Image from HPI Racing

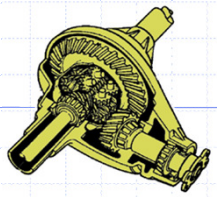


Image from JTEKT Torsen NA, Inc.

Gear Trains

Image from Fortune, Apr. 30, 2007

Image from Piaget

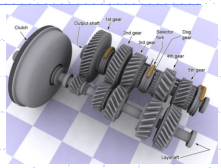


Image from ProQuest

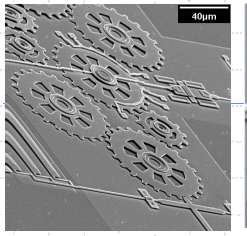


Image from Simon Fraser University

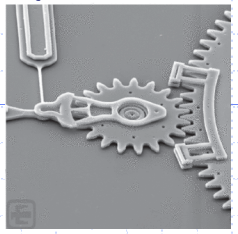


Image from blog of Haja Sherief

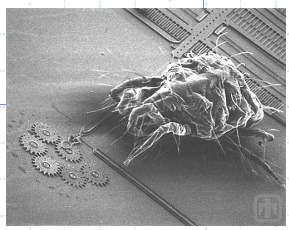
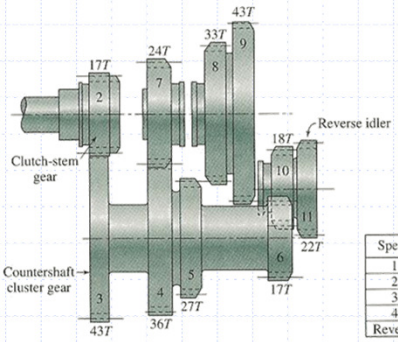


Image from Sandia National Labs

Variations on Gear Trains



Speed	Drive
1	2-3-6-9
2	2-3-5-8
3	2-3-4-7
4	Straight through
Reverse	2-3-6-10-11-9

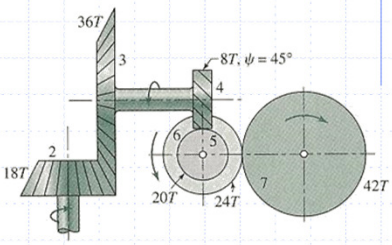
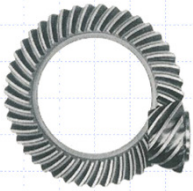


Image from carbibles.com



Gear Trains

- Gear trains are used to:

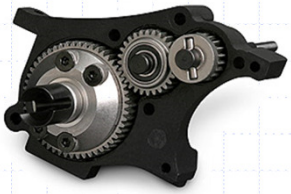
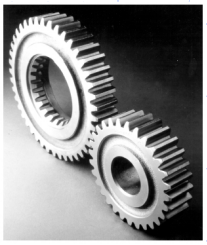


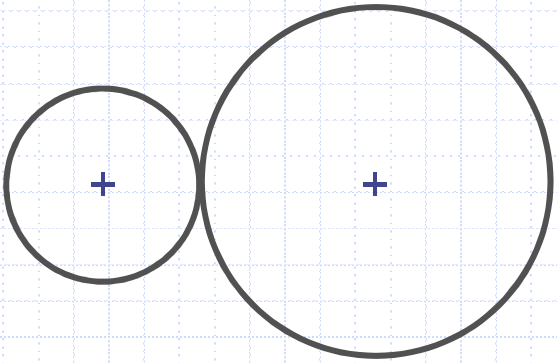
Image from HPI Racing

Image from carbibles.com

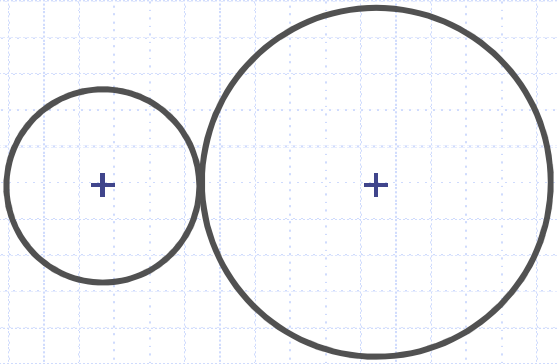
Gear Trains

- Naming and labeling:





Gear Pairs



- The angle relationship is:

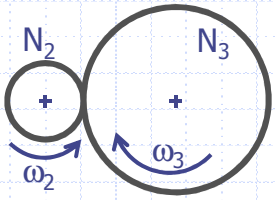
Gear Pairs

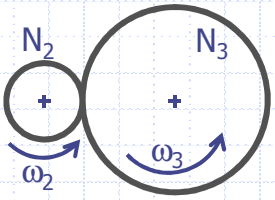
- The "Kinematic Coefficient" is the rate at which a gear rotates with respect to the input gear:

- The speed ratio is:

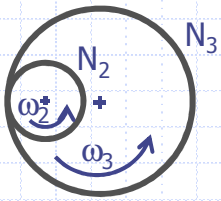
Gear Pairs

- Be careful with rotation directions:
  - For two external gears:





  - For external and internal gear pair:

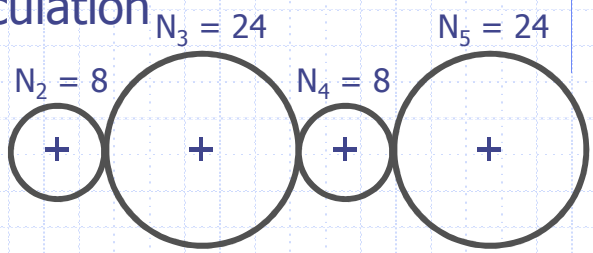


Gear Pairs

- The torque ratio is given by:

Parallel-Axis Gear Trains

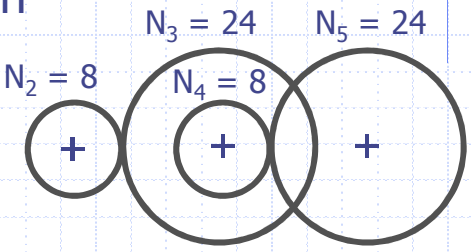
- Speed ratio calculation



- Idler gears

Parallel-Axis Gear Trains

- Speed ratio calculation

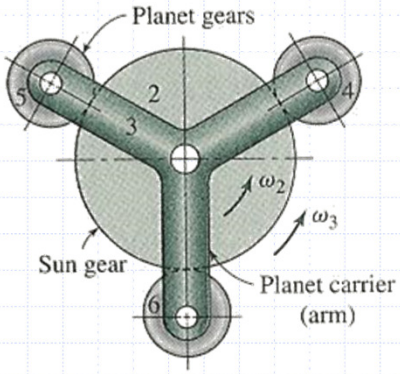


- Speed calculation

If $\omega_2 = 120$ RPM, $\omega_5 =$

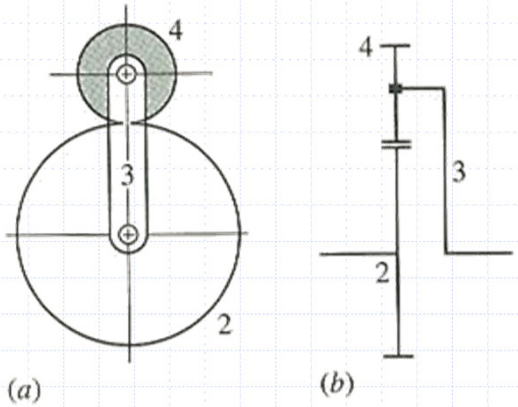
Epicyclic Gear Trains

- Also called:
- Comprised of:



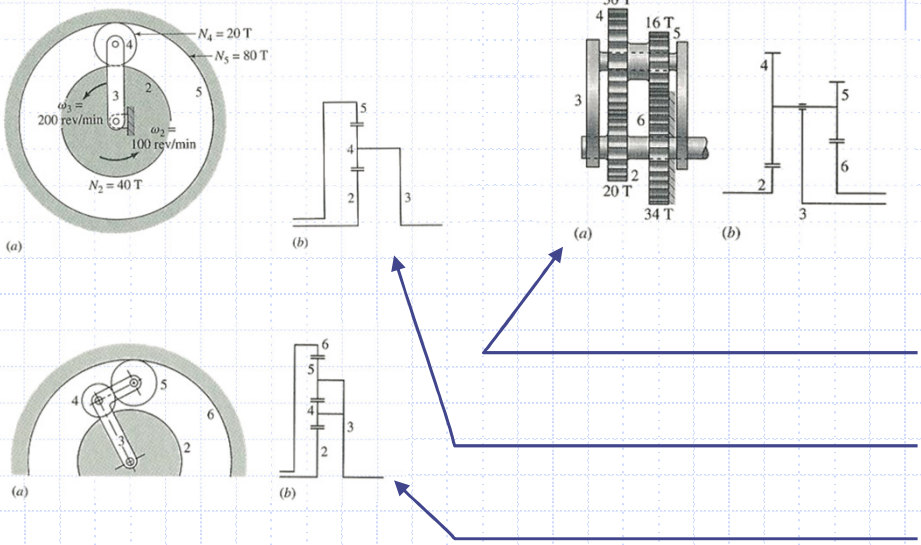
Epicyclic Gear Trains

- These can be drawn schematically



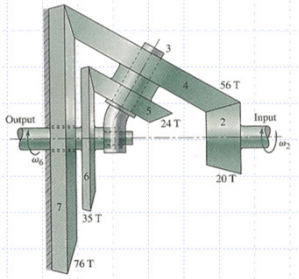
Epicyclic Gear Trains

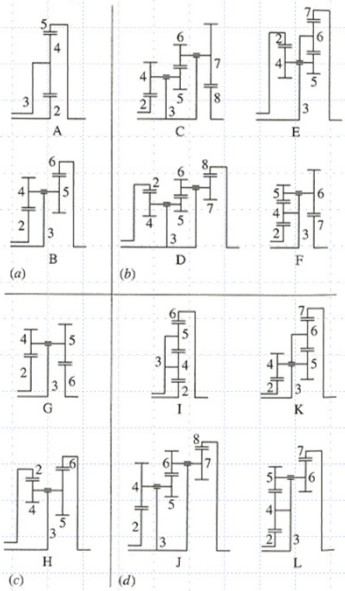
- A variety of arrangements are possible



Epicyclic Gear Trains

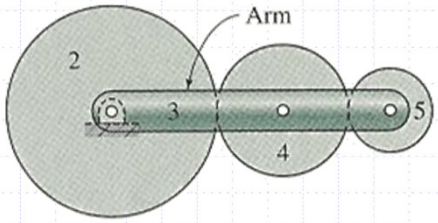
- 12 possible variations according to Lévai.
- Bevel Gear Epicyclic Trains





