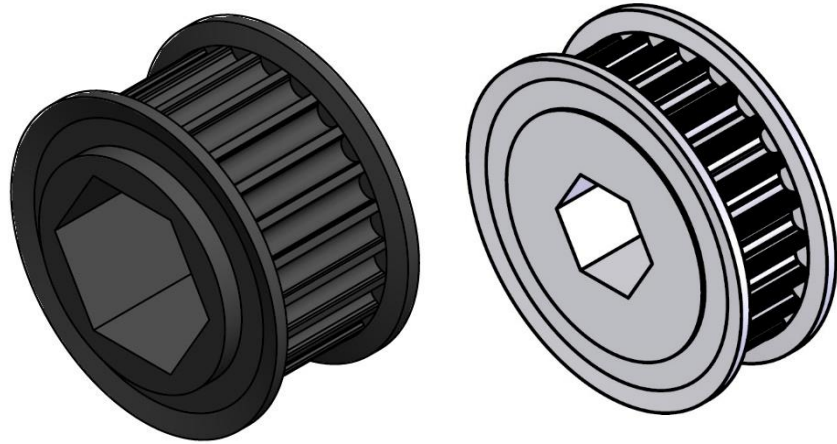
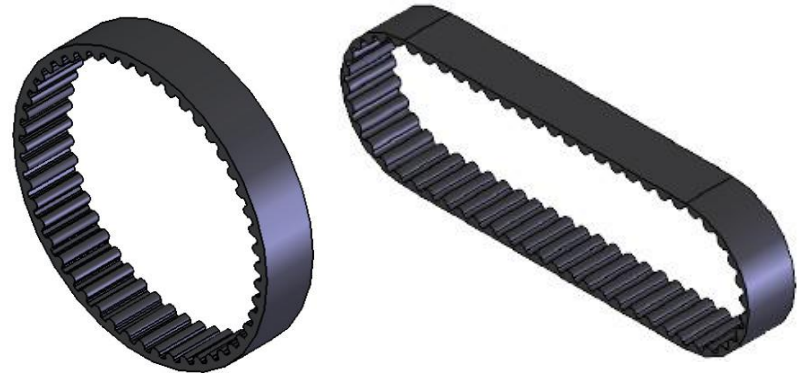


ADAMBOTS

Team 245

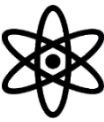


Application Guide for Belts and Pulleys





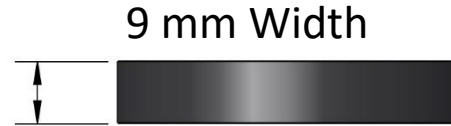
Belts & Pulleys for Robot Applications



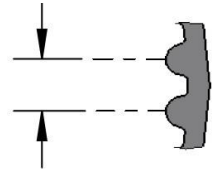
Two types of Timing Belts and Pulleys are typically used for Robot applications:

GT2 Family:

9 mm Width with
3 mm Tooth Pitch

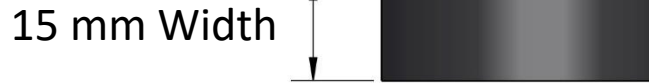


3 mm Tooth Pitch

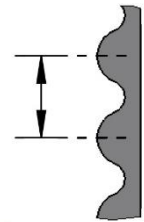


HTD Family:

9 or 15 mm Width with
5 mm Tooth Pitch

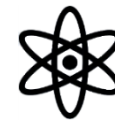


5 mm Tooth Pitch





Belt Availability



GT2 Belts

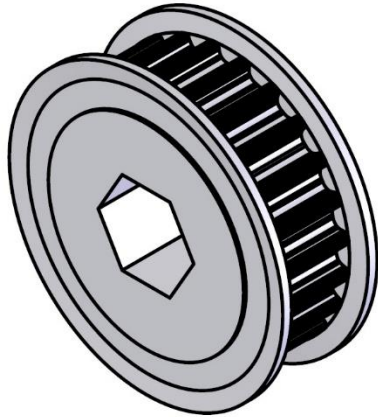
# OF TEETH	PITCH LENGTH (MM)	WIDTH
45	135	9
50	150	9
55	165	9
60	180	9
70	210	9
85	255	9
90	270	9
100	300	9
105	315	9
110	330	9
115	345	9
120	360	9
125	375	9
140	420	9
180	540	9

