General Basics for Spur Gears

Spur gears enable a non-slip power transmission between two parallel-mounted shafts. The spur gears listed in the catalogue are involute gears with a pressure angle of 20°.

Please note that gears with a number of teeth < 17 are undercut for manufacturing reasons (one reason for this is the simple calculation of the centre distance). The centre distance tolerances depend on the tooth quality in line with DIN 3964. The modules for spur gears used in the catalogue were derived from DIN 780 Series 1.

The formulas below apply to straight and helical spur gears for the usual gear-cutting tools (see table) and for the addendum modification 0 for sprocket and wheel (the so-called reference centre distance tooth system).

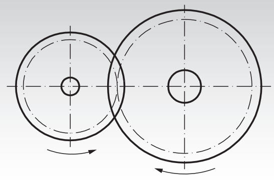
Module-Series 1

Module 0.3 Module 0.5 Module 0.7 Module 1.0 Module 1.25 Module 1.5
Module 2.0 Module 2.5 Module 3.0 Module 4.0 Module 5.0 Module 6.0
Module 8.0

Module-Series 2

Module 0.75 Module 3.5 Module 7.0

Rotational direction changes with every gear



Teeth straight

to be calculated	given unit	formula
No. of Teeth = z	Pitch Ø and Module	$\frac{d}{m}$
	Addendum-Circle Ø	$\frac{d_a - 2m}{m}$
Module = m in mm	Pitch p	$\frac{p}{\pi}$
	Tip Ø and No. of Teeth	$\frac{d_a}{z + 2}$
	Pitch Ø and No. of Teeth	$\frac{d}{z}$
Pitch Ø = d in mm	No. of Teeth and Module	$z \cdot m$
	No. of Teeth and Tip Ø	$\frac{z \cdot d_a}{z + 2}$
	Tip Ø and Module	$d_a - 2m$
Tip Ø = d_a in mm	No. of Teeth and Module	$(z + 2) \cdot m$
	No. of Teeth and Pitch Ø	$d + \frac{2d}{z}$
	Pitch Ø and Module	$d + 2m$
Centre distance = a in mm	No. of Teeth and Module	$\left(\frac{z_1 + z_2}{2}\right) \cdot m$
	Pitch Ø and Pitch Ø	$\frac{d_1 + d_2}{2}$
Reduction Ratio = i	No. of Teeth and No. of Teeth	$\frac{z_2}{z_1}$
	Speed and Speed	$\frac{n_1}{n_2}$
Torque = Md in Nm	Power and Speed [kW] [min^{-1}]	$9550 \cdot \frac{P}{n}$
Peripheral Speed = V in m/sec.	Pitch Ø and Speed [mm] [min^{-1}]	$\frac{\pi \cdot d \cdot n}{60.000}$

Material quality: Information about the material quality can be found at each individual group of gears.

Teeth helical

to be calculated	given unit	formula
No. of Teeth	Pitch Ø, Standard Module and Spiral Angle	$\frac{d \cdot \cos ß}{m_n}$
	Tip Ø, Standard Module and Spiral Angle	$\frac{(d_a - 2\,m_n) \cdot \cos ß}{m_n}$
Normal Module	Standard Pitch p_{n0}	$\frac{p_{n0}}{\pi}$
	Pitch Ø, No. of Teeth and Spiral Angle	$\frac{d \cdot \cos ß}{z}$
	Tip Ø, No. of Teeth and Spiral Angle	$\frac{d_a}{\frac{z}{\cos ß} + 2}$
Real module	Reference Circle Pitch p_s	$\frac{p_s}{\pi}$
	Standard Module and Spiral Angle	$\frac{m_n}{\cos ß}$
	Pitch Ø and No. of Teeth	$\frac{d}{z}$
Pitch Ø	No. of Teeth, Standard Module and Spiral Angle	$\frac{z \cdot m_n}{\cos ß}$
	No. of Teeth, Tip Ø and Spiral Angle	$\frac{z \cdot d_a}{z + 2 \cdot \cos ß}$
	Tip Ø and Standard Module	$d_a - 2\,m_n$
Tip Ø	No. of Teeth, Standard Module and Spiral Angle	$\left(\frac{z}{\cos ß} + 2\right) m_n$
	Pitch Ø and Standard Module	$d + 2m_n$
	Pitch Ø, No. of Teeth and Spiral Angle	$d + \frac{2\,d \cdot \cos ß}{z}$
Centre distance	No. of Teeth, Standard Module and Spiral Angle	$\left(\frac{z_1 + z_2}{2}\right) \frac{m_n}{\cos ß}$
	Pitch Ø and Pitch Ø	$\frac{d_1 + d_2}{2}$
Spiral Angle	Standard Module u. Real Module	$\frac{m_n}{m_s} = \cos ß$
	Standard Module, No. of Teeth and Pitch Ø	$\frac{z \cdot m_n}{d} = \cos ß$

Recommendations for the Lubrication of Spur Gear Units

Peripheral Speed	Lubrication	Lubricant
up to 1 m/s	Application of Lubricant	Adhesive Lubricant
up to 4 m/s	Splash Lubrication/Spray Lubrication	Grease or Adh. Lubricant
up to 15 m/s	Splash Lubrication	Oil
over 15 m/s	Pressure-Circulation or Spray Lubrication	Oil

Note Regarding the Torque-Values Stated in the Catalogue

The torque values given for gears in the dimension tables (the value “perm. MT” stated in Nm or Ncm) only relate to the teeth, without considering the shaft diameter or key size.

