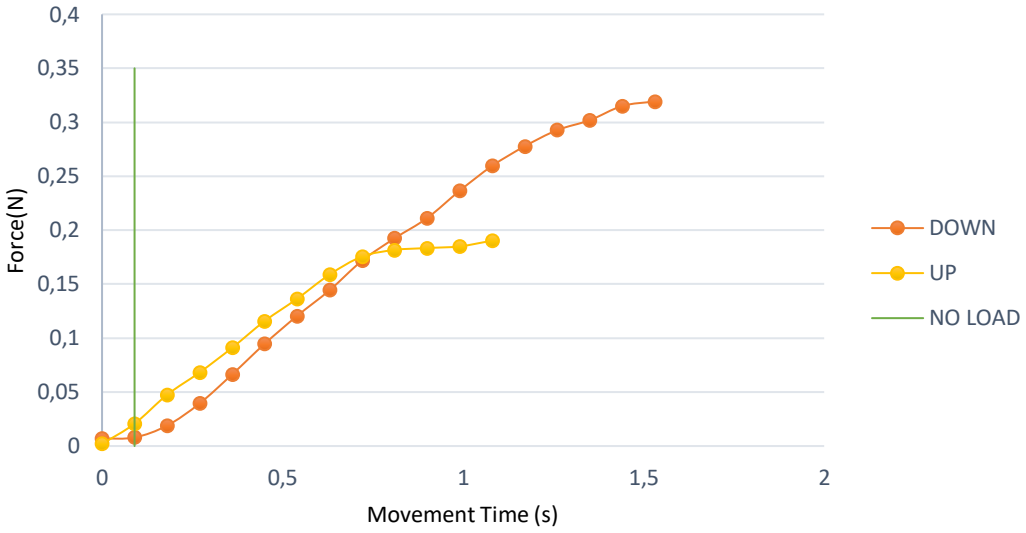
DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,86	0,0084366	1,11	0,0108891	3,781644
0,090044	0,3556738	1,01	0,0099081	0,22	0,0021582	3,6916
0,1801	0,711395	1,32	0,0129492	0,94	0,0092214	3,601564
0,360176	1,4226952	2,19	0,0214839	1,49	0,0146169	3,511528
0,45022	1,778369	2,73	0,0267813	1,97	0,0193257	3,42148
0,54026	2,134027	3,22	0,0315882	2,43	0,0238383	3,331436
0,630316	2,4897482	3,46	0,0339426	2,88	0,0282528	3,2414
0,720348	2,8453746	3,84	0,0376704	3,39	0,0332559	3,151352
0,810392	3,2010484	4,55	0,0446355	4,01	0,0393381	3,061316
0,900436	3,5567222	5,33	0,0522873	4,79	0,0469899	2,97128

0,99048	3,912396	6,07	0,0595467	5,61	0,0550341	2,881252
1,080512	4,2680224	6,87	0,0673947	6,39	0,0626859	2,791204
1,170552	4,6236804	7,59	0,0744579	7,26	0,0712206	2,701176
1,260596	4,9793542	7,92	0,0776952	8,16	0,0800496	2,611128
1,440684	5,6907018	9,11	0,0893691	9,1	0,089271	2,521092
1,530728	6,0463756	9,92	0,0973152	10,08	0,0988848	2,431056
1,620772	6,4020494	10,81	0,1060461	10,95	0,1074195	2,34102
1,710804	6,7576758	11,58	0,1135998	11,69	0,1146789	2,250984
1,800848	7,1133496	12,17	0,1193877	12,29	0,1205649	2,160936
1,89088	7,468976	12,79	0,1254699	12,51	0,1227231	2,070896
1,98092	7,824634	13,34	0,1308654	12,25	0,1201725	1,980864
2,070956	8,1802762	13,92	0,1365552	11,78	0,1155618	1,890828
2,161	8,53595	14,45	0,1417545	11,23	0,1101663	1,80078
2,25104	8,891608	15,01	0,1472481	10,49	0,1029069	1,710748
2,341072	9,2472344	15,49	0,1519569	9,86	0,0967266	1,620704
2,431108	9,6028766	15,99	0,1568619	9,51	0,0932931	1,530664
2,521152	9,9585504	16,52	0,1620612	9,24	0,0906444	1,440628
2,611184	10,3141768	17,09	0,1676529	8,89	0,0872109	1,350592
2,701228	10,6698506	17,62	0,1728522	8,63	0,0846603	1,260556
2,8813	11,381135	18,51	0,1815831	8,49	0,0832869	1,170516
2,971344	11,7368088	19,12	0,1875672	8,24	0,0808344	1,080472
3,151424	12,4481248	20,06	0,1967886	7,97	0,0781857	0,990432
3,241464	12,8037828	20,63	0,2023803	7,67	0,0752427	0,900396
3,331508	13,1594566	21,17	0,2076777	7,35	0,0721035	0,810352
3,42154	13,515083	21,15	0,2074815	6,91	0,0677871	0,720316
3,511572	13,8707094	21,58	0,2116998	6,38	0,0625878	0,630272
3,601616	14,2263832	22,03	0,2161143	5,89	0,0577809	0,540236
3,69164	14,581978	22,69	0,2225889	5,28	0,0517968	0,450204
3,781684	14,9376518	23,14	0,2270034	4,53	0,0444393	0,360168
3,871728	15,2933256	20,04	0,1965924	3,55	0,0348255	0,270132
3,961772	15,6489994	10,81	0,1060461	2,21	0,0216801	0,180084
4,051808	16,0046416	4,07	0,0399267	0,5	0,004905	0,090048
4,141848	16,3602996	1,11	0,0108891	0,58	0,0056898	0



2.21. 0.8 mm diameter for 15,5 mm/s feed velocity

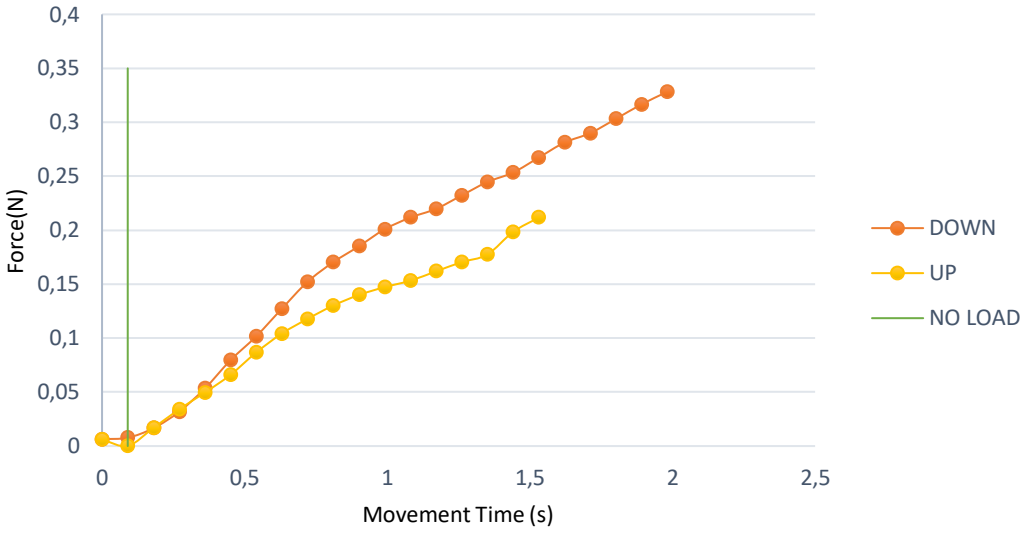
DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,7	0,006867	3,72	0,0364932	1,440684
0,090032	1,395496	0,81	0,0079461	13,74	0,1347894	1,350648
0,180076	2,791178	1,93	0,0189333	17,43	0,1709883	1,260612
0,270116	4,186798	4,02	0,0394362	19,36	0,1899216	1,170564
0,360144	5,582232	6,76	0,0663156	19,4	0,190314	1,080528
0,450188	6,977914	9,65	0,0946665	18,86	0,1850166	0,99048
0,54022	8,37341	12,29	0,1205649	18,7	0,183447	0,900444
0,63026	9,76903	14,72	0,1444032	18,52	0,1816812	0,810408
0,720304	11,164712	17,51	0,1717731	17,9	0,175599	0,72036
0,810344	12,560332	19,62	0,1924722	16,2	0,158922	0,630316
0,900376	13,955828	21,53	0,2112093	13,91	0,1364571	0,540268
0,990416	15,351448	24,11	0,2365191	11,8	0,115758	0,450224
1,08046	16,74713	26,46	0,2595726	9,28	0,0910368	0,360176
1,170508	18,142874	28,31	0,2777211	6,95	0,0681795	0,270132
1,260552	19,538556	29,84	0,2927304	4,84	0,0474804	0,180104
1,350584	20,934052	30,77	0,3018537	2,11	0,0206991	0,090056
1,440628	22,329734	32,12	0,3150972	0,2	0,001962	0
1,530668	23,725354	32,55	0,3193155			
1,620708	25,120974	19,12	0,1875672			



2.22. 0.8 mm diameter for 11,6 mm/s feed velocity

DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,65	0,0063765	5,64	0,0553284	1,890944
0,090044	1,0445104	0,79	0,0077499	10,39	0,1019259	1,800896
0,180076	2,0888816	1,69	0,0165789	14,96	0,1467576	1,710864
0,27012	3,133392	3,24	0,0317844	19	0,18639	1,62082
0,360164	4,1779024	5,43	0,0532683	21,58	0,2116998	1,530784
0,4502	5,22232	8,1	0,079461	20,22	0,1983582	1,440744
0,54024	6,266784	10,36	0,1016316	18,09	0,1774629	1,350708
0,63028	7,311248	12,97	0,1272357	17,37	0,1703997	1,260664
0,720324	8,3557584	15,51	0,1521531	16,5	0,161865	1,170616
0,810356	9,4001296	17,36	0,1703016	15,62	0,1532322	1,08056
0,9004	10,44464	18,87	0,1851147	15,01	0,1472481	0,990516
0,990444	11,4891504	20,47	0,2008107	14,27	0,1399887	0,900468
1,080484	12,5336144	21,58	0,2116998	13,27	0,1301787	0,81042
1,170516	13,5779856	22,4	0,219744	12,01	0,1178181	0,720364
1,26056	14,622496	23,67	0,2322027	10,63	0,1042803	0,630316
1,3506	15,66696	24,94	0,2446614	8,83	0,0866223	0,540268
1,440636	16,7113776	25,83	0,2533923	6,73	0,0660213	0,450224
1,530676	17,7558416	27,24	0,2672244	5,04	0,0494424	0,360176
1,620716	18,8003056	28,66	0,2811546	3,47	0,0340407	0,270128
1,71076	19,844816	29,55	0,2898855	1,71	0,0167751	0,180096
1,800792	20,8891872	30,89	0,3030309	0,02	0,0001962	0,09004
1,890836	21,9336976	32,27	0,3165687	0,6	0,005886	0
1,98088	22,978208	33,45	0,3281445			
2,07092	24,022672	23,78	0,2332818			

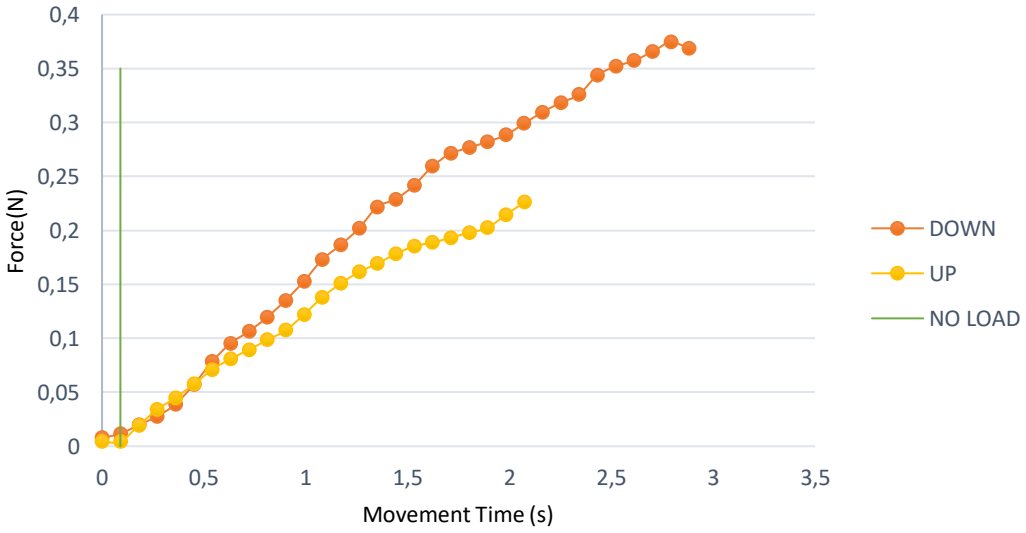
2,160964	25,0671824	3,18	0,0311958			



2.23. 0.8 mm diameter for 7,8 mm/s feed velocity

DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,8	0,007848	9,06	0,0888786	3,06158
0,090052	0,7024056	1,18	0,0115758	0,87	0,0085347	2,97154
0,180088	1,4046864	2,01	0,0197181	4,9	0,048069	2,881504
0,270112	2,1068736	2,82	0,0276642	7,9	0,077499	2,791456
0,360156	2,8092168	3,97	0,0389457	10,43	0,1023183	2,70142
0,450188	3,5114664	5,83	0,0571923	12,82	0,1257642	2,611376
0,540232	4,2138096	7,99	0,0783819	15,01	0,1472481	2,521332
0,630264	4,9160592	9,72	0,0953532	16,88	0,1655928	2,431296
0,720304	5,6183712	10,84	0,1063404	18,9	0,185409	2,341252
0,810336	6,3206208	12,19	0,1195839	20,92	0,2052252	2,251204
0,90038	7,022964	13,77	0,1350837	22,46	0,2203326	2,16116
0,990424	7,7253072	15,58	0,1528398	23,03	0,2259243	2,07112
1,080464	8,4276192	17,62	0,1728522	21,84	0,2142504	1,981064
1,170496	9,1298688	19,01	0,1864881	20,63	0,2023803	1,891008
1,26054	9,832212	20,57	0,2017917	20,17	0,1978677	1,800964
1,350572	10,5344616	22,6	0,221706	19,7	0,193257	1,71092
1,440624	11,2368672	23,33	0,2288673	19,23	0,1886463	1,620864
1,53066	11,939148	24,63	0,2416203	18,89	0,1853109	1,530816
1,620692	12,6413976	26,42	0,2591802	18,16	0,1781496	1,440772
1,710732	13,3437096	27,64	0,2711484	17,24	0,1691244	1,350712
1,800772	14,0460216	28,2	0,276642	16,46	0,1614726	1,260676
1,890816	14,7483648	28,75	0,2820375	15,36	0,1506816	1,17062

1,980856	15,4506768	29,39	0,2883159	14,07	0,1380267	1,080576
2,0709	16,15302	30,47	0,2989107	12,42	0,1218402	0,990528
2,16094	16,855332	31,55	0,3095055	10,94	0,1073214	0,90048
2,250984	17,5576752	32,44	0,3182364	10,03	0,0983943	0,810424
2,341028	18,2600184	33,23	0,3259863	9,11	0,0893691	0,72038
2,431072	18,9623616	35,04	0,3437424	8,24	0,0808344	0,630332
2,521108	19,6646424	35,87	0,3518847	7,24	0,0710244	0,540288
2,61114	20,366892	36,42	0,3572802	5,86	0,0574866	0,450244
2,701184	21,0692352	37,26	0,3655206	4,58	0,0449298	0,360184
2,791224	21,7715472	38,16	0,3743496	3,46	0,0339426	0,270144
2,881256	22,4737968	37,6	0,368856	1,97	0,0193257	0,1801
2,9713	23,17614	28,56	0,2801736	0,43	0,0042183	0,090044
3,061344	23,8784832	9,06	0,0888786	0,45	0,0044145	0

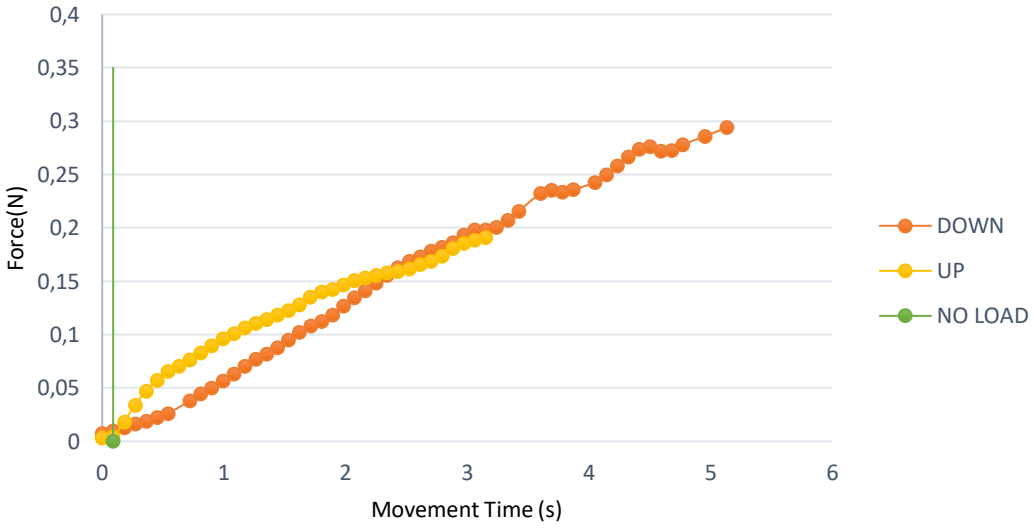


2.24. 0.8 mm diameter for 3.95 mm/s feed velocity

DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,78	0,0076518	0,08	0,0007848	5,312568
0,090032	0,3556264	1,01	0,0099081	1,17	0,0114777	5,222524
0,180076	0,7113002	1,32	0,0129492	2,47	0,0242307	5,13248
0,270108	1,0669266	1,68	0,0164808	3,49	0,0342369	5,042432
0,360136	1,4225372	1,93	0,0189333	4,48	0,0439488	4,952392
0,450188	1,7782426	2,26	0,0221706	5,56	0,0545436	4,862344
0,540232	2,1339164	2,67	0,0261927	6,64	0,0651384	4,7723
0,72032	2,845264	3,86	0,0378666	7,65	0,0750465	4,682252
0,810352	3,2008904	4,53	0,0444393	8,6	0,084366	4,592204
0,900396	3,5565642	5,09	0,0499329	9,51	0,0932931	4,50216

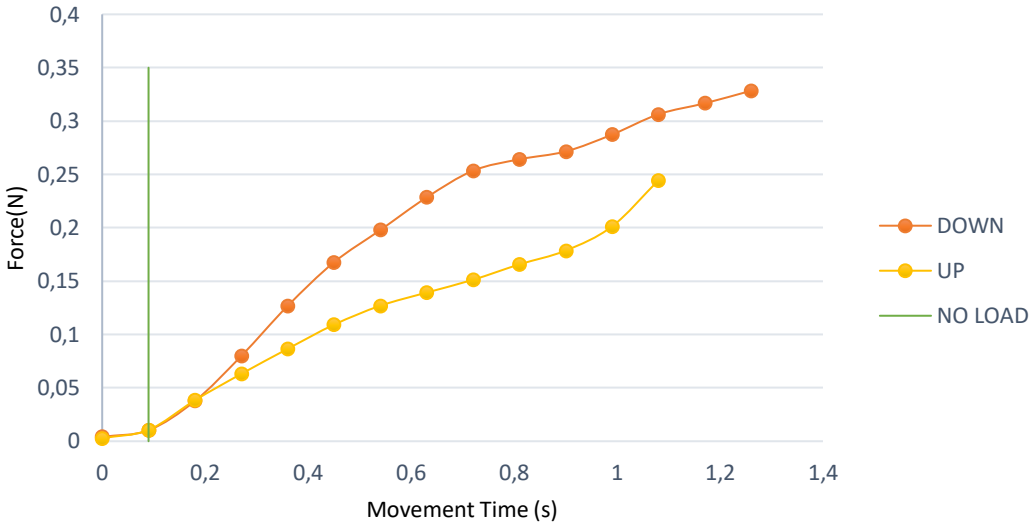
0,99044	3,912238	5,77	0,0566037	10,42	0,1022202	4,412116
1,080488	4,2679276	6,44	0,0631764	11,25	0,1103625	4,322076
1,170532	4,6236014	7,17	0,0703377	11,89	0,1166409	4,232032
1,260576	4,9792752	7,82	0,0767142	12,54	0,1230174	4,141996
1,350612	5,3349174	8,33	0,0817173	13,11	0,1286091	4,051936
1,440656	5,6905912	8,92	0,0875052	13,72	0,1345932	3,961892
1,530696	6,0462492	9,69	0,0950589	14,42	0,1414602	3,871836
1,620748	6,4019546	10,39	0,1019259	15,14	0,1485234	3,78178
1,710792	6,7576284	11,02	0,1081062	15,97	0,1566657	3,69172
1,800832	7,1132864	11,46	0,1124226	16,73	0,1641213	3,60168
1,890876	7,4689602	12,08	0,1185048	17,39	0,1705959	3,511636
1,98092	7,824634	12,95	0,1270395	18,06	0,1771686	3,421588
2,070972	8,1803394	13,69	0,1342989	18,72	0,1836432	3,331552
2,161016	8,5360132	14,39	0,1411659	19,24	0,1887444	3,241504
2,25106	8,891687	15,12	0,1483272	19,45	0,1908045	3,151464
2,341104	9,2473608	15,84	0,1553904	19,24	0,1887444	3,06142
2,43114	9,603003	16,62	0,1630422	18,89	0,1853109	2,971384
2,521176	9,9586452	17,23	0,1690263	18,44	0,1808964	2,88134
2,61122	10,314319	17,65	0,1731465	17,72	0,1738332	2,791304
2,701272	10,6700244	18,16	0,1781496	17,2	0,168732	2,701256
2,791308	11,0256666	18,54	0,1818774	16,92	0,1659852	2,611208
2,881352	11,3813404	18,98	0,1861938	16,48	0,1616688	2,52116
2,971396	11,7370142	19,72	0,1934532	16,21	0,1590201	2,431124
3,06144	12,092688	20,18	0,1979658	16,08	0,1577448	2,341076
3,151484	12,4483618	20,17	0,1978677	15,88	0,1557828	2,251028
3,241536	12,8040672	20,46	0,2007126	15,63	0,1533303	2,160984
3,331576	13,1597252	21,11	0,2070891	15,38	0,1508778	2,070948
3,42162	13,515399	21,96	0,2154276	14,95	0,1466595	1,9809
3,601704	14,2267308	23,68	0,2323008	14,53	0,1425393	1,89086
3,691748	14,5824046	23,97	0,2351457	14,25	0,1397925	1,800816
3,781784	14,9380468	23,83	0,2337723	13,78	0,1351818	1,710768
3,871816	15,2936732	24,06	0,2360286	13,03	0,1278243	1,620732
4,051912	16,0050524	24,72	0,2425032	12,47	0,1223307	1,530692
4,141952	16,3607104	25,44	0,2495664	12,04	0,1181124	1,440648
4,231996	16,7163842	26,33	0,2582973	11,64	0,1141884	1,350608
4,322048	17,0720896	27,15	0,2663415	11,29	0,1107549	1,260564
4,412092	17,4277634	27,92	0,2738952	10,85	0,1064385	1,17052
4,502136	17,7834372	28,12	0,2758572	10,32	0,1012392	1,080488
4,5922	18,13919	27,71	0,2718351	9,81	0,0962361	0,99044
4,682244	18,4948638	27,76	0,2723256	9,14	0,0896634	0,900396
4,772284	18,8505218	28,33	0,2779173	8,43	0,0826983	0,810348
4,95238	19,561901	29,13	0,2857653	7,78	0,0763218	0,720308
5,13246	20,273217	29,97	0,2940057	7,2	0,070632	0,630272
5,222504	20,6288908	22,37	0,2194497	6,66	0,0653346	0,540236

