

Build it yourself: the quarter-gear water lifter

Print at 100% — this bar must measure 50 mm

A desk model of the machine in Category V, Chapter 1-2 of the Book of Knowledge of Ingenious Mechanical Devices (1206).

Al-Jazarī's trick: a gear with teeth on only one quarter of its rim. While those four teeth pass through the rungs of the wheel below, the ladle is lifted. When the last tooth slips free, the ladle falls back with great force, and waits three quarters of a turn. Put four quarter-wheels on one axle, each turned a quarter further than the last, and one ladle is always rising.

YOU NEED

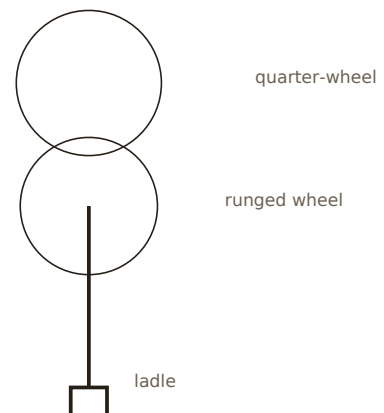
- Card: cereal-box or 2–3 mm craft card (laminates 2–3 layers for the wheels), glue stick, PVA glue, craft knife, ruler
- Upper axle: $\frac{3}{4}$ in (6.4 mm) square dowel, 100 mm for one ladle, 170 mm for four. Lower axle: 6 mm round dowel or pencil, 80 / 150 mm
- Rungs: 15 toothpicks or bamboo-skewer pieces per rung wheel (≈ 14 mm long)
- A shoebox lid or board as the base (about 150 × 180 mm). Optional: a small dish of water and a bead as a counterweight

STEPS

- 1 Print pages 2–4 at 100% (check the 50 mm bar). One ladle: pages 2, 3 once and page 4 twice. Four ladles: page 2 four times, page 4 twice.
- 2 Glue the templates onto card. Cut the solid lines. For each wheel, cut 2–3 identical layers and glue them into one thick wheel.
- 3 Quarter-wheel: cut the square hole tight so it grips the square axle. Its four teeth must be crisp.
- 4 Runged wheel: make two flanges per wheel. Pierce the 15 rung marks, push toothpicks through both flanges (about 10 mm apart) and glue. The ladle arm is part of one flange; fold and glue a scoop box from page 4 onto its tip.
- 5 Side frames: glue each frame to 2 layers of card, then stand both frames on the base, about 50 mm (one ladle) or 115 mm (four ladles) apart.
- 6 Slide the round lower axle through the lower holes with the rung wheel on it (it must spin freely). Slide the square upper axle through the upper holes with the quarter-wheel on it, right above the rung wheel, so the teeth reach the rungs.
- 7 Fix the crank on one end of the square axle and turn it: the teeth catch the rungs, the ladle rises a quarter turn, then drops back.
- 8 Four ladles: put four quarter-wheels on the square axle, turning each one a quarter turn (90°) from the last; a square axle makes this automatic. Now one ladle is always lifting, just as al-Jazarī wrote.

3D PRINTER INSTEAD?

