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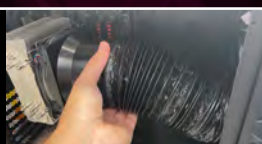

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Welcome

Custom PC Issue 229

/ FROM THE EDITOR

Back to basics

Every PC builder has to start somewhere, and I know from past experience that many people will be starting their computer construction journey with this 'PC building masterclass' issue of **Custom PC**. If this is the first issue of **Custom PC** you've ever picked up off the shelf, then I'd like to welcome you to the world of custom computers, where you get the exact spec of PC you want, and the satisfaction of knowing you've built it all yourself.

It's for this reason that our lead feature this month (see p72) goes back to the basics of PC building. Don't worry, that doesn't mean it's going to be several pages of patronising drivel with no substance. Rather, it's going to be taking you through every step of the build process, from start to finish, without taking any previous high-tech knowledge for granted.

Along the way we'll show you the best ways to install all your components, fit your CPU cooler, test your hardware and tidy all your cables. We'll tell you what tools you'll need, the functions of all the major plugs and sockets, and we'll also show you how to install Windows and get your PC set up.

Even if you've built a fair few PCs before, there are also plenty of people who might be out of the loop and are thinking about upgrading from an old system. They might know all about fitting a SATA SSD, but may have never seen an M.2 port before, for example, or perhaps they don't know the best way to mount the radiator for an all-in-one liquid cooler.

This is a fast-moving industry, where standards change quickly, as do the best methods of installing hardware. The best techniques for applying thermal paste have changed several times over the past decade, for example, as CPUs have radically evolved.

Whatever your level of PC-building experience, we hope that this issue tells you all you need to know about building your next PC, whether it's a basic setup for your student digs, or a top-end 4K gaming rig. You'll also want to keep this issue on hand for the next year or so, as we'll be referring back to it in our future, more specialist build guides. CPC

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Raspberry Pi PRESS

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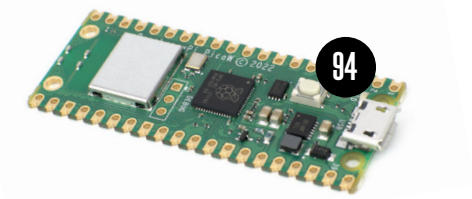

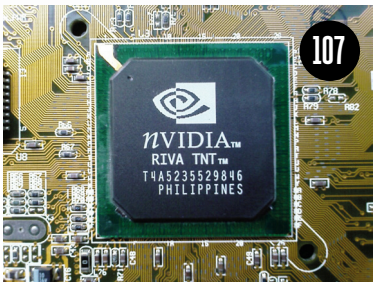

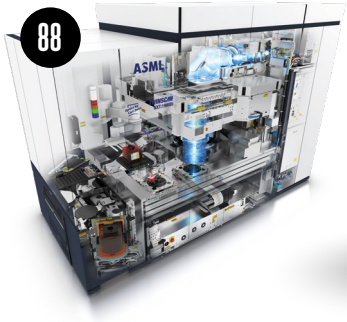

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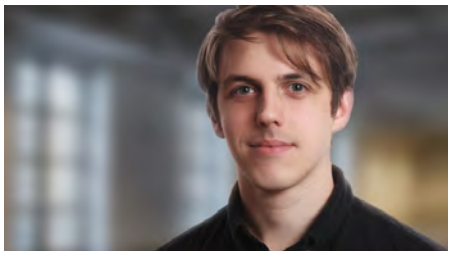

RICHARD SWINBURNE / VIEW FROM TAIWAN

CURRENT CHIPS ARE FINE

New PC tech might be on the horizon, but there's still plenty of life left in current-gen components, argues Richard Swinburne

Intel's 13th-gen CPUs, AMD's Ryzen 7000-series CPUs and possibly Nvidia's RTX 4000-series GPUs are a month or two away, but if you're looking for a cost-conscious build that maximises price-performance, you've most likely been holding out for the past few years while GPU prices have been extortionate.

However, I think current-gen hardware is definitely worth a closer look, despite all the new hardware on the horizon. As one example, MSI has just launched its MAG B660M Mortar Max WIFI DDR4 motherboard, which includes an external clock generator. This enables you to overclock 12th-gen non-K-series CPUs, giving the venerable Core-i5 12400F a shot at hitting 5GHz.

Some other boards could do this already, but they were expensive and used DDR5 memory, whereas the new Mortar Max promises to be much more affordable and uses cheap DDR4 memory. What's more, if the forecasts for September and October ring true, DDR4 memory will only get cheaper.

This enables you to overclock 12th-gen non-K-series CPUs

Current-gen graphics cards are continuing to drop in price too, so you could now build a cheap PC with a solid spec that will see you through the upcoming years, with room to upgrade to an Intel 13th-gen CPU later. Normally, we'd advise holding out for a next-gen GPU now, but the past two years have set a precedent of MSRPs rising for equivalent next-gen cards compared with their predecessors – Nvidia and AMD's mid-cycle refreshes saw a consistent bump in prices.

Meanwhile, TSMC has issued several rounds of silicon wafer price rises that continue through next year, and the leading-edge processes making these GPUs are costlier than their predecessors. In addition, it's rumoured that the forthcoming generation of GPUs will raise power budgets higher than ever, which will add further cost to the cards, as you'll need high-quality PCBs and power management chips that can cope. While performance will definitely improve, I'll be surprised if we see any price-performance winners, and existing generations will co-exist alongside new cards to fill the lower price brackets.

What's more, there's potentially some good news for owners of existing AM4 systems. The rumour mill has been fired up with fresh talk that AMD might be bringing some new Zen 4 cores to the veteran AM4 platform. We don't know what sort of numbers are involved yet, but there's word that AMD needs to accommodate the aggressive cost targets of the Chinese market, and that new AM5 motherboards with DDR5 memory will be just too expensive.

AMD would need to partner a Zen 4 core complex die with an older Zen 3 I/O die to make it work, and its chiplet design and common interconnect system certainly makes this possible. This seems wholly plausible, so I give the rumour a decent likelihood of happening. If they exist, we'll then be able to see the direct performance difference between the two platforms, so we can evaluate Zen 4's real advantage over Zen 3 without the help of faster memory.

However, AMD has also developed a method to completely lock its CPUs into a single motherboard, so even if these chips exist, they might only see the light of day in OEM platforms. While AMD's OEM CPUs have so far been limited to its business-only 'Pro' CPUs, this aberrant design has already been condemned for preventing people from recycling perfectly good CPUs when those systems reach the end of their useful lives. Let's hope AMD sees reason and doesn't extend its use further. **CPC**

Richard has worked in tech for over a decade, as a UK journalist, on Asus' ROG team and now as an industry analyst based in Taiwan @ricswi

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TRACY KING / SCEPTICAL ANALYSIS

LOST NIGHT OF THE PROMS

Tracy King discusses the snobbery surrounding game soundtracks in classical music circles

After two years of postponed or avoided gigs, I finally got back into live music a few months back. The band Meshuggah were playing on the Jubilee weekend at The Royal Albert Hall. If you haven't been to the Royal Albert Hall, it's renowned for its grandeur and acoustics. The interior is all gold leaf and red velvet, and the ceiling looks like a classy spaceship. It's a great venue, but it was odd seeing an extreme metal band in a venue most famous for classical music.

I had a laugh to myself imagining what some of the more uptight members of the Proms would think about it. I like classical music too, but some of the snobbery around it winds me up. I'm not a great fan of tradition for its own sake, and classical music is a genre rather than an era, so there's no reason other than personal preference to claim it can't – or shouldn't – include compositions or arrangements of contemporary music too.

The Telegraph recently published an article headlined: 'Why is the BBC intent on ruining the Proms?' – an opinion piece by a senior journalist that starts off complaining that the Proms included classical covers of pop, soul and jazz songs, and then *record scratch* suggests that 'the first ever Gaming Prom' is something so ruinous, it will destroy the BBC itself'.

'An electronically expanded Royal Philharmonic Orchestra explores the musical universe of gaming: from the classic console titles of the 1980s to the European concert premiere of a suite from Battlefield 2042,' he complains derisively, while I'm sitting there thinking, 'ooh where can I see that?' (BBC Four, Friday, 5 August, thereafter on iPlayer).

Video game music has a long and wonderful history that intersects with classical music – the composer Eímear Noone hosts the popular gaming music show High Score (I see what they did there) on Classic FM, and games have been credited with introducing classical music to entirely new generations who might not otherwise have gone to the Royal Albert Hall.

And this is precisely why the Proms was founded (even allowing smoking in the auditorium to make it more attractive) in 1890. The entire point of the Proms was to introduce people to new music, and that presents a golden opportunity.

> This is precisely why the Proms was founded

Video game live orchestra events are now huge, particularly in Europe and Japan. The Symphonic Game Music Concerts, which originated in Germany, have toured the world, and Nintendo even sponsored an educational school tour to teach kids about classical and game music. This is obviously good for the classical music genre, a gateway to Beethoven. Classical music snobs should embrace the new generation who will buy a ticket to a 100-piece orchestra because of video game music.

One of the most famous Proms conductors, Henry Wood, was often criticised for including the 'wrong' sort of music, saying of critics, 'I got very fed up with them, always finding fault with any arrangement or orchestrations that I made ... "spoiling the original" etc.'

In 1929, he played a prank in which he passed off one of his own arrangements of a Bach piece as a transcription by a Russian composer. It worked, and he didn't reveal the truth for five years.

It would be hard and arguably unethical to do that now, but we have to acknowledge that it would be very funny to sneak a composition from Final Fantasy into the Proms and tell the Telegraph critic that it's Brahms. CPC

Gamer and science enthusiast Tracy King dissects the evidence and statistics behind popular media stories surrounding tech and gaming @tkingdot

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Incoming

ALIENWARE TOUTS 480Hz LAPTOP

If you thought that 360Hz refresh rates were bordering on the silly side, then you'll want to give some serious side eye to Alienware's new 480Hz laptop. The company's new m17 R5 has beaten the rest of the field to hit the 480Hz figure on its 1,920 x 1,080 screen.

While that's a great headline number for marketing, though, you'll need some serious GPU power (and undemanding games) to sync your GPU's frame rate with the screen, and it's highly unlikely you'll see much difference between 360Hz and 480Hz.

A number of spec options are available, with a choice of 8-core AMD Ryzen 7 6800H or 6900HX CPUs, and various Nvidia and AMD GPU options. However, you can only specify the 480Hz panel with an Nvidia GPU at the moment, and you'd need the top-end RTX 3080 Ti option if you wanted to even have a chance of hitting 480fps. An m17 R5 with this spec currently costs £3,099 inc VAT from **dell.co.uk**

LIAN LI MAKES FULL-TOWER LANCOOL CASE

Lian Li has updated its award-winning line-up of Lancool cases with a full-tower model. The Lancool III has three 140mm PWM intake fans in the front as standard, as well as a 140mm PWM exhaust fan. Making room for fans and cooling gear is clearly Lian Li's main goal with the new case, with room for a 360mm radiator in the top, front and bottom of the chassis.

The spacious interior also has room for an E-ATX motherboard up to 280mm wide, and a graphics card up to 420mm long. There's plenty of room for storage too, with the ability to accommodate four 3.5in hard drives and eight 2.5in SSDs simultaneously.

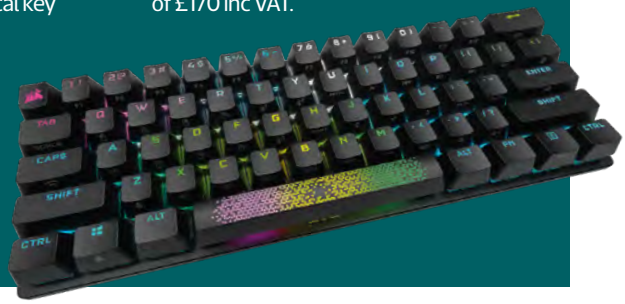
Meanwhile, hinged side panels make for easy access, and they're split, with separate hinged panels for the PSU area and motherboard tray. Prices for the Lancool III start at £150 inc VAT from **overclockers.co.uk**, with an extra tenner buying you a version with RGB fans.

CORSAIR SHRINKS K70 FURTHER

Following on from the award-winning tenkeyless version of the K70 (see Issue 214, p31), Corsair has shrunk the design further to create a 60 per cent form factor version. The new K70 Pro Mini Wireless retains the premium aluminium frame of its bigger siblings, and comes with a choice of Cherry MX Red or Speed key switches, which you can also hot-swap with other standard mechanical key switch designs.

Meanwhile, the switches are topped with double-shot PBT keycaps, which can also be replaced with keycaps of your choice. Other features include per-key RGB lighting, as well as an RGB lighting strip around the edge of the frame.

The keyboard can either be connected with a detachable USB Type-C cable, or wirelessly, with Corsair claiming a 32-hour battery life with the RGB lighting or 200 hours with the backlight disabled. The Corsair K70 Pro Mini Wireless is available now from **scan.co.uk** for a price of £170 inc VAT.



REBATE ON RTX 3090 Ti CARDS

Nvidia has started offering a £280 rebate on purchases of its top-end GeForce RTX 3090 Ti Founders Edition card. While that might seem pretty generous on the face of it, the card already costs £1,879 inc VAT, so that's still £1,599 for a card that isn't massively quicker than the £1,049 GeForce RTX 3080 Ti in games (see Issue 226, p19).

We'd also advise against spending so much money on a high-end graphics card when the next generation of GPUs is on the horizon, but if you want the current fastest GPU available, you can get your card and rebate from **store.nvidia.com** now.

ADATA SHOWS OFF PCI-E 5 SSD

ADATA has lifted the lid on its first PCI-E 5 SSD, quoting a colossal sequential read speed of up to 14GB/sec. The XPG PCIe GEN 5 uses a Silicon Motion SM2508 controller, and comes in capacities up to 8TB. The drive uses four PCI-E 5 lanes to hit its top speed, and supports the new NVMe 2 protocol.

ADATA has also quoted a sequential write speed of up to 12GB/sec for the drive, while 4K random read and write speeds are quoted at 1.8 million IOPS and 1.6 million IOPS respectively.

KINGSTON UNVEILS 6400MHz MEMORY

Kingston has launched a new line-up of DDR5 RGB memory modules, with effective speeds of up 6400MHz. The new Kingston Fury Renegade DDR5 RGB modules also feature RGB lighting, and come with 32-39-39 latency timings. The modules require a voltage of 1.4V and also supports Intel's new XMP 3 profile system.

A 32GB kit of 6400MHz Fury Renegade DDR5 RGB memory will currently cost you £271 inc VAT from **cclonline.com**, with the equivalent 6000MHz kit going for £236 inc VAT.

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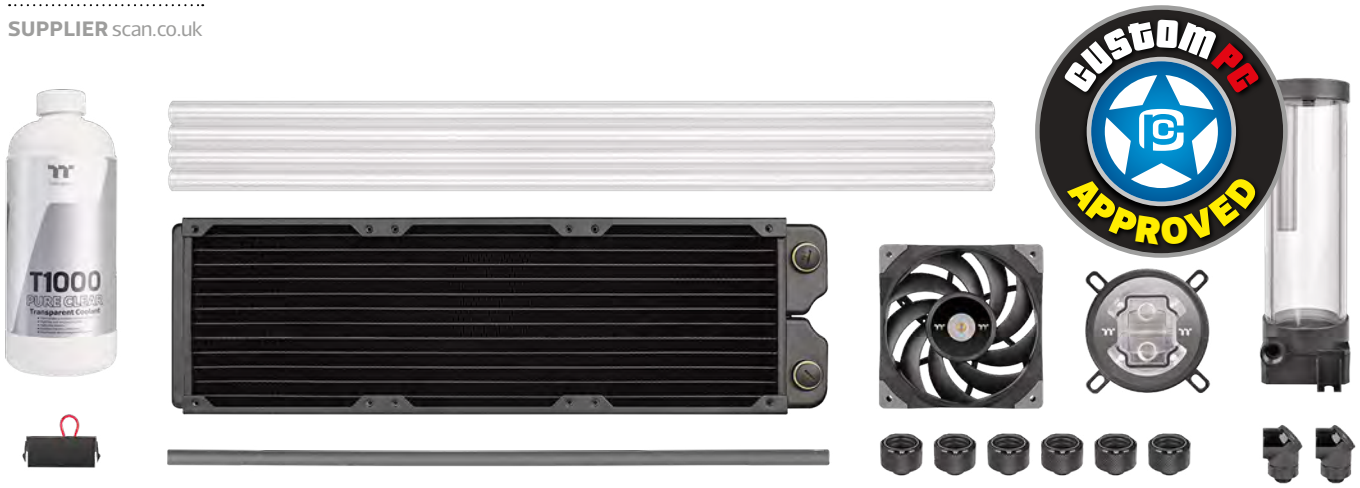


We're big fans of water cooling here at **Custom PC**, and with a greater choice of components now than ever, catering for all manner of builds, it's now relatively easy and safe to water-cool your PC these days too. That said, picking the right components and ensuring every part is compatible can still be a challenge, so water-cooling kits can often be a good place to start.

The Thermaltake Pacific Tough C360 DDC retails for a slightly eye-watering price of £411 inc VAT, but it offers an easier route to building your dream PC than buying all the parts separately. There's some serious kit in the box too, as you'd expect at this price.

SPEC

Intel compatibility
LGA1700, LGA115x, LGA1200, LGA2066, LGA2011, LGA1366

AMD compatibility
Socket AM4, AM3/+, AM2/+, FM2, FM1

Radiator size with fans (mm)
119 x 399 x 55 (W x D x H)

Fans
3 x Thermaltake Toughfan 12 120mm

CPU waterblock
Thermaltake Pacific W7

Reservoir/pump
Thermaltake Pacific PR22-DDC

Radiator
Thermaltake Pacific C360 Copper

Coolant
Thermaltake T1000 Pure Clear

Tube type
Rigid PETG

Tube dimensions
16mm OD, 12mm ID

The tube

First and foremost, this is a rigid-tubing kit that includes PETG rigid tubing that you'll need to bend into shape. While the kit includes a tubing insert to prevent kinks when you're bending it, you'll need to invest in a heat gun, as this isn't included, probably as it's too big and would mean doubling the width of the already hefty box. You'll also need to invest in tube-bending guides in order for you to hit the right angles once the tubing is heated, unless you intend to eyeball the bends freehand.

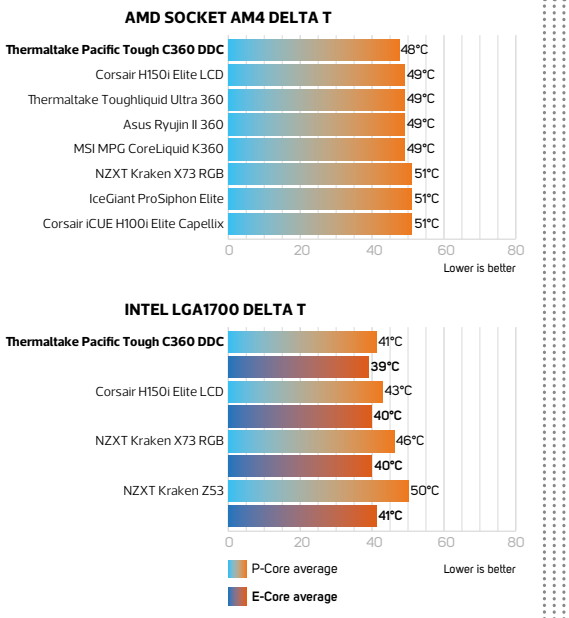
One other essential tool that isn't included in the box is a fine-tooth hacksaw to cut the tube to length, although you may already have one of these, and they're not expensive to pick up from a DIY store.

Seeing as you'll have to provide your own cutter anyway, and as PETG tubing is relatively soft, a tube or pipe cutter would make for a sensible additional purchase, making for quicker and easier tube cutting.

In addition, there's no tube reamer included in the box to smooth the inner and outer edges of the tubing, which is needed to remove sharp edges once they're cut, so they pass through the O-rings more easily. We'd have liked to see one of these included, even if the kit then ended up costing £10-20 more.

The best feature about the kit is the generous amount of tubing included. You get eight 50cm lengths of PETG tubing, which is more than enough to cater for a CPU-only loop, or even if you want to add a GPU waterblock. This means that you'll have plenty of tubing with which to practise if you're new to tube bending, seeing as only three lengths would be needed to connect the included components.

TEMPERATURE RESULTS



The 16mm (OD) PETG tubing included is also easier to bend than standard acrylic tubing, thanks to a lower melting temperature, which also means it's practically shatter-proof. You'll need to apply less heat than you would with acrylic tubing, and the PETG tubing will become pliable more quickly.

However, we'd also suggest setting up temperature alarms for the fans, and especially the pump, using your motherboard's EFI or software, as any failures here, however unlikely, can see the coolant warm sufficiently for the tube to become flexible and potentially cause leaks.

Fixtures and fittings

A GPU waterblock isn't included in the kit, as they lack the universal compatibility of CPU blocks. If you want to fit a waterblock to your GPU, you'll need to visit Thermaltake or another water-cooling manufacturer's website to locate a block that's compatible with your particular graphics card.

You'll also need to buy a pair of extra fittings, as the six Pacific black rigid tube 16mm compression fittings included in the box only give you enough fittings to connect the combined pump and reservoir, CPU waterblock and radiator together in a loop.

In order to reduce the number of bends with which you have to contend when sorting out the tubing, Thermaltake has also included a pair of 90-degree rotary fittings that will connect directly to one of the components in order to point the tubing in the right direction.

If you'd prefer not to bend the tubing, a few more straight fittings, plus female-female 90-degree fittings will enable you to connect straight runs of tubing without the need for bending. Again, the amount of tubing included means this is possible without buying more tubing, even with a graphics card added to the loop.

We were impressed with Thermaltake's fittings too. They have double the usual number of O-ring seals, at four rather than the usual two, making for a leakproof design. Even if one O-ring in the fitting fails or gets damaged, there are three more acting as backups.

Pump up the volume

Coolant is pumped around the Thermaltake kit's loop with a PR22-DDC combined pump and reservoir unit; as its name suggests, this uses a DDC pump, but sadly there's no PWM control here and it runs at a fixed speed. There are also just single inlets and outlets, with the former sitting in the roof, which can look a little unsightly.

The reservoir also uses a rather dated and inflexible mounting kit, which requires there to be mounting holes in your motherboard tray. That's great if you have them already, but plenty of cases don't.

Thankfully, as DDC-type pumps are very popular for water cooling, some cases include pump mounts, and it's possible to buy them separately too. Even so, we'd have liked to see an adaptor in the kit to allow you to mount the pump/res combo to front fan mounts, as this is the easiest way to secure this type of hardware.

Thankfully, there's a separate fill port, and when it comes to actually adding coolant, there's a one-litre bottle of clear coolant included in the box, as well as a fill bottle to make filling the loop simple and drip-free.

Fans and waterblock

Thermaltake's Toughfan 12 fans are included too, which picked up an Approved Award in this month's fan Labs test (see p40), thanks to their high efficiency and low-noise operation, with three of them bundled in the box to kit out the 360mm radiator, along with a three-way splitter cable.

PACIFIC RIM

- \+ Excellent cooling
- \+ Plenty of rigid tubing included
- \+ Expandable

TOILET RIM

- – Expensive
- – Limited gains over high-end AIO liquid coolers
- – Lacks some tools

In terms of cooling capacity, this will be enough to handle any current desktop CPU, or a mid-range CPU and GPU such as a Core i5-12600K and GeForce RTX 3070 or Radeon RX 6700 XT. However, we would advise adding a 240mm radiator into the mix if you want to effectively cool more than that, especially as the fans weren't the most powerful models available in our testing.

Meanwhile, the included Pacific W7 CPU block is very attractive although, like the fans, it doesn't include RGB lighting. As you only get clear coolant as well, this kit might lack a little colour for some people's tastes, so you could consider adding a colour dye or alternative coolant to your shopping basket. The waterblock is simple to install, though, using a backplate and sprung thumbscrews. Intel's new LGA1700 socket is supported, as is LGA2066, but sadly there's no support for AMD's Threadripper sockets.

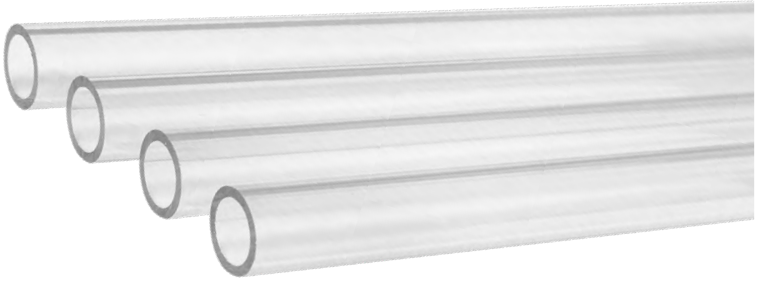
Installation

If you're new to water cooling or tube bending, YouTube is a fantastic recourse for guides, and Thermaltake has a couple of its own guides on the site, so we'd highly recommend taking a look at those for advice. The instructions give you a basic idea of what goes where, but they're not much use beyond that.

Once you've constructed your loop, another useful tool included in the box is an ATX jumper. This allows you to disconnect all the PSU cables from your hardware except the pump. You can then fill your loop without risk of any leaks damaging your hardware. This is a tried and tested method, but even better would be the inclusion of a leak-testing pressure tool. Thermaltake actually offers these in its product line-up, so again it's an inclusion we'd like to have seen to make the kit more appealing to newcomers.

Performance

We had our concerns about not being able to tune down the DDC pump, as it's not usually necessary to run it at full speed, which can also make it noisy. Thankfully, the model included here exhibited little noise and vibration, and once the loop was bled of air, the pump wasn't audible outside of the case above the noise of the rest of the hardware.



The CPU delta T of 48°C beat the monstrous Corsair H150i Elite LCD, albeit by only one degree, but that means the Thermaltake kit managed the best result we've seen when cooling our Ryzen 7 5800X. Pitched against our Core i9-12900K, the Pacific Tough C360 DDC kit shaved 2°C off the Corsair cooler on the CPU's average P-Core delta T, and one degree of the average E-Core delta T. The former was nearly 10°C cooler than the NZXT Kraken Z53 and 5°C cooler than the NZXT Kraken X73 RGB too.

Conclusion

We like a lot of aspects of Thermaltake's Pacific Tough C360 DDC water-cooling kit. It has enough tubing to allow practice bending, and to add additional components to the loop. It also has a quiet, powerful pump, excellent cooling performance, a useful mix of fittings and enough cooling capacity to handle any compatible CPU.

Unlike most AIO liquid coolers, it's easily expandable, with plenty of headroom provided by the pump for adding additional radiators and waterblocks. There are a few items we'd have liked to see included given the price, though, such as a leak-testing tool, tube reamer and tube cutter. None of these components would have added significantly to the price tag and would have meant a more complete package.

That's exactly what the competition offers, with kits from Corsair retailing for just a little more, but including components such as tube reamers, bending guides and tube cutters, as well as PWM-controlled pumps. Still, Thermaltake does include more tubing as standard, which is an important advantage.

However, the fact it offers some, but not all, the essentials for building a rigid tubing kit means that, while this kit ultimately offers good value for what you get, it's not quite as newbie-friendly as possible. This is a decent water-cooling kit, but there's also room for improvement.

ANTONY LEATHER

VERDICT

Missing a few useful tools, but otherwise a mostly inclusive water-cooling kit with rigid tubing.

LGA1700

COOLING **39/40**

FEATURES **15/20**

DESIGN **15/20**

VALUE **14/20**

FITTING **EASY**

OVERALL SCORE **83%**

Socket AM4

COOLING **39/40**

FEATURES **15/20**

DESIGN **15/20**

VALUE **13/20**

FITTING **EASY**

OVERALL SCORE **82%**

32IN GAMING MONITOR

SAMSUNG ODYSSEY NEO G8 / £1,299 inc VAT

SUPPLIER overclockers.co.uk

HOMER

- \+ Sensational contrast
- \+ Fantastic backlight
- \+ Good colours
- \+ Excellent core specification

MONTGOMERY

- – Needs a mighty GPU
- – Some exterior design issues
- – Not the best for serious esports

The Odyssey Neo G8 is the first gaming monitor to combine a curve with a 4K resolution and a 240Hz refresh rate, and the impressive specifications don't stop there – the G8 also uses a 10-bit VA panel with advanced backlighting. The 4K resolution keeps the image crisp, the 1000R curve is immersive and the 240Hz refresh rate is plenty for most people's needs, plus this monitor will adaptively sync with both AMD and Nvidia GPUs to stop tearing and stutter.

Meanwhile, the 1,196 Samsung Quantum Mini LEDs that make up the backlight alter their brightness levels independently to deliver stunning contrast that's ideal for HDR.

It's not cheap at £1,299, but the Samsung is still more affordable than the Asus ROG Swift PG32UQX, which costs £3,199 and includes 1,152 backlighting zones across its 32in IPS screen, alongside a weaker 144Hz refresh rate.

On the outside, the G8 has glossy white plastic and good movement options. Around the rear, the G8 deploys two HDMI 2.1 ports, a DisplayPort 1.4 socket and two USB 3.2 Gen 1 ports, but no USB Type-C connection. The G8 also has front and rear-mounted RGB LEDs that aren't bright or versatile enough to be useful. An absence of tool-free building disappoints as well, and the shallow, unresponsive D-pad undermines the slick on-screen display.

Those physical issues occasionally irritate, but the G8 fully redeems itself in benchmarks. Out of the box, the G8 supplied a sensational contrast ratio of 9,600:1 thanks to a 0.02-nit black point – this panel delivers more depth and vibrancy than any conventional IPS or VA screen. Not surprisingly, the G8 also performed well in HDR tests, with a peak brightness of 1,411 nits, creating a revised contrast ratio of 70,550:1. The Asus is great here too, but the Samsung is even better, and it makes games look fantastic.

SPEC

Screen size
32in

Resolution
3,840 x 2,160

Panel technology
VA

Maximum refresh rate
240Hz

Stated response time
1ms

Stated contrast ratio
1,000,000:1

Active sync
AMD FreeSync Premium Pro, Nvidia G-Sync compatible

Display inputs
1 x DisplayPort 1.4a, 2 x HDMI 2.1

Audio
N/A

Stand adjustment
Height, tilt, swivel

Extras
100 x 100mm VESA mount, 2 x USB-C 3.2 Gen 1

HDR standard
Quantum HDR 2000

The Samsung's delta E of 2.17 and colour temperature of 6,065K are middling but accurate enough for gaming, although the Asus is marginally better here. The G8 also rendered 99.5 per cent of the sRGB gamut with 129.8 per cent volume and 91.2 per cent of the DCI-P3 space at 92 per cent volume, so it produces a broad, vibrant range of colours in both gamuts without looking oversaturated.

Meanwhile, the G8's 240Hz performance is crisp and smooth, with only modest ghosting visible in dark areas – it's better than most 240Hz screens. The G8's average initial response time of 7.58ms is also good for single-player games, but it's a little slow if you're serious about super-fast esports.

With adaptive sync deactivated and the Standard overdrive setting applied the response time improved to 3.47ms, which is excellent, and a minor, manageable halo effect then replaced the ghosting. In the Faster and Extreme overdrive modes, the response times improved further to 2.7ms and 2.38ms, but overshoot increased dramatically and the halo was more noticeable. If you want extra speed while games remain visually impressive, we'd stick with the Standard option.

Conclusion

The G8's VA panel might not quite have the responsiveness required for top-tier esports, but it has the speed for any other gaming scenario, alongside good colour reproduction, incredible contrast and a rock-solid core spec. While you'll need to spend a lot of money on this monitor, and a GPU that can output to 4K at high frame rates, there's no denying that the G8 delivers the best all-round 16:9 gaming experience around today.

MIKE JENNINGS

VERDICT
Incredible technology supplies a near-unmatched 4K experience, despite some design niggles.

IMAGE QUALITY **28/30**
GAMING **27/30**
FEATURES **18/20**
VALUE **17/20**
OVERALL SCORE **90%**

ATX CASE

KOLINK CITADEL MESH ATX ARGB / £110 inc VAT

SUPPLIER overclockers.co.uk

As we see in this month's fan Labs test (see p40), it's not always cheap to kit out your case with RGB lighting, but there are also plenty of cases available that offer a glowing treat for your eyes out of the box. The Kolink Citadel Mesh ATX ARGB is one example, including four digital RGB fans as standard, so not only will it look pretty, but it will hopefully keep your PC cool too.

The fans are preinstalled and pre-wired to a remote-controlled hub that offers two additional 4-pin PWM ports for connecting extra fans. In addition, the fans' 3-pin RGB cables are connected to the hub, again with a further two ports on offer. The hub uses a single 3-pin RGB cable and 4-pin PWM cable to power all the ports, so there will be minimal cables trailing to your motherboard – you have to do very little in terms of cabling and connections to get it all working.

If you don't want to use software to control the lighting, you can use the on-board LED control on the front panel or a remote control instead. The latter cycles through various funky lighting modes, as well as fixed colour options, but while Kolink mentions speed too, this appears to be the speed of the lighting effects and not the speed of the fans.

As the front features a large dense mesh, rather than tempered glass like the side panel, the colours at the front aren't as vibrant compared with a glass panel, but you can still make them out. We particularly liked the fact that the hub and fan frame ring have their own LEDs, so some of the lighting effects really do look good.

As well as LED control, the front panel also offers a USB 2 port, two USB 3 ports and a USB 3.2 Gen 2 Type-C port as well, plus two audio ports and a reset switch. There are dust filters up top and below too, with the former held in place using magnets and peeling off easily. Meanwhile, the front section uses the external mesh as a dust guard, rather than having a pull-out filter, presumably not to further obscure the view of the fans.

It's a fairly large case, measuring 48cm tall and 46cm long, but while it has an above average width of 23cm, there's not as much clearance behind the motherboard tray as we'd like – despite tidying our cables properly, the side panel did need a bit of persuasion to close.

We don't have any other complaints about the interior though – there's a generous 180mm of CPU cooler clearance, vertical triple-slot graphics card support and 385mm of graphics card clearance, although it doesn't include a riser cable or vertical mounting kit in the box.

SPEC

Dimensions (mm)
231 x 460 x 484 (W x D x H)

Material
Steel, plastic, glass

Available colours
Black

Weight
9.2kg

Front panel
Power, reset, 1 x USB 3.2 Gen 2 Type-C, 2 x USB 3, 1 x USB 2, stereo, mic, LED control

Drive bays
2 x 2.5in/3.5in, 2 x 2.5in

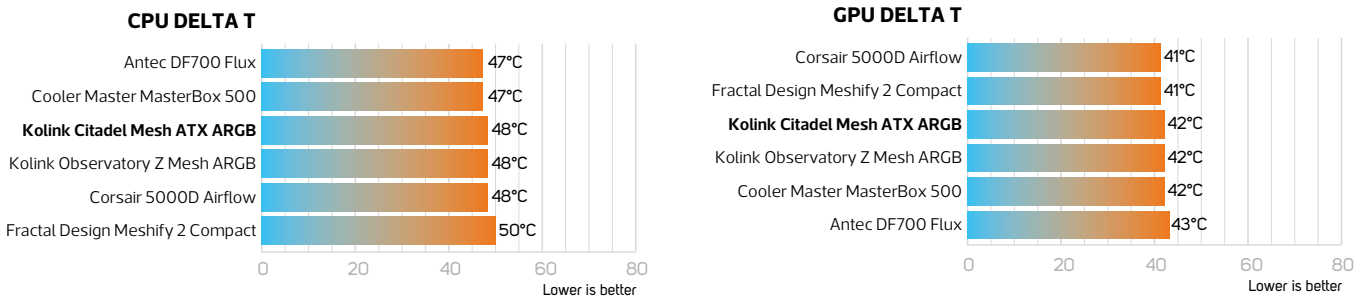
Form factor(s)
E-ATX, ATX, micro-ATX

Cooling
3 x 120mm/3 x 140mm front fan mounts (3 x 120mm fans included), 1 x 120mm/140mm rear fan mount (120mm fan included), 3 x 120/2 x 140mm roof fan mounts (fans not included)

CPU cooler clearance
180mm

Maximum graphics card length
380mm

TEMPERATURE RESULTS



The Citadel Mesh can also support full-width E-ATX motherboards, courtesy of an extended motherboard tray and a second set of cable-routing holes positioned further to the right than usual. There are plenty of cable-routing holes as well – they're located above, below and to the right of the motherboard and all are equipped with rubber grommets, plus there are a few Velcro cable anchors.

The Citadel Mesh also has excellent water-cooling support, with 360mm and 280mm radiator clearance in the roof and front sections, while it's even possible to use a massive 420mm radiator in the front, thanks to triple 140mm fan support. The roof has no fans out of the box, but you can add three 120mm fans or two 140mm fans here too.

Meanwhile, for storage, the Citadel Mesh provides two dedicated 2.5in mounts and two shared 2.5in/3.5in mounts. The fact you can only install a pair of hard disks is the only niggle we found with hardware support. We also found the two dedicated 2.5in mounts behind the side panel can get in the way of cable routing too, with two anchor points sat between the SSD trays.

Easier-to-use side panels would have been welcome too. As it stands, you need to use thumbscrews to secure the Citadel Mesh's side panels, while many competitors often use push fittings or other tool-free methods.

Performance

The Kolink Citadel Mesh ATX ARGB's quartet of fans certainly kept thermals in check, with a CPU delta T of 48°C, although we have seen marginally cooler results from other cases. The fans were very quiet at full speed too – like the Kolink Observatory Z Mesh ARGB we reviewed last month, a couple of hundred more RPM would be welcome to provide a bit more cooling headroom, especially as the hub makes it so easy to control all the fans.

The GPU delta T of 42°C was again within a degree of the best result, but higher-airflow cases such as the Corsair 5000D Airflow did shave an extra degree off the temperature, albeit with slightly higher noise levels at full speed.

Conclusion

Retailing for £10 less than the Kolink Observatory Z Mesh ARGB, the Kolink Citadel Mesh ATX ARGB is certainly our pick of the two, offering slightly more vivid RGB lighting visible through the front panel, courtesy of fans with additional RGB LEDs. It has an extra RGB fan compared with the likes of the Antec DF700 Flux too. We can't argue with its premium features either, such as USB Type-C and E-ATX support, ample room for water-cooling gear, four digital RGB fans and the ability to house a high-end system for just over £100.

If you want a solid case that can cope with liquid cooling systems and high-end hardware for around £100, and has extensive RGB lighting out of the box, the Citadel Mesh ATX ARGB certainly does the job. However, as with the Observatory Z Mesh ARGB, there are no stand-out features beyond the RGB lighting, and Kolink needs to innovate with its basic case design if it wants to really compete in this crowded market.

ANTONY LEATHER

CITADEL MINIATURE

+ Good cooling
+ Excellent water-cooling support
+ Four remote-controlled RGB fans

PLASTIC COUNTER

– Not many stand-out features
– Panels lack refinement
– Could do with more powerful fans

VERDICT

Plenty of high-end credentials and four RGB fans, but there's not much else that stands out from the crowd.

COOLING	25/30
FEATURES	16/20
DESIGN	25/30
VALUE	17/20
OVERALL SCORE	83%

STREAMING BUNDLE

STREAMPLIFY COMPLETE BUNDLE / £370 inc VAT

SUPPLIER overclockers.co.uk

Streamplify is a new streaming gear-focused brand from the same company that brought us noblechairs, Nitro Concepts, Endgame Gear and Kolink. Designed to take on the likes of Corsair's Elgato brand, Streamplify provides a full range of streaming products, such as webcams, microphones, lights and green screens. You can buy each item individually or in the form of a bundle, such as the one we're reviewing here.

The complete bundle includes a Streamplify CAM webcam, MIC microphone with mounting arm (as opposed to the mini tripod option), both the smaller LIGHT 10 and larger LIGHT 14 ring lights, a 200 x 150cm portable green screen and a HUB CTRL 7 USB hub. With a total price of £370 inc VAT, it's quite the outlay, but a full £130 of that is taken up by the sizeable green screen. For most streamers, the £130 inc VAT starter bundle that includes the camera, mic (with mini tripod) and one light will be enough for a starting point.

STREAMLINED

- \+ Well thought-out, useful designs
- \+ Mostly good-value products
- \+ Works well with other gear

STREAMING NOSE

- – Sub-par webcam image quality
- – Naff mic mounting system
- – Basic build quality

LIGHTS

Starting with the cheapest item of the lot, the £20 LIGHT 10 is a 10in ring light that comes with a surprisingly sturdy and easy-to-use, bendable-armed smartphone holder for holding your phone in the middle of the ring – ideal for vlogging – and a more conventional camera mount for fitting either a webcam or full-sized camera. It also includes a mini tripod with extendable legs, which will set the base of the light at a height of 15-18cm. The legs also fold into a convenient carry handle that's again ideal for vlogging.

For just £20 in VAT, it's a cracking bit of kit. The light is powered via USB and is strong enough for basic streaming and vlogging duties. The inline remote also provides power, brightness and three light-temperature settings (cool, warm and a combined mid-tone) making it versatile and easy to control.

The two main downsides to the LIGHT 10 are the limited height provided by the mini tripod (you'll generally want a light for streaming to be placed above your head), and the strength of the ball joint that links the ring to the tripod. The latter would struggle to reliably hold up both the ring and any camera that's much heavier than a phone or webcam.

The larger LIGHT 14 has a higher price tag of £65 inc VAT, but it delivers considerably more too. It comes with a proper telescoping tripod that can be set between 50-170cm and is topped by a sturdy hinge mount. The light itself is larger and much brighter than the LIGHT 10 too, plus it can be controlled by touch buttons on the ring or via a remote control (no AAA batteries included), with again variable settings for brightness (ten levels) and colour temperature (four settings).

Being mains powered, the LIGHT 14 won't take up a USB port and even provides two USB sockets for powering any devices attached to it. There are also three camera hot shoe-style mounts inside the ring, along with a 1/4in-threaded hole, giving you plenty of spots to affix your kit. All told, it's another impressive addition to the Streamplify kit.

CAMERA

We're less impressed by the £60 CAM webcam. The camera design is neat enough. It's very compact, with a folding, rubber-footed stand that works well for propping the camera on the top edge of a monitor, and it folds flat with a 1/4in thread for mounting on a tripod (or in one of the ring lights). An outer sleeve can also be slid left and right to provide a physical barrier for the lens, for extra privacy.

However, picture quality is a letdown. The image is oversharpened, grainy and doesn't cope well with strong contrast. It's certainly passable but the identically priced Logitech C920 is sharper, smoother and copes better with

high contrast. The CAM could do with dropping in price even further to justify its poorer image quality.

When it comes to the MIC microphone, there are no such issues with its core function. While audio quality from the mic and its headphone socket (for mic monitoring and headphone output from your PC) certainly isn't out of this world, it's comparable to several other entry-level USB streaming microphones.

The mounting arm, despite looking thin and cheap, works perfectly well, with a well-balanced movement in its full range of motion, and its adjustment points for the mic mount are easy to undo and move, yet they still hold the mic securely when tightened. The included anti-vibration mount also does a good job of isolating any table knocks or rubbing sounds from holding and moving the arm.

However, despite having a threaded section on its base, the mic is held in place by a rubber ring system that just grips onto the threaded section of the mic. It's tightened via a plastic knob on the underside of the vibration cage and the whole setup is awkward to fit and insecure.

Likewise, the otherwise quite effective metal grille pop shield is only held in place by the clamping force between the mic and vibration mount, and this force is only provided by how hard you push those two pieces together while you tighten the knob on the underside. We eventually got it fitted, but we have reservations about it staying in place with prolonged use.

ACTION

The penultimate addition to the Complete streamer bundle is the green screen. It rolls upwards from its case, and is held in place by a scissor-lift arm system. The case is mounted on castors and the feet on which they're mounted rotate inwards to sit flush with the width of the case when in transit. It very much just feels like a perfectly decent but unremarkable, low-price green screen.

The final piece of the puzzle is the HUB CTRL 7 USB (£45 inc VAT), a switchable 7-port USB hub. Around the back are the seven client device ports and single host port along with the mains power input, and up front are seven buttons for powering on each device. RGB lighting shines out from slots above each socket, and you can slide a selection of clear plastic tabs into these slots, which are then used to indicate which device is plugged into which socket.

