BUILD GUIDE

Watt Beam Engine

29 different parts, 35 prints in total, 7 steps



Before you start

A model of a Watt rotative beam engine, 252 mm long and about 25 cm tall. Turn the knob on the flywheel and the sun gear swings the planet gear round on the foot of the connecting rod. That rocks the beam, and at the other end Watt's parallel motion pulls the piston rod straight up and down in the cylinder, where you can watch the piston through a window. Behind the gears a flyball governor spins on a pair of mitre gears. Everything is held with M3 screws, and every part prints without supports.

You need

- A 3D printer and filament (PLA or PETG). The bedplate needs a 256 mm bed.
- M3 socket head screws: 3 × M3 × 8, 22 × M3 × 10, 4 × M3 × 12, 4 × M3 × 16, 1 × M3 × 25 and 1 × M3 × 30.
- 7 M3 nyloc nuts and 2 M3 washers.
- A drop of superglue for the mitre gears, the governor head, the collar and the balls, and a little grease for the gears, the beam pin and the piston.
- A 2.5 mm hex key.

Print settings

0.20 mm layer height (0.12 mm for the gears looks better), 3 walls, 15% gyroid infill, PLA or PETG material.

Every STL file is already turned the right way up for printing. Check the “Print” note for each part on the next pages.

How to read this guide

Parts you add in this step are orange with an outline.

Parts you fitted earlier are shown pale.

Safety

The engine has small parts: keep them away from small children. Keep fingers away from the gears while someone turns the knob.

All parts at a glance

Every printed part, pulled apart from where it sits. Use this view to see where a part belongs when the steps are not clear enough.



Parts list

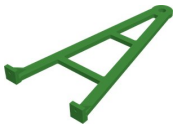


Bedplate × 1

beam-engine-bedplate.stl

The base everything stands on, 252 × 90 mm, with the plinth that closes the bottom of the cylinder. Every foot and the cylinder screw into it: the holes are tapped by the screws.

Print: Flat on the bed, plinth up. It needs a 256 mm bed (A1, P1S, X1C, MK4).



Front beam trestle × 1

beam-engine-trestle-front.stl

The A-frame in front of the beam. The beam pin runs through the eye at the top, 185 mm above the bedplate.

Print: Flat, feet up. No supports.

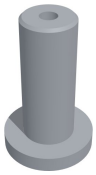


Rear beam trestle × 1

beam-engine-trestle-rear.stl

The A-frame behind the beam, with an arm that carries the fixed pin of the radius rod. That pin is the one point of the parallel motion that does not move.

Print: Flat, feet up. No supports.



Beam pin × 1

beam-engine-beam-pin.stl

Ø8 mm pin the beam rocks on, with a head at the back and an M3 screw and washer at the front.

Print: Standing on its head.

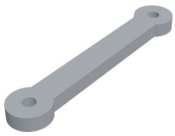


Beam × 1

beam-engine-beam.stl

170 mm between the end pins, deeper in the middle like a cast iron beam, with a sunk panel on the front. The pins for the connecting rod, the main link and the back link are tapped M3.

Print: Front face up. No supports.



Link × 2

beam-engine-link.stl

Two of them, 50 mm between the holes: the main link hangs from the end of the beam to the piston rod, the back link from the beam to the radius rod.

Print: Flat.

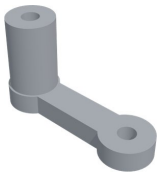


Parallel bar × 1

beam-engine-parallel-bar.stl

Joins the foot of the back link to the head of the piston rod, so the links form a parallelogram that copies the straight line 2.5 times larger.

Print: Flat.



Radius rod × 1

beam-engine-radius-rod.stl

22.7 mm between the holes. It swings round the fixed pin on the rear trestle and holds the foot of the back link on a straight line. The long boss keeps the links in place on their pin.

Print: Flat, boss up.