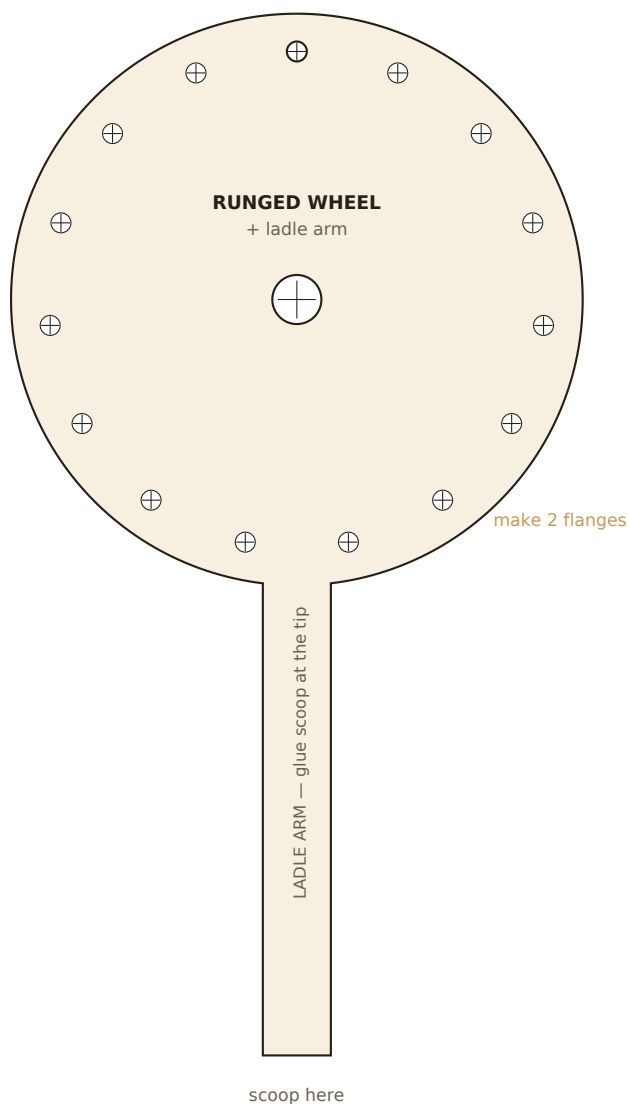
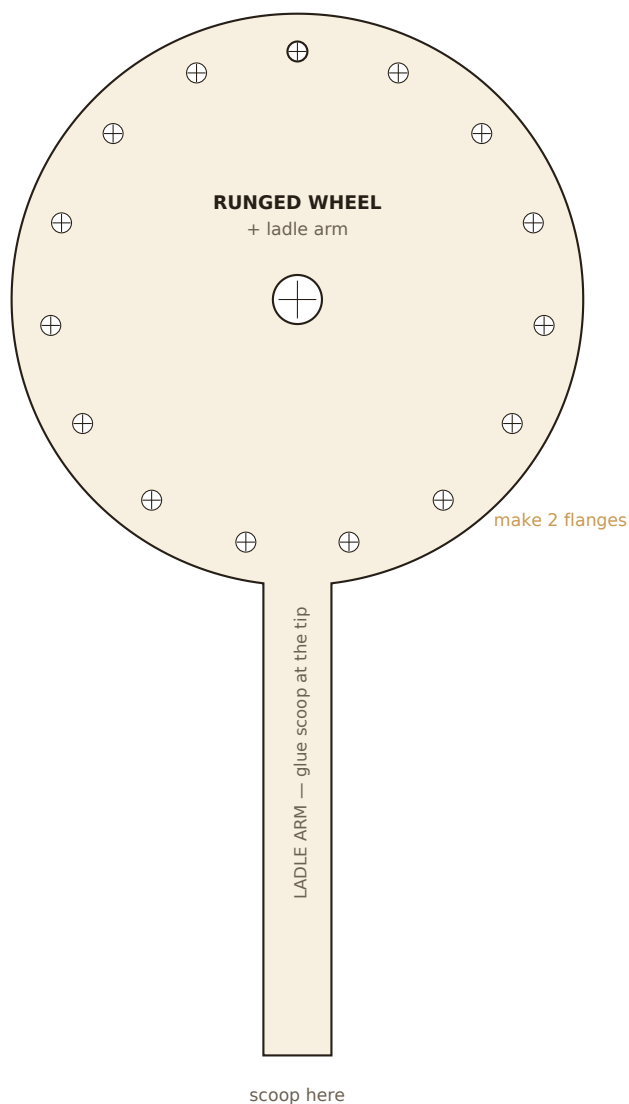
The same parts are free as STL files at aljazari.trieflow.com/build — print 4 quarter-wheels, 4 rung wheels (with ladle), 2 side frames and 1 crank. PLA, 0.2 mm layers, 3 walls, 20% infill, no supports. The rung pins are printed on.



Templates 1 · runged wheels with ladle arms

Print at 100% — this bar must measure 50 mm

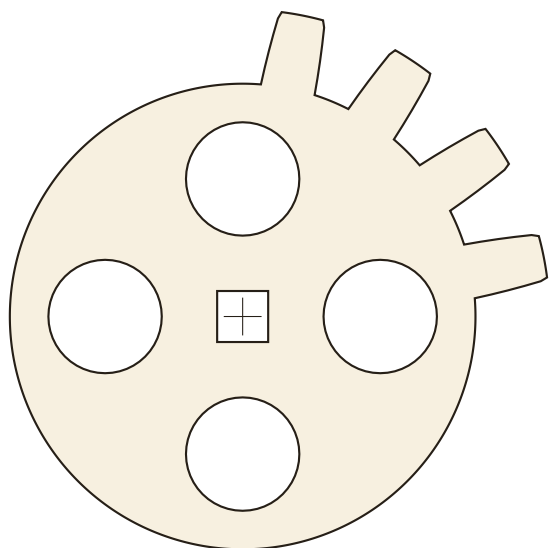
Cut solid lines. Each runged wheel needs 2 flanges. Print this page 4 times for the four-ladle machine (once per ladle: 2 flanges).