The load bearing capacity calculations are based on the basic principles regarding the pitting resistance of the tooth flanks and the occurring tooth root stress. The calculations are based on the DIN 3990 (Method B). For the calculation, the following assumptions were made:

Calcul. Factor/Determining Factor	Abbreviation	Value	Note
Calculation Method	-	-	DIN 3990, method B
DIN Quality	-	8	-
Tooth-Number Ratio	U	1	If U > 1, the flank safety for long and short addendum teeth increases while the tooth-root safety decreases For other tooth-number ratios please check both pinion and gear!
Manufacturing Tool: Addendum/Dedendum/ Tip Rounding	$h_{aP0}/h_{fP0}/rho_{aPo}$	1.25/1/0.25	Hob
Flank Safety	S_H	1.0	Endurance strength 10.000 h (for steel)
Tooth-Root Safety	S_F	1.5	Endurance strength 10.000 h (for steel)
Application Factor	K_A	1.25	Industrial gear mechanisms, uniform, light shocks.
Dynamics Factor	K_V	1.0	Usually without great influence
Load Distribution over Width	K_{Hbeta}	1	Idealised; requires precise, rigid and symmetric mounting
Lubricant/Surface Roughness Speed Factor	$Z_L * Z_V * Z_R$	1	• sufficient oil-lubrication • relative surface roughness R_{Z100} = 10 • peripheral speed 10 m/s
Lifetime Factor	Z_N	1	Endurance strength 10.000 h (for steel)
Operating temperature for plastic gears	T_{Betr}	up to 60°C	The material parametres of plastic gears largely depend on the temperature

The load bearing capacity of a gear depends on various different factors. The stated torques are only reference values, serving to facilitate the selection process. If necessary, a specific calculation of strength and load bearing capacity must be carried out for each application.

Depending on the operating conditions the wear lifespan may be influenced by adequate grease/oil lubrication. Please also note that insufficient lubrication may lead to scuffing of the gear flanks.

IMPORTANT

Please make sure you always check the permissible torque separately for the pinion and the gear side!
Due to their higher elasticity plastic gears are calculated with a K_{Hbeta} of 1. Gears made from brass and zinc-die-cast are also calculated with a K_{Hbeta} of 1, as a good running-in characteristic is assumed for these materials.

For the materials used, the following characteristic values were taken as basis:

Material	Perm. Pulsating Fatigue Strength under Bending Stress s_{bw} in N/mm²	Perm. Flank Pressure s_{Hlim} in N/mm²
POM	28 (VDI-2545)	40 (VDI-2545)
Polyacetal resin	28 (VDI-2545)	40 (VDI-2545)
PA12G	40	48
ZnAl4Cu1	60	150
Ms58 (2.0401)	100	250
11SMnPb30+SH (1.0718)	150	350
C45 heat treated	200	590
42CrMo4 hardened	350	1360
16MnCr5 case hardened	400	1630
X10CrNiS18 9 (1.4305, stainless, austenitic)	200	400

Real Size of the Module Teeth DIN 867 BP II (Tooth Height = 2,25 x Module)

Module 0.3

Module 0.5

Module 0.7

Module 1

Module 1.25

Module 1.5

Module 1.59 (Pitch 5 mm)

Module 2

Module 2.5

Module 3

Module 3.18 (Pitch 10 mm)

Module 4

Module 5

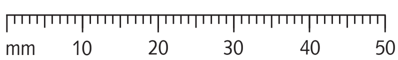
Module 6

Module 8

Module 10

Note

The dimensions are shown correctly in the print catalogue.
At an office printer, the output is normally a little bit smaller.
On a monitor, the size depends on the software, hardware and the zoom factor.



Module / Diametral Pitch / Circular Pitch - Calculation and Comparison Table

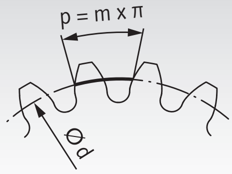
The module (m) in mm is the diameter pitch. This is the pitch circle in mm, divided by the number of teeth z.

Diametral Pitch and Circular Pitch are used in the Anglo-American measuring system.

Diametral Pitch (DP) in 1/inch is the number of teeth, divided by the pitch circle diameter in inch.

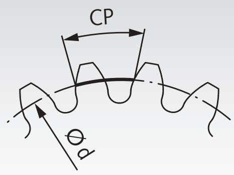
Circular Pitch (CP) in inch is the pitch, the distance from tooth to tooth, as radian measure on the pitch circle.

