

Slider-Crank Degrees of Freedom Cheat Sheet

Kinematic assessment of a front-end loader with rake

ENGINEERING
CHEAT SHEET

Key equations

Quantity	Equation	Notes
Degrees of freedom	$DOF = 3(L - 1) - J(3 - dof_j)$	L = links, J = joints, dof_j = freedom of each joint
Loader bucket linkage	$L = 4, J = 4 \text{ full joints} \rightarrow DOF = 3(3) - 4(2) = 1$	One motor drives it
Rake linkage	$L = 4, J = 4 \text{ full joints} \rightarrow DOF = 1$	Second motor, same arithmetic
Whole machine	2 motors $\rightarrow$ 2 DOF	One DOF per slider-crank

Key takeaways

- Both the bucket and rake mechanisms are slider-cranks, inversion #1: crank (link 2), coupler (link 3), slider (link 4), ground (link 1).
- Rotation from the motor becomes translation, which moves the arm up and down.
- The John Deere loader also has 1 DOF per linkage (same link and joint count), but uses hydraulic pistons to move the bucket.
- Design fix recorded in the article: the rake crank first connected directly, giving only three links. A coupler was added to make the fourth link and complete the slider-crank.
- Rake lift is only a few degrees, enough to clear the ground when idle; the bucket needs a steeper lift.