5,312548	20,9845646	10,47	0,1027107	5,84	0,0572904	0,4502
5,402596	21,3402542	4,14	0,0406134	4,81	0,0471861	0,360152
5,492636	21,6959122	0,08	0,0007848	3,47	0,0340407	0,27012
				1,86	0,0182466	0,180072
				0,46	0,0045126	0,090036
				0,35	0,0034335	0



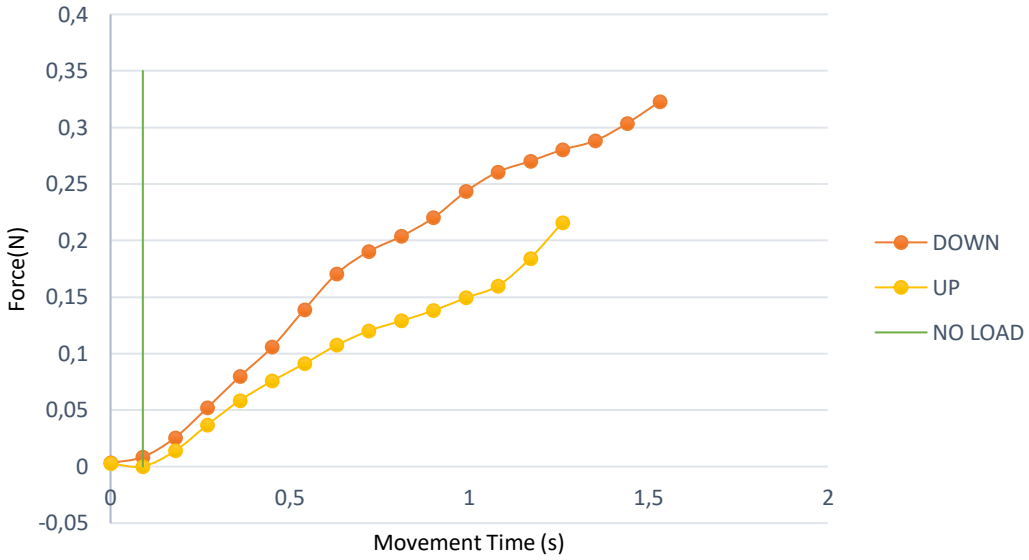
2.25. 0.9 mm diameter for 15,5 mm/s feed velocity

DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,42	0,0041202	5,08	0,0498348	1,350472
0,09004	1,39562	1,05	0,0103005	11,06	0,1084986	1,26044
0,180072	2,791116	3,84	0,0376704	20,68	0,2028708	1,170396
0,270112	4,186736	8,14	0,0798534	24,92	0,2444652	1,080372
0,360144	5,582232	12,92	0,1267452	20,52	0,2013012	0,990344
0,450184	6,977852	17,09	0,1676529	18,21	0,1786401	0,900316
0,540208	8,373224	20,17	0,1978677	16,89	0,1656909	0,810292
0,630252	9,768906	23,29	0,2284749	15,42	0,1512702	0,720256
0,720292	11,164526	25,84	0,2534904	14,2	0,139302	0,63022
0,810324	12,560022	26,93	0,2641833	12,94	0,1269414	0,540196
0,900368	13,955704	27,68	0,2715408	11,13	0,1091853	0,450164
0,990408	15,351324	29,29	0,2873349	8,82	0,0865242	0,360128
1,080452	16,747006	31,23	0,3063663	6,43	0,0630783	0,270088
1,170496	18,142688	32,28	0,3166668	3,91	0,0383571	0,180052
1,260528	19,538184	33,48	0,3284388	1,08	0,0105948	0,090024
1,350572	20,933866	27,86	0,2733066	0,29	0,0028449	0
1,440616	22,329548	5,08	0,0498348			



2.26. 0.9 mm diameter for 11,6 mm/s feed velocity

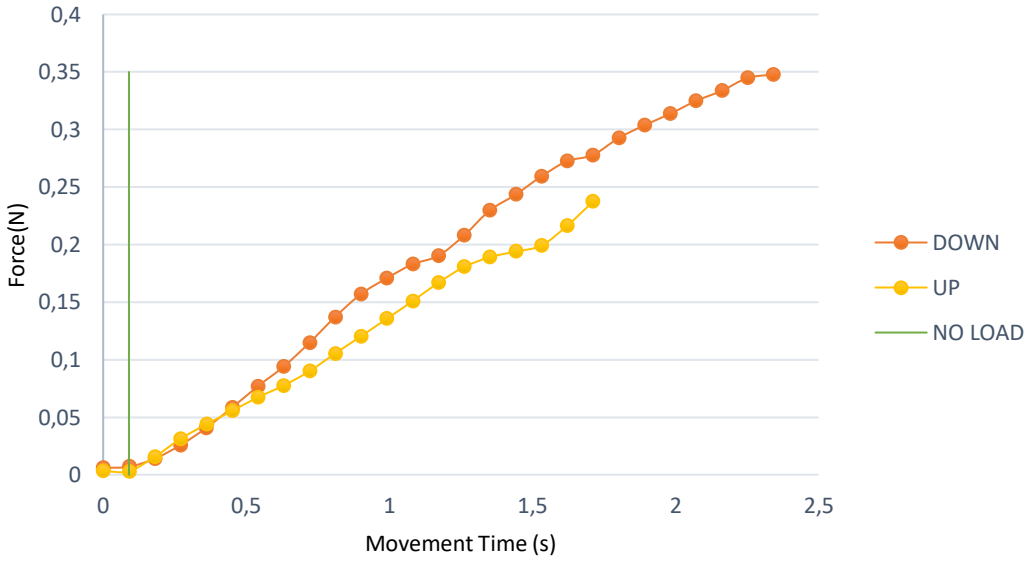
DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,32	0,0031392	12,57	0,1233117	1,710776
0,090052	1,0446032	0,87	0,0085347	3,5	0,034335	1,620732
0,180108	2,0892528	2,61	0,0256041	9,37	0,0919197	1,530684
0,270148	3,1337168	5,31	0,0520911	15,08	0,1479348	1,440636
0,360204	4,1783664	8,12	0,0796572	19,96	0,1958076	1,350604
0,450244	5,2228304	10,76	0,1055556	22,01	0,2159181	1,26056
0,540296	6,2674336	14,15	0,1388115	18,78	0,1842318	1,170528
0,630332	7,3118512	17,38	0,1704978	16,3	0,159903	1,08048
0,720388	8,3565008	19,4	0,190314	15,21	0,1492101	0,990444
0,810436	9,4010576	20,76	0,2036556	14,07	0,1380267	0,900408
0,900492	10,4457072	22,43	0,2200383	13,14	0,1289034	0,810376
0,990532	11,4901712	24,79	0,2431899	12,24	0,1200744	0,720328
1,080576	12,5346816	26,57	0,2606517	10,94	0,1073214	0,630284
1,170628	13,5792848	27,54	0,2701674	9,27	0,0909387	0,540248
1,260668	14,6237488	28,57	0,2802717	7,71	0,0756351	0,4502
1,35072	15,668352	29,37	0,2881197	5,95	0,0583695	0,360152
1,440764	16,7128624	30,96	0,3037176	3,76	0,0368856	0,270116
1,53082	17,757512	32,89	0,3226509	1,42	0,0139302	0,18008
1,620872	18,8021152	30,94	0,3035214	0,02	0,0001962	0,090048
1,710916	19,8466256	12,57	0,1233117	0,27	0,0026487	0



2.27. 0.9 mm diameter for 7,8 mm/s feed velocity

DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,6	0,005886	0,31	0,0030411	2,341516
0,090036	0,7022808	0,71	0,0069651	4,86	0,0476766	2,251452
0,180076	1,4045928	1,42	0,0139302	8,56	0,0839736	2,161396
0,270128	2,1069984	2,62	0,0257022	12,75	0,1250775	2,071348
0,360172	2,8093416	4,15	0,0407115	16,98	0,1665738	1,981292
0,450216	3,5116848	5,94	0,0582714	20,47	0,2008107	1,891232
0,540256	4,2139968	7,83	0,0768123	23,24	0,2279844	1,801176
0,630304	4,9163712	9,57	0,0938817	24,19	0,2373039	1,711124
0,720348	5,6187144	11,68	0,1145808	22,05	0,2163105	1,621068
0,8104	6,32112	13,97	0,1370457	20,3	0,199143	1,531
0,90044	7,023432	16	0,15696	19,77	0,1939437	1,440932
0,990492	7,7258376	17,4	0,170694	19,27	0,1890387	1,350876
1,080536	8,4281808	18,64	0,1828584	18,4	0,180504	1,260816
1,170592	9,1306176	19,39	0,1902159	17	0,16677	1,17076
1,260632	9,8329296	21,19	0,2078739	15,37	0,1507797	1,080696
1,350676	10,5352728	23,41	0,2296521	13,81	0,1354761	0,990636
1,44072	11,237616	24,81	0,2433861	12,26	0,1202706	0,90058
1,530752	11,9398656	26,42	0,2591802	10,74	0,1053594	0,810512
1,620796	12,6422088	27,77	0,2724237	9,16	0,0898596	0,720456
1,710844	13,3445832	28,32	0,2778192	7,9	0,077499	0,6304
1,800888	14,0469264	29,82	0,2925342	6,85	0,0671985	0,540344
1,890928	14,7492384	30,96	0,3037176	5,65	0,0554265	0,450288
1,980972	15,4515816	31,97	0,3136257	4,46	0,0437526	0,360244

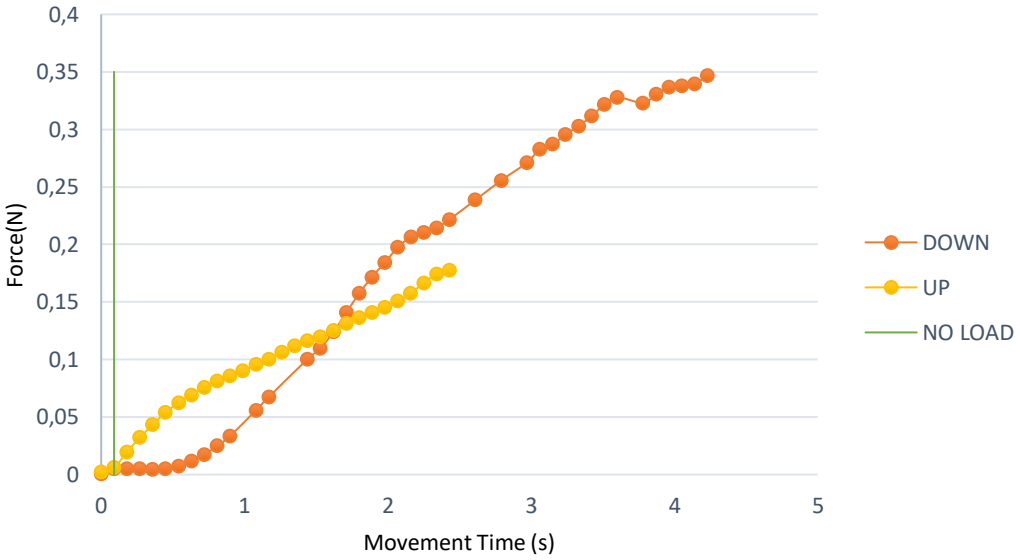
2,071012	16,1538936	33,11	0,3248091	3,18	0,0311958	0,270184
2,161056	16,8562368	34,01	0,3336381	1,59	0,0155979	0,180128
2,251112	17,5586736	35,14	0,3447234	0,3	0,002943	0,090068
2,341156	18,2610168	35,46	0,3478626	0,33	0,0032373	0
2,4312	18,96336	32,51	0,3189231			
2,521252	19,6657656	15,76	0,1546056			
2,611308	20,3682024	0,31	0,0030411			



2.28. 0.9 mm diameter for 3.95 mm/s feed velocity

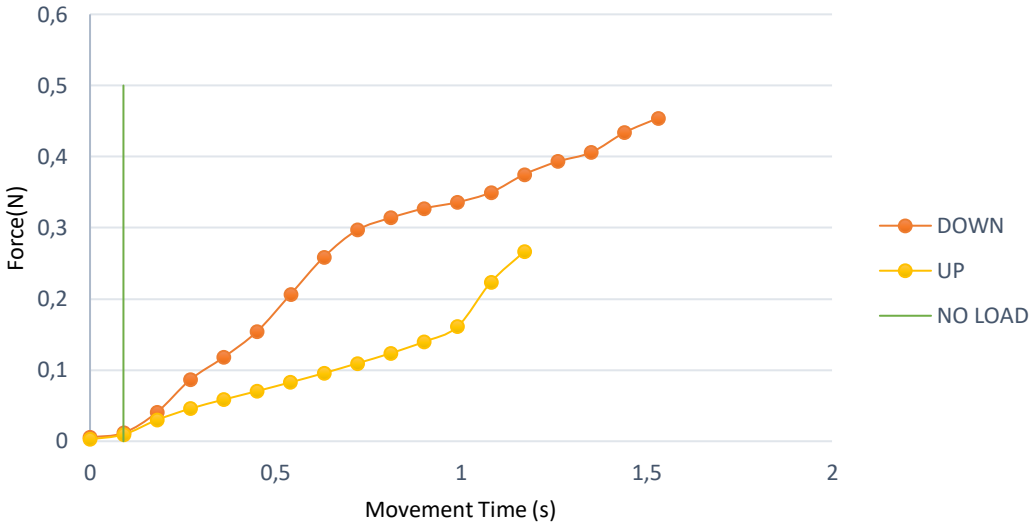
DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,05	0,0004905	3,19	0,0312939	3,871752
0,090044	0,3556738	0,52	0,0051012	0,14	0,0013734	3,78172
0,180088	0,7113476	0,51	0,0050031	2,01	0,0197181	3,69168
0,270132	1,0670214	0,51	0,0050031	3,38	0,0331578	3,601632
0,36018	1,422711	0,49	0,0048069	4,71	0,0462051	3,511596
0,450212	1,7783374	0,54	0,0052974	6,26	0,0614106	3,42156
0,540256	2,1340112	0,75	0,0073575	8,06	0,0790686	3,331516
0,6303	2,489685	1,19	0,0116739	9,94	0,0975114	3,24148
0,720344	2,8453588	1,79	0,0175599	11,67	0,1144827	3,151432
0,810384	3,2010168	2,55	0,0250155	13,01	0,1276281	3,061396
0,900428	3,5566906	3,42	0,0335502	14,14	0,1387134	2,971352
1,080528	4,2680856	5,72	0,0561132	15,23	0,1494063	2,881304
1,170572	4,6237594	6,89	0,0675909	16,17	0,1586277	2,791268
1,440696	5,6907492	10,24	0,1004544	16,96	0,1663776	2,70122
1,530736	6,0464072	11,18	0,1096758	17,6	0,172656	2,61118

1,62078	6,402081	12,65	0,1240965	18,03	0,1768743	2,521136
1,710824	6,7577548	14,35	0,1407735	18,13	0,1778553	2,431088
1,800856	7,1133812	16,06	0,1575486	17,77	0,1743237	2,341048
1,8909	7,469055	17,52	0,1718712	16,98	0,1665738	2,251004
1,980944	7,8247288	18,81	0,1845261	16,08	0,1577448	2,160964
2,070988	8,1804026	20,15	0,1976715	15,37	0,1507797	2,07092
2,161028	8,5360606	21,07	0,2066967	14,84	0,1455804	1,98088
2,251072	8,8917344	21,46	0,2105226	14,39	0,1411659	1,89084
2,341116	9,2474082	21,85	0,2143485	13,93	0,1366533	1,800796
2,431148	9,6030346	22,61	0,2218041	13,41	0,1315521	1,710756
2,61122	10,314319	24,33	0,2386773	12,78	0,1253718	1,620712
2,791296	11,0256192	26,06	0,2556486	12,21	0,1197801	1,530664
2,971368	11,7369036	27,65	0,2712465	11,86	0,1163466	1,44062
3,061412	12,0925774	28,85	0,2830185	11,4	0,111834	1,350572
3,151456	12,4482512	29,28	0,2872368	10,83	0,1062423	1,260532
3,241496	12,8039092	30,16	0,2958696	10,25	0,1005525	1,170488
3,33154	13,159583	30,88	0,3029328	9,75	0,0956475	1,080452
3,421584	13,5152568	31,76	0,3115656	9,23	0,0905463	0,99042
3,511628	13,8709306	32,79	0,3216699	8,76	0,0859356	0,900384
3,601672	14,2266044	33,42	0,3278502	8,33	0,0817173	0,810336
3,78176	14,937952	32,94	0,3231414	7,72	0,0757332	0,720308
3,871784	15,2935468	33,73	0,3308913	7,08	0,0694548	0,630272
3,961828	15,6492206	34,32	0,3366792	6,38	0,0625878	0,540224
4,051872	16,0048944	34,48	0,3382488	5,53	0,0542493	0,450184
4,141904	16,3605208	34,64	0,3398184	4,43	0,0434583	0,360148
4,23194	16,716163	35,34	0,3466854	3,29	0,0322749	0,270112
4,321972	17,0717894	35,08	0,3441348	2	0,01962	0,180072
4,412008	17,4274316	24,64	0,2417184	0,63	0,0061803	0,090036
4,502052	17,7831054	10,24	0,1004544	0,23	0,0022563	0
4,592096	18,1387792	3,19	0,0312939			



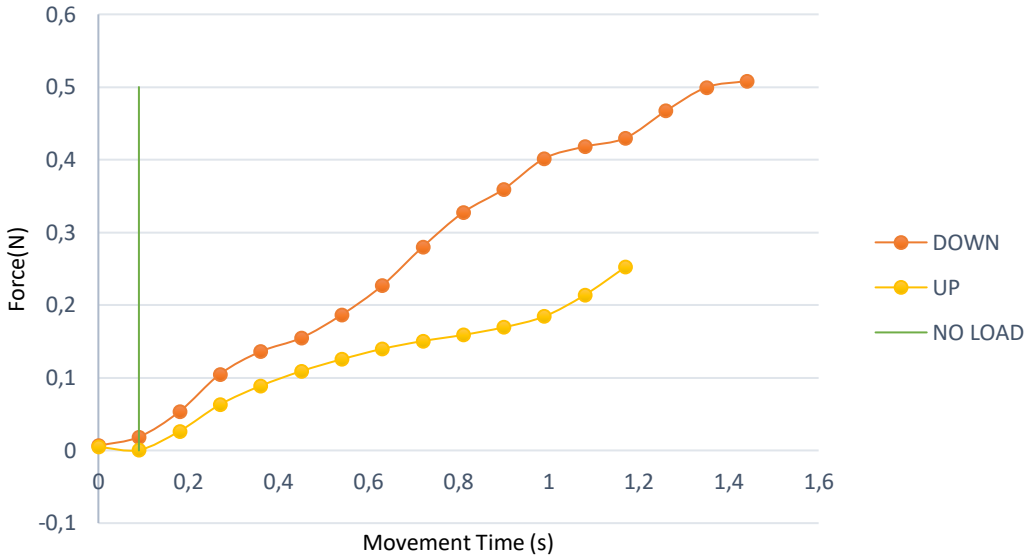
2.29. 1.2 mm diameter for 15,5 mm/s feed velocity

DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,55	0,0053955	10,17	0,0997677	1,530644
0,090044	1,395682	1,19	0,0116739	8,44	0,0827964	1,440608
0,180084	2,791302	4,13	0,0405153	15	0,14715	1,350572
0,27012	4,18686	8,82	0,0865242	21,74	0,2132694	1,260528
0,360164	5,582542	12,03	0,1180143	27,17	0,2665377	1,170492
0,450204	6,978162	15,72	0,1542132	22,79	0,2235699	1,08046
0,540248	8,373844	21,03	0,2063043	16,42	0,1610802	0,990412
0,630288	9,769464	26,39	0,2588859	14,26	0,1398906	0,900376
0,720328	11,165084	30,26	0,2968506	12,6	0,123606	0,810344
0,810368	12,560704	32,01	0,3140181	11,16	0,1094796	0,720296
0,900408	13,956324	33,35	0,3271635	9,75	0,0956475	0,630256
0,99046	15,35213	34,25	0,3359925	8,44	0,0827964	0,540212
1,080508	16,747874	35,64	0,3496284	7,18	0,0704358	0,450192
1,170544	18,143432	38,23	0,3750363	5,96	0,0584676	0,360148
1,260576	19,538928	40,08	0,3931848	4,67	0,0458127	0,270112
1,350608	20,934424	41,37	0,4058397	3,04	0,0298224	0,180072
1,440644	22,329982	44,23	0,4338963	0,96	0,0094176	0,09004
1,530672	23,725416	46,29	0,4541049	0,27	0,0026487	0
1,620708	25,120974	41,05	0,4027005			
1,710748	26,516594	10,17	0,0997677			



