GEFORCE TO GO RTX 3000-SERIES LAPTOPS REVIEWED

CUSTOM PC

THE BEST-SELLING MAG FOR PC HARDWARE, OVERCLOCKING, GAMING & MODDING / ISSUE 212

BUILD A FIRST-CLASS GAMING PC

MAKE A SENSATIONAL HIGH-END GAMING SYSTEM JUST LIKE THE PROS

HOW TO

- BUILD IT
- WATER-COOL IT
- LIGHT IT
- OVERCLOCK IT

WHAT'S YOUR TYPE?

- 8 mechanical keyboards tested
- How mechanical switches work

MAY 2021 / £5.99

9 771740 744059 05

Raspberry Pi PRESS

HOW TO CLEAN YOUR WATERBLOCKS TO A SHINE


AGON
ULTIMATE
IMMERSION
with the
AG49UCX
DQHD
5120x1440
120HZ
1MS
HDR 400
Available at:
amazon
OVERCLOCKERS UK
AOC
@aocgaming
@aoc_gaming
@aocgaming
aocgaming.com

Welcome

Custom PC Issue 212

/ FROM THE EDITOR

First step into water cooling

If you've ever gazed at the photos of gorgeous water-cooled PCs on the Internet, with coloured coolant and lights, and thought 'wow, I wish my PC looked like that', then this issue's main cover feature (see p76) is for you. Building a water-cooled PC certainly has its challenges, and you'll want to set aside a decent chunk of time to do it, but the end result will be a cool, quiet and lush-looking system that you can proudly put on Instagram and say 'I built this!'

We're looking at this as your first step into a larger world (it's best to imagine that line in Alec Guinness' voice, obviously). We haven't gone all-out on custom case modding and hard line water cooling for this PC – we've based it on a readily available case, standard components and soft tubing. It won't be easy, but if you've already built PCs with all-in-one liquid coolers, this is a great next step in the land of custom rigs.

It's not all about custom water cooling, of course. We've also taken you through the best component choices for building a high-end gaming PC, and detailed the options for overclocking them, so you can eke out as much performance as possible from your new system.

The big furry mammoth in the room, of course, is the depressingly low stock of many new components, but we're starting to see some hope on the horizon here. AMD's Ryzen 5 5600X and Ryzen 7 5800X CPUs are now easy to find in stock, and Nvidia has also revealed plans to limit the mining performance of its GeForce RTX 3060 cards in cryptocurrency mining (see p12), while introducing a new line of dedicated mining cards with no display outputs.

If AMD follows suit, and future gaming graphics cards are steered away from miners, then the stock problems will start to ease. Likewise, if the world can get to grips with vaccinating its population against Covid, and stay on top of new variants, we can also start to plug other holes in the supply chain. In the meantime, though, now is a great time to have a think about what you might put in a new PC and how you'll build it. CPC

EDITOR
Ben Hardwidge

ben.hardwidge@raspberrypi.com

@custompcmag

CUSTOM PC

EDITORIAL

EDITOR
Ben Hardwidge
ben.hardwidge@raspberrypi.com

FEATURES EDITOR
Edward Chester
edward.chester@raspberrypi.com

MODDING EDITOR
Antony Leather

GAMES EDITOR
Rick Lane

CONTRIBUTORS
Gareth Halfacree, James Gorbold, Mike Jennings, Phil Hartup, Richard Swinburne, Tracy King

PRODUCTION EDITOR
Julie Birrell

PHOTOGRAPHY
Antony Leather, Brian O'Halloran, Fiacre Muller, Gareth Halfacree

PUBLISHING

PUBLISHING DIRECTOR
Russell Barnes
russell@raspberrypi.com

DESIGN
criticalmedia.co.uk

HEAD OF DESIGN
Lee Allen

DESIGNERS
Ty Logan, James Legg

COMMERCIAL & ADVERTISING

ADVERTISING
Charlotte Milligan
charlotte.milligan@raspberrypi.com
+44 (0)7725 368887

DISTRIBUTION
Seymour Distribution Ltd
2 East Poultry Ave,
London EC1A 9PT
+44 (0)207 429 4000

SUBSCRIPTIONS
Unit 6 The Enterprise Centre
Kelvin Lane, Manor Royal,
Crawley, West Sussex, RH10 9PE

Phone
01293 312182

Email
custompc@subscriptionhelpline.co.uk

Website
custompc.co.uk/subscribe

ISSUE 212

ISSUE 212
SUBSCRIBERS EDITION

This magazine is printed on paper sourced from sustainable forests. The printer operates an environmental management system which has been assessed as conforming to ISO 14001.

Custom PC magazine is published by Raspberry Pi (Trading) Ltd., Maurice Wilkes Building, St. John's Innovation Park, Cowley Road, Cambridge, CB4 0DS. The publisher, editor, and contributors accept no responsibility in respect of any omissions or errors relating to goods, products or services referred to or advertised. ISSN: 1740-7443.

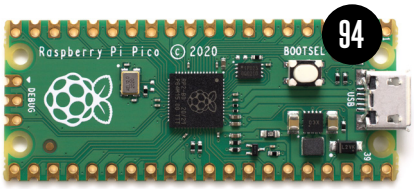
Contents

Welcome to Issue 212

Highlights

Cover guide

Regulars



Reviewed

38 PRODUCTS REVIEWED

Custom kit

Case Labs

Mechanical keyboard Labs

Games

Hobby tech

Windows 10

CyberPowerPC recommends Windows.
One experience for everything in your life.