It's essentially an analogue equivalent to Elgato's software-programmable Stream Deck controller, but there's no software and macro control. Despite this, it's actually one of the standout additions to the Streamplify ecosystem. It saves you six USB ports and offers a really convenient way to turn your devices on and off.

CONCLUSION

All told, then, the full range of Streamplify devices has a few hits and a few misses. The camera's image quality is a letdown for the price, the microphone's mounting system is an issue and the green screen is perfectly fine but does nothing to set it apart from any other cheap green screen. Overall build quality is certainly basic across the range, but by and large this is fairly reflected in the price of each unit.

The USB hub and lights, though, are great entry-level options. What's more, the whole kit is ripe for easy upgrades, due to its simple nature. In contrast, Elgato's system is very slick and good quality but its reliance on software control can make it feel restrictive.

Whether this bundle is worth buying depends on whether you need a green screen. Many streamers swear by having one, whereas others don't mind viewers seeing what's behind them. For a streamer starting out, we'd certainly be inclined to go without.

EDWARD CHESTER

VERDICT

A decent range of value-focused streaming gear, though some devices are more successful than others.

DESIGN **18/25**

FEATURES **20/25**

PERFORMANCE **18/25**

VALUE **22/25**

OVERALL SCORE **78%**

GAMING CHAIR

CORSAIR TC200 / £350 inc VAT

SUPPLIER corsair.com

CUSHIONING

+ Good seat padding
+ Solid build quality
+ Comfortable

CRUSHING

- Basic tilt system
- Stiff castors
- Armrests not soft enough

We were impressed by the modest styling and wonderfully soft plush fabric of the first Corsair gaming chair we reviewed, the T3 Rush. However, it was quite basic, with a hard, narrow seat cushion and aggressively high sides. It made for a slightly more authentic racing seat feel than some chairs, but it wasn't that comfortable or suited to large sitters.

The TC200 is an altogether more generous chair, with a wider seat and back, more padding and a few extra features. Available in light grey or black, the TC200 has a muted, simplistic styling, but it doesn't quite have the same sleekness of the T3 Rush. It's available in either leatherette or plush fabric finishes. The former gives you a wipe-clean surface but some areas are perforated (to help breathability of the fabric for long gaming sessions), so spills can still leak into the seat padding.

For extra features, you get larger-diameter castors than the T3 Rush, and they include an anti-roll mechanism, so the wheels only spin when there's weight on the seat. This makes sense for accessibility and safety but is a little less fun than free-rolling castors. Moreover, even when weight is applied, the wheels don't roll all that smoothly.

Other extras include 4D armrests, which provide the option to slide the armrest in all axes (XYZ) and twist it about the Y axis. The surface of the armrests is a little softer than some gaming chairs we've tried but still firmer than we'd ideally like.

Meanwhile, the proportions of the chair give more room for wider sitters than the T3 Rush, with a wider seat and back, and the raised wings around the seat base and back sit much lower relative to the seat padding, so they're less likely to dig into you. It's still not quite at the level of roominess offered by the noblechairs Hero, which has a wider seat – you're still largely contained by the side wings, but it is a big improvement over the T3 Rush.

The real revelation with this chair, though, is the comfort level of the seat base and back. Both offer among the most comfortable and supportive padding we've yet encountered on a gaming chair – rivalled only by the AK Racing Masters Series Premium. The seat padding is relatively soft and drops off slightly at the front, so it doesn't dig into your legs – some gaming chairs have a slightly raised front edge (again, like a racing seat), which is terrible for long-term comfort.

Most surprising of all, though, the back padding actually offers good lumbar support. Nearly all gaming chairs we've tested so far offer almost completely flat backs, relying on additional cushions to (usually poorly) provide this function. Here, though, you get a genuinely supportive curve in the seat back. A very satisfyingly squishy headrest cushion is provided for looping over the chair's headrest too.

Less impressive is this chair's tilt mechanism. While the gas lift provides plenty of height adjustment, and the back can fold fully flat, the recline hinges from the back and requires the front of the chair to rise, as opposed to mechanisms that hinge from the front with the chair dropping down at the back.

The latter systems mean you can simply lean back into a recline (once the recline is unlocked), whereas the Corsair needs you to either tilt the seat back quite a long way to counterbalance your bodyweight, or rest your feet on an object and essentially push yourself backwards. You can get a relaxed recline but it's a bit of a faff.

Conclusion

Corsair's latest gaming chair is a big improvement on the T3 Rush. Its seat and back padding are much more comfortable, offering better support for your back and more cushioning for your backside. The uprated armrests are good too, and it's a smart-looking chair. The basic tilt system is disappointing, but that's why this chair costs £350 rather than the £500 inc VAT of more premium gaming chairs.

EDWARD CHESTER

VERDICT

The tilt system could be better, but the TC200 nails the single most important aspect of an office or gaming chair: it's comfortable.

COMFORT 20/25

DESIGN 21/25

FEATURES 20/25

VALUE 19/25

OVERALL SCORE 80%

HackSpace

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SECURE USB SSD

KINGSTON IRONKEY VAULT PRIVACY 80ES / £285 inc VAT

SUPPLIER buykingston.co.uk

ENCRYPTED

- \+ Convenient touchscreen password input
- \+ Large capacities
- \+ Very secure yet very easy to use

IN THE CRYPT, ED

- − Not very fast
- − Expensive compared with 'normal' drives
- − A little slow to boot up

The Kingston Ironkey Vault Privacy 80ES is a solid-state USB storage device with password-protected XTS-AES 256-bit hardware encryption. So far, so relatively commonplace. However, what makes this device particularly interesting is that instead of requiring software to unlock the drive, it relies on a built-in touchscreen that lets you key in your PIN or password, making it completely standalone.

The 2.8in, 240 x 320 pixel, full-colour, resistive touchscreen is sufficiently large and sharp to present instructions and other information in a clear fashion. Whether it's tapping a number into the pinpad, navigating a full alphabet of characters for a longer password or reading the setup instructions, you really can rely just on the screen.

Passwords can be 6-64 characters long, with the latter option making for a very secure key but one that will be a pain to input one character at a time on this touchscreen. It's doable but you wouldn't want to do it regularly.

For shorter keys of between 6-12 characters, the touchscreen works well – the resistive touch response also means you can tap precisely with a fingernail (or stylus or any other fine object that won't scratch the soft plastic surface), rather than being forced to use the pad of your finger, as would be needed with a capacitive touchscreen.

Initial setup is simple. Just plug the drive into a computer and the device will boot up – which takes roughly ten seconds – and present you with the option to enter your desired password. Once entered, the device will connect to your computer and show the contents of the drive, ready to be written to. If you want to disconnect the drive, you just tap the screen, hit the 'Lock and disconnect' button, then choose to either 'power off' or 'unlock' the device.

Upon subsequent connections, if you use just a numeric PIN for unlocking the device, it will present the numpad in a scrambled fashion. This further helps security by ensuring people can't just look for fingerprints or scratches on the screen to inform their password guesses. Including boot up and unlocking, it takes roughly 20 seconds to get access to your files. Admin and user passwords can also be created to further manage access of the drive.

The device itself is quite bulky for an SSD, with dimensions of 201 x 82 x 17mm. It uses a single USB Type-C socket for connection, and includes both Type-A to Type-C cable and Type-C to Type-C cables. A neoprene carry case is also included, which will be sufficient to keep most scratches at bay, although it won't protect against harder knocks. The drive isn't waterproof.

Transfer speeds aren't blistering. In our transfer tests, the drive took one minute 53 seconds to transfer 23.7GB (eight files) to the drive and one minute 38 seconds to read them back, for transfer speeds of 210MB/sec and 242MB/sec respectively. Transferring a folder of 4,785 files totalling 4.92GB in size took three minutes and five seconds to write to the drive and 55 seconds to read back.

In terms of cost for the capacity, you can certainly get larger, much faster drives for a lot less. The very fast Samsung T7 is just £110 inc VAT for a 1TB drive, while Kingston's own XS2000 is just £85 inc VAT for a 500GB model. However, encrypted drives demand a premium and the inclusion of the touchscreen adds to the price too.

Conclusion

The Kingston Ironkey Vault Privacy 80ES is a fantastic encrypted drive system for those seeking large, secure, portable storage without the hassle of extra software. The touchscreen interface works well and totally takes the headache out of accessing your files. It's not particularly fast or cheap, but it's fast enough for most uses.

EDWARD CHESTER

VERDICT

Capacious and easy to use, this is a great option for those that need encrypted file access on any device anywhere.

DESIGN	20/25
FEATURES	24/25
PERFORMANCE	18/25
VALUE	18/25
OVERALL SCORE	80%

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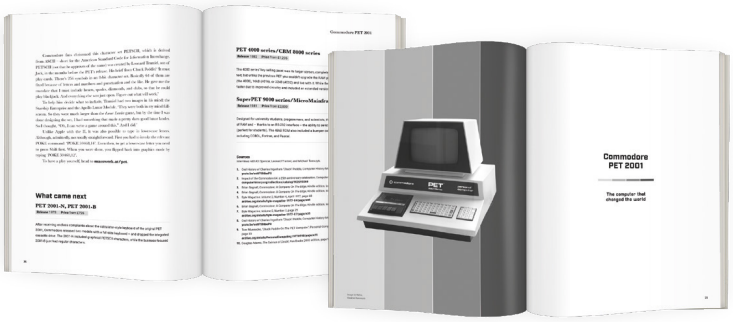

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GAMING LAPTOP

MSI GF63 THIN 11UC / £699 inc VAT

SUPPLIER cclonline.com

The MSI GF63 Thin 11UC only costs £699, making it one of the cheapest gaming laptops available today, which means you get appropriately modest components. The GeForce RTX 3050, for instance, is Nvidia's entry-level laptop GPU, so it only has 2,048 CUDA cores and 4GB of memory. It runs here at 40W – a long way short of the GPU's theoretical 80W peak.

Elsewhere, the specification is modest. The Intel Core i5-11400H CPU has six Hyper-Threaded cores and a peak turbo speed of 4.5GHz but it doesn't have the latest Alder Lake architecture, and MSI's rig only uses 8GB of single-channel DDR4 memory – although, thankfully, it's easy enough to pop open the base panel and install a second SODIMM. Meanwhile, you get a 512GB SSD with a reasonable read speed of 2,230MB/sec, but its write pace of 350MB/sec is poor.

None of that is a shock considering the price, and the exterior offers few surprises. Positively, it looks decent thanks to its brushed aluminium panels, slim bezels and red accents, and it only weighs 1.86kg – it's one of the lightest 15.6in gaming laptops around. The chassis is only 21.7mm thick, so it's not chunky either.

Negatively, though, build quality is poor. The metal above the keyboard moves too much and the underside has so much flex, you can push the plastic right up against the internals. That's not a big deal for home use, but a protective sleeve is a good idea for frequent travellers.

In terms of connections, you'll find one full-sized USB port on the MSI's left-hand edge, and the right-hand side serves up two more USB ports and a USB Type-C socket. They all use the USB 3.2 Gen 1 protocol, which means speeds are capped at 5Gbps. At the rear, there's an HDMI 2b output, and the laptop also supports Gigabit Ethernet, dual-band 802.11ax Wi-Fi and Bluetooth 5.2.

That covers most people's needs, but faster USB ports would have been handy. There are no Thunderbolt ports here either, or card or fingerprint readers, and the 720p webcam doesn't support Windows Hello.

In similar fashion, the keyboard misses a numberpad, and it doesn't have RGB LEDs – just a single-zone red backlight. It does deliver good quality typing, though, thanks to fast, quiet and reasonably crisp buttons. On pricier laptops, you'll get more travel and a snappier feel, but the GF63's typing gear is perfectly usable. We can't say the same for the trackpad, which is too small.

Our favourite affordable gaming laptop is the Lenovo Legion 5 Pro, but even that rig costs £1,499 for the specification we reviewed, and its prices start at £1,169. Instead, the MSI's closest rival is Lenovo's conventional Legion 5i, which costs £899 and pairs the i5-11400H with an RTX 3060 graphics core and RGB LED keyboard in a sturdier but chunkier chassis.

SPEC

CPU
2.7GHz Intel Core i5-11400H

Memory
8GB 32000MHz DDR4

Graphics
Nvidia GeForce RTX 3050 4GB

Screen
15.6in 1,920 x 1,080 IPS 144Hz

Storage
512GB Kingston OM8PDP3512B-A01 M.2 SSD

Networking
Gigabit Ethernet, dual-band 802.11ax Wi-Fi, Bluetooth 5.2

Weight
1.86kg

Ports
1 x USB 3.2 Gen 1 Type-C, 3 x USB 3.2 Gen 2, 2 x audio, 1 x HDMI 2b

Dimensions (mm)
359 x 254 x 21.7 (W x D x H)

Operating system
Windows 10 Home 64-bit

Warranty
One year parts and labour return to base

PERFORMANCE

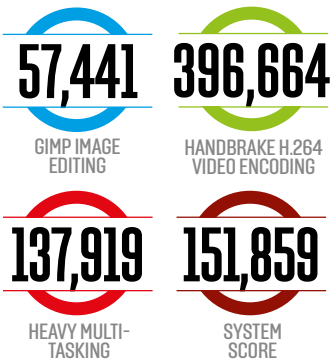
The low-power RTX 3050 proved sluggish in games tests – its 99th percentile results in Assassin's Creed Valhalla and Cyberpunk 2077 were far off being playable. We only achieved playable frame rates with settings dropped down to Medium – the MSI then ran those titles at 36fps and 32fps with averages at 50fps and 41fps. On the plus side, running Doom Eternal at Medium settings nets you a 99fps average, but that's still a disappointing result in this undemanding game.

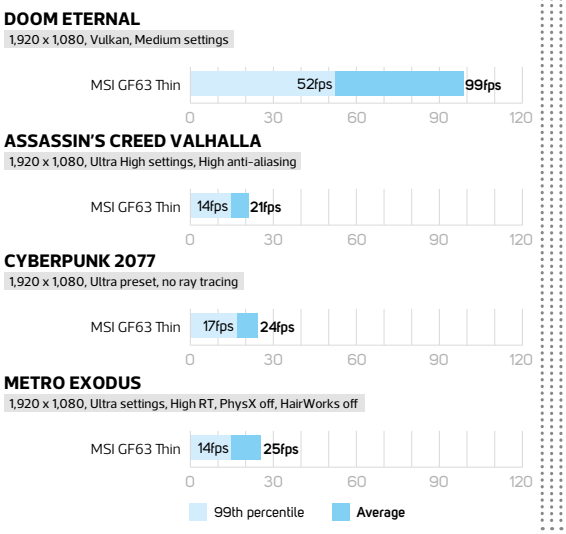
These slow results have real-world implications. You'll only be able to play mainstream single-player titles smoothly if you drop graphics settings. Not all esports games will run at top settings at the speeds required by the 144Hz display either – titles such as CS:GO, League of Legends and Fortnite will be fine, but racing games and titles such as Call of Duty and Rainbow Six will struggle. A modest RTX 3060, such as the one in the £899 Lenovo, will offer a significant gaming boost.

The processor followed suit. Its overall benchmark score of 151,859 is enough to handle most people's office and web browsing needs, but it's miles behind current Intel and AMD chips. MSI also sells this laptop with a Core i7-11800H, RTX 3050 Ti and dual-channel memory for £799, and that CPU scores around 166,000 points in our benchmarks.

There's no doubt that the MSI is hindered by its 8GB of single-channel memory too. We installed a second 8GB SODIMM and the MSI's benchmark score improved to 160,880. That's only a 5.7 per cent jump, but that gets you a 12 per cent boost in the multi-tasking benchmark. The memory upgrade helps games too: the MSI's Assassin's Creed medium settings average leapt from 50fps to 54fps, and the rig's Doom Eternal average leapt to 122fps. That's a healthy performance increase for the cost of a £30 SODIMM.

BENCHMARK RESULTS





Happily, the modest pace does mean good thermal ability. The MSI is quieter than virtually every other gaming laptop we've tested. On the flip side, though, don't expect much longevity from the MSI's meagre 52.4Wh battery. The MSI's gaming lifespan of one hour, 15 minutes is conventional, but it only played video and ran everyday work tasks for three hours.

Games and web browsers won't look great on the MSI's display either. Its 1,920 x 1,080 resolution and 144Hz refresh rate are fine specs, but the delta E of 4.86 is mediocre and the display only rendered 58.1 per cent of the sRGB colour gamut, so colours look a little washed out.

The contrast level of 946:1 is acceptable, though, and means the MSI's panel can still cope with everyday computing scenarios, but nothing looks particularly bold or vibrant. Alongside the underwhelming screen are speakers with flat bass and a slightly tinny top end. They're serviceable, but a headset will be better.

THIN CRUST

- \+ Extremely affordable
- \+ Plays modest games at reasonable speeds
- \+ Satisfying keyboard
- \+ Thin, light design

THIN ICE

- – Underwhelming performance
- – Single-channel memory
- – Pallid screen
- – Poor battery life

CONCLUSION

The GF63 Thin 11UC is one of the cheapest gaming laptops we've ever seen, and for just £699, you get a machine that's capable of handling mainstream esports games and single-player titles, albeit with some graphical compromises. It's slim and light, it has a good keyboard, and a second stick of memory is a sensible and affordable upgrade.

Those attributes mean the MSI is worth considering if you need a budget gaming laptop, as long as you're aware of its limitations, but you'll be massively rewarded if you can afford to spend just a little bit more money on a machine with an RTX 3060 GPU, a faster processor and a superior display.

MIKE JENNINGS

VERDICT

A bargain-basement esports laptop, but it can't offer much beyond the basics.

PERFORMANCE 14/25

DESIGN 18/25

HARDWARE 17/25

VALUE 20/25

OVERALL SCORE 69%

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INTEL B660 GAMING PC

PC SPECIALIST PRISM NOVA / £1,199 inc VAT

SUPPLIER custompc.co.uk/PrismNova

PC Specialist's new Prism Nova pairs an Nvidia GeForce RTX 3060 GPU with an Intel Core i5-12400F CPU – a combination that's proving popular inside affordable gaming rigs. The Nova's Zotac graphics card has an overclocked boost speed of 1777MHz, 12GB of memory and includes 3,584 CUDA cores. Meanwhile, the Core i5-12400F is our budget gaming CPU of choice, including six Hyper-Threaded P-Cores and a boost clock of 4.4GHz.

The Nova also includes 16GB of DDR4 memory running at 3200MHz, and a 1TB Intel 670p PCI-E 3 SSD with read and write speeds of 2,436MB/sec and 2,142MB/sec. All the gear is powered by a Corsair TX650M PSU, which has 80 Plus Gold certification and a semi-modular design – a fine inclusion at this price.

Those components attach to an Asus Prime B660-Plus D4 motherboard that has some surprisingly potent features for this price. At the rear, it has a high-speed USB 3.2 Gen 2x2 Type-C port that rattles along at 20Gbps. The board also has 2.5Gbps Ethernet, and it supports overclocked DDR4 memory at 5066MHz. There are M.2 sockets, a Thunderbolt header and two spare memory slots as well. What's more, PC Specialist has also added dual-band 802.11ax Wi-Fi, which is pleasing – we've criticised the company for installing sluggish wireless cards in the past.

That decent spec enables rapid connections and ample room for upgrades, but the board lacks in other departments. The third M.2 connector only runs at 2x PCI-E 4 speeds – half as much as the other two on-board slots – and there's no PCI-E 5 support anywhere. At the rear, there are only three audio jacks, and the Asus looks plain, without lighting or large heatsinks.

Those omissions aren't a surprise at this price, though, and they're not unique to the PC Specialist – this month's £1,349 Stormforce Crystal Cougar uses the same motherboard. The Stormforce has the same processor too, and even the same memory and PSU hardware.

Two factors explain the £150 price difference between the PC Specialist and its rival - the Stormforce has a GeForce RTX 3060 Ti and a three-year collect and return warranty that covers parts and labour. The PC Specialist only has one year of parts and labour coverage followed by two years of labour only protection.

PC Specialist's machine also squares up to the Wired2Fire Phoenix Intel, which was our previous favourite budget build. That PC doesn't compare well with the Nova though – the Wired2Fire has a weaker PSU, a basic micro-ATX motherboard and a simple CPU air cooler, compared with the 240mm liquid cooling system in the Nova.

Meanwhile, PC Specialist's Prism chassis ticks most of the boxes when it comes to mid-range enclosures. Its front and side panels are made from tempered glass, it has RGB LED fans, and users benefit from magnetic dust filters and a PSU shroud. On top there's one USB 3.2 Gen 1 port and two slower USB 2 connections, and build quality is consistently good.

There are no surprises on the inside – you won't find a fan hub here – but the Prism can accommodate two 2.5in drives and a sole 3.5in hard disk. There's loads of space in which to work too, and there's clearance for a front-mounted 360mm radiator. At 490mm tall and 450mm deep, it's larger than the Cougar chassis used by Stormforce, but it's far roomier, and it's better than the Wired2Fire's basic case.

SPEC

CPU
2.5GHz Intel Core i5-12400F

Motherboard
Asus Prime B660-Plus D4

Memory
16GB Corsair Vengeance LPX 3200MHz DDR4

Graphics
MSI GeForce RTX 3060 12GB

Storage
1TB Intel 670p M.2 SSD

Networking
2.5Gbps Ethernet, dual-band 802.11ax Wi-Fi, Bluetooth 5

Case
PC Specialist Prism TG Black

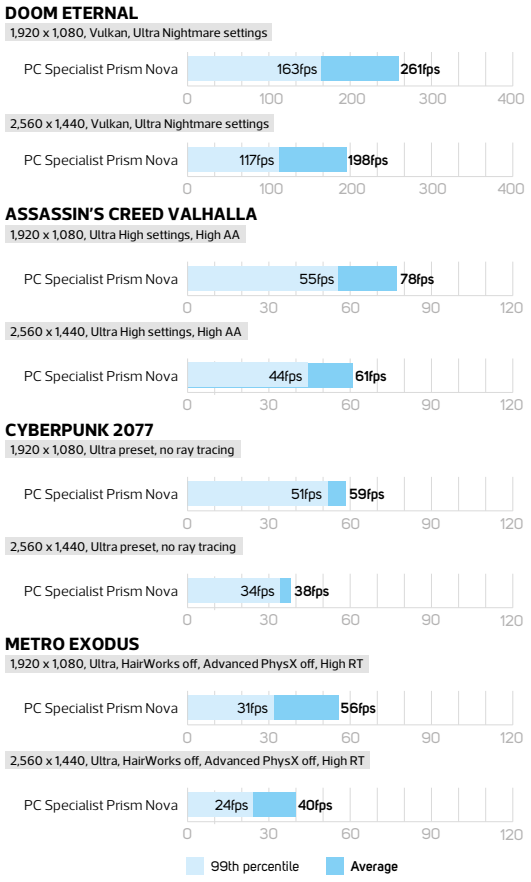
Cooling
CPU: PC Specialist FrostFlow 240 with 2 x 120mm fans; GPU: 2 x 90mm fans; front: 3 x 120mm fans; rear: 1 x 120mm fan

Ports
Front: 1 x USB 3.2 Gen 1, 2 x USB 2, 2 x audio; rear: 1 x USB 3.2 Gen 2x2 Type-C, 2 x USB 3.2 Gen 2, 1 x USB 3.2 Gen 1, 2 x USB 2, 3 x audio

Operating system
Windows 11 Home 64-bit

Warranty
One year parts and labour with first month collect and return, then two years labour only return to base

BENCHMARK RESULTS



61,702
GIMP IMAGE EDITING

537,940
HANDBRAKE H.264 VIDEO ENCODING

243,223
HEAVY MULTI-TASKING

213,913
SYSTEM SCORE

PERFORMANCE

The RTX 3060 still retains decent 1080p gaming ability. Its Assassin's Creed Valhalla and Cyberpunk 2077 99th percentile results of 51fps and 55fps prove it has enough power to handle mainstream single-player titles, and the average frame rates went beyond 60fps. The Doom Eternal average of 261fps also shows that this PC has enough power to play undemanding games in sync with 240Hz 1080p screens.

The Nova was consistently faster than the Wired2Fire PC, but the RTX 3060 runs out of juice when tasked with gameplay at 2,560 x 1,440. While this PC will play some titles at this higher resolution, its 34fps 99th percentile in Cyberpunk and sub-30fps score in Metro Exodus indicate that more demanding games will prove too much for this core. If you need that extra pace, you'll get it from the RTX 3060 Ti in the Stormforce.

Switch to processing tests and the PC Specialist and Stormforce returned near-identical benchmark results, which don't set the world alight but are fine for the money. The Nova's overall score of 213,913 is fine, being only marginally slower than the Cougar, and it shows there's enough power to tackle everyday computing tasks and light content creation. The award-winning Wired2Fire delivered the same level of performance, and you'll have to spend several hundred pounds more to get a significant improvement here.

Happily, the PC Specialist doesn't make much noise either – it's subtle in all situations and if you're using speakers or a headset you just won't hear the system. It's a bit quieter than the Stormforce when gaming, and a tad louder during workloads, and its CPU and GPU delta Ts of 35°C and 48°C are great.

CONCLUSION

The PC Specialist's £1,199 price does mean compromises – this PC can only comfortably handle 1080p gaming, and it doesn't offer high-end motherboard features or processing grunt. It's a perfectly capable gaming PC for the price, though, and it supplies consistently quiet performance and a tidy, accessible chassis.

This PC is better than the Wired2Fire system that it's knocked off the Elite List, and you'll have to pay £150 more if you want a decent performance gain. If you're on a tight budget, this is a great gaming PC.

MIKE JENNINGS

DRAX

+ Good 1080p gaming performance
+ Excellent price
+ Quiet operation

RONAN

– RTX 3060 Ti is much quicker
– Limited motherboard
– Middling CPU speed

VERDICT

Good mainstream gaming pace in a quiet, robust and accessible build.

PERFORMANCE **19/25**
DESIGN **20/25**
HARDWARE **20/25**
VALUE **23/25**
OVERALL SCORE **82%**

INTEL B660 GAMING PC

STORMFORCE CRYSTAL COUGAR / £1,349 inc VAT

SUPPLIER custompc.co.uk/CrystalCougar

The Crystal Cougar is the pricier of the two PCs reviewed in this issue, and it has the most graphics power too – its Nvidia GeForce RTX 3060 Ti is a step up from the RTX 3060 used inside PC Specialist's Prism Nova. The Asus RTX 3060 Ti card used in this machine also has its boost clock improved from 1665MHz to 1710MHz, and the GPU has a total of 4,864 CUDA cores.

In most other areas, though, the Stormforce and PC Specialist systems are near identical. They share Intel's Core i5-12400F CPU, which has six Hyper-Threaded P-Cores that peak at 4.4GHz, and they both have 16GB of DDR4 memory. They even use the same Corsair TX650M power supply.

Both rigs also use the same motherboard, and the Asus Prime B660-Plus D4 is a solid slab of mid-range PCB. Positively, it's got a USB 3.2 Gen 2x2 Type-C port, 2.5Gbps Ethernet and support for fast memory alongside all the usual essentials, but it doesn't support PCI-E 5 and it looks aesthetically underwhelming.

Aside from the graphics card, there aren't many areas where the specifications diverge. The Stormforce has a 1TB SSD, just like the PC Specialist, and its read and write speeds of 3,556MB/sec and 3,110MB/sec outpace those of the Prism, but you're unlikely to notice much of a difference in real-world use. Meanwhile, the Stormforce's Realtek wireless card only supports 802.11ac rather than the latest 802.11ax standard. The Stormforce does have a better warranty, though, with three years of parts and labour coverage, while PC Specialist only supplies one year of parts cover.

All of the gear is housed in a Cougar MX430 Air chassis. It looks decent, thanks to an angular front area with RGB LEDs, and it measures just 467mm tall and 371mm deep, so it's smaller than the PC Specialist's enclosure. That bodes well if you want to cram your gaming PC into a small space.

At the front of the Cougar, you'll find neat cabling and the radiator for a Cooler Master MasterLiquid ML 120L V2 liquid cooler sits in the roof, while there's a fan hub around the back. Build quality is solid, and on top of the case there are two USB 3.2 Gen 1 ports – one more than the PC Specialist.

It's not all good news though. The PC's smaller size means the CPU cooler blocks the memory slots, and there's only room for sole 3.5in and 2.5in drives at the rear. The hard disk bay also doesn't have a caddy. The PC Specialist's case might be larger, but it's easier to manage and upgrade.

Performance

The RTX 3060 Ti might have less memory than the RTX 3060, but 8GB is more than enough, and the fact that it's attached to a 256-bit wide interface, rather than the RTX 3060's 192-bit interface, gives it plenty of memory bandwidth. Add the extra CUDA cores, and it delivers a convincing lead in game tests over the standard RTX 3060.

It will play any game well at 1080p – its 64fps 99th percentile result in Cyberpunk 2077 is testament to that – and a 320fps average in Doom Eternal shows you'll be able to run undemanding games at decent settings on monitors with high refresh rates. The scores remained consistent with ray tracing and DLSS activated, and at 2,560 x 1,440 the Stormforce hit 99th percentile results beyond 40fps in Assassin's Creed Valhalla and Cyberpunk 2077.

CRYSTAL MAZE

+ Rapid in 1080p games
+ Small, good-looking case
+ Generous warranty
+ Faster SSD than rivals

CRYSTAL SKULL

– Mediocre CPU
– Cramped enclosure
– Missing motherboard features

SPEC

CPU
2.5GHz Intel Core i5-12400F

Motherboard
Asus Prime B660-Plus D4

Memory
16GB Corsair Vengeance LPX 3200MHz DDR4

Graphics
MSI GeForce RTX 3060 Ti 8GB

Storage
1TB WD Blue SN750 M.2 SSD

Networking
2.5Gbps Ethernet, dual-band 802.11ax Wi-FI, Bluetooth 5.2

Case
Cougar MX430 Air RGB

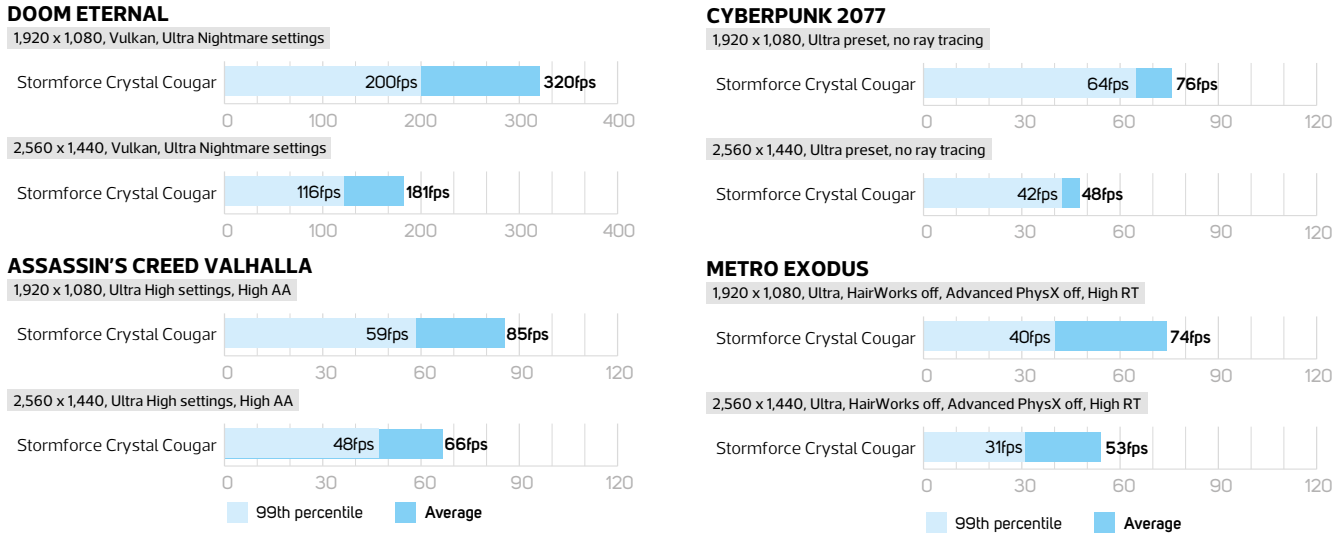
Cooling
CPU: Cooler Master MasterLiquid ML 120L V2 with 2 x 120mm fans; GPU: 3 x 90mm fans; front: 2 x 120mm fans; rear: 1 x 120mm fan

Ports
Front: 2 x USB 3.2 Gen 1, 1 x USB 2, 2 x audio; rear: 1 x USB 3.2 Gen 2x2 Type-C, 2 x USB 3.2 Gen 2, 1 x USB 3.2 Gen 1, 2 x USB 2, 3 x audio

Operating system
Windows 11 Home 64-bit

Warranty
Three years collect and return parts and labour

BENCHMARK RESULTS



It's an impressive slate of results that allows gamers to tackle most mainstream scenarios, from 2,560 x 1,440 displays and modest widescreen monitors to 1080p panels with high refresh rates. There's also a significant gap between this RTX 3060 Ti and the RTX 3060 inside the cheaper PC Specialist system.

The Stormforce has a clear lead over the PC Specialist in games, but the presence of the Core i5-12400F in both machines means there's little to choose between the two in application tests. The Cougar had a small lead in all of our benchmarks, including its overall result of 216,776, and the Core i5 chip will handle everyday gaming, loads of browser tabs and light content creation without complaint. If you want more power, you'll need to spend more money on a machine with a Core i5-12600K, which is far more capable with multi-tasking and creative workloads.

In terms of noise, the Cougar was marginally louder than the PC Specialist when gaming, but it's still one of the quietest gaming rigs you'll find. It was almost silent during processing benchmarks, and its CPU and GPU delta Ts of 48°C and 43°C are rock solid.

Conclusion

There's plenty to like here for the £1,349 inc VAT price, including loads of 1080p gaming power and solid performance in more demanding games, alongside a well-balanced specification, a decent SSD and a good warranty.

This PC isn't flawless though. The case is small but cramped, and the motherboard misses high-end features, while the processor is a mid-range affair. Also, the price difference between RTX 3060 and 3060 Ti cards is around £100, rather than £150. Nevertheless, the Stormforce delivers plenty of gaming power, and it's great that you can now buy this sort of gaming pace for £1,349 inc VAT. It's an ideal choice if you'd like more headroom than the PC Specialist can offer.

MIKE JENNINGS

VERDICT

A pacey, quiet and compact PC that offers a decent amount of gaming performance for a reasonable price.

COOLING **20/25**

FEATURES **19/25**

DESIGN **20/25**

VALUE **22/25**

OVERALL SCORE **81%**

Custom kit

Phil Hartup checks out the latest gadgets, gizmos and geek toys

KIKKERLAND FELT iBED STORAGE / **£34.46** inc VAT

SUPPLIER kikkerlandeu.com

The Felt iBed Storage is a handy marriage of a static tablet stand and a simple box. It works because both aspects are similarly uncomplicated and each part complements the other.

For instance, the Felt iBed's tablet stand is raised to a good height off whatever surface on which it's resting, by doubling as the lid of the box.

Meanwhile, the box itself is comfortably large enough to contain any tablet that fits in the 31cm long stand, as well as cables, chargers and other minor miscellanea that comes with it.

The flat space of the lid is also large enough to fit a small keyboard if you want to go for a laptop-style setup. There are no dividers or compartments in the box, which gives a great degree of freedom, but also sounds a note of caution in terms of bits and pieces bouncing around. Using felt as the box material also gives the whole unit a comfy and fuzzy vibe. Neither the tablet stand nor the box have been radically re-envisioned, but sticking them both together makes for a very convenient setup.

Felt rough ●●●●○ **Felt good**

REDTHUNDER MINI GAMING KEYBOARD / **£17.99** inc VAT

SUPPLIER amazon.co.uk

The RedThunder Mini Gaming Keyboard tries to take the left half of a keyboard and turn it into a different device – it feels almost exactly like half a keyboard. There's no ergonomic refinement – it's like somebody lopped a chunk off a regular keyboard and wired it back up.

This immediate familiarity makes it surprisingly easy to get used to the RedThunder if you're coming from a full-sized keyboard. The lighting is good enough, and easy to control using a function button that replaces the Windows key – you can pick static colours, wave patterns, or just turn it off. It's not mechanical, but it feels fine in use.

The RedThunder is unambitious but competently assembled, and as a space-saving, sawed-off alternative to a full-length keyboard, it's solid enough if you don't have much money to spend.

Seen off ●●●○○ **Sawn off**

BLACK SHARK MANTA P6 / **£19.99** inc VAT (80 x 30cm); **£24.99** inc VAT (90 x 40cm)

SUPPLIER rugdlife.com

The Black Shark Manta P6 is an extended mouse pad that also sports USB-powered RGB lights, because why not? The lighting has 11 different colour and pattern options, and you can rather awkwardly cycle through them sequentially with a single button, although they're well implemented – the lights are bright and looks good, as long as you're not shooting for an ARGB grade show.

A mouse pad of these elongated proportions can accommodate a keyboard as well, and it works well in this regard. Its 4mm thickness also makes it comfy to rest your wrists, and it has a water-resistant fabric top layer and a rubbery base layer for stability. The RGB version of the Manta is available in two sizes, with the largest size being 90 x 40cm, which offers a little more wiggle room. It's fine to use, and it looks good for a such a hefty pad – it could just do with a more sophisticated lighting controller.

One button does everything ●●●●○ **Simple interface**

CREATIVE BT-W4 / **£49.99** inc VAT

SUPPLIER uk.creative.com

The Creative BT-W4 is a Bluetooth audio transmitter with a whole bushel of functions. Firstly, it beefs up the quality of the sound from the device to which it's attached. Secondly, it boosts the signal and thirdly, it implements a simple method to switch between up to four paired audio outputs. The sound quality upgrade is achieved by using the aptX Adaptive codec, which adjusts the bit rate of the audio stream on the fly to try to maintain an unbroken and glitch-free stream of sound.

The BT-W4 also makes use of Bluetooth 5.2, which is still the latest version of Bluetooth, even if it's not entirely new. Swapping between paired Bluetooth devices is achieved by pushing a button on the top to cycle through them; compared with the regular way of swapping Bluetooth devices, this feels like a borderline revolutionary feature.

An analogue microphone is included, which is suitable for connection to a gamepad, potentially acting as a mic for Bluetooth headsets that might not have them. It does all this on PCs, Macs and Nintendo Switch consoles too. The devices connect via USB Type-C by default, but it comes with a regular USB adaptor. The stack of functions, combined with the ease of use, makes the Creative BT-W4 an extremely handy helper if you're struggling to stay on top of your Bluetooth audio devices.

Creeps ●●●●● **Features**

PROPEN MAGNETIC KEYCHAIN / **£12** inc VAT

SUPPLIER amazon.co.uk

If the Swiss Army needed cables instead of tiny sporky knives, it might come up with a device such as the Propen. It's a magnetically connected loop of flat cable that you can attach to a key ring, and there are connectors at either end of the cable that have a foldaway plug that you can flip into different types of connector.

Both ends have USB Type-C, and then one end also offers conventional USB, while the other end offers a combination of Apple Lightning and micro-USB. The micro-USB plug isn't the most solid fit, but it isn't bad considering it's sort of a hybrid version to fit both sorts of socket.

The cable itself is 14cm long, and there's a bit of clumsiness that goes with using it when the alternate connectors are deployed, but that's a fair trade-off for the whole unit being so small and convenient that you can basically forget it's there until you need it. Overall, the Propen is a clever way to carry an almost universal connector around – it's much less hassle than a pocket full of wires.

Fondue ●●●●○ **Chocolate**

Seen something worthy of appearing in Custom Kit? Send your suggestions to phil.hartup@gmail.com

How we test

MOTHERBOARDS

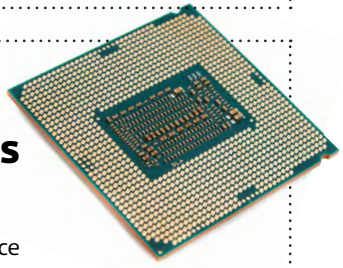
TEST PROCESSORS

- **Intel LGA1700** Intel Core i5-12600K
- **Intel LGA1700 mini-ITX** Intel Core i7-12700K
- **AMD AM4** AMD Ryzen 9 5900X

Common test hardware between our test rigs includes a WD Red SN750 SSD, plus a WD Black SN850 SSD to test the speed of M.2 ports, and an Nvidia GeForce RTX 3070. We use 16GB (2 x 8GB) of Corsair Vengeance RGB Pro 3466MHz DDR4 RAM, or 32GB (2 x 16GB) of Corsair 5200MHz Dominator Platinum DDR5 RAM.

All CPUs are cooled by a Corsair Hydro-X water-cooling loop with two XR5 240mm radiators, an XD3 RGB reservoir and an XC7 RGB waterblock. We test with our RealBench suite and Far Cry 6 on Windows 11. We also test each board's M.2 ports, and record the noise level and dynamic range of integrated audio using RightMark Audio Analyzer.

PROCESSORS



TEST MOTHERBOARDS

- **Intel LGA1700**
  Asus ROG Maximus Z690 Apex
- **Intel LGA1200** MSI MEG Z490 Ace
- **AMD AM4 APU** MSI MPG Gaming B550 Carbon WiFi
- **AMD AM4** MSI MEG X570 Unify

Common gear includes a 2TB Samsung 970 Evo SSD and Nvidia GeForce RTX 3070 FE graphics card. For LGA1700 CPUs, we use 32GB (2 x 16GB) of Kingston Fury 5200MHz DDR5 RAM and a Thermaltake Toughliquid Ultra 360 CPU cooler. For other systems, we use 16GB (2 x 8GB) of Corsair Vengeance RGB Pro 3466MHz RAM and a Corsair Hydro-X water-cooling loop, with two XR5 240mm radiators, an XD3 RGB reservoir and an XC7 RGB waterblock.

We use the latest version of Windows 11 with security updates, plus the latest BIOS versions and drivers. We record results at stock and overclocked speeds, and tests include our RealBench suite, Cinebench, Far Cry 6 and Dirt 5.

For games, we record the 99th percentile and average frame rates either using the game's built-in benchmark or Nvidia FrameView. Finally, we note the idle and load power draw of the whole system, using Prime95's smallfft test with AVX disabled.

MONITORS

We test image quality with an X-Rite iDisplay Pro colorimeter and DisplayCal software to check colour accuracy, contrast and gamma, while assessing more subjective details such as pixel density and viewing angles by eye. For gaming, we test a monitor's response time with an Open Source Response Time Tester, and use Blur Busters' ghosting UFO test to check the sharpness of a display in high-speed motion.

CPU COOLERS

We use CoreTemp to measure the CPU temperature, before subtracting the ambient air temperature from this figure to give us a delta T result, which enables us to test in a lab that isn't temperature controlled. We use Prime95's smallest FFT test with AVX instructions disabled to load the CPU and take the temperature reading after ten minutes.

For the Intel LGA1200 system, we take an average reading across all eight cores, and for the LGA1700 system, we take an average reading across both the P-Cores and E-Cores. AMD's CPUs only report a single temperature reading, rather than per-core readings, so we list what's reported in CoreTemp.

TEST KIT

Fractal Design Meshify C case, 16GB of Corsair Vengeance RGB Pro memory, 256GB Samsung 960 Evo SSD, Corsair CM550 PSU.

INTEL LGA1700

Intel Core i9-12900K at stock speed, Asus ROG Maximus Z690 Apex motherboard.

INTEL LGA1200

Intel Core i9-11900K at stock speed with Adaptive Boost enabled, MSI MEG Z590 Ace motherboard.

AMD AM4

Ryzen 7 5800X overclocked to 4.6GHz with 1.25V vcore, or Ryzen 5 5600X overclocked to 4.6GHz with 1.25V vcore on low-profile coolers, MSI MEG X570 Unify motherboard.

