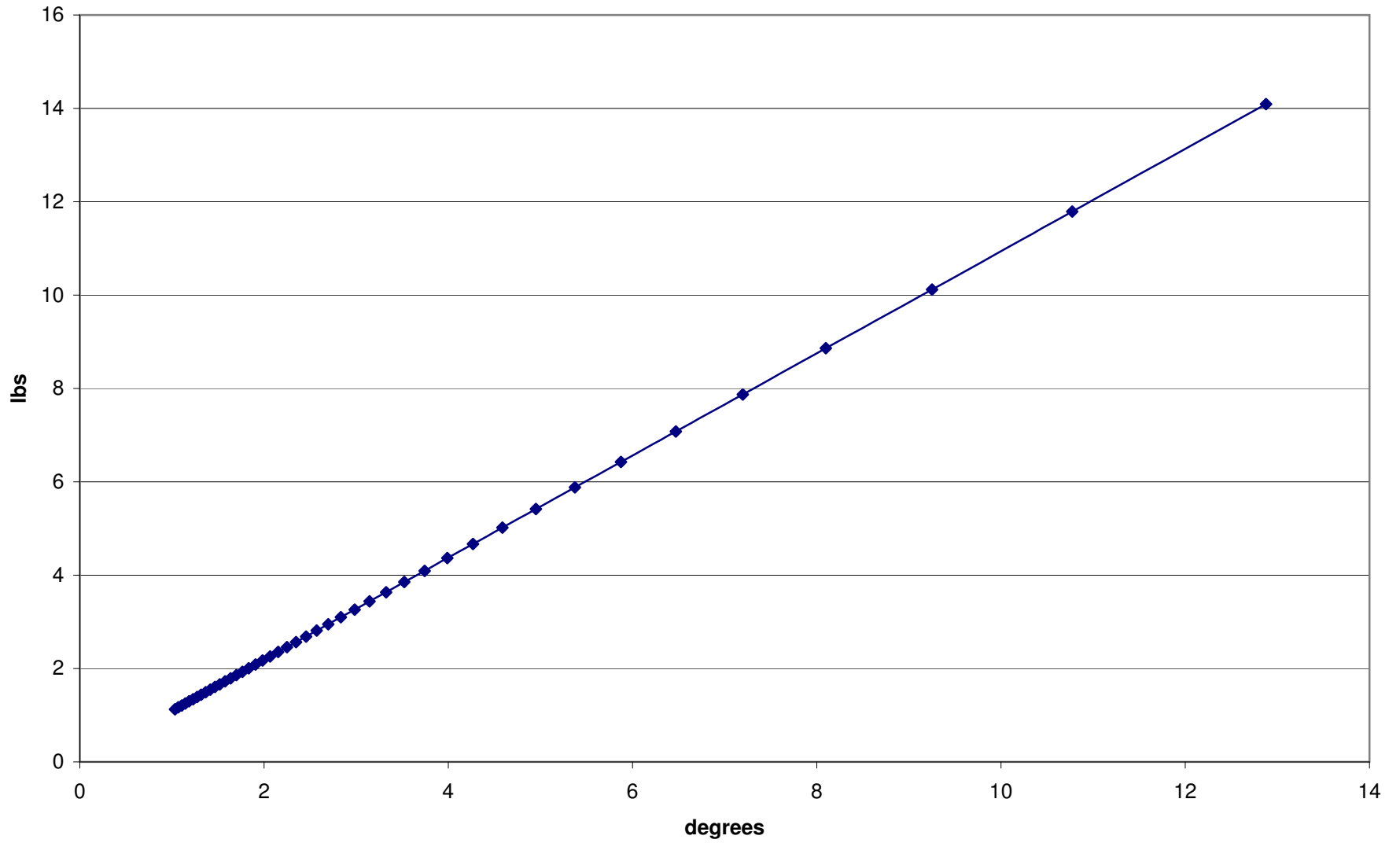


**Delta Force vs. Lean Angle**



$H_{\text{boat}}$  34.5455 in  
 $H_{\text{cog,b}}$  15.0000 in  
 $H_{\text{cog,p,ob}}$  44.6155 in  
 $H_{\text{above}}$  10.0700 in  
 $H_{\text{hornt}}$  25.0000 in