Liquid Cooling Included

FROM
£2399

Infinity X10 GT

Windows 10 Home

Intel® Core™ i9-10900KF Processor
NVIDIA GeForce RTX 3080 10GB
MSI Z490-A PRO Motherboard
16GB DDR4 3200mhz Hyperx Fury Black
500GB WD Blue SN550 NVMe SSD
2TB Seagate BarraCuda SATA-III HDD
NZXT H511 Case Matte Black Case
Corsair RM750x 750W Power Supply
Cooler Master MasterLiquid Lite 240 Watercooling
300mbps Wireless Card
Pro Overclocking

HD 7.1 | Optional | Optional

Liquid Cooling Included

FROM
£2549

Infinity X10 Elite

Windows 10 Home

Intel® Core™ i7-10700KF Processor
AMD RX 6900 XT 16GB
MSI Z490-A PRO Motherboard
16GB DDR4 3200mhz Hyperx Fury Black
1TB WD Blue SN550 NVMe SSD
Corsair Graphite 220T Black Case
Corsair RM850X 850W Power Supply
Cooler Master MasterLiquid Lite 120 Watercooling
300mbps Wireless Card

HD 7.1 | Optional | Optional

Liquid Cooling Included

FROM
£1849

Infinity X99 GT

Windows 10 Home

Intel® Core™ i9-9900K Processor
NVIDIA GeForce RTX 3070 8GB
MSI Z390-A PRO Motherboard
16GB DDR4 3200mhz Hyperx Fury Black
500GB WD Blue SN550 NVMe SSD
2TB Seagate BarraCuda SATA-III HDD
Corsair 4000D Black Case
Cooler Master 650W Power Supply
Cooler Master MasterLiquid Lite 240 Watercooling
Pro Overclocking

HD 7.1 | Optional | Optional

FROM
£1099

Infinity X99 Elite

Windows 10 Home

Intel® Core™ i7-9700F Processor
AMD RX 580 8GB
Asrock B365M-PRO4-F Motherboard
16GB DDR4 3200mhz Hyperx Fury Black
250GB WD Blue SN550 NVMe SSD
1TB Seagate BarraCuda SATA-III HDD
Cyberpower Onyxia 2.0 Black Tempered Glass Case
Cooler Master 550W Power Supply
Intel Standard CPU Cooler
300mbps Wireless Card

HD 7.1 | Optional | Optional

FROM
£899

Infinity X66

Windows 10 Home

Intel® Core™ i5-9400F Processor
NVIDIA GeForce GTX 1660 Super 6GB
Asrock B365M-PRO4-F Motherboard
8GB DDR4 3200mhz Hyperx Fury Black
240GB Adata SU630 SATA-III SSD
2TB Seagate BarraCuda SATA-III HDD
MSI Mag Vampiric 010 CP Edition Case
Cooler Master 550W Power Supply
Intel Standard CPU Cooler

HD 7.1 | Optional | Optional

15.6"QHD

FROM
£1379

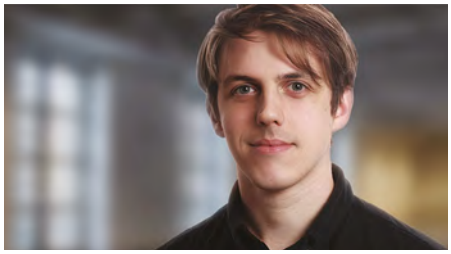
Tracer Studio Pro

Windows 10 Home

Intel® Core™ i7-10875H Processor
NVIDIA® GeForce® RTX 3060 6GB Video Card
Intel® HM470 Chipset
16GB DDR4 2666Mhz Corsair Vengeance SODIMM
500GB WD Blue SN550 NVMe SSD
15.6" QHD (2560x1440) 165Hz Display
Intel® Wireless AX200 - Wi-Fi 6 (802.11ax)
Bluetooth 5

4 hrs | Bluetooth 5 | 2x USB 3.1 Gen2 2x USB 3.1 Gen1

1x HDMI Port | Built-in 720P HD Webcam | 1.7 kg | Wi-Fi 6



RICHARD SWINBURNE / VIEW FROM TAIWAN

WHAT'S IN A NAME?

Buying a laptop with a GeForce RTX 3060, 3070, 3080? You might be getting one of 28 versions, explains Richard Swinburne

After launching its RTX 3000-series of GPUs for laptops, Nvidia decided to remove the Max-P branding, allowing laptop makers to set the chips' power draw and clock speeds in practically any way to fit their designs. The Max-Q branding stays, but you could be buying any of 28 variations of the RTX 3060, 3070 or 3080.

This means an RTX 3080 with baseline 80W TDP would have a fraction of the performance compared with one with a full-fat 150W TDP, yet it still costs the same amount of money. Buying a mobile RTX 3080 only guarantees that you'll get 6,144 CUDA cores – otherwise, the base clock ranges from 780MHz to 1350MHz, while boosts vary from 1245MHz to 1710MHz. Nvidia says you can find this information in the Control Panel, which is pretty useless if you're still deciding which laptop to buy.

After some outcry, Nvidia recently changed its mind, saying it 'strongly encourages' (but doesn't require) partners to list the power use and clock speeds on the product pages of each laptop, which it says 'communicates the expected GPU performance in that system'. No, it doesn't. Due to the way transistors work, increasing power use doesn't increase performance linearly, and the cooling factor of any laptop isn't quantified, so how do you know how any system will actually perform?

If you're shopping for a new gaming laptop, you're better off creating a spreadsheet of data, cross-referencing the chip spec with power and boost clocks. There's an 88 per cent difference in power draw between the top and bottom options of each chip, so it's exceptionally difficult to make a reasonably accurate guess. The Max-Q line-up is slightly less confusing, with only three varying options for each chip, but there's still a 92 per cent difference in power draw between the lowest and highest versions (60-115W)!