Cylinder × 1

beam-engine-cylinder.stl

Ø40 mm bore with flanges top and bottom, a valve chest at the back and a tall window at the front so you see the piston. It stands on the plinth of the bedplate, which closes its bottom.

Print: Standing on its bottom flange. The window has a pointed top and the valve chest a 45° underside: no supports.

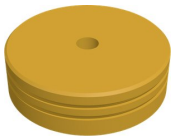


Cylinder cover × 1

beam-engine-cylinder-cover.stl

The top of the cylinder with the gland the piston rod slides through.

Print: Flat, gland up.



Piston × 1

beam-engine-piston.stl

Ø39.4 mm with two ring grooves. An M3 × 12 from below holds it on the piston rod.

Print: Flat, crown down.



Piston rod × 1

beam-engine-piston-rod.stl

Ø6 mm rod with a flat eye at the top for the pin of the parallel motion.

Print: Lying on its flat side.

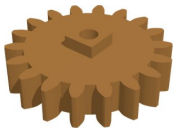


Connecting rod × 1

beam-engine-connecting-rod.stl

117 mm from the beam pin to the centre of the planet gear, with a square pocket for the planet's key.

Print: Flat, the pocket down.



Planet gear × 1

beam-engine-planet-gear.stl

18 teeth, module 1.5. Its square key fits the rod one way only, so it swings with the rod but never spins on its own: that is the whole trick of the sun and planet.

Print: Flat, key up.



Sun gear × 1

beam-engine-sun-gear.stl

18 teeth, module 1.5, on the front end of the shaft. Its screw sinks into the front face, because the rod sweeps over it.

Print: Flat.



Orbit link × 1

beam-engine-orbit-link.stl

Turns freely on the shaft and holds the planet on the sun, 27 mm out.

Print: Flat.



Shaft × 1

beam-engine-crankshaft.stl

The flywheel shaft: a D of Ø10 mm, 62 mm long, tapped at both ends.

Print: Lying on its flat.



Shaft A-frame × 2

beam-engine-crank-stand.stl

Two of them carry the shaft, one in front of the flywheel and one behind the gears.

Print: Flat, foot up.



Flywheel × 1

beam-engine-flywheel.stl

Ø112 mm, six spokes, with a long hub that rests against the rear A-frame and a boss for the knob.

Print: Back face down, hub up.



Knob × 1

beam-engine-handle.stl

The knob you turn the engine by. It spins on an M3 × 25 in the back of the flywheel.

Print: Standing on its base.



Mitre gear × 2

beam-engine-mitre-gear.stl

Two of the same, 16 teeth, module 1.5: one on the shaft, one on the governor spindle.

Print: On the small face, hub up: the teeth flare out at 45°.



Governor stand × 1

beam-engine-governor-stand.stl

An upright with two eyes the governor spindle turns in.

Print: Lying on its back. The eyes have pointed tops.

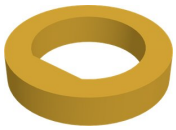


Governor spindle × 1

beam-engine-spindle.stl

A D of Ø10 mm, 80 mm long.

Print: Lying on its flat.

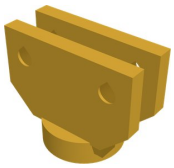


Spindle collar × 1

beam-engine-collar.stl

Glued on the spindle just above the lower eye, so the spindle hangs on it and not on the gears.

Print: Flat.



Governor head × 1

beam-engine-governor-head.stl

Sits on top of the spindle; the two arms swing in its slot on M3 screws.

Print: Standing up, hub down.

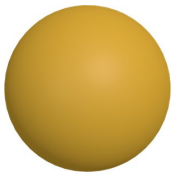


Ball arm × 2

beam-engine-ball-arm.stl

Two of them, with a square peg for the ball and a hole for the link.

Print: Flat.



Ball × 2

beam-engine-ball.stl

Ø13 mm, glued on the arm's peg.

Print: On its flat.