**Variables**

$H_{\text{patient}}$  76 in  
 $W_{\text{patient}}$  310 lbs  
 $W_{\text{wake}}$  35 lbs  
 Patient Lean 0 degrees  
 spring k 21.0 lbs/in

Average constant  
0 radians  
22.9254

Angle of Wire (degrees)	Angle of wire (radians)	Force for 0 moment	Spring Force due to bike tilt (pounds)	Total Winch Force (pounds)	Winch x-force (pounds)	Winch z-force (pounds)	Distance Mount Shifts L/R (inches)	total wire displacement (inches)	Ideal Spring Constant (pounds/inch)	Bike Tilt (radians)	Bike Tilt (degrees)	Bike tilt w/ patient lean (degrees)	Natural Oscillation Frequency
86	1.5010	157.9062	159.4505	159.8398	159.4505	11.1499	7.1503	7.2203	22.0838	0.2786	15.9612	17.4692	1.13536487
85	1.4835	127.9688	128.7810	129.2729	128.7810	11.2669	5.7150	5.7513	22.3916	0.2247	12.8766	14.0900	1.263346348
84	1.4661	107.3429	107.8191	108.4130	107.8191	11.3322	4.7572	4.7783	22.5644	0.1880	10.7739	11.7876	1.380703998
83	1.4486	92.3181	92.6198	93.3154	92.6198	11.3723	4.0722	4.0855	22.6705	0.1615	9.2515	10.1212	1.489691512
82	1.4312	80.9023	81.1048	81.9019	81.1048	11.3985	3.5577	3.5666	22.7402	0.1414	8.0992	8.8602	1.59193382
81	1.4137	71.9398	72.0819	72.9805	72.0819	11.4167	3.1569	3.1631	22.7883	0.1258	7.1969	7.8728	1.688632256
80	1.3963	64.7176	64.8209	65.8209	64.8209	11.4297	2.8356	2.8402	22.8229	0.1129	6.4712	7.0787	1.780696337
79	1.3788	58.7730	58.8503	59.9518	58.8503	11.4393	2.5723	2.5757	22.8486	0.1025	5.8746	6.4260	1.868847346
78	1.3614	53.7933	53.8526	55.0557	53.8526	11.4467	2.3523	2.3549	22.8683	0.0938	5.3753	5.8798	1.953642375
77	1.3439	49.5598	49.6061	50.9109	49.6061	11.4525	2.1657	2.1678	22.8836	0.0864	4.9511	5.4158	2.035545653
76	1.3265	45.9149	45.9517	47.3584	45.9517	11.4570	2.0054	2.0070	22.8957	0.0800	4.5862	5.0165	2.114958478
75	1.3090	42.7423	42.7720	44.2908	42.7720	11.4607	1.8660	1.8673	22.9055	0.0745	4.2887	4.6692	2.19321412
74	1.2915	39.9546	39.9788	41.5900	39.9788	11.4637	1.7437	1.7448	22.9136	0.0696	3.9898	4.3641	2.267426741
73	1.2741	37.4844	37.5044	39.2181	37.5044	11.4663	1.6354	1.6363	22.9203	0.0653	3.7428	4.0939	2.341030567
72	1.2566	35.2793	35.2960	37.1124	35.2960	11.4684	1.5388	1.5396	22.9259	0.0615	3.5223	3.8527	2.4131582
71	1.2392	33.2977	33.3117	35.2311	33.3117	11.4701	1.4521	1.4527	22.9306	0.0580	3.3242	3.6361	2.483990964
70	1.2217	31.5062	31.5181	33.5409	31.5181	11.4717	1.3737	1.3743	22.9347	0.0549	3.1402	3.4402	2.556360443
69	1.2043	29.8780	29.8881	32.0145	29.8881	11.4730	1.3025	1.3030	22.9382	0.0521	2.9825	3.2623	2.622402014
68	1.1868	28.3907	28.3994	30.6297	28.3994	11.4741	1.2375	1.2379	22.9412	0.0495	2.8339	3.0997	2.69025765
67	1.1694	27.0261	27.0336	29.3682	27.0336	11.4751	1.1779	1.1783	22.9438	0.0471	2.6976	2.9506	2.75737821
