## **Contents**

1. Introduction		3
1.1 Terminology		3
1.2. Degree of freedom		7
1.3 Functional states of Simple PGS		9
2. Basic relations		10
2.1 Basic ratio		10
2.2 Kinematic equation		11
2.2.1 Relative speeds		11
2.2.2 Willis formulae		11
2.3 Torque and power equilibrium		13
2.4 Number of independent equations and	input parameters	14
2.5 Efficiency and losses		16
2.5.1 Lubrication losses		16
2.5.2 Tooth-friction losses		16
2.5.3 Losses in bearings		17
2.5.4 Losses in more stage transmis		18
3. Simple planetary set		19
3.1 Graphical (Kutzbach method)		19
3.2 Analytical method		21
3.2.1 Calculation of ratio and kinen	•	21
3.2.2 Calculation of power loss		21
3.2.3 Power flow in mechanism with		22
3.2.4 Torques on external elements		23
3.3 Matrix method	• • • • • • • • • • • • • • • • • • • •	25
3.3.1 Matrix of kinematics		25
3.3.2 Efficiency		26
3.3.3 Matrix of torques		26
3.4 Assembly of PGS		29
3.4.1 Number of teeth of planet		29
•		30
		33
3.4.3 Adjacency of planets	• • • • • • • • • • • • • • • • • •	33 34
4. United planetary sets	* * * * * * * * * * * * * * * * * * * *	35
4.1 Analytical method		35 35
4.1.1 Calculation of torque and effi		33 41
4.2 Matrix method		41
4.2.1 Matrix of torque for United P		
5. Nested planetary sets		48
5.1 Graphical (Kutzbach) method		48
5.2 Matrix method		49
5.3 Calculated examples of automotive ges		50
5.3.1 Mercedes-Benz W5A 580		51
5.3.2 ZF 6 HP 26	• • • • • • • • • • • • • • • • • • • •	57
6. Powersplit transmissions	• • • • • • • • • • • • • • • • • • • •	70
7. Differentials		75
7.1 Kinematics of differential		76
7.2 Torques on output shafts and total efficiency		77
7.3 Forces acting on an axle with different		80
7.4 Behaviour of differential on adhesion		80
List of symbols		86
References		87