Contents

100

06 SPARK

06 **Top Projects**
Special things made by special people

18 **Objet 3d'art**
3D-printed magnificence

20 **Meet the Maker:** Ivan Kuleshov
Clustered computing, developed in the open

26 **Letters**
FreeCAD, ion thrusters, and upcycling

28 **Crowdfunding now**
A voice-activated 3D printer!

31 LENS

32 **Retro Computers Reborn**
Remake the glory days of switches and blinkenlights

44 **Gears**
Control rotational force through mathematics

50 **Interview:** Jude Pullen
How to make things without damaging the world

58 **Improviser's Toolbox:** Bamboo
What to do with nature's scaffolding poles

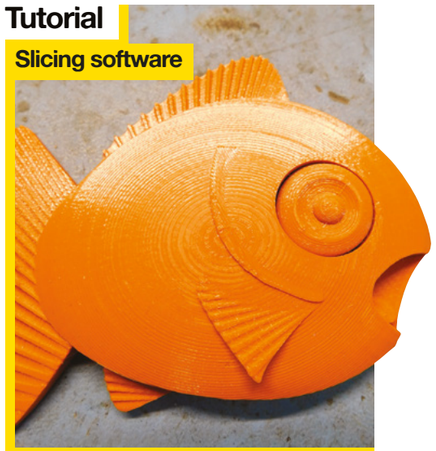
62 **In the workshop:** Failure and success
Flexible LED filament is harder than it looks

Cover Feature

The kits, the builds, and the computers that inspired them: retro computers are making a comeback!

32

Tutorial
Slicing software

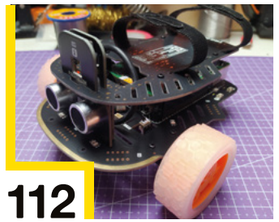


94 Discover the slicer options that can make or break your prints

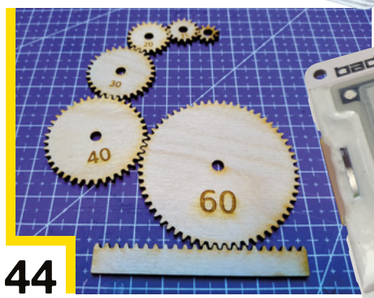
18

62

106



112



44

In the workshop
Bean slicer

62 Failure in our workshop gives rise to beautiful success

Interview
Jude Pullen

50 Product design tips from a master of the craft

110

67 FORGE

68 **SoM** Analogue output
Output a range of voltages with a bunch of resistors

74 **Tutorial** Emotional LEGO
Build a face that reacts to its environment

82 **Tutorial** Earth communications
Send messages through the earth

88 **Tutorial** K40 laser cutter
Better; stronger; faster; safer

94 **Tutorial** Slicing options
Make prints smoother, lighter, and faster

99 FIELD TEST

100 **Best of Breed**
Great gear for gardening geeks

106 **Review** Pimoroni Badger
Tiny e-ink display powered by RP2040

110 **Review** Shaper Origin
An incredibly cool handheld CNC router

112 **Review** Pimoroni Trilobot
A programmable Triassic-inspired robot

Some of the tools and techniques shown in HackSpace Magazine are dangerous unless used with skill, experience and appropriate personal protection equipment. While we attempt to guide the reader, ultimately you are responsible for your own safety and understanding the limits of yourself and your equipment. HackSpace Magazine is intended for an adult audience and some projects may be dangerous for children. Raspberry Pi (Trading) Ltd does not accept responsibility for any injuries, damage to equipment, or costs incurred from projects, tutorials or suggestions in HackSpace Magazine. Laws and regulations covering many of the topics in HackSpace Magazine are different between countries, and are always subject to change. You are responsible for understanding the requirements in your jurisdiction and ensuring that you comply with them. Some manufacturers place limits on the use of their hardware which some projects or suggestions in HackSpace Magazine may go beyond. It is your responsibility to understand the manufacturer's limits.
HackSpace magazine is published monthly by Raspberry Pi Ltd, Maurice Wilkes Building, St. John's Innovation Park, Cowley Road, Cambridge, CB4 0DS, United Kingdom. Publishers Service Associates, 2406 Reach Road, Williamsport, PA, 17701, is the mailing agent for copies distributed in the US and Canada. Application to mail at Periodicals prices is pending at Williamsport, PA. POSTMASTER: Send US and Canadian address changes to HackSpace magazine c/o Publishers Service Associates, 2406 Reach Road, Williamsport, PA, 17701.