66	1.1519	25.7689	25.7754	28.2147	25.7754	11.4760	1.1230	1.1233	22.9461	0.0449	2.5720	2.8133	2.823875301
65	1.1345	24.6063	24.6119	27.1562	24.6119	11.4767	1.0723	1.0725	22.9482	0.0429	2.4559	2.6863	2.889652829
64	1.1170	23.5272	23.5322	26.1819	23.5322	11.4774	1.0252	1.0254	22.9500	0.0410	2.3482	2.5684	2.955408301
63	1.0996	22.5225	22.5269	25.2825	22.5269	11.4780	0.9813	0.9815	22.9516	0.0392	2.2478	2.4587	3.020333993
62	1.0821	21.5842	21.5880	24.4499	21.5880	11.4785	0.9404	0.9405	22.9530	0.0376	2.1541	2.3562	3.085617588
61	1.0647	20.7054	20.7087	23.6774	20.7087	11.4790	0.9020	0.9022	22.9543	0.0361	2.0664	2.2602	3.15043627
60	1.0472	19.8800	19.8830	22.9589	19.8830	11.4795	0.8660	0.8662	22.9555	0.0346	1.9840	2.1701	3.215193617
59	1.0297	19.1031	19.1057	22.2894	19.1057	11.4799	0.8321	0.8323	22.9566	0.0333	1.9064	2.0852	3.27946998
58	1.0123	18.3998	18.3722	21.6641	18.3722	11.4802	0.8002	0.8003	22.9575	0.0320	1.8332	2.0051	3.34478167
57	0.9949	17.7674	17.6785	21.0792	17.6785	11.4806	0.7699	0.7700	22.9584	0.0308	1.7640	1.9294	3.40974544
56	0.9774	17.1912	17.0211	20.5311	17.0211	11.4808	0.7413	0.7414	22.9592	0.0296	1.6984	1.8577	3.475020251
55	0.9599	16.6691	16.3967	20.0167	16.3967	11.4811	0.7141	0.7141	22.9599	0.0286	1.6361	1.7895	3.54054063
54	0.9425	15.8013	15.8028	19.5333	15.8028	11.4814	0.6882	0.6883	22.9606	0.0275	1.5768	1.7247	3.606467198
53	0.9250	15.2353	15.2366	19.0783	15.2366	11.4816	0.6635	0.6636	22.9612	0.0265	1.5203	1.6629	3.672859614
52	0.9076	14.6948	14.6960	18.6496	14.6960	11.4818	0.6400	0.6400	22.9617	0.0256	1.4664	1.6039	3.739797136
51	0.8901	14.1780	14.1791	18.2451	14.1791	11.4820	0.6174	0.6175	22.9623	0.0247	1.4148	1.5475	3.80736089
50	0.8727	13.6830	13.6839	17.8631	13.6839	11.4822	0.5959	0.5959	22.9627	0.0238	1.3654	1.4934	3.875634352
49	0.8552	13.2081	13.2089	17.5020	13.2089	11.4824	0.5752	0.5752	22.9632	0.0230	1.3180	1.4416	3.94470384
48	0.8378	12.7518	12.7526	17.1603	12.7526	11.4825	0.5553	0.5553	22.9636	0.0222	1.2725	1.3918	4.014659048
47	0.8203	12.3129	12.3136	16.8368	12.3136	11.4827	0.5362	0.5362	22.9640	0.0214	1.2287	1.3439	4.085593601
46	0.8029	11.8911	11.8908	16.5301	11.8908	11.4828	0.5178	0.5178	22.9643	0.0207	1.1865	1.2977	4.157605657
45	0.7854	11.4823	11.4829	16.2393	11.4829	11.4829	0.5000	0.5000	22.9647	0.0200	1.1458	1.2532	4.230798964
44	0.7679	11.0885	11.0890	15.9630	11.0890	11.4830	0.4833	0.4833	22.9650	0.0193	1.1065	1.2102	4.305315576
43	0.7505	10.7077	10.7082	15.7012	10.7082	11.4831	0.4663	0.4663	22.9653	0.0186	1.0685	1.1687	4.38117064
42	0.7330	10.3391	10.3396	15.4522	10.3396	11.4832	0.4502	0.4502	22.9655	0.0180	1.0317	1.1284	4.458589273