> Increasing power use doesn't increase performance linearly

Product names used to signify performance on a branded scale of low to high, but they now merely convey the silicon being used. As this latest naming rule doesn't require disclosure on sales pages such as Amazon, you'll have to dig into manufacturer websites to find it. What's more, laptops can have the same name but different specs in different regions, so you have to be careful which URL you're checking – how many times have you ended up reading the 'global' US website instead of the local UK one?

What's particularly frustrating is that Nvidia is keen to protect its branding in every other product – G-Sync monitors have a long list of very strict quality and performance requirements to which manufacturers have to adhere before they can use the logo. Nvidia does this because it claims it cares about the gaming experience, so why are laptop chips any different?

Nvidia could require every laptop to issue a performance quotient for easy comparison – an RTX 3060 at 80W could be 1, then an 80W RTX 3070 might be 1.3, but an RTX 3060 at 150W might be 1.4. This gives buyers a clearer understanding of what they're getting for their money without having to dig into every laptop maker's product page, while having to guess how much power equals how much more performance. Reviews can ultimately provide this insight, but manufacturers rarely sample every spec, so there are inevitable gaps. If Nvidia really cares about the quality of gaming experience, it will do more to articulate these details up front. **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

CORSAIR

/ CORSAIR

MAKE YOUR NEXT BUILD YOUR BEST BUILD

4000X RGB & H100i ELITE CAPELLIX

Start your new PC off with the latest from CORSAIR. A 4000 Series case combines easy cable management and exceptional cooling, with two included CORSAIR AirGuide fans. Keep your system running at peak efficiency with an iCUE ELITE CAPELLIX Liquid CPU Cooler, delivering powerful, low-noise cooling along with ultra-bright dynamic RGB lighting.

FIND OUT MORE AT CORSAIR.COM

CAPELLIX
CORSAIR LED TECHNOLOGY

iCUE
A CORSAIR INTERFACE

TRACY KING / SCEPTICAL ANALYSIS

GAMER SNAKE OIL

Tracy King takes aim at nutrient supplements being marketed at gamers

It's been a year of pandemic. A year is a short time in science, and a huge number of amazing medical advances have been made very quickly that would otherwise have taken a decade, or perhaps never been funded at all. If governments and private pharmaceutical companies (Big Pharma) throw enough money at a problem then positive things happen, such as the vaccines. In this case, Big Pharma is providing an expensive light at the end of a long, dark tunnel.

Big Pharma does lots of amazing, life-saving or life-improving things that cost a fortune to research, develop and test, and I fully support that.

But they also do some ugly, profiteering, cynical or outright dangerous stuff (Ben Goldacre wrote a great book about this called Bad Pharma). Enter the supplements industry.

Supplements, vitamins, tonics and other general health pseudo-medicines aren't new. While we're doing reading lists, HG Wells wrote a satirical novel called Tono-Bungay in 1909, which demonstrated that the industry and culture around wellness are as old as modern medicine itself. It's quite straightforward: humans get fatigued, achy or slower as we age, and getting regular exercise, water, sunlight and a healthy diet, as well as abstinence from fun-but-unhealthy stuff, isn't always easy.

Okay, drinking water is easy, but I'm on my third coffee today anyway. Coffee is a mood and performance enhancer (and tastes delicious), and I feel optimised when I'm fully caffeinated. Of course, the crash afterwards takes away more energy than I would have otherwise lost, but that's the cycle of addiction for you.

My point is that I quite often feel like crap and would like a magic pill to not feel like crap. I would like an Exhaustion-Be-Gone, a panacea with none of the caffeine side effects. I'm ripe for being sold what's called a 'nostrum'. Tono-Bungay, in the HG Wells book, is a nostrum, a tonic drink that makes you feel more focused, energised and enhanced.

Or so the sales pitch goes, and because those symptoms are experienced by pretty much everyone, the product sells well. Sadly, it's snake oil, and while snake oil has many more contemporary names, it's always going to sell well because humans are always going to want a magic pill for being knackered or stressed.

> Taking a supplement that I don't need just creates expensive pee

Twitter recently brought my attention to an advert for supplements specifically for gamers. I won't name the supplement in question because there are many such products – a pill or powder that claims to enhance video game performance has nothing to do with the product and everything to do with marketing.

They are snake oil in fancy packaging and gamers are being exploited for profit. Sometimes relying on mystical Eastern inference (if they've used this leaf or root for thousands of years in India then it must work, amirite?! Hint: no), sometimes comparing the brain to a server or computer, these supplements all have one factor in common: we don't need them and they don't work as claimed.

If I have symptoms of a vitamin deficiency or inefficiency then I speak to my GP and get a blood test, and only then do I take vitamins in line with medical advice. Taking a supplement that I don't need just creates expensive pee.

There's a caveat, as always. I broadly support the right of anyone to put whatever they choose into their body. But the caveat to the caveat is this: if it's not an informed choice then it isn't really a choice. Beware the snake oil in modern disguise. **GPG**

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

TIME TO SHINE!

PURE LOOP

Quiet and superior cooling

The Pure Loop All-in-One water cooler is a real eye-catcher in your PC, featuring a stylish white LED. It offers you powerful and silent cooling whenever you need it. It's not just the cooling block that shines here!

