Epicyclic (Planetary) Gear Train Ratio

Speed ratio of a simple planetary gear set (sun, planets, ring, carrier) for any member held fixed, from the tooth numbers (Willis equation), with the planet speed.

Method: Rattan; Theory of Machines; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Sun gear teeth	24.000	
Ring gear teeth	72.000	
Member held fixed	Ring fixed (sun in, carrier out)	
Number of planets (for the equal-spacing check)	3.0000	
Input speed	1,500.0	rpm

Calculated results

Parameter	Value	Unit
Planet teeth (for equal module)	24.000	
Ratio input/output	4.0000	
Output speed	375.00	rpm
Equal spacing check for n_p planets (1 = possible)	1.0000	

Notes for this case

• Willis: (N_s − N_c)/(N_r − N_c) = −z_r/z_s. A negative ratio means the output turns the other way. Equal spacing of n planets needs (z_s + z_r)/n to be a whole number.

Formula and method

$$\frac{N_s - N_c}{N_r - N_c} = -\frac{z_r}{z_s}, \quad i_{ring\ fixed} = 1 + \frac{z_r}{z_s}, \quad z_p = \frac{z_r - z_s}{2}$$

Variables

z_s	Sun gear teeth	-
z_r	Ring gear teeth	-
fixed	Member held fixed	-
n_p	Number of planets (for the equal-spacing check)	-
N_{in}	Input speed	1/s
z_p	Planet teeth (for equal module)	-
i	Ratio input/output	-
N_{out}	Output speed	1/s
$\mathrm{assembly}$	Equal spacing check for n_p planets (1 = possible)	-

Method and standards

Willis equation.

Assumptions and limits

- Simple planetary; equal module; whole tooth numbers.
- Equal spacing of n_p planets needs (z_s + z_r)/n_p to be whole; planet undercut (fewer than 17 teeth at 20°) is flagged. Ring–planet tip interference is not checked.

References

- Rattan
- Theory of Machines
- 4th ed. (McGraw-Hill, 2014); Bhandari
- Design of Machine Elements
- 4th ed. (McGraw-Hill, 2017) (epicyclic gear trains, tabular and Willis methods)

Report details

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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/mechanical/machine-design/epicyclic-gear-ratio

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.