HTD Belts

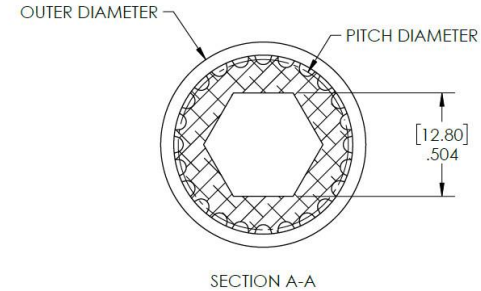
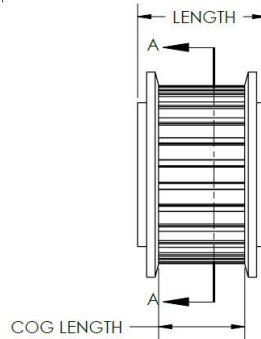
9mm Part#	15mm Part#	# of Teeth	Pitch Length (mm)
217-3293	217-3294	60	300
217-3455	217-3472	70	350
217-3456	217-3473	80	400
217-3457	217-3474	90	450
217-3458	217-3475	100	500
217-3459	217-3476	104	520
217-3460	217-3477	110	550
217-3461	217-3478	120	600
217-3462	217-3479	130	650
2147-3463	217-3480	140	700
217-3464	217-3481	150	750
217-3465	217-3482	160	800
217-3466	217-3483	170	850
217-3467	217-3484	180	900
217-3468	217-3485	200	1000
217-3469	217-3486	225	1125
217-3470	217-3487	250	1250



GT2 Pulley Availability

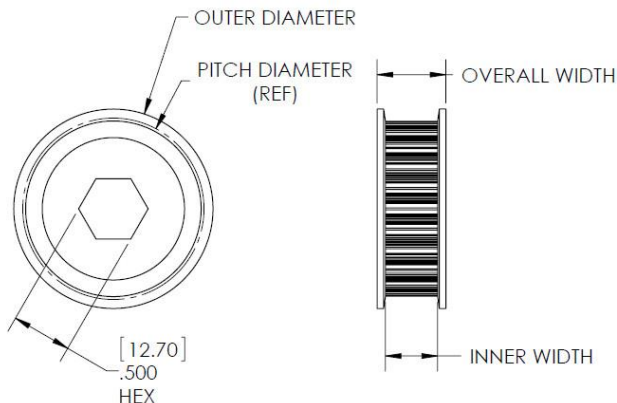
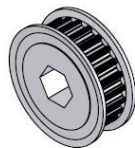


PART #	NUMBER OF TEETH	OUTER DIAMETER	PITCH DIAMETER	COG LENGTH	LENGTH	MATERIAL
217-5875	24	1.000"	0.902"	0.420"	0.625"	ALUMINUM
217-5873	36	1.535"	1.353"	0.420"	0.625"	ALUMINUM
217-5874	48	2.008"	1.805"	0.420"	0.625"	ALUMINUM
217-5876	60	2.402"	2.256"	0.420"	0.625"	ALUMINUM