GRAPHICS CARDS

We mainly evaluate graphics cards on the performance they offer for the price. However, we also consider the efficacy and noise of the cooler, as well as the GPU's support for new gaming features, such as ray tracing. Every graphics card is tested in the same PC, so the results are directly comparable. Each test is run three times, and we report the average of those results. We test at 1,920 x 1,080, 2,560 x 1,440 and 3,840 x 2,160, using an AOC U28G2XU monitor.

TEST KIT

AMD Ryzen 9 5900X, 16GB (2 x 8GB) of Corsair Vengeance RGB Pro SL 3600MHz DDR4 memory, Asus ROG Strix B550-E Gaming motherboard, Thermaltake Floe Riing 240 CPU cooler, Corsair RM850 PSU, Cooler Master MasterCase H500M case, AOC U28G2XU monitor, Windows 10 Professional 64-bit.

GAME TESTS

Cyberpunk 2077 Tested at the Ultra quality preset and Medium ray tracing preset if the GPU supports it. We run a custom benchmark involving a 60-minute repeatable drive around Night City, and record the 99th percentile and average frame rates from Nvidia FrameView.

Assassin's Creed Valhalla Tested at Ultra High settings with resolution scaling set to 100 per cent. We run the game's built-in benchmark, and record the 99th percentile and average frame rates with Nvidia FrameView.

Doom Eternal Tested at Ultra Nightmare settings, with resolution scaling disabled. We run a custom benchmark in the opening level of the campaign, and record the 99th percentile and average frame rates with Nvidia FrameView. This test requires a minimum of 8GB of graphics card memory to run, so it can't be run on 6GB cards.

Metro Exodus Tested at Ultra settings with no ray tracing and both Advanced PhysX and HairWorks disabled. We then test it again with High ray tracing if the GPU supports it. We run the game's built-in benchmark, and report the 99th percentile and average frame rates.

POWER CONSUMPTION

We run Metro Exodus at Ultra settings with High ray tracing at 2,560 x 1,440, and measure the power consumption of our whole graphics test rig at the mains, recording the peak power draw.

CUSTOM PC AWARDS

EXTREME ULTRA

Some products are gloriously over the top. They don't always offer amazing value, but they're outstanding if you have money to spend.

PREMIUM GRADE

Premium Grade products are utterly desirable, offering a superb balance of performance and features without an over-the-top price.

PROFESSIONAL

These products might not be appropriate for a gaming rig, but they'll do an ace job at workstation tasks.

APPROVED

Approved products do a great job for the money; they're the canny purchase for a great PC setup.

CUSTOM KIT

For those gadgets and gizmos that really impress us, or that we can't live without, there's the Custom Kit award.

CUSTOM PC REALBENCH

Our own benchmark suite, co-developed with Asus, is designed to gauge a PC's performance in several key areas, using open source software.

GIMP IMAGE EDITING

We use GIMP to open and edit large images, heavily stressing one CPU core to gauge single-threaded performance. This test responds well to increases in CPU clock speed.

HANDBRAKE H.264 VIDEO ENCODING

Our heavily multi-threaded Handbrake H.264 video encoding test takes full advantage of many CPU cores, pushing them to 100 per cent load.

LUXMARK OPENCL

This LuxRender-based test shows a GPU's compute performance. As this is a niche area, the result from this test has just a quarter of the weighting of the other tests in the final system score.

HEAVY MULTI-TASKING

This test plays a full-screen 1080p video, while running a Handbrake H.264 video encode in the background.

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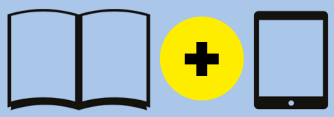

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LABS TEST

Whirling blades

Antony Leather tests a dozen of the latest 120mm fans to find the best balance of noise and airflow

How we test

Fans are vital PC components, but not all fans are created equal. Some are highly efficient and shift more air while generating less noise than their siblings, while some lack the grunt to be flexible enough to handle heavy heat loads on hot days.

This month we're pitching 12 fans against each other, focusing on efficiency and raw performance. We've tweaked our fan testing to include a more sensitive anemometer to measure airflow, and we've also changed the way we actually test fans. In the past, we've focused on specific voltages to measure fan speed performance, but this isn't realistic given the clever ways motherboards control fans with PWM control rather than brute force voltages these days.

To take this fact into account, we've tested each fan using PWM control where possible, at its maximum speed in terms of airflow in metres per second (m/sec) and noise in decibels (dBA), but also at certain fixed settings.

To start, we set each fan to 1,000rpm to give a speed-normalised result that's more useful than comparing at 7V, for example, where each fan will likely be spinning at different speeds. Not all fans have the same maximum speed either, so using a fixed speed they all can achieve means every fan can be tested at the same speed.

This is also closer to the speed at which your fans are likely to be spinning at low to medium loads, so the airflow and noise it produces here are clear indicators of efficiency. We've also carried out a noise-normalised test at 50dBA, which typically saw most fans spinning between 1,000rpm and 1,400rpm. If you're noise-sensitive and tend to tune your fan speed according to the noise it makes, then knowing which fans shift more air than others at the same noise level is very useful.

As some fans are extremely quiet at 1,000rpm, we place our sound meter closer to the fan than you would typically sit from your PC. We're not so much interested in proving manufacturers' noise level claims as we are in obtaining results for all fans in an isolated test, so we can compare them all fairly, even at lower speeds.

We've scored fans on their raw air-shifting potential, but given more points for efficiency, while also taking into account sound quality, features such as RGB lighting and finally value to give an overall score.

Contents

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- Gamemax Velocity / p43
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- Noctua NF-P12 redux / p44
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ANTEC PRIZM X 120 ARGB / £50 inc VAT (for three)

SUPPLIER scan.co.uk

Limited to triple packs at the time of writing that will set you back around £50, the Antec Prizm X 120 ARGB offers three digital RGB fans that extend their bright and punchy lighting to the fan hub as well as an outer ring, offering a little more pizzazz than the Deepcool FC120.

They use standard 4-pin PWM fan plugs and 3-pin digital RGB connectors, so they're easy to hook up to your PC and don't have proprietary cables. Antec also includes a hub and lighting controller with five fan and lighting ports, which can be controlled from your motherboard or other devices with single PWM and LED cables.

Noise was mid-table against the other fans on test this month, but a fair amount of vibration meant the Antec Prizm X 120 ARGB's sound quality was average. At full speed, it was a poor result in terms of airflow and efficiency, though, sitting at the opposite end of the scale to the Deepcool FC120.

Dropping to 1,000rpm didn't improve matters for noise and airflow, although its efficiency was better. While the Antec's speed was mid-table in our noise-normalised test, its airflow and efficiency were again near the bottom, while the Deepcool FC120 was cheaper and consistently in the top three.

Poor airflow and efficiency let down the Antec Prizm 120 RGB, despite the good package. If you want affordable, decent-performing RGB fans, the DeepCool FC120s are far better and cheaper.

PRISM
- \+ RGB lighting
- \+ Fan and lighting hub
- \+ Standard connectors

PRISON
- − Poor airflow
- − Sub-par efficiency
- − Uncompetitive price

VERDICT

Poor airflow and noise efficiency let down this otherwise decent package.

PERFORMANCE	EFFICIENCY	OVERALL SCORE
11/20	31/50	62%
FEATURES	VALUE	
9/10	11/20	

BE QUIET! SILENT WINGS 4 HIGH SPEED / £23 inc VAT

SUPPLIER overclockers.co.uk

On paper, the Silent Wings 4 High Speed boasts some hefty specs. Hitting a peak of 2,500rpm, this model offers a massive claimed 3.96mm H_2O static pressure, in part thanks to small blade-tip clearances, while a six-pole motor and fluid-dynamic bearing reduces vibration and noise. The fans come with easy-to-use push-pin corner clips for mounting in cases, with separate clips for use with coolers and radiators. However, there's no RGB lighting here.

Sound quality was exceptional, and at full speed, the be quiet! managed the second lowest noise level on test, despite also hitting a massive 2.6m/sec in airflow, which was second only to the monstrous and deafening Phanteks T30. This gave it the third best efficiency. It managed the lowest noise at 1,000rpm, but it did slip down the airflow table here to 0.76m/sec, while the Phanteks T30 was only slightly louder and managed 0.9m/sec.

Still, the Silent Wings 4 High Speed beat the Phanteks in efficiency, and was a match for the Deepcool FC120, while it topped the chart in all three noise-normalised tests.

With superb high-speed airflow, excellent efficiency at all speeds and great sound quality, the fantastic be quiet! Silent Wings 4 High Speed is attractive for any situation. It won't be cheap to kit out a PC case or large radiators, but if you want great airflow and static pressure with low noise, it's worth every penny.

SILENT WING
- \+ Great airflow-to-noise ratio
- \+ Good sound quality
- \+ Decent top-speed airflow

SILENT WIND
- − Average airflow at 1,000rpm
- − No RGB lighting
- − Pricey

VERDICT

Fantastic efficiency, airflow and low noise, but it's not cheap.

PERFORMANCE	EFFICIENCY	OVERALL SCORE
16/20	48/50	80%
FEATURES	VALUE	
5/10	11/20	

CORSAIR LL120 RGB / £18 inc VAT

SUPPLIER cclonline.com

Corsair's LL120 RGB is available in single and triple-pack form, but if you want to use the lighting, you'll need to hook it up to a Lighting Node Pro and control the lighting using its iCUE software. Those components come with the triple pack, but not the single fan, so make sure you factor this into your budget. Once the lighting is running, it looks fantastic, with rich, vibrant colours spanning the hub and semi-translucent blades. Sadly, you'll need to hook up each fan individually, as there's no daisy-chain option.

At full speed, the LL120RGB managed a decent airflow of 2.11m/sec, but it also produced a huge amount of noise to get there. It exhibited a high-pitch whine, while the be quiet! Silent Wings 4 High Speed managed 2.6m/sec and was significantly quieter.

It wasn't much better at 1,000rpm, with the Corsair's 52dBA noise level again being far louder than the be quiet! fan, and again the latter offered far greater efficiency. In our sound-normalised test, it was clear that the LL120 RGB lacks efficiency, with the be quiet! able to offer more than twice the airflow for the same noise level, adding 400rpm compared with the Corsair fan at the same noise.

The Corsair LL120 RGB is one of the more powerful fans on test, and its lighting looks fantastic. However, it's far too loud and inefficient compared with the new kits on the block.

LIGHT FANTASTIC

+ Fantastic RGB lighting
+ Decent airflow at full speed
+ Compatible with iCUE

LIGHT HEADED

- Poor efficiency
- Loud at full speed
- Extras required for lighting

VERDICT

A powerful fan with decent lighting, but it's loud and inefficient.

PERFORMANCE	EFFICIENCY	OVERALL SCORE
13/20	31/50	63%
FEATURES	VALUE	
8/10	11/20	

DEEPCOOL FC120 / £35 inc VAT (for three)

SUPPLIER scan.co.uk

Supplied as a triple pack in the UK, the FC120s feature fantastic digital RGB lighting, which does a good job of diffusing across the semi-transparent blades. The fans each have inputs and outputs, allowing you to daisy-chain them together, so you only need one 4-pin fan header and one 3-pin RGB header to control their speed and lighting.

Each fan has chunky anti-vibration mounts too, but the best bit is the price. At just £35 for three fans, you're paying a little more than a tenner a fan. They're powered by a SATA connector, so they only need the PWM signal from your motherboard's CPU fan header to work. However, our Asus test motherboard's AI Suite software wasn't keen on talking to the fans. Manually setting the EFI fan control to PWM solved the issue, but we didn't have this issue with other PWM fans.

The FC120 only hit a peak airflow of 1.82m/sec, but this is still in the same league as the Noctua NF-P12 redux. Sound quality was reasonable, with only a slight audible tone and very low noise level of 55dBA, giving it the best airflow-to-noise ratio on test at full speed and 1,000rpm, and it came second in the noise-normalised test.

The Deepcool FC120 has excellent efficiency, RGB lighting, decent performance and a bargain price for three of them. The be quiet! Silent Wings 4 is a better performer, but the Deepcool FC120 wins on value.

BREEZE

+ Great airflow-to-noise ratio
+ Good airflow at 1,000rpm
+ Superb value

TORNADO

- Limited maximum airflow
- No single-fan option yet

VERDICT

Excellent efficiency and RGB lighting for a great price.

PERFORMANCE	EFFICIENCY	OVERALL SCORE
12/20	48/50	85%
FEATURES	VALUE	
9/10	16/20	

EK VADAR X3M D-RGB / £20 inc VAT

SUPPLIER overclockers.co.uk

EK's Vadar X3M D-RGB is one chunky, weighty fan. Its large rotor is illuminated by digital RGB lighting with a 3-pin connector, and the translucent fan blades allow the light to diffuse fairly evenly along them. There's extra customisation available in the form of optional corner sections in a variety of colours.

It's one of the more powerful fans on test too, with a peak speed of 2,200rpm, although all this comes at a price of £20 per fan. Digging into the data, the noise level of 67dBA isn't great, and like so may other loud fans there's a distinct whine at full speed, which only peaked at a somewhat disappointing airflow of 1.9m/sec.

This was less than the slower-spinning Noctua NF-P12 redux, which was quieter and only marginally better than the Deepcool FC120.

The EK was a little better at 1,000rpm in terms of noise, but its airflow at this fixed speed was comparatively low, resulting in mediocre efficiency compared with the Noctua NF-P12 redux and Deepcool FC120. The EK again failed to impress in our noise-normalised test, with the two aforementioned fans offering more airflow and the similarly-priced be quiet! Silent Wings 4 High Speed completely outclassing it.

The EK Vadar X3M D-RGB has excellent build quality, great RGB lighting and customisation options, as well as being quite eye-catching. However, at this price, it struggles to compete in terms of efficiency and airflow.

DARTH VADER

- \+ RGB lighting
- \+ Good build quality
- \+ Reasonable peak airflow

JAR JAR BINKS

- – Poor sound quality
- – Loud at full speed
- – Uncompetitive price

VERDICT

Decent build quality, but let down by poor sound quality and efficiency.

PERFORMANCE	EFFICIENCY	OVERALL SCORE
12/20	34/50	63%
FEATURES	VALUE	
7/10	10/20	

GAMEMAX VELOCITY / £7 inc VAT

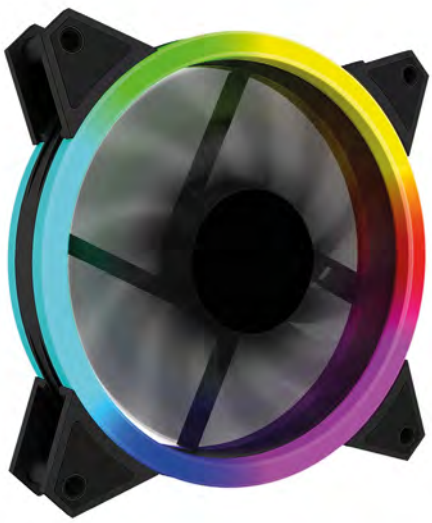
SUPPLIER cclonline.com

The Gamemax Velocity retails for a price of just £7, and it even comes with digital RGB lighting, allowing for individual LEDs to be controlled independently via a 3-pin cable. Only the outer ring on the fan illuminates, but you can't have everything. More annoying is that there's no 4-pin fan connector and only a 3-pin one, so you'll need to make sure your motherboard can either recognise the Gamemax or set it to direct voltage mode.

The peak fan speed is also very low at just 1,500rpm, making the Velocity primarily a case fan, rather than a radiator or heatsink fan. Thankfully, it was very quiet, at just 62dBA in close proximity, but the Velocity also had the worst airflow on test at full-speed, with a measurement of just 1.13m/sec.

The Deepcool FC120 managed 1.82m/sec and was quieter too. Dipping down to 1,000rpm saw the Velocity being among the louder fans on test, but it again failed to put that noise into airflow with the second lowest result on test, as well as the lowest efficiency. This was mirrored in the sound-normalised tests, where it was either at the bottom of the results or next to the bottom result across the board.

If you just want to kit out a case with RGB fans, the Gamemax Velocity is a temptingly cheap option. However, its airflow and efficiency credentials leave a lot to be desired – it's only worth considering for low budgets and systems that don't need much airflow.



VELOCIRAPTOR

- \+ Only costs £7
- \+ RGB lighting
- \+ Lighting cable can be daisy-chained

BARNEY THE DINOSAUR

- – Poor airflow
- – Lowly efficiency

VERDICT

A great price for RGB lighting, but its airflow and efficiency are poor.

PERFORMANCE	EFFICIENCY	OVERALL SCORE
10/20	26/50	61%
FEATURES	VALUE	
7/10	18/20	

GELID RADIANT-D / £12 inc VAT

SUPPLIER quietpc.com

The £12 Gelid Radiant-D boasts a reasonable peak speed of 2,000rpm and also has RGB lighting. There are no accessories in the box, and it has a basic fan frame and design, but thankfully Gelid hasn't cut the 4-pin PWM connector. Despite having a 4-pin RGB connector, though, it only supports 5V 3-pin headers, and using the former can actually kill the lighting circuitry. There's nothing in the box mentioning this, which is a serious problem.

At full speed, there was a mild whine but significant airflow noise. The noise did at least translate into airflow and static pressure, with the Gelid landing the third best airflow speed on test of 2.2m/sec, only beaten by the Phanteks T30 and be quiet! Silent Wings 4 High Speed.

Its airflow-to-noise efficiency was poor, but got better at 1,000rpm. Here, despite a still mediocre 50dBA, it again achieved one of the better airflow results and even bettered the be quiet! Silent Wings 4. When sound-normalised it managed a mid-table result, despite only managing to hit 1,000rpm at this sound level.

The Gelid offers great airflow and RGB lighting for a reasonable price, although it's noisy. If you're not particularly bothered by noise and just want an RGB fan and decent airflow, it's definitely worth considering.

However, the terrible decision to ship with a 4-pin RGB connector definitely mars our view. If you buy this fan, proceed with caution.

GOOD RADIANCE
- + RGB lighting
- + Great airflow
- + Reasonable price

GOOD RIDDANCE
- – Rather noisy
- – Loud at full speed
- – Should have 3-pin RGB plug

VERDICT

Decent airflow and RGB lighting for a reasonable price, but it's noisy.

PERFORMANCE	EFFICIENCY	OVERALL SCORE
14/20	40/50	69%
FEATURES	VALUE	
5/10	10/20	

NOCTUA NF-P12 REDUX / £13 inc VAT

SUPPLIER overclockers.co.uk

Picking up our Premium Grade award in our last fan Labs, the Noctua NF-P12 redux offered great performance for the price. There's some stiff competition now, though, with alternatives that can ramp up further than the NF-P12 redux's paltry 1,700rpm.

That's likely all you need for a case fan, but you might need more if you need to deal with significant amounts of heat on rare occasions.

It also lacks RGB lighting, unlike several similarly priced fans. However, in the flesh, it looks fantastic, shedding Noctua's usual brown colouring in favour of gunmetal grey. The NF-P12 redux still holds its own, although it slips down the table in a few tests. It has decent efficiency at full speed, outstripping the XSPC RGB Series 2, Scythe Kaze Flex 120 RGB and Gelid Radiant-D, but the XSPC did have slightly better sound quality, with the NF-P12 redux exhibiting a slight whine at 1,700rpm. The XSPC was also slightly quieter at 1,000rpm, but shifted noticeably less air, with the NF-P12 redux offering better efficiency here, while shifting more air in our noise-normalised test too.

The Noctua NF-P12 redux remains a good choice as an affordable fan to pad out vacant fan mounts in your PC. It's a better performer than the similarly priced offerings from XSPC, Scythe and Gelid as well, although we'd pick the Scythe if you also want RGB lighting.

REDUCTION
- + Good airflow-to-noise ratio
- + Excellent airflow at 1,000rpm
- + Good value

REDACTION
- – No RGB lighting
- – Average sound quality
- – Lacks high-speed grunt

VERDICT

Good performance for the cash, but it could do with a little more power now.

PERFORMANCE	EFFICIENCY	OVERALL SCORE
12/20	42/50	75%
FEATURES	VALUE	
5/10	16/20	

PHANTEKS T30 / £30 inc VAT

SUPPLIER overclockers.co.uk

The Phanteks T30 offers great build quality and built-in speed control, with its Advanced mode allowing it to peak at a monstrous 3,000rpm. You get a few accessories too, such as a 50cm PWM extension cable, radiator screws with 6-32 threads, plus an extended set of these screws to enable you to use Phanteks' Halos RGB fan frames on top with a radiator. However, it lacks RGB lighting out of the box.

Not surprisingly, noise at its peak speed was high, although the Corsair LL120 RGB was slightly louder. Thankfully, that noise buys you a gargantuan airflow of 3.79m/sec, which was over 1m/sec higher than the be quiet! Silent Wings 4 High Speed. Despite this, efficiency was also fairly good.

At 1,000rpm, it also racked up the second best airflow, along with the fourth lowest noise level, giving it the third best airflow-to-noise ratio on test. Its noise-normalised test was similar, with the fourth best airflow on test, despite only needing 1,100rpm to get there and coming fourth in the efficiency chart.

The Phanteks T30 has huge airflow on tap when you need it, and also delivers at lower speeds with excellent airflow and low noise levels. If money were no object, we'd strap it to all our cases and radiators, but £30 is a lot of money for a single fan and the be quiet! Silent Wings 4 and Deepcool FC120 also offer good performance for much less money.

PREMIUM
- + Monstrous airflow
- + Excellent efficiency
- + Low noise at low speeds

OVERPRICED
- – Loud at full speed
- – Expensive
- – Cheaper fans are more efficient

VERDICT

Mega performance and efficiency, but it's really pricey.

PERFORMANCE	EFFICIENCY	OVERALL SCORE
19/20	45/50	79%
FEATURES	VALUE	
5/10	10/20	

SCYTHE KAZE FLEX 120 RGB / £12 inc VAT

SUPPLIER quietpc.com

Scythe's Kaze Flex 120 RGB has a 4-pin header, so lighting controls impact all LEDs, resulting in one colour at a time. The lighting looks good, though, with the semi-translucent blades allowing the illuminated hub to dish out colour all the way along them. There's also only 3-pin speed control, rather than 4-pin PWM, but most motherboards can still control 3-pin speed effectively. You get a Molex cable in the box too.

There are several variations available, with our sample hitting a peak speed of 1,800rpm. Its peak noise of 66dBA here was average, with a noticeable whine, but many other fans exhibited the same issue. Airflow was excellent, though, at 2.16m/sec. This puts it just behind the slightly louder Gelid Radiant-D, but comfortably ahead of the Noctua NF-P12 redux – only the be quiet! Silent Wings 4 and Phanteks T30 offered noticeably more airflow.

The Scythe was also the loudest fan on test at 1,000rpm. However, it also offered the best airflow here, meaning its efficiency isn't bad. Our noise-normalised test saw the Scythe struggle, as it only reached 950rpm before it hit our noise level limit, but it still had far from the worst efficiency on test here.

Thanks to a low price, reasonable efficiency, RGB lighting and decent airflow, the Scythe Kaze Flex 120 RGB is a decent offering, although the Deepcool FC120 is better and cheaper if you need three or more fans.

LAWNMOWER
- + Good airflow
- + Reasonable efficiency
- + Low price

SCYTHE
- – Loud at most speeds
- – No PWM control
- – No 3-pin digital RGB lighting

VERDICT

Decent airflow, lighting and efficiency, but not particularly quiet.

PERFORMANCE	EFFICIENCY	OVERALL SCORE
13/20	40/50	77%
FEATURES	VALUE	
7/10	17/20	

THERMALTAKE TOUGHFAN 12 / £18 inc VAT

SUPPLIER scan.co.uk

Thermaltake's Toughfan 12 looks premium, feels premium and has a relatively premium price, at £18 each or £32 for a pair. It can cope with any situation too, with its peak speed of 2,000rpm sitting higher than that of the Noctua NF-P12 redux and Deepcool FC120.

It also has a hydraulic bearing and steel-reinforced motor hub, plus large anti-vibration mounts and liquid crystal polymer fan blades, which Thermaltake claims reduces vibration. It lacks RGB lighting, but it does come in a variety of colours, allowing a modicum of colour matching to the rest of your hardware.

TOUGH FAN

+ Great airflow-to-noise ratio at full speed
+ Good sound quality
+ Reasonable price

TOUGH CROWD

− Limited maximum airflow
− Mediocre airflow at 1,000rpm
− No RGB lighting

At full speed, it matched the Deepcool FC120's lowest noise level on test of 55dBA, but wasn't quite able to match the Deepcool's airflow and efficiency, despite having a higher RPM. Dropping back to 1,000rpm saw the Toughfan 12 offer a slightly lower noise level than the Deepcool, but less airflow. When fixed at 50dBA, it managed to hit 1,400rpm and was a match for the Deepcool fan.

The Thermaltake's airflow is only average at full speed, but it makes up for this in efficiency, especially at full speed. Its raw airflow trails pricier fans, but its good noise-to-airflow ratio means it's worth considering for cases, coolers and radiators if you can't afford to really splash out. If you don't care about lighting, the Toughfan 12 is well worth considering.

VERDICT

Good efficiency and low noise with a reasonable price tag.

PERFORMANCE	EFFICIENCY	OVERALL SCORE
12/20	45/50	76%
FEATURES	VALUE	
5/10	14/20	

XSPC RGB SERIES 2 / £11 inc VAT

SUPPLIER watercoolinguk.co.uk

For £11, the XSPC RGB Series 2 doesn't look like a bad deal, with its digital RGB lighting and a 2,200rpm peak speed. There are large anti-vibration pads too although, as you'd expect at this price, there are no accessories or other features. The RGB lighting sits only in a patterned ring around the fan frame (though it is visible on both sides), with no light finding its way onto the fan blades or hub. Thankfully, unlike Scythe, XSPC has stuck with PWM control, so your motherboard should have full management over it.

The XSPC's sound quality was well above average, despite a high noise level, with only a slight drone noticeable above the airflow noise.

MODERATION

+ Good airflow
+ Snazzy RGB lighting
+ Low price

EXCESS

− Loud at full speed
− Poor airflow-to-noise ratio
− Not very efficient

It managed a decent 2.03m/sec airflow too, although the amount of noise saw its efficiency fall. Dropping down to 1,000rpm saw the noise level sit lower than the majority of fans on test, but its sub-par airflow harmed its efficiency here. Finally, the noise-normalised test once again had mediocre airflow at the same noise level as other fans despite, being the XSPC hitting 1,150rpm at 50dBA.

The XSPC RGB Series 2 is an affordable fan with decent airflow and great-looking digital RGB lighting, but its efficiency lets it down and it generates too much noise in order to output its impressive peak airflow. The Deepcool FC120 is a better buy if you want affordable fans with RGB lighting, while the be quiet! Silent Wings 4 High Speed offers a better noise-to-airflow ratio.

VERDICT

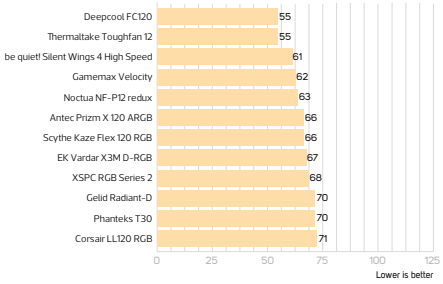
Decent airflow, but it generates too much noise.

PERFORMANCE	EFFICIENCY	OVERALL SCORE
13/20	36/50	73%
FEATURES	VALUE	
7/10	17/20	

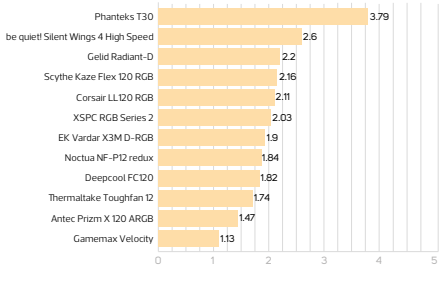
120MM FANS BENCHMARK RESULTS

FULL SPEED

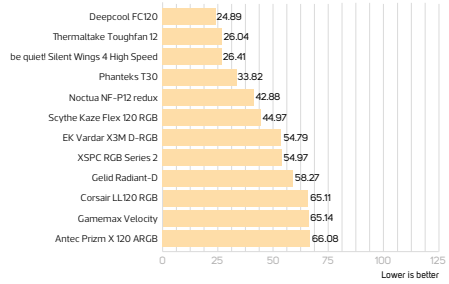
NOISE (DBA)



AIRFLOW (M/SEC)

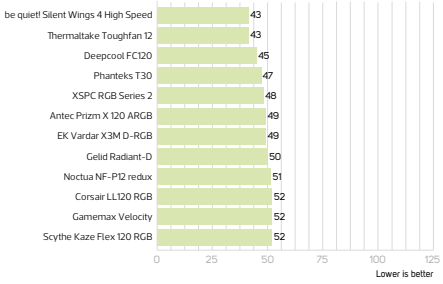


AIRFLOW-TO-NOISE RATIO

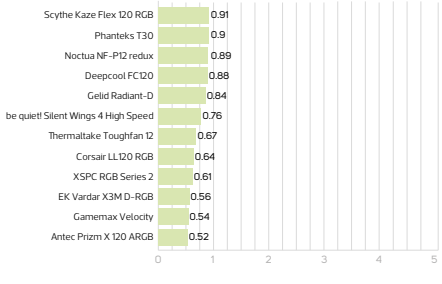


SPEED NORMALISED (1,000RPM)

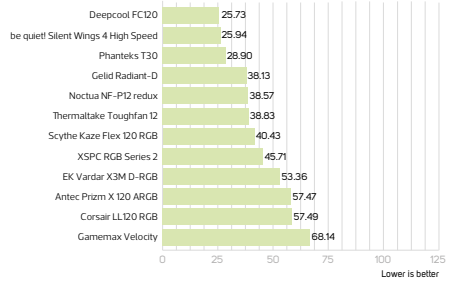
NOISE (DBA)



AIRFLOW (M/SEC)

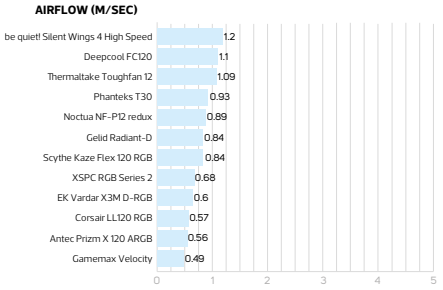


AIRFLOW-TO-NOISE RATIO

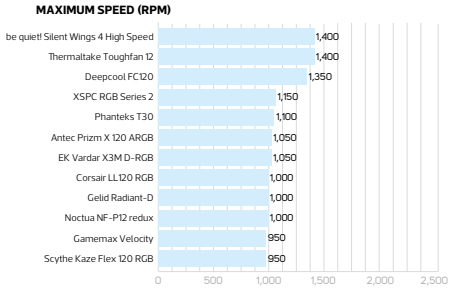


NOISE NORMALISED (50DBA)

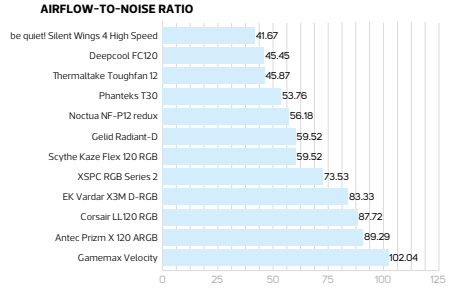
AIRFLOW (M/SEC)



MAXIMUM SPEED (RPM)



AIRFLOW-TO-NOISE RATIO



LABS TEST

Monitoring the situation

With monitor prices steadily falling in recent years, 2,560 x 1,440 27in gaming screens can now readily be bought for well under £300. Edward Chester puts seven of the latest models through their paces

How we test

Balancing screen size, resolution and affordability, 27in monitors with a resolution of 2,560 x 1,440 (1440p) have long been a great all-round option. They have a high enough resolution to look sharp, with enough desktop space for a couple of windows to sit side by side, but not so high a resolution that you need an RTX 3080 Ti just to run the latest games at native resolution. What's more, unlike even larger screens, you don't need to worry about finding desk space to accommodate them.

While the upper echelons of 27in gaming monitors now have 144Hz, 4K panels or 1440p screens with 240Hz refresh rates, at the lower end of the market you can still get up to 180Hz, 1440p screens for under £300. Not all the screens in this test are quite so cheap, but all are £400 or under. To test these screens, we focused on three main areas: image quality, gaming performance and features. Image quality is tested largely with an X-Rite iDisplay Pro colorimeter, which we use to assess the maximum brightness, contrast, colour balance, gamma (the rate of change from dark to light tones), uniformity of the whole panel and the colour space coverage.

Many modern displays stretch beyond the standard sRGB colour space used as standard on PCs, and instead can produce the larger range of colours used in HDR content. We test for this and also look for whether a monitor has an sRGB mode that reduces the colour range of the display so that it can still be used to correctly show colours intended for the sRGB colour space. We also check the viewing angles, look for any obvious backlight bleed and look out for any anomalies.

Gaming performance is initially tested subjectively by playing fast-paced games such as first-person shooters. These sorts of games demand a high refresh rate and fast pixel response time, so we can quickly detect when a screen feels sluggish.

We also test the response time using an OSRTT device. This switches the screen between various grey tones and measures the brightness change, providing a comprehensive picture of how quickly the LCD panel's pixels respond.

We test at every overdrive setting, and report the results for the ideal overdrive setting that balances the fastest response time with the least colour overshoot.

Finally, we look at what features, such as USB hubs, video connections and stand adjustability the monitor offers, and look at how all the above is balanced with the price.

Contents

- AOC AGON AG273QXP / p49
- Asus TUF Gaming VG27AQL1A / p50
- BenQ Mobiuz EX2710Q / p51
- iiyama G-Master GB2770QSU-B1 / p52
- LG Ultragear 27GP850 / p53
- MSI MAG274QRF-QD / p54
- ViewSonic XG2705-2K / p55
- Results graphs / p56

AOC AGON AG273QXP / £260 inc VAT

SUPPLIER box.co.uk

AOC's AGON AG273QXP hosts the same core specs of the other displays on test, with a 27in IPS panel and 2,560 x 1,440 resolution, but the AG273QXP adds a few extra goodies to the formula. The most prominent one is the quality stand. It's made from solid metal, from its curved pointy feet all the way up to the useful carry handle at its top. It looks great, feels secure and its range of ergonomic adjustments – height, rotation, pivot and tilt – all feel smooth.

Around the back you also get a ring of RGB lighting. It's not bright enough to provide an eye-strain-reducing glow behind the panel, but it's a fun decorative extra. Other premium touches include the use of USB 3.2 ports for the 2-port hub, the addition of side-mounted, flip-down headphone stands and a clip-on hood to reduce glare.

This display also goes all the way up to a 170Hz refresh rate, rather than the 165Hz or 144Hz of some other models. The gaming advantage of 170Hz over 144Hz is certainly modest, let alone the tiny advantage over 165Hz, but it's an advantage nonetheless.

SPEC

Screen size 27in

Resolution 2,560 x 1,440

Panel technology IPS

Maximum refresh rate 170Hz

Stated response time 1ms

Max brightness 400cd/m² (SDR and HDR)

Stated contrast ratio 1,000:1 (SDR and HDR)

Adaptive sync FreeSync and G-Sync compatible

Display inputs 2x DisplayPort 1.4, 2 x HDMI 2

Audio Headphone out, 2 x 2W speakers

Stand adjustment Height, pivot, rotation, tilt

Extras 100 x 100mm VESA mount, 2 x USB 3 ports, monitor hood, headphone stands

What's clearer is the responsiveness of this display's panel. At its default and optimal Medium overdrive setting, it produced an average initial response time of 4.36ms in our tests – the second fastest on test – with an average perceived response time of 6.53ms. There's a little bit of colour overshoot at this overdrive setting (an average RGB value miss of 6) leading to that slightly higher perceived response time, but it's not enough to be a concern in most gaming scenarios.

You can get an even faster average initial response time of 3.34ms with the Strong overdrive setting, but this causes overshoot to leap up to 25, so we don't recommend it for most circumstances.

One gaming feature this display lacks is any sort of backlight-strobing blur reduction mode. It's not commonplace on displays of this price, but the Asus VG27AQL1A includes it and it just pips the AOC for motion clarity when it's engaged.

Elsewhere, the AG273QXP has a smart design and ample connection options, with two HDMI ports and even two DisplayPort inputs. There's a headphone jack and speakers too, though the latter are quite weak.

The menu system is controlled by a single mini D-pad on the central underside of the panel. The control works well, and the menus offer all the settings you'd want, including a proper sRGB mode that reins in the wide default colour gamut of 140 per cent sRGB to 96 per cent sRGB, although the menu layout can be a little confusing at times.

Image quality is otherwise largely good too. Contrast isn't outstanding (874:1) for an IPS panel, but is still enough for the display not to look washed out. The default colour balance and gamma are also decent, but not perfect (even in the sRGB mode), so some calibration is required for colour critical work. The maximum brightness is massive, though, which will help in bright environments, and it gives HDR content a boost, even if the lack of a multi-zone backlight means HDR isn't truly impressive.

HERE TODAY

- \+ Loads of features
- \+ Excellent gaming performance
- \+ Excellent value
- \+ Solid image quality

AGON TOMORROW

- – No backlight strobing blur reduction
- – Middling contrast
- – Default colour balance isn't perfect

Conclusion

AOC has done it again with a truly fantastic gaming monitor that delivers features, image quality and gaming performance that belies its modest price. The default image quality isn't quite as good as that of some competitors, but this will only be of concern for colour critical work and can be corrected with calibration.

VERDICT

Features and performance aplenty for a petite price.

IMAGE QUALITY	GAMING	OVERALL SCORE
22/30	25/30	86%
FEATURES	VALUE	
19/20	20/20	

ASUS TUF GAMING VG27AQL1A / £320 inc VAT

SUPPLIER cclonline.com

Asus' TUF gaming monitors have firmly established themselves as excellent-value, no-frills options. With its latest 27in IPS panel this trend certainly seems to continue, with a near-£300 price tag and all the usual features. Plus, it includes Asus' ace in the sleeve, its ELMB Sync technology, which combines adaptive sync (such as FreeSync and G-Sync) with backlight strobing blur reduction technology. Only Asus currently combines both technologies at once.

Otherwise, the VG27AQL1A looks smart enough, using a simple black plastic stand with flat, V-shaped feet. The stand offers a full range of ergonomic adjustments – height, rotation, pivot and tilt – and they move smoothly enough. It's not quite as snazzy-looking or stable as the AOC display but it's entirely adequate.

Unlike the AOC, you don't get RGB lighting nor any other physical extras beyond the USB hub, although you at least get USB 3 ports. For display inputs you get one DisplayPort 1.2 and two HDMI 2 inputs, and all the connections are on the back of the display, aiming down towards the desk. Speakers are included, but sound weedy with a peculiar floaty, almost pretend surround sound quality. Most monitors have rear or down-firing speakers, so have a similar lack of true stereo placement, but it's particularly pronounced here.

Meanwhile, the menu system is controlled via a mini D-pad and four buttons down the screen's rear, right edge. The controls feel responsive, and the menus are intuitively laid out. Image quality is also largely excellent right out of the box. Colour balance is near perfect at a 6,468K colour temperature, while gamma (2.15) is very good too. Contrast is also on the higher side for an IPS panel at 1,053:1 and you get a reasonably wide 138 per cent sRGB colour gamut.

Switching to the User colour mode (from Warm default) to calibrate the display further worsened the colour balance slightly, requiring us to dial in the RGB colour balance to 98 x 100 x 96, and even then the default setting was better. There's also an sRGB setting, but it doesn't reduce the sRGB colour gamut to 100 per cent and drops contrast to just 565:1.

When it comes to gaming, we were shocked to find this panel performed quite badly in our response time tests. Nearly all the average response times from the monitors on test hover around 4-5ms, with an average perceived response time of 6-8ms. However, even with overdrive at its maximum, this display's initial response time only hit 6.5ms, with a perceived response time of over 10ms.

This sluggishness was perceptible in games, with a smeariness and loss of clarity in fast motion. It's still better than many older IPS panels and most VA panels, but trails most of the other panels on test.

On the plus side, the backlight strobing blur reduction works wonders for masking the slow response and tricking your eyes into seeing a clearer picture during fast motion. When enabled, ELMB Sync elevates this display to among the best of the bunch for clarity in fast motion, although not by as much as it would have if the panel had a faster response time in the first place.

Conclusion

ELMB Sync rescues this monitor from a low score, adding back in the motion clarity that's lost due to a quite sluggish pixel response time. Still, some people don't get on with backlight strobing blur reduction, so it's not a fix-all – this is still a half-decent gaming monitor, but it could do with a faster panel.

SPEC

Screen size 27in

Resolution 2,560 x 1,440

Panel technology IPS

Maximum refresh rate 170Hz

Stated response time 1ms

Max brightness 350cd/m² (SDR), 400cd/m² (HDR)

Stated contrast ratio 1,000:1 (SDR and HDR)

Adaptive sync FreeSync and G-Sync compatible

Display inputs 1x DisplayPort 1.2, 2 x HDMI 2

Audio Headphone out, 2 x 2W speakers

Stand adjustment Height, pivot, rotation, tilt

Extras 100 x 100mm VESA mount, 2 x USB 3 ports, ELMB Sync

TOUGH TYRES

+ Decent image quality
+ Good motion clarity thanks to ELMB Sync
+ Nice simple design

TOUGH TIMES

– Sluggish native response time
– Weedy speakers
– Low contrast in sRGB mode

VERDICT

ELMB Sync is great, but the rest of this monitor is less impressive.

IMAGE QUALITY	GAMING	OVERALL SCORE
25/30	20/30	77%
FEATURES	VALUE	
17/20	15/20	

BENQ MOBIUZ EX2710Q / £400 inc VAT

SUPPLIER cclonline.co.uk

BenQ has carved out a niche in the gaming monitor market, creating a line of displays with premium touches. It's a laudable attempt to stand out, but it does mean the likes of the EX2710Q demand a higher price than simpler displays. For your extra £100 inc VAT, the EX2710Q buys you uprated speakers, with a pair of 2W tweeters and a 5W subwoofer.

The speaker quality improvement is vast too, with good clarity and genuine bass presence. We happily listened to music and watched longer-form YouTube videos on this panel and didn't find it lacking. It's only when sitting back and wanting a more room-filling sound that it starts to struggle. For the sake of avoiding the cable and desk clutter of dedicated desktop speakers, there's a definite advantage for paying the premium here.

Another extra feature is a dedicated HDRi button on the front of the thick lower bezel. This brings up various image quality presets to enhance the screen, to match whatever you're watching or playing. Unfortunately, it's a far less impactful addition than the speakers. Without a multi-zone backlight, the panel simply doesn't have the native contrast to do HDR content justice – as is the case with all the displays in this test. And even if it did, you shouldn't need all these esoteric modes to get the most from the panel – it should just be good enough.

The rest of the menu system is controlled by a mini D-pad on the right rear of the panel and the system works smoothly and quickly. However, the menu system itself is a bit of a head scratcher. There are so many extra modes and settings buried within those modes – it gets you there in the end but it's far more hassle than it should be.

One crucial setting is the availability of an sRGB mode. This properly clamps the sRGB colour gamut to under 100 per cent, while the default colour gamut of the display reaches to 143 per cent, giving you vibrant, HDR-ready colours. Less obviously HDR-ready is the modest maximum brightness of 230 nits, but this restriction only applies for non-HDR modes. In HDR mode, the screen stretches to 400 nits. Otherwise, image quality is solid, if not spectacular, with decent out-of-the-box colour balance and gamma, but a rather low contrast ratio of just over 789:1.

When it comes to gaming performance, the EX2710Q tops out at 165Hz but its response time is reasonably nippy. Its average initial response time is 4.66ms, with a perceived response time of 5.81ms, using the Overdrive 2 setting that comes with minimal overshoot. The display supports FreeSync and G-Sync with compatible cards too, but it doesn't have a backlight strobing blur reduction mode.

Meanwhile, the display itself is quite hefty, with a thick panel and wide lower bezel, but it gives off a reassuring feeling of sturdy quality, rather than just a cheap and chunky quality.

The stand is very robust too, and offers height, rotation and tilt adjustment, but can't pivot the screen into a portrait orientation.