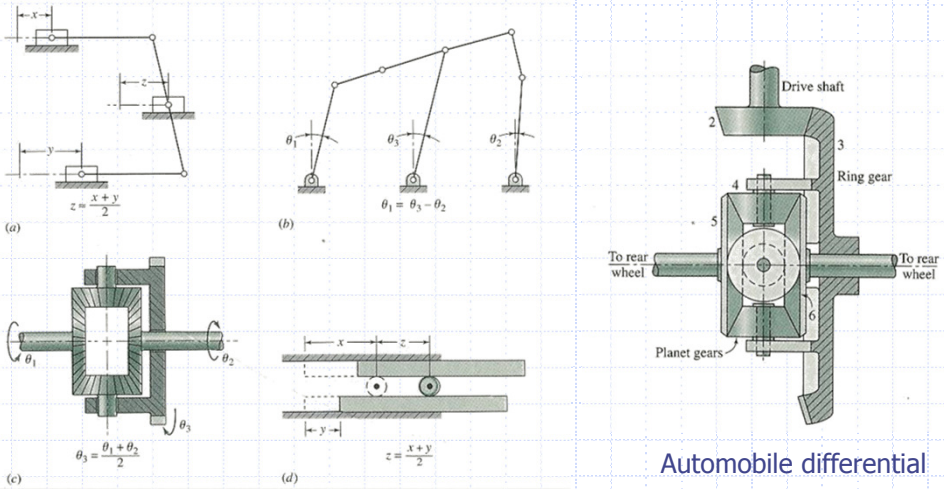
Epicyclic Gear Trains

- Speed ratio calculation



Adders and Differentials

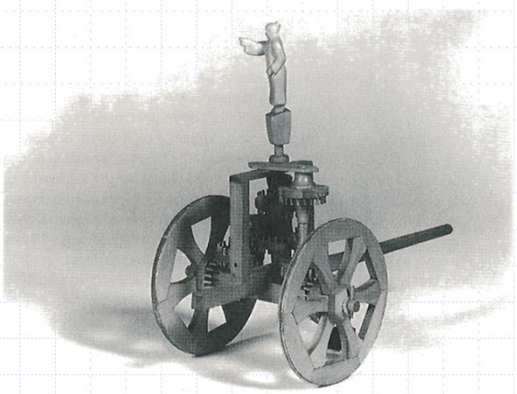
- Some variations

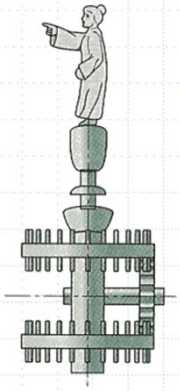


Automobile differential

Adders and Differentials

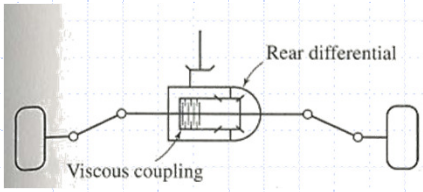
- Chinese mechanism for tracking direction.



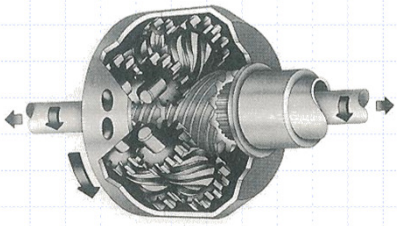


Adders and Differentials

- Limited Slip Differential



- Worm Gear (TORSEN) Differential



Designing Gear Trains

Given (typically):

- Overall speed ratio
- Input torque
- Available space
- Location of input and output shafts

Solution:

1. Choose gear arrangement (see tables from Gear Handbook).
2. Choose approximate gear ratios for each reduction.
3. Simultaneously choose pitch/number of teeth/pitch circle radii/center distances.
4. "Source" the gears.

Designing Gear Trains

Table 3-2. How to Obtain Ratios

Kind of arrangement	Min. No. of toothed parts	Ratio range		
		5:1	50:1	100:1
Single reduction:				
Spur	2	Yes	No	No
Helical	2	Yes	No	No
Bevel	2	Yes	No	No
Hypoid	2	Yes	Yes	Yes
Face	2	Yes	No	No
Worm	2	Yes	Yes	Yes
Spiroid	2	No	Yes	Yes
Planoid	2	Yes	No	No
Simple planetary	3	Yes	No	No
Fixed differential	5	No	Yes	Yes
Planocentric	2	No	Yes	Yes
Harmonic Drive	2	No	Yes	Yes

From Gear Handbook (Editor D.W. Dudley) McGraw Hill

Designing Gear Trains

Table 3-3. General Survey of Power and Efficiency

Kind of arrangement	Nominal max. hp	Typical efficiency, %		
		5:1 ratio	50:1 ratio	100:1 ratio
Single reduction:				
Spur	3,000	98		
Helical	30,000	98		
Straight bevel	500	98		
Zerol bevel	1,000	98		
Spiral bevel	5,000	98		
Hypoid	1,000	95	80	60
Crossed-helical	100	95	80	60
Cylindrical worm	750	95	80	60
Double-enveloping worm	1,000	95	80	60
Spiroid	500	95	80	60
Planoid	1,000	95		
Helicon	100	95	80	60
Double reduction:				
Spur	3,000	97	96	94
Helical	30,000	97	96	94
Spiral bevel	5,000	97	96	
Simple planetary	10,000	97		
Fixed differential	.....	...	80	60
Planocentric	.....	...	90	85
Harmonic Drive	.....	...	90	85

From Gear Handbook (Editor D.W. Dudley) McGraw Hill

Designing Gear Trains

Table 3-4. Gearbox Relative Size and Weight

Kind of arrangement	Ratio range			
	5:1	20:1	50:1	100:1
Single reduction:				
Spur, helical, bevel	Small	Small	Small	Small
Worm	.....	Small	Small	Small
Hypoid	Small	Small	Small	Small
Spiroid	.....	Small		
Planoid	Small			
Double reduction:				
Single power path, helical gears	.....	Med. size	Very small	
Multiple power path, helical gears	.....	Small		
Epicyclic gears:				
Simple planetary	Very small	Very small	Very small	Very small
Compound planetary	.....	Very small	Very small	
Double-reduction planetary	.....	Small		
Fixed differential	.....			

From Gear Handbook (Editor D.W. Dudley) McGraw Hill