HTD Pulley Availability



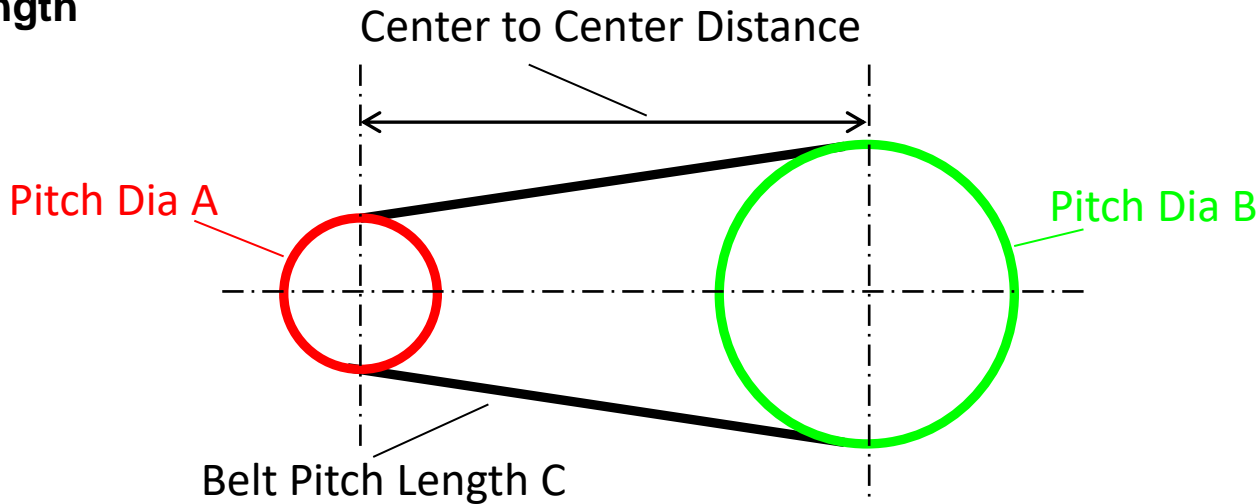
Part #	Tooth Count	Pitch Diameter (ref)	Outer Diameter	Inner Width	Overall Width
217-3225	18	[28.65] 1.128	[32] 1.260	[11] .433	[14.50] .571
217-3226	18	[28.65] 1.128	[32] 1.260	[17] .669	[20.50] .807
217-4100	18	[28.65] 1.128	[32] 1.260	[18.50] .728	[22] .866
217-3227	24	[38.20] 1.504	[42] 1.654	[11] .433	[14.50] .571
217-3228	24	[38.20] 1.504	[42] 1.654	[17] .669	[20.50] .807
217-4101	24	[38.20] 1.504	[42] 1.654	[18.50] .728	[22] .866
217-3229	30	[47.75] 1.880	[51] 2.008	[11] .433	[14.50] .571
217-3230	30	[47.75] 1.880	[51] 2.008	[17] .669	[20.50] .807
214-4102	30	[47.75] 1.880	[51] 2.008	[18.50] .728	[22] .866
217-3231	36	[57.30] 2.256	[60] 2.362	[11] .433	[14.50] .571
217-3232	36	[57.30] 2.256	[60] 2.362	[17] .669	[20.50] .807
217-4103	36	[57.30] 2.256	[60] 2.362	[18.50] .728	[22] .866



Center to Center Distance

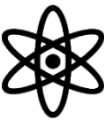


- ⌘ Timing pulleys must have a specific center to center distance when paired with a given belt length to have proper belt tension
- ⌘ Center to Center distance is function of pulley pitch diameter and belt pitch length





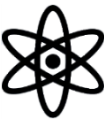
Selecting Pulley / Belt Combinations



- ✱ **HTD Belts are best for main drive wheel applications where chains are not used**
- ✱ **GT2 Belts are good for most other robot applications**
- ✱ **Belts and pulleys can be used for:**
 - ✱ **Drive features with same speed by using same pulley on both ends of same belt: 1:1 Pulley ratio**
 - ✱ **Drive features with either increase or decrease in speed between both ends of belt:**
 - ✱ **24 and 30 teeth pulleys can give either a 1.25 Increase in speed or a 0.80 Reduction in speed**



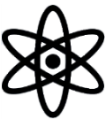
Steps for Selecting Pulley / Belt Combinations



- ✱ **Determine if speed Increase/Decrease or same speed is desired:**
 - ✱ Different size pulleys on each end to change speed
 - ✱ Same size pulleys on each end if no change in speed is desired
- ✱ **Determine if smaller GT2 or Larger HTD belts/pulleys are needed**
 - ✱ Based on power and torque required
- ✱ **Determine Ideal center to center distance needed to fit robot application**
- ✱ **Consult chart on next page for Center to Center distance for given belt length and pulley combinations**



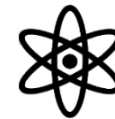
Center to Center Distance for GT2 Pulleys