Conclusion

The addition of genuinely good speakers elevates this monitor considerably, but it otherwise struggles to justify its high price. Gaming performance is solid, if unexceptional, and the same can be said for most other aspects of the display. If a clutter-free desk is a priority, it's a decent option, but otherwise you can find competing displays with the same core features for less money.

MORPHEUS

- \+ Great speakers
- \+ Decent image quality
- \+ Solid gaming performance

MORBIUS

- – HDRi modes are pointless
- – Cluttered menu system
- – High price

SPEC

Screen size 27in

Resolution 2,560 x 1,440

Panel technology IPS

Maximum refresh rate 165Hz

Stated response time 1ms

Max brightness 250cd/m² (SDR), 250cd/m² (HDR)

Stated contrast ratio 1,000:1 (SDR and HDR)

Adaptive sync FreeSync and G-Sync compatible

Display inputs 1 x DisplayPort 1.4, 2 x HDMI 2

Audio Headphone out, 2 x 2W speakers and 5W subwoofer

Stand adjustment Height, pivot, tilt

Extras 100 x 100mm VESA mount, 2 x USB 3 ports, HDRi button

VERDICT

Fantastic speakers but more middling elsewhere, despite a relatively high price.

IMAGE QUALITY	GAMING	OVERALL SCORE
20/30	20/30	70%
FEATURES	VALUE	
17/20	13/20	

IIYAMA G-MASTER GB2770QSU-B1 / £250 inc VAT

SUPPLIER iiyama-monitors.co.uk

The GB2770QSU is the cheapest display on test this month, though not by a huge margin. Nonetheless, its low price makes for a strong start, and while there are a few signs of cost cutting, it largely keeps up with its pricier peers. Where that low cost is somewhat in evidence is the basic design. While several of the monitors in this Labs test have quite plain styling, the iiyama is perhaps the most lacking in any flair.

The centre of the V-shaped stand is about the only curve used on the whole display, and it's a similar story with the ergonomic adjustment of the stand. It offers height, pivot and tilt adjustment, but rotation (turning the display left and right) has been left out. It's a small omission but a surprisingly frustrating one nonetheless.

Connection options sees a further omission with just one HDMI port along with the single DisplayPort input, though you do get a 2-port USB 3 hub. On a positive note, though, this display is one of only two on test to use a mains kettle lead – most others have an external power brick. Speakers are included too, along with a headphone output, but their quality is particularly bad, with very little volume and a generally tinny sound – they're useful for basic system pings and little more.

Meanwhile, the on-screen display is controlled via five buttons on the underside of the panel, rather than a mini D-pad. The arrangement is intuitive enough but, on several occasions when trying to change a setting, we accidentally hit the power button and turned off the display.

Overall image quality is decent, with a particularly high contrast ratio of over 1,100:1 being the main highlight. The default colour balance is a little off, but still passable, while a high colour gamut of 140 per cent of the sRGB colour space makes for dazzling colours in standard or HDR content. As with the other displays on test, though, the lack of a multi-zone backlight means this display lacks the contrast to make a big visual impact in HDR.

One factor with the image quality is that dark colours seemed to lack a little differentiation. Nothing was flagged in our tests – we'd normally expect a high gamma level to be the culprit – but we found that using the Black Tuner setting to slightly increase the black level brightness helped bring out these colours. The display also includes an sRGB range limit setting, but we didn't find this reduced the colour gamut so it's of little use.

As for gaming, the GB2770QSU put in a decent performance with an average initial response time of 4.69ms and an average perceived response time of 5.62ms, with just a little bit of colour overshoot, using the default middle overdrive setting. Cranking the overdrive right up drops the average initial response time to 3.13ms but overshoot then hits an average of 27 (deviation from expected RGB value), which has a very obvious negative impact on image quality and clarity.

SPEC

Screen size 27in
Resolution 2,560 x 1,440
Panel technology IPS
Maximum refresh rate 165Hz
Stated response time 0.5ms
Max brightness 400cd/m² (SDR and HDR)
Stated contrast ratio 1,000:1 (SDR and HDR)
Adaptive sync FreeSync and G-Sync compatible
Display inputs 1 x DisplayPort 1.4, 1 x HDMI 2
Audio Headphone out, 2 x 2W speakers
Stand adjustment Height, pivot, tilt
Extras 100 x 100mm VESA mount, 2 x USB 3 ports

MASTER

+ Very low price
+ Decent performance
+ Solid feature set

PADAWAN

− Speakers are pathetic
− Dark colours look a little crushed
− Slightly better displays for only £10 more

Conclusion

A class-bottoming price makes the G-Master GB2770QSU appealing, and with decent features and performance all round it delivers enough to be worth considering. However, that cost saving is evident in several areas, so if you don't mind spending just a little more, you can get a few more features and better image quality. The difference isn't huge, but neither is the price gap.

VERDICT

A low price and decent performance make for a good combination, but you don't have to spend much more cash to get a little more.

IMAGE QUALITY	GAMING	OVERALL SCORE
22/30	20/30	73%
FEATURES	VALUE	
12/20	19/20	

LG ULTRAGEAR 27GP850 / £280 inc VAT

SUPPLIER currys.co.uk

LG's nano IPS gaming monitors have topped the charts for pixel response time for some years now, which in turn has tended to make them some of the pricier panels available. However, the Ultragear 27GP850 is very competitively priced, plus it tops out at 180Hz when overclocked and wants for little in terms of other features too.

This is a reasonably smart-looking display, but it's also one of the few displays on test to add meaningful gamer-centric touches to its design. Red plastic highlights along the stand's base, on the back of the panel and hidden in the recess of the cable-tidying slot on the back of the stand leave little doubt that this is a gaming panel.

The stand offers height, pivot and tilt movements, but like the iiyama, it annoyingly lacks left-to-right rotation. Like all the other displays on test, though, it does at least include a 100 x 100mm VESA mount for fitting alternative monitor arms.

LG's signature move of having all the connections stick straight out the back of the panel, rather than facing downwards, is present here too. It makes it easier to plug cables into the monitor, but generally makes for a less tidy setup afterwards. The connection options are fairly typical, with one DisplayPort input, two HDMI ports and a 2-port USB 3 hub. There's also a headphone jack but no speakers.

A single mini D-pad on the central underside of the panel controls the on screen display, and it's largely a slick, intuitive system, although it tends to take just a second longer than you expect to initially get you into the main menu. A key feature for some image and video editing operations is the inclusion of a proper sRGB mode, which reduces the default 140 per cent sRGB colour space of the display to just under 100 per cent sRGB.

Default image quality is also superb, with essentially no need to adjust any setting unless you're dealing with seriously colour-critical work, in which case a gaming display such as this one shouldn't really be your first choice. The only caveat is that contrast is a little low at just 871:1, which is a typical trait of nano IPS panels.

As for gaming performance, the 27GP850 is excellent, comfortably topping our pixel response time graphs.

While the average initial response time of 4.24ms wasn't that far ahead of some other panels when using the default Fast overdrive mode, the almost complete lack of overshoot meant the perceived response time was just 4.36ms.

What's more, using the Fastest overdrive mode drops the initial response time to just 2.78ms, and although overshoot jumps up considerably to an average RGB value error of 15, this is still well below the level most other monitors hit at these extreme overdrive settings (typically 25 or above).

Moreover, subjectively we found the overshoot when gaming at this overdrive setting much less distracting than using the other screens at their maximum overdrive settings – we'd consider using it for gaming when seeking the fastest possible response.

SPEC

Screen size 27in

Resolution 2,560 x 1,440

Panel technology IPS

Maximum refresh rate 165Hz (overclockable to 180Hz)

Stated response time 1ms

Max brightness 400cd/m² (SDR and HDR)

Stated contrast ratio 1,000:1 (SDR and HDR)

Adaptive sync FreeSync and G-Sync compatible

Display inputs 1 x DisplayPort 1.2a, 2 x HDMI 2

Audio Headphone out

Stand adjustment Height, pivot, tilt

Extras 100 x 100mm VESA mount, 2 x USB 3 ports

ULTRAMARINE

+ Class-leading gaming performance
+ Excellent default image quality
+ Exceptionally low response time
+ Usable sRGB mode

CHAOS MARINE

– Stand lacks left/right rotation
– No speakers
– Basic design

Conclusion

LG continues its run at the top with yet another gaming monitor that can claim to be the fastest-responding in its class. With superb out-of-the-box image quality, an adequate feature set and a low price, it's hard to beat. There are no speakers and no stand rotation, but its price is low enough that these omissions don't feel like dealbreakers.

VERDICT

Class-leading performance and excellent image quality make the LG a compelling buy.

IMAGE QUALITY	GAMING	OVERALL SCORE
28/30	28/30	87%
FEATURES	VALUE	
13/20	18/20	

MSI MAG274QRF-QD / £400 inc VAT

SUPPLIER overclockers.co.uk

With a relatively high price, the MSI MAG274QRF-QD comes with high expectations. It's good, then, that this display comes with features such as quantum dot technology in its LCD panel, and a USB Type-C connection round the back.

Another addition is a slash of RGB lighting across the back. Along with some aggressive angles in the plastic of the base and back of the panel, this makes for one of the more obviously gamer-centric designs of the monitors on test. Thankfully the design isn't too wacky, and this display is also impressively slim.

Otherwise, it's largely on par with the other monitors on test, with the same core panel specs and a refresh rate that tops out at 165Hz. The monitor's stand offers a full complement of ergonomic adjustments, and can also be removed to reveal a 100 x 100mm VESA mount.

Connection options consists of one DisplayPort input and two HDMI ports, along with a USB Type-C input that can be used for video, making this an ideal display to use with a modern laptop. It only has 15W power delivery, though, so it won't charge high-powered laptops. There's also a 2-port USB 2 hub and a headphone jack, but no speakers.

A single mini D-pad on the right rear of the panel controls the on-screen menus, which are intuitively laid out and respond quickly. There isn't an sRGB mode for reducing the display's otherwise high colour gamut though. Speaking of which, this panel's use of quantum dots – an alternative to the traditional colour filters used in LCD panel manufacturing – helps this screen to hit a whopping 166 per cent sRGB colour space coverage according to our tests, making for truly dazzling colours.

As with the other panels on test, this doesn't translate into amazing HDR reproduction, as there's no boost in contrast from a multi-zone backlight, but you certainly get the extended colour range of HDR. The native contrast of the panel is decent too, at 1,100:1.

What's more, the default colour balance is excellent, at least at full brightness. At our standard 150 nits test brightness, it wasn't quite so good but still acceptable, so there should be no need for most users to jump into the custom colour settings to balance the RGB values. In fact, when we switched to the custom colour mode, contrast dropped to under 500:1, so it's not a route we'd recommend.

The MSI doesn't boast any particularly groundbreaking features when it comes to gaming, but it puts in a very solid performance. At its default and optimal overdrive setting, the panel delivered a slightly sluggish 4.97ms average initial response time, but an impressive 5.02ms average perceived response time, thanks to minimal overshoot.

Moreover, at its maximum overdrive setting, the initial response time dropped to just 3.57ms while over/undershoot only hit an average of 14. That still makes for some obvious colour overshoot but it's much more usable than some panels for those times you need the fastest response possible.

SPEC

Screen size 27in

Resolution 2,560 x 1,440

Panel technology IPS

Maximum refresh rate 165Hz

Stated response time 1ms

Max brightness 300cd/m² (SDR and HDR)

Stated contrast ratio 1,000:1 (SDR and HDR)

Adaptive sync FreeSync G-Sync compatible

Display inputs 1 x DisplayPort 1.2a, 2 x HDMI 2, 1 x USB Type-C

Audio Headphone out

Stand adjustment Height, pivot, rotation, tilt

Extras 100 x 100mm VESA mount, 2 x USB 2 ports

DAZZLING

+ Very high colour gamut
+ Useful USB Type-C connection
+ Good default colour balance
+ Solid gaming performance

DAZED

- High price
- No sRGB mode
- No speakers

Conclusion

The addition of quantum dot technology certainly makes the MSI MAG274QRF-QD a dazzling display, with a reasonably high maximum brightness and chart-topping colour range. The addition of a USB Type-C input is also useful for those wishing to connect a laptop. Gaming performance is decent too, if not quite class-leading. The lack of an sRGB mode and speakers feel like major commissions considering the premium price though.

VERDICT

A dazzling colour gamut and useful Type-C connection, but it's not cheap and lacks a few other features.

IMAGE QUALITY	GAMING	OVERALL SCORE
22/30	25/30	73%
FEATURES	VALUE	
14/20	12/20	

VIEWSONIC XG2705-2K / £370 inc VAT

SUPPLIER cclonline.com

ViewSonic's flagship Elite range of gaming monitors pack premium features aplenty, leaving the likes of the Elite XG270QG demanding a high price, despite having nearly the same core spec as many monitors in this test. It's good, then, that ViewSonic has a more value-orientated non-Elite range of displays, such as the XG2705-2K. This is a 144Hz model, rather than the 165Hz of the XG270QG, but otherwise it sports all the core features you'd expect at this price, including a stated 1ms response time.

Physically, the XG2705-2K is more mundane than its Elite sibling, with none of that model's RGB lighting or anti-glare side wings. For this calibre of monitor, though, it's very much in line with expectations, with three slim bezels around the top and sides, and an otherwise plain black exterior.

The stand offers a full range of ergonomic adjustments, and can be unscrewed to reveal a VESA mount for using other monitor arms. The stand's base also has a slight brushed effect to its top, which looks a little more fetching than the black mottled effect of the rest of the display.

SPEC

Screen size 27in

Resolution 2,560 x 1,440

Panel technology IPS

Maximum refresh rate 144Hz

Stated response time 1ms

Max brightness 350cd/m² (SDR and HDR)

Stated contrast ratio 1,000:1 (SDR and HDR)

Adaptive sync FreeSync G-Sync compatible

Display inputs 1 x DisplayPort 1.2, 2 x HDMI 2

Audio Headphone out, 2 x 2W speakers

Stand adjustment Height, pivot, rotation, tilt

Extras 100 x 100mm VESA mount

Connection options consist of the usual single DisplayPort input and two HDMI 2 ports and a headphone jack. You also get some basic 2 x 2W speakers, although there's no USB hub at all. The ports all face downwards, and this display also uses a mains kettle lead with an internal power supply, rather than an external power brick.

The on-screen display is controlled via five buttons on the right underside of the panel. Unlike those on the iiyama display, these ones constantly change function depending on what's on-screen. We found this helped to prevent us from accidentally turning off the display, as the button position is clearly shown on-screen, but it's still not as slick as using a mini D-pad. The menus are mostly comprehensive, but there's no sRGB mode.

Image quality of this panel is broadly very good. At maximum brightness, its colour balance is near perfect, and although the balance isn't quite as good at our standard 150cd/m² test brightness, it still puts in a solid showing. Meanwhile, contrast is solidly middle of the pack, colour gamut is plentiful and gamma is pretty close to perfect.

What's more, switching from the default Standard overdrive setting to the Ultra Fast setting improves some measurements, with a better colour balance and slightly higher contrast. That bodes well for being able to leave the monitor on a high overdrive setting all the time – not just when gaming.

Unfortunately, while our response time tests showed absolutely no overshoot regardless of which overdrive setting we used, in games, the Ultra Fast overdrive mode looked bad to the subjective eye. There were very clear bright trails around moving objects, which were very distracting, which just goes to show that raw response time results don't always give you the big picture.

Regardless, whichever overdrive setting was chosen, this display is a bit sluggish when gaming. That Ultra Fast setting brought the initial response time down to 8.84ms, but at the Standard and Advanced settings, it was above 10ms.

ELITE

+ Great default image quality
+ Solid feature set

LITE

– Sluggish response time
– Only 144Hz refresh rate
– High price for spec

Conclusion

The ViewSonic XG2705-2K makes for a much more affordable alternative to the company's Elite XG270QG, yet it wants for little in terms of core features and its default image quality is also largely very good. However, its response time is sluggish, making it a slightly underwhelming screen for high-speed competitive gaming. Considering it's far from the cheapest panel in its class, that makes it hard to recommend against the stiff competition. CPC

VERDICT

Solid image quality and features, but underwhelming gaming performance for the price.

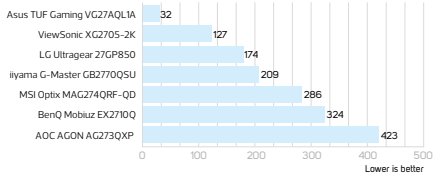
IMAGE QUALITY	GAMING	OVERALL SCORE
25/30	16/30	66%
FEATURES	VALUE	
13/20	12/20	

27IN MONITOR BENCHMARK RESULTS

DEFAULT

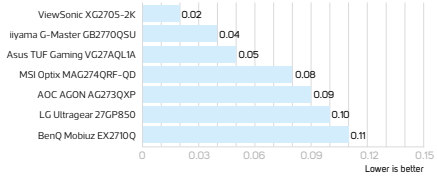
COLOUR TEMPERATURE (KELVIN)

Deviation from ideal result (6,500K)



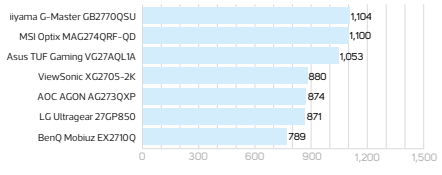
AVERAGE GAMMA

Deviation from ideal result (2.2)



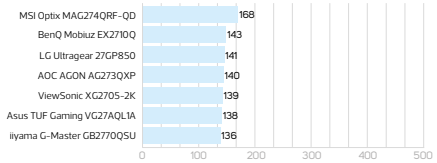
CONTRAST RATIO

Ratio of white-to-black luminance



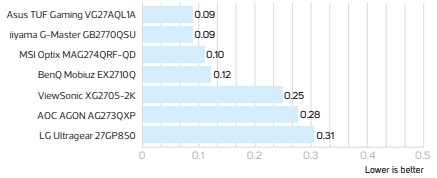
SRGB COLOUR SPACE

Percentage of sRGB colour space covered



COLOUR ACCURACY

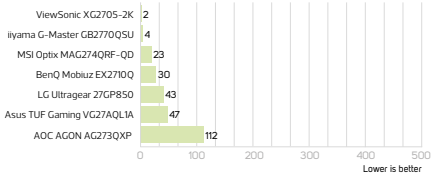
Average delta E 2000



CALIBRATED

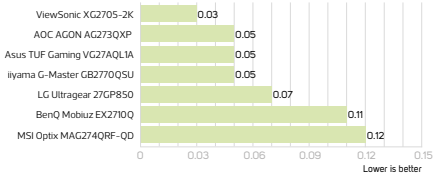
COLOUR TEMPERATURE (KELVIN)

Deviation from ideal result (6,500K)



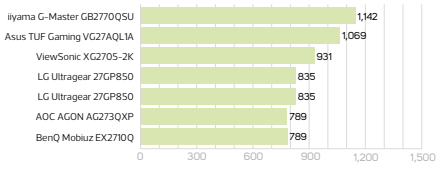
AVERAGE GAMMA

Deviation from ideal result (2.2)



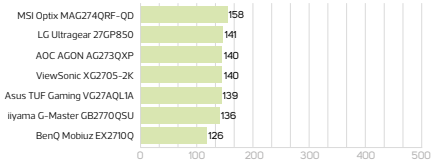
CONTRAST RATIO

Ratio of white-to-black luminance



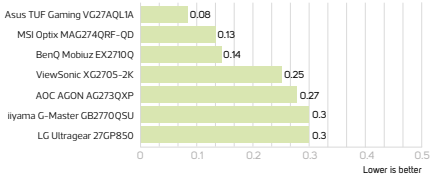
SRGB COLOUR SPACE

Percentage of sRGB colour space covered



COLOUR ACCURACY

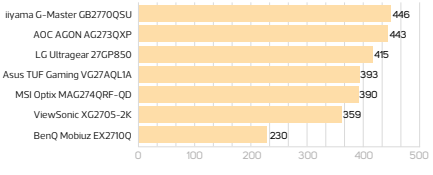
Average delta E 2000



GENERAL

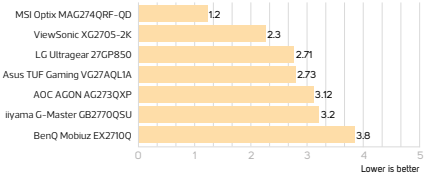
MAXIMUM BRIGHTNESS

Brightness in cd/m² (nits)



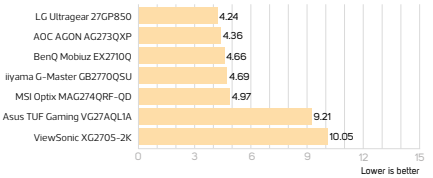
PANEL UNIFORMITY

Deviation from ideal 150cd/m² (nits)



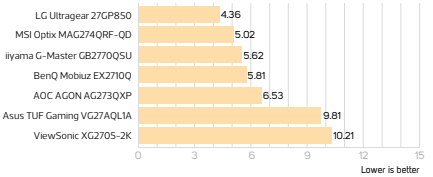
AVERAGE INITIAL RESPONSE TIME

Time in milliseconds (ms)



AVERAGE PERCEIVED RESPONSE TIME

Time in milliseconds (ms)



Wireframe

Join us as we lift the lid on video games

Visit **wfmag.cc** to learn more

Elite

Our choice of the best hardware available

Core component bundles

The fundamental specifications we recommend for various types of PC. Just add your preferred case and power supply, and double-check there's room in your case for your chosen components, especially the GPU cooler and graphics card. We've largely stopped reviewing power supplies, as the 80 Plus certification scheme has now effectively eliminated unstable PSUs. Instead, we've recommended the wattage and minimum 80 Plus certification you should consider for each component bundle. You can then choose whether you want a PSU with modular or captive cables.

8-core system with integrated graphics

8-core CPU, basic gaming

Needs a micro-ATX or ATX case. We recommend a 450W 80 Plus Bronze power supply. See Issue 218, p76 for an example build guide.

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 7 5700G	scan.co.uk	**#218** p20	£280
CPU COOLER	AMD Wraith air cooler included with CPU	N/A	**#218** p20	£0
GRAPHICS CARD	AMD Radeon RX Vega 8 integrated into CPU	N/A	**#218** p20	£0
MEMORY	16GB (2 x 8 GB) Corsair Vengeance LPX Pro 3200MHz (CMK16GX4M 2B3200C16)	scan.co.uk	**#218** p78	£59
MOTHERBOARD	Asus TUF B450M-PLUS II (micro-ATX) with BIOS flash	awd-it.co.uk	**#218** p78	£90
STORAGE	500GB WD Blue SN570 (M.2 NVMe)	scan.co.uk	**#222** p20	£44
		Total £473		

1,920 x 1,080 gaming

6-core CPU, 1080p gaming

Needs an ATX case. We recommend a 500W 80 Plus power supply. See Issue 224, p76 for an example build guide.

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	Intel Core i5-12400F	cclonline.com	**#227** p51	£174
CPU COOLER	ARCTIC Freezer i13X	scan.co.uk	**#224** p76	£20
GRAPHICS CARD	AMD Radeon RX 6600 XT	overclockers.co.uk	**#228** p90	£350
MEMORY	16GB (2 x8 GB) Corsair Vengeance LPX DDR4 3200MHz (CMK16GX4 M2B3200C16)	scan.co.uk	**#224** p76	£59
MOTHERBOARD	Gigabyte B660 Gaming X DDR4 (ATX)	scan.co.uk	**#224** p50	£148
STORAGE	1TB WD Blue SN570 (M.2 NVMe)	scan.co.uk	**#222** p20	£70
		Total £821		

UPGRADES				
SWAP GRAPHICS CARD	Nvidia GeForce RTX 3060 Ti	overclockers.co.uk	**#228** p90	£450
SWAP STORAGE	1TB WD Black SN850	scan.co.uk	**#225** p27	£120

2,560 x 1,440 gaming system

10-core CPU, 2,560 x 1,440 gaming and ray tracing

Needs an ATX case. We recommend a 550-600W 80 Plus Bronze power supply.

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	Intel Core i5-12600K	scan.co.uk	**#227** p56	£290
CPU COOLER	ARCTIC Liquid Freezer II 240 RGB (240mm AIO liquid cooler)	scan.co.uk	**#226** p49	£80
GRAPHICS CARD	Nvidia GeForce RTX 3070	scan.co.uk	**#228** p90	£540
MEMORY	16GB (2 x 8GB) Corsair Vengeance RGB Pro 3200MHz DDR4 (CMW16GX 4M2C3200C16)	scan.co.uk	**#221** p76	£72
MOTHERBOARD	Gigabyte Z690 Gaming X DDR4	scan.co.uk	**#222** p46	£210
STORAGE	1TB WD Black SN850	scan.co.uk	**#225** p27	£120
		Total £1,312		

UPGRADES				
ADD SECONDARY STORAGE	Western Digital Blue 4TB	ebuyer.com	**#166** p54	£86

Mid-range gaming system

10-core CPU, smooth 2,560 x 1,440 gaming and ray tracing, some 4K gaming

Needs an ATX case with room for a 240mm all-in-one liquid cooler. We recommend a 750W 80 Plus Bronze power supply.

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	Intel Core i5-12600K	scan.co.uk	**#227** p56	£290
CPU COOLER	ARCTIC Liquid Freezer II 240 RGB (240mm AIO liquid cooler)	scan.co.uk	**#226** p49	£80
GRAPHICS CARD	Nvidia GeForce RTX 3080 10GB	scan.co.uk	**#228** p90	£690
MEMORY	16GB (2 x 8GB) Corsair Vengeance RGB Pro 3200MHz DDR4 (CMW16GX 4M2C3200C16)	scan.co.uk	**#221** p76	£72
MOTHERBOARD	MSI MAG Z690 Tomahawk WiFi DDR4	scan.co.uk	**#222** p48	£260
STORAGE	1TB WD Black SN850	scan.co.uk	**#225** p27	£120
		Total £1,512		

UPGRADES				
ADD SECONDARY STORAGE	Western Digital Blue 4TB	ebuyer.com	**#166** p54	£86

Core component bundles cont ...

4K gaming system

12-core CPU, 4K gaming and ray tracing

Needs an ATX case with room for a 360mm all-in-one liquid cooler. We recommend an 850W 80 Plus Gold power supply.

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	Intel Core i7-12700K	scan.co.uk	**#227** p59	£420
CPU COOLER	Corsair iCUE H150i Elite LCD (360mm AIO liquid cooler)	scan.co.uk	**#226** p78	£220
GRAPHICS CARD	Nvidia GeForce RTX 3080 Ti	nvidia.com	**#226** p78	£1,050
MEMORY	16GB (2 x 8GB) Corsair Vengeance RGB Pro 3200MHz DDR4 (CMW16GX4M2 C3200C16)	scan.co.uk	**#226** p78	£72
MOTHERBOARD	MSI MAG Z690 Tomahawk WiFi DDR4	scan.co.uk	**#226** p78	£260
STORAGE	2TB WD Black SN850	scan.co.uk	**#215** p49	£180

Total £2,202

UPGRADES

ADD SECONDARY STORAGE	4TB Western Digital Blue	ebuyer.com	**#166** p54	£86

Content creation system

16-core CPU, 1,920 x 1,080 gaming

Needs an E-ATX case with room for a 360mm all-in-one liquid cooler. We recommend a 750W 80 Plus Gold power supply.

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	Intel Core i9-12900K	cclonline.com	**#227** p62	£567
CPU COOLER	Corsair iCUE H150i Elite LCD (360mm AIO liquid cooler)	scan.co.uk	**#226** p78	£220
GRAPHICS CARD	AMD Radeon RX 6600 XT	overclockers.co.uk	**#220** p53	£350
MEMORY	32GB (2 x 16GB) Corsair Dominator Platinum RGB 5200MHz DDR5 (CMT32GX5M2 B5200C40)	scan.co.uk	**#221** p76	£298
MOTHERBOARD	MSI MEG Z690 Unify	scan.co.uk	**#222** p50	£520
STORAGE	2TB WD Black SN850	scan.co.uk	**#215** p49	£180

Total £2,135

UPGRADES

SWAP GRAPHICS CARD	Nvidia GeForce RTX 3080 Ti	nvidia.com	**#221** p48	£1,050
ADD SECONDARY STORAGE	4TB Western Digital Blue	ebuyer.com	**#166** p54	£86

Mini PCs

Our favourite components for building a micro-ATX or mini-ITX PC. Always double-check how much room is available in your chosen case before buying your components. Some mini-ITX cases don't have room for large all-in-one liquid coolers, for example, or tall heatsinks. You'll also need to check that there's room for your chosen graphics card.

Mini-ITX

Motherboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
Intel Z690 (LGA1700)	Gigabyte Z690I Aorus Ultra Plus	amazon.co.uk	**#228** p46	£330
Intel B660 (LGA1700)	Gigabyte B660I Aorus Pro DDR4	scan.co.uk	**#228** p47	£213
AMD X570 (AM4)	Asus ROG Strix X570-I Gaming	cclonline.com	**#228** p40	£301
AMD B550 (AM4)	Asus ROG Strix B550-I Gaming	cclonline.com	**#228** p39	£217

Cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
ALL-PURPOSE	Cooler Master MasterBox NR200P	scan.co.uk	**#206** p18	£100
TOWER	Ssupd Meshlicious	overclockers.co.uk	**#225** p51	£90
HIGH AIRFLOW	Fractal Design Torrent Nano	scan.co.uk	**#225** p45	£117
PREMIUM	Streacom DA2 V2	quietpc.com	**#214** p51	£203

Other components

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
LOW-PROFILE CPU COOLER	Noctua NH-L12S	scan.co.uk	**#219** p54	£55
SFX POWER SUPPLY	Phanteks Revolt SFX 750W	overclockers.co.uk	**#228** p74	£130

ATX cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET RGB	Antec DF700 Flux	cclonline.com	**#214** p26	£84
SUB-£100 AIRFLOW	Corsair 4000D Airflow	scan.co.uk	**#222** p56	£90
COMPACT	Fractal Design Meshify 2 Compact	scan.co.uk	**#215** p20	£125
HIGH AIRFLOW	Fractal Design Meshify 2	scan.co.uk	**#212** p45	£155
PREMIUM HIGH AIRFLOW	Fractal Design Torrent RGB TG	scan.co.uk	**#225** p20	£245
LUXURY	Corsair iCUE 5000T RGB	scan.co.uk	**#224** p22	£300

Micro-ATX

Motherboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
AMD B450 (AM4)	Asus TUF B450M-PLUS II	awd-it.co.uk	**#218** p76	£80
AMD B550 (AM4)	MSI MAG B550M Mortar	scan.co.uk	**#204** p42	£130

Cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET	Kolink Citadel Mesh RGB	overclockers.co.uk	**#218** p26	£65

Networking

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET ROUTER	Belkin RT3200-UK	currys.co.uk	**#216** p52	£120
ROUTER	Asus RT-AX68U	scan.co.uk	**#216** p51	£177
MESH ROUTER	Asus ZenWiFi AX Hybrid XP4	amazon.co.uk	**#226** p59	£260
WI-FI ADAPTOR	TP-Link Archer TX3000E	overclockers.co.uk	**#196** p58	£60
DUAL-BAY NAS BOX	Synology DS220j	box.co.uk	**#200** p22	£154
DUAL-BAY MEDIA NAS BOX	Synology DS218play	box.co.uk	**#174** p34	£202
2.5 GIGABIT DUAL-BAY NAS BOX	QNAP TS-231P3	box.co.uk	**#212** p25	£295

Monitors

F – FREESYNC, G – G-SYNC, W – ULTRAWIDE

Up to 25in

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
24IN, 144HZ, IPS, 1,920 X 1,080, F, G	AOC 24G2U	cclonline.com	#214 p28	£160
25IN, 240HZ, IPS, 1,920 X 1,080, F, G	Acer Predator XB253Q	box.co.uk	#209 p57	£269
25IN, 360HZ, IPS, 1,920 X 1,080, F, G	Asus ROG Swift PG259QN	ebuyer.com	#212 p20	£659

Up to 28in

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
27IN, 144HZ, IPS, 1,920 X 1,080, F, G	AOC 27G2U	overclockers.co.uk	#201 p53	£180
27IN, 165HZ, IPS, 2,560 X 1,440, F, G	LG Ultragear 27GP850	currys.co.uk	#229 p48	£280
27IN, 165HZ, VA, 2,560 X 1,440, F, G	AOC CQ27G3SU	box.co.uk	#223 p45	£249
27IN, 240HZ, TN, 2,560 X 1,440, F, G	AOC AG273QZ	overclockers.co.uk	#202 p27	£570
27IN, 240HZ, IPS, 2,560 X 1,440, F, G	Alienware AW2721D	dell.com	#212 p21	£699
28IN, 144HZ, IPS, 3,840 X 2,160, F, G	AOC U28G2XU	amazon.co.uk	#221 p29	£571

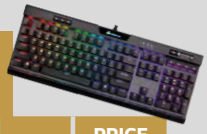
Over 28in

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
31.5IN, 60HZ, VA, 3,840 X 2,160, F	iiyama ProLite XB3288UHSU	scan.co.uk	#205 p43	£370
32IN, 144HZ, VA, 2,560 X 1,440, F, G	iiyama G-Master GB3266QSU	scan.co.uk	#224 p30	£320
32IN, 165HZ, IPS, 2,560 X 1,440, F, G	LG UltraGear 32GP850	currys.co.uk	#220 p38	£349
34IN, 144HZ, IPS, 3,440 X 1,440, W, F	iiyama G-Master GB3461WQSU	overclockers.co.uk	#206 p53	£440
34IN, 144HZ, IPS, 3,440 X 1,440, W, F, G	LG UltraGear 34GN850	currys.co.uk	#206 p55	£649
38IN, 144HZ, IPS, 3,840 X 1,600, W, F, G, HDR	LG UltraGear 38GN950	currys.co.uk	#208 p30	£1,199
32IN, 240HZ, VA, 3,840 X 2,160, F, G, HDR	Samsung Odyssey Neo G8	overclockers.co.uk	#229 p17	£1,299

Non-gaming

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
27IN, 75HZ, IPS, 2,560 X 1,440, F	LG 27QN880	amazon.co.uk	#210 p26	£402

Peripherals and audio



Gaming keyboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET TKL	SteelSeries Apex 3 TKL	currys.co.uk	#221 p59	£40
OPTICAL ESPORTS	Asus ROG Strix Scope RX	amazon.co.uk	#209 p43	£73
MECHANICAL TKL	NZXT Function MiniTKL	cclonline.com	#226 p32	£100
MECHANICAL MMO	Corsair K95 RGB Platinum	scan.co.uk	#164 p26	£180
PREMIUM TKL MECHANICAL	Corsair K70 RGB TKL	scan.co.uk	#214 p31	£150
PREMIUM MECHANICAL	Corsair K70 RGB Pro	overclockers.co.uk	#225 p30	£160
PREMIUM WIRELESS MECHANICAL	Razer BlackWidow V3 Pro	overclockers.co.uk	#208 p60	£230

Gaming mice

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET GAMING	NZXT Lift	scan.co.uk	#226 p32	£40
FIRST-PERSON SHOOTER	Glorious PC Gaming Race Model O	overclockers.co.uk	#215 p57	£50
AMBIDEXTROUS	Razer Viper 8K	currys.co.uk	#215 p59	£40
MULTI-BUTTON	Roccat Kone XP	roccat.com	#225 p60	£80
WIRELESS	Razer Viper Ultimate	currys.co.uk	#217 p54	£60
PREMIUM WIRELESS	Razer DeathAdder V2 Pro	scan.co.uk	#210 p28	£80
ULTRA LIGHTWEIGHT	Asus TUF Gaming M4 Air	overclockers.co.uk	#227 p36	£48
PREMIUM LIGHTWEIGHT WIRELESS	Logitech G Pro X Superlight	currys.co.uk	#217 p52	£109

Peripherals and audio cont ...

Game controllers

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
RACING WHEEL	Logitech G29 Driving Force	currys.co.uk	**#202** p50	£239
BUDGET GAMEPAD	PowerA Spectra Infinity Xbox Series X	amazon.co.uk	**#228** p55	£35
MID-RANGE GAMEPAD	Sony DualSense	scan.co.uk	**#228** p58	£60
PREMIUM GAMEPAD	Scuf Instinct Pro	scufgaming.co.uk	**#228** p57	£200
BUDGET FLIGHT STICK	Logitech Extreme 3D Pro Joystick	currys.co.uk	**#207** p52	£36
FLIGHT STICK	Thrustmaster T.16000M FCS HOTAS	scan.co.uk	**#207** p56	£115

Gaming headsets

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET STEREO	Roccat Elo X Stereo	scan.co.uk	**#210** p56	£40
STEREO	Epos | Sennheiser GSP 300	amazon.co.uk	**#210** p54	£50
WIRELESS	Corsair Virtuoso RGB Wireless	ebuyer.com	**#204** p50	£146
PREMIUM WIRELESS	Razer BlackShark V2 Pro	scan.co.uk	**#211** p26	£158

Speakers

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
STEREO	Edifier R1280DB	overclockers.co.uk	**#224** p59	£110

Non-gaming keyboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
WIRELESS 84-KEY ELECTRO-CAPACATIVE	Niz Mini 84 Pro	keyboardco.com	**#220** p29	£165
BUCKLING SPRING MECHANICAL	Unicomp New Model M	keyboardco.com	**#219** p26	£129

PCs and laptops

Pre-built PC systems

CATEGORY	NAME	CPU	GPU	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET GAMING	PC Specialist Prism Nova	Intel Core i5-12400F	Nvidia GeForce RTX 3060	custompc.co.uk/PrismNova	**#229** p30	£1,199
QUIET GAMING	Gladiator Nocturnal	Intel Core i5-12600K	Nvidia GeForce RTX 3070	custompc.co.uk/Nocturnal	**#225** p36	£1,799
MID-RANGE GAMING	CCL Horizon 5 Intel RTX 3080 Gaming PC	Intel Core i5-12600K	Nvidia GeForce RTX 3080 10GB	custompc.co.uk/CCL3080	**#228** p28	£1,905
4K GAMING	PC Specialist Magnus Pro K500	Intel Core i7-12700K	Nvidia GeForce RTX 3080 Ti	custompc.co.uk/MagnusPro	**#225** p34	£2,499
WATER-COOLED ULTIMATE PERFORMANCE	CyberPower Hydro-X Infinity RTX	Intel Core i9-12900KS	Nvidia GeForce RTX 3090 Ti	custompc.co.uk/CPHX	**#228** p26	£4,630

Laptops

CATEGORY	NAME	CPU	GPU	SCREEN	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET GAMING	Lenovo Legion 5 Pro	AMD Ryzen 7 5800H	Nvidia GeForce RTX 3070 Laptop	16in, 2,560 x 1,600 IPS 165Hz G-Sync	custompc.co.uk/Legion5Pro	**#222** p32	£1,499
ULTRA PORTABLE GAMING	Razer Blade 14	AMD Ryzen 9 5900HX	Nvidia GeForce RTX 3070 Laptop	14in 1,920 x 1,080 IPS 144Hz	custompc.co.uk/Blade14	**#220** p40	£2,120
MID-RANGE GAMING	Asus ROG Strix Scar 15 G533ZW	Intel Core i9-12900H	Nvidia GeForce RTX 3070 Ti Laptop	15.6in 2,560 x 1,440 IPS 240Hz	custompc.co.uk/AsusScar15	**#227** p40	£2,399
HIGH-SPEED GAMING	Alienware x17 R2	Intel Core i7-12700H	Nvidia GeForce RTX 3080 Ti Laptop	17.3in 1,920 x 1,080 IPS 360Hz G-Sync	custompc.co.uk/AlienwareX17	**#227** p38	£3,173

RICK LANE / INVERSE LOOK

ON THE MOVE

PC and mobile gaming are growing closer together, bringing some exciting benefits, but also some major risks, says Rick Lane

PC and mobile gaming have historically been treated as separate entities, on the face of it, with good reason. The PC is the home of premium gaming, of the best-looking mainstream experiences and the most complex strategy games. On the flip side, mobile's most popular experiences have tended to be casual puzzlers, such as Angry Birds and Candy Crush Saga.

However, PC and mobile gaming aren't as different as they might first appear. The gap between the two has shrunk markedly over the past few years, and the amount of crossover is growing. This opens up some intriguing new opportunities regarding how we play games together, but it also comes with significant risks in terms of how the biggest games are made.

Today's smartphones are markedly more powerful than they were even a few years ago, enabling them to support more technically demanding and mechanically complex games. While the most popular mobile games remain light affairs, such as Candy Crush and Clash of Clans, you'll also see games such as Minecraft and Fortnite ranking high on the Google Play store. We're also seeing more simultaneous releases of major titles across both platforms, such as last year's JRPG smash Genshin Impact, and the recent launch of Blizzard's Diablo Immortal.

Minecraft and Fortnite rank high on the Play store

The PC is also broadly much more tolerant of free-to-play gaming than consoles. Indeed, the PC is where free-to-play gaming was invented, with MMOs such as Runescape and browser games such as Farmville blazing the trail. Despite the intense dislike of free-to-play gaming by die-hard PC gaming fans, these games account for a much bigger portion of PC gaming's global annual revenue than traditional premium games.

This shared lineage between PC and mobile gaming will probably continue to expand, and the growing parity makes it much easier to play games with your friends and family. Most people would struggle to afford one high-end PC, let alone several, so being able to host a server for Minecraft or Among Us on your PC, and have your pals or partner join on their Android phone, is a welcome bit of flexibility.

But there's a big caveat. The hostility from core PC gamers towards free-to-play gaming means most free-to-play PC games tread carefully about how they eke money from players, with most microtransactions limited to cosmetic purchases and optional gameplay enhancements, such as Apex Legends' alternate playable characters.

There's no such resistance in the mobile space, where free-to-play tactics are generally far more predatory. Diablo Immortal, for example, uses every psychological trick in the book to get players to spend money, from artificially slowing down player progression to basing the core of the game around buying tokens to use with randomised dungeons, which are essentially virtual slot machines.

Fortunately, the overwhelmingly negative response to Immortal's free-to-play design shows that PC players remain hyper-aware of when a game is taking them for a ride. In an ideal world, this will serve as a warning to other designers looking to cross the streams between mobile and PC, and they'll have to soften or outright eliminate the most exploitative practices when bringing their games to the platform. CPC

Rick Lane is Custom PC's games editor @Rick_Lane

Hardspace: Shipbreaker / £29.99 inc VAT

DEVELOPER Blackbird Interactive / **PUBLISHER** Focus Entertainment

While most games are either about creation or destruction, Hardspace: Shipbreaker is about careful, methodical disassembly. Its brilliant premise sees you dismantling decommissioned spaceships for an interstellar manufacturing corporation.

You play a trainee shipbreaker for Lynx Industries known simply as Cutter who, like all of Lynx's other shipbreakers, is trying to clear the enormous debt accrued through his training by working daily shifts for the company. Each in-game 'day' sees you tasked with dismantling a ship of your choice, ranging from small, multipurpose spacecraft, such as the Mackerel, to huge shipping freighters such as the mighty Javelin.

Your primary tools for this delicate and dangerous job are a laser cutter and an energy grapple, which are used to break down the ships into more manoeuvrable parts, then dispose of them. Waste metals are melted down in furnaces, advanced materials such as nanocarbons are recycled in the processor, and reusable items such as pilot seats and computer terminals are collected on a giant green barge.

How you disassemble a ship is entirely up to you, but the safest way is to cut through each ship's hazard-yellow connection points, then carefully prise the ship apart like a jigsaw puzzle in reverse. As you work, you'll periodically hit corporate-assigned goals, resulting in promotions that let you take on ships that are more lucrative, but also riskier to dismantle. It isn't long before you're dealing with ships whose massive thrusters begin to ignite the moment you start cutting, or that are riddled with air pockets air that must be carefully depressurised.

Speaking of pressure, each shift lasts exactly 15 minutes, and every passing day sees the interest on your debt balance eat at your profits, so the thrill of Shipbreaker is in balancing efficiency with safety.