Governor link × 2

beam-engine-governor-link.stl

Two of them, from the middle of each arm to the sleeve.

Print: Flat.



Sleeve × 1

beam-engine-sleeve.stl

Slides on the spindle. In a real engine it would rise with the balls and close the steam valve.

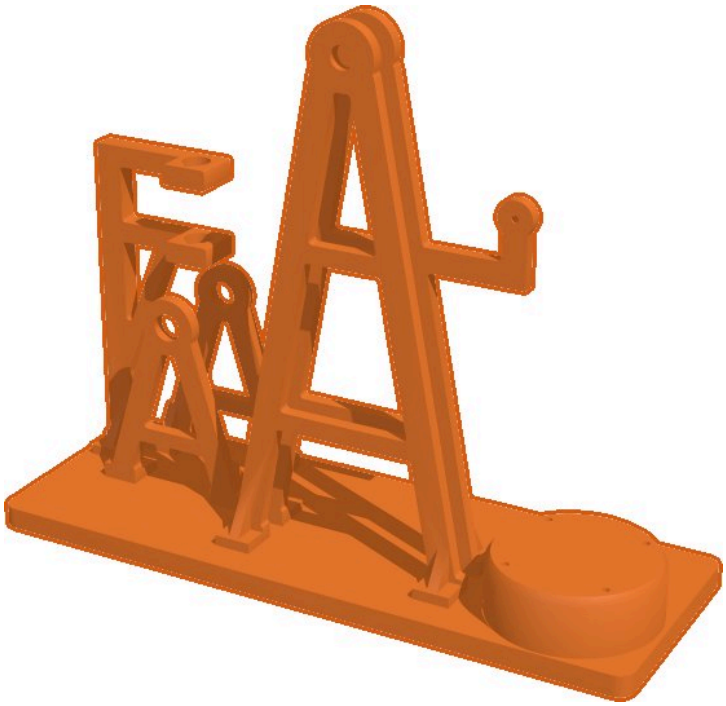
Print: Standing up.

1 Print the parts

Nothing needs supports. Only the bedplate needs a 256 mm bed. Clean any elephant's foot off the gears, the piston and the shaft, and check that the shaft and the spindle turn freely in their holes.

2 Frames on the bedplate

Screw the two beam trestles, the two shaft A-frames and the governor stand to the bedplate with M3 × 10 screws through their feet. The screws cut their own thread.



3 Cylinder

Push the piston rod down through the gland of the cover, slide the piston into the cylinder from below and fix it to the rod with an M3 × 12. Screw the cover on with four M3 × 10, then stand the cylinder on the plinth and screw it down with four more.