GT2 Pulley Center to Center Distance by Belt Size and Pulley Size Pair											
	No Pulley Ratio Same Pulleys				Increase	1.25	1.33	1.50	1.67	2.00	2.50
	Both Ends				Decrease	0.80	0.75	0.67	0.60	0.50	0.40
Belt Teeth	24-24	36-36	48-48	60-60	Belt Teeth	48-60	36-48	24-36	36-60	24-48	24-60
45	1.241				45						
50	1.536				50						
55	1.831				55			1.460			
60	2.126				60			1.758			
70	2.717	2.009			70		1.638	2.352		1.955	
85	3.603	2.894	2.184		85		2.530	3.241	2.137	2.858	2.445
90	3.898	3.190	2.480		90	2.114	2.826	3.537	2.439	3.157	2.751
100	4.489	3.780	3.070		100	2.707	3.418	4.128	3.037	3.752	3.357
105	4.784	4.076	3.366	2.657	105	3.003	3.714	4.424	3.336	4.050	3.658
110	5.079	4.371	3.661	2.952	110	3.299	4.009	4.720	3.633	4.347	3.958
115	5.374	4.666	3.956	3.248	115	3.595	4.305	5.015	3.931	4.643	4.257
120	5.670	4.961	4.251	3.543	120	3.891	4.601	5.311	4.228	4.940	4.556
125	5.965	5.257	4.547	3.838	125	4.186	4.896	5.606	4.525	5.236	4.855
140	6.851	6.142	5.432	4.724	140	5.073	5.783	6.493	5.415	6.125	5.748
180	9.213	8.505	7.795	7.086	180	7.437	8.147	8.856	7.782	8.492	8.121
	= Belt too small for pulley pairing										



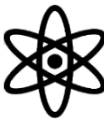
Center to Center Distance for HTD Pulleys



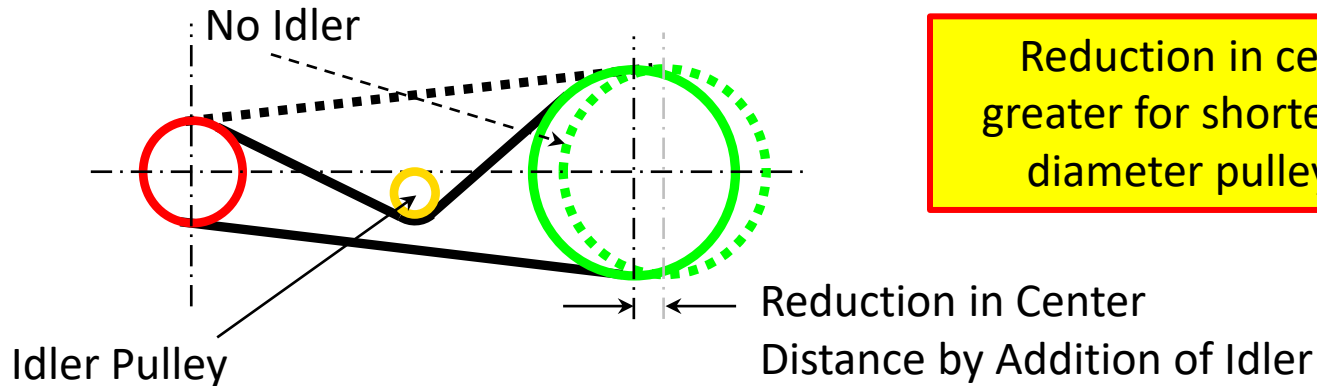
HTD Pulley Center to Center Distance by Belt Size and Pulley Size Pair											
	No Pulley Ratio Same Pulleys Both				Increase	1.20	1.25	1.33	1.50	1.67	2.00
	Ends				Decrease	0.83	0.80	0.75	0.67	0.60	0.50
Belt Teeth	18-18	24-24	30-30	36-36	Belt Teeth	30-36	24-30	18-24	24-36	18-30	18-36
60	4.134	3.543	2.952	2.362	60	2.650	3.242	3.834	2.928	3.523	3.198
70	5.118	4.527	3.937	3.346	70	3.637	4.228	4.819	3.919	4.512	4.194
80	6.102	5.512	4.921	4.330	80	4.622	5.213	5.804	4.907	5.499	5.186
90	7.086	6.496	5.905	5.315	90	5.607	6.198	6.789	5.893	6.485	6.175
100	8.071	7.480	6.889	6.299	100	6.591	7.182	7.773	6.879	7.471	7.163
104	8.464	7.874	7.283	6.693	104	6.985	7.576	8.167	7.274	7.865	7.557
110	9.055	8.464	7.874	7.283	110	7.576	8.167	8.758	7.865	8.456	8.149
120	10.039	9.449	8.858	8.267	120	8.561	9.151	9.742	8.850	9.441	9.136
130	11.023	10.433	9.842	9.252	130	9.545	10.136	10.726	9.835	10.426	10.122
140	12.008	11.417	10.826	10.236	140	10.529	11.120	11.711	10.820	11.411	11.107
150	12.992	12.401	11.811	11.220	150	11.514	12.105	12.695	11.805	12.396	12.093
160	13.976	13.386	12.795	12.204	160	12.498	13.089	13.680	12.789	13.380	13.078
170	14.960	14.370	13.779	13.189	170	13.483	14.073	14.664	13.774	14.365	14.063
180	15.945	15.354	14.763	14.173	180	14.467	15.058	15.648	14.759	15.349	15.048
200	17.913	17.323	16.732	16.141	200	16.436	17.026	17.617	16.728	17.318	17.018
225	20.374	19.783	19.193	18.602	225	18.896	19.487	20.078	19.189	19.780	19.480
250	22.834	22.244	21.653	21.063	250	21.357	21.948	22.538	21.650	22.241	21.941