- Impressively high cooling performance
- Doubly decoupled pump for quiet operation
- Silent Pure Wings 2 PWM fan with high air pressure
- Stylish white LED illumination and black design
- Available in 120, 240, 280 and 360mm

Available at:
scan.co.uk · overclockers.co.uk · ebuyer.com
novatech.co.uk · aria.co.uk · cclonline.com · amazon.co.uk

be quiet!®

Incoming

CORSAIR WATER-COOLS SSD

Corsair has launched a new range of high-performance PCI-E 4 NVMe SSDs, with the top model featuring a waterblock that can be plumbed into a custom water-cooling loop. The new range starts with the MP600 Core, which has stated sequential read and write speeds of 4,950MB/sec and 3,950MB/sec respectively, and comes in 1TB, 2TB and 4TB capacities.

The two top models are the MP600 Pro and MP600 Pro Hydro X (pictured), which have a sequential read speed of 7,000MB/sec, and a write speed of 6,550MB/sec. The MP600 Pro has a heatsink, but the Hydro X model features Corsair's new XM2 waterblock, which will also be available separately.

Do you need a waterblock on an SSD? Nope, but the latest PCI-E 4 SSDs do get very hot, and a waterblock will certainly make an attractive alternative to a large chunky heatsink when it comes to aesthetics.

NVIDIA DRIVER LIMITS MINING PERFORMANCE

Nvidia says it will deliberately restrict the mining performance of its new GeForce RTX 3060 gaming GPU, in a bid to ensure that cards can be snapped up by gamers during the current Ethereum mining boom. Meanwhile, the company is also introducing a line-up of Cryptocurrency Mining Processor (CMP) cards with improved airflow and no graphics capabilities, which will be specifically targeted at miners.

In a post on **blogs.nvidia.com**, Nvidia's VP of Global GeForce Marketing, Matt Wuebbling, stated that 'RTX 3060 software drivers are designed to detect specific attributes of the Ethereum cryptocurrency mining algorithm, and limit the hash rate, or cryptocurrency mining efficiency, by around 50 per cent'. The limit will apply to the company's Linux drivers as well as its Windows drivers.

The GeForce RTX 3060 is set to be priced from £299, and contains 3,584 CUDA cores. The new GPU will be available to buy by the time you read this, and we hope to have a full review in our next issue.

ASUS DITCHES M.2 SCREWS

Combing your case for lost tiny M.2 screws could be a frustration of the past if you buy one of Asus' upcoming Z590 motherboards. The company's new Q-Latch M.2 system uses a rotating plastic catch to grip your SSD – the latch can be simply turned with your fingertips, with no need for a micro screwdriver.

Asus first unveiled the system at the digital CES 2021 trade show in January; it's since revealed that it will be featured on some of the company's new Z590 motherboards. In addition, Asus will also preinstall MemTestx86 on the UEFI of some of its Z590 ROG boards, giving you an easy way to test your memory properly for errors without having to boot from a separate thumb drive.

ALPHACOOL EISBAER GETS G/14IN QUICK-RELEASE CONNECTORS

Water-cooling specialist Alphacool has introduced a new quick-release connector kit for its all-in-one liquid cooling systems, making it easy to disconnect the tubing.

Alphacool's previous HF quick-release system for its AIO coolers looked untidy, as it was mounted in the middle of the tubing. However, the new system features G1/4in threads, so the connector can be tidily fitted directly to the waterblock or radiator.

The fittings feature a twist-lock system and are made from nylon. Alphacool says the new HF quick-release connector kit is compatible with all its Eisbaer systems, as well as its Eissturm external cooling system.

RAZER UNVEILS KEYBOARD WITH ANALOGUE SWITCHES

Snaky peripheral maker Razer has released a new gaming keyboard, with optical switches that have variable analogue control, rather than a single actuation. The new Razer Analog Optical Switches feature an analogue input that the company says emulates an analogue joystick for 'smoother more nuanced control and manoeuvrability'.

In addition, the switches' actuation level is adjustable from 1.5mm to 3.6mm, and you can set two stages to the actuation process. Razer calls the latter feature Dual-step Actuation, and it means you can effectively assign two purposes to each key, depending on how far down you press it.

The Razer Huntsman V2 Analog is the first keyboard to feature the new switches, but it's not cheap, with a UK price tag of £250 inc VAT.

ZOTAC MAKES MINING FAUX PAS

Zotac has caused a kerfuffle on Twitter this month, after its US Twitter account proudly shared a photo of a line of its GeForce RTX 3070 Twin Edge OC White Edition cards installed in a system, with the caption 'An army of #ZOTACGAMING GPU's hungry for coin!' Zotac then poured more petrol on the fire by adding several PC gaming hashtags to the tweet.

The tweet resulted in a very negative reaction, and not just from people who can use apostrophes properly. Many gamers are irritated that the latest GPUs are so difficult to buy, partly because of their popularity with cryptocurrency miners. The post has since been removed.

SAPPHIRE UNLEASHES TOXIC MONSTER

Sapphire has released a massive limited-edition Radeon RX 6900 XT card, which is equipped with three power connectors and a massive AIO liquid-cooling system with a 360mm radiator. In addition, there's a fan on top of the stack of heatsink fins inside the GPU cooler itself, which shifts air from the memory and VRMs.

Sapphire says that the cooler system means the GPU stays below 70°C, with a noise output below 34dBA. The immense cooling power has also enabled Sapphire to push up the clock speed, quoting a game clock of up to 2135MHz and a boost clock of up to 2365MHz. However, you can also enable Sapphire's Toxic Boost system, which will reportedly allow the GPU to boost even further than 2365MHz.

As a point of comparison, a standard Radeon RX 6900 XT has a 2015MHz game clock and a 2250MHz boost clock. With this level of cooling power, however, the Sapphire Toxic card should also be able to maintain high clock speed boosts for longer than a standard air-cooled card. Sapphire quotes the price of the Toxic card at £1,299 inc VAT, but that's obviously a bit of a laugh with the current stock situation – **overclockers.co.uk** is currently listing it at £1,799 inc VAT, and it's not in stock either.