2.30. 1.2 mm diameter for 11,6 mm/s feed velocity

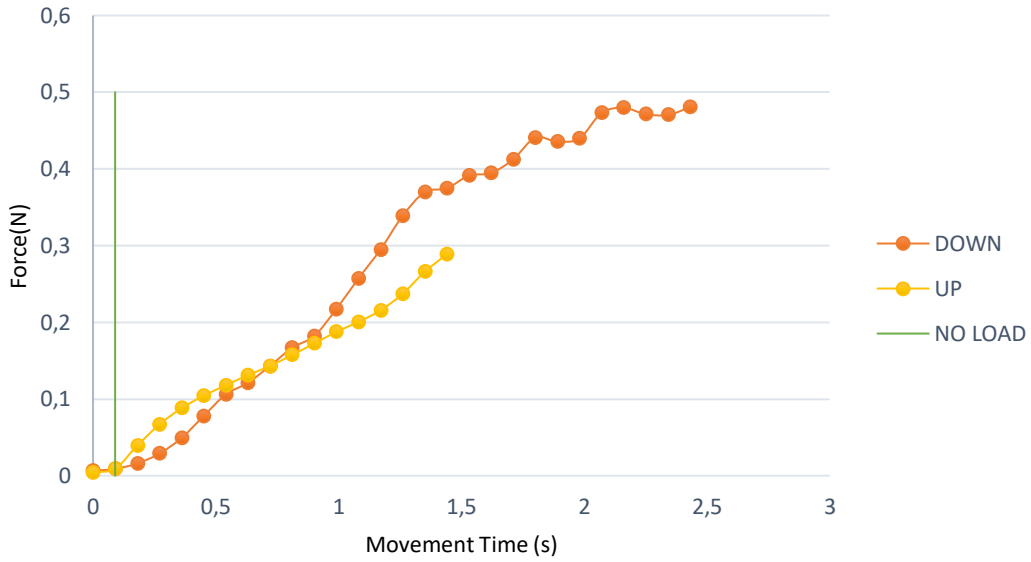
DOWN				UP		
Rel.Time (s)	**Rel. Position(mm)**	**Mass (g)**	**Force(N)**	**Mass (g)**	**Inverted Force(N)**	**Inverted Time (s)**
0	0	0,66	0,0064746	Mass (g)	Force(N)	Inverted Time (s)
0,090032	1,0443712	1,89	0,0185409	3,98	0,0390438	1,710724
0,180076	2,0888816	5,45	0,0534645	4,41	0,0432621	1,620692
0,270108	3,1332528	10,7	0,104967	8,76	0,0859356	1,530656
0,360148	4,1777168	13,87	0,1360647	13,55	0,1329255	1,440608
0,4502	5,22232	15,77	0,1547037	19,06	0,1869786	1,350572
0,540232	6,2666912	19,02	0,1865862	24,33	0,2386773	1,260544
0,630272	7,3111552	23,11	0,2267091	25,71	0,2522151	1,1705
0,720316	8,3556656	28,54	0,2799774	21,8	0,213858	1,080464
0,81036	9,400176	33,38	0,3274578	18,79	0,1843299	0,990428
0,900392	10,4445472	36,64	0,3594384	17,27	0,1694187	0,900392
0,990432	11,4890112	40,94	0,4016214	16,2	0,158922	0,810356
1,080468	12,5334288	42,61	0,4180041	15,34	0,1504854	0,720312
1,1705	13,5778	43,81	0,4297761	14,24	0,1396944	0,630276
1,260544	14,6223104	47,61	0,4670541	12,78	0,1253718	0,540232
1,35058	15,666728	50,92	0,4995252	11,11	0,1089891	0,450184
1,440612	16,7110992	51,81	0,5082561	9,05	0,0887805	0,360152
1,530656	17,7556096	51,14	0,5016834	6,43	0,0630783	0,270112
1,620692	18,8000272	46,7	0,458127	2,7	0,026487	0,180076
1,710736	19,8445376	27,09	0,2657529	0,07	0,0006867	0,09004
1,80078	20,889048	3,98	0,0390438	0,49	0,0048069	0



2.31. 1.2 mm diameter for 7,8 mm/s feed velocity

DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,66	0,0064746	2,59	0,0254079	2,431124
0,090032	0,7022496	0,91	0,0089271	2,27	0,0222687	2,341092
0,180072	1,4045616	1,63	0,0159903	4,69	0,0460089	2,251048
0,270116	2,1069048	2,93	0,0287433	6,71	0,0658251	2,161
0,36016	2,809248	5,01	0,0491481	9,2	0,090252	2,070956
0,4502	3,51156	7,92	0,0776952	12,54	0,1230174	1,980928
0,540236	4,2138408	10,79	0,1058499	16,42	0,1610802	1,89088
0,63028	4,916184	12,34	0,1210554	20,43	0,2004183	1,800836
0,72032	5,618496	14,58	0,1430298	24,09	0,2363229	1,710792
0,810364	6,3208392	17	0,16677	27,13	0,2661453	1,620744
0,900408	7,0231824	18,56	0,1820736	29,37	0,2881197	1,530708
0,990448	7,7254944	22,14	0,2171934	29,44	0,2888064	1,44066
1,080488	8,4278064	26,2	0,257022	27,09	0,2657529	1,350616
1,17054	9,130212	30,06	0,2948886	24,17	0,2371077	1,26058
1,260584	9,8325552	34,52	0,3386412	21,97	0,2155257	1,170524
1,350628	10,5348984	37,68	0,3696408	20,44	0,2005164	1,080488
1,440676	11,2372728	38,2	0,374742	19,11	0,1874691	0,99044
1,53072	11,939616	39,87	0,3911247	17,56	0,1722636	0,900404
1,620756	12,6418968	40,24	0,3947544	16,04	0,1573524	0,81036
1,710796	13,3442088	42,04	0,4124124	14,58	0,1430298	0,720324
1,800844	14,0465832	44,92	0,4406652	13,36	0,1310616	0,630284
1,89088	14,748864	44,4	0,435564	12,01	0,1178181	0,540252
1,98092	15,451176	44,83	0,4397823	10,62	0,1041822	0,450216

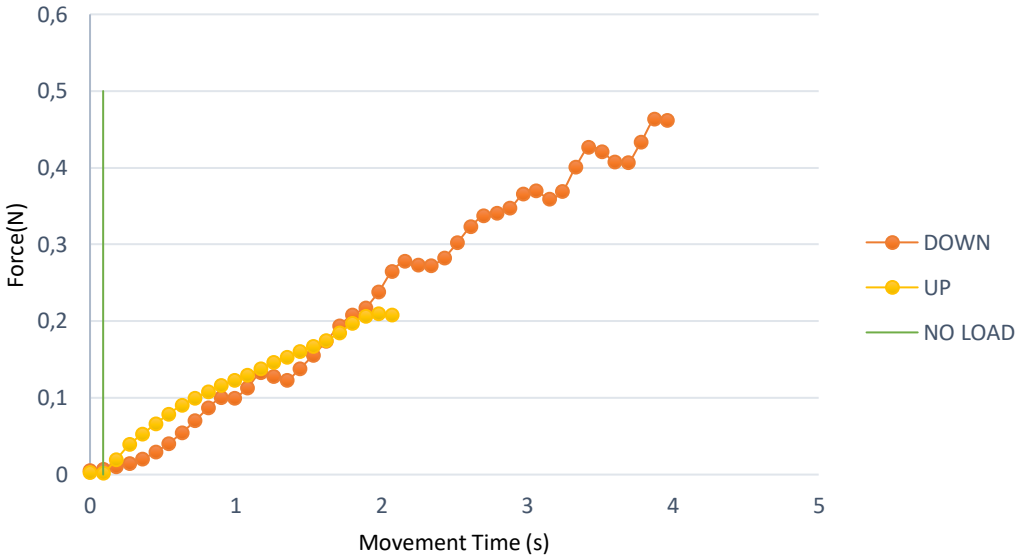
2,070964	16,1535192	48,21	0,4729401	8,97	0,0879957	0,360168
2,161008	16,8558624	48,88	0,4795128	6,8	0,066708	0,270128
2,251052	17,5582056	48,04	0,4712724	4	0,03924	0,18008
2,341096	18,2605488	47,95	0,4703895	0,95	0,0093195	0,090036
2,43114	18,962892	48,96	0,4802976	0,41	0,0040221	0
2,521172	19,6651416	48,73	0,4780413			
2,61122	20,367516	39,57	0,3881817			
2,70126	21,069828	16,03	0,1572543			
2,791316	21,7722648	2,59	0,0254079			



2.32. 1.2 mm diameter for 3.95 mm/s feed velocity

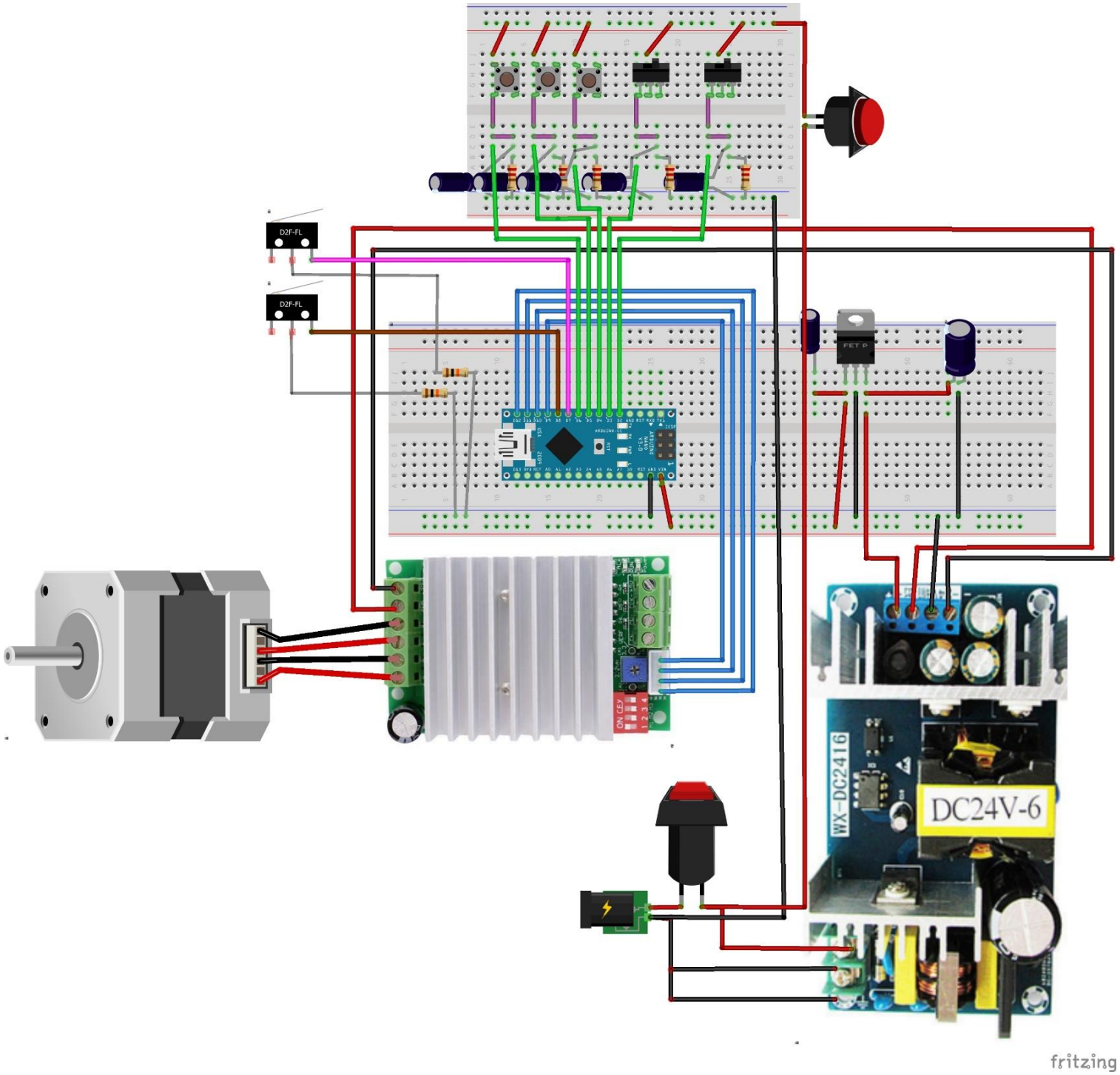
DOWN				UP		
Rel.Time (s)	Rel. Position(mm)	Mass (g)	Force(N)	Mass (g)	Inverted Force(N)	Inverted Time (s)
0	0	0,55	0,0053955	1,79	0,0175599	3,78154
0,09004	0,355658	0,72	0,0070632	0,07	0,0006867	3,691504
0,180076	0,7113002	1,05	0,0103005	1,25	0,0122625	3,60146
0,270104	1,0669108	1,46	0,0143226	2,1	0,020601	3,511424
0,360148	1,4225846	2,08	0,0204048	2,89	0,0283509	3,421388
0,450176	1,7781952	2,99	0,0293319	3,64	0,0357084	3,331352
0,540208	2,1338216	4,15	0,0407115	4,41	0,0432621	3,241312
0,630252	2,4894954	5,57	0,0546417	5,35	0,0524835	3,151276
0,720284	2,8451218	7,14	0,0700434	6,51	0,0638631	3,06124
0,810332	3,2008114	8,85	0,0868185	7,84	0,0769104	2,971208
0,900364	3,5564378	10,25	0,1005525	9,28	0,0910368	2,881164
0,990404	3,9120958	10,13	0,0993753	10,78	0,1057518	2,791128
1,080436	4,2677222	11,56	0,1134036	12,38	0,1214478	2,701092

1,17048	4,623396	13,52	0,1326312	14,08	0,1381248	2,611056
1,260524	4,9790698	13,09	0,1284129	15,76	0,1546056	2,521016
1,350564	5,3347278	12,53	0,1229193	17,3	0,169713	2,430968
1,440596	5,6903542	14,11	0,1384191	18,63	0,1827603	2,340936
1,53064	6,046028	15,84	0,1553904	19,85	0,1947285	2,250884
1,620668	6,4016386	17,72	0,1738332	20,74	0,2034594	2,160852
1,7107	6,757265	19,78	0,1940418	21,25	0,2084625	2,07082
1,80074	7,112923	21,24	0,2083644	21,4	0,209934	1,980784
1,890772	7,4685494	22,18	0,2175858	21,07	0,2066967	1,890748
1,980804	7,8241758	24,31	0,2384811	20,15	0,1976715	1,80072
2,070844	8,1798338	27	0,26487	18,85	0,1849185	1,710684
2,160876	8,5354602	28,33	0,2779173	17,8	0,174618	1,620648
2,250908	8,8910866	27,86	0,2733066	17,02	0,1669662	1,530616
2,340952	9,2467604	27,78	0,2725218	16,33	0,1601973	1,44058
2,430984	9,6023868	28,83	0,2828223	15,62	0,1532322	1,350544
2,521024	9,9580448	30,83	0,3024423	14,88	0,1459728	1,260508
2,611056	10,3136712	32,97	0,3234357	14,04	0,1377324	1,170476
2,701088	10,6692976	34,42	0,3376602	13,26	0,1300806	1,080428
2,791136	11,0249872	34,73	0,3407013	12,56	0,1232136	0,990396
2,88116	11,380582	35,4	0,347274	11,83	0,1160523	0,900348
2,971192	11,7362084	37,26	0,3655206	11	0,10791	0,810312
3,061232	12,0918664	37,72	0,3700332	10,18	0,0998658	0,720272
3,151268	12,4475086	36,63	0,3593403	9,25	0,0907425	0,630236
3,241304	12,8031508	37,63	0,3691503	8,06	0,0790686	0,540204
3,331336	13,1587772	40,85	0,4007385	6,73	0,0660213	0,450168
3,42138	13,514451	43,48	0,4265388	5,41	0,0530721	0,360132
3,511416	13,8700932	42,95	0,4213395	3,99	0,0391419	0,270104
3,601448	14,2257196	41,52	0,4073112	2,03	0,0199143	0,180068
3,691484	14,5813618	41,46	0,4067226	0,24	0,0023544	0,090036
3,78152	14,937004	44,21	0,4337001	0,29	0,0028449	0
3,871556	15,2926462	47,22	0,4632282			
3,961588	15,6482726	47,05	0,4615605			
4,051616	16,0038832	44,48	0,4363488			
4,141652	16,3595254	33,23	0,3259863			
4,231684	16,7151518	18,36	0,1801116			
4,321728	17,0708256	9,79	0,0960399			
4,411772	17,4264994	4,81	0,0471861			
4,501804	17,7821258	1,79	0,0175599			

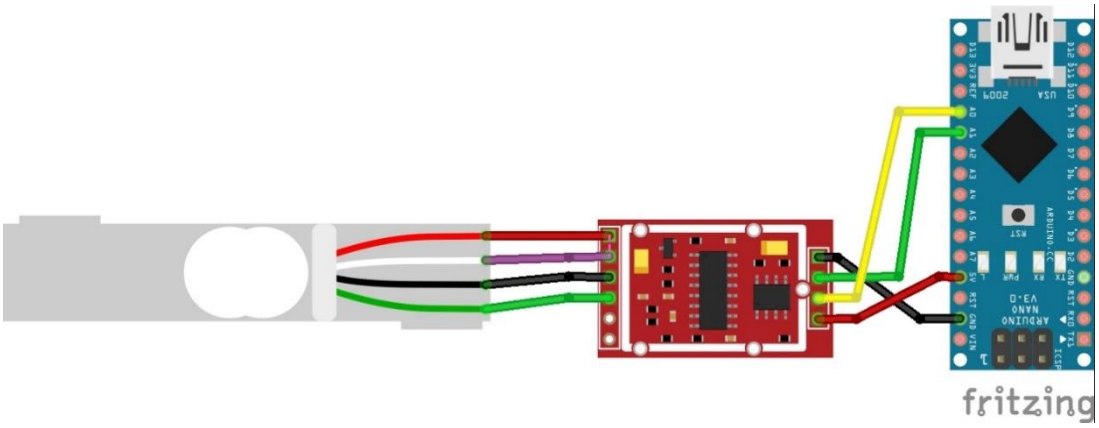

0,6
0,5
0,4
0,3
0,2
0,1
0
Force(N)
0
1
2
3
4
5
Movement Time (s)
DOWN
UP
NO LOAD

A3. Electrical Schemes

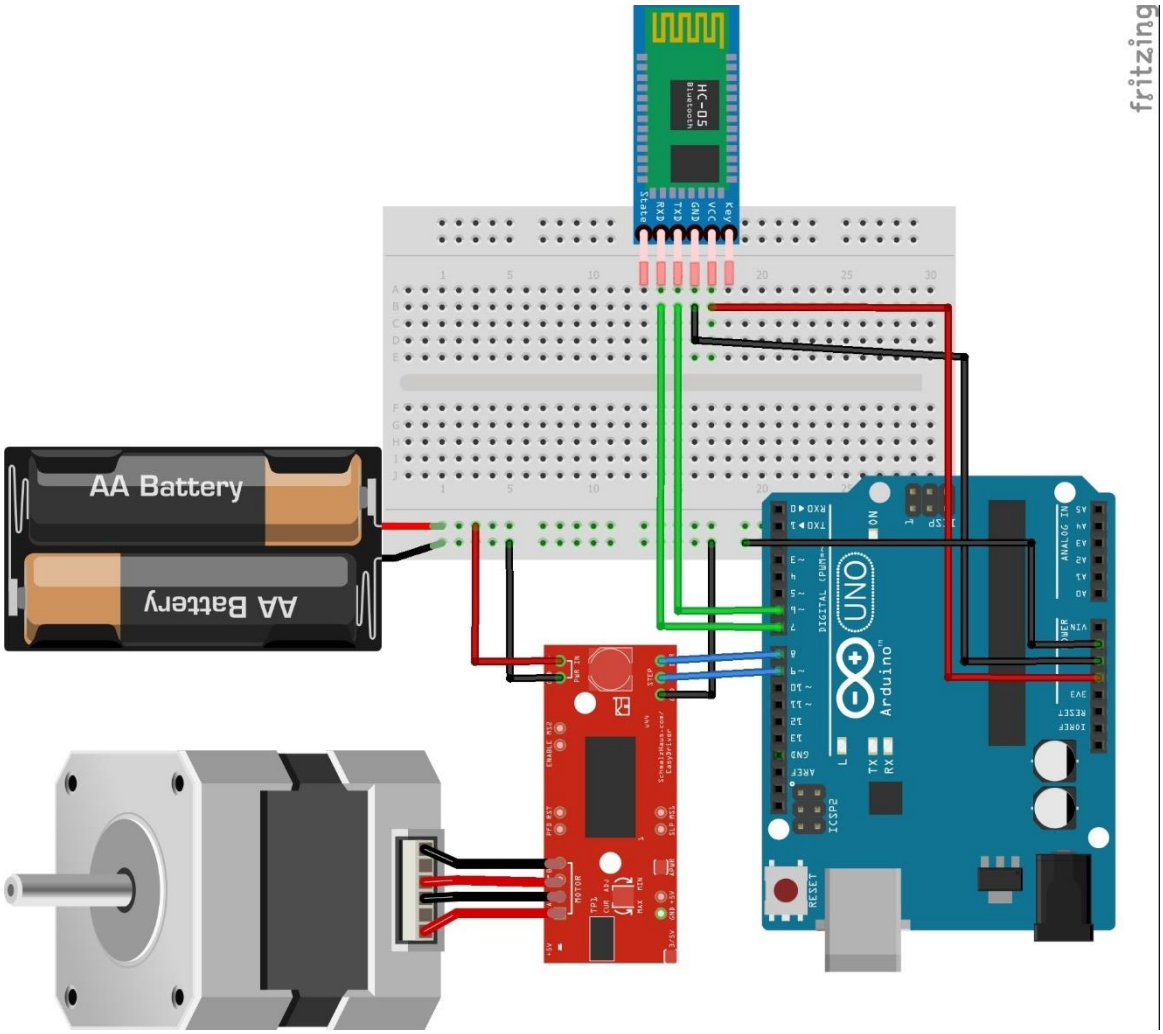
3.1. Linear Actuator



3.2. Load Cell



3.3. Stepper motor remote control setup



A4. Arduino Codes

4.1. Linear Actuator Movement Code

```
#include <AccelStepper.h> //Libreria driver motor

#include <GFButton.h> //Libreria botones

AccelStepper MotorVertical(1,11,10); //Define nº de motor, pulsos y dirección del motor.

GFButton buttonP_Up(6); //Define los botones con GFButton button, el botón que sube en el pin 6.

GFButton buttonP_Down(3); ////Define los botones con GFButton button, el botón que baja en el pin 3.

GFButton buttonP(2); //Define los botones con GFButton button, el botón automatico en el pin 3.

GFButton buttonV_1(4); //Define los botones con GFButton button, el botón de velocidad 1 en el pin 4.

GFButton buttonV_2(5); //Define los botones con GFButton button, el botón de velocidad 2 en el pin 5.

GFButton buttonEndUp(7); //Define final de carrera de arriba con el pin 7.

GFButton buttonEndDown(8); //Define final de carrera de abajo con el pin 8.

int Vel;

void setup() {

 MotorVertical.setMaxSpeed(800); //Define el numero de pulsos del motor, en este caso 800 pulsos.

 MotorVertical.setAcceleration(500); //Define la acceleración del motor en nº de pulsos del motor, en este caso 500 pulsos.

 pinMode(9, OUTPUT);

}
```

```
void loop() {
  digitalWrite(9, HIGH);
  if((not buttonV_1.isPressed()) && (not buttonV_2.isPressed())){
  Vel=800;
  }
   if((not buttonV_1.isPressed()) && (buttonV_2.isPressed())){
  Vel=600;
  }
  if((buttonV_1.isPressed()) && (not buttonV_2.isPressed())){
  Vel=400;
  }
  if((buttonV_1.isPressed()) && (buttonV_2.isPressed())){
  Vel=100;
  }
 if((not buttonP_Up.isPressed()) && (buttonEndUp.isPressed()))
  {
  MotorVertical.setSpeed(Vel);
  MotorVertical.runSpeed();
 }
 if((not buttonP_Down.isPressed()) && (buttonEndDown.isPressed())) {
  MotorVertical.setSpeed(-Vel);
  MotorVertical.runSpeed();
 }
```

```
 if((not buttonP.isPressed()) && (buttonEndDown.isPressed())) {
   MotorVertical.setSpeed(-Vel);
   MotorVertical.runSpeed();
 }
}
```