Addition of Idler to Reduce Center Distance



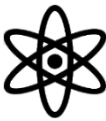
- ✱ Robot features may require a fixed center to center distance that cannot be achieved by combinations of available belts and pulleys for desired speed ratio
- ✱ Can use an idler between centers to reduce center distance for a larger pulley/belt combo to achieve desired center distance



Reduction in center distance is greater for shorter distance, larger diameter pulley combinations



Reduction in Center Distance by Addition of Idler



Tables on next slides identify reduction in center distance addition of a 1/2" idler pulley can achieve

No Pulley Ratio Same Pulleys Both Ends								
Belt Teeth	18-18 Teeth		24-24 Teeth		30-30 Teeth		36-36 Teeth	
	With Idler	W/O Idler	With Idler	W/O Idler	With Idler	W/O Idler	With Idler	W/O Idler
60	3.916	4.134	3.058	3.543	2.569	2.952	2.361	2.362
70	4.946	5.118	4.174	4.527	3.198	3.937	2.916	3.346
80	5.960	6.102	5.230	5.512	4.380	4.921	3.345	4.330
90	6.965	7.086	6.261	6.496	5.471	5.905	4.589	5.315
100	7.965	8.071	7.278	7.480	6.525	6.889	5.713	6.299

0.353" Reduction for 70 Tooth Belt and 24-24 Teeth Pulleys

Center with Idler

Center without Idler



Center Distance Reduction by Idler for GT2 Pulleys



GT2 Pulley Center to Center Distance with Max Reduction Possible by Addition of 1/2" Idler by Belt Size and Pulley Size Pair

		No Pulley Ratio Same Pulleys Both Ends								Increase	1.25	1.33	1.50	1.67	2.00	2.50						
										Decrease	0.80	0.75	0.67	0.60	0.50	0.40						
Belt Teeth	24 Teeth		36 Teeth		48 Teeth		60 Teeth		Belt Teeth	48-60		36-48		24-36		36-60		24-48		24-60		
	With Idler	W/O Idler	With Idler	W/O Idler	With Idler	W/O Idler	With Idler	W/O Idler		With Idler	W/O Idler	With Idler	W/O Idler	With Idler	W/O Idler	With Idler	W/O Idler	With Idler	W/O Idler	With Idler	W/O Idler	
45		1.241							45													
50		1.536							50													
55		1.831							55					1.460								
60	1.811	2.126							60					1.758								
70	2.494	2.717		2.009					70					2.352					1.955			
85	3.444	3.603	2.371	2.894		2.184			85			2.529	2.976	3.241		2.137			2.858		2.445	
90	3.752	3.898	2.741	3.190		2.480			90			2.439	2.826	3.298	3.537		2.439	2.750	3.157		2.751	
100	4.363	4.489	3.422	3.780		3.070			100			2.707	2.878	3.418	3.930	4.128		3.037	3.436	3.752	2.906	3.357
105	4.667	4.784	3.750	4.076		3.366		2.657	105			3.003	3.236	3.714	4.241	4.424	2.717	3.336	3.757	4.050	3.211	3.658
110	4.970	5.079	4.070	4.371	2.886	3.661		2.952	110			3.299	3.548	4.010	4.536	4.720	2.964	3.633	4.061	4.347	3.550	3.958
115	5.270	5.374	4.388	4.666	3.268	3.956		3.248	115	2.961	3.595	3.888	4.305	4.843	5.015	3.339	3.931	4.378	4.644	4.644	3.875	4.257
120	5.573	5.670	4.702	4.961	3.629	4.251		3.543	120	3.051	3.891	4.216	4.601	5.149	5.311	3.693	4.228	4.691	4.940	4.209	4.556	
125	5.872	5.965	5.013	5.257	3.972	4.547	3.193	3.838	125	3.447	4.186	4.539	4.896	5.453	5.606	4.038	4.525	4.987	5.236	4.489	4.855	
140	6.771	6.851	5.938	6.142	4.979	5.432	3.864	4.724	140	4.560	5.073	5.489	5.783	6.363	6.493	4.980	5.415	5.918	6.125	5.487	5.748	
180	9.154	9.213	8.359	8.505	7.507	7.795	6.577	7.086	180	7.059	7.437	7.942	8.147	8.761	8.856	7.494	7.782	8.345	8.492	7.930	8.121	