Letters

Please send us your feedback and correspondence to
custompc@raspberrypi.com

One more Valhalla test?

While your recent graphics card reviews were interesting, I wondered if you might be able to do me a little favour and run one of your new tests on an old GPU. I currently have an AMD Radeon RX 5700 XT, and I'm very interested in Assassin's Creed Valhalla (I'm a Bernard Cornwell fan, and I love the idea of traipsing around Anglo-Saxon England).

However, if I buy the game now, and it runs like a dog, I know I'm going to end up looking for a new GPU on eBay, and then I'm going to be much poorer. The new Radeons cope with the game surprisingly well – how do the old ones fare?

You don't happen to have an old Radeon RX 5700 XT knocking about, do you? If so, would you mind running your Assassin's Creed Valhalla test on it? I have a 2,560 x 1,440 monitor that runs at 60Hz (no active sync, it's quite old). Will I need a new GPU, or can my existing one do the job? Go on, help out a fellow tech and history nerd.

JUSTIN ALEXANDER

Ben: As luck would have it, we do have a Radeon RX 5700 XT here Justin, and I've run our Assassin's Creed Valhalla test on it for you. We test at the Ultra High preset with High anti-aliasing, where the 5700 XT maintained an average of bang on 60fps, with a 99th percentile result of 44fps. It only hits the latter rarely though – the 90th percentile result is 53fps.

That's not far off the GeForce RTX 3060 Ti (48fps 99th percentile, 64fps average), which isn't bad when you consider that it's the performance-equivalent of the GeForce RTX 2080 Super from the last generation.

If you drop down to Very High settings with Medium anti-aliasing, you get an average of 69fps and a 99th percentile result of 49fps (90th percentile of 59fps). In short, Valhalla is perfectly playable on your GPU at the top settings. It will only take a little more tweaking to get it running constantly at a vsync-friendly 60fps. Happy exploring!

The Radeon RX 5700 XT is still perfectly capable of playing Assassin's Creed Valhalla at decent settings

When's the next issue out?

CUSTOM PC

APRIL 01

Issue 213
On sale on Thursday, 1 April

Stock broken

That's it, I'm done. I've given up hope of upgrading from the GeForce GTX 1070 I bought years ago. I've watched the new GPUs disappear from the shops minutes after going on sale, then appear on eBay at twice the price. I've watched supplies get hoovered up by crypto miners in large quantities. I've watched Overclockers add Big Navi cards to the 3D printer sections of its website at ridiculous prices – it's got so silly that system builders are selling PCs without GPUs now.

Nvidia's latest graphics cards are practically non-existent at retail

I couldn't even upgrade to a Turing card if I wanted – they've all gone – even the non-RTX ones! If I want a new graphics card at a normal price, I have to either buy a GeForce GT 1030, or hand over a ludicrous sum of money to an eBay scalper. Your graphics card test made me want to buy a new GPU, but they've all gone – what am I supposed to do?

STEVE WHITE

Ben: We all feel your frustration Steve. A currency-mining boom, new technology, huge demand, soaring shipping costs and a global pandemic have combined to create a truly ridiculous situation for gamers – it's not just on the PC – stock of the PlayStation 5 has become a joke as well.

Unless you're happy to pay over the odds, all we can do is wait it out. We've experienced a GPU shortage resulting from a mining boom before – it subsided after a few months and GPUs eventually came back into stock. Assuming the world can get to grips with the pandemic, this situation won't go on forever. In the meantime, we might just have to stick with our old GPUs for a few months longer than we'd like.

Chillblast

CUSTOM BUILT PCs

Get the Perfect PC for your needs and budget.

Anything you dream of

Choose from our pre-made specifications, use our website or speak to our friendly team to build the perfect computer for your needs. Something quiet and simple? Or something bright and powerful, we cater for all needs.

Complete Support

Our PCs are hand-built in our UK facility, come with Windows 10 pre-installed and are rigorously tested to ensure the utmost reliability. Backed by our industry leading 5-year warranty and lifetime access to our support staff, you're in good hands.

Finance Available | Free UK delivery | 5 year warranty | Lifetime-Support | Trustpilot Rated 'Excellent'