Module pitch



$$d = \frac{p \times z}{\pi} = m \times z$$

Circular Pitch



$$d = \frac{CP \times z}{\pi} = \frac{z}{DP}$$

$$m = \frac{d}{z} = \frac{p}{\pi} = \frac{25{,}4}{DP}$$

$$DP = \frac{z}{d} = \frac{\pi}{CP} = \frac{25{,}4}{m}$$

$$CP = \frac{d \times \pi}{z} = \frac{\pi}{DP} = \frac{p}{25{,}4}$$

m [mm] = Module
d [mm] = Pitch diameter for calculation of module
d [inch] = Pitch diameter for calculation of DP und CP
z = Number of teeth
p [mm] = Pitch (metric)
π = number Pi = 3,141592654…
DP [1/inch] = Diametral pitch
CP [inch] = Circular pitch (pitch in inch size)

In the comparison table, the basic values are indicated in bold. The values beside are the calculated measures. Some of the values with three decimal places are irrational, rounded numbers.

Module mm	DP 1/Inch	CP Inch
25,4	**1**	3,142
25,266	1,005	**3 1/8**
25	1,016	3,092
24,255	1,047	**3**
23,204	1,093	**2 7/8**
22,578	**1 1/8**	2,793
22,234	1,142	**2 3/4**
22	1,155	2,721
21,223	1,197	**2 5/8**
20,32	**1 1/4**	2,513
20,213	1,257	**2 1/2**
20	1,270	2,474
19,202	1,323	**2 3/8**
18,473	**1 3/8**	2,285
18,191	1,396	**2 1/4**
18	1,411	2,226
17,181	1,478	**2 1/8**
16,933	**1 1/2**	2,094
16,170	1,571	**2**
16	1,588	1,979
15,631	**1 5/8**	1,933
15,160	1,676	**1 7/8**
14,514	**1 3/4**	1,795
14,149	1,795	1 3/4
14	1,814	1,732
13,547	**1 7/8**	1,676
13,138	1,933	1 5/8
12,7	**2**	1,571
12,128	2,094	**1 1/2**
12	2,117	1,484
11,289	**2 1/4**	1,396
11,117	2,285	**1 3/8**
10,616	2,393	**1 5/16**
10,16	**2 1/2**	1,257
10,106	2,513	1 1/4
10	2,54	1,237
9,236	**2 3/4**	1,142
9,096	2,793	**1 1/8**
9	2,822	1,113
8,467	**3**	1,047
8,085	3,142	**1**
8	3,175	0,989
7,815	**3 1/4**	0,967
7,58	3,351	**15/16**

Module mm	DP 1/Inch	CP Inch
7,257	**3 1/2**	0,898
7,074	3,590	**7/8**
7	3,629	0,865
6,773	**3 3/4**	0,838
6,569	3,867	**13/16**
6,35	**4**	0,785
6,064	4,189	**3/4**
6	4,233	0,742
5,976	**4 1/4**	0,739
5,558	4,570	**11/16**
5,5	4,618	0,68
5,347	**4 3/4**	0,661
5,08	**5**	0,628
5,053	5,027	**5/8**
5	5,080	0,618
4,838	**5 1/4**	0,598
4,618	**5 1/2**	0,571
4,548	5,585	**9/16**
4,5	5,644	0,557
4,417	**5 3/4**	0,546
4,233	**6**	0,524
4,043	6,283	**1/2**
4	6,350	0,495
3,908	**6 1/2**	0,483
3,629	**7**	0,449
3,537	7,181	**7/16**
3,5	7,257	0,433
3,387	**7 1/2**	0,419
3,175	**8**	0,393
3,032	8,378	**3/8**
3	8,467	0,371
2,988	**8 1/2**	0,370
2,822	**9**	0,349
2,75	9,236	0,34
2,674	**9 1/2**	0,331
2,54	**10**	0,314
2,527	10,053	**5/16**
2,5	10,160	0,309
2,309	**11**	0,286
2,25	11,289	0,278
2,117	**12**	0,262
2,021	12,566	**1/4**
2	12,700	0,247
1,954	**13**	0,242

Module mm	DP 1/Inch	CP Inch
1,814	**14**	0,224
1,75	14,514	0,216
1,693	**15**	0,209
1,588	**16**	0,196
1,516	16,755	**3/16**
1,5	16,933	0,186
1,494	**17**	0,185
1,411	**18**	0,175
1,337	**19**	0,165
1,27	**20**	0,157
1,25	20,32	0,155
1,155	**22**	0,143
1,058	**24**	0,131
1,016	**25**	0,126
1,011	25,133	**1/8**
1	25,4	0,124
0,977	**26**	0,121
0,907	**28**	0,112
0,847	**30**	0,105
0,8	31,75	0,099
0,794	**32**	0,098
0,75	33,867	0,093
0,747	**34**	0,092
0,706	**36**	0,087
0,7	36,286	0,087
0,668	**38**	0,083
0,635	**40**	0,079
0,605	**42**	0,075
0,6	42,333	0,074
0,577	**44**	0,071
0,552	**46**	0,068
0,529	**48**	0,065
0,508	**50**	0,063
0,505	50,265	**1/16**
0,5	50,8	0,062
0,454	**56**	0,056
0,423	**60**	0,052
0,41	**62**	0,051
0,397	**64**	0,049
0,385	**66**	0,048
0,3	84,666	0,037
0,253	100,531	**1/32**