Center Distance Reduction by Idler for HTD Pulleys



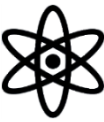
HTD Pulley Center to Center Distance with Max Reduction Possible by Addition of 1/2" Idler by Belt Size and Pulley Size Pair

No Pulley Ratio Same Pulleys Both Ends																							
Belt Teeth		18-18 Teeth		24-24 Teeth		30-30 Teeth		36-36 Teeth		Increase		1.20		1.25		1.33		1.50		1.67		2.00	
										Decrease		0.83		0.80		0.75		0.67		0.60		0.50	
Belt Teeth		With Idler		W/O Idler		With Idler		W/O Idler		30-36		24-30		18-24		24-36		18-30		18-36			
										With Idler		W/O Idler		With Idler		W/O Idler		With Idler		W/O Idler		With Idler	
60	3.916	4.134	3.058	3.543	2.569	2.952	2.361	2.362	60	2.650	2.650	2.484	3.242	3.524	3.834	2.928	2.928	3.049	3.523	2.845	3.198		
70	4.946	5.118	4.174	4.527	3.198	3.937	2.916	3.346	70	3.050	3.637	3.728	4.228	4.582	4.819	3.203	3.919	4.169	4.512	3.705	4.194		
80	5.960	6.102	5.230	5.512	4.380	4.921	3.345	4.330	80	3.895	4.622	4.827	5.213	5.611	5.804	4.385	4.907	5.227	5.499	4.811	5.186		
90	6.965	7.086	6.261	6.496	5.471	5.905	4.589	5.315	90	5.043	5.607	5.881	6.198	6.625	6.789	5.475	5.893	6.258	6.485	5.869	6.175		
100	7.965	8.071	7.278	7.480	6.525	6.889	5.713	6.299	100	6.126	6.591	6.913	7.183	7.632	7.773	6.528	6.879	7.276	7.471	6.903	7.164		
104	8.364	8.464	7.682	7.874	6.940	7.283	6.148	6.693	104	6.549	6.985	7.322	7.576	8.032	8.167	6.944	7.274	7.680	7.865	7.312	7.557		
110	8.960	9.055	8.287	8.464	7.559	7.874	6.789	7.283	110	7.178	7.576	7.932	8.167	8.633	8.758	7.562	7.865	8.285	8.456	7.923	8.149		
120	9.954	10.039	9.290	9.449	8.580	8.858	7.839	8.267	120	8.212	8.561	8.943	9.151	9.630	9.742	8.583	8.85	9.289	9.441	8.935	9.135		
130	10.947	11.023	10.290	10.433	9.594	9.842	8.872	9.252	130	9.235	9.545	9.949	10.136	10.625	10.726	9.596	9.835	10.288	10.426	9.942	10.121		
140	11.937	12.008	11.287	11.417	10.602	10.826	9.895	10.236	140	10.250	10.529	10.950	11.120	11.618	11.711	10.604	10.820	11.285	11.411	10.944	11.107		
150	12.927	12.992	12.282	12.401	11.605	11.811	10.911	11.220	150	11.259	11.513	11.949	12.105	12.610	12.695	11.607	11.805	12.280	12.396	11.943	12.092		
160	13.916	13.976	13.275	13.386	12.606	12.795	11.922	12.204	160	12.264	12.498	12.945	13.089	13.601	13.680	12.608	12.789	13.274	13.380	12.940	13.078		
170	14.904	14.960	14.267	14.370	13.604	13.779	12.928	13.189	170	13.266	13.483	13.940	14.073	14.590	14.664	13.606	13.774	14.266	14.365	13.935	14.063		
180	15.892	15.945	15.258	15.354	14.600	14.763	13.921	14.173	180	14.266	14.467	14.933	15.058	15.579	15.648	14.602	14.759	15.257	15.350	14.929	15.048		
200	17.866	17.913	17.237	17.323	16.589	16.732	15.929	16.141	200	16.258	16.436	16.917	17.026	17.556	17.617	16.590	16.727	17.327	17.318	16.912	17.017		
225	20.332	20.374	19.709	19.783	19.068	19.193	18.419	18.602	225	18.743	18.896	19.391	19.487	20.024	20.078	19.069	19.189	19.708	19.780	19.288	19.479		
250	22.797	22.834	22.178	22.244	21.542	21.653	20.901	21.062	250	21.222	21.357	21.863	21.948	22.490	22.538	21.544	21.650	22.177	22.241	21.859	21.941		