Call our sales team on: 01202 068 333

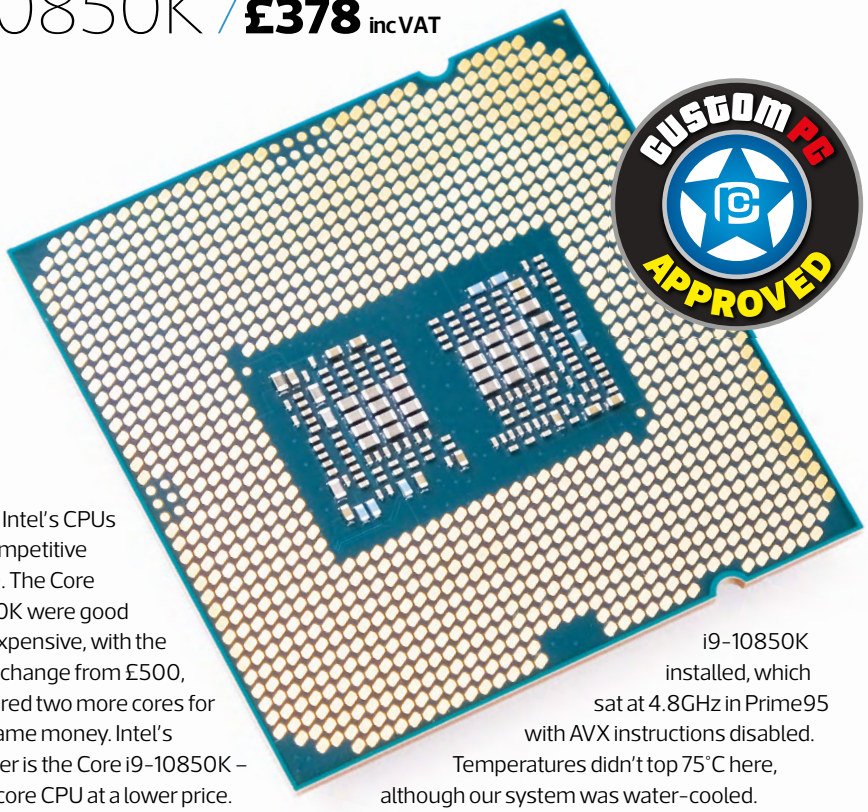
www.chillblast.com

Reviews

LGA1200 CPU

INTEL CORE i9-10850K / £378 inc VAT

SUPPLIER ebuyer.com



One main reason why Intel's CPUs haven't been that competitive recently is their price. The Core i5-10600K and Core i9-10900K were good CPUs, but they were just too expensive, with the latter not leaving you with any change from £500, while the Ryzen 9 5900X offered two more cores for the same money. Intel's answer is the Core i9-10850K – a 10-core CPU at a lower price. What's more, it's in stock in the shops, which is more than you can say for AMD's Ryzen 9 5900X.

In the Core i9-10850K's favour, it has the same ten cores and 20 threads as its more expensive siblings and surprisingly hefty frequencies, despite coming from lower-binned rungs of Intel's production line. It has a 5.2GHz peak boost frequency, which is only 100MHz short of the flagship, with the same deficit on the base frequency and Turbo Boost Max 4 and 2 speeds.

At stock speed, the Core i9-10900K's all-core boost sat at 4.9GHz in our water-cooled test system, and again it was a 100MHz deficit with the Core i9-10850K installed, which sat at 4.8GHz in Prime95 with AVX instructions disabled. Temperatures didn't top 75°C here, although our system was water-cooled.

We're still dealing with a 14nm CPU here, though, and there haven't been any significant changes under the hood. By the time you read this, Intel's new Rocket Lake CPUs will be approaching too. You also get the same 20MB of L3 cache as the 10900K, with 256KB of L2 cache for each core.

In short, apart from the possibility of a slightly higher overclock thanks to preferential binning, the Core i9-10900K doesn't offer any benefit on paper that will result in noticeably more performance. In terms of price, its main competitors are AMD's Ryzen 5 5600X at around £340 and the Ryzen 7 5800X at £420.

SPEC

Base frequency
3.6GHz

Max boost frequency
5.2GHz

Core
Comet Lake

Manufacturing process
14nm

Number of cores
10 x physical (20 threads)

Cache
20MB L3, 10 x 256KB L2

Memory controller
Dual-channel DDR4, up to 2933MHz

Packaging
LGA1200

Thermal design power (TDP)
125W

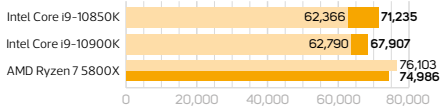
Features
Thermal Velocity Boost, Turbo Boost Max 3, Turbo Boost 2, FMA3, F16C, SHA, BMI / BMI1 + BMI2, AVX-512, AVX2, AVX, AES, SSE4a, SSE4, SSSE3, SSE3, SSE2, SSE, MMX

Performance

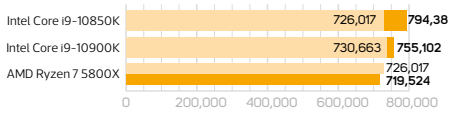
At stock speed, the Core i9-10850K largely performed as expected, with scores nearly identical to the Core i9-10900K. The image editing score was within a few hundred points, and the video editing scores of 730,663 and 726,017 were neck and neck, as were the overall system scores. There were barely 200 points between the

BENCHMARK RESULTS

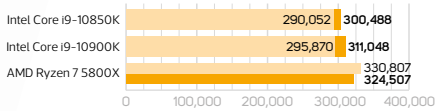
GIMP IMAGE EDITING



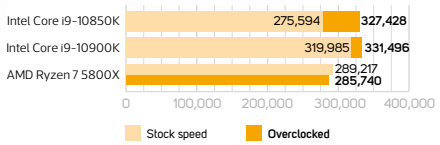
HANDBRAKE H.264 VIDEO ENCODING



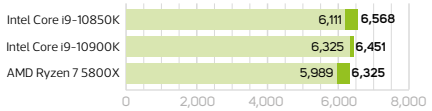
HEAVY MULTI-TASKING



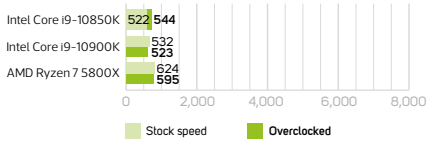
SYSTEM SCORE



CINEBENCH R20 MULTI-THREADED

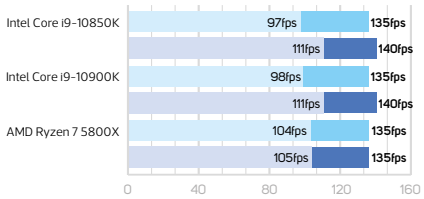


CINEBENCH R20 SINGLE-THREADED



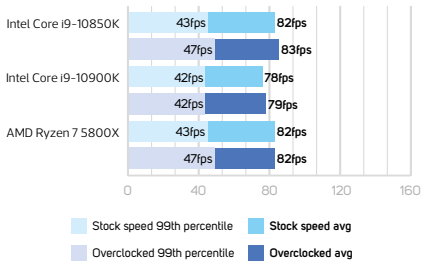
FAR CRY NEW DAWN

1,920 x 1,080, Ultra settings

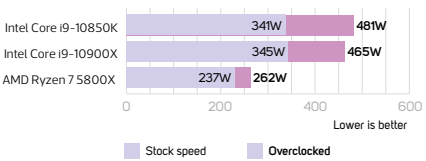


METRO EXODUS

1,920 x 1,080, Ultra settings, HairWorks off



LOAD TOTAL SYSTEM POWER CONSUMPTION



two chips in the Cinebench multi-threaded test too. The single-threaded test of 522 was a little way behind the Core i9-10900K's result of 532, but the game results were very similar.