There are many tricks you can use to speed up the shipbreaking process, from using the pressurised crawlspaces of a Mackerel to pop the cockpit off the ship like a bottlecap, to performing a clean 'reactor pull', so these lucrative but unstable nuclear generators reach the barge before exploding.

Visually and mechanically, Shipbreaker is a quality experience. The story is strong too, a low-key tale about corporate exploitation and unions, told with empathetic and intelligently written characters. The only downside is that Shipbreaker can too accurately represent the drudgery of working a nine-to-five job. The ranking system that gives you access to new ships advances too slowly, and there are only so many Mackerels you can dismantle before the game really does start to feel like work.

Aside from occasionally drifting into repetition, Shipbreaker executes its concept as well as you could imagine, and finds some time to explore the themes beneath its systems. There's also nothing else quite like it, which alone makes it worth putting in a shift at the shipyard.

RICK LANE

HARD SPACE

+ Innovative concept
+ Smart, tangible disassembly puzzles
+ Thematically intriguing story

HARD CHEESE

– Some shifts can be tedious

/ VERDICT

Original, clever and topical, Hardspace: Shipbreaker puts in the work.

OVERALL SCORE

87%

Sniper Elite 5 / £44.99 inc VAT

DEVELOPER Rebellion / **PUBLISHER** Rebellion

Custom PC PREMIUM GRADE

BULLSEYE

+ Fantastic stealth sandboxes
+ Flexible and refined stealth
+ Great multiplayer components

BULLPLOP

– Missions could still be more open
– Unremarkable character progression

At first glance, little has changed in Sniper Elite 5. You still play as Karl Fairburne, a veteran sharpshooter who is increasingly responsible for winning World War II single-handed. The game still blends open-world stealth, action and killing Nazis from ludicrous distances. You spend a lot of time watching bullets rip through Nazi bodies in slow motion, courtesy of the game's grisly yet fascinating X-Ray system. Sniper Elite 5 is familiar, yet it's also completely different from any of the games that preceded it.

Having already wiped out Hitler's forces in North Africa and Italy, Karl Fairburne now travels to France, laying the groundwork for the D-Day invasion. As he stalks between the Normandy hedgerows, he uncovers a secret Nazi project known as Operation Kraken that threatens the entire Allied war effort.

As with all the Sniper Elite games, the story isn't the main draw, but it does a good enough job of providing a framework for all the sneaking and sniping you'll be doing. Indeed, on paper, Sniper Elite 5 should be the most derivative entry in the series, as Normandy is a far more familiar World War II setting than either North Africa or Italy.

But this potential problem forces Rebellion's level designers to be more creative, resulting in the most imaginative collection of scenarios in the series yet. This is most evident in the third level – Spy Factory – that sees Fairburne gathering intelligence in a meticulous recreation of the famous Mont St Michel Abbey, situated atop a craggy tidal island. With a glorious opening reveal followed by some knotty navigation of the island's medieval streets, it's a superb setting for stealth gaming.

But this is only one of several standout maps. The fourth level, War Factory, sees you exploring a vast industrial complex that's truly stunning in scope, while the sixth level, Liberation, offers a huge chunk of French countryside to explore, complete with three villages to clear of Nazi scum.

Even the weaker levels, such as the second level's Chateau and Fairburne's trip to the island of Guernsey, still impress with their size and varied angles of attack.

Indeed, what truly makes these levels special is how they push you to use all the equipment in your arsenal. Although sniping still occupies the lion's share of the game, there are often situations when your sniper rifle isn't the best tool for the job.

Spy Academy is a great example. The early part of the level is pure sharpshooting fun, as you pop the heads of counter snipers and enemy patrols from across the bay,

the noise of your shots masked by the drone of enemy aircraft patrolling overhead. Once you get onto the island itself, however, the twisting streets make sniping more difficult, so you're better off using silenced pistols or melee kills to quietly deal with enemies.

Every level demonstrates a similar knack for encouraging a varied play style, rather than treating the game as a straightforward shooting gallery. This variety is enabled by your secondary equipment, including items such as the non-lethal 'schu' mines that can act as lures, and decoys in the form of German helmets on a stick.

Such items are great for pulling enemies away from patrol routes or guard posts. It also helps that the AI is cannier than in previous games. Able to spot you at long distances and call in reinforcements if alerted to your presence, your enemies make using these tools necessary to progression.

Overall, the leap in quality is impressive, but Rebellion's approach to stealth game design still isn't without its problems. Although levels allow sufficient flexibility, they're not always as open as possible, with the player occasionally funnelled through pathways by fences or hedges, over which Fairburne arbitrarily can't climb.

In addition, every level has myriad side objectives, including optional sabotage targets such as anti-aircraft guns, and bonus assassination missions that you can complete as you explore. These are fun to tackle for their own sake, but the game struggles to provide a more tangible reason to do them.

Meanwhile, the game's character upgrade system offers some useful abilities, such as extra inventory space or faster melee takedowns, but there's nothing memorable about these upgrades. New weapons are also primarily unlocked by visiting workbenches scattered through the level, which is an odd way to mete out these rewards.

As a dedicated single-player experience, Sniper Elite 5 is the best in the series, but it still falls behind the leaders of its the genre, such as Hitman and Metal Gear Solid V. However, Sniper Elite 5 also has extensive multiplayer options. As with Sniper Elite 4, the entire game can be played cooperatively, and coordinating with a fellow marksman in these massive levels is enormous fun.

What seals Sniper Elite 5's greatness, however, is its invasion mechanic. Inspired by games such as Dark Souls and Deathloop, Sniper Elite 5 allows other players to drop into your single-player campaign, assuming the role of rival 'Jaeger' snipers who will try to hunt you down. At this point, the tempo of your mission switches from methodical stealth to a thrillingly tense game of cat and mouse, as you and the Jaeger try to sniff each other out and get the drop on one another.

Jaeger mode cleverly balances freedom with fun. You can hide anywhere on the level, but the minimap will always highlight the general direction of your target. Moreover, if you stay in one place too long, it will reveal your exact locations to one another, forcing you both to relocate. Once the round is over, the game lets players request a rematch. If that rematch is declined, it will drop you back into your game at your last save point.

Sniper Elite 5's multiplayer offerings elevate the whole experience. By weaving all the benefits of cooperative and competitive multiplayer through the campaign, Rebellion turns what would be a decent single-player experience into a thoroughly excellent broader package. It's without a doubt the definitive sniping game, and a hot contender for the best stealth game of the year.

RICK LANE

/ VERDICT

A great single-player stealth game, and a fantastic multiplayer stealth game, Sniper Elite 5 hits the mark.

OVERALL SCORE

90%

VAMPIRE: THE MASQUERADE – SWANSONG / £34.99 inc VAT

DEVELOPER Big Bad Wolf Studio / **PUBLISHER** Nacon/Bigben Interactive

DRACULA

+ Interesting premise
+ Some decent detective puzzling

MORBIUS

– Boring characters
– Over-elaborate dialogue system
– Inconsistent puzzle design

/ VERDICT

Swansong may drain the life from you, but otherwise this tedious narrative vampire puzzler is an underwhelming experience.

OVERALL SCORE

50%

Based on the famous pen-and-paper roleplaying game, Vampire: The Masquerade – Swansong is an ambitious affair. Set in modern-day Boston, Swansong sees you play as three different vampires all working for the Boston Camarilla, essentially the governing body/crime syndicate of Boston's vampire community. The story kicks off when a potential alliance between the Camarilla and another vampire faction is threatened after the negotiators are massacred by unknown forces, and your trio of vampires are individually dispatched to investigate.

The game plays out over three acts, with each character leading at least one scene per act. Galeb is the Camarilla's right hand, a sophisticated and unflinchingly loyal henchman. Emem is a more rebellious figure who constantly straddles the line between an asset and a liability. Finally, there's Leysha, a vampire with powerful psychic abilities who also suffers from debilitating mental delusions, making her a useful but potentially dangerous ally.

Each scene sees you following a different lead as one of these characters, which involves a combination of conversations and puzzle solving. The game's most interesting feature is its dialogue system, where conversations can be influenced by around a dozen different character skills, alongside several vampiric powers.

However, the system is too broad for the game's limited scope, making it difficult to gauge where best to place your experience points. These points are also awarded based on how well you complete each scene, so a few bad choices can hobble that character's progression for the whole game.

Outside of dialogue, Swansong offers a weird mix of ideas that never fully gel together. The game is strongest in Galeb's first two chapters, which are both well-crafted detective puzzles that resemble smaller, more scripted versions of Hitman's lavish sandboxes.

However, the scenes focusing on Emem and Leysha are far less consistent. One of Emem's chapters features a cleverly designed puzzle themed around hacking, but the other involves a terribly designed pattern-matching conundrum, which Emem herself complains about having to repeat.

By far Swansong's biggest issue, however, is that the writing simply isn't strong enough. The script is flat and almost entirely humourless, while the characters are neither sympathetic nor fun to be around. It's a shame, because some of the plot threads are interesting, particularly a subplot revolving around Leysha's adoptive vampire daughter. Unfortunately, the portrayal of the relationship is intensely annoying, which undermines the twists when they eventually happen.

If you want to play a vampire game with a great story, check out 2004's Vampire: The Masquerade – Bloodlines. While released in a buggy state, today it's perfectly playable with the addition of a freely available unofficial patch. For a more modern vampire experience, the Early Access V Rising offers some entertaining bloodsucking action. Sadly, Vampire: The Masquerade – Swansong is best left slumbering in its coffin.

RICK LANE

TREK TO YOMI / £16.79 inc VAT

DEVELOPER Flying Wild Hog / **PUBLISHER** Devolver Digital

Trek to Yomi is a playable homage to Japanese cinema's most famous director, Akira Kurosawa. Players assume the role of Hiroki, an honourable samurai whose village is embroiled in a generational conflict with a gang of local bandits. When said bandits kidnap a group of foragers from the village, Hiroki sets out alone to rescue them. However, the kidnapping isn't what it seems, and Hiroki spends the rest of the game dealing with the fallout from his decision to pursue them.

Trek to Yomi's main attraction is its aesthetic, which superbly mimics the look of Kurosawa's films. It isn't simply the fact that the game is presented in black and white, but that Kurosawa's style is also reflected in every aspect, from the movement of the in-game camera and transitions between scenes, to tiny details, such as the kanji title cards separating chapters and the simulation of film artefacts.

Even the way characters move is inspired by Kurosawa's films. Your character's stance when drawing his bow is taken directly from the way actor Takashi Shimura stands in Seven Samurai's most iconic scene. In play, Trek to Yomi most closely resembles games such as Little Nightmares or Playdead's Inside, with you exploring 3D spaces on a mostly two-dimensional axis.

The game combines lavish environments with a cinematic eye, creating dramatic set-pieces that range from large-scale sequences, such as Hiroki exploring a burning village, to smaller encounters, such as duels with other samurai on rickety wooden bridges.

Indeed, Trek to Yomi's interactions are almost exclusively combat-focused. Most scenes will see Hiroki battle one or several foes, using blocks, parries, dodge-rolls and a range of attacks that expands as you progress through the game. Hiroki can also use an array of ranged weapons, such as a bow and throwing knives, to thin the ranks of his enemies before drawing his sword.

Visually, these fights fit well with the broader style. Most duels are over in a handful of sword swipes, and the combination of an authentic, percussive soundtrack and judicious use of slow-motion action makes every fight look and feel dramatic. However, the counter system is highly unreliable, and timing your parries successfully comes mostly down to guesswork.

Combined with the fact that saving is checkpoint based, this makes it difficult to experiment with the combat. The most effective way to progress is to rely on a handful of basic moves which, while reliable, isn't much fun.

Given the overwhelming focus on combat, this looseness at the core of the system is a significant flaw. Fortunately, the strength of Trek to Yomi's setting and style, alongside its spooky, surrealist second act, makes it worth grappling with this system even in its most frustrating moments.

RICK LANE

SEVEN SAMURAI

- \+ Fantastic visual style
- \+ Good story
- \+ Dramatic set pieces

SEVEN PSYCHOPATHS

- – Overwhelming emphasis on combat
- – Combat isn't refined enough to carry the game

/ VERDICT

An entertaining suffusion of cinema, but not quite the playable Kurosawa movie it deserves to be.

OVERALL SCORE

70%

REALITY CHECK

Rick Lane sets his clones to follow his movements for pulping virtual fruit, and looks at a great-looking Half-Life: Alyx mod, in this month's VR roundup

REVIEW

THE LAST CLOCKWINDER / £19 inc VAT

DEVELOPER Pontoco / **PUBLISHER** Cyan Ventures

The Last Clockwinder is the most innovative VR game since Half-Life: Alyx. This brilliantly designed puzzler uses the player's own physical movements to create Rube Goldberg-style contraptions. The game's premise sees you trying to save a historically significant clocktower built into an ancient tree on an aquatic planet, which has been abandoned by its resident 'Clockwinder' for reasons unknown. You play a former apprentice of the Clockwinder, who returns to save the tree by restarting the pump that keeps the clocktower from becoming flooded by the planet's ocean.

It's an interesting yet bizarre setup, made even stranger by two additional points. The pump runs on the juice of various fruits grown by the Clockwinder, far more fruit than you could ever process yourself. Fortunately, you can speed up the growing process with the aid of some special cloning technology developed by your former master. This tech lets you record your body's own movements, whether that's throwing an object or pulling a lever, and then spawns a robotic 'clone' that repeats those exact movements in a loop.

You can then use these recordings to create animation-based assembly lines. A simple example might involve recording one clone picking a piece of fruit and then tossing it across a room, and a second clone catching that fruit and placing it in a press for pulping. The two clones will then repeat this process infinitely, and because the recordings are all based on your own timings, it all lines up perfectly.

The potential in this idea is enormous, and developer Pontoco wisely keeps the early puzzles open-ended. There's no limit on the number of clones you can create to solve a puzzle, so you could create a conga line of robots handing fruit to one another if you wanted.

However, the challenges become sterner as the game progresses. The contraptions you need to build become more complex, while later fruit types have quirkier traits around which you must work, such as 'bomb-berries' that explode if held for too long, turning your contraptions into a game of single-player hot-potato.

This system alone would make The Last Clockwinder a special event, but the game is also superbly presented. The visual style elegantly blends sci-fi, fantasy and steampunk elements, while the story offers a quietly intriguing personal drama that manages to be emotional without becoming sentimental. The action also takes place entirely in a single room, but the way the game works around this limitation is astonishingly clever.

The only real 'issue' with The Last Clockwinder is how it exposes the terrifying data-gathering abilities of VR headsets. Seeing a recording of your physical movements play out in real time in front of you is surreal, especially when those recordings do involuntary actions, such as punching the air when you land a perfect throw. We should probably be worried that Meta has access to this data, but that doesn't change the fact that Pontoco's game is a marvellously clever puzzler.

CLOCKS GO BACK

+ Ingenious concept
+ Beautifully crafted puzzles
+ Pleasant story
+ Looks pretty

CLOCKS GO FORWARD

– Exposes the horror of our data dystopia

VERDICT

The Last Clockwinder joins the small but elite ranks of VR masterpieces.

OVERALL SCORE

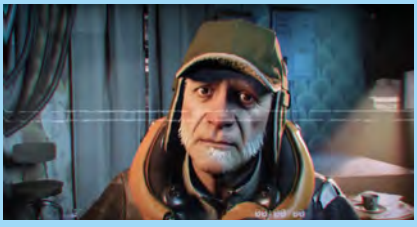
91%

NEWS

HALF-LIFE: ALYX: LEVITATION

Half-Life: Alyx's modding scene is surprisingly vibrant, with available mods ranging from alternate stories in the Half-Life universe to an attempt to recreate BioShock's Rapture in VR. But by far the most exciting mod project in the works is Half-Life: Alyx: Levitation, which could easily be mistaken for an official expansion to Valve's VR masterpiece.

Developed by a pair of veteran Source modders, Levitation is a four or five-hour campaign that continues Alyx's solo adventure. Specifically, it sees her investigating a distress signal from two Resistance members about a mysterious floating building in an area of City 17's Quarantine Zone named Sector X.



Levitation is so impressive that it was shown off at this year's PC Gaming show. The seven-minute demo centred around a chapter called Dig Deep, in which Alyx battles Combine soldiers on and around a giant industrial quarrying machine.

The scale and detail of the environments, alongside the pacing of the combat, highlights the professionalism with which the mod is being made, and the creators' understanding of how a Half-Life game should function. Even the actor playing Russell, originally voiced by New Zealand comic Rhys Darby, sounds impressively on point.

The mod is also designed specifically to follow on after the ending of Half-Life: Alyx; given the spectacularly weird nature of the original game's ending, this makes for a tantalising premise. Half-Life: Alyx: Levitation is scheduled to launch in Q3 of this year, and will be free to download on Steam.

NEWS

HELLSWEEPER

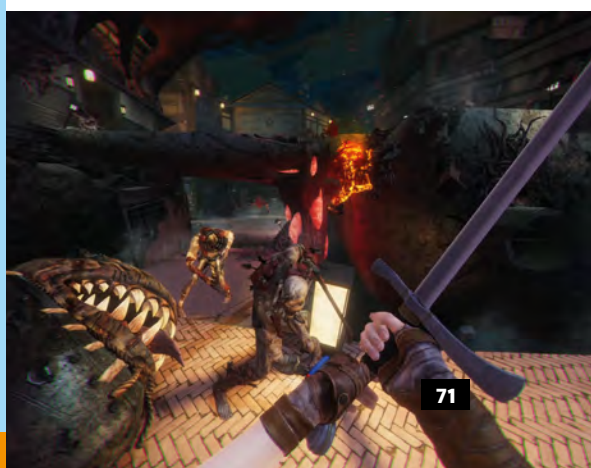
Swordfighting games are commonplace on VR now, but Hellsweeper's fantasy action involves a lot more than swords. In fact, it resembles a distant cousin to Dark Messiah: Might and Magic, the 2007 swashbuckling adventure.

The game puts you in the role of an undead warrior blazing through the underworld in a whirlwind of slaughter. Its key feature is an 'intense, no-holds barred locomotion system', that will see players able to power-slide, run along walls and perform backflips. Whether or not it comes bundled with a free bucket for vomiting is yet to be confirmed.

Putting aside the game's nauseating-sounding movement system, we're intrigued by the sheer number of ways you can fight your enemies. Yes, there's a highly detailed melee combat system that lets you hack your demonic foes into pieces, but you can also wield an array of firearms and conjure powerful magical spells, such as fireballs and piercing shards of ice.

You can also combine weapons in myriad ways, wielding a sword in one hand and a pistol in the other, or using your spells to enchant your weapons, imbuing them with flame or freezing abilities.

Hellsweeper will be somersaulting over a VR headset near you before the end of the year. It's initially releasing as an Early Access project, with a further year or so worth of development planned. CPC



PC BUILDING MASTERCLASS

NEW TO THE WONDERFUL WORLD OF PC BUILDING? **ANTONY LEATHER** TAKES YOU THROUGH EVERY STEP OF THE PROCESS IN OUR FULL GUIDE TO MAKING YOUR OWN PC

While the cutting-edge tech available to PCs undoubtedly gives them an edge over games consoles, it's the ability to customise or upgrade every single component that makes building and owning a PC so much fun. If you're super-keen to build your own PC, but have some niggling questions about certain aspects of the build process, or just want to see how it's done, this feature is for you.

We'll be going through every step of the process of assembling your own PC, covering every detail. You'll be able to go away, pick your own hardware and put it all together, even if you currently have zero knowledge or experience of building a PC. We'll be including tips we've learned from our decades-long obsession with PC hardware too, with hacks that make your PC easier to build, and to help it to run cooler and quieter.

TOOLS YOU'LL NEED

It's really important to have the right tools for the job – if you don't, that highly anticipated Friday evening of PC building you have planned will come to an abrupt halt when all the shops are shut and Amazon can't deliver until the next day. This our list of essential items you'll need.

CABLE TIES

Many PC cases include cable ties, and even handy Velcro ties that help to gather cables into neat groups. However, nearly all cases lack an adequate number of cable ties to anchor down all the cables in a typical PC. A pack of 100 costs under £3, and it's definitely worth having a couple of dozen to hand, so you have enough ties to do a decent job of cable tidying.

MINI SCREWDRIVERS

There are instances where your average screwdriver isn't small enough. You'll need a mini screwdriver set to deal with smaller screws, such as those in M.2 SSD slots. These sets only cost a few quid and are available from most hardware stores.

NEEDLE-NOSE PLIERS

Chunky pliers have their place, but you'll need a more delicate set of pliers for PC building. Needle-nose pliers give you more control and accuracy when dealing with fan clips, expansion slot covers and other items that need a bit of force to remove, but will mince your fingers if you try to do it with your hands.

THERMAL PASTE

Most processor coolers include thermal paste, but some have it pre-applied or only include pitiful amounts. If you mess up the first application, you can end up without the means to properly apply more thermal paste. It's inexpensive and a small spare tube is an essential item in any PC enthusiast's toolbox. If it's your first time building a PC, we recommend using a ceramic paste, such as ARCTIC MX-4.

SIDE CUTTERS

Side cutters are ideal for quickly trimming cable ties once you've fixed them in place. They're common in most toolsets, but if you need to buy a pair they only cost a few pounds and are essential for tidying your PC – scissors are often a bit too blunt and unwieldy for the job.

NO.2 PHILLIPS SCREWDRIVER

This screwdriver will fit the majority of screws in your PC, which are usually quite large and require reasonable force to screw into place. Avoid using an electric screwdriver, as they have too much toque and can easily strip screw threads. If you have one with a torque setting, only use it on a very loose setting.

Having a magnetic screwdriver is essential too, as many PC screws have been lost in the dark corners of PC cases, never to be seen again. A lot of PC screws are also secured horizontally, and will simply fall off your screwdriver if it's not magnetic, or will at least require you to use both hands to get it in place. If you already have a screwdriver, but it isn't magnetic, then you can easily magnetise it with the help of (yep, you've guessed it) a magnet.

If you have some magnets lying around the house anywhere, even if they're just ones sticking novelty souvenirs to the fridge, place one onto the screwdriver shaft closest to your hand and then move the magnet down to the tip of the screwdriver.

Pull it off then repeat this process ten times. You should now find the screwdriver is magnetic and will hold onto your screws itself.

THERMAL PASTE CLEANER

Thermal paste cleaner makes removing old thermal paste much easier by breaking it down and cleansing the surfaces ready for fresh paste to be applied. It can also help remove any paste that you get on your hands or clothes, so it's useful to have some to hand. There are specific thermal paste cleaners available, but isopropyl alcohol works just as well and can be cheaper too.

MICROFIBRE CLOTH

Using the right cleaning cloth is important for PC building for several reasons. You don't to use a cloth that sheds fibres, as this will create dust that can cling to thermal paste and hamper cooling.

Standard kitchen towel or household tissues must be avoided, and you need to ensure the cloth is lint-free too, as lint can build up static charges. Lint-free microfibre towels are perfect for several jobs with PCs, from cleaning thermal paste off your CPU to polishing glass side panel windows.

CHOOSE COMPATIBLE COMPONENTS

It goes without saying that you need to ensure you've chosen the correct hardware in order to avoid any compatibility issues with your newly PC.

You can see our Elite list (see p58) for help picking the right hardware, but make sure you're aware of the various motherboard sizes available, that you pick the right motherboard for your case or vice versa and that your chosen CPU cooler is compatible with your motherboard.

It's also worth checking case clearances. Cases have limits for the length and height of CPU coolers and graphics cards. A typical ATX case doesn't usually have any issues, but occasionally a particularly large CPU cooler might not fit into a smaller-than-average case.

You'll also need to ensure your CPU is compatible with your motherboard. The easiest way to do this is to head to your motherboard manufacturer's website, or even an etailer website, and use the menus to select products that only use a specific chipset or CPU socket.

For Intel's 12th-gen CPUs, that would be motherboards based on the Z690 or B660 chipsets or the LGA1700 socket. The website **pcpartpicker.com** is also a useful tool for picking compatible components.

Large CPU coolers may stretch the limits of some small cases

INSTALL YOUR CPU

We'll start with a warning, which is that the pins in Intel's CPU sockets and the backs of AMD's CPUs are extremely fragile. The socket pins are particularly damage-prone and the slightest knock can kill your motherboard. Be extremely careful when you install the CPU into the socket as it's by far the most hazardous step when you're building a PC.

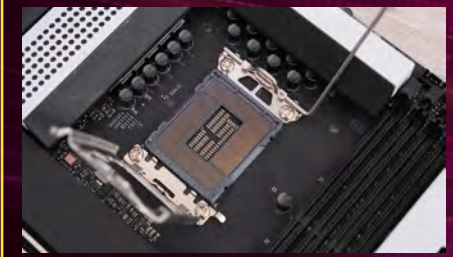
With Intel CPUs, leave the black socket cap in place [1]. It will pop out itself when you install the CPU. It's designed to protect the socket pins until you actually install the CPU. Start by prising out the CPU socket latch to the right and lifting it up to open the socket.

Next, lower the CPU down next to the socket, so there's no chance of you dropping it into the socket and damage the pins. There are notches on the side of the CPU to help you orientate it correctly [2]. Once the CPU is in place, bring the CPU socket cover down over the CPU and then bend the latch down, securing it in place [3].

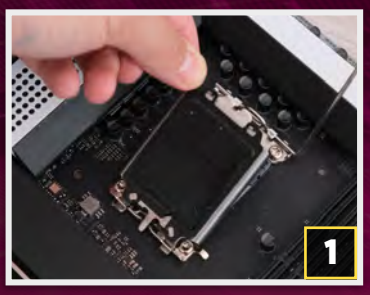
With AMD's current Socket AM4 platforms, the pins are on the CPU [4]. Like Intel's CPUs, they fit into the socket in a particular orientation, which can be found by aligning arrows on the socket and edge of the CPU. The pins sit in holes in the socket, but you need to open the holes first by opening the latch on the side of the socket.

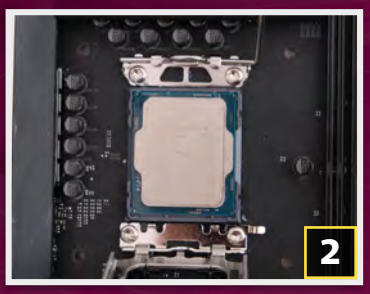
Lower the CPU into the socket. It should slot freely down into place. Occasionally it may require a small push to ensure its underside sits flush with the socket all the way around.

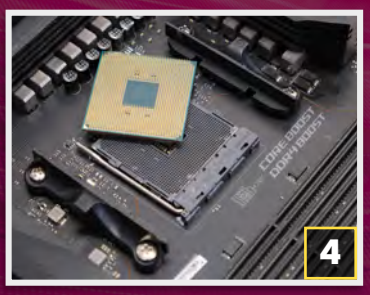
Once it's sat flat in the socket, lower the latch, which this will lock the CPU in place [5]. If you ever need to remove your CPU cooler, twist it first. This will loosen the thermal paste, which can otherwise stick to the CPU and actually pull AMD CPUs out their sockets.



The pins in Intel's CPU sockets are incredibly fragile, so you need to be extra careful when installing the CPU







INSTALL YOUR MEMORY

Memory modules can only be fitted into your motherboard's DIMM slots one way around, and it's easy to identify as the modules have notches that match up with pins in the slots.

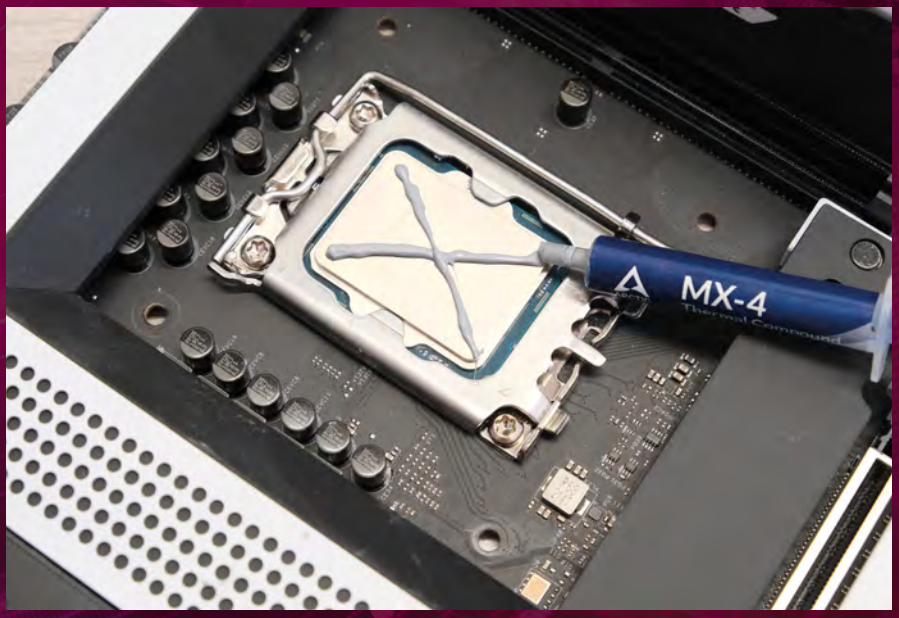
Most motherboards have four slots, but your memory kit will probably only have two memory modules. You need to place your modules into specific slots, though, as your motherboard has the ability to access data on both modules at once using a feature called dual-channel mode. This can dramatically increase performance and is one reason why using just one large memory module is a bad idea.

To ensure dual-channel mode is activated, place your pair of modules into slots two and four, or the second and fourth furthest away from the CPU socket. To actually install the modules, insert one edge of the module into the slot first, lifting any latches on the ends of the slots first if they're present.

You need to press quite firmly on the middle of the module to get it to clip into the socket and you'll hear it click into place. Any latches at the ends of the CPU socket will lock into the module. Ensure both modules are seated properly – they need to be level and sitting at the same height.

Insert one edge of the module into the slot first

APPLY THERMAL PASTE



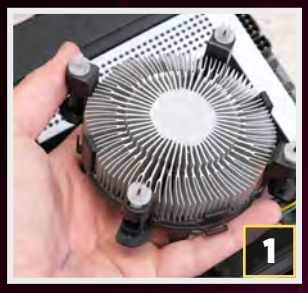
Draw a thin cross shape from corner to corner on the CPU's metal heatspreader

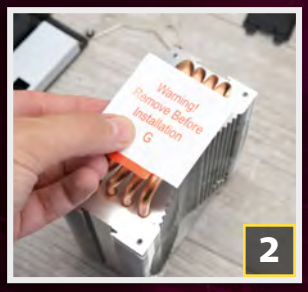
Thermal paste is often pre-applied to CPU coolers, but there are still plenty of situations where you need to apply it yourself. If this is the case with your chosen CPU cooler, this is how you do it. Aim to draw a thin cross shape from corner to corner on the CPU's metal heatspreader.

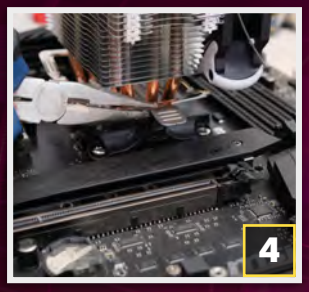
Both AMD and Intel's current CPUs have heatspreaders that are large enough to need a reasonable amount of paste, so just applying a small blob in the middle of the heatspreader won't guarantee that the paste will spread over the whole surface.

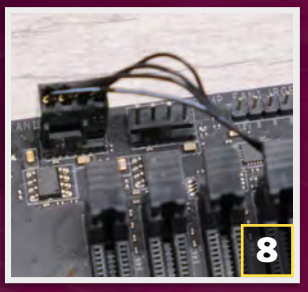
Any areas that don't have paste applied won't transfer heat as quickly from the heatspreader to the cooler's contact plate and could hinder cooling. Use thin lines around the width of a dry stick of spaghetti. For older, smaller Intel CPUs, a single line from top to bottom in the middle of the heatspreader is enough.

FIT A CPU AIR COOLER









There are two types of cooler you'll typically want to use in your first PC. The first is an air cooler comprising a heatsink and fan, and we'll look at how to install one now. With Intel motherboards, there are simply four mounting holes around the CPU socket that enable coolers to secure to the motherboard and clamp down onto the CPU heatspreader.

Some Intel coolers use push pins [1], where you push the usually white outside plastic parts of the pins into the holes around the CPU socket, then push down the usually black inner parts of the pins and turn them to secure them. However, air coolers that retail for more than £20 usually have more elaborate mounting kits that use backplates and thumbscrews.

Start by removing the plastic film on the base of the cooler [2]. This is there to protect the polished surface as it's otherwise easy to scratch, and it can also tarnish when it's exposed to air, both of which can reduce thermal transfer. It's easy to forget the film is there, though, only to see your CPU temperature skyrocket when you leave it accidentally on the cooler. We've all done it.

Next, install any mounting gear for your CPU cooler onto the CPU socket. We can't cover every variation here, but your cooler will come with instructions showing you step how to fit it to a variety of CPU sockets. You'll probably need to fit a backplate to your motherboard to mount your CPU cooler for an Intel CPU, and then screw the cooler's mount into the backplate [3].

Coolers for Intel CPUs will usually require a specific set of mounts for your socket, and you may need to buy a separate adaptor for Intel's LGA1700 CPUs. Always take care with your screwdriver when it comes to mounting your cooler, as one slip could end up scraping a trace on the motherboard and render it useless.

AMD coolers use one of two routes for securing to the motherboard. Some make use of the standard socket brackets with which AMD motherboards are equipped, while others require the removal of these brackets and have their own mounting mechanisms that you'll need to install.

Using the mounting clips on AMD's AM4 sockets is very easy, as the cooler has its own clips that hook onto them, although you might need a pair of needle nose pliers to press them into place [4].

Removing the clips from AMD motherboards is simple as well. There are two screws in each clip that need to be removed, allowing you to lift the clips off the motherboard [5]. Underneath, there's a backplate, which might be used to mount your cooler or it will include a new backplate – this will be detailed in your cooler's instructions. The installation process will then very probably involve screwing the mount for your cooler into either the default backplate on the back of your motherboard, or a new one that comes with the cooler [6].

When it comes to mounting your cooler, orientate it so that the fan is blowing air through the heatsink and towards the rear of your case [7]. This is the airflow direction for the vast majority of cases, especially if they have a rear exhaust fan, as this helps the CPU cooler expel its warm exhaust air out of the case. However, some cases do differ in their airflow designs, for example with a bottom to top airflow direction, so it's well worth checking the manual for your case.

The fan is likely to be powered using a 4-pin connector, which needs to be connected to your motherboard's CPU fan header [8]. This is usually labelled on the PCB, but its location can vary. It's important to use this header and not any of the other ones dotted around your motherboard's PCB, as this one is specifically designed to deal with the fan on your CPU cooler and may dish out different fan speeds accordingly.

KNOW YOUR PORTS AND CONNECTORS

It's generally impossible to plug a cable into completely the wrong port when it comes to PC building these days, so if you're afraid of something blowing up, you can rest assured this won't happen.

However, some connectors are more appropriate than others for certain jobs, and it can be useful to know what each connector looks like, and where you install them.

Power supplies (PSUs) come with dozens of different connectors to cater for varying configurations of hardware. You don't need to make sure every cable on your PSU is connected to a component – you'll almost certainly have some left over. Below you'll find a list of the common cables and connectors you'll come across, on both your PSU and your other components.

PCI-E POWER CONNECTOR

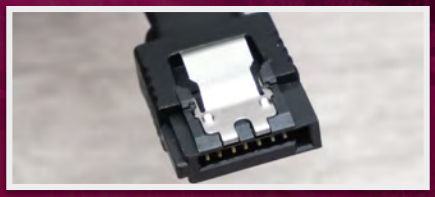
This powers your graphics card and usually comes split into two pieces, with one 6-pin connector and one 2-pin. Graphics cards have either 6-pin or 8-pin ports, so with your PSU offering several of these connectors, you can power practically any graphics card. The only way you'll come unstuck is if you have a very lowly PSU that doesn't have enough of them, but most PSUs have at least two, and only the most massive and expensive graphics cards have more than this number of power connectors.

MOLEX CONNECTOR

Rarely used today, since SATA connectors do the same job and are easier to install. These days, Molex connectors are occasionally used for fans or water-cooling pumps.

SATA POWER CONNECTOR

If you're using a 2.5in SSD and/or a 3.5in hard disk, you'll need to power them using a SATA connector. Many liquid coolers also use them. You'll find several on a single cable on your PSU, which can pose a cable-tidying challenge.



SATA DATA CONNECTOR

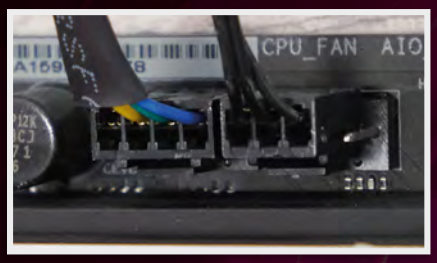
Hard disks or 2.5in SSDs need to be connected to your motherboard to allow the back and forth transfer of data, requiring a SATA data cable to connect the two. Motherboards have at least two of these ports, with four or six ports being the most common.

24-PIN ATX CONNECTOR

This is the biggest port on your motherboard with a corresponding connector on your PSU too. It provides power to components and ports on your motherboard.

8-PIN EPS 12V CONNECTOR

This provides power to your CPU. Cheap motherboards occasionally have just four of the eight pins, requiring you to use just one half of the connector. Some high-end motherboards have more than a single 8-pin connector too, but this is only needed if you're an extreme overclocker building a very powerful system. In the vast majority of situations, you just need to connect the 8-pin connector from your PSU to the corresponding socket on your motherboard, which is usually located above the CPU socket.

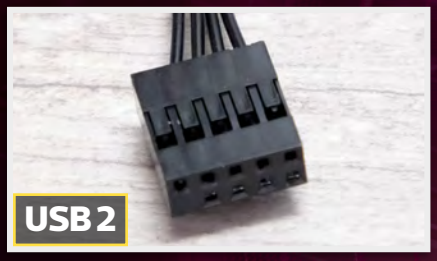


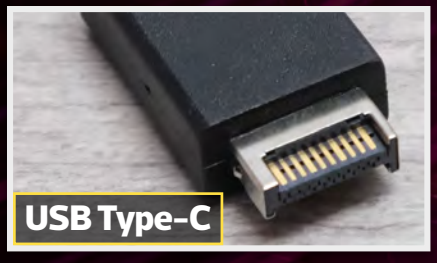
3-PIN AND 4-PIN FAN CONNECTORS

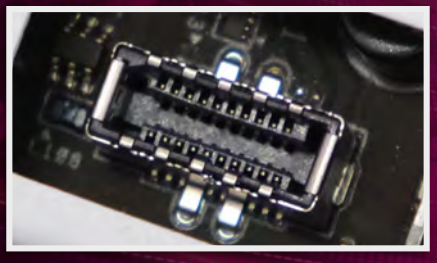
Your case's fans (and radiator fans if you're using liquid cooling) will probably have one of these two power connectors on the end of their cables, but both of them connect to the same type of power header on your motherboard – you can also plug a 3-pin plug into a 4-pin header if necessary.

The 3-pin connector provides power and that's it. Meanwhile, a 4-pin connector has a clever additional pin that provides what's known as a PWM or pulse width modulation signal to your motherboard.

This can allow the motherboard to control the voltage, and hence the speed, so you can run it at lower than default speeds, making it run slightly quieter.







USB HEADERS

Understanding USB isn't easy these days with so many speeds and ports available, but you'll need to familiarise yourself with three types of headers in your PC, so you can get all the USB ports on your case working properly. There are cables coming from these ports inside your case that need to be connected to headers on your motherboard.

The USB 2 header provides data and power to your case's USB 2 ports, while the USB 3 header does the same for faster USB 3 ports.

Finally, there's the newer, short and blocky Type-C header, which as you may have guessed, needs to be connected to your case's front panel Type-C port if it has one, although this is still a feature that you only find on more expensive cases.

3-PIN AND 4-PIN RGB CONNECTORS

There are two types of standard RGB lighting connectors, and these come in 3-pin and 4-pin flavours. The latter allow you to control all the LEDs in a strip or component at the same time, perhaps showing the same colour or altering the brightness for all LEDs at once. The 3-pin RGB connectors can do all that, but also give you control over individual LEDs, providing greater scope for lighting effects, or simply having different colours showing across an LED strip at the same time.

AUDIO HEADER

If your case's front panel has analogue jack sockets for mic and headphones, then it will also have an audio cable that hooks up to the header on your motherboard and enables these jack sockets to work – it's usually in the bottom left corner of your motherboard.

FRONT PANEL HEADER

Your case will have a power button, and often a reset button too, as well as lights that show when it's powered on, and sometimes for when the SSD or hard disk is being accessed. All these case features work by using cables that connect to your motherboard in the same way as the USB ports covered, except they're much smaller.

You connect them to your motherboard's front panel header. You'll need to refer to your motherboard manual to identify the right pins and, be warned, this can often be fiddly, especially if you do it once your motherboard is already screwed into your case. We'll look at the best ways to deal with this part of the installation later on.

FIT A CPU AIO LIQUID COOLER

The AIO here stands for 'all-in-one', and these coolers essentially offer a sealed loop comprising a pump and waterblock that sit on your CPU, plus a radiator with fans mounted to it, which work in a similar way to an air cooler.

With two key components making up the setup, they're slightly more complicated to install than air coolers, but the process is still straightforward. We'll run through the whole process of installing one here, so you can refer back to it later when we cover the key PC building steps.

Start by removing the plastic protective film off the underside of the pump's contact plate [1], then source the parts from the box needed to fit the block to your motherboard's specific CPU socket. As with most coolers, several sockets are likely to be supported by your liquid cooler.

Install the components required to secure the pump to your motherboard [2]. This process always involves a mounting kit for Intel motherboards, while with AMD Socket AM4 motherboards you either use the plastic brackets already on the board, or you'll be required to remove them in order to create a more elaborate mounting contraption.

It's now best to install the pump/waterblock unit to your motherboard before you install the motherboard in your case [3]. You may need to hold a backplate in place while you secure the pump from the top side of the motherboard, as that's a tricky job if the motherboard is already installed in your case.

Ideally, you want to install the radiator so that it's higher than the pump, and any air in the loop gets trapped in the radiator and not in the pump. For this reason, it's best to place a liquid cooler's radiator in your case's roof.

The fans will also need to be placed so that they blow air through the radiator, which needs to be mounted directly to the roof. Start by fitting the fans to the radiator using the long screws included in the box.

These pass through the fans and secure them to the radiator. The open side of the fan is the intake, with the framed side of the fan being the exhaust [4].

To secure the radiator to the case, you'll need to use the smaller screws included in the box [5]. Place the radiator in the roof fan mounts and line up the radiator mounting holes with the fan holes in the roof [6].

Not all cases have roof fan mounts or space enough for a radiator, so in this situation place the radiator in the front of the case with the tubes at the top [7].

You ideally want to have the tube end of the radiator sitting slightly higher than the pump attached to your motherboard.

Finally, you need to connect your cooler's fans and pump to your motherboard. Some AIO liquid coolers require the use of a SATA connector from your PSU for power [8], relying

1

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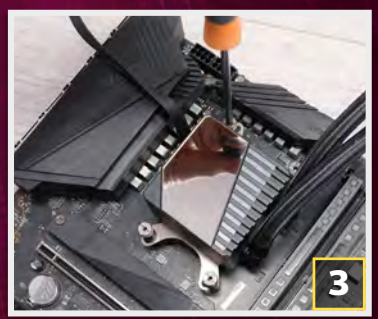
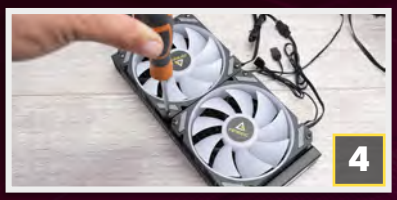

3

on your motherboard only for fan speed control, while others get all their power from the motherboard.

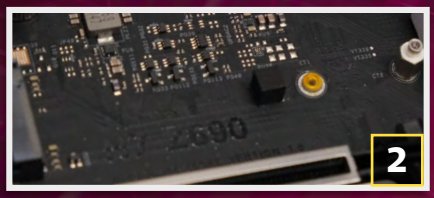
In any case, unless the cooler uses some sort of hub, or a software control system, you'll need to connect the fans to your motherboard to get their power.