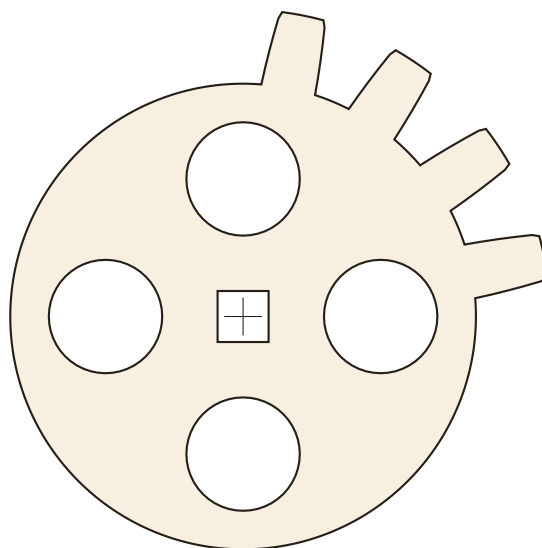
Templates 2 · quarter-wheels and crank

Print at 100% — this bar must measure 50 mm

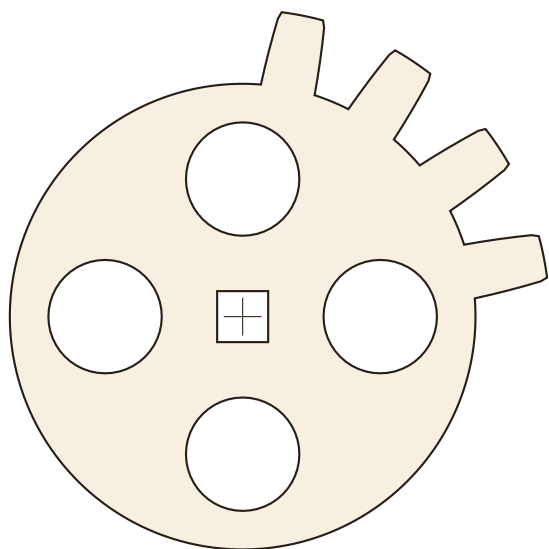
Make each quarter-wheel from 2–3 glued layers of card. Four on this page are enough for the four-ladle machine.



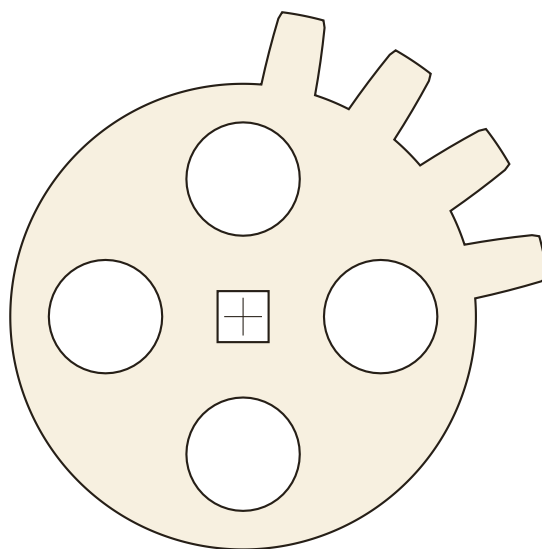
QUARTER-WHEEL A
teeth on $\frac{1}{4}$ of the rim



QUARTER-WHEEL B
teeth on $\frac{1}{4}$ of the rim



QUARTER-WHEEL C
teeth on $\frac{1}{4}$ of the rim



QUARTER-WHEEL D
teeth on $\frac{1}{4}$ of the rim

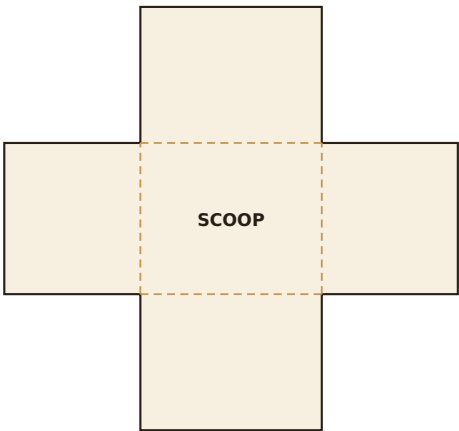
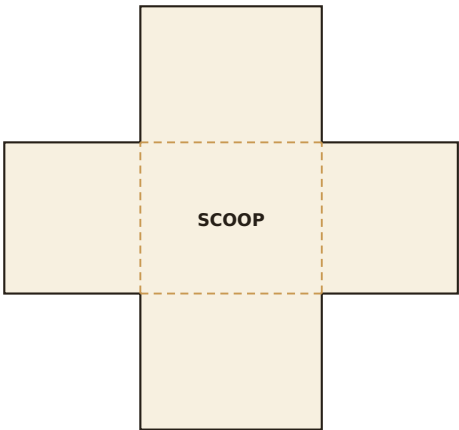


CRANK — glue a pencil stub on the circle as the handle

Templates 3 · frame and scoops

Print twice: you need 2 side frames.

Print at 100% — this bar must measure 50 mm



Fold up the four sides on the dashed lines
and tape the corners: an open box.

upper (square) axle turns here



lower (round) axle