Overclocking also proved very fruitful, and our sample actually managed to better the 5.1GHz all-core overclock we achieved with the Core i9-10900K, reaching 5.2GHz with 1.35V, although we did need to apply some fairly high loadline calibration to get there. Still, this means we see no drop in peak boost frequency, since 5.2GHz is the same clock the CPU can achieve at stock speed. The already hefty power draw rose from 341W for the system under load to 481W though.

The boost from overclocking was significant, with the Core i9-10850K leapfrogging the Core i9-10900K in the image editing and video encoding test, and coming within the margin of error overall.

In games, while the Core i9-10850K was slower than the Ryzen 9 5800X at stock speed in Far Cry New Dawn, it leapfrogged all the AMD CPUs we've tested once it was overclocked, with the 99th percentile frame rate rising from 97fps to 111fps, compared to 104fps for the Ryzen 9 5800X. Metro Exodus, meanwhile, saw the 99th percentile frame rate rise from 43fps to 47fps – again, a faster result than the AMD CPU.

Conclusion

The Core i9-10850K is an interesting CPU for a few reasons. Firstly, as it has two more cores than the Ryzen 7 5800X, it offers similar multi-threaded performance for less cash. AMD is clearly offering far more performance per core here, but in terms of bang for your buck, Intel has a strong case. It's also not likely to be noticeably slower in games, but even our comparatively modest RTX 2070 Super showed a definite advantage over the AMD CPUs at 1080p. Above this, though, the differences will get smaller.

The issue for Intel is that its IPC and single-threaded performance – while excellent at launch – is no match for Zen 3. The Core i9-10850K also has no support for PCI-E 4 for the latest SSDs either, unlike AMD's Zen 3 chips. AMD's CPUs had massive leads in our image editing test, and will have leads in other games and lightly threaded applications too.

For a pure gaming system, the Ryzen 5 5600X is a better bet for the money, while the Ryzen 7 5800X costs £40 more but has that extra lightly threaded grunt. Still, if £400 is your limit, the Core i9-10850K offers great performance when it's overclocked, where it can still match AMD's latest chips.

ANTONY LEATHER

VERDICT

As quick as a Zen 3 CPU when it's overclocked, and it offers much better value than Intel's other 10-core K-series CPUs.

TEN CORES

- \+ Good overclocker
- \+ Matches Core i9-10900K in most tests
- \+ As quick as AMD CPUs when overclocked

TEN GREEN BOTTLES

- – AMD CPUs faster at stock speed
- – Poor power efficiency
- – No PCI-E 4 support

PERFORMANCE **40/50**

FEATURES **14/15**

VALUE **30/35**

OVERALL SCORE **84%**

MINI-ITX CASE

THERMALTAKE TOWER 100 / £90 inc VAT

SUPPLIER overclockers.co.uk

If you like your mini-ITX cases to be barely any bigger than the hardware they house, with your graphics card sitting end-to-end in a shoebox-sized enclosure, look away now. Large cases aren't unusual for Thermaltake, as its oversized behemoths stretch from its mini-ITX offerings all the way up to its full towers. It's the mini version of one of the latter that we're looking at here, as the Tower 100 is essentially a dinky version of the monstrous Tower 900.

At £90 inc VAT, it's certainly more affordable than other mini-ITX cases we've reviewed recently, and it's also well made, sturdy and not as flimsy as its price might suggest. However, at 46cm tall and 27cm deep, its size eclipses every other tower mini-ITX case out there. Part of the reason for this is its huge panoramic set of glass windows, which provide a fantastic view into the case, a bit like a compact aquarium, with your hardware taking centre stage.

Thermaltake has improved on the prototype of this case we saw at CES last year, adding more vents for improved cooling. The vertical graphics card mount now sits partly over the side vent, so while there's still a big pane of glass in front of your graphics card, there is at least a nearby vent feeding it cool air, so it won't cook. With 330mm of clearance, there's space for a sizeable card too.

The CPU cooler height stands at 190mm, so there will be no issues accommodating even the biggest heatsinks.

However, despite the size of the case, there's only support for a single 120mm AIO liquid cooler with its radiator located in the roof. This is probably the oddest design element of the Tower 100, as larger mini-ITX cases usually focus on providing better water-cooling support than their smaller counterparts.

You can just about squeeze another radiator into the second 120/140mm fan mount, but only if you use a custom loop with a super-slim model such as XSPC's TX120, along with a 15mm-thick fan – standard-size fans and radiators won't fit here. There's a third 120/140mm fan mount on top of the PSU mount in the base, but most other cases of this size still provide more than three fan mounts in total. Two 120mm fans are included in the box, which reside in the roof and rear of the case.

The rest of the case is well thought-out, with each of the three glass-clad panels paired up with vented panels below them. These panels allow air into the bottom of the case, which otherwise wouldn't be possible if the glass stretched from the top to the bottom. The base and roof also sport large vents, so aside from the potential three fans, the case also lends itself to a bottom-to-top movement of air, getting rid of heat with a chimney effect.