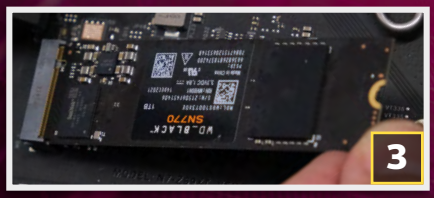
Most motherboards have a dedicated header for pumps (often labelled 'AIO'), which provides a steady voltage stream, as it's a good idea to run the pumps at full speed all the time – this is the header to which you cant to connect your cooler's pump/waterblock unit. The only exception is if there's just a single cable that powers the pump and fans together, in which case this cable should be connected to the CPU fan header.

With the pump connected to your motherboard's pump header [9], connect the fans to your CPU fan header. Your cooler should come with a splitter cable if it has multiple fans, allowing you to power two or more fans from a single CPU fan header.



FIT M.2 SSDs





If you're building a PC for the first time, or upgrading from an old system, you might not have seen M.2 SSDs before. Unlike hard disks or 2.5in SSDs, they don't require cables and instead connect directly to one of several M.2 ports on your motherboard, and you'll need to use the right one.

If you've bought an M.2 SSD recently, it probably uses your motherboard's PCI-E interface to send and receive data. If it's the older PCI-E 3 standard then it should work in any M.2 port. If it's the new PCI-E 4 standard, though, then check your motherboard's manual to see which M.2 ports support PCI-E 4. It will still work in a PCI-E 3 M.2 slot, but it will run slower.

Your motherboard will also very probably provide a heatsink for at least one M.2 SSD, particularly if it's a new model. This isn't essential for PCI-E 3 M.2 SSDs, but it can help PCI-E 4 M.2 SSDs hit their maximum speeds for long periods without thermally throttling. Remove the heatsink from the motherboard and peel off any protective plastic that's on the thermal pad beneath [1].

Your SSD will be secured using a small screw or latch. The former screws into a standoff, which you may need to install yourself. The vast majority of M.2 SSDs are 80mm long and the correct threaded hole for the standoff will be labelled either 80mm or 2280 [2].

Next, insert the M.2 SSD into the connector, so its end section lines up with the notches in the M.2 port. You'll need to hold the other end up by around 30 degrees, so it's inserted at a slight angle [3]. Next you'll need a mini screwdriver to deal with the tiny screw that secures the M.2 SSD [4]. Depending on your motherboard, this may also secure the heatsink too in one go.

Some newer motherboards use tool-free latches to secure the SSD instead, which are far less fiddly than using screws. To use one of these, install the SSD then secure the latch by rotating it until it locks the SSD in place [5]. You might need to rotate it around a few times to see how it works.

FIRST TEST

On very rare occasions, one component may arrive faulty. The chances of this happening are extremely slim, but it pays to test your components before you build your PC. You don't want to have to go through the process of building your PC only to have to dismantle it again if it doesn't work.

There's a simple way to check all your parts are working, which is to build your PC outside of the case. This involves connecting the core hardware, plugging in a keyboard, powering it on and ensuring there's an output to your display from the graphics card. If you get a display, then you know the basic system works, and you can then get into the EFI to confirm the SSD is recognised and set the correct memory speed.

You'll want to have your CPU, memory, cooler and SSD installed in the motherboard at this point, but if you're using an AIO liquid cooler, make sure it's connected to the motherboard and power supply, but without the motherboard or radiator installed in your case yet. Put the radiator to one side – we'll cover how to fit the radiator to your case later.

Place the motherboard onto its box [1], as this will insulate it and give you room to install expansion card backplates. Think of the box as a temporary test bench.

Next, locate the 24-pin and 8-pin CPU motherboard power connectors on your PSU and hook them up to the corresponding ports on the motherboard (see Know your ports and connectors, p77) [2].

Next, do the same for your graphics card, using whatever combinations of PCI-E power connectors you need, before installing the graphics card into the top 16x PCI-E slot on the motherboard [3]. The 16x PCI-E slots are the longest horizontal slots on the motherboard underneath the CPU socket, and the one at the top always supports the fastest speed available.

Connect your mouse, keyboard and monitor, with the first two going to USB ports on the motherboard's I/O panel, and the latter using an HDMI or DisplayPort cable to a corresponding port on the rear of your graphics card [4].

Next, we need to be able to power on your PC. Connect your PSU to the mains and ensure it's switched on at the back [5].

If your motherboard doesn't have a power button on-board, the easiest way to turn on your PC is with a small screwdriver to short the power button pins on the front panel header [6].

This is where you connect your case's power button (see Know your ports and connectors, p77). Shorting or connecting the pins together for a moment will tell the motherboard and power supply to fire up. There are no high voltages going through these pins – you're perfectly safe.

Hopefully your PC will power on, fans will start spinning and you can give yourself a pat on the back for building your first PC. However, we're not quite done yet.

When prompted, hit the Del key on your keyboard to enter the EFI. If you're not prompted, turn off the PSU to power the PC down, then power it on again and start tapping the Del key at one second intervals.

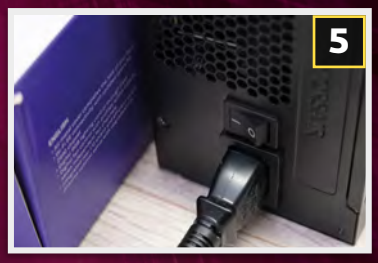
At some point the PC should enter the EFI, where we need to check a few settings. Start by looking for the XMP profile setting. This might be visible on the EFI's landing page straight away, but if not, look for the Advanced or Tweaker settings tabs and check the menus for XMP profile .

This is also called D.O.C.P on some Asus AMD motherboards. Enabling the XMP profile that matches your memory's speed will ensure the memory runs at the correct settings such as frequency and timings.

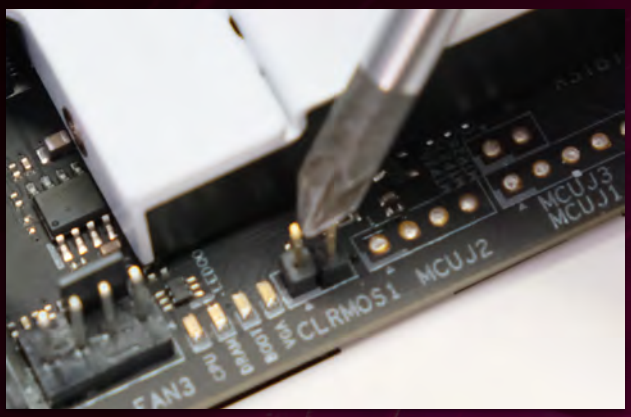
Next, locate the boot options in the EFI. Find the boot menu and check your SSD is listed in the drop-down menu. This will ensure it's accessible and installed properly, waiting for Windows to be installed.

Finally, we need to make sure the cooler is working properly, so the CPU isn't going to overheat while we're installing Windows. The temperature is visible on the home page of most BIOS screens, or in the fan control and monitoring section.

At stock speed the CPU temperature shouldn't be much above 50°C while it's sitting idle in the EFI – if it's above 80°C there's a problem, so make sure the CPU cooler's fan is spinning, or that the pump on your liquid cooler is definitely plugged in and working.



HELP, IT DOESN'T WORK!



You can usually clear your motherboard's CMOS by shorting out two pins with a screwdriver

YOUR PC DOESN'T POWER ON

This points at a fundamental problem somewhere, but first make sure the PSU's power switch is on, that you've plugged it into the mains and check all the power cables to your components, giving each an extra press into its port. It's even worth detaching the 24-pin ATX connector and plugging it in again, as we've seen this solve problems occasionally. It's also worth unplugging your memory modules and reinserting them – as a last resort, do the same with the CPU.

YOUR PC POWERS ON, BUT THERE'S NO DISPLAY

This can point again at loose components, such as the graphics card, power connectors, CPU or memory, so make sure they're all seated properly, but also make sure your BIOS is up to date and supports the CPU you're using. You can try updating it if your motherboard has USB BIOS flashback (see p87), but it's also worth resetting the BIOS too by using the clear-CMOS feature. Your motherboard may have a button to do this, or you may need to short two pins using a screwdriver, but consult your motherboard manual on the best way to do it.

IDENTIFYING FAULTY HARDWARE

In terms of component failures, there are a couple of ways to test some of the hardware to see if it's faulty. For example, you can check if your graphics card is faulty by removing the graphics card, connecting you monitor to your motherboard and using your CPU's on-board graphics. Not all CPUs have on-board graphics, including most of AMD's latest CPUs and Intel's F-series CPUs, but this is a handy option if you have it available.

Your memory could also be at fault, but it's highly unlikely both sticks are dead. Remove one and place the other into the last slot on your motherboard, powering on your PC to see if the issue is solved, then do the same with the other stick.

Your CPU, motherboard and power supply are more difficult to isolate, and you'll need to borrow a compatible model from a friend or get them to test the components in their PC. Alternatively, if you have a local PC retailer, they will often test components for a fee. Finally, you should reach out to the retailer from which you purchased the hardware from and explain that you suspect one component is faulty. You can also return hardware under distance selling regulations, which gives you 14 days to make your return.

If your motherboard has a video output and your CPU has on-board graphics, you can see if your graphics card is at fault by bypassing it

BUILDING YOUR PC

PLAN YOUR PC BUILD

We now know what goes where, that our hardware works and we're ready to install it into our case. However, there are still some factors to consider before you reach for your screwdriver. Start by having a good look at your case and cables, and working out where your wires need to go [1].

Once you know which components go where, you need to work out how to get the cables to and from all the right places while minimising clutter. You case will have cable routing holes conveniently placed around the motherboard tray and elsewhere, enabling you to route cables cleanly from your PSU to your components without trailing them all across your motherboard.

FIT THE POWER SUPPLY

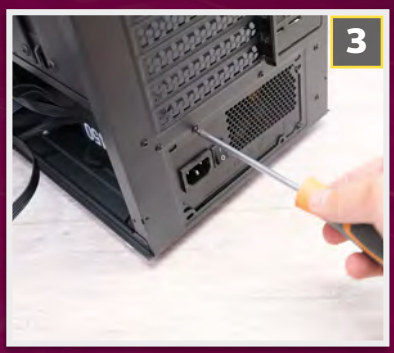
Most cases have just one PSU mount, but be sure to follow your case's manual to check whether the fan points up or down. Feed the cables into the case [2] and then secure the PSU to the mount [3]. Modular PSUs have detachable cables, allowing you to remove those you don't need to save space.

INSTALL THE MOTHERBOARD

Before you install the motherboard, check that there are standoffs installed in your case's motherboard area [4]. These are small metal pins that support the motherboard in specific locations, raising it off the motherboard tray beneath and preventing it from short circuiting. These are usually installed out of the box, but occasionally you need to screw them yourself, so check the case's manual to work out if you need to do this, and then line up the standoffs with the screw holes on your motherboard.

It's a good idea to install some cables before you lower the motherboard into the case. One of these is the 8-pin EPS 12V connector. Route this from the PSU, around the back of your case's motherboard tray, to the cable-routing hole at the top of the case and then pull it out of the hole by a few inches. Then lower the motherboard into the case and connect the cable to the connector [5].

Now is a good time to connect your case's front panel cables to your motherboard's front



panel header (see Know your ports and connectors, p77), which will be much easier before the motherboard is fitted into the case. Run them behind the motherboard tray and out of a hole below the motherboard area, before hooking them up to the correct headers [6], which will be detailed in your motherboard manual. However, if your case's cables aren't long enough, you may have to wait until the motherboard is inside your case before you can do this.

The final step before installing your motherboard is to install the I/O shield. Most motherboards have these integrated these days, but some still have separate shields that you'll need to install yourself. This will be included with the motherboard and sits around the rear ports to prevent dust ingress and provide an earth.

Line up the shield with the rear of the motherboard and its ports, then place it into the I/O panel cut-out in the rear of the case [7]. This can take some persuasion, but it will fit into place eventually.

Finally, gently lower the motherboard into place so that the I/O panel is a centimetre or so out from the I/O shield then move it across so that its mounting holes line up. Be careful not to let the motherboard scrape against the standoffs, as they can damage the PCB traces. Instead, lift the motherboard slightly before moving it across.

Now you can use your case's motherboard screws to secure the motherboard [8]. Make sure you use all the available mounting points and have the case sat flat, so the motherboard isn't left dangling vertically.

INSTALL SATA DRIVES

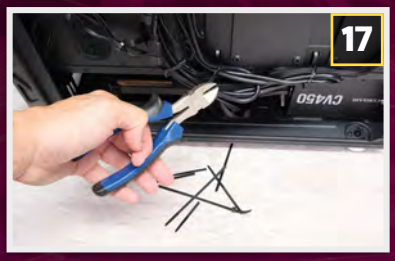
Your case will likely have mounts for both 3.5in hard disks and 2.5in SSDs, so check your case's manual to see where these mounts are located. When it comes to 3.5in hard drives, you usually have to screw a mounting system to the sides of your drive, in order to easily slide it in and out of the drive bay [9].

The end with the connectors nearly always needs to sit facing the motherboard tray side of the case, so cables can be routed out of sight and the drive can be easily removed, often by sliding it out [10]. Try to mount your drives as close to your motherboard's SATA connectors as possible, as this will give you an easier time when cable tidying.

SSDs are more flexible and have mounts in all manner of positions, but they're usually secured to the mount using screws in either the sides or underside of the drives [11]. A lot of cases have 2.5in SSD mounts behind the motherboard tray, which is our preferred location for them, as it keeps the drives out of sight and makes cable tidying easy [12].

REMOVE EXPANSION SLOT COVERS

To prevent dust ingress, your case's rear slots, where the rear panels for PCI-E expansion devices such as graphics cards sit, are covered by blanking plates. You'll need to remove the ones that sit where your graphics card needs to go, as it will have its ports and cooling vents there. These usually unscrew and slide out, but occasionally you'll need to pry out metal



sections using pliers – don't use your fingers as they can get scraped [13].

INSTALL EXTRA FANS

If you have any extra fans to install, look at your case's airflow out of the box and aim to complement it. If there's no rear fan, but there's a fan mount, this is an ideal place for an extra fan, as are any vacant front fan mounts. The former should be installed so it's in line with your CPU cooler's fan [14], while front fans are best placed, so at least one is in line with your graphics card, with most of its depth sitting below the card to feed its cooling fans.

TIDY YOUR CABLES

With all your cables installed and connected, it's time to tidy them up behind the motherboard try. This might seem like a waste of time, but a mass of spaghetti looks hideous and can actually hinder airflow and make your PC run hotter too, as well as increasing the risk of cables finding their way into exposed fans and blocking access to components.

If your case has any natural channels to which you can anchor cables, definitely use them, but the key is consistency. Pull any slack from the motherboard area through the cable routing holes to the back, gather bunches of cables together and do a test fit to see which anchor points make sense and which are out of range of some cables [15]. You can then use cable ties to secure the cables in bunches to the case's anchors. Run the ties under the bunches of cables, thread the cable ties through your case's anchors, put the thin end of the tie through the buckle and pull it tight.

Don't be afraid to gather large bunches of cables together and stow them under the PSU cover if your case has one [16]. It will have minimal impact on airflow down there and keep it all out of sight. Once you've finished your cable tidying, it's time to use your side cutters to trim the ends, hopefully leaving a neat line of cable ties [17].

Remember that you need to put your case's side panel back, so try to keep bunches of cables as flat as possible, without bulging outwards. Your cable tidying doesn't need to look immaculate, but it does need to be secure [18]. At this point, you're basically done with the hardware side. You can connect your keyboard, mouse and monitor, plug in a power cable, switch on your PSU and hit your case's power button ready for the next stage [19].

If it doesn't fire up, double-check all your power cables, as well as the cables for the case front panel – you already know your core PC works from the first test, so it should be easy to find the problem.

EFI SETUP

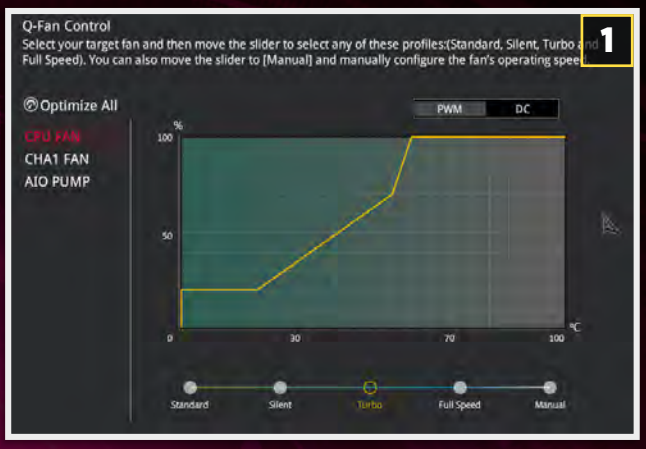
Power up your PC and hit the Del key to enter the EFI system so you can perform some final tweaks. First, head to the EFI's fan control section and familiarise yourself with it.

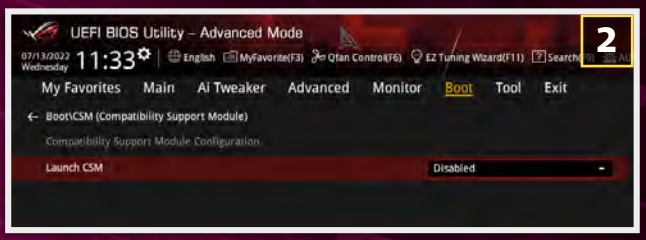
If any fans in your case are annoying loud, you can identify them and select a less aggressive speed profile, or even create your own fan curve [1].

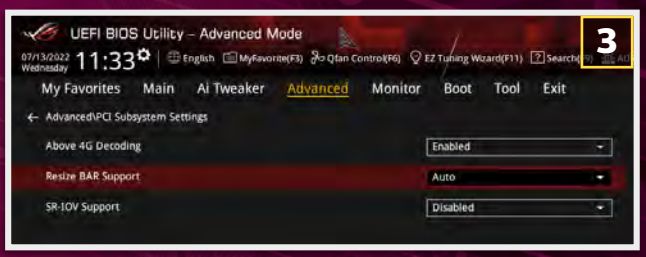
Beware of limiting fan speeds too much, though, as lengthy gaming sessions on hot days could see your PC stifled – always allow your fans to hit maximum speed if your CPU temperature tops 90°C.

If your graphics card supports Resizable BAR (called Smart Access Memory by AMD), you'll need to ensure it's enabled in the EFI as it can boost performance in some games. This is located in different places depending on your motherboard manufacturer. First, locate the option for CSM, which is usually located in the boot menu, and disable it [2].

Next you need to enable Resizable BAR. Gigabyte boards have the option for BAR under the Settings menu, while Asus and MSI boards have it under the Advanced tab in PCI Subsystem Settings. ASRock motherboards put it in the Advanced menu and sometimes called Clever Access Memory. Once you've found it, enable it [3].





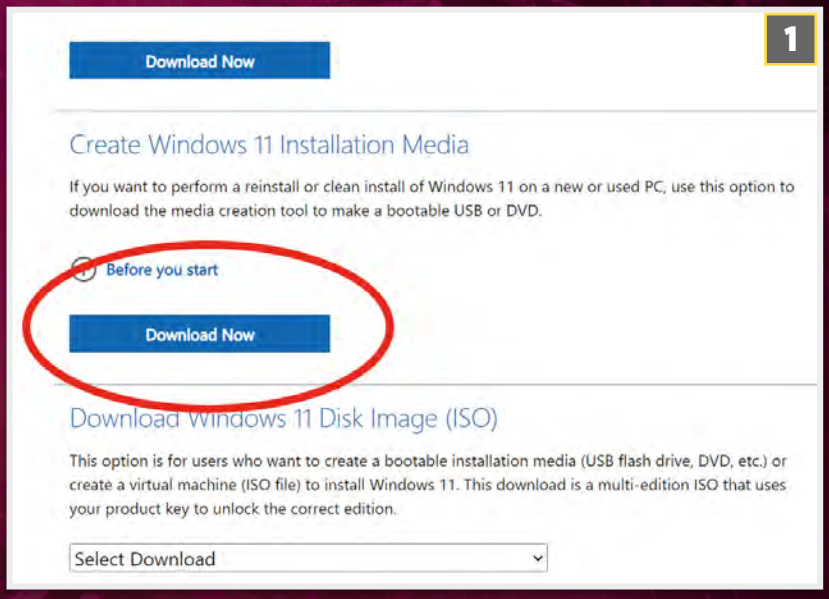


SOFTWARE INSTALLATION

INSTALL WINDOWS

If you have access to another PC or laptop, you can download Microsoft's Media Creation Tool software for either Windows 10 or 11 (**custompc.co.uk/InstallWindows**) [1], which enables you to create a bootable Windows installation USB flash drive and makes the process of installing Windows easy.

This tool will grab the latest version and allow you to install the operating system, meaning you just need to obtain an official licence code to enter later. Your USB stick needs to have a capacity of at least 8GB, and the process will wipe everything on the drive, so back up any data you want to keep.



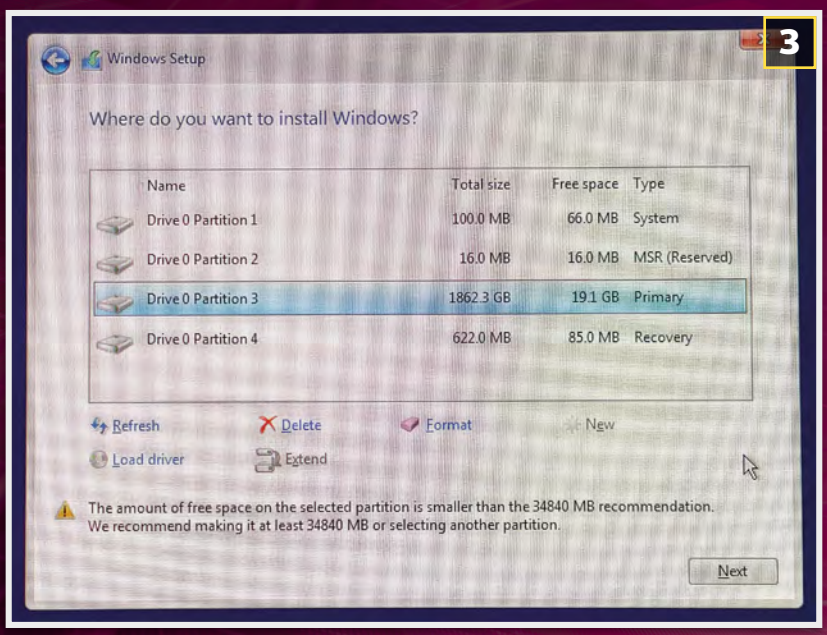
If you don't have access to another computer, but already have a licence for a genuine copy of Windows, USB flash drives are available on eBay pre-loaded with the same installer for as little as £7. Microsoft itself now offers Windows 11 on USB flash drives too, so grab one of those if you're starting afresh and don't have another PC.

Once you have your bootable USB flash drive, head to the EFI and find the boot menu. Select boot options and locate your USB flash drive, which may indicate it has a Windows installation on it, then pick it as your first boot option 2. You then need to save and exit your settings and restarting the PC will see it enter the Windows installation.

Head through the installer's menus until you get to the part where you picking the drive and partitions on which to install Windows. Here, you should be able to identify the storage device onto which you want to install Windows onto, but if not, it's safer to switch off your PC, disconnect all other storage devices apart from this drive and your install USB flash drive, and try the process again.

If there are any partitions on your SSD, they'll show up like the image above 3 and you can delete them if you no longer want any files on the drive if you're reusing one.

Allow Windows to do the rest of the process by clicking on the drive and selecting Install. When the PC reboots, you'll be free to enter the EFI again and switch the primary boot device to your SSD rather than the USB thumb drive – by now, your SSD will indicate that it has the beginnings of a Windows installation on it.



INSTALL YOUR DRIVERS

Once you've installed Windows, hopefully you'll have access to the Internet, at which point you can download your motherboard's chipset drivers from its product web page, and grab the latest networking and sound drivers too.

If your motherboard's Wi-Fi or Ethernet adaptors aren't recognised when you first boot into Windows, and you don't have access to another PC, it's best to get a cheap 802.11ac USB Wi-Fi adaptor from an online retailer such as Amazon.

This basic, old-standard Wi-Fi adaptor will be more likely to be recognised by Windows than some of the latest integrated Wi-Fi adaptors, and allow you to connect to your Wi-Fi router and access the latest drivers for your hardware.

Once you're online and able to access your motherboard manufacturer's website to download the drivers for your specific motherboard, start by installing the chipset driver first, then your networking and sound drivers. You also need to download the latest driver your graphics card, either from Nvidia or AMD's website. You can then fire up Windows Update and let it check for updates and install any it finds for itself and your hardware.

INSTALL YOUR SOFTWARE

A quick way to install multiple programs at once automatically is to us **ninite.com**. This allows you to select from multiple installers, such as Chrome, Firefox, Steam, Skype, Discord and iTunes, and it will install all of them without you need to do anything.

Some extra bits of software to grab are CoreTemp (**alcpu.com**), GPU-Z (**techpowerup.com**), CPU-Z (**cpuid.com**) and Cinebench R23 (**maxon.net/en/downloads**). CoreTemp will show you the CPU temperature, and Cinebench R23 can run a ten-minute stress test on your CPU.

As long as the CPU temperature doesn't top 90˚C you'll be fine. Meanwhile, GPU-Z does the same for your graphics card, except it's worth playing your usual games for 30 minutes and recording the peak GPU temperature. As long as it isn't topping 80˚C on a regular basis then it's fine.

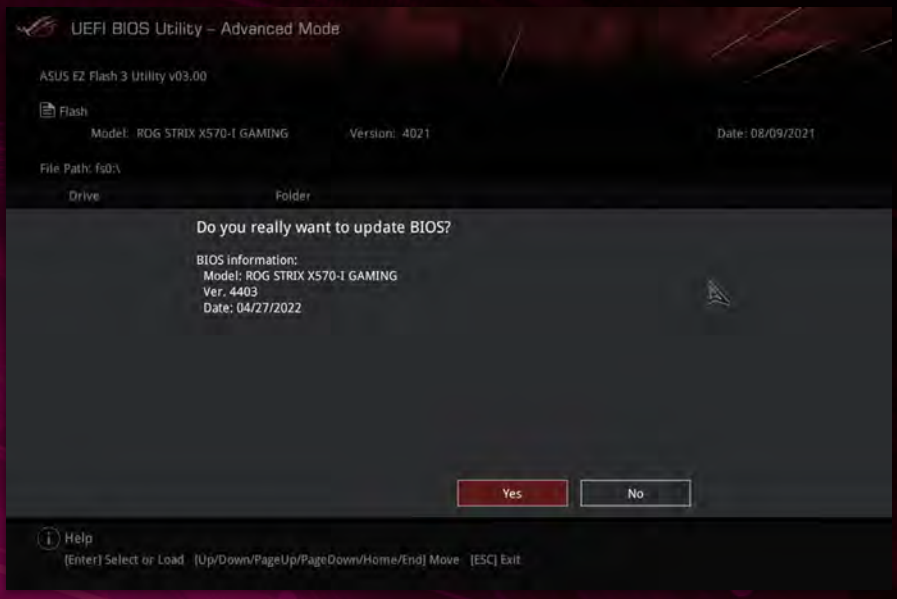
BIOS FLASHBACK

Motherboard releases often coincide with the launch of a specific range of CPUs, so the former are programmed out of the box to support the latter. There may well be updates to the motherboard's software brain, also known as an EFI or BIOS, that fix certain issues identified after launch or allow it to perform better, but you can guarantee that the motherboard will work with the generation of CPUs with which it launched.

For example, Intel's current 12th-gen CPUs are all supported by 600-series chipset motherboards, such as those with Z690 and B660 chipset. However, Intel plans on releasing its 13th-gen CPUs this year, and it's likely that motherboards for sale at the moment won't support them out-of-the-box, and will instead need their EFI to be updated. This same issue applies to using old AM4 motherboards with AMD's latest CPUs.

The problem arises if you buy a new or second-and motherboard and try to combine it with a CPU that's physically compatible, but not supported by the EFI currently installed on the motherboard. If this happens, you'll likely be met with a black screen and an effectively useless PC.

If this happens, you need to update the motherboard's EFI. There are two ways you can do this. You can borrow an older CPU from a friend to fire up your PC, install the latest BIOS and then drop in your new CPU. Alternatively, you can update the BIOS using a highly useful feature known as BIOS flashback.



If you can borrow a compatible CPU from a friend, you can enter the EFI and update it to a newer version that's programmed to support new CPUs

This is a feature included with some, but not all motherboards, and it enables you to update the EFI without a compatible CPU. In fact, you don't even need a CPU to be installed in the motherboard. Every motherboard manufacturer has a slightly different way of going about it, but if your PC fires up, there's nothing on the screen and you've checked all the cables, next check if the processor was released at the same time as the motherboard. If it wasn't and the motherboard supports BIOS flashback, it's well worth trying the following.

First you'll need access to another PC – ask your friends if necessary, then download the latest EFI from your motherboard manufacturer's website and unzip the file if necessary. This will be available in the 'support' or 'download' section on your motherboard's product page. Make sure you visit the exact product page. For example, if your motherboard is an Asus TUF Gaming Z590, but you try to download the EFI for the Asus TUF Gaming Z590 WiFi, it won't work.

If it's supported, your motherboard will use a specific USB port for USB BIOS flashback and may also use a flashback button

Next, follow the manufacturer's instructions for placing the file onto a USB stick. For example, MSI requires you to rename the BIOS file MSI.ROM, while Asus requires you to use a simple renaming program to allow your motherboard to see the file. It's important to follow this advice step by step, and also ensure the file isn't in a folder on the USB drive.

Next, locate the USB BIOS flashback port on your motherboard's I/O panel. If you're not sure about its location, refer to the manual. Now follow the next step in the update guide, which is usually to connect the USB stick to the BIOS flashback port, ensure the power cables are connected to the motherboard, switch on the PSU and then press the BIOS flashback button.

There's often a light near the button that will flash, showing you the various stages of programming the EFI – after a few minutes the process will be complete. If an old, incompatible BIOS was preventing your PC working properly, then you'll know straight away, as powering it on will now bring up a display and allow you to get into the EFI. CPC

THE ROAD AHEAD

AMD AND INTEL HAVE RECENTLY PROVIDED FRESH DETAILS OF THEIR UPCOMING PRODUCTS AND MANUFACTURING TECHNIQUES. EDWARD CHESTER PICKS THROUGH THE DETAILS TO SEE WHAT WE CAN EXPECT OVER THE COMING YEARS

Last month saw AMD and Intel both reveal some key details of their upcoming products, with AMD using its Financial Analyst Day – an event used to show off what the company is doing to bolster interest from investors – to reveal several key future projected technologies.

They include a few details about the company's imminent Zen 4 CPU architecture, its future Zen 5 architecture and some of what's in store for its future RDNA 3 graphics products.

Meanwhile, Intel revealed some of the details of its upcoming Intel 4 process node at the recent IEEE VLSI (Very Large Scale Integration) Symposium – an annual event dedicated to exploring 'emerging trends and novel ideas and concepts covering a broad range of topics in the area of VLSI'. Intel 4 is the new chip manufacturing process that will be at the heart of Intel's silicon products arriving next year.

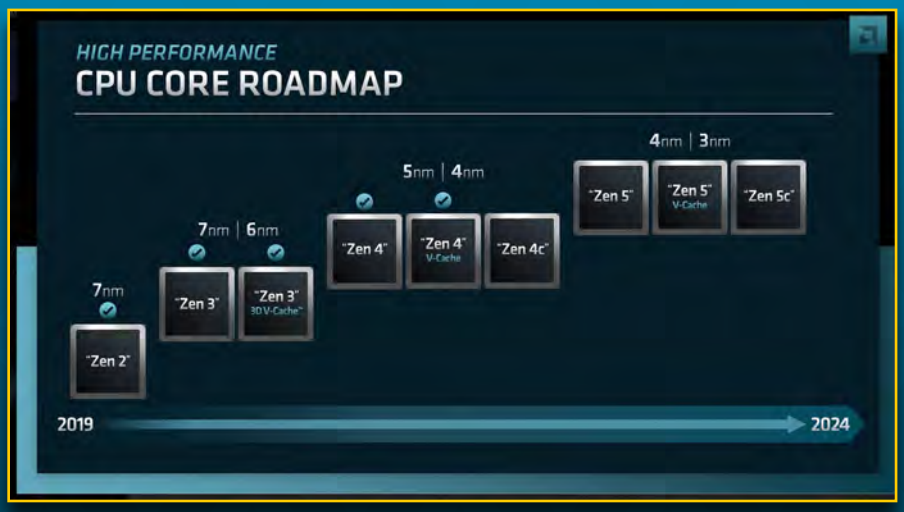
AMD Zen 4

The most immediate of all these recent announcements will be AMD's Zen 4 architecture-based products, which will be released later this year. These will arrive in the form of Ryzen 7000-series (codenamed Raphael) desktop CPUs and 4th-generation EPYC (codenamed Genoa) server CPUs.

Many of the overarching details of Zen 4 have previously been revealed, such as the use of new CPU core chiplets and a new I/O die that will add support for the latest features, such as the PCI-E 5 interface and DDR5 memory. The new chips will also use a new socket, with the AM4 design that has been used for all Ryzen processes so far being replaced by a brand-new AM5 LGA-based socket.

Newly announced, then, is that the company has confirmed the new CPUs will see an 8-10 per cent instructions per clock (IPC) improvement over Zen 3. While this may not immediately leap out as a huge uplift, AMD has also confirmed gains in clock speed that, when combined with the IPC improvements, will net a single-thread performance gain of greater than 15 per cent. AMD hasn't been specific about the clock speeds yet, but the company

AMD HAS CONFIRMED THAT THE NEW CPUs WILL SEE AN 8-10 PER CENT INSTRUCTIONS PER CLOCK (IPC) IMPROVEMENT OVER ZEN 3



AMD has revealed rough timelines and manufacturing processes for its next two CPU architectures

has previously shown footage of a Zen 4 chip boosting to over 5.5GHz.

If that 5.5GHz figure is reasonably representative of retail chips, Zen 4 will mark a big improvement over current Ryzen CPUs, which max out at 4.9GHz. AMD has also previously confirmed that Ryzen 7000-series CPUs will have increased thermal design power (TDP) ratings over current chips, moving from a current maximum TDP of 105W to a whopping 170W.

The net result of these IPC and clock speed improvements, and increased TDPs, is slated to be a 35 per cent improvement in multi-threaded chip performance for a 16-core chip, moving from Zen 3 to Zen 4 (based on Cinebench R23 multi-threaded tests). Although these figures hint at AMD simply cranking up the voltage and running these chips as hot as possible, the company does also point out that the same 16-core Zen 4 chip will come with a 25 per cent boost in performance per watt over Zen 3.

AMD has also confirmed that at least some Zen 4 processors will include ISA extensions for AI and AVX-512 instructions, although it hasn't specified whether all the processors in the line-up will include them.

The silicon space required for hardware AVX-512 support is significant, while also being of little relevance to desktop use, so it could well only be added to server versions of this processor line-up.

It's unclear what the AI instruction support involves at the moment, but at least in terms of features ticked off the list, AMD is pulling itself back into parity with Intel.

Zen 4 cores will be produced in three overarching variants, starting with the standard Zen 4 core. There will also be a Zen 4c core, which is a compact variant meant for high-density server applications, such as the upcoming 128-core EPYC Bergamo processor. Finally, AMD also announced there will be 3D V-Cache variants, which sandwich a separate L3 cache chip on top of the core chiplet dies, as seen on the impressive Ryzen 7 5800X 3D.

Initial client CPUs will be produced using a 5nm process for the CPU cores and a 6nm process for the I/O die, but AMD has said that future Zen 4 products will be produced using a combination of TSMC's 5nm and 4nm processes. It hasn't specified which process will be used for which parts though. TSMC's 4nm process is a refinement of its 5nm process, rather than a whole new manufacturing node, so it's often classed as a 5nm node anyway, but it technically will have a slightly higher density.

That's it for new Zen 4 announcements but we can expect to learn more soon, as Zen 4 products are slated to arrive in Q4 of this year, and of course, you can expect us to be primed and ready with reviews as soon as they land.

AMD Zen 5

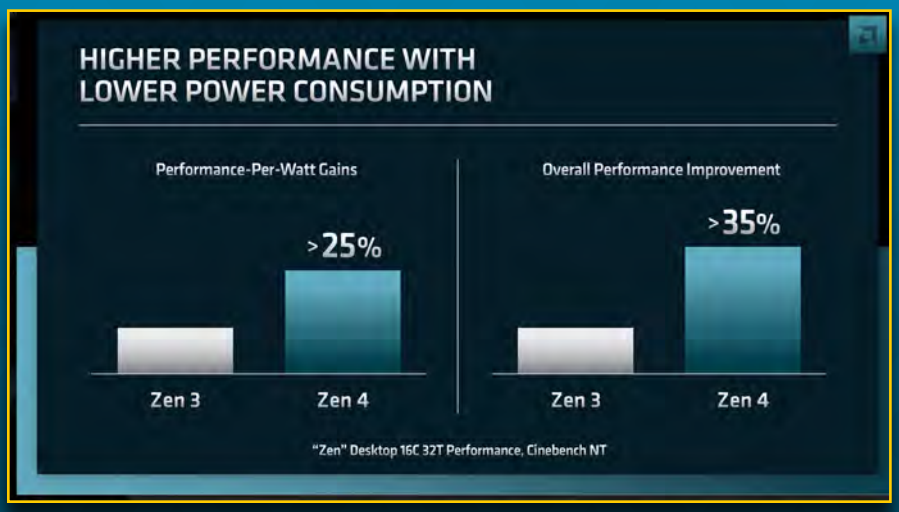
The second big reveal from AMD was the official announcement of the Zen 5 architecture, which will be at the heart of the company's CPU products from 2024 onwards. Details are thin at the moment, but AMD is bullish about the level of improvements the architecture will bring to the table.

Perhaps most significant of all is that AMD is terming Zen 5 a 'new grounds-up microarchitecture', implying that it won't just be an incremental improvement over Zen 4. There are few details of what will change – there's certainly no industry standard for how much has to change to classify as 'new' or 'grounds-up'. However, AMD has said the front end is being re-pipelined, increasing the issue width of the processor. Zen 3 uses a 4-wide instruction decoder, while Intel Alder Lake's P-Cores uses a 6-wide decoder, so it looks like AMD may be following suit.

Zen 5 will also introduce further 'integrated AI and machine learning optimisations', which is about as vague as you can get, but again hints at AMD learning from and integrating popular trends seen in its competitors' products.

As for manufacturing processes, AMD says Zen 5 will use a combination of TSMC's 4nm and 3nm processes. Unlike the 5nm/4nm split, where 4nm is a refinement of the 5nm

Zen 4 is set to provide an 8-10 per cent boost in instructions per clock over Zen 3



Zen 4 performance per watt for a 16-core processor is set to improve by 25 per cent

process node, the 3nm process uses a whole new node so should bring larger gains in efficiency and/or performance.

Notable with both Zen 4 and Zen 5 is AMD's continued commitment to using a single-core design for entire processors, rather than following in Intel's footsteps and implementing a separate Performance core and an Efficiency core. So far AMD's single-core design approach continues to deliver the goods, but it will be interesting to see how the differing approaches stack up over the coming years.

AMD RDNA 3 and 4

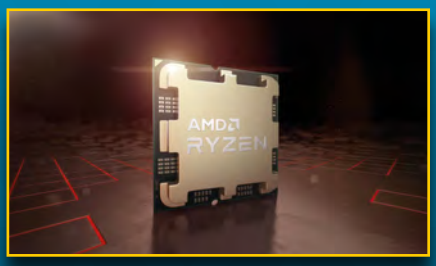
Moving from CPUs to GPUs, AMD has also provided more details of its upcoming RNDA 3 graphics cards, which will be arriving later this year. First and foremost is the fact that AMD has finally officially confirmed RDNA 3 will be available as a chiplet design, where instead of the whole GPU being a single monolithic die, the processing power will be spread across multiple dies.

We don't yet know if it will just be just the highest-end card that will use the technique, or whether it will be implemented at several levels of processing power. The hope would certainly be, though, that by combining the power of two or more GPU dies, AMD will finally be able to bridge the performance gap between its current most powerful single-GPU graphics cards and Nvidia's best.

Using chiplets seems like an obvious approach to graphics card design, given that the industry has already proven how multiple graphics cards can be combined for extra performance, via technologies such as SLI and Crossfire. However, the difficulty has always been twofold.

Firstly, the amount of data that needs to be transferred between GPU dies is immense – in the order of terabytes of data per second – requiring interconnects that involve some seriously sophisticated engineering. AMD has hinted at some innovative ideas with its chiplet design, which it calls 'advanced' – a term generally used to refer to designs beyond the simple placement of multiple dies on the same package next to each other. However, given the heat output and density of GPUs, there are some serious heat dissipation challenges to overcome.

The other challenge with multi-GPU setups has been that they require developers to specifically program their games to use the extra GPUs, and developers haven't been keen on that. As a result, SLI or Crossfire support has often been either non-existent, unstable or resulted in underwhelming performance



The AM4 design used for all Ryzen processes so far will be replaced by a brand-new AM5 LGA-based socket

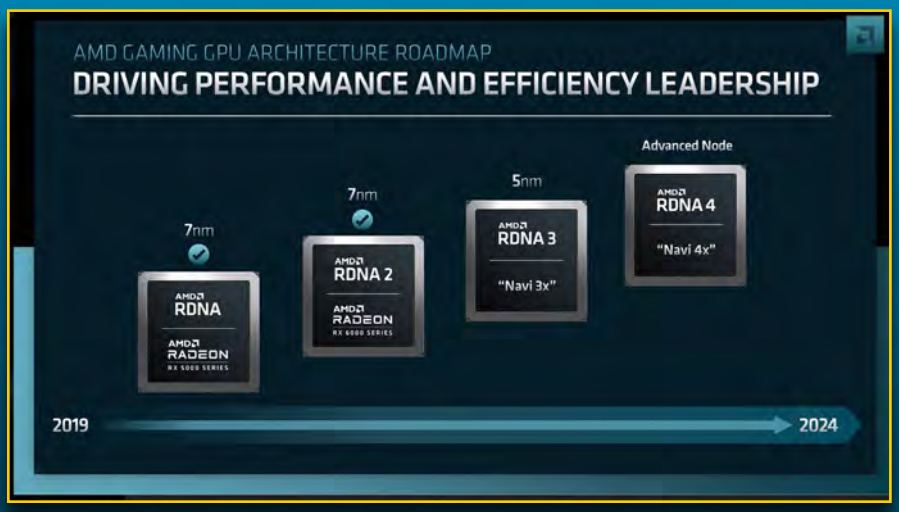
uplift. So, for a chiplet-based GPU to work, it will have to present to developers as a single GPU and reliably deliver its extra performance entirely in the background. Time will tell just how AMD has gone about achieving this feat.

Getting back to what we do now know, AMD has revealed that it's targeting a 50 per cent increase in performance per watt with RDNA 3 over RDNA 2 (Radeon RX 6000-series cards). That's a bold claim, and one of which we might be sceptical had AMD not managed to deliver just that sort of improvement with its move from RDNA 1 to RDNA 2.

One factor that will helping AMD to reach those lofty efficiency goals will be a move from the current 7nm process node used to manufacture RDNA 2 cards to a 5nm process. AMD hasn't specified which company's 5nm process it will use but it's a strong likelihood it will be TSMC.

While a new smaller manufacturing process will help when it comes to performance per watt, it certainly won't account for a 50 per cent improvement, so there are sure to be plenty of architectural changes too. Details are very vague at the moment, but AMD has

A 'grounds-up' design for Zen 5 implies significant architectural changes over Zen 4



hinted at a next generation of on-die Infinity Cache, an optimised graphics pipeline and a rearchitected GPU Compute Unit (CU).