41	0.7156	9.9819	9.9823	15.2156	9.9823	11.4833	0.4346	0.4347	22.9658	0.0174	0.9960	1.0894	4.537669545
40	0.6981	9.6354	9.6357	14.9905	9.6357	11.4834	0.4195	0.4196	22.9660	0.0168	0.9614	1.0516	4.618553171
39	0.6807	9.2989	9.2992	14.7765	9.2992	11.4835	0.4049	0.4049	22.9663	0.0162	0.9279	1.0149	4.701392759
38	0.6632	8.9717	8.9720	14.5729	8.9720	11.4836	0.3907	0.3907	22.9665	0.0156	0.8952	0.9797	4.785353312
37	0.6458	8.6533	8.6536	14.3791	8.6536	11.4837	0.3768	0.3768	22.9667	0.0151	0.8634	0.9444	4.873613357
36	0.6283	8.3432	8.3434	14.1947	8.3434	11.4837	0.3633	0.3633	22.9668	0.0145	0.8325	0.9106	4.963637742
35	0.6109	8.0408	8.0410	14.0191	8.0410	11.4838	0.3501	0.3501	22.9670	0.0140	0.8023	0.8776	5.055828801
34	0.5934	7.7458	7.7460	13.8520	7.7460	11.4838	0.3373	0.3373	22.9672	0.0135	0.7729	0.8454	5.151292886
33	0.5760	7.4576	7.4577	13.6930	7.4577	11.4839	0.3247	0.3247	22.9673	0.0130	0.7441	0.8139	5.249825212
32	0.5585	7.1758	7.1760	13.5416	7.1760	11.4840	0.3124	0.3124	22.9675	0.0125	0.7160	0.7832	5.351899734
31	0.5411	6.9002	6.9003	13.3976	6.9003	11.4840	0.3004	0.3004	22.9676	0.0120	0.6885	0.7531	5.457762973
30	0.5236	6.6302	6.6303	13.2606	6.6303	11.4841	0.2887	0.2887	22.9677	0.0115	0.6616	0.7236	5.567765717
29	0.5061	6.3656	6.3657	13.1304	6.3657	11.4841	0.2772	0.2772	22.9679	0.0111	0.6352	0.6947	5.68295365
28	0.4887	6.1061	6.1062	13.0066	6.1062	11.4841	0.2659	0.2659	22.9680	0.0106	0.6093	0.6664	5.80178737
27	0.4712	5.8515	5.8515	12.8890	5.8515	11.4842	0.2548	0.2548	22.9681	0.0102	0.5839	0.6386	5.926732113
26	0.4538	5.6012	5.6012	12.7774	5.6012	11.4842	0.2439	0.2439	22.9682	0.0098	0.5589	0.6113	6.057684396
25	0.4363	5.3551	5.3552	12.6715	5.3552	11.4843	0.2332	0.2332	22.9683	0.0093	0.5343	0.5844	6.195275023
24	0.4189	5.1131	5.1131	12.5711	5.1131	11.4843	0.2226	0.2226	22.9684	0.0089	0.5102	0.5580	6.340224996
23	0.4014	4.8748	4.8748	12.4761	4.8748	11.4843	0.2122	0.2122	22.9684	0.0085	0.4864	0.5320	6.493363065
22	0.3840	4.6399	4.6400	12.3863	4.6400	11.4844	0.2020	0.2020	22.9685	0.0081	0.4630	0.5064	6.65647625
21	0.3665	4.4084	4.4084	12.3014	4.4084	11.4844	0.1919	0.1919	22.9686	0.0077	0.4399	0.4811	6.828194282
20	0.3491	4.1800	4.1800	12.2214	4.1800	11.4844	0.1820	0.1820	22.9687	0.0073	0.4171	0.4562	7.012310502
19	0.3316	3.9544	3.9544	12.1462	3.9544	11.4844	0.1722	0.1722	22.9687	0.0069	0.3946	0.4316	7.20542859
18	0.3142	3.7315	3.7315	12.0755	3.7315	11.4845	0.1625	0.1625	22.9688	0.0065	0.3723	0.4072	7.40730868
17	0.2967	3.5111	3.5112	12.0092	3.5112	11.4845	0.1529	0.1529	22.9688	0.0061	0.3503	0.3832	7.619090069
16	0.2793	3.2931	3.2931	11.9473	3.2931	11.4845	0.1434	0.1434	22.9689	0.0057	0.3286	0.3594	7.900311972
15	0.2618	3.0773	3.0773	11.8896	3.0773	11.4845	0.1340	0.1340	2				