4.2. Scale Code

```
//iphone 8--> 148g
#include "HX711.h"
const int DOUT=A1;
const int CLK=A0;
HX711 balanza;
void setup() {
 Serial.begin(9600);
 balanza.begin(DOUT, CLK);
 Serial.print("Lectura del valor del ADC:t");
 Serial.println(balanza.read());
 Serial.println("No ponga ningún objeto sobre la balanza");
 Serial.println("Destarando...");
 balanza.set_scale(); //La escala por defecto es 1
 balanza.tare(20);  //El peso actual es considerado Tara.
 Serial.println("Coloque un peso conocido:");
}
```

```
void loop() {
  Serial.print("Valor de lectura:");
  Serial.println(balanza.get_value(10),0);
  delay(100);
}
```

4.3. Force Measuring Code

```
#include <HX711.h>
#define DOUT  A1
#define CLK  A0
HX711 balanza;
int masa;
unsigned long t0 = 0;
unsigned long dt = 0;
void setup() {
  Serial.begin(9600);
  balanza.begin(DOUT, CLK);
  Serial.print("Lectura del valor del ADC:  ");
  Serial.println(balanza.read());
  Serial.println("No ponga ningun  objeto sobre la balanza");
  Serial.println("Destarando...");
  Serial.println("...");
  balanza.set_scale(-1921.12); // Establecemos la escala
```

```
  balanza.tare(20);    //El peso actual es considerado Tara.
  Serial.println("Listo para pesar");
  delay (1000);
  Serial.println( "Tiempo (micros), Masa (centig)");
  t0 = micros();  //tiempo del inicio de la toma de muestras
}
void loop() {
  masa = balanza.get_units(1) * 100;
  dt = micros() - t0; // Tiempo que ha tardado en medir la balanza
  Serial.print(dt);
  Serial.print(",");
  Serial.println(masa);
}
```

4.4. Stepper motor remote control Mit app inventor application


```
//llibreries bt i motor

#include <SoftwareSerial.h>

#include <AccelStepper.h>

//definim stpp

AccelStepper stepper(AccelStepper::DRIVER, 9, 8);

//definim bt

int Tx = 6;

int Rx = 7;

SoftwareSerial BT (Tx, Rx);

//definim variables

int letra;
```

```
int vel;

void setup() {

 //activem bt

 BT.begin (9600);

 Serial.begin(9600);

}

void loop() {

 // llegim el bt

 letra = 0;

 if (BT.available()) {

  letra = BT.read();

  delay(1000);

  vel = BT.read() * 10;

  //Serial.println(letra);

  //Serial.println(vel);

  stepper.setMaxSpeed(vel);

  stepper.setAcceleration(1000);

  Serial.println(vel);

  Serial.println(BT.read());

 }

 // programa del motor

 if (letra == 1) {

  if (stepper.distanceToGo() == 0) {
```

```
    delay(100);

    stepper.moveTo(1000);

    stepper.runToPosition();

    delay(100);

    stepper.moveTo(0);

    stepper.runToPosition();

   }

 }

}

//app:

//http://ai2.appinventor.mit.edu/?locale=es_ES#6146686506631168
```

A5. Datasheets and Specifications

5.1. Linear Actuator Components

Linear Actuator component

Description:
HPV6 Linear Module SFU1204 Ball Screw Linear Actuator with HGR15 Linear Guides with NEMA23 2.8A 56mm 57 Stepper Motor

Specification:
Model: HPV6
Base: 20100 Aluminum Extrusions
Linear Guide: HGR15
Ball Screw: SFU1204
Effective Travel: 100-1000mm
Motor: 23HS5628 Stepper Motor
Motor leads: 30cm
Total lenght= Effective stroke+134MM

Scope: 3D Printers, Monitor Equipment, Medical Machinery, Textile Machinery, Packaging Machinery, Stage Lighting, Laser engraving, Automation Equipment, Non-standard Equipment, Placement machine ect.

23HS5628 Stepper Motor:

Model	23HS5628
Phase	2
Step Angle	1.8°
Motor Frame Size	57 x 56mm
Outlet way	"4" plug line
Motor leads	30cm Wire
Adapter drive	Two-phase step drive
Scope	3D Printers, Monitor Equipment, Medical Machinery, Textile Machinery, Packaging Machinery, Stage Lighting, Laser engraving, Automation Equipment, Non-standard Equipment, Placement machine ect.

Electrical Specifications:

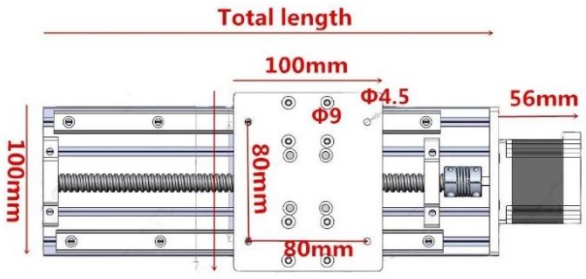
Model No.	Step Angle	Motor Length	Rated Voltage	Rated Current	Resistance /Phase	Inductance /Phase	Holding Torque	Inertia Of Rotor	Lead
	(°)	(L)mm	(V)	(A)	(Ω)	(mH)	(N.cm)	(G. cm²)	(No.)
23HS5628	1.8	56	2.5	2.8	0.9	2.5	126	300	4

General Specification:

Precision angle step	±5% (full step, no charge)
Resistance accuracy	±10%
Precision inductance	±20%
Temperature rise	80deg Max (rated current, 2 phase on)
Ambient temperature	(- 20°)-(+ 50°)
Insulation resistance	100MΩ Min, 500VDC
Insultion Force	500VAC for a minute

Package Included:
1set x HPV6 HGR LINEAR ACTUATOR

More Details:



https://www.banggood.com/HPV6-Linear-Module-SFU1:

Total length = effective stroke + 134MM
Stepper motor : 23HS5628 2.8A 128N.cm
Linear Guides : HGR15
Ballscrew : SFU1204

Stepper Motor Drier

ROBOKITS INDIA

TB6600 STEPPER MOTOR DRIVER 4.5A

Technical specifications:

- **Operating voltage DC 10V-45V. (32VDC Recommended)**
- **Rated maximum output reached: ± 4.5A.**
- **for 4.2A 42,57,86 within the two-phase / four-phase / four-wire / six-wire stepper motor.**
- **Subdivision: full step, half step, 1/4-step, step 1/8, 1/16-step, up to 16 segments.**
- **Volume: Width Length 82 * 50 * high 35 (MM)**

Features:

- **high current, high voltage TB6600HG new original chip, there are low-pressure shut-off, overheating parking and over-current protection circuit, short-circuit protection and increased compared to TB6560**
- **high-speed optical coupling 6N137, ensure high speed without losing step**
- **The output current is infinitely adjustable to meet various application requirements**
- **Automatic half current function. And a semi-automatic flow switch, easy to use**
- **The use of high-speed optical coupling 6N137 ensure high-speed without losing step**
- **Printed on the back panel are subdivided setup instructions**
- **Used to increase the heat sink, good heat dissipation**
- **Output short-circuit protection**
- **Using common anode input mode, there are two input terminals, wiring more convenient**

ROBOKITS INDIA

Interface	Description
8-45V	DC 8-45V power supply
2A 2B	One phase of stepping motor
1A 1B	Other phase of stepping motor
EN	stepping enable signal
DIR	step direction signal
CLK	step pulse signal
GND	step signal grand

MKS TB6600 Mode

	M1	M2	M3		TQ
1/1	OFF	OFF	ON		
1/2	OFF	ON	OFF	Auto	OFF
1/4	ON	OFF	OFF		
1/8	ON	OFF	ON		
1/16	ON	ON	OFF	100%	ON

Nema 17 Stepper Motor

Descripción:
HANPOSE 17HS4401-S 40 mm Nema 17 Stepper motor 42 motor 42BYGH 1.7A 40N.cm 4-lead motor para impresora 3D CNC Láser
Certificación: CE, ROSH, ISO, FCC
Color: Negro (Tratamiento de Superficies)

Especificación:

Modelo	17HS4401-S
Tipo	Híbrido
Fase	2
Ángulo de paso	1.8 °
Tamaño motor	42 x 40mm
Eje	Eje "D" 22 x Φ5mm
Camino de salida	"4" línea de enchufe
motor conductores	Línea Dupont (1M)
Unidad de adaptador	Paso de dos fases de accionamiento
Alcance	Impresoras 3D, Monitor Equipos, Médico Maquinaria, Maquinaria Textil, Maquinaria de embalaje, Iluminación de escenario, Láser grabado, Automatización Equipo, Equipo no estándar, Máquina de colocación, etc.

Especificaciones electricas:

N ° de Modeloo.	Ángulo de paso	motor longitud	Clasificado Corriente	Resistencia /Fase	Inductancia /Fase	Par de mantenimiento	Fijador Esfuerzo de torsión	Inercia de Rotor	Di
	(°)	(L) mm	(UNA)	(Ω)	(mH)	(N.cm)	(N.cm)	(G. cm²)	(N
17HS4401-S	1.8	40	1.7	1.5	2.8	40	2.2	54	

Especificación general:

Paso de ángulo de precisión	± 5% (paso completo, sin cargo)
Exactitud de resistencia	± 10%
Inductancia de precisión	± 20%
Aumento de la temperatura	80deg Max (corriente nominal, 2 fases en)
Temperatura ambiente	(- 20 °) - (+ 50 °)
Resistencia de aislamiento	100MΩ Min, 500VDC
Fuerza de aislamiento	500VAC por un minuto

caracteristicas:
1. Bajo nivel de ruido.
2. Bajo calor.
3. Operación suave.
4. Buen rendimiento de aceleración.
5. Tratamiento superficial negro.

Paquete incluido:
1 X 17HS4401-S Stepper motor

Más detalles:

Power Oulet

3/1/2021 220v/110v 5a power outlet socket with switch and 6a fuse for 3d printer Sale - Banggood.com

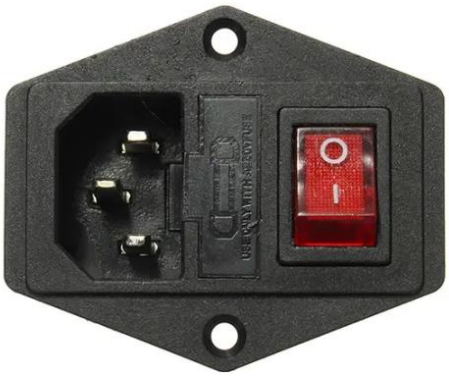
Detalles Especificación Comentarios (167) Q&A Envío y Pago Investigación de mayorista

caracteristicas:

De color negro
Voltaje: 110/220 V
Corriente: 15A (viene con un fusible 6A)

Paquete incluido:

1 x tomacorriente



Power Supply module

3/1/2021 Geekcreit® ac100-220v to dc 24v switching power supply board ac-dc power module Sale - Banggood.com

Detalles Comentarios (1344) Q&A Envío y Pago Investigación de mayorista

Característica:

Modelo de potencia: XK-2412-24
Protección: Protección contra cortocircuito, sobrecorriente y sobrevoltaje
Entrada de la CA: AC100-220V (Común global)
Frecuencia de la CA: 50HZ / 60HZ
Voltaje de salida: DC 24V
Corriente de salida: 4A - 6A
Potencia de salida: 100W
Modulación: Modulación de anchura de pulso

Paquete incluido:

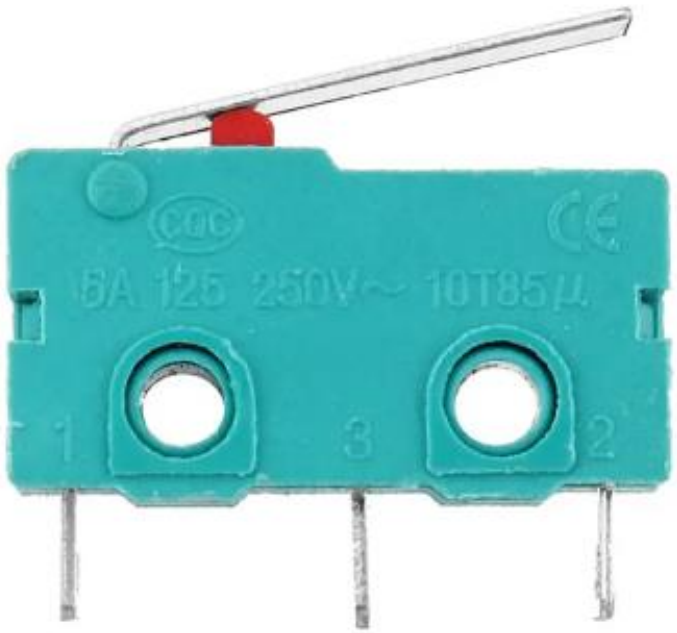
1 x 4A a 6A Placa de alimentación de conmutación 24V módulo de alimentación AC-DC

Limit Switches

Presupuesto:
N / O / N / C Interruptor de límite con palanca larga.
Clasificación: 5A 125 / 250VAC 3A 125 / 250VAC
Rigidez dieléctrica: 1500VAC, 1 minuto
Resistencia de contacto: 30 mΩ máx.
Temperatura de funcionamiento: -25 ~ + 80C
Resistencia de aislamiento: 500VDC 100mΩ min
Vida eléctrica: 100000 ciclos
Cantidad: 3 piezas

OF （N）	0.2 ~ 3.0
MD Max（mm）	1.2
FP Max（mm）	14.5
OP Min （mm）	10.5

Paquete incluido:
3 x interruptor de límite



5.2. Load Cell Components

Load Cell controller

3/1/2021 Hx711 dual channel 24-bit a/d conversion weighing sensor controller module Sale - Banggood.com

Detalles Comentarios (2) Q&A Envío y Pago Investigación de mayorista

caracteristicas:

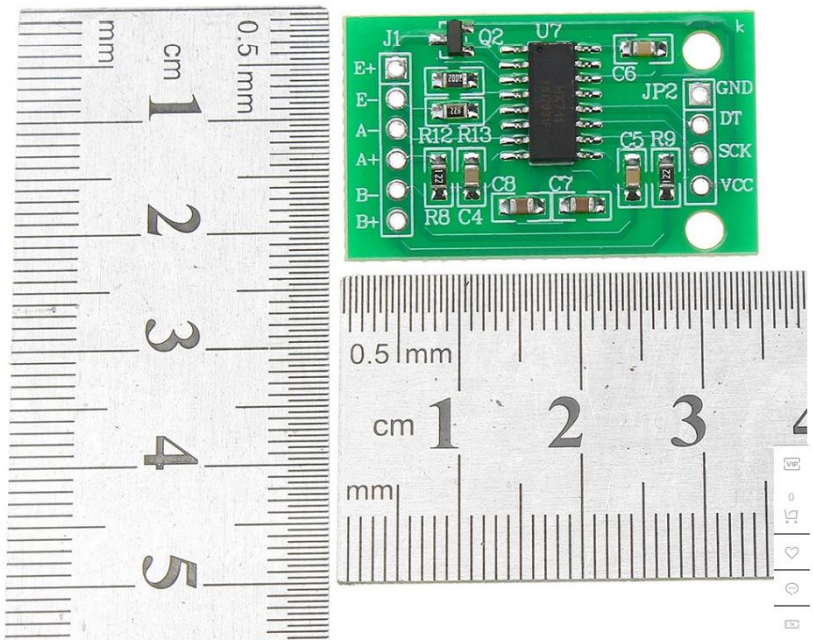
1. Con blindaje de metal, fuerte anti-interferencia, obligada posición MCU (STC15F104), puede mejorar el desarrollo secundario.
2. Dos vías pueden elegir entrada diferencial
3. El amplificador programable de bajo ruido del chip, ganancia opcional a 32, 64 y 128.
4. El circuito estabilizador de voltaje del chip puede ser directamente a los sensores externos y chips dentro del convertidor A / D para proporcionar alimentación.
5. El chip oscilador del reloj sin ningún dispositivo externo, cuando sea necesario, también puede usar cristales externos o reloj
6. Circuito de reinicio automático
7. El control digital simple y la comunicación de la interfaz serial son controlados por el pin de entrada, registro de chip sin programación
8. Puede elegir 10 hz o la velocidad de salida de datos de 80 hz.
9. Sincronización de supresión de interferencias en la fuente de alimentación de 50 hz o 60 hz

Presupuesto:

Corriente de trabajo típica: <1.7 mA, corriente de potencia: <1 mu A
Rango de voltaje de trabajo: 2.6 ~ 5.5 V
Rango de temperatura de funcionamiento bajo: - 20 ~ + 85
Voltaje de funcionamiento del módulo: 4.8V a 5.5V
Tamaño: 29 * 17 * 4 mm

Embalaje incluido:

1 x Pesaje Sensor AD Módulo
1 x escudo de metal
4 x Pin Header



Load Cell

YZC-131A Load Cells

Contents

What do you have to know?

A load cell is a force sensing module - a carefully designed metal structure, with small elements called strain gauges mounted in precise locations on the structure. Load cells are designed to measure a specific force, and ignore other forces being applied. The electrical signal output by the load cell is very small and requires specialized amplification.

Load cells are designed to measure force in one direction. They will often measure force in other directions, but the sensor sensitivity will be different, since parts of the load cell operating under compression are now in tension, and vice versa.

How does it work

Strain-gauge load cells convert the load acting on them into electrical signals. The measuring is done with very small resistor patterns called strain gauges - effectively small, flexible circuit boards. The gauges are bonded onto a beam or structural member that deforms when weight is applied, in turn deforming the strain-gauge. As the strain gauge is deformed, it's electrical resistance changes in proportion to the load.

The changes to the circuit caused by force is much smaller than the changes caused by variation in temperature. Higher quality load cells cancel out the effects of temperature using two techniques. By matching the expansion rate of the strain gauge to the expansion rate of the metal it's mounted on, undue strain on the gauges can be avoided as the load cell warms up and cools down. The most important method of temperature compensation involves using multiple strain gauges, which all respond to the change in temperature with the same change in resistance. Some load cell designs use gauges which are never subjected to any force, but only serve to counterbalance the temperature effects on the gauges that measuring force. Most designs use 4 strain gauges, some in compression, some under tension, which maximizes the sensitivity of the load cell, and automatically cancels the effect of temperature.

Installation

This Single Point Load Cell is used in small jewelry scales and kitchen scales. It's mounted by bolting down the end of the load cell where the wires are attached, and applying force on the other end **in the direction of the arrow.** Where the force is applied is not critical, as this load cell measures a shearing effect on the beam, not the bending of the beam. If you mount a small platform on the load cell, as would be done in a small scale, this load cell provides accurate readings regardless of the position of the load on the platform.

Calibration

A simple formula is usually used to convert the measured mv/V output from the load cell to the measured force:

$$Measured\ Force = A * Measured\ mV/V + B\ (offset)$$

It's important to decide what unit your measured force is - grams, kilograms, pounds, etc.

This load cell has a rated output of 1.0±0.15mv/v which corresponds to the sensor's capacity of 5kg.

To find A we use

$$Capacity = A * Rated\ Output$$

$$A = Capacity / Rated\ Output$$

$$A = 5 / 1.0$$

$$A = 5$$

Since the Offset is quite variable between individual load cells, it's necessary to calculate the offset for each sensor. Measure the output of the load cell with no force on it and note the mv/V output measured by the PhidgetBridge.

$$Offset = 0 - 5 * Measured\ Output$$

YZC-131A Series Product Specifications	
Mechanical	
Housing Material	Aluminum Alloy
Load Cell Type	Strain Gauge
Capacity	1/2/3/5 kg
Dimensions	Lx12.7x12.7 mm
Mounting Holes	M5 (Screw Size)
Cable Length	210 mm
Cable Size	30 AWG (0.2mm)
Cable - no. of leads	4
Electrical	
Precision	0.05%
Rated Output	1.0±0.15 mV/V
Non-Linearity	0.05% FS
Hysteresis	0.03% FS
Non-Repeatability	0.03% FS
Creep (per 5 minutes)	0.1% FS
Temperature Effect on Zero (per 10°C)	0.02% FS
Temperature Effect on Span (per 10°C)	0.05% FS Zero
Balance	±1.5% FS
Input Impedance	1000±50 Ohm
Output Impedance	1000±50 Ohm
Insulation Resistance (Under 50VDC)	≥2000 MOhm
Excitation Voltage	5 VDC
Compensated Temperature Range	-10 to ~+40°C
Operating Temperature Range	-21 to ~+40°C
Safe Overload	120% Capacity
Ultimate Overload	150% Capacity

Glossary

Capacity
The maximum load the load cell is designed to measure within its specifications.

Creep
The change in sensor output occurring over 30 minutes, while under load at or near capacity and with all environmental conditions and other variables remaining constant.

FULL SCALE or FS
Used to qualify error - FULL SCALE is the change in output when the sensor is fully loaded. If a particular error (for example, Non-Linearity) is expressed as 0.1% F.S., and the output is 1.0mV/V, the maximum non-linearity that will be seen over the operating range of the sensor will be 0.001 mV/V. An important distinction is that this error doesn't have to only occur at the maximum load. If you are operating the sensor at a maximum of 10% of capacity, for this example, the non-linearity would still be 0.001mV/V, or 1% of the operating range that you are actually using.