Rounding out the latest AMD GPU news the company confirmed it's working on RDNA 4, which is set for a vague arrival time of 2024. There's little to unpack yet, but AMD describes the architecture as using an 'advanced node', which hints at another change in manufacturing process. Whether that will be a full step down to a 3nm node, or whether it will be an intermediary 4nm step as on Zen 5 CPUs, we'll have to wait and see.

AMD claims that RDNA 3 will offer a massive 50 per cent uplift in performance per watt

Intel 4 details

Moving onto Intel's announcements, instead of architecture features, the big focus of its VLSI Symposium presentation was its upcoming manufacturing process, Intel 4, which will be at the heart of its 14th-generation Core processors (codenamed Meteor Lake) arriving in 2023. Given the company's troubled development of its 10nm process, and how hot its current top-end CPUs run, the importance of a new reliable, denser and more power efficient node can't be overstated.

AMD HAS REVEALED THAT IT'S TARGETING A 50 PER CENT INCREASE IN PERFORMANCE PER WATT WITH RDNA 3 OVER RDNA 2

To recap, in recent years Intel rejigged the naming scheme for its manufacturing process nodes. It used to have a less generous system for measuring how small it classed the components on its chips, when compared to the likes of Samsung and TSMC.

AMD describes the RDNA 4 as using an 'advanced node', hinting at another change in the manufacturing process

This meant that Intel's 10nm process node, for instance, was comparable in transistor density to TSMC's 7nm process. As such, Intel changed the name of its 10nm process to Intel 7 (the process used in today's 12th-gen Alder Lake processors), while Intel 4 was previously the company's 7nm process but will be comparable in density to TSMC's 5nm and 4nm processes.

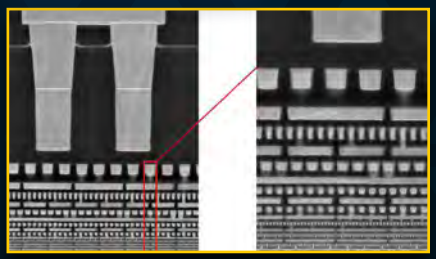
To enable this significant drop in component size – nominally from 7nm to 4nm – Intel has had to incorporate Extreme Ultra Violet (EUV) lithography for the first time. Lithography is the process of using a mask in front of a light source to project the image of a CPU's circuit onto the silicon, and EUV is the next step of that technology that uses the very smallest possible wavelengths of light to create the smallest possible on-die components.

EUV has been used by Samsung and TSMC for some time, leaving Intel in catch-up mode on this technology. Incidentally, all the machines used for EUV are created by one Dutch company imaginatively called Advanced Semiconductor Lithography (ASML), and to date it's only ever made around 150 units (costing up to $200 US million each).

As well as enabling the creation of ever smaller components, EUV has also allowed Intel to reduce the number of the number of masks required to produce a chip by 20 per cent. Yields have also improved – as might be expected by a reduction in the number of manufacturing steps, although Intel hasn't specified how much this situation has improved.

Other changes in the overall process include an increase in the number of metal layers for logic to 16 up from 15 – these layers

A cross-section of an Intel 4 chip, showing the smallest, lower layers produced using EUV



An ASML EUV source vessel, where a powerful laser hits tin droplets to generate extreme ultraviolet light

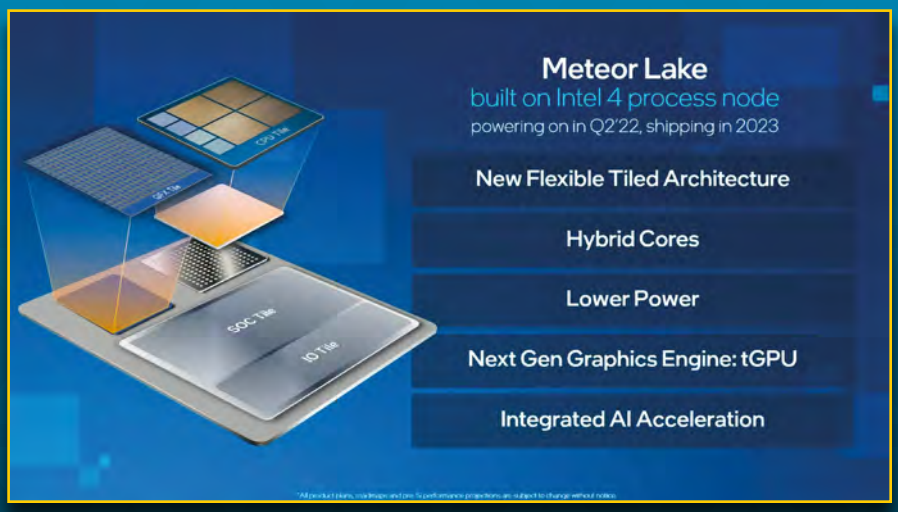
can be seen in the cross-section image on the previous page. The composition of some of those layers has also changed from some using pure cobalt to using a combined copper and cobalt layer.

Intel had introduced cobalt for the smallest, lowest layers of the Intel 7 process in order to increase the life of the transistors by increasing the electromigration (EM) resistance.

However, using cobalt alone proved problematic for performance due to its increased resistance, so now the company has switched to this combined metal recipe that balances improved EM lifetime with reduced line resistance.

Intel 4 is also being targeted purely for use with what are considered low-density, high-performance cell libraries. Cell libraries are

Intel 3 promises more use of EUV and an 18 per cent improvement in performance per watt



Intel Meteor Lake chips will be the company's first to adopt a Ryzen-like chiplet design

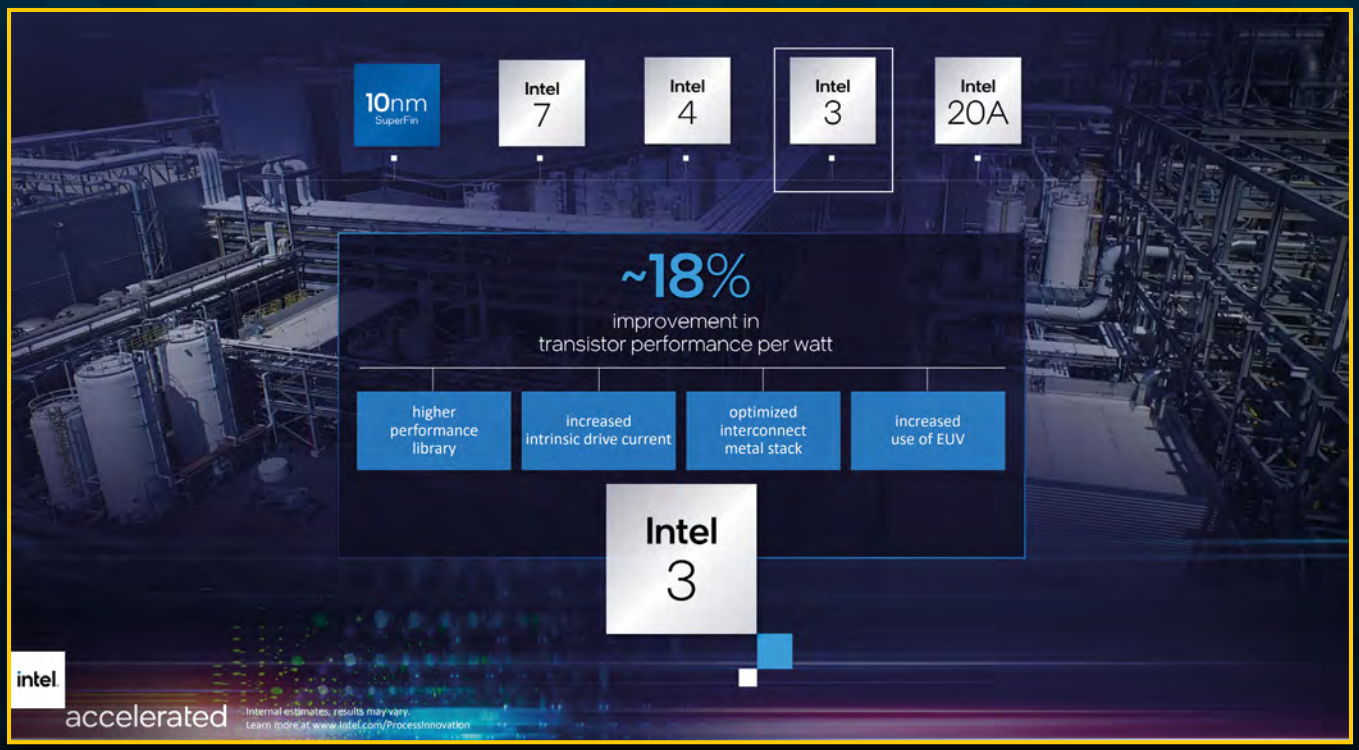
the standardised sets of logic gates that are used to construct the circuits in a CPU.

You can design a chip layout then use different sizes/classes of cell library to manufacture it, depending on your requirements. Lower-density designs are generally optimised for components with fast clock speeds, such as CPUs, rather than slower, denser components such as memory.

The reason for focusing solely on low-density designs with Intel 4 is that it gives Intel the best chance of bringing the most high-profile and profitable chips – desktop CPUs and especially server CPUs – to market.

Then, in the meantime, it can develop its subsequent Intel 3 process, which Intel claims will offer around an 18 per cent improvement in performance per watt over Intel 4, to cover both low-density and high-density products shortly thereafter.

The upshot of these changes is that the Intel 4 manufacturing process is set to provide up to a 2x increase in transistor density over Intel 7. Along with this, Intel is also expecting big uplifts in efficiency and some gains in performance too.



All the machines used for EUV are created by one Dutch company called ASML, and to date, it's only ever made around 150 units

Although Intel's data doesn't hint at the sort of frequencies we'll see on retail products, it shows that for an industry-standard core design with a nominal power level of 0.65V, there's a 21.5 per cent increase in clock speed with Intel 4 over Intel 7.

At higher power levels the gains drop considerably – to 10 per cent at 0.85V – so it remains to be seen just how high a frequency Intel will be able to squeeze out of these chips.

As for power efficiency, using that same standard core design set to a frequency of 2.1GHz, Intel 4 nets a 40 per cent reduction in power consumption compared with Intel 7. Again, the advantage drops as frequency increases, but at the very least these numbers point to large drops in power consumption for light workloads. The net result is that Intel is broadly claiming a 20 per cent improvement in performance per watt for Intel 4 over Intel 7.

TO ENABLE THIS SIGNIFICANT DROP IN COMPONENT SIZE, INTEL HAS HAD TO INCORPORATE EXTREME ULTRA VIOLET (EUV) LITHOGRAPHY FOR THE FIRST TIME

Intel 4 is set to debut with Intel's Meteor Lake CPUs, which are also set to be the company's first chiplet-based CPU designs, using a mix of dies for CPU cores, I/O controllers and GPU cores. It's yet to be confirmed what process will be used for each die, but we wouldn't be surprised to see a mixture in a similar manner to how AMD has uses older nodes to produce its I/O dies, saving the latest nodes for use with the CPU core dies.

Intel graphics and Nvidia

Notable by its absence from these slews of recent announcements has been any word at all from Nvidia on key upcoming products and from Intel about its Xe graphics. Regarding, the former, there have been many leaks espousing the monstrous performance and power consumption of upcoming GeForce RTX 4000-series GPUs but still nothing official.

The expectation was that the first GeForce RTX 4000-series cards would be announced and arrive around October this year, but rumours currently suggest this might be pushed back to December, as retailers are struggling to clear out stock of RTX 3000-series GPUs following the crypto crash and subsequent flooding of the second-hand market.

Meanwhile, Intel's much hyped Arc desktop graphics card have failed to materialise in any meaningful sense as yet, despite initial hopes that cards they would be in our hands in the first half of this year. The modest Arc A380 card has just become available but only in China, although pricing for it is impressively aggressive.

Indeed, current rumours suggest Intel is set to be very aggressive with pricing across the board, due both to significant stock availability, and because of Arc performance being apparently underwhelming in older non-DirectX 12 or Vulkan-based games. Regardless, there's still plenty of time for fresh announcements in time for a wider Q4 2022 launch of faster Arc cards, so let's hope we'll hear some more news soon. **CPC**

Intel's Arc GPUs have so far failed to materialise in any meaningful way on the desktop

GARETH HALFACREE'S

Hobby tech

The latest tips, tricks and news in the world of computer hobbyism, from Raspberry Pi, Arduino, and Android to retro computing

REVIEW
Blink Smart Camera System

Blink promises a smart-home camera without the cabling

Home security is one of the most popular routes into smart home features, trailing behind the ever-popular option of being able to control your home lighting with your voice. If you're looking for off-the-shelf systems, there's a dizzying array of choices, but it boils down to a horde of smaller companies and three main giants – Ring, Blink and Google's Nest products.

Blink has recently started offering USB-connected accessories, including this battery-powered 700-lumen floodlight

Amazon has it good, here. The company is playing both ends of the market, offering Ring devices to the higher end of the market and the more basic Blink cameras to cost-conscious consumers.

Unlike Ring, which offers hardware above and beyond cameras, Blink focuses purely on the visual element. Its first product was an indoor camera system, which it has since expanded to cover weather-sealed outdoor cameras and a freshly launched doorbell camera.

Let's start with the Blink Video Doorbell. Available in black and white finishes, this doorbell camera – which effectively competes with Ring's most famous product, despite both companies being owned by Amazon – houses a wide-angle 1080p camera with a 135-degree horizontal and 80-degree field of vision. Below this is a button, which sounds a chime when triggered.

The chime, sadly, comes out of the doorbell itself, which is on the other side of your door. There's no separate chime unit as you get with the Ring doorbell cameras, although if you have one of Blink's wired indoor cameras, you can repurpose that as a chime.

Instead, it relies on notifications through its smartphone app, alongside the option of integrating into Amazon's Alexa smart home infrastructure. In either case, the journey from the doorbell camera to Blink's servers and back to your house means a delay – as little as five seconds or as much as 30 seconds, depending on how the servers are feeling that day.

If that's too much, the doorbell comes with pigtails for attaching the device to an existing 12-24VAC doorbell system in place of the

Like the doorbell, installing the floodlight requires just a few screws

original button. Doing so, though, means giving up on one of the Blink system's biggest selling points. Bar a single model of indoor camera, its devices are powered entirely by internal AA lithium batteries, meaning that there's no wiring involved – you just drill a few holes and mount the cameras wherever you want them.

The Blink Video Doorbell is only partially functional, however, until you add in the optional Sync Module 2 accessory – a small local server that communicates with the cameras over a 900MHz radio link and with your smartphone via Wi-Fi.

Physical installation is as simple as fitting two screws and clipping the doorbell unit home

Without a Sync Module, the doorbell operates in 'event response' mode. While it functions as a doorbell and a motion-triggered alert system, it doesn't offer a live-view mode. You'll also need to pay for a subscription to Blink's cloud service if you want the motion trigger to actually record any video.

Add the Sync Module, though, and all the features unlock, including the option to record video to a USB flash drive inserted into the side of the Sync Module, avoiding the need for a subscription. The Sync Module also allows you to define zones in the field of view that won't activate the motion detector, as well as 'privacy zones', which are blocked out with grey boxes. Oddly, however, while motion-detection zones can be configured using a grid of blocks, the privacy zones are limited to two rectangles of your chosen size.

Another half-baked feature is the 'photo mode'. Exclusively available to paying subscribers, this mode instructs the camera to capture a low-resolution still image every hour – and, if there's no camera activation over the period, to stitch them together into a time-lapse video daily. There's no way to view individual photos outside the video, and they're not even used to update the camera's thumbnail on the app.

The app, meanwhile, is set up for multiple cameras, and you have a range of choices. We added an Outdoor Camera to our test setup, along with the optional floodlight accessory; unusually, this is also powered by batteries and requires no wiring. Even with a Sync Module and just two cameras, the system proved occasionally unreliable. Messages saying that live view is unavailable sometimes appeared, despite good signal strength. Motion capture is also spotty, often triggering late.

When it works, though, the Blink system is a joy. The simple installation is impressive, and the prices are keen for the specification – £49.99 for the Blink Video Doorbell, £29.99 for the Sync Module 2 – or £124.98 for a bundle with the Blink Outdoor camera, floodlight accessory and Sync Module 2 (all inc VAT).

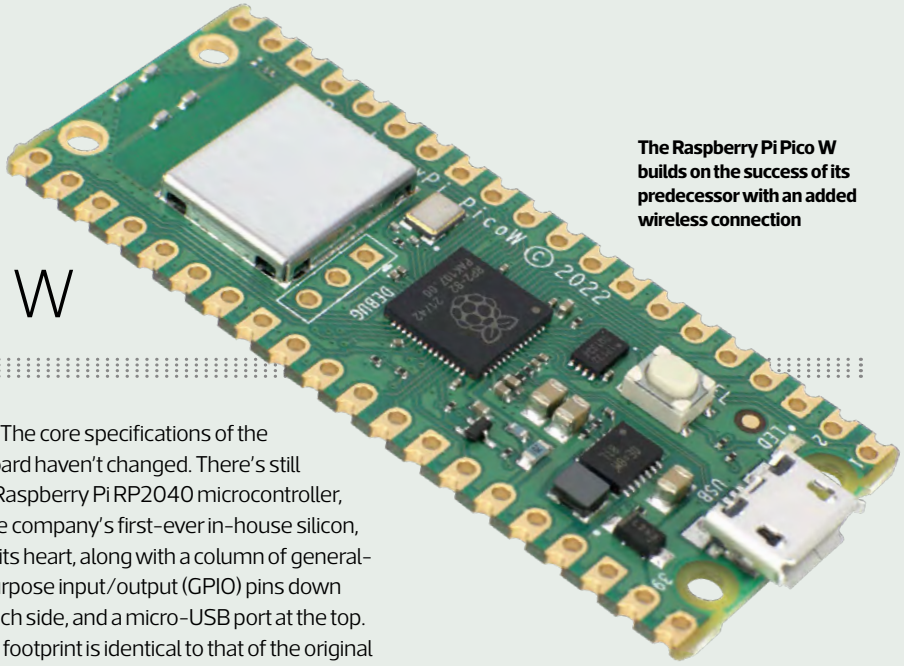
The cloud subscription service is priced well too. A single-camera system costs £2.50 a month or £24.99 a year, while unlimited cameras costs £8 a month or £80 a year (inc VAT). Just remember that there's a ten-device limit per Sync Module 2 if you're pricing up a big deployment. All the Blink hardware reviewed here is available to buy from **amazon.co.uk** now.

NEWS IN BRIEF

Microsoft launches Jacdac standard

Microsoft has thrown its hat into the ring of competing solderless microcontroller-peripheral connections, with Jacdac, a free and open standard based around three-pin edge connectors and low-cost cabling.

Launching as an accessory for the BBC micro:bit V2, with software support in MakeCode, Jacdac gives microcontroller 'brains' quick plug-and-play connections to external hardware, including buttons, sensors and LEDs. To encourage adoption, the company has released both the hardware specifications and the software under permissive licenses. See **custompc.co.uk/jacdac** for more information.



The Raspberry Pi Pico W builds on the success of its predecessor with an added wireless connection

UPDATE

Raspberry Pi Pico W

The Raspberry Pi Pico microcontroller development board (reviewed in Issue 212) has been an absolute smash hit, for two key reasons. The first is that it offers impressively high specifications for a bargain-basement price of just £3.90 (inc VAT). The second is that it's one of the few low-cost microcontroller boards you can actually find in stock to purchase anywhere, as the world's component shortage crisis continues to bite.

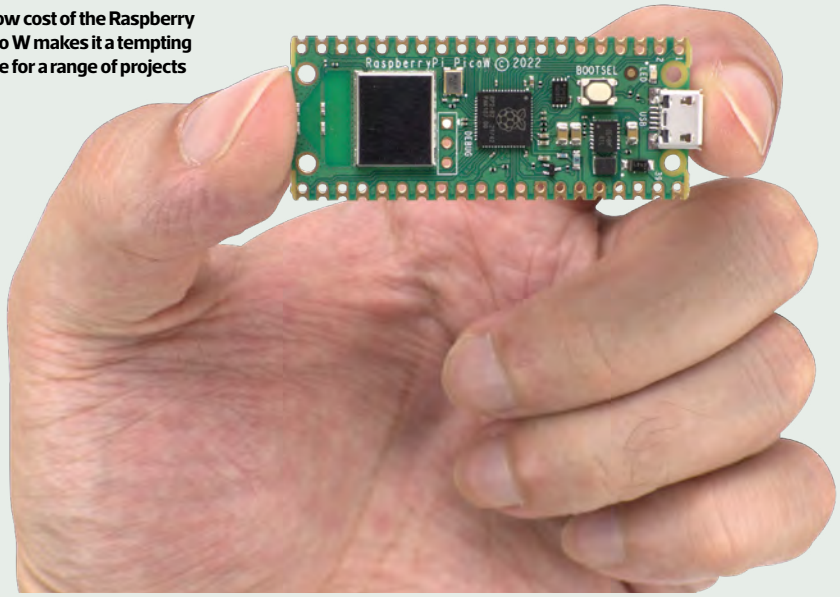
While the Raspberry Pi Pico offers plenty of features, from its dual Arm cores to the clever programmable input/output (PIO) state machines, there's one area in which it lacks: connections. The micro-USB port at the end is effectively your only choice for getting data into or out of the microcontroller, unless you're willing to buy external hardware.

Or you could pick up a Raspberry Pi Pico W. Just as the Raspberry Pi Zero was followed by the Raspberry Pi Zero W, so too has the Raspberry Pi Pico gained a W suffix to indicate the presence of a radio.

The core specifications of the board haven't changed. There's still a Raspberry Pi RP2040 microcontroller, the company's first-ever in-house silicon, at its heart, along with a column of general-purpose input/output (GPIO) pins down each side, and a micro-USB port at the top. Its footprint is identical to that of the original Pico, but the layout on the top of the board has shifted.

The three-pin Serial Wire Debug (SWD) header at the bottom edge has been moved further up the board, and for good reason. In the space vacated by its repositioning, there's a silver box hiding the Infineon CYW43439 radio, plus a PCB antenna.

Any job that the Raspberry Pi Pico can do, can also be done by its W-suffixed sibling, and UF2 files compiled for Pico will run fine on a Pico W in most cases, although you may have some missing features. For instance, if you use the MicroPython firmware compiled for Pico, you won't have access to the on-board LED on Pico W — as it's wired

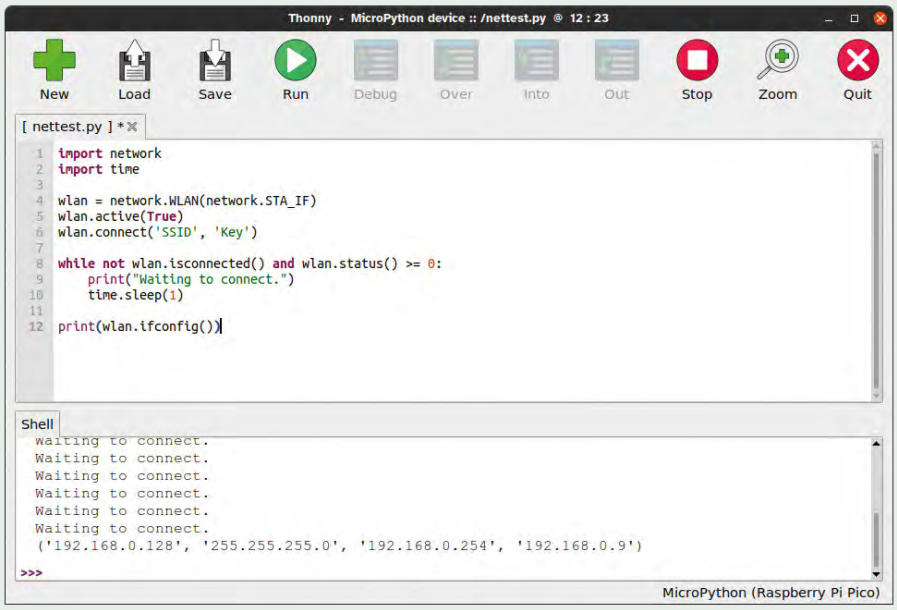


The low cost of the Raspberry Pi Pico W makes it a tempting device for a range of projects

NEWS IN BRIEF

Clockwork Pi's DevTerm gets CM4 option

Clockwork Pi's retro-themed DevTerm portable PC (reviewed in Issue 222) has received another system-on-module accessory – an adaptor board for the Raspberry Pi Compute Module 4 (CM4). Designed to slot into the existing DevTerm motherboard, the CM4 carrier sits alongside the in-house A-06 and A-04 modules and the original CM3 support, plus the new and still experimental RISC-V SOM built around the Allwinner D1. The adaptor is available to buy as a standalone upgrade for $19 US or with the full DevTerm kit for $238 from **clockworkpi.com** (around £15.50 and £194 respectively, ex VAT).



MicroPython support for wireless is well established

to the CYW43439 wireless chip rather than to the board's RP2040 microcontroller — or any networking support. In order to access those features, you'll need to install the latest MicroPython UF2 file specifically compiled for the Pico W.

Hardware, meanwhile, should be directly compatible. Aside from the SWD header, the pinout hasn't changed, although the on-board LED now links to the radio chip, rather than the RP2040. The new radio is handled over the Serial Peripheral Interface (SPI) bus, meaning all 26 GPIO pins are still fully accessible.

The real changes are in the software. The Raspberry Pi Pico MicroPython port has been extended to include simple functions for network access. Import the network library, use the connect function to specify a wireless network SSID and key, and you're away.

Signal strength from the PCB antenna is good, being easily on par with that provided by a Raspberry Pi Zero W or Zero 2 W.

However, some problems have been seen with mesh networks, and it could take longer to connect to them than it does with a standard router.

The official documentation for the wireless feature includes samples for making HTTP requests, hosting an HTTP server complete with the ability to toggle the on-board LED, and a guide to benchmarking the device's throughput.

Those who might be expecting an 802.11n device to easily max-out a multi-megabit DSL connection, though, need to temper their expectations. In testing, the Raspberry Pi Pico W maxed out at around 850Kb/sec – to be clear, however, this is a perfectly decent throughput for a low-power microcontroller.

At launch, however, not all the board's features are ready to go. The biggest missing feature is Bluetooth. While the Infineon CYW43439 fully supports Bluetooth 5.2, it's not currently exposed in software. Given the original Raspberry Pi Pico's popularity with makers and in education, Raspberry Pi has opted (entirely reasonably) to focus on MicroPython support for wireless. The support for C/C++ is all there, and the underlying SDK fully supports the new networking hardware, but there isn't much in the way of documentation.

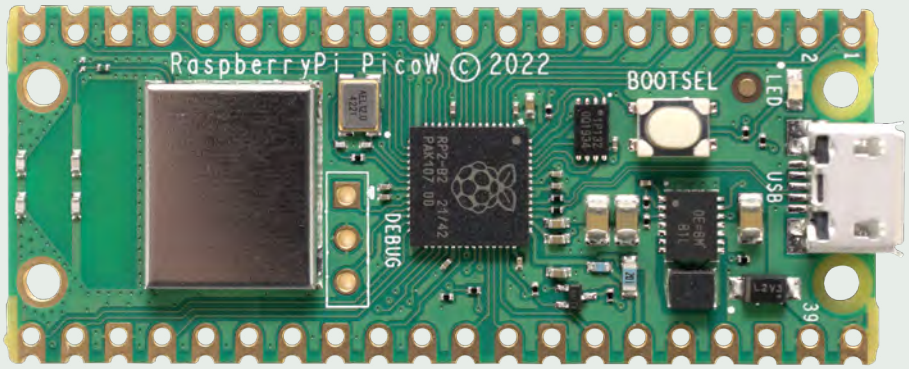
The new board is based on the same RP2040 microcontroller as its predecessor

Software – and firmware – updates should come thick and fast, if the original Raspberry Pi Pico's development history holds true. For now, though, it's best to treat the new board as being non-Bluetooth until Raspberry Pi announces otherwise.

However, a couple of the less popular design choices from the original Raspberry Pi Pico haven't been addressed in this revision. The pinout silkscreen is still on the underside, meaning it's impossible to read once it's installed in a breadboard, but to be fair, there's limited room for it on the top of the board anyway. Also, the board still relies on a micro-USB port, while the Raspberry Pi 4 made the jump to the more modern USB Type-C connector, although that's not surprising when you consider that it's basically a wireless Pico, and the original board also used micro-USB.

Despite a few minor quibbles, the Raspberry Pi Pico W is an amazing device – doubly so given that it has launched for just £6 (inc VAT). At that price, you're guaranteed to find a dozen projects that could benefit from being online. The Raspberry Pi Pico W is available from all Raspberry Pi resellers now, with many offering a variant with pre-soldered headers for breadboard use.

The board shares the layout of the original design, bar the shifting of the SWD header



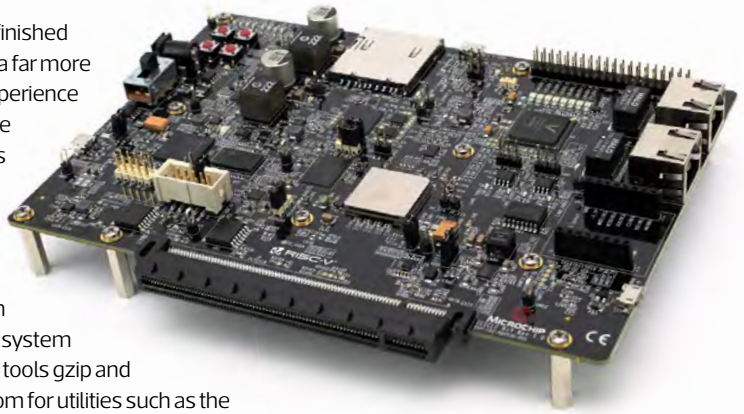
REVIEW

Linux on the PolarFire SoC Icicle Kit

When Microchip's ambitious PolarFire SoC Icicle Kit first passed across our test bench (see Issue 224), the state of its Linux distribution was an undeniable disappointment. The barebones set of applications made it difficult to compile software on-device, the tiny root partition was already nearly full when you started, and there was a bug that meant only half the already limited 2GB of RAM on the board was unavailable. It wasn't a great welcome to the board.

While Microchip's precompiled Linux images are still designed for an arguably overly spartan footprint, it's been squashing bugs and improving the experience nevertheless. For those who want an experience closer to a more mainstream and arguably usable Linux environment on the board, Microchip has released a board support package (BSP) for the Yocto Project.

Yocto isn't a Linux distribution, but a way of making a Linux distribution – one specifically tailored for devices such as the Icicle Kit. Let's start with the good news – the board support package includes a less barren package selection than the precompiled images, although the latter can be built too.

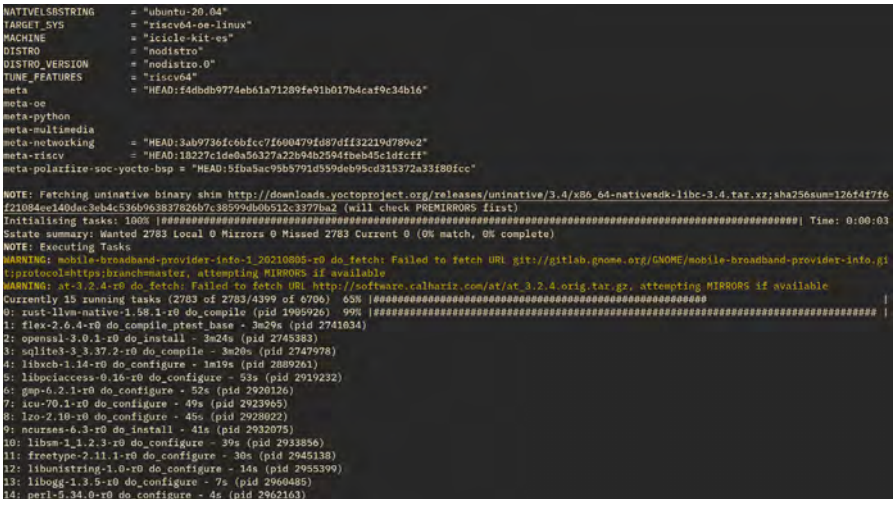


The PolarFire SoC's limited Linux distribution improves massively with a self-compiled replacement

Booting into the finished Yocto build reveals a far more welcoming user experience than before, with the majority of the tools you would expect to see on a development platform. This goes from text editor Vim and version control system Git, to compression tools gzip and bzip2, with even room for utilities such as the attractive htop system monitor.

It's all compiled and ready to run, giving you an ideal platform for on-device development. Better still, the bugs have been fixed. The full 2GB of RAM is available to the user, and the root partition extends across the entire 8GB eMMC storage device with no wasted unallocated space.

There is, however, one little catch – you have to build it yourself. If you're planning to customise the build, that's no big deal; if you just wanted a better Linux, it's a little bit of a slog. Microchip's instructions are relatively easy to follow, with a video guide if you're a visual learner, but you'll need a Linux machine with at least 120GB of free space, a decent wodge of RAM, and patience. The build process takes several hours, even on a multi-core chip such as our test bench's AMD Ryzen 2700X. You'll also need to update the Hart Software Services (HSS) on the FPGA before the new Linux image will boot.



Expect to spend a few hours staring at this screen, even on a fast desktop

Microchip recommends you write the disk image onto the eMMC over USB, using bmaptool to avoid wasting time copying empty blocks. Your effort is also rewarded with a cross-compilation environment capable of building 64-bit RISC-V binaries in a fraction of the time it takes to compile them on-device.

There are also a few other build targets available in the board support package. There's a version which is even more minimalist than the stock image, designed to run entirely from RAM, and one that demonstrates the asymmetric processing mode of the PolarFire SoC – it splits the device in half, with one core running a real-time operating system or bare-metal application while the other three run Linux.

While Microchip may have its reasons for pointing users towards the smaller barebones Linux image, for anyone experimenting with Linux on RISC-V, the larger Yocto BSP build target is definitely the way to go.

The Yocto BSP for the Icicle Kit is available on **custompc.co.uk/PolarYocto**, with the PolarFire SoC Icicle Kit sold via **uk.farnell.com** for £539 (inc VAT). CPC

Gareth Halfacree is a keen computer hobbyist, journalist, and author. His work can be found at freelance.halfacree.co.uk @ghalfacree

WIN

A BE QUIET! CASE AND COOLERS

If you like your PC to not make a horrendous noise, here's an awesome chance to get some quiet-running PC gear with RGB lighting.

The lovely people at be quiet! are offering some great new prizes for three **Custom PC** readers, with a Pure Base 500 FX case, Pure Loop 2 FX 240mm AIO liquid cooler and a Pure Rock 2 FX high-end air cooler all up for grabs.

BE QUIET! PURE BASE 500 FX

The new Pure Base 500 FX is the RGB upgrade of the very popular Pure Base 500DX, with a total of four Light Wings PWM fans for high airflow and quiet operation.

- ARGB lighting
- Multiple lighting colours and modes
- 4 x Light Wings PWM fans for high airflow and quiet operation
- Hub enables synchronisation of six ARGB components and PWM fans
- High-airflow intake front panel and top cover
- Ready for up to 360mm radiators

BE QUIET! PURE ROCK 2 FX

The Pure Rock 2 FX Black combines vibrant illumination with high cooling efficiency, and makes for an excellent CPU cooler if you require quiet operation.

- High 150W TDP cooling rating
- Light Wings 120mm PWM high-speed fan
- Airflow-optimised fan blades for high pressure and low noise
- Four high-performance 6mm heat pipes with HDT technology
- Asymmetrical construction avoids blocking memory slots

BE QUIET! PURE LOOP 2 FX

The Pure Loop 2 FX is a high-performing, practically inaudible all-in-one CPU liquid-cooling system with impressive illumination. The winner gets a 240mm version, but it's available in 280mm and 360mm versions as well.

- High cooling performance
- 2 x 120mm Light Wings PWM high-speed fans offer high air pressure and vibrant illumination
- Doubly decoupled PWM pump for quiet operation and minimal vibration
- Nickel-coated coldplate allows optimum use of liquid metal thermal compound

INSIDERS' TIP

As be quiet! celebrates its 20-year anniversary, all its brand-new FX products will be sold with massive discounts of up to £30 during August and September. It's worth checking out the offers at participating retail partners!

SUBMIT YOUR ENTRY AT **CUSTOMPC.CO.UK/WIN**

20 YEARS | be quiet!

Competition closes on Friday, 9 September. Prize is offered to participants in the UK aged 13 or over, except employees of the Raspberry Pi Foundation and Raspberry Pi Ltd, the prize supplier, their families or friends. Winners will be notified by email no more than 30 days after the competition closes. By entering the competition, the winner consents to any publicity generated from the competition, in print and online. If you choose to enter by subscribing to our newsletter, be assured that we don't like spam: participants' details will remain strictly confidential and won't be shared with third parties. Prizes are non-negotiable and no cash alternative will be offered. Winners will be contacted by email to arrange delivery. Any winners who have not responded 60 days after the initial email is sent will have their prize revoked.

ANTONY LEATHER'S

Customised PC

Case mods, tools, techniques, water-cooling gear and everything to do with PC modding

We shouldn't have to mod hardware to improve performance

There's a disturbing trend with hardware at the moment. It involves quite a few items such as coolers, CPUs and motherboards and what seems to be an endless need to modify certain parts of them in order to get the best cooling performance. The most obvious one is delidding your CPU. As we found in the past with Intel's infamous thermal paste that replaced solder between the heatspreader and CPU core, tweaking your CPU yielded huge thermal benefits.

Replacing the cheap thermal paste with a high-performance compound could result in CPU temperatures falling dramatically, either due to the quality of the paste, or the existence of small gaps between the CPU die and the heatspreader. This mod could turn a hot-running CPU that no traditional cooler could tame, even at stock speed, to a CPU with decent overclocking headroom. It could even run cooler once delidded and overclocked than it did at stock speed in its original configuration.

Delidding has, unfortunately, been a feature for not one, but several generations of Intel CPUs. We've covered the process several times on various CPUs, although Intel has recently moved back to soldered CPUs and mostly better thermals, assuming all other factors are equal. However, this month, we're looking at yet another fix for Intel, this time relating to CPU socket mounting pressure.

Intel's new LGA1700 socket is elongated, and the increased leverage on the socket mechanism appears to be applying too much pressure to the CPU. We've seen at least one unexplained bent CPU in our own labs, and owners are also reporting numerous instances of pressure or other forces bending their heatspreaders too. This can result in higher CPU temperatures, which can be a real issue when Intel's 12th-gen CPUs don't exactly run cool in the first place.

You can use a support bracket to prevent LGA1700 CPUs from bending

Thankfully, this situation has been a little better with AMD CPUs, but this doesn't mean AMD has been completely immune to outside influences. The move to its chiplet design with Zen 2 meant that components under the hood were laid out very differently to Zen and Zen+ CPUs. So differently, in fact, with core complexes and I/O dies spread all over the CPU substrate, that coolers that had performed well with previous Ryzen CPUs sometimes required you

to adjust the contact plate to get decent performance on the newer CPUs.

German overclocker De8auer produced the OC bracket to fix this issue, and when we looked at it back in Issue 203 we found it resulted in up to a 5°C drop in load temperatures. Admittedly, this was nowhere near as much as delidding, but I didn't see any cooler manufacturers taking advantage of this situation, by offering slightly tweaked versions of existing coolers, with an adjusted mount to cut temperatures.

In addition, only this week a Twitter user by the name of @Madness7771 managed to delid his Ryzen 7 5800X3D, which most people have found to be particularly hot-running as a side effect of its 3D V-Cache. He found the load temperature dropped by up to 10°C after replacing the CPU's stock solder with Thermal Grizzly Conductonaut liquid metal paste.

A delidded CPU, courtesy of a De8auer kit

All this leaves me in two minds. Firstly, I always love tinkering and optimising my hardware. It's part of why I love PCs, especially the cooling and overclocking aspects of them. You might only gain a few degrees here and there for a few hours work, but it's fun and rewarding, and can even a little therapeutic too, even if you have to spend a tenner on fancy thermal paste or a bit more on delidding tools or other gadgets.

However, the other part of me feels that many of these issues shouldn't be left to consumers to fix. This is especially true with Intel's delidding and bending-related issues. The temperature drops with the former were unacceptable, and Intel should have spent more on R&D to fix the issue in the first place.

Intel still hasn't admitted to the bending problem with its 12th-gen CPUs either, but in one of this month's guides (see p106) you can see what you need to do to prevent it from happening.

Hands-on with Alphacool's slim radiators

There are dozens of radiator manufacturers, but only XSPC has so far offered slim radiators for squeezing water-cooling hardware into confined spaces.

These slim radiators aren't just useful for mini-ITX cases – they can look neater compared with their standard counterparts, and as they're a centimetre or more thinner than the usual sizes, there are some instances where they're beneficial in ATX systems too.

However, last month Alphacool sent me some of its new thin radiators that have the same 20mm thickness as the XSPC models.

They're well made and have a few useful features as well, but what's great is that the range doesn't just cater for 120mm and 240mm sizes, but 140mm and 280mm radiators too. We've not seen slim radiators for 140mm fans before, and this will open up more possibilities for water cooling, with greater cooling capacities possible.

For instance, many cases with a limited number of 120mm fan mounts also support 140mm fans, so upsizing to a 140mm radiator will add cooling capacity. Delving into niche areas, some mini cases such as Ssupd's Meshlicious can actually house two double-fan radiators if the one in the side panel is a slim model. Until now, that's been limited to 240mm, but this is one of several cases that could benefit from using 280mm radiators.

Alphacool's slim radiators are available in 140mm variations, which offer much greater surface areas than their 120mm equivalents

In fact, the perfect mini-ITX case for water cooling is now one that can house two slim 280mm radiators, especially as ARCTIC now offers 140mm slim fans – you could have one in the roof and one in the base. This would offer enough cooling capacity to keep all but the highest-end hardware cool and quiet.

Another feature I like about the Alphacool radiators is that their screw holes pass right through the radiator, so if you're using slim fans, you can use standard-length fan screws and not worry about damaging the radiator when they're fully tightened.

Sadly, however, the screws that Alphacool includes have very short threads. If they were longer, they could screw further down into the radiator to support slimmer fans, but the threads are so short they only work with standards fans. That's a shame given that the company actually makes its own slim fans too. You can see Alphacool's new range of slim radiators over at **aquatuning.co.uk** CPC

Antony Leather is Custom PC's modding editor @antonyleather

How to Fit a CPU cooler duct

Antony Leather shows you how to install a ducting system in order to improve your CPU temperatures

TOTAL PROJECT TIME / 2 HOURS

If you've noticed your CPU running hotter on warm days, you might also have wondered if shoving cool air from outside your case directly into your CPU cooler would have the opposite effect. Doing so would shave a few degrees or more off the CPU temperature, thanks to cooler air flowing through your cooler's heatsink, and the resulting larger temperature difference between the heatsink fins and air temperature.

That's not to say modern cases are flawed, as many have excellent airflow. However, your motherboard, CPU cooler and graphics card all dump significant amounts of heat into your case, meaning your chassis' internal air temperature will be noticeably higher than the air in the room. However, you can use ducting to feed your CPU cooler with air fed directly from outside your case, instead of from within it. In this guide, we'll show you how it's done.

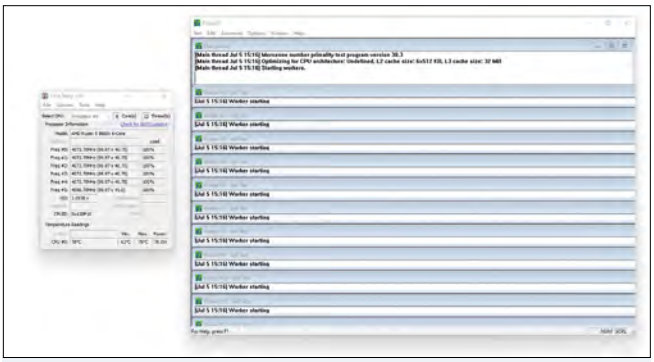
TOOLS YOU'LL NEED

4in insulated ducting
amazon.co.uk

120mm or 140mm 4in ducting fan adaptors
ebay.co.uk

Fan screws
ebay.co.uk

Duct tape
Most hardware stores



1 / CHECK TEMPERATURES

You can obtain CPU temperatures before you install the ducting, to compare against the temperatures with it installed. Grab Prime95 from **mersenne.org** and run the smallfft test with AVX instructions disabled. Then go to **alcpu.com** and grab CoreTemp to measure the average core temperature after ten minutes.