Alternate Idler Configuration

Idler Beyond Pulleys



Idler can be added to extend belt beyond area between pulleys

- ✱ Offers larger reduction in center distance if packaging space is available in area between both pulleys
- ✱ Reduces wrap on pulleys that can limit maximum torque transfer
- ✱ Offers wide range of center distance combinations



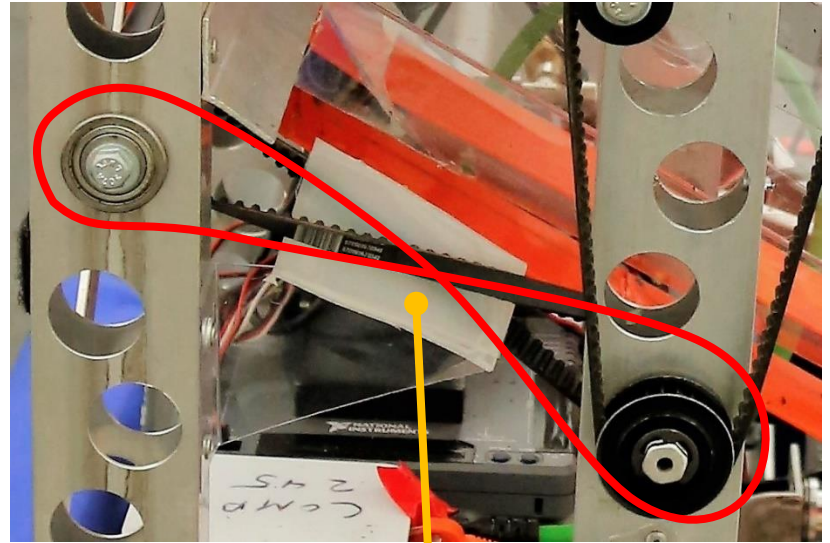
Can use this configuration for lower power transfer applications when available belts and pulleys cannot meet robot requirements

- ✱ Or if proper belt and pulley combinations are not on hand



“Figure 8” Belt to Change Pulley Rotation

- ✱ Longer belts can easily be “Twisted” in a Figure 8 Configuration to provide opposite rotation of pulleys at both ends
- ✱ Need a physical separator between belt sides in area of crossover in the Figure 8
- ✱ Wrap on pulleys is increased which does not negatively impact power transfer
- ✱ Operating speed may be limited



Separator with Teflon Tape to reduce Friction



Assembly Tips



- ✱ **Use CAD to locate Drive pulley and/or motor position using Driven pulley location as the base**
 - ✱ **Use motor position in CAD to confirm acceptable packaging of motor and design motor mounts with this location**
 - ✱ **Drill bolt/rivet holes in motor mounts**
- ✱ **Stretch belt wrapped between motor drive and driven pulley to full extent to position motor mount on frame**
 - ✱ **Use clamp to hold motor mount in place and drill holes in frame element using motor mount holes as guides and insert bolts/rivets**
 - ✱ **Clamping motor mount with belt at full stretch results in a tight/proper belt tension and avoids use of an Idler to tighten up a loose belt**