Hysteresis
If a force equal to 50% of capacity is applied to a load cell which has been at no load, a given output will be measured. The same load cell is at full capacity, and some of the force is removed, resulting in the load cell operating at 50% capacity. The difference in output between the two test scenarios is called hysteresis.

Excitation Voltage
Specifies the voltage that can be applied to the power/ground terminals on the load cell. In practice, if you are using the load cell with the PhidgetBridge, you don't have to worry about this spec.

Input Impedance
Determines the power that will be consumed by the load cell. The lower this number is, the more current will be required, and the more heating will occur when the load cell is powered. In very noisy environments, a lower input impedance will reduce the effect of Electromagnetic interference on long wires between the load cell and PhidgetBridge.

Insulation Resistance
The electrical resistance measured between the metal structure of the load cell, and the wiring. The practical result of this is the metal structure of the load cells should not be energized with a voltage, particularly higher voltages, as it can arc into the PhidgetBridge. Commonly the load cell and the metal framework it is part of will be grounded to earth or to your system ground.

Maximum Overload
The maximum load which can be applied without producing a structural failure.

Non-Linearity
Ideally, the output of the sensor will be perfectly linear, and a simple 2-point calibration will exactly describe the behaviour of the sensor at other loads. In practice, the sensor is not perfect, and Non-linearity describes the maximum deviation from the linear curve. Theoretically, if a more complex calibration is used, some of the non-linearity can be calibrated out, but this will require a very high accuracy calibration with multiple points.

Non-Repeatability
The maximum difference the sensor will report when exactly the same weight is applied, at the same temperature, over multiple test runs.

Operating Temperature
The extremes of ambient temperature within which the load cell will operate without permanent adverse change to any of its performance characteristics.

Output Impedance
Roughly corresponds to the input impedance. If the Output Impedance is very high, measuring the bridge will distort the results. The PhidgetBridge carefully buffers the signals coming from the load cell, so in practice this is not a concern.

Rated Output
Is the difference in the output of the sensor between when it is fully loaded to its rated capacity, and when it's unloaded. Effectively, it's how sensitive the sensor is, and corresponds to the gain calculated when calibrating the sensor. More expensive sensors have an exact rated output based on an individual calibration done at the factory.

Safe Overload
The maximum axial load which can be applied without producing a permanent shift in performance characteristics beyond those specified.

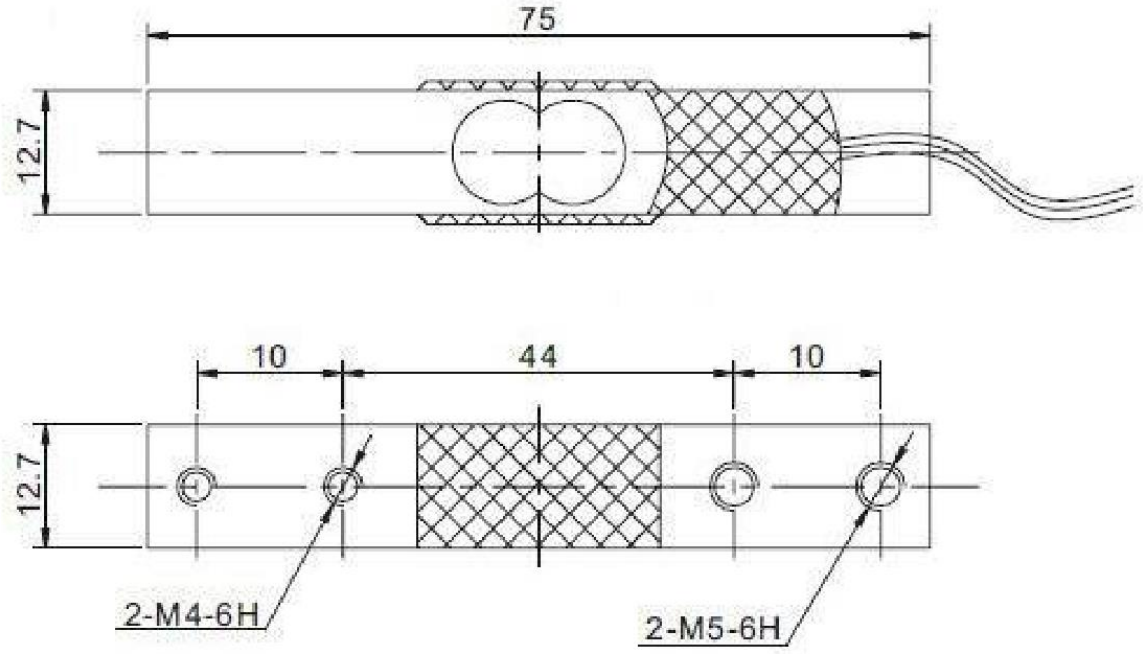
Compensated Temperature
The range of temperature over which the load cell is compensated to maintain output and zero balance within specified limits.

Temperature Effect on Span
Span is also called rated output. This value is the change in output due to a change in ambient temperature. It is measured over 10 degree C temperature interval.

Temperature Effect on Zero
The change in zero balance due to a change in ambient temperature. This value is measured over 10 degree C temperature interval.

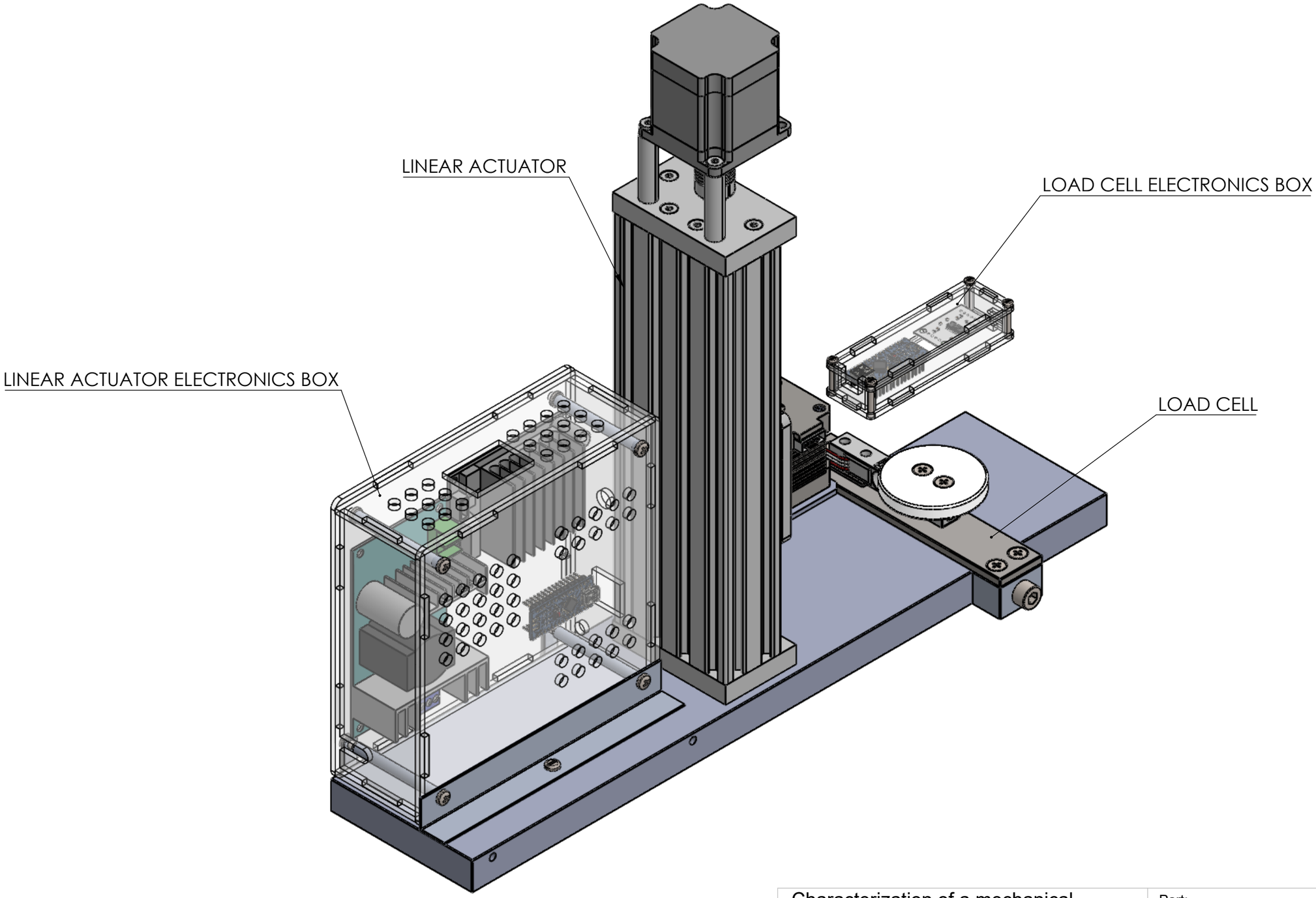
Zero Balance
Zero Balance defines the maximum difference between the +/- output wires when no load is applied. Realistically, each sensor will be individually calibrated, at least for the output when no load is applied. Zero Balance is more of a concern if the load cell is being interfaced to an amplification circuit - the PhidgetBridge can easily handle enormous differences between +/-. If the difference is very large, the PhidgetBridge will not be able to use the higher Gain settings.

Dimensiones

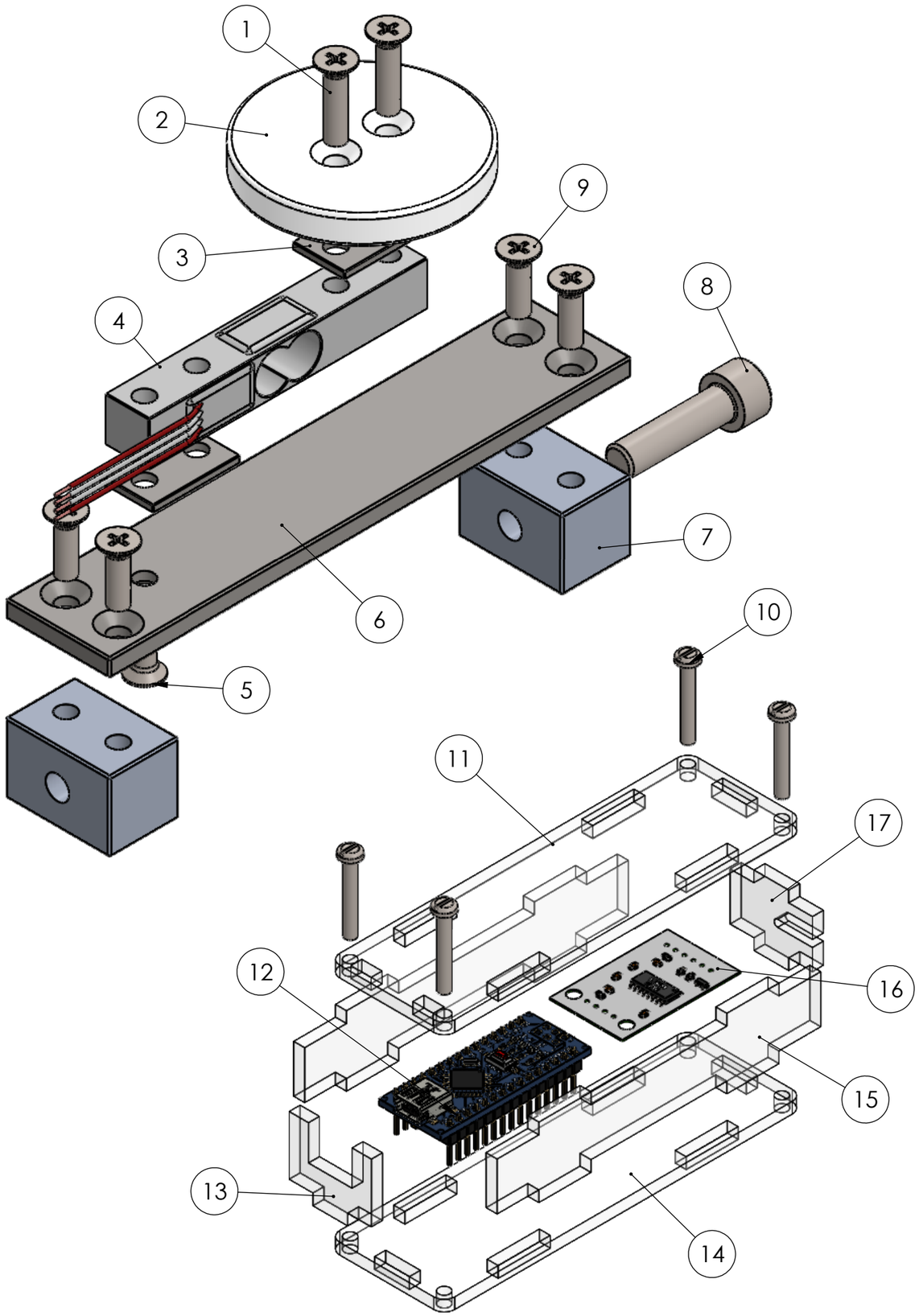


A6. Drawings

6.1. Drawings Index

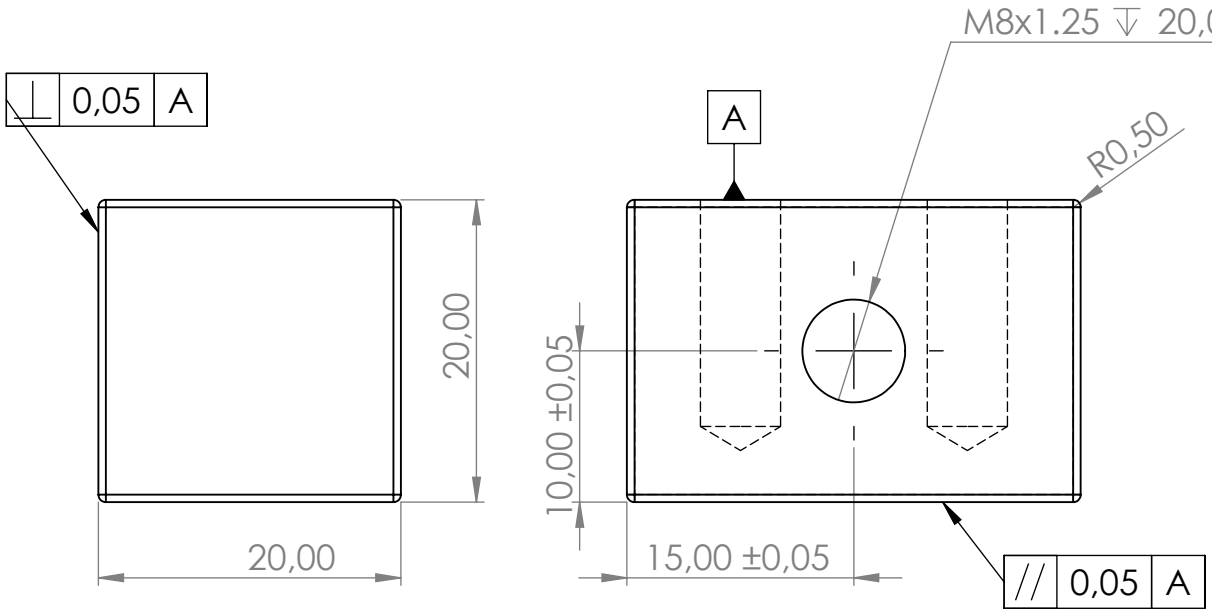


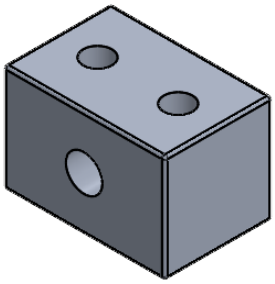
Characterization of a mechanical bench to study the behavior of needles in soft tissue.	Part: Machine assembly	Drawing nº: 1
Cheked by: Antonio José Sánchez Egea	Date: 21/11/2020	Quantity: X
Draftsman: Alba Bertran Segales	Format: DIN A3	Scale: 1:2
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH Escola d'Enginyeria de Barcelona Est	Material: XXXXXXXXX	

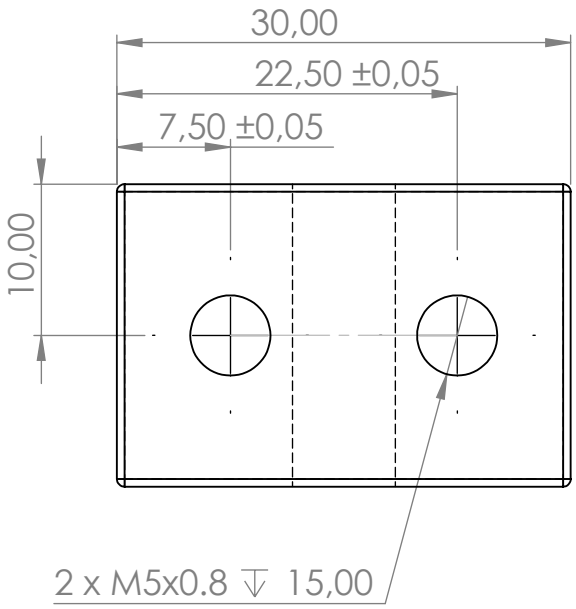


ELEMENT N.º	PART NAME	QUANTITY
1	ISO 7046-1 - M5 x 20 - Z - 20N	2
2	Load cell pot holder	1
3	Load cell base 3	2
4	1Kg Load cell	1
5	ISO 7046-1 - M5 x 12 - Z - 12N	1
6	Load cell base 2	1
7	Load cell base1	2
8	ISO 4762 M8 x 30 - 30N	1
9	ISO 7046-1 - M5 x 16 - Z - 16N	4
10	ISO 1580 - M3 x 20 - 20N	4
11	Load cell electronics box 5	1
12	Arduino_NANO_CH340	1
13	Load cell electronics box 2	1
14	Load cell electronics box 4	1
15	Load cell elctronics box 3	2
16	HX711.1	1
17	Load cell electronics box 1	1

Characterization of a mechanical bench to study the behavior of needles in soft tissue.	Part: Load cell assembly	Drawing nº: 2
Cheked by: Antonio José Sánchez Egea	Date: 6/10/2020	Quantity: X
Draftsman: Alba Bertran Segales	Format: DIN A3 / Scale: 1:1	
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH Escola d'Enginyeria de Barcelona Est	Material: XXXXXXXXX	

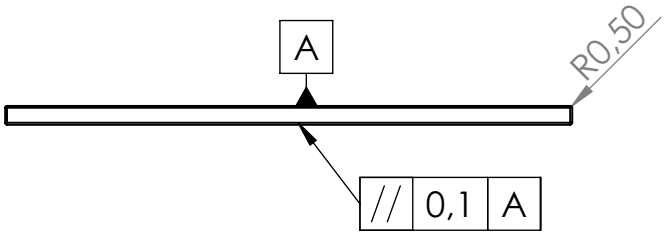


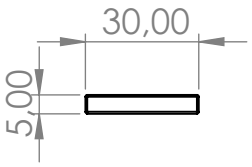


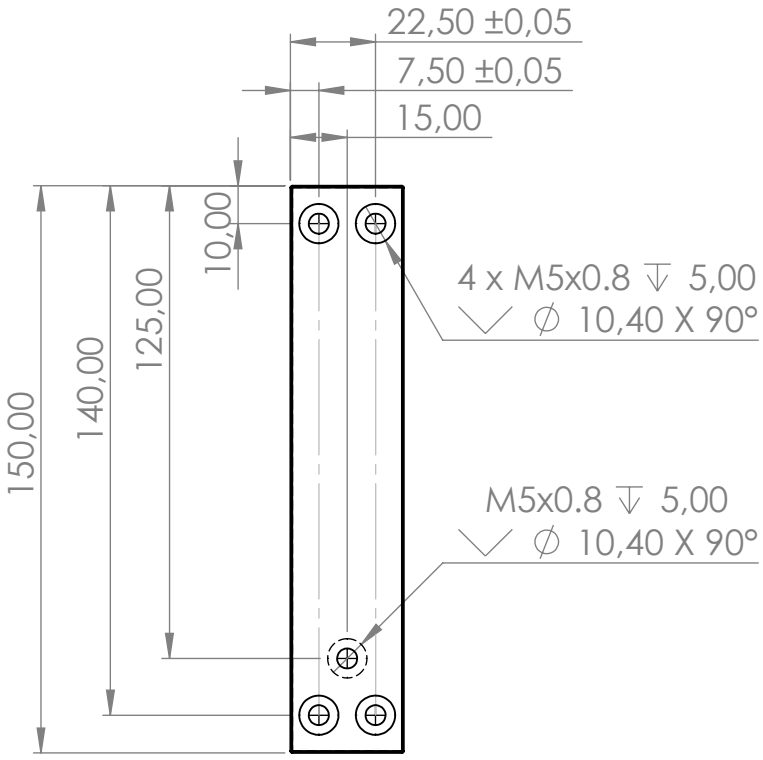


Units: mm
Not specified tolerances: 0,2mm

Characterization of a mechanical bench to study the behavior of needles in soft tissue.	Part: Load cell base 1		Drowing nº: 2.1
Cheked by: Antonio José Sánchez Egea	Date: 29/09/2020		Quantity: 2
Drafsman: Alba Bertran Segales	Format: DIN A4	Scale:	2:1
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH Escola d'Enginyeria de Barcelona Est	Material: Aluminio		