Calculated Spring Constants for different heights and heights

		100	120	140	160	180	200	220	240	260	280	300
62	5'2"	6.651	7.805	9.976	10.127	11.301	12.45					
63	5'3"	6.737	7.917	9.097	10.277	11.457	12.637	13.817				
64	5'4"	6.831	8.03	9.228	10.427	11.625	12.824	14.023				
65	5'5"	6.925	8.142	9.359	10.577	11.794	13.011	14.229	15.463			
66	5'6"	7.018	8.254	9.49	10.726	11.962	13.198	14.434	15.67			
67	5'7"	7.112	8.366	9.621	10.876	12.131	13.386	14.64	15.895			
68	5'8"		8.479	9.752	11.026	12.299	13.573	14.846	16.12	17.393		
69	5'9"		8.591	9.883	11.175	12.468	13.76	15.052	16.344	17.636		
70	5'10"		8.703	10.014	11.325	12.636	13.947	15.258	16.569	17.879		
71	5'11"		8.826	10.145	11.475	12.804	14.134	15.464	16.793	18.122	19.476	
72	6'0"			10.276	11.625	12.973	14.321	15.67	17.018	18.366	19.714	
73	6'1"			10.407	11.774	13.141	14.508	15.875	17.242	18.609	19.976	21.344
74	6'2"			10.538	11.924	13.31	14.696	16.081	17.467	18.852	20.238	21.624
75	6'3"				12.074	13.487	14.883	16.287	17.629	19.096	20.5	21.905
76	6'4"				12.238	13.647	15.07	16.513	17.916	19.363	20.762	22.219

Max bending shear =  $M \cdot c / I$   
 Max torque shear (handlebar post) =  $T \cdot r / J = 1803.15 \text{ lbs/in}^2$

$J = \pi / 32 (d_o^4 - d_i^4)$   
 $I =$

Weight Class	90-129	130-169	170-229	230-269	270-309
Average K	7.7741875	10.55114286	13.76413636	17.402	20.7758

*** century spring	7.5	11	14	17	21
	CS-863	CS-853	CS-4385	CS-851	CS-844

Associated Spring	7.6	10	12.6	17.1	19.36
Raymond	D13510	D13470	D13720	D14000	D23960

WM sim	7.5	10.6	13	17	21
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