

Planetary Gear Cheat Sheet

Kinematics, torque balance and the THS-II layout

ENGINEERING
CHEAT SHEET

Key equations

Quantity	Equation	Notes
Parts	Sun (S), ring (R), planets (P) on a carrier (C)	Planets mesh with both sun and internal ring gear
Speed constraint (lever analogy)	$\omega_S R_S + \omega_R R_R = \omega_C (R_S + R_R)$	Two degrees of freedom: fix any two speeds and the third follows
Torque balance (zero inertia)	$\tau_S + \tau_R + \tau_C = 0$	Article's static torque analysis
Power balance (no friction)	$\omega_S \tau_S + \omega_R \tau_R + \omega_C \tau_C = 0$	Article's conservation-of-power assumption
Torque split	$\tau_S : \tau_R = R_S : R_R$	Carrier torque divides by a fixed ratio between sun and ring
Powertrain model	Variables $m_v, v, r_w, i_f, T_{load}$; inertias J_e, J_m, J_g	Sample Problem 2 derives the governing equations; gearbox inertia ignored

Key takeaways

- Why it is used: compact, high efficiency and large transmission ratios (helicopters, wind turbines, vehicles, mining machinery).
- In automatic transmissions, a planetary train makes all required gear ratios by locking or releasing sun, ring and carrier.
- Basic sets come as single-planet and double-planet forms; the article's FAQ lists simple, compound, Simpson and Ravigneaux types.
- Toyota THS-II: sun to generator, carrier to engine, ring to motor. Modes covered: standby, smooth launch (motor only) and quick launch (generator starts the engine).
- Planet balancing matters more as manufacturing precision falls and planet count rises; floating or flexible mounts help equalise planet loads.
- Faults (cracks, pitting, wear) show up as changes in time-varying mesh stiffness and transmission error; vibration analysis is the main detection method.
- Source equations are images. The speed constraint and torque split above are the standard textbook forms, not read from the article.

Sample Problem 1 (power-split HEV)

Item	Value
Sun / ring radius	3.0 / 7.0
Engine (carrier) speed	2000 rpm
Ring speed at 100 mph	4000 rpm
Generator (sun) speed	-2,667 rpm
Note	Worked here with the constraint above; the article's solution is an image, so check it