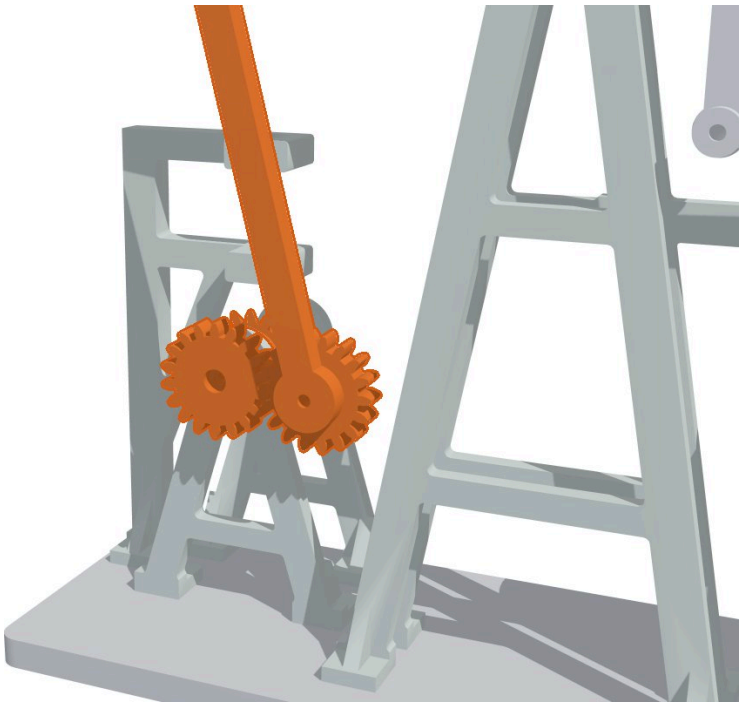
4 Beam and parallel motion

Hang the beam between the trestles on the beam pin and fix the pin with an M3 × 8 and a washer. Screw the main link and the back link to the beam (M3 × 12), the radius rod to the arm of the rear trestle (M3 × 10), then join the foot of the back link, the parallel bar and the radius rod with the M3 × 30 and a nut, and the main link, the parallel bar and the piston rod eye with an M3 × 16.



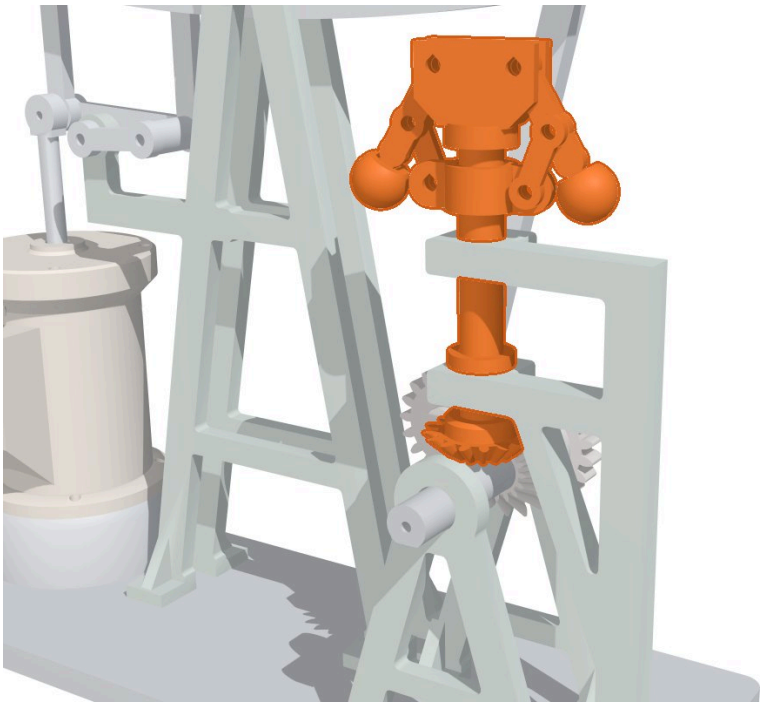
5 Shaft and gears

Slide the shaft through both A-frames from behind with the mitre gear between them, flat of the D down. Put the orbit link and then the sun gear on the front end and fix the sun with an M3 × 8. Push the planet's key into the pocket on the back of the connecting rod, hang the rod from the beam (M3 × 12), mesh the planet with the sun and screw rod and planet to the orbit link with an M3 × 16.



6 Governor

Glue the balls on the arms. Bolt the arms into the head and the links between the arms and the sleeve (M3 screws with nyloc nuts, just tight enough to swing). Push the spindle down through the upper eye, slide the collar on between the eyes and the spindle on through the lower eye, then glue the collar against the lower eye. Put the sleeve on the top, push the head on and glue it, then push the second mitre gear on the bottom, meshed with the first, and glue it.



7 Flywheel

Push the flywheel on the back of the shaft until its hub touches the A-frame, fix it with an M3 × 8 and a washer, and screw the knob on with the M3 × 25. Leave the knob loose enough to spin. Turn the knob: the beam rocks, the piston goes up and down and the governor spins.



Finished

Enjoy building it, and enjoy showing it off. If anything is unclear or a part does not fit, write to info@shapekit.cc and we will help you out.