Storage support is also restricted, though, with space for up to two hard disks if you don't use a rear fan and up to two SSDs using a side bracket. That's hardly stellar for such a large case. You do get a Type-C USB 3.1 Gen 2 port, though, plus two USB 3 ports. Plus, if the black model looks a little bland for your tastes, it also comes in white.

We can't deny that the Tower 100 looks appealing in the flesh. Its girth and width are reasonably restrained, and you get an unparalleled view of your hardware in a unique chassis that's sure to generate some interest. It's fairly easy to create a clutterfree PC in it too, as the PSU is housed below the motherboard in its own chamber, with cable-routing holes provided to thread cables through to the motherboard and graphics card.

Your hardware should stay looking shiny too, as there are several dust filters covering every vent and hole. However, the build process isn't quick. Each panel has its own mounting

SPEC

Dimensions (mm)
463 x 266 x 266 (W x D x H)

Materials
Steel, glass

Available colours
Black, white

Weight
6.1kg

Front panel
Power, reset, 2 x USB 3, USB 3.1 Type-C, 1 x stereo jack, 1 x mic jack

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

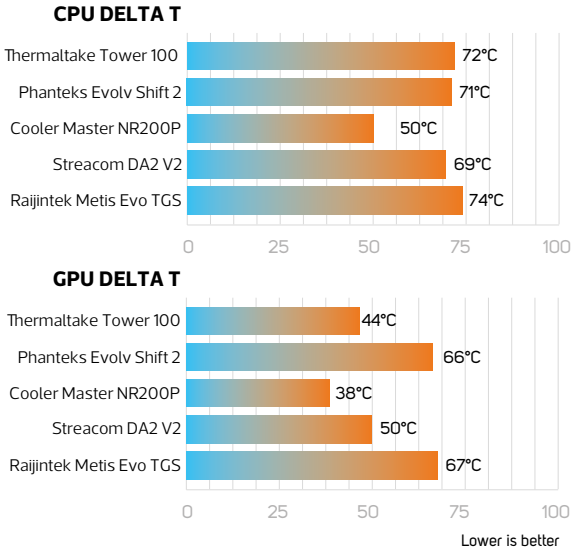
Form factor(s)
Mini-ITX

Cooling
1 x 120/140mm rear fan mount (1 x 120mm fan included), 1 x 120/140mm base fan mount (fan not included), 1 x 120/140mm roof fan mount (120mm fan included)

CPU cooler clearance
190mm

Maximum graphics card length
330mm

TEMPERATURE RESULTS



mechanism, and there are more than ten individual pieces of the exterior, which makes getting inside the case a bit of a faff. Single-piece side panels would solve this problem, but we would prefer the status quo if it meant reducing the number of mesh panels.

Performance

With such an unusual design, we couldn't estimate how the Tower 100 would perform, but with a CPU delta T of 72°C, it's clear that it's not particularly well suited to low-air profile coolers, which is what we used in the test. It would benefit from an AIO liquid cooler instead. This result was similar to that of the Phanteks Shift 2 and Streacom DA2 V2, and a little cooler than the Raijintek Metis Evo TGS, but noticeably warmer than the Cooler Master MasterCase NR200P.

The GPU delta T was more competitive at 44°C, and that large side vent clearly helped here – this result was only second to the 38°C achieved by the NR200P in our tests. This temperature was 22°C cooler than the Phanteks Shift 2 and it even managed to beat the Streacom DA2 V2. The case was quiet too, with the fans buried in the case seeing much of their noise deadened by the various panels and filters.

Conclusion

The design of the Thermaltake Tower 100 is far more focused on creating a unique design and view of your hardware than on cooling performance or features. There's next to no water-cooling support, which is odd given its size, storage support is limited and it has few standout features, which a lot of the current cream of the crop use as their main selling points. Comparatively, the Streacom DA2 V2 is highly customisable, while the Cooler Master MasterCase NR200P offers great out-of-the-box cooling and good water-cooling support.

The Tower 100 is quite attractive, though, and the extensive use of glass really does make you take a second glance at it. We'd love to see a build in it that makes extensive use of RGB lighting, especially in the white model. Overall, it has a funky design and will appeal to those who want something different. As long as you're aware of its shortcomings, the Tower 100 is a reasonable chassis in which to house a high-end mini PC, as long as you maximise your CPU cooling.

ANTONY LEATHER

TOWER OF LONDON

- \+ Interesting, unique design
- \+ Great view of hardware
- \+ Good GPU cooling

TOWER OF SAURON

- – Poor use of space
- – Lacks water-cooling and storage potential
- – Too many panels

COOLING 23/40

FEATURES 14/20

DESIGN 25/20

VALUE 17/20

OVERALL SCORE 79%

VERDICT

An alluring case with good GPU cooling and a great view of your hardware, but it has some limitations.

25IN GAMING MONITOR

ASUS ROG SWIFT PG259QNR / £750 inc VAT

SUPPLIER overclockers.co.uk

The ROG Swift PG259QNR is Asus' new flagship high-refresh gaming monitor, sporting a maximum refresh rate of a whopping 360Hz. What's more, it includes a new system latency tracking tool, where you plug your mouse into the screen and it will tell you the delay between clicking the mouse and the muzzle flash (or other trigger) appearing on screen. It's impressive stuff, but does it add up to being the ultimate performance gaming monitor?

The biggest elephant in the room is the size and resolution. When you're paying £750 and still just getting a 1080p screen with a 25in diagonal, it doesn't make for the most dazzling first impression. Thankfully, the image quality is decent. The use of an IPS panel means viewing angles