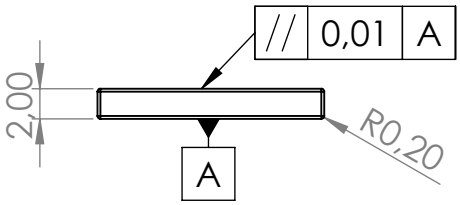


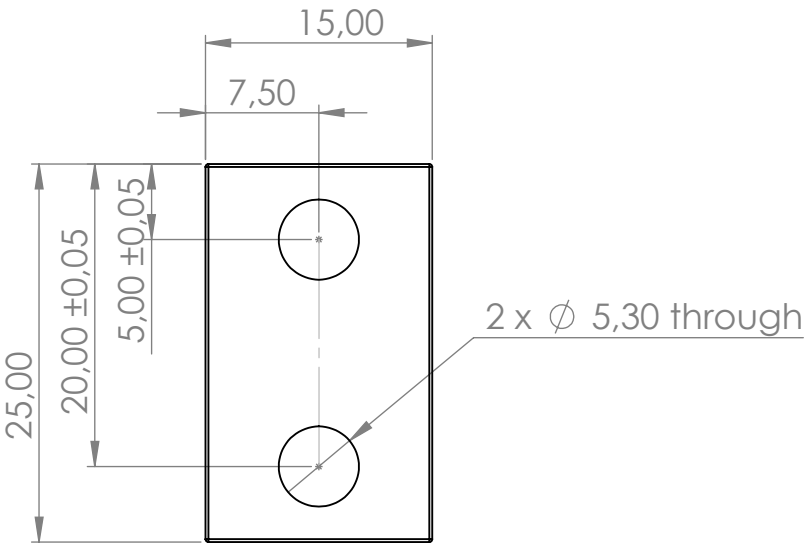


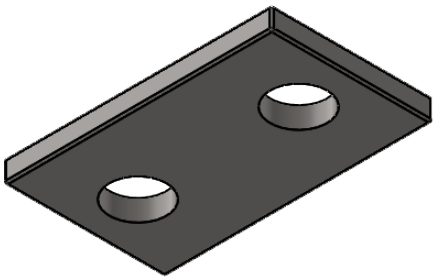


Units: mm
Not specified tolerances: 0,2mm

Characterization of a mechanical bench to study the behavior of needles in soft tissue.	Part: Load Cell Base 2	Drowing nº: 2.2
Cheked by: Antonio José Sánchez Egea	Date: 29/09/2020	Quantity: 1
Drafsman: Alba Bertran Segales	Format: DIN A4	Scale: 1:1
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH Escola d'Enginyeria de Barcelona Est	Material: Acero XXX	

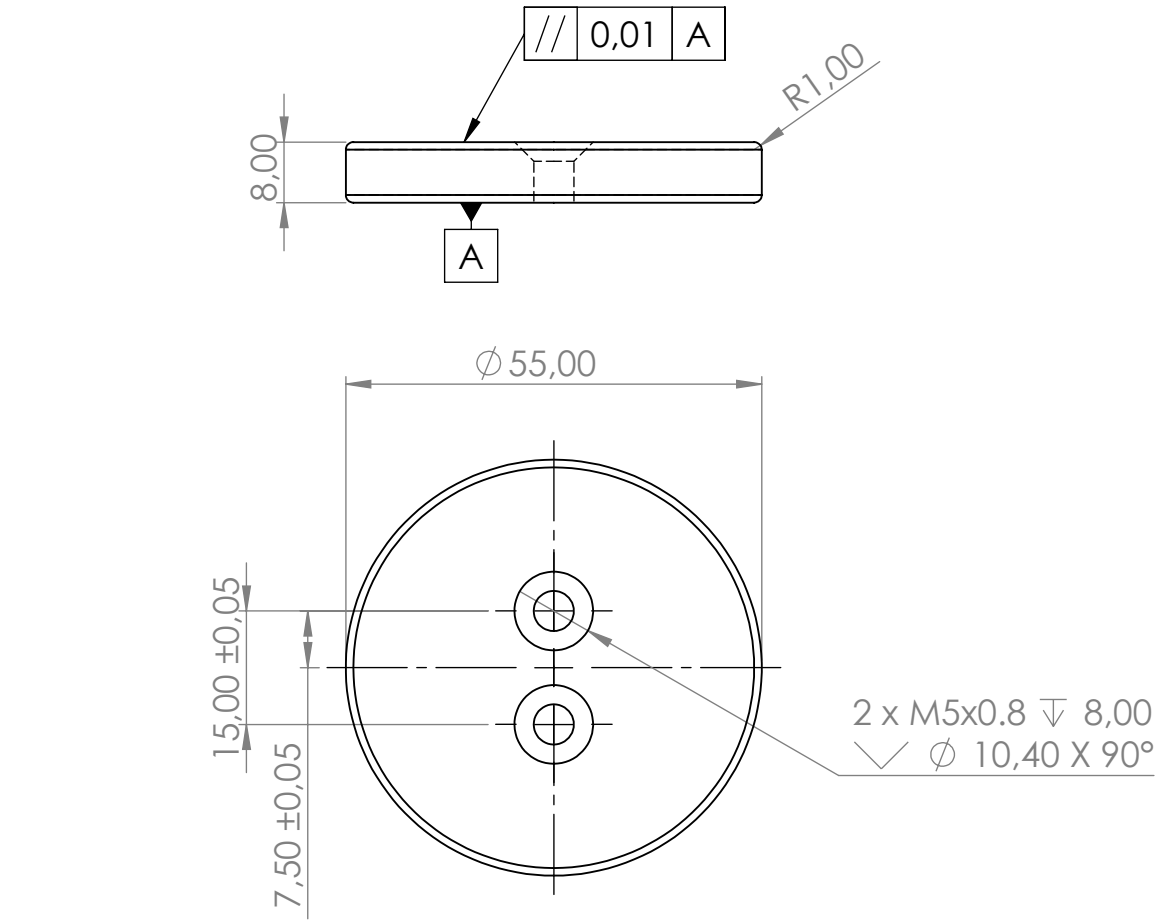


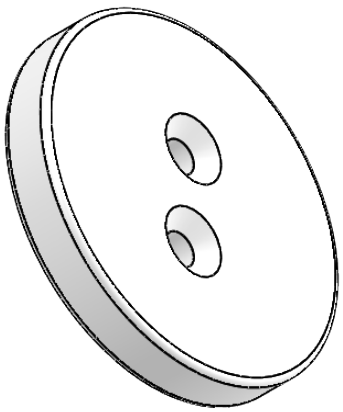




Units: mm
Not specified tolerances: 0,2mm

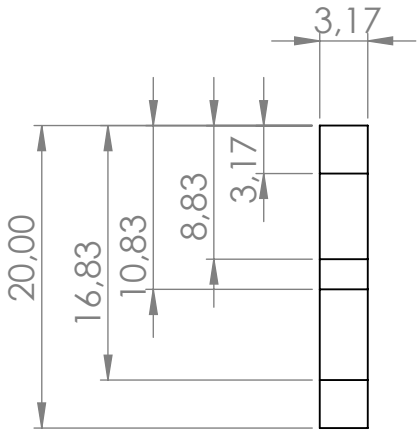
Characterization of a mechanical bench to study the behavior of needles in soft tissue.	Part: Load Cell base 3		Drowing nº: 2.3
Cheked by: Antonio José Sánchez Egea	Date: 29/09/2020		Quantity: 2
Drafsman: Alba Bertran Segales	Format: DIN A4	Scale:	2:1
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH Escola d'Enginyeria de Barcelona Est	Material: Acero XXX		

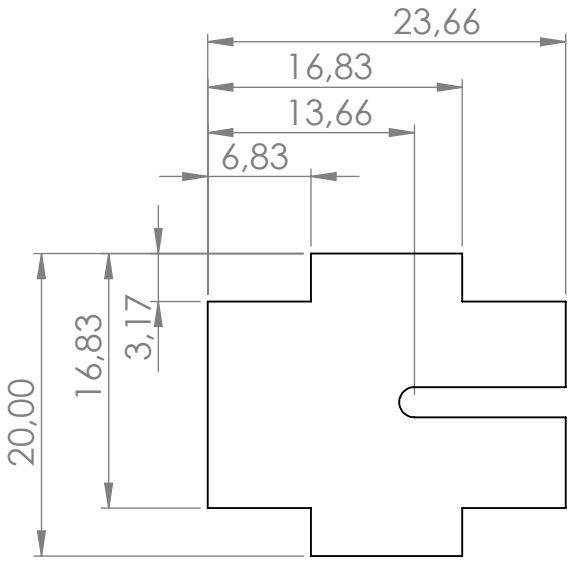




Units: mm
Not specified tolerances: 0,2mm

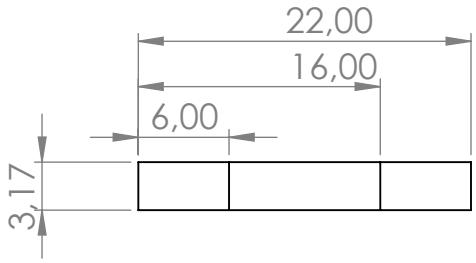
Characterization of a mechanical bench to study the behavior of needles in soft tissue.	Part: Load cell pot holder		Drowing nº: 2.4
Cheked by: Antonio José Sánchez Egea	Date: 30/09/2020		Quantity: 1
Drafsman: Alba Bertran Segales	Format: DIN A4	Scale: 1:1	
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH Escola d'Enginyeria de Barcelona Est	Material: PMMA		

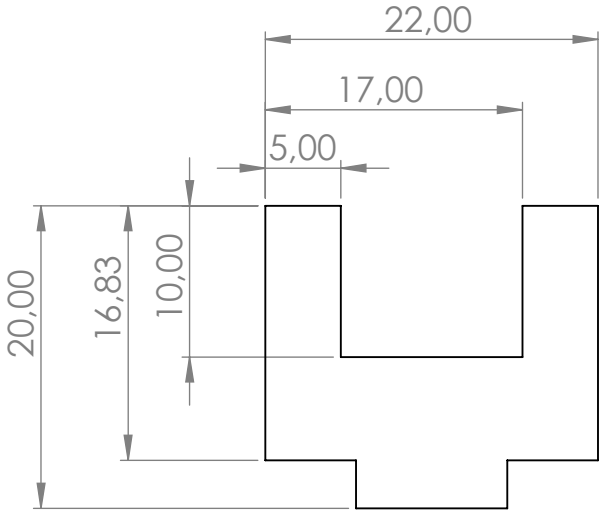




Units: mm
Not specified tolerances: 0,2mm

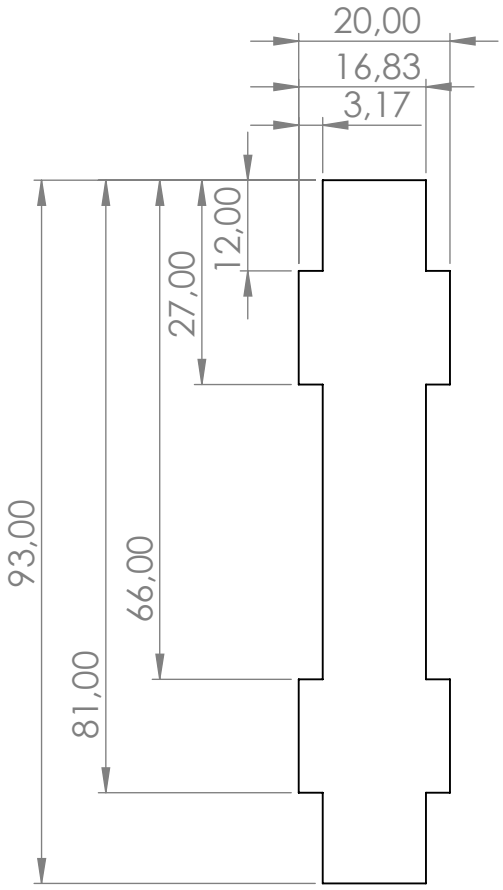
Characterization of a mechanical bench to study the behavior of needles in soft tissue.	Part: Load cell electronics box 1		Drowing nº: 2.5
Cheked by: Antonio José Sanchez Egea	Date: 04/10/2020		Quantity: 1
Drafsman: Alba Bertran Segales	Format: DIN A4	Scale:	2:1
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH Escola d'Enginyeria de Barcelona Est	Material: PMMA		

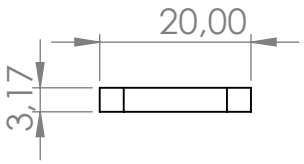




Units: mm
Not specified tolerances: 0,2mm

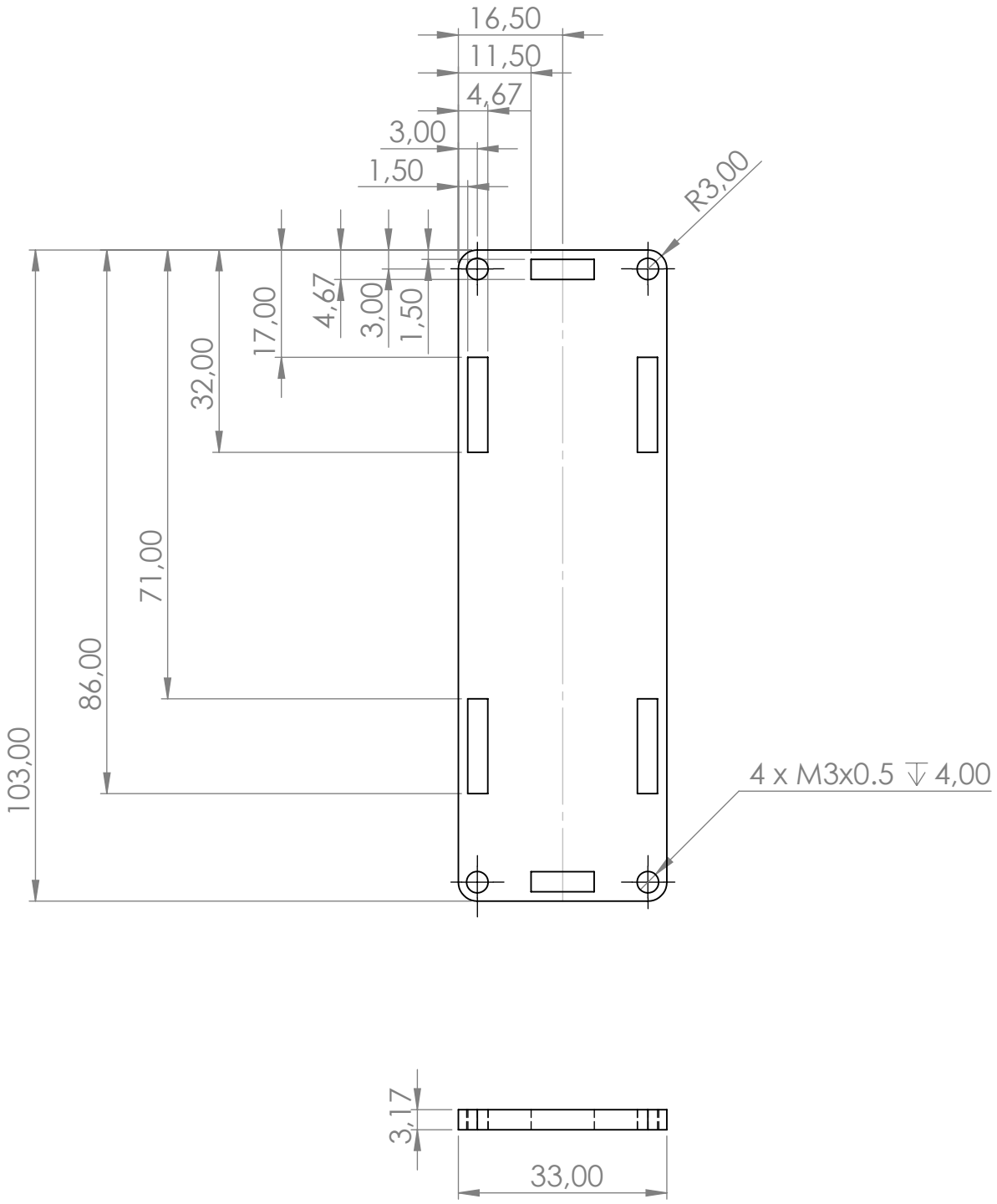
Characterization of a mechanical bench to study the behavior of needles in soft tissue.	Part: Load cell electronics box 2		Drowing nº: 2.6
Cheked by: Antonio José Sánchez Egea	Date: 04/10/2020		Quantity: 1
Drafsman: Alba Bertran Segales	Format: DIN A4	Scale:	2:1
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH Escola d'Enginyeria de Barcelona Est	Material: PMMA		





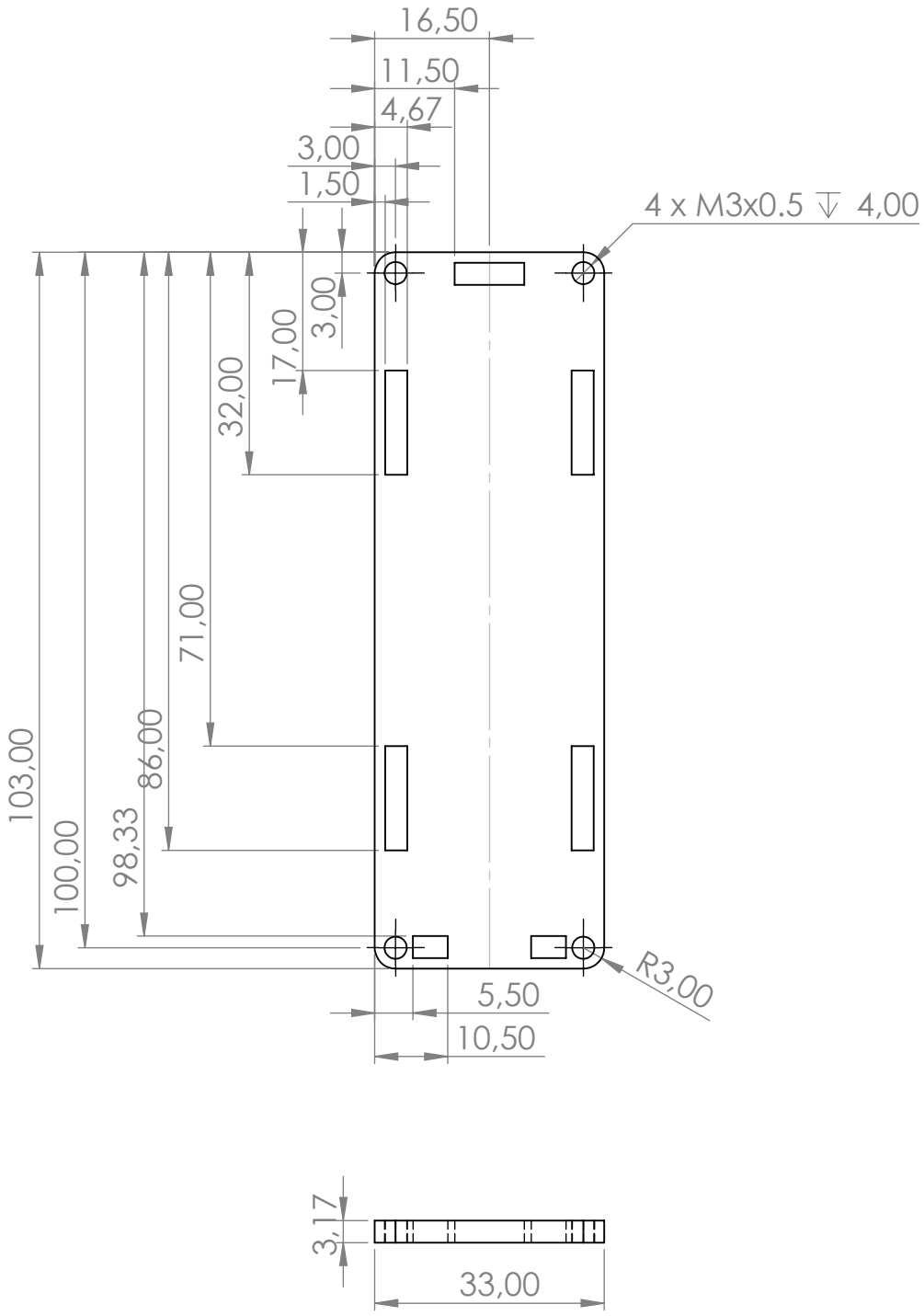
Units: mm
Not specified tolerances: 0,2mm

Characterization of a mechanical bench to study the behavior of needles in soft tissue.	Part: Load cell electronics box 3		Drowing nº: 2.7
Cheked by: Antonio José Sánchez Egea	Date: 04/09/2020		Quantity: 2
Drafsman: Alba Bertran Segales	Format: DIN A4	Scale:	1:1
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH Escola d'Enginyeria de Barcelona Est	Material: PMMA		



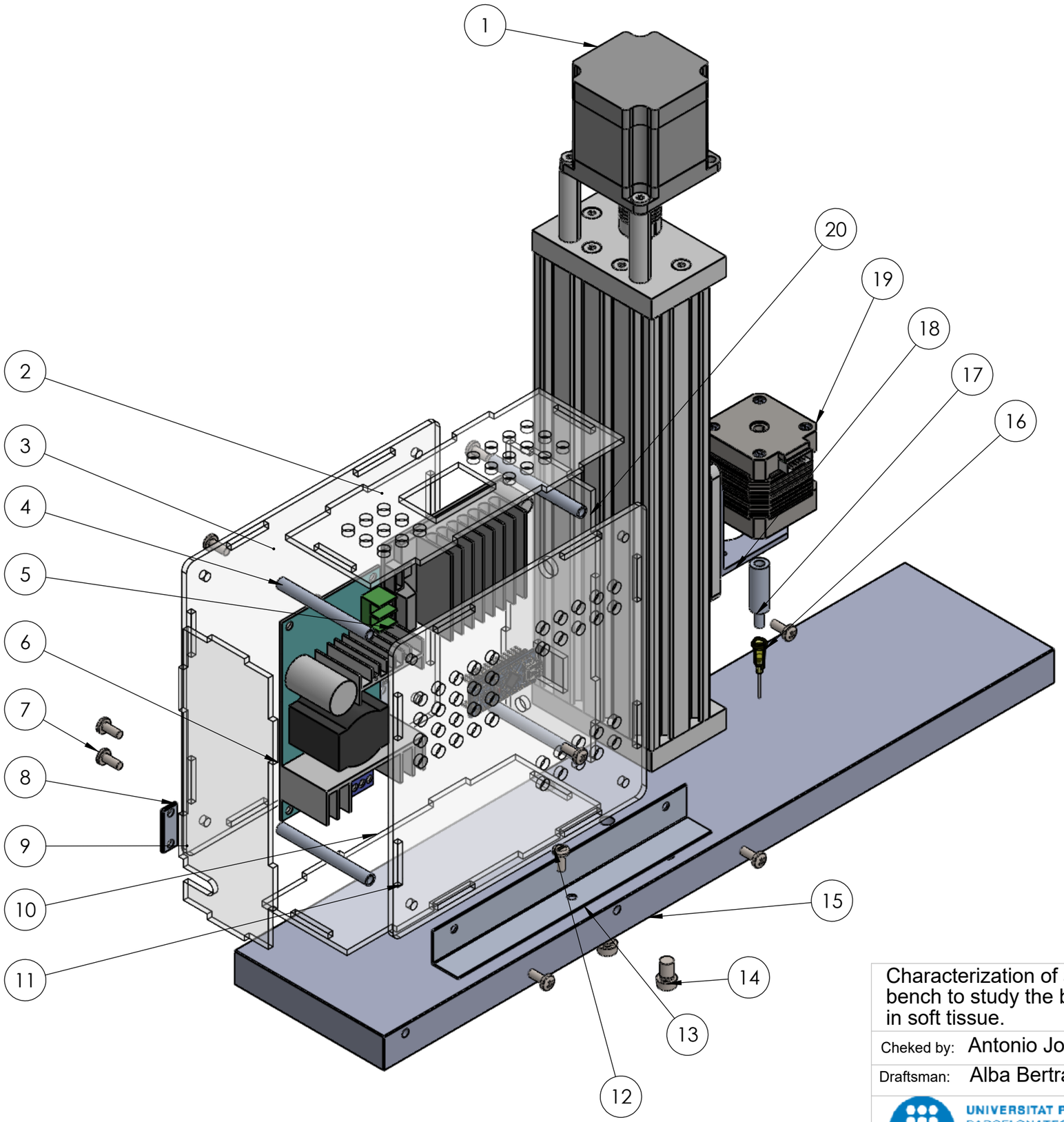
Units: mm
Not specified tolerances: 0,2mm

Characterization of a mechanical bench to study the behavior of needles in soft tissue.	Part: Load cell electronics box 4		Drowing nº: 2.8
Cheked by: Antonio José Sanchez Egea	Date: 04/09/2020		Quantity: 1
Drafsman: Alba Bertran Segales	Format: DIN A4	Scale:	1:1
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH Escola d'Enginyeria de Barcelona Est	Material: PMMA		



Units: mm
Not specified tolerances: 0,2mm

Characterization of a mechanical bench to study the behavior of needles in soft tissue.	Part: Load cell electronics box 5		Drowing nº: 2.9
Cheked by: Antonio José Sanchez Egea	Date: 04/09/2020		Quantity: 1
Drafsman: Alba Bertran Segales	Format: DIN A4	Scale:	1:1
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH Escola d'Enginyeria de Barcelona Est	Material: PMMA		



ELEMENT N.º	PART N.º	QUANTITY
1	C-Beam Linear Actuator	1
2	Linear caturator electronics box 2	1
3	Linear caturator electronics box 5	1
4	Linear caturator electronics box 7	4
5	TB66001	1
6	Power Supply 24V6.6A open frame	1
7	ISO 7045 - M4 x 10 - Z - 10N	11
8	Linear caturator electronics box 9	2
9	Linear caturator electronics box 4	1
10	Linear caturator electronics box 1	1
11	Linear caturator electronics box 6	1
12	ISO 1580 - M4 x 10 - 10N	1
13	Linear caturator electronics box 8	1
14	ISO 14580 - #6 x 10 x 8 - 4.8-N	3
15	Lineal actuator base	1
16	Syringe Needle, With Luer	1
17	Needle holder	1
18	stepper base	1
19	nema17	1
20	Linear caturator electronics box 3	1

Characterization of a mechanical bench to study the behavior of needles in soft tissue.