2 / USE INSULATED DUCTING

The preferable size of ducting for ATX cases is 4in, as it's small enough to be flexible while not limiting airflow. It's important to use insulated ducting – you don't want bare metal tubes in your case, as they can run the risk of short-circuiting your components. We got ours from Amazon, which had jubilee clips on both ends.

3 / IDENTIFY CPU FAN SIZES

You'll need to get the ducting to fit to the fans on your CPU cooler and front case fan, so identify their size by measuring the width of the fan frames. Adaptors are available in both 120mm and 140mm sizes, so it's not a problem if your case and cooler have different fan sizes.

4 / USE THE RIGHT FAN ADAPTOR

Now you can purchase the correct adaptors to connect your 120mm or 140mm fans to the 4in ducting. These are available to buy on eBay for under £10, but make sure your adaptors have the correct ducting hose diameter.

5 / TEST FIT DUCTING TO ADAPTOR

Once the parts arrive, test-fit the ducting and fan adaptor, so you know they fit together. The ducting will probably have a jubilee clip that secures it to the adaptor, so check this works with your setup and that the ducting isn't loose.

6 / USE SCREWS TO SECURE ADAPTORS

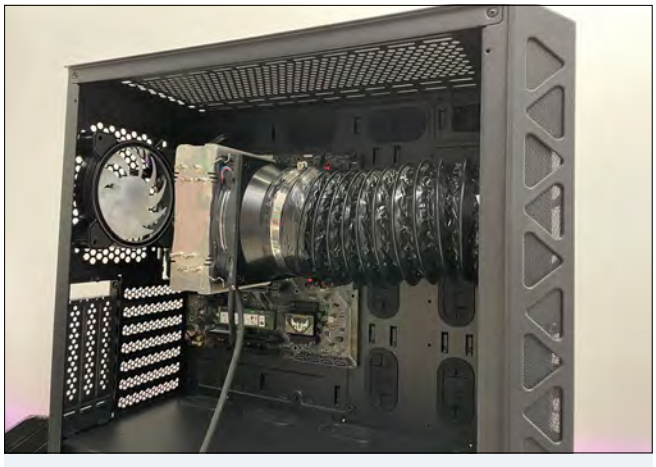
You can use standard fan screws to secure the adaptor to your CPU cooler's fan, but if the fan is held in place using its outer mounts, you might be able to extend components such as fan clips a little further, so they secure the adaptor and fan together.

7 / SECURE ADAPTOR WITH DUCT TAPE

If you're unable to use the existing fan holes to secure the adaptor, the easiest alternative is duct tape. This is available in a variety of colours, allowing you to match it to your cooler and ducting. Wrap it sparingly around both components, holding the adaptor firmly in place while you do it.

8 / ROUTE DUCTING AND CUT TO SIZE

With the adaptors installed, go ahead and test-fit the ducting in place so you can cut it to length. You'll probably need to route it around your graphics card, but try to keep it clear of components if possible, and avoid it sagging.



9 / FIT TO ADAPTORS

Our ducting had jubilee clips at both ends, but you can purchase large jubilee clips from eBay or use duct tape to secure your duct at the other end. At first we only saw a 1°C difference, but running Prime95 for 15 minutes saw the difference in CPU temperature rise to 5°C, with the ducting providing cooler air than the air inside our toasty PC.

How to

Fit ducting to a low-profile CPU cooler

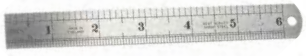
You can even fit ducting in a mini-ITX system, using a low-profile CPU cooler. **Antony Leather** shows you how it's done

TOTAL PROJECT TIME / 2 HOURS

There often isn't much room to add extra airflow to mini-ITX cases, and low-profile CPU air coolers are often left to draw air that has been sitting in the case, which has been warmed by exhaust air from graphics cards and the CPU cooler itself. Getting cool air from outside the case to your low-profile CPU cooler as quickly as possible is important, and there's a way to do it easily using Noctua's NA-FD1 fan duct kit.

This kit is designed specifically for the company's NH-L9 low-profile coolers and 92mm fans, enabling you to easily direct cool air to the fan as quickly and easily as possible. We'll show you how to install the kit, measure the impact on temperatures and give you the minimum and maximum CPU clearance your case will need in order to get it to work

TOOLS YOU'LL NEED



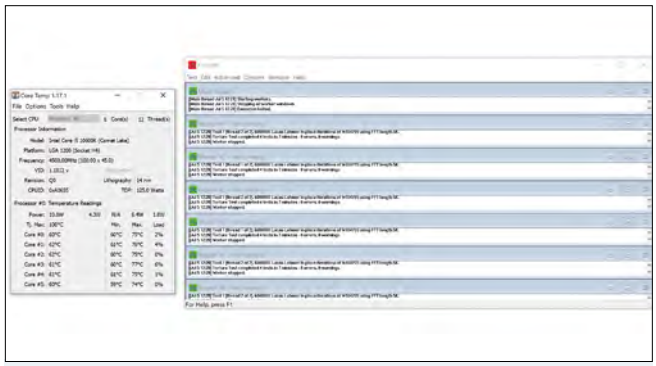
Ruler
Most hardware stores

Noctua NH-L9-series CPU cooler
quietpc.com

Scissors
Most hardware stores

Dry spaghetti or cocktail sticks
Most grocery stores

Noctua NA-FD1 fan duct kit
quietpc.com

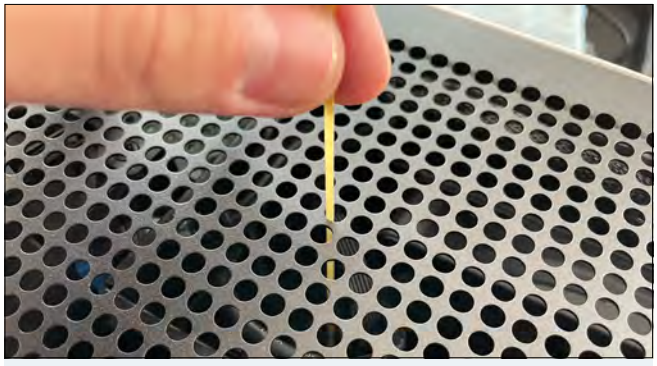


1 / CHECK TEMPERATURES

As with any cooling modification, you need before and after temperatures, so you can see if the changes actually made your hardware run cooler. Run the Prime95 (**mersenne.org**) smallfft test with AVX instructions disabled, and use CoreTemp (**alcpu.com**) to measure the average core temperature after ten minutes.

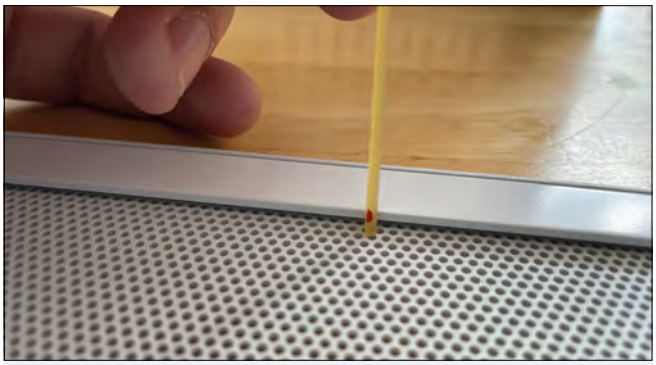
2 / USE NOCTUA DUCTING KIT

The Noctua NA-FD1 ducting kit is inexpensive and reusable, thanks to extra duct supports being included, so you can create up to four ducts for different cases if you change your setup in the future. However, it's only compatible with Noctua's popular NH-L9 coolers.



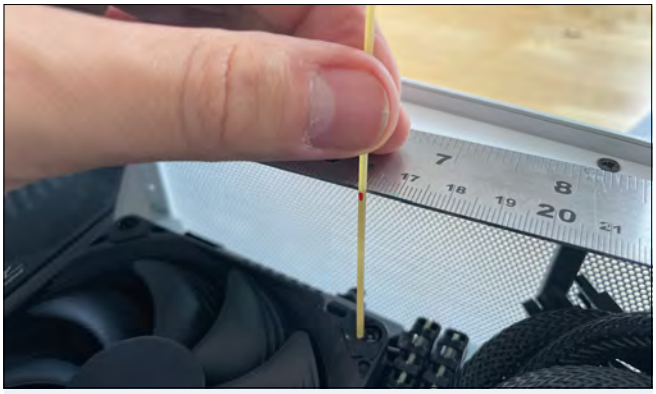
3 / USE SPAGHETTI

You can put spaghetti sticks, cocktail sticks or similar through your case's vents to measure the clearance between the cooler fan and your case's side panel mark the spaghetti when it hits the cooler fan, measure it and then subtract the width of the side panel. You can then create the correct height of duct using the pieces provided.



4 / MEASURE SIDE PANEL INSET

Some side panel meshes are inset, meaning you can't just subtract the total panel width from your measurement down to the cooler. Instead, use spaghetti again as in step 3, or a ruler if there's room, to work out how much further the duct will need to rise, so it seals against the inset side panel's mesh.



5 / USE A RULER

Unfortunately, some cases have mesh that's too fine to even use spaghetti, so we used a ruler sat on the case edge over the cooler, before marking the spaghetti to work out how far above the cooler the side panel sits. You may then need to do step 4 if you have an inset panel as well.

6 / INSTALL REPLACEMENT FAN SCREWS

The kit comes with replacement screws, enabling you to secure the fan and mount the duct supports at the same time. Install one of these screws in each corner of the fan.

7 / ATTACH DUCT SUPPORTS

The black duct supports fit over the replacement fan screw ends and thread through the ducting. Apply one duct support to each fan screw, ensuring they're fully pressed onto the screws.

8 / INSTALL DUCTING AND TRIM SUPPORTS

Create a duct stack using the provided pieces that matches your total measurements from the previous steps, then place them onto the duct supports, with the thinnest section at the bottom for stability. Use scissors to cut each support flush with the ducting, then trim another 2mm to ensure the top section sits flush with the side panel.

9 / TEST THE DUCTING

After fitting the ducting, our system took several minutes longer for our CPU to ramp up its fan speed and reach a peak temperature. Without the ducting, it hit 87°C after a ten-minute stress test, but this dropped to a maximum of 84°C after the ducting was installed.

How to Fit an LGA1700 CPU bending corrector

Antony Leather shows you how to prevent your Alder Lake CPU from bending under pressure, by fitting a corrector frame

TOTAL PROJECT TIME / 1 HOUR

Our reviews have already established that Intel's 12th-gen CPUs are fantastic, offering awesome content creation and multi-threaded performance, as well as killer gaming pace. However, the elongated latch mechanism on the LGA1700 socket can put a lot of pressure onto the lengthened CPU packaging, causing it to bend, which can in turn increasing CPU temperatures.

Thankfully, a cheap and easy fix that solves the issue is available, by removing the latch completely. What's more, it can be installed on any LGA1700 motherboard. Using a protection frame, the CPU is still held in place as normal, but without the usual latch mechanism, removing the pressure that's focused on the middle of the CPU. If you suspect your CPU is running hotter than it should then it's worth refitting it with a bending corrector frame.

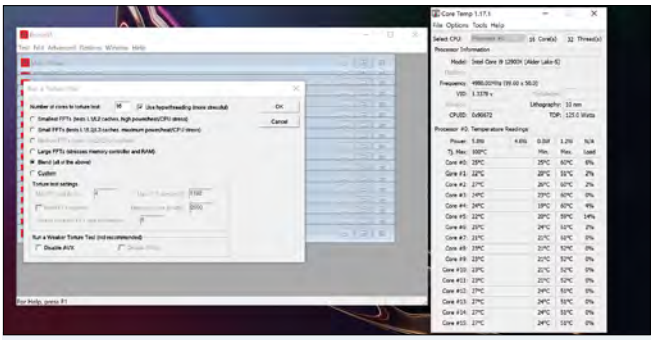
We're using a Thermalright LGA1700-BCF Bending Corrector Frame in our example, which you can find on **ebay.co.uk** and **aliexpress.com**, but you can get similar devices from other manufacturers too.

TOOLS YOU'LL NEED

Microfibre cloth
amazon.co.uk

TIM cleaner or isopropyl alcohol
amazon.co.uk

Thermalright LGA1700-BCF Bending Corrector Frame
ebay.co.uk



1 / GET TEMPERATURES

Check the temperatures before and after installing the corrector frame. You'll need to remove your cooler, reapply thermal paste and then reinstall your cooler to ensure that the first test is comparable to the second one. Run the Prime95 (**mersenne.org**) smallfft test with AVX instructions disabled, using CoreTemp (**alcpu.com**) to record the average core temperature after ten minutes.

2 / REMOVE SOCKET LATCH MECHANISM

After you've removed your CPU cooler, and cleaned off any thermal paste with TIM cleaner or isopropyl alcohol and a lint-free cloth, remove the four screws on the CPU socket with the supplied screwdriver. You can then remove the CPU latch mechanism and clear the way for the corrector frame. Leave your CPU in place while you do this, in order to protect the delicate pins beneath it.

3 / INSTALL PROTECTION PLATE

Install the corrector plate, and then secure it using the original socket mounting screws. Turn each screw three times, then move from corner to corner, so pressure is applied evenly. Rerun your temperature test and compare the results. We found an average 2°C drop. CPC

Retro tech

Nvidia partnered up with the likes of Creative (pictured), STB, Hercules and Diamond to deliver cards based on its chip. Photo own work by Tors, Public Domain

NVIDIA RIVA TNT

Stuart Andrews looks back at the first graphics chip that really put Nvidia on the map, keeping pace with the Voodoo 2 and proving you didn't need separate 2D and 3D cards any more

In March 1998, Nvidia launched a product that punched a hole in the 3D graphics map. It's hard to imagine, but at this point, Team Green was very much a secondary player. 3dfx ruled the sector with its mighty Voodoo 2 – the dedicated 3D graphics card every PC gamer wanted.

The Voodoo 2 offered a vastly higher level of performance than the integrated 2D/3D chipsets of the time, including ATI's 3D Rage Pro and Nvidia's Riva 128. There was some hype around Nvidia's next 2D/3D chipset, codenamed NV4, but arguably more around ATi's upcoming 3D Rage 128 and S3's Savage 3D. As a tech journalist at the time, I'll tell you frankly – we weren't prepared for what NV4 would do.

Admittedly, the NV3 chip in the Riva 128 should have given us some idea. With 3.5 million transistors, a 100MHz core clock speed and support for Intel's new Accelerated Graphics Port (AGP), it was one of the first 2D/3D chipsets fast enough to slug it out with the original 3Dfx Voodoo Graphics cards.

However, dodgy drivers and odd choices when it came to mipmapping and texture filtering – both key to making PC games look good – meant that image quality wasn't where it should have been. It was another contender, nothing more.

This made the debut of NV4 as the Riva TNT all the more shocking. Here was a chip that could go toe-to-toe with the Voodoo 2. What's more, in early briefings, Nvidia claimed it would hit the same performance levels as two Voodoo 2 cards in an SLI configuration.

On top of that, it would be able to run games at resolutions of up to 1,600 x 1,200, where a single-card Voodoo 2 stopped at 800 x 600, while an SLI setup was limited to 1,024 x 768. Just as crucially, Nvidia's image quality problems were over. Some even believed the TNT's render quality was superior to 3dfx's best.

TWIN TEXEL ACTION

So how did Nvidia pull this off? The secret ingredient is actually hidden in the product name, with TNT standing for TwiN Texel. Where rival 2D/3D chips had a single rendering pipeline, the TNT had two, operating in parallel to produce one pixel per clock cycle. This effectively doubled the pixel fill-rate – the number of pixels the card could render to the screen every second – and did much the same to overall performance. It was a feat that, at this point in time, only 3dfx had managed.

By doubling up on the Riva 128's technology with its Twin Texel engine, the TNT redefined what a single 2D/3D chip could do. Photo own work by Hyins, Wikimedia, CC BY-SA 2.5

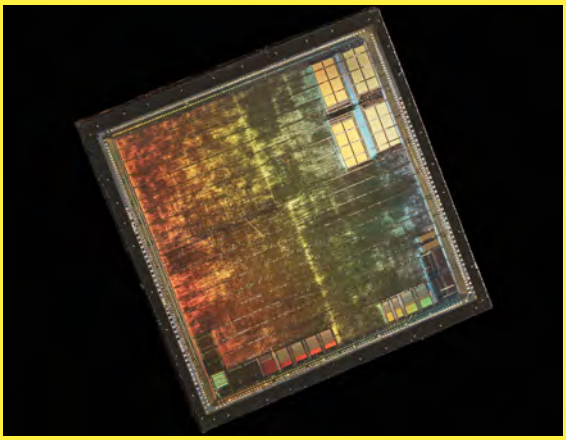
Nvidia's timing here was nearly perfect. At this point in the development of 3D graphics, game engines and APIs were growing more sophisticated. With 1st-generation products, such as 3dfx's Voodoo Graphics or Rendition's Verite V1000, it was enough to render fairly simply polygon scenes with bilinear filtered textures and gouraud shading – the hallmark of realistic 3D graphics of the time.

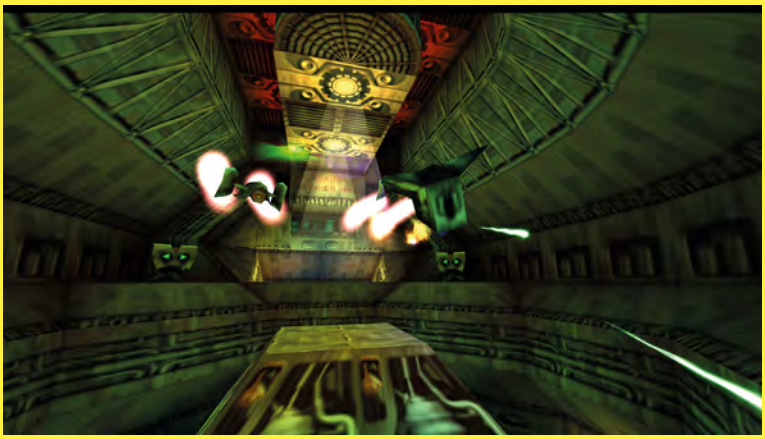
By 1998, however, programmers were implementing techniques such as bump mapping and multi-texturing, allowing new lighting, shadow and depth effects to be used in games.

Crucially, these same features were supported in DirectX 6 – the next version of the API and the first to get real traction with most game developers – along with OpenGL, as used in id Software's Quake II and the soon-to-be-released Unreal. With a single texture pipeline, most graphics chips had to process these effects in two passes, slowing down frame rates at a time when sub-30fps frame rates were the norm for many PC gamers. In 1998, every last frame counted.

The Voodoo 2 had a real advantage here, with two pipelines through which to accelerate these new effects, while the Riva

With 8 million transistors in a 128mm² die, the Riva TNT pushed 0.35-micron technology hard. Running at 120MHz was a step too far. Photo own work by Fritz Fritzchens, Wikimedia, CC BY-SA 1.0





One of the most cutting-edge games of 1998, Forsaken used a range of new DirectX 6 effects. This screenshot is taken from the 2018 HD remaster

128 – like all other 2D/3D graphics chips then – had just the one. As a result, while earlier 3D titles flew on Nvidia's chip, newer games with multi-texturing effects were a different story. The Riva TNT was the first graphics chip produced outside 3dfx that could handle these operations in a single pass. What's more, it supported higher-resolution textures and trilinear texture filtering, enhancing visual quality.

Nor had Nvidia neglected key upwards elsewhere. It had already moved to the faster AGP 2x speed with the ZX spin of the Riva 128, doubling bandwidth over the bus from 266MB/sec to 533MB/sec. What's more, it had shifted from the EDO DRAM of previous graphics cards – the same EDO still being used in the Voodoo 2 – to much faster SDRAM. Plus, where the Riva 128 had been limited to 4MB and the Riva 128ZX to 8MB, the Riva TNT had a glorious 16MB, clocked up from 100MHz to 110MHz.

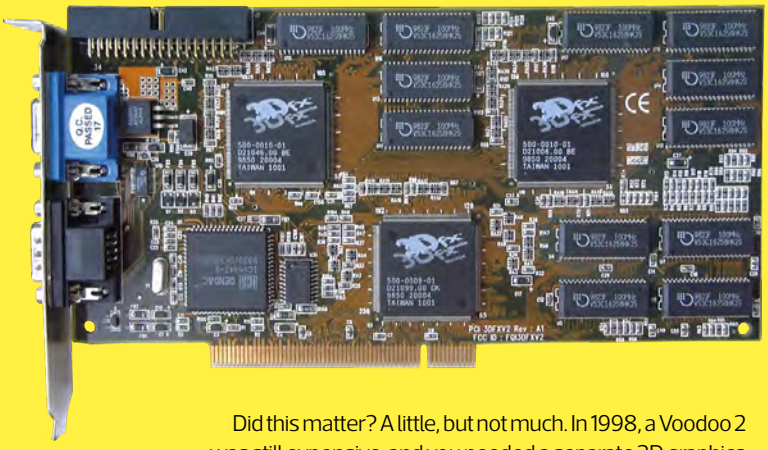
The TNT also supported 32-bit colour at a point where many graphics chips were limited to 16-bit. This wasn't a big deal, given that most game engines couldn't handle any more than 64,000 on-screen colours, but it gave the TNT in a degree of futureproofing as more advanced titles came out.

PROOF OF PERFORMANCE

When Nvidia announced the Riva TNT at the WINHEC conference in March 1998, it pushed out some pretty big numbers. Cards would be capable of a 250 megatexels per second fill rate, and an 8 million triangle per second polygon throughput, at a time when most 2D/3D chips were struggling to reach 100 megatexels per second and 2 million triangles. Nvidia claimed that early performance tests showed results that competed directly with two Voodoo 2 cards in SLI.

Sadly, this didn't translate to the finished product, as Nvidia's new chip struggled with overheating. The Riva TNT was designed to run at 125MHz, but it was a massive chip with 8 million transistors, pushing the limits of the 0.35-micron technology of the time.

At 125MHz, the chip ran too hot to be reliable, particularly when most graphics cards relied on passive cooling. As a result, Nvidia clocked the final Riva TNT down to 90MHz, with a corresponding loss of performance. The single chip built to thrash the Voodoo 2 was now 'only' on a par.



The 3dfx Voodoo 2 dominated 3D graphics like no other card before or since. Before the TNT, no 2D/3D card could rival it. Photo own work by Stonda, Wikimedia, CC BY-SA 2.5

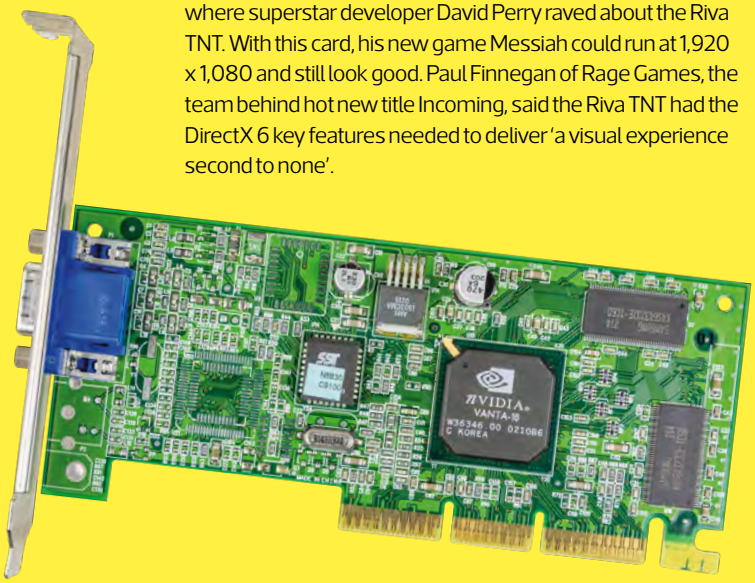
Did this matter? A little, but not much. In 1998, a Voodoo 2 was still expensive, and you needed a separate 2D graphics card to handle every job outside 3D games. Whereas the Voodoo 2 on its own would set you back around £200, you could find a Riva TNT card for slightly less money, and it was the only graphics card you needed. What's more, the early benchmarks told their own tale.

The Riva TNT was also one of the first graphics processors that rewarded overclocking

In Forsaken, one of the era's big Direct X showcase games, Nvidia's card was significantly faster than any of its 2D/3D rivals, and ahead of the Voodoo 2 at both 640 x 480 and 800 x 600. It was a close match for the Voodoo 2 in Turok: Dinosaur Hunter, it could beat it in Quake 2 at 800 x 600, and it wasn't far behind in 640 x 480. We put it to the test in the lab and came away amazed; where even the most advanced 2D/3D chips slowed down and stuttered, this thing flew.

Game developers were equally impressed. Nvidia put out a press release around the ECTS game show in September, where superstar developer David Perry raved about the Riva TNT. With this card, his new game Messiah could run at 1,920 x 1,080 and still look good. Paul Finnegan of Rage Games, the team behind hot new title Incoming, said the Riva TNT had the DirectX 6 key features needed to deliver 'a visual experience second to none'.

The Vanta was the first in a long line of cut-down Nvidia graphics chips. You might have found this one in a Compaq desktop PC. Photo own work by Raimond Spekking, Wikimedia, CC BY-SA 2.5



However, there were still two caveats to the Riva TNT's performance – 3dfx still had the edge on many games that used its own proprietary Glide API, while its cleverly optimised MiniGL drivers sometimes gave it the edge in games based on OpenGL. As this included any game running on the Quake engine, and many of the era's biggest blockbusters, this remained a thorn in the side of the Team Green challenger.

More seriously, Riva TNT was still dependent on the CPU to handle the initial triangle setup, whereas the Voodoo 2 handled that on-board. As a result, the Riva TNT was a monster on the fastest Pentium MMX and Pentium II systems of the day and pretty good on AMD's K6. Give it the older AMD K5, a floating-point challenged Cyrix 686 or lower-end Celeron, however, and the CPU just couldn't keep pace. On those machines, you were better off sticking with a Voodoo 2.

THE TNT LEGACY

The launch of the Riva TNT had big implications for the future of the graphics card industry. It put paid to the idea that you needed a dedicated 3D card, and pushed both 3dfx and Videologic's PowerVR team to focus on their own 2D/3D processors. Even then, Nvidia opened up a technology lead, with its successor TNT2 chip outperforming 3dfx's Voodoo 3.

The TNT's success also made it harder for existing graphics specialists to compete in an aggressive market. Rendition and S3 would soon abandon their own 2D/3D efforts, while Matrox largely retreated from the gaming market to focus on high-resolution, high-colour chips for professional graphics and design. Only 3dfx and ATi would remain in the battle, the former eventually purchased by Nvidia, the latter by AMD.

The Riva TNT was also one of the first graphics processors that rewarded overclocking, as enthusiasts and some card manufacturers realised that a chip designed to run at 125Hz could still be pushed to 100MHz or over, particularly with some help from active cooling. The manufacturers released utilities with which you could push the core clocks and memory clocks upwards, and soon gamers were enjoying the free speed boost.

Most of all, the Riva TNT and its successor put Nvidia on the path it treads today: a leader in graphics, AI accelerators and even system-on-chips in certain markets. It would have other revolutionary products, such as the GeForce 256 and the first RTX chips – but the TNT was where it all kicked off. CPC

TAKING ADVANTAGE

Nvidia set a new standard for the graphics card industry by releasing a budget version of the TNT, dubbed Vanta. This was effectively the same chip running at a lower clock speed, with a 64-bit memory interface and half the amount of RAM as a standard TNT.

Designed to bring Nvidia's graphics tech to business desktops, it also found its way into budget gaming systems, leading to some disappointment when it didn't deliver the same levels of performance. Today, of course, using GPUs that don't make the grade at their intended spec in a lower-end product is standard practice, and this wasn't to be the last time that Nvidia released cut-down chips to expand into a cost-conscious market.

Readers' drives

SpongeBob SquarePants PC

Armed with a load of EVA foam and plenty of yellow paint, Dewayne Carel built this SpongeBob SquarePants PC case mod

SEE THE FULL PROJECT LOG AT custompc.co.uk/SpongeBob

CPC: Who lives in a pineapple under the sea?
Dewayne: SpongeBob SquarePants PC!

CPC: How did this SpongeBob project come about?
Dewayne: It was EVGA that wanted this project – the company wanted to do something special for one of its partners, Arabian Prince from the rap group NWA, who by the way is a huge SpongeBob fan. He even showed up to the unveiling of the case mod – not knowing what it was about or that it was for him – in SpongeBob shoes, pants and shirt.

/MEET THY MAKER

Name Dewayne Carel
Age 59
Occupation Chief engineer of a Marriott resort
Location Phoenix, Arizona
Likes The case modding community, Star Wars, pizza, fried chicken, beer and whiskey
Dislikes Too much RGB and arrogant people

CPC: How did you plan and design this build?
Dewayne: I looked at tonnes of images on the Internet of SpongeBob, and it became apparent that the EVGA DG-77 case I'd been given and SpongeBob were basically the same shape. Some would say, 'Now that is good luck!' Maybe, but I knew I had to create a case mod where people's reactions wouldn't be: 'All you had to do was paint a case yellow' – yes, you know who you are. I needed to go to the next level to create a PC that didn't look like it was a weekend project.

Once again, I headed off to the Internet in search of some inspirational images of SpongeBob. I was, of course, able to find an endless supply of images. This was great to get the colours and details needed – close-ups of his eyes, mouth, nose, shoes, and yes, his pants.

However, in most of the images, he was either standing or running, and I knew this wouldn't work – how would I balance a fully loaded PC on toothpick legs without some sort of support? Then it hit me – he could be sitting down with his legs sticking straight out. With that vision in my mind, I quickly worked out the design with pencil and paper, which is my normal way of visualising my ideas. This plan was perfect – his feet would extend out and his arms would be to his side with his hands flat, making it look like he was sitting and holding himself up.

The face of SpongeBob was the make-or-break feature of the whole build. If it didn't look like him then I might as well just scrap the whole case mod and save myself from the modding community's comments. I spent many hours on the design – working out how big to make his eyes, for example, as well as the size of his mouth and how it curves – his smile is a main recognisable feature, and the bottom and top of his mouth protrudes out to form lips. I had to get his nose right too.

CPC: You needed to ship this PC to your customer after you'd finished it. How did this affect the build process?
Dewayne: The SpongeBob mod had to be able to be shipped, which meant it had to fit into some sort of box or case. That wasn't going to be easy with two legs and large shoes sticking out from his body by around 12in, his arms on each side and, most importantly, his nose, which was going to be at least 3.5-4in long and right in the middle of one side of the case mod.

You needed to be able to reattach these parts to the case in the right

spots, they needed to be secure and, most importantly, they had to still look like part of the overall design. Looking around my modding shop, I spotted some 0.25in-diameter magnets, which I'd used before. I thought I could embed the small magnets into the EVA foam I'd used on the case (more on that later), and then glue a small/thin piece of metal to the flat parts of the legs, arms and nose, which would match up to where the magnets were placed.

CPC: How did you make that case look like SpongeBob's head?

Dewayne: I wanted to make sure that SpongeBob looked like he'd walked out of the show and then sat down on a desk. It had to look real, with recessed holes and notches, as well as sponge-like feel. I needed to create that sponge look and effect, but the machine also had to be able to withstand being shipped, moved around, and taken apart for maintenance and future upgrades.

Before this case mod, I had been watching people making Cosplay props and outfits, and thought it would be something fun to do, as I enjoy creating stuff. That's when it hit me that I could use the same EVA foam they used for this project. This foam is rugged and dense, and it's also easy to carve and shape into any shape you want. After some measurements and brainstorming, I ordered some different thickness and sizes of EVA foam.

The larger pieces of EVA foam were for the actual body of SpongeBob – they're glued to the all the side panels and the front of the case. The EVA foam was 0.5in thick, and I figured I could double up the foam to give me the two different levels of depth that I needed for the transition from SpongeBob's body to his pants, and that I could carve holes and sculpt the edges to create the sponge effects.

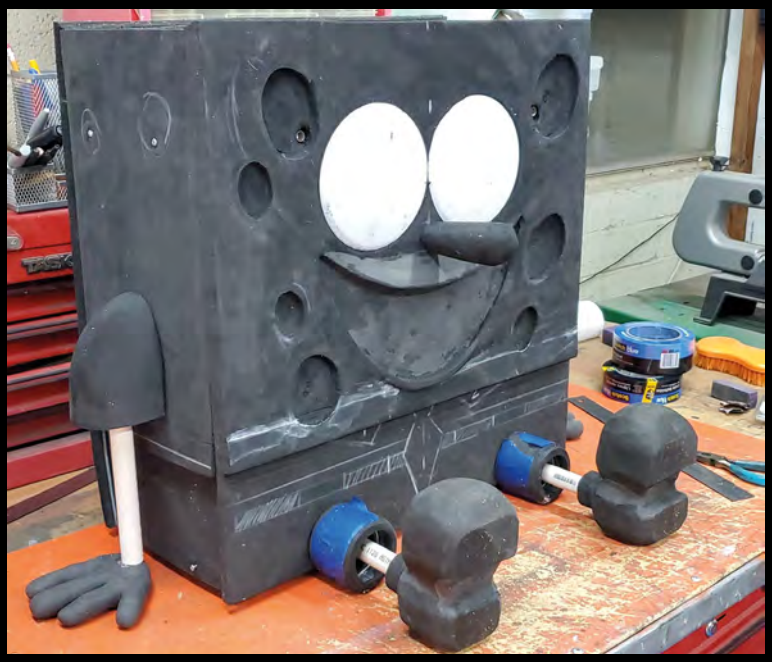
After getting all the foam attached to the case with some heavy-duty spray glue, I made sure that it looked fairly seamless, so that it looked like one huge piece of foam. I then had to work on the design of his eyes, nose, mouth, arms, hands, legs and shoes to make sure that they were in proportion to his body. Using a pencil, paper and a grease pencil I drew directly onto the EVA foam. After many revisions and adjustments, I found a look that I liked.

The side panels for this case were held on by thumbscrews that went through the panels themselves. I didn't want any screws to be visible, as they would ruin the look, so I made sure the carved holes in the

> I wanted it to look like he'd walked out of the show and then sat down on a desk

SYSTEM SPECS

CPU Intel Core i7-9700K
GPU EVGA GeForce RTX 2080 Ti XC Ultra
Case EVGA DG-77
Storage Intel Optane SSD 9
Memory 16GB Viper 3200MHz DDR4
Motherboard EVGA Z390 FTW
PSU 800W EVGA
Cooling EVGA 280mm AIO liquid cooler



'sponge' would be located where the screws went through the panels. I carved out the holes in different shapes to make sure they looked like random holes in the sponge.

To cover the screws, I cut some thin sheet metal into the shapes of the holes around the screws. I then glued EVA foam over them, and left a small tab that could be used to pull off the concealment covers. I then embedded some small magnets into the thick foam and the removable concealment covers for the screws.

CPC: How did you go about making the arms, legs and shoes?

Dewayne: SpongeBob wears some pretty big, old-style shoes with a very distinctive look. There's a huge, rounded end at the front of the shoe, and a very small, narrow part for his legs. How in the heck was I going to make these without them weighing too much?

I searched on the Internet and found a yoga block that was made from, you guessed it, EVA foam – when I cut it in half, it was the perfect size for carving out two shoes. It took a couple of hours for the first shoe to come to life from the block foam, but it looked great, so I hammered out the second one in less time.

In the images I'd seen online, it appeared that SpongeBob's arms and legs were the same diameter. After a quick rummage through some leftover modding supplies, I found a section of 0.75in PVC pipe, which was exactly the correct diameter to be in proportion to the overall design. I figured out the lengths I needed for the legs and arms and continued with the build.

To finish off his legs, I needed to make the 'pants' part that would come off his body and attach to his PVC pipe legs.

I cut some strips of EVA foam, rolled them, glued them and put an end piece on both sides – one to attach to the case via the magnet setup, and one for his leg to go through. I then made a hole in the top of one of the shoes, inserted the leg piece and SpongeBob now had at least one completed leg.

Switching over to the arms, I figured I would use the same ideas and materials as the legs. However, I didn't want to try to carve the hands out of EVA blocks.

I first thought I could create them out of clay, but I soon tossed out that idea, as it would be rather heavy and easy to break. I wanted a material that would give me the same texture and look as the rest of the SpongeBob's body.

I checked to see if there was a 'clay-like' material like EVA foam, and there was! I knew this foam would need some sort of support inside it, so I designed and 3D-printed a bone-like skeleton around which I could mould the clay.

CPC: How did you create the little details, such as SpongeBob's eyes and nose?

Dewayne: For SpongeBob's face, I attached some long skinny strips of EVA foam to make the raised portions of his mouth, and then used some of the clay foam to fill in the rest of the shape.

I then proceeded to sand down and shape it to the final look. Meanwhile, his eyes had to be large, slightly rounded and smooth. I know I couldn't get the right look with the foam, so I designed them in SketchUp and 3D-printed them. I then applied a thin layer of Bondo on them and sanded it to a smooth finish.

Then there's the nose, which you might think was easy – it's kind of round and a few inches long. But again, it's a very distinctive feature that had to be right to make his face

look perfect. I probably spent as much time getting the nose to look right as I spent carving out both shoes. Once I got the appearance I wanted, it was time to see if a single magnet would hold the nose in place without it falling off. I placed one magnet into the foam on the case and attached a small piece of sheet metal to the flat part of the base of the nose – it worked perfectly.

CPC: What paints did you use to get those striking colours?
Dewayne: A huge mountain to climb was getting the right colour of yellow. If the yellow was too light, SpongeBob would look washed out and pale. If it was too dark, he would look like he was living in a cave instead of a pineapple.

I went to a couple of my local hardware stores and, like a miracle, I found a yellow colour that I thought would be perfect, so I bought one can. After doing a few test sprays, I determined that it *was* the perfect colour of yellow for SpongeBob, so I went back to the hardware store for a few more cans.

With the right shade of yellow in hand, I painted the entire case inside and out with the yellow paint. This was done so that any exposed parts of the case weren't covered with the foam would match, and give it a seamless look. SpongeBob's clothes were just basic red, white, brown and black colours, thank goodness.

CPC: How does the airflow system work with all that solid material surrounding the case?
Dewayne: That was the same question I asked myself throughout the build process. I knew that adding about an inch of foam to the outside of the case would defeat the conduction process that normally happens with a case.

I first made sure that any of the original airflow design was kept intact as much as possible and worked around it.

Any hidden areas with air intakes, such as the bottom of the case and bottom of the front bezel, got special treatment – IU enlarged existing holes and added more holes in order to increase the airflow.

I was quite pleased with my stress testing, as it showed the temperatures were only a few degrees above those of a stock setup.

CPC: How long did it take you to complete this build, from start to finish?
Dewayne: The actual build time was around 80 hours or more, but the time dedicated to the design, learning how to work with unfamiliar materials and so on went way past 120 hours.

CPC: Are you completely happy with the end result, or do you wish you'd done some of it differently in retrospect?
Dewayne: I will admit that I was surprised that it came out as well as it did! All through the build, I was hoping that it would all come together and not look terrible. The end result really impressed me when I was done. CPC

WIN CORSAIR HYDRO X WATER-COOLING GEAR

To enter your rig for possible inclusion in Readers' Drives, your build needs to be fully working and, ideally, based in the UK. Simply send us a couple of photos on Twitter (**@CustomPCMag**) or Facebook (**CPCMagazine**), or email low-res ones to **ben.hardwidge@raspberrypi.com**. Fame isn't the only prize; you'll also get your hands on some fabulous prizes, courtesy of Corsair.

Corsair Hydro X Series XD3 RGB Pump/Reservoir C

WORTH £151

The Corsair Hydro X Series XD3 RGB Pump/Reservoir Combo features a high-performance DDC PWM pump, integrated RGB lighting and in-loop temperature sensor to drive even the most compact custom cooling systems. It has a high-performance Xylem DDC PWM pump controlled via PWM to deliver the perfect flow balance for your loop. There are also 16 individually addressable RGB LEDs, which light up the pump head to produce stunning, customisable lighting effects to match your build.

Corsair Hydro X Series XC7 RGB CPU Water Block

WORTH £70

The Corsair Hydro X Series XC7 RGB CPU Water Block combines premium construction, vivid RGB lighting and extreme cooling performance to become the centrepiece of your water-cooling loop. It has a nickel-plated copper cold plate and more than 60 high-efficiency micro-cooling fins, which efficiently draw heat away from your CPU, lowering operating temperatures and allowing for maximum overclocks. You can choose a version for Intel or AMD CPU sockets.

Corsair Hydro X Series XR5 240mm Radiator

WORTH £55

The Corsair Hydro X Series XR5 240mm Water Cooling Radiator delivers extreme custom cooling performance, with a 30mm radiator thickness and premium copper core. Its dual 120mm fan mounts on each side are ready for your most ambitious custom cooling build, and its 25 micron-thick cooling fins offer a high thermal transfer rate.

JAMES GORBOLD / HARDWARE ACCELERATED

GET YOUR PC SUMMER READY

James Gorbold makes the case for making PCs cooler and more power-efficient

So, you've finally managed to get hold of the GPU of your dreams, and no doubt stocked up on a tonne of new games in the recent Steam and GOG sales, but now it's time for the next challenge – summer.

When I first got into PCs decades ago, British summers were a bit of a joke – you did get a few warm days here and there, but by and large, the climate didn't have any impact on your PC use apart from your parents pleading with you to spend more time outside. Not only was the weather cooler, but PCs also didn't require enormous cooling systems. However, with ambient temperatures now going over 30°C on a regular basis in the UK, it's starting to become an issue.

A big part of the problem is that gaming PCs emit a lot of heat, with modern CPUs and in particular GPUs, dissipating hundreds of watts into the air. This situation is only getting worse with each generation, despite valiant efforts from PSU manufacturers to produce more efficient designs.

A few extra per cent efficiency is helpful, but it barely makes a dent when current GPUs consume 100W more than their predecessors. And, if rumour is to be believed, Nvidia's next-gen Lovelace gaming GPUs will be even more power-hungry. Certainly, the company's next-gen Hopper datacentre GPUs are power guzzlers, with a TDP of 700W, a 75 per cent increase over the equivalent Ampere GPU.

There have been some days where I've had to stop gaming, thanks to my PC getting obnoxiously noisy, or it raising the ambient room temperature too high. I know I'm not alone either, having experienced multiple gaming sessions end early because the other players and their PCs were suffering too. The situation is further exacerbated by so much of British housing stock being badly insulated, not just for cold weather but hot weather too.

There have been some days where I've had to stop gaming

Air conditioning your PC room isn't going to be practical for most gamers on cost grounds, so what can PC enthusiasts do to alleviate the problem? The biggest impact you can make is voting with your wallet, choosing components or systems that are less power-hungry, or at the very least cool-running and power-efficient.

A good example is one of my pet hatreds – hard drives. While I still have fond memories of my very first 10MB hard drive, these days I can't stand their laggy performance, rattling and excessive heat. One of the best things you can do is buy an SSD instead, and if you do need the larger capacities that hard drives offer, put them as far away from you as possible in a NAS box.

Keeping your PC clean can also really help. Whether your PC is air or water-cooled, if the heatsinks, fans and radiators are covered in dust, they can't work at their full potential. Older PCs are often really bad in this respect, doing sucking far too much dust into your case's delicate interior. Modern cases are far better in this regard, as many include easily removable dust filters that can be washed under a tap or hoovered.

Then of course there is undervolting. Even typing the word still feels weird as an ex-reformed overclocker, but there's something to be said for dialling down the voltage of components in order to reduce their energy consumption and heat output. There isn't room in this column to get into specifics, but it's well worth looking into it, particularly when the next generation of energy-guzzling GPUs is released. **CPC**

James Gorbold has been building, tweaking and overclocking PCs ever since the 1980s. He now helps Scan Computers to develop new systems.

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