



Pitch perfect: Standard over custom eases costs

Circular pitch, diametral pitch, and module – what is pitch anyway?

What is perfect pitch? In music, it is the ability to identify notes without any point of reference. It can be best described as being able to hear a tone and being able to identify or reproduce the note without any reference. In gearing, pitch is defined as the distance between two identical points on two adjacent gear teeth. There is no perfect pitch in gearing, but there are several choices to consider.

There are four designations of pitch within the gearing world. These are diametral pitch, module, circular pitch in inches and circular pitch in millimeters. Within each of these designations there are preferred sizes for which tooling is commonly available.

Diametral Pitch, commonly known as DP, is the primary gear pitch designator for inch gearing. It is based on the unit circle, whereas the pitch of the gear is determined by the number of teeth that exists within a one-inch pitch diameter. If the gear had 32 teeth and a two-inch pitch diameter, then this would be a 16DP gear. Similarly, a 16-tooth gear with a 4-inch pitch diameter would be a 4DP gear. The addendum of a diametral pitch gear tooth is $1/DP$ and the dedendum of a diametral pitch gear tooth is $1.157/DP$. This result is a whole tooth depth of $2.157/DP$.

Module is the primary gear pitch designator for metric gearing. The pitch of a metric gear is calculated in the inverse to DP gearing. For example, a 16-tooth spur gear with a 24-millimeter pitch diameter would be a Module 1.5 gear. Similarly, a 32-tooth gear with an 8-millimeter pitch diameter would be a Module 0.4 gear. The addendum of metric pitch gear tooth is equal to the module and the dedendum of a metric gear is equal to the addendum multiplied by 1.25. This results in a whole tooth depth of $2.25 * \text{module}$.

Since pitch is measured at the pitch line and the formula for circumference is:

$$C = \pi * D$$

where C = Circumference

$$\pi = 3.14159$$

D = Diameter

the use of DP or Module will result in a linear translation of the gear along the pitch line to equal a fractional value. If your application requires the gear to rotate a specific number of complete revolutions and transverse linearly across a fixed distance, then neither DP nor Module pitch will accomplish this task. The solution to this dilemma is to use circular pitch gearing instead. The values for circular pitch are set such that the value of π is negated.

Detailed below is a reference chart detailing the equivalencies between Module, Diametral Pitch, Metric Circular Pitch, and Inch Circular Pitch. In the chart, the values that are in bold type are the standardized preferred sizes within that pitch designator.

It is important to acknowledge that although the values of pitch have a mathematical equivalency, they are not able to be interchanged so easily. There are several combinations that are frequently confused and lead to noise, fit and wear issues. The more common interchange mistake is 5 DP and Module 5. These two pitch sizes are close in value and a worn 5DP can easily be measured as Module 5. A less common, but more difficult to identify pair is 5mm CP and 16DP. The metric equivalent of 16DP is 4.987mm and the inch equivalent of 5mm CP is 15.959DP. The issue with this interchange is that the whole depth of the gearing is different as the tooth depth of a 16DP gear will be 3.42mm but the tooth depth of a 5mm CP gear will be 3.58mm. This will result in the tooth tip bottoming out in the tooth root of the mating gear.

It is recommended that you limit yourself to designing your gear system using one of the standardized pitch sizes detailed in the table. This will afford you the opportunity to source your gears without incurring tooling costs for custom gear cutting. With the large selection of preferred sizes, there should be a standardized gear pitch that is pitch perfect for your design.

Module	Diametral Pitch	Circular Pitch mm	Circular Pitch inch
0.396875	64	1.246819584	0.049087385
0.4	63.5	1.256637061	0.0494739
0.5	50.8	1.570796327	0.061842375
0.529166667	48	1.662426113	0.065449847
0.6	42.33333333	1.884955592	0.07421085
0.7	36.28571429	2.199114858	0.086579325
0.75	33.86666667	2.35619449	0.092763563
0.79375	32	2.493639169	0.09817477
0.795774715	31.91858136	2.5	0.098425197
0.8	31.75	2.513274123	0.0989478
0.9	28.22222222	2.827433388	0.111316275
1	25.4	3.141592654	0.12368475
1.058333333	24	3.324852225	0.130899694
1.25	20.32	3.926990817	0.154605938
1.27	20	3.98982267	0.157079633
1.5	16.93333333	4.71238898	0.185527125
1.5875	16	4.987278338	0.196349541
1.591549431	15.95929068	5	0.196850394
1.75	14.51428571	5.497787144	0.216448313

Module	Diametral Pitch	Circular Pitch mm	Circular Pitch inch
1.814285714	14	5.699746672	0.224399475
2	12.7	6.283185307	0.2473695
2.021267777	12.56637061	6.35	0.25
2.116666667	12	6.64970445	0.261799388
2.25	11.28888889	7.068583471	0.278290688
2.387324146	10.63952712	7.5	0.295275591
2.5	10.16	7.853981634	0.309211875
2.54	10	7.97964534	0.314159265
2.75	9.236363636	8.639379797	0.340133063
3	8.466666667	9.424777961	0.37105425
3.031901666	8.37758041	9.525	0.375
3.175	8	9.974556675	0.392699082
3.183098862	7.97964534	10	0.393700787
3.25	7.815384615	10.21017612	0.401975438
3.5	7.257142857	10.99557429	0.432896625
3.75	6.773333333	11.78097245	0.463817813
3.978873577	6.383716272	12.5	0.492125984
4	6.35	12.56637061	0.494739001
4.042535555	6.283185307	12.7	0.5
4.233333333	6	13.2994089	0.523598776
4.5	5.644444444	14.13716694	0.556581376
4.774648293	5.31976356	15	0.590551181
5	5.08	15.70796327	0.618423751
5.08	5	15.95929068	0.628318531
6	4.233333333	18.84955592	0.742108501
6.063803332	4.188790205	19.05	0.75
6.35	4	19.94911335	0.785398163
6.366197724	3.98982267	20	0.787401575
8	3.175	25.13274123	0.989478001
8.085071109	3.141592654	25.4	1
8.466666667	3	26.5988178	1.047197551
10	2.54	31.41592654	1.236847501
10.10633889	2.513274123	31.75	1.25
11.11697277	2.284794657	34.925	1.375
12.12760666	2.094395102	38.1	1.5
12.7	2	39.8982267	1.570796327
16.17014222	1.570796327	50.8	2
25.4	1	79.7964534	3.141592654



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