Part: Linear actuator assembly

Drawing nº: 3

Cheked by: Antonio José Sánchez Egea

Date: 21/11/2020

Quantity: X

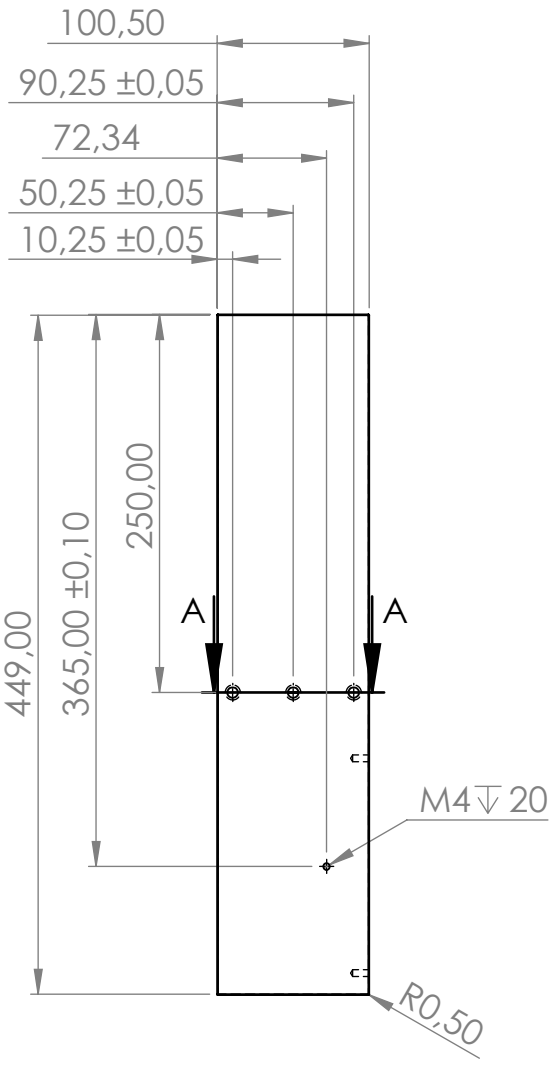
Draftsman: Alba Bertran Segales

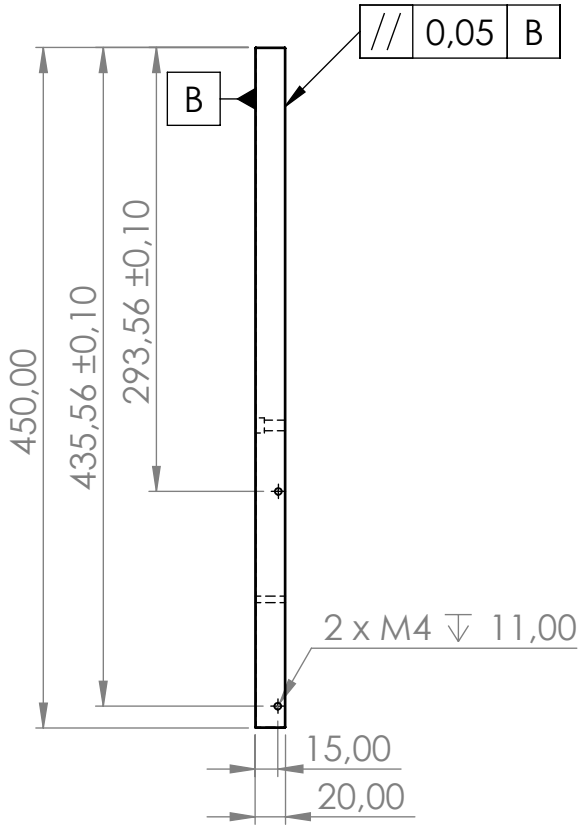
Format: DIN A3

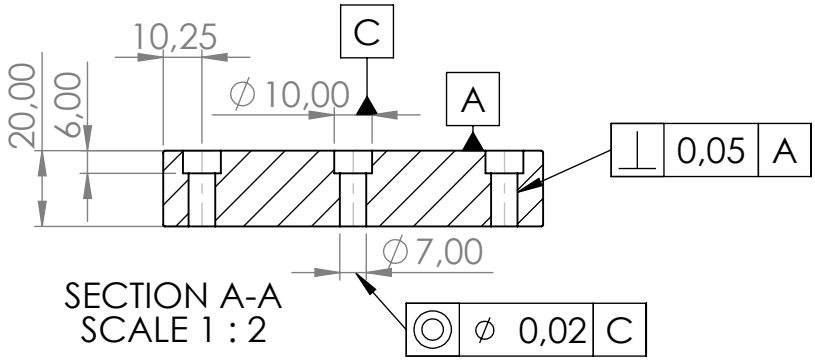
Scale: 1:2

UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
Escola d'Enginyeria de Barcelona Est

Material: XXXXXXXXX



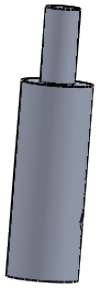




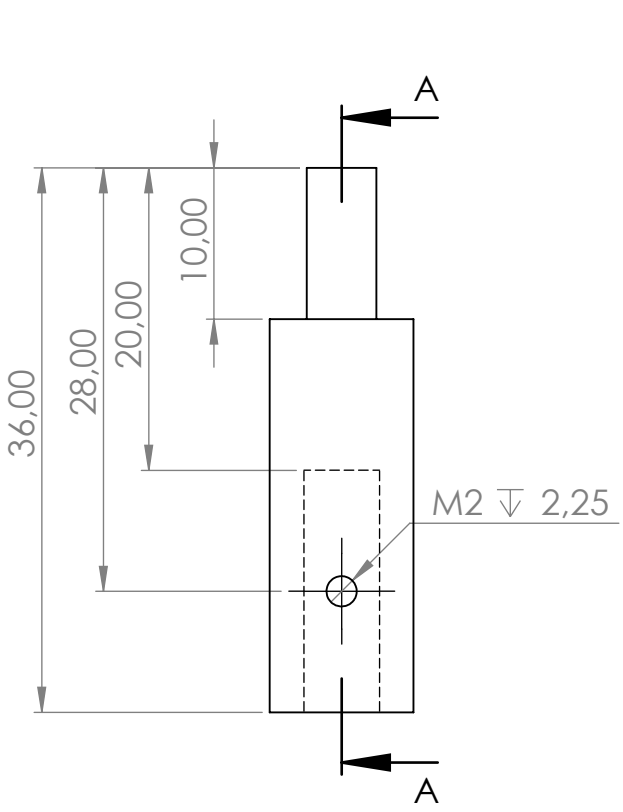
Rounded edges: 0,5mm

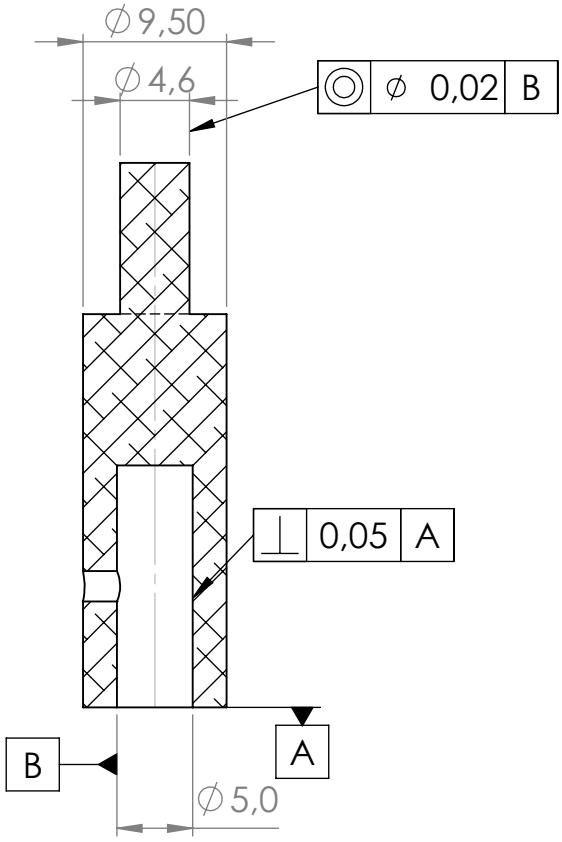
Units: mm
Not specified tolerances: 0,2mm

Characterization of a mechanical bench to study the behavior of needles in soft tissue.	Part: Linear actuator base		Drowing nº: 3.1
Cheked by: Antonio José Sánchez Egea	Date: 14/11/2020		Quantity: 1
Drafsman: Alba Bertran Segales	Format: DIN A4	Scale: 1:5	
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH Escola d'Enginyeria de Barcelona Est	Material: Aluminium 70-75 T6		



SCALE 1:1

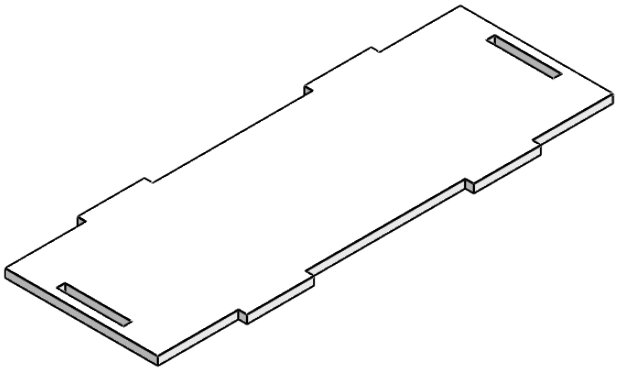


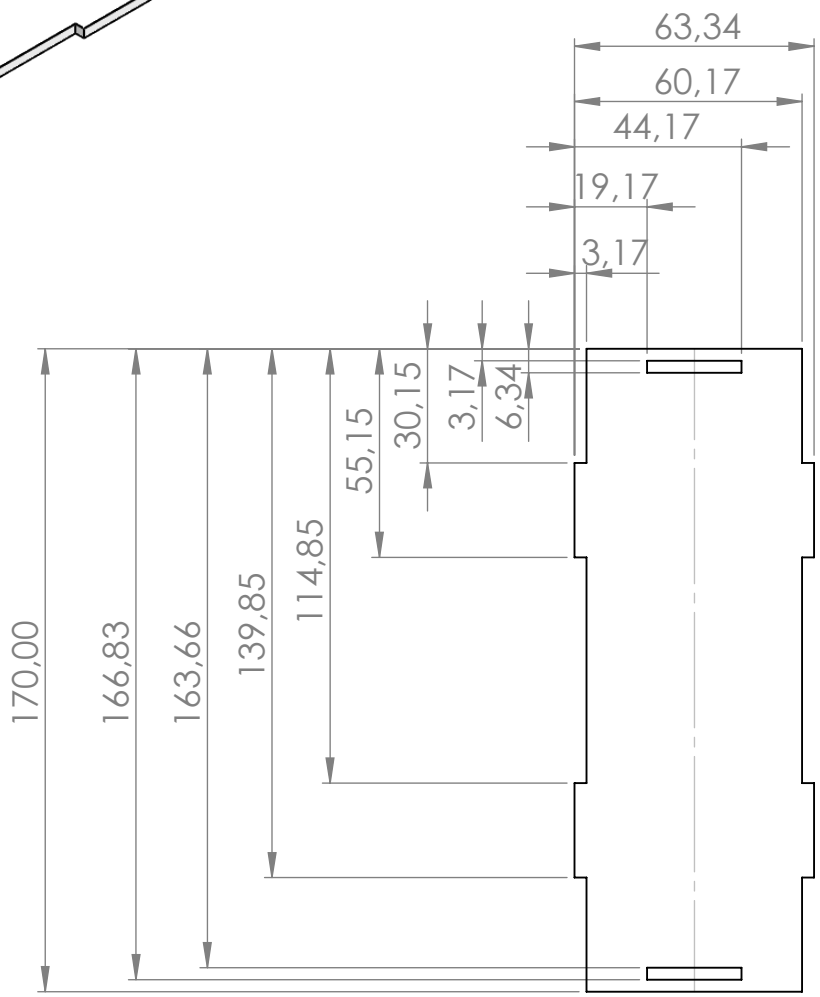


SECTION A-A

Units: mm
Not specified tolerances: 0,2mm

Characterization of a mechanical bench to study the behavior of needles in soft tissue.	Part: Needle holder		Drowing nº: 3.2
Cheked by: Antonio José Sánchez Egea	Date: 14/11/2020		Quantity: 1
Drafsman: Alba Bertran Segales	Format: DIN A4	Scale:	2:1
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH Escola d'Enginyeria de Barcelona Est	Material: Aluminium		

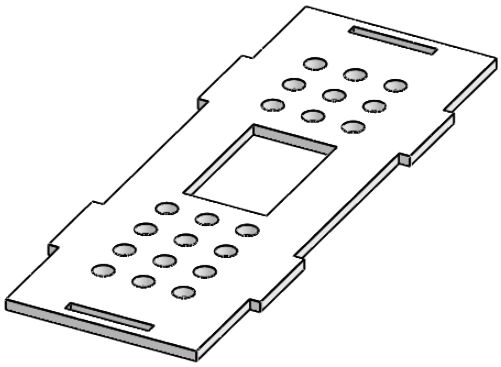


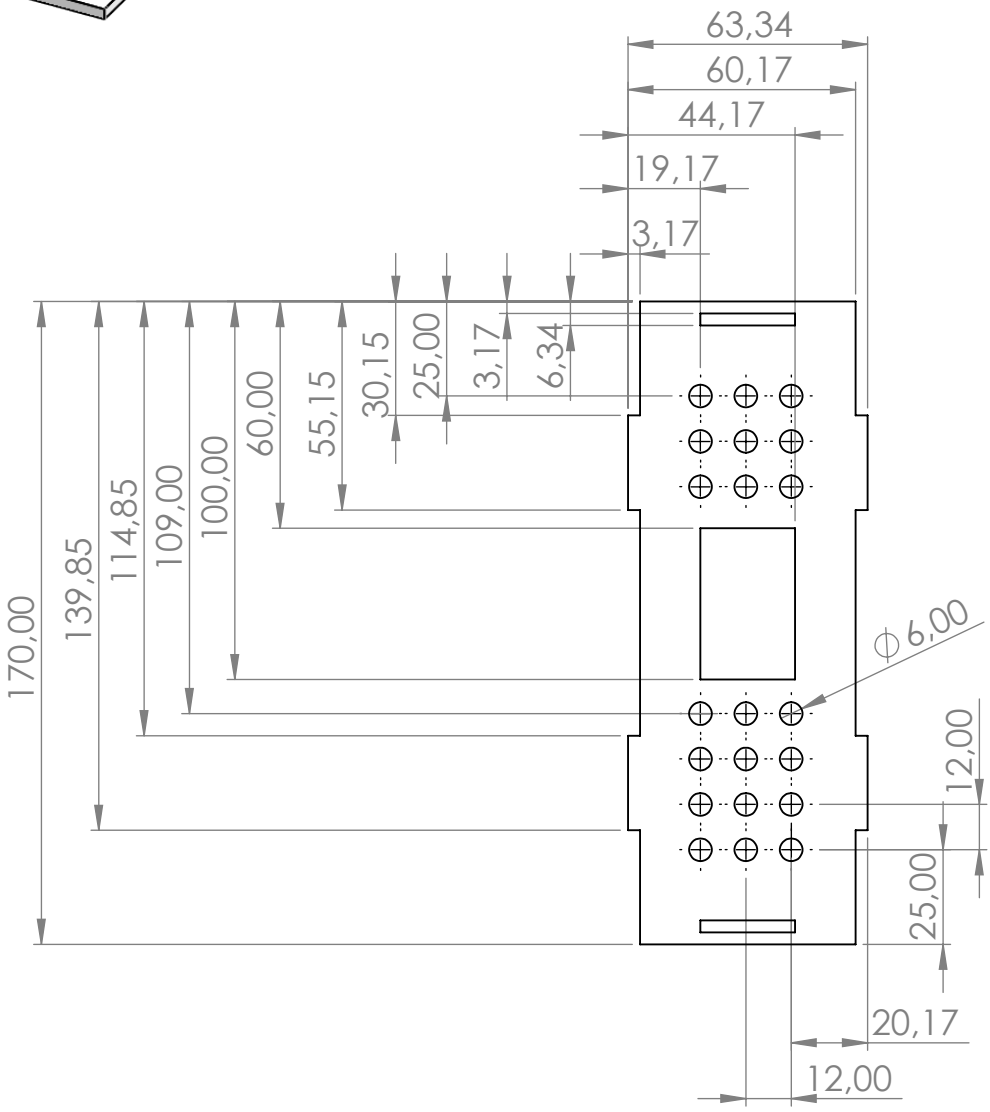


Thikness : 3,17 mm

Units: mm
Not specified tolerances: 0,2mm

Characterization of a mechanical bench to study the behavior of needles in soft tissue.	Part: Linear actuator electronics box 1		Drowing nº: 3.3
Cheked by: Antonio José Sánchez Egea	Date: 14/11/2020		Quantity: 1
Drafsman: Alba Bertran Segales	Format: DIN A4	Scale:	1:2
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH Escola d'Enginyeria de Barcelona Est	Material: PMMA		

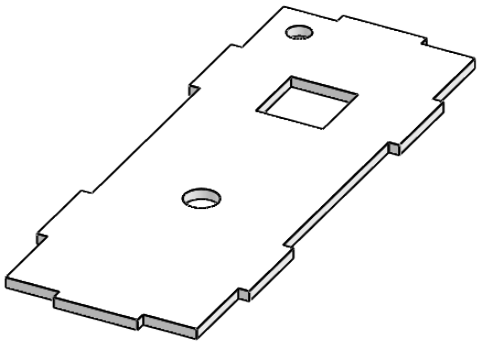


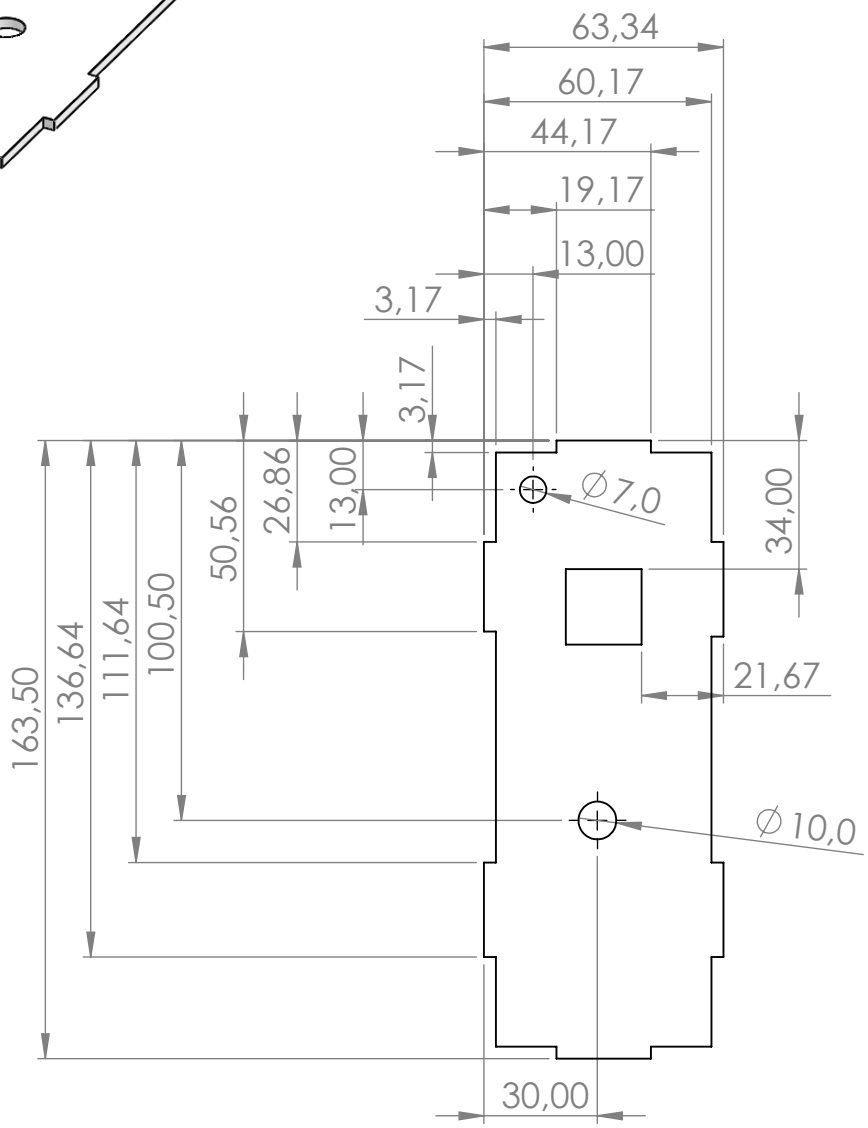


Distances between holes are 12x12 mm
Thikness : 3,17 mm

Units: mm
Not specified tolerances: 0,2mm

Characterization of a mechanical bench to study the behavior of needles in soft tissue.	Part: Linear actuator electronics box 2		Drowing nº: 3.4
Cheked by: Antonio José Sánchez Egea	Date: 14/11/2020		Quantity: 1
Drafsman: Alba Bertran Segales	Format: DIN A4	Scale:	1:2
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH Escola d'Enginyeria de Barcelona Est	Material: PMMA		

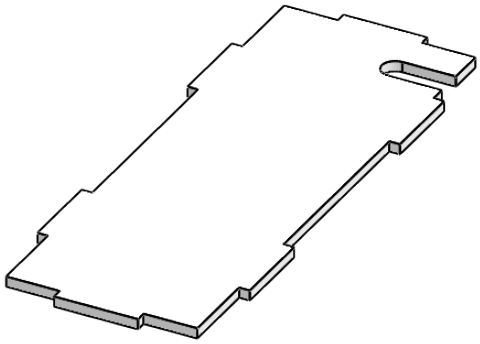


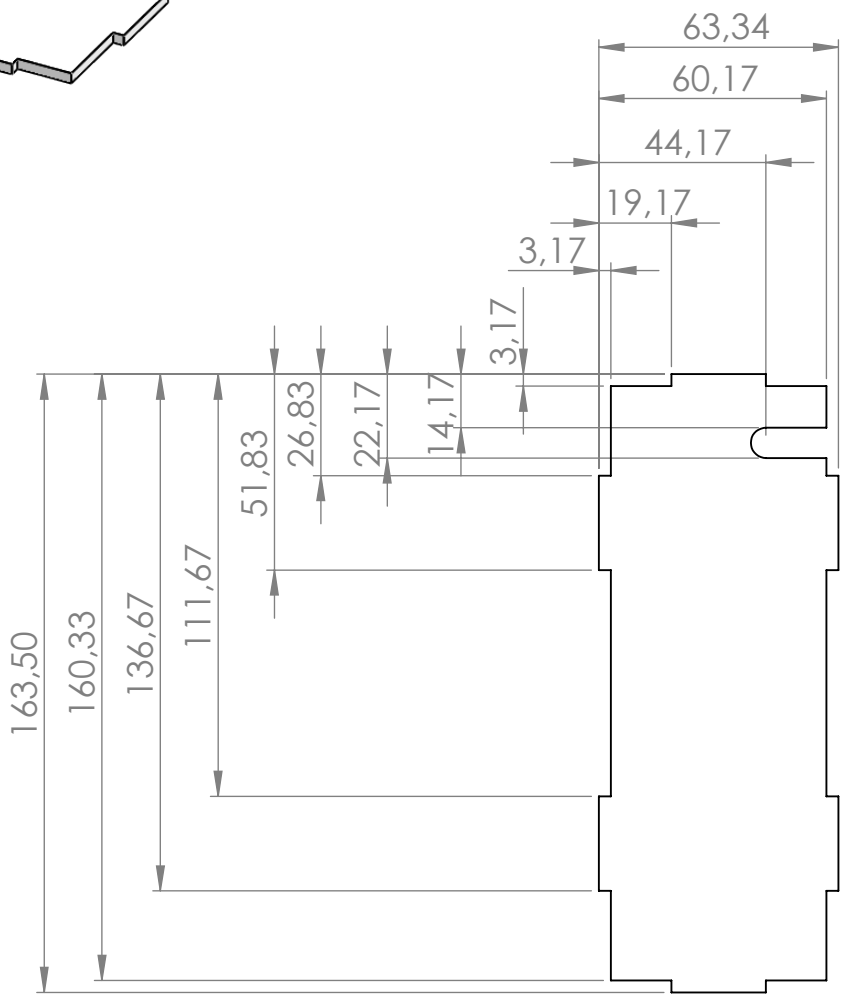


Thikness : 3,17 mm

Units: mm
Not specified tolerances: 0,2mm

Characterization of a mechanical bench to study the behavior of needles in soft tissue.	Part: Linear actuator electronics box 3		Drowing nº: 3.5
Cheked by: Antonio José Sánchez Egea	Date: 14/11/2020		Quantity: 1
Drafsman: Alba Bertran Segales	Format: DIN A4	Scale:	1:2
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH Escola d'Enginyeria de Barcelona Est	Material: PMMA		

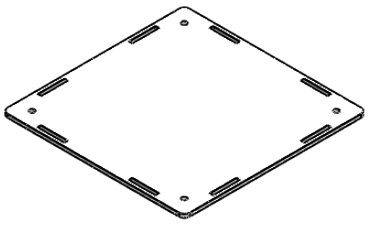




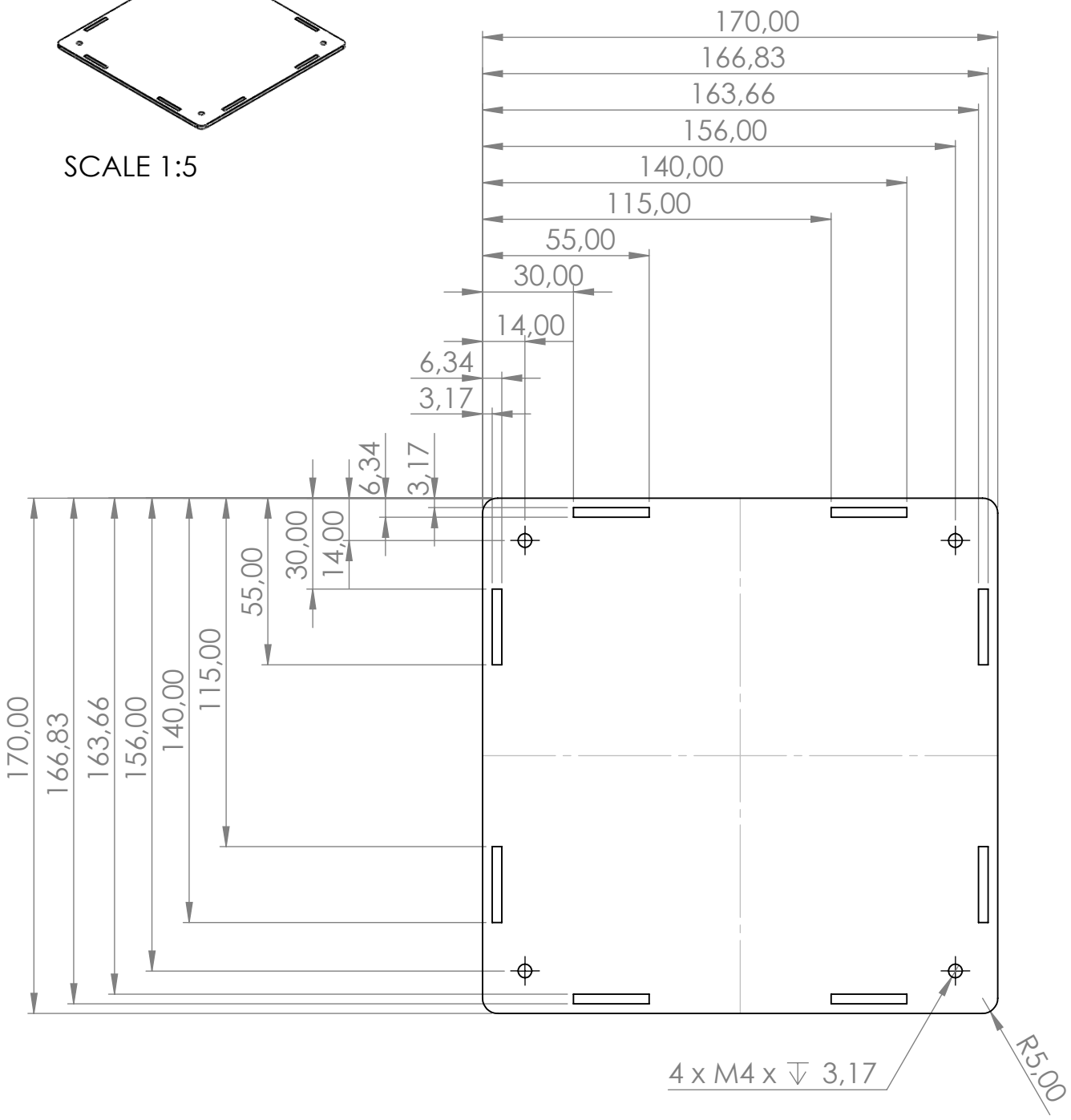
Thikness : 3,17 mm

Units: mm
Not specified tolerances: 0,2mm

Characterization of a mechanical bench to study the behavior of needles in soft tissue.	Part: Linear actuator electronics box 4		Drowing nº: 3.6
Cheked by: Antonio José Sánchez Egea	Date: 14/11/2020		Quantity: 1
Drafsman: Alba Bertran Segales	Format: DIN A4	Scale:	1:2
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH Escola d'Enginyeria de Barcelona Est	Material: PMMA		



SCALE 1:5

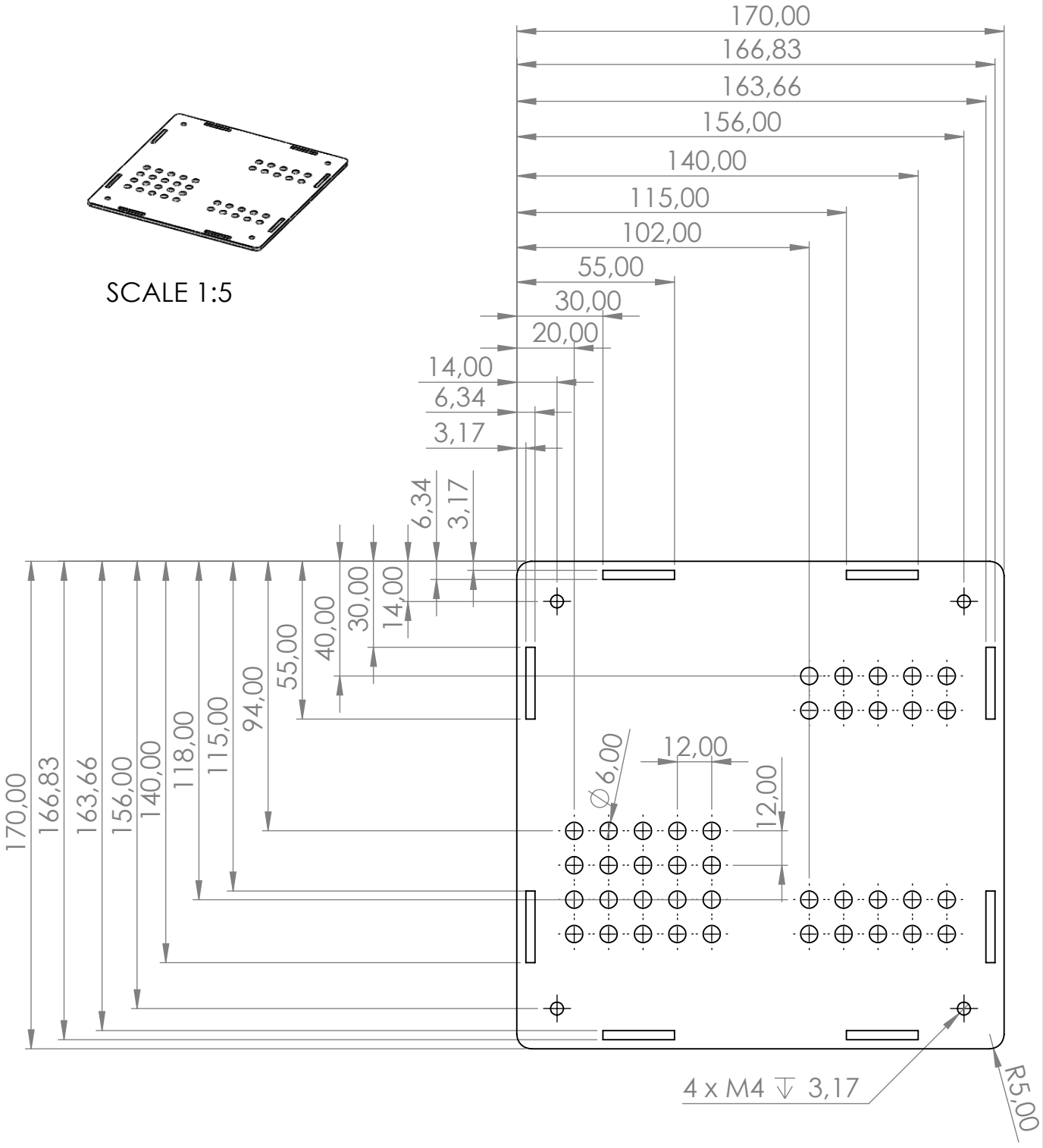


Thikness : 3,17 mm

Units: mm
Not specified tolerances: 0,2mm

Characterization of a mechanical bench to study the behavior of needles in soft tissue.	Part: Linear actuator electronics box 5		Drowing nº: 3.7
Cheked by: Antonio José Sánchez Egea	Date: 14/11/2020		Quantity: 1
Drafsman: Alba Bertran Segales	Format: DIN A4	Scale:	1:2
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH Escola d'Enginyeria de Barcelona Est	Material: PMMA		

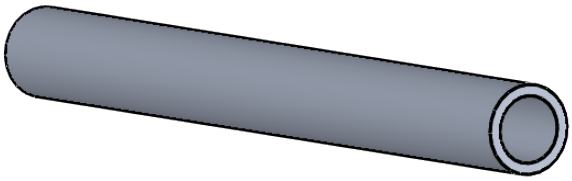
SCALE 1:5

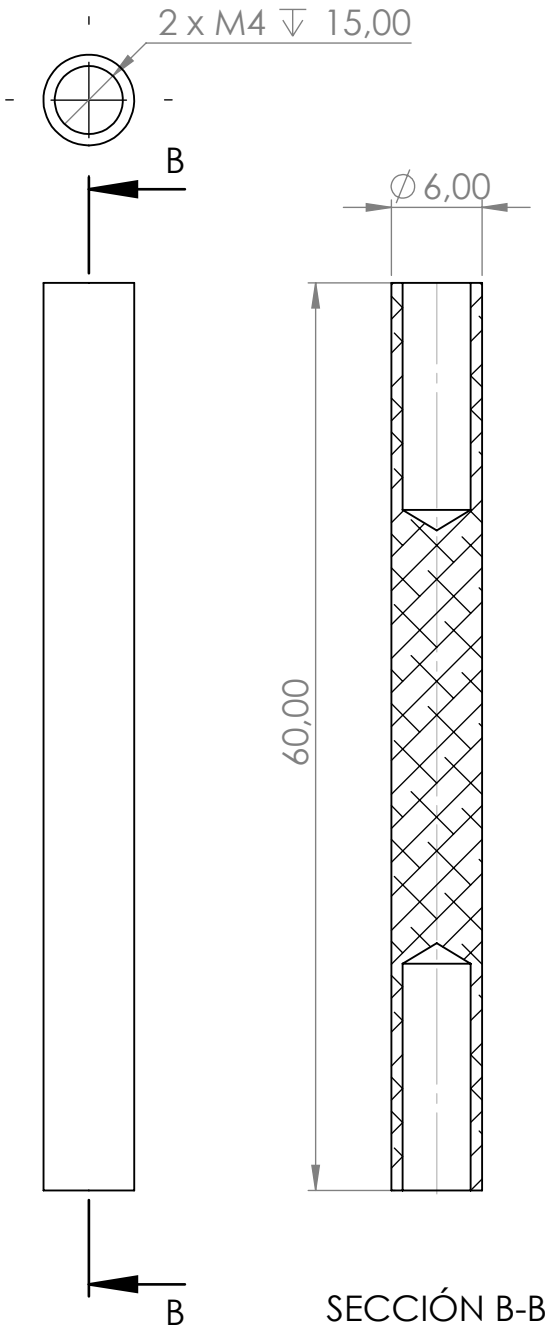


Distances between holes are 12x12 mm
Thikness : 3,17 mm

Units: mm
Not specified tolerances: 0,2mm

Characterization of a mechanical bench to study the behavior of needles in soft tissue.	Part: Linear actuator electronics box 6		Drowing nº: 3.8
Cheked by: Antonio José Sánchez Egea	Date: 14/11/2020		Quantity: 1
Drafsman: Alba Bertran Segales	Format: DIN A4	Scale:	1:2
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH Escola d'Enginyeria de Barcelona Est	Material: PMMA		

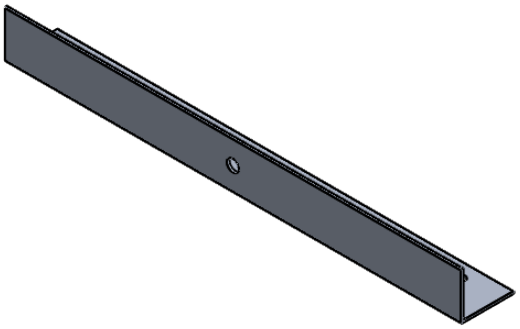


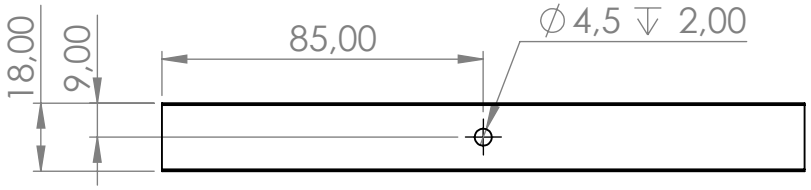


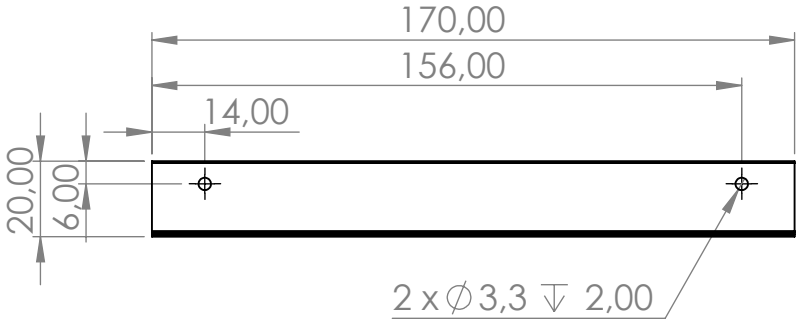
SECCIÓN B-B

Units: mm
Not specified tolerances: 0,2mm

Characterization of a mechanical bench to study the behavior of needles in soft tissue.	Part: Linear actuator electronics box 7		Drowing nº: 3.9
Cheked by: Antonio José Sánchez Egea	Date: 14/11/2020		Quantity: 4
Drafsman: Alba Bertran Segales	Format: DIN A4	Scale:	2:1
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH Escola d'Enginyeria de Barcelona Est	Material: Aluminium		



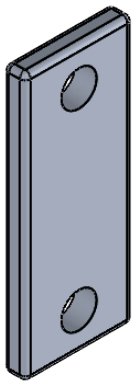


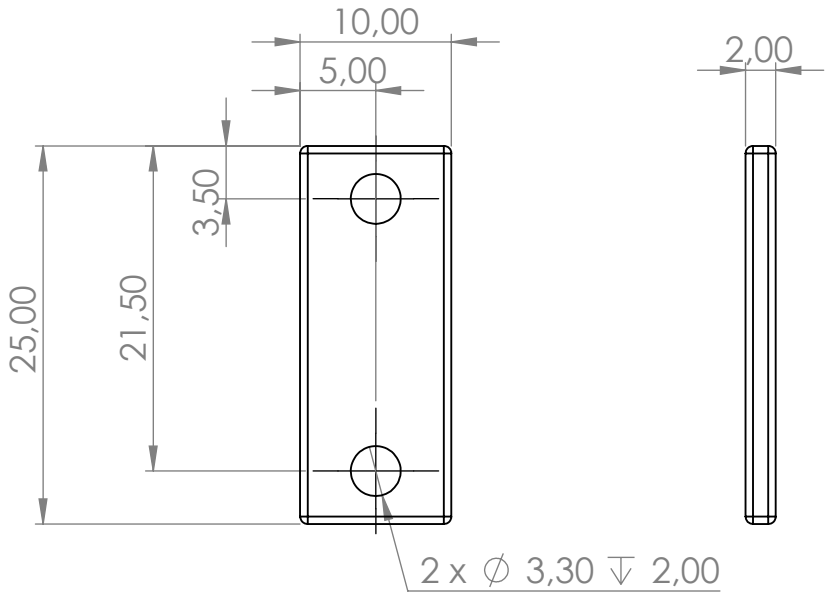


L shaped profile was bought in a hardware store.

Units: mm
Not specified tolerances: 0,2mm

Characterization of a mechanical bench to study the behavior of needles in soft tissue.	Part: Linear actuator electronics box 8		Drowing nº: 3.10
Cheked by: Antonio José Sánchez Egea	Date: 14/11/2020		Quantity: 1
Drafsman: Alba Bertran Segales	Format: DIN A4	Scale:	1:2
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH Escola d'Enginyeria de Barcelona Est	Material: X		





Rounded edges: 0,5 mm

Units: mm
Not specified tolerances: 0,2mm

Characterization of a mechanical bench to study the behavior of needles in soft tissue.	Part: Linear actuator electronics box 9		Drowing nº: 3.11
Cheked by: Antonio José Sánchez Egea	Date: 14/11/2020		Quantity: 1
Drafsman: Alba Bertran Segales	Format: DIN A4	Scale:	2:1
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH Escola d'Enginyeria de Barcelona Est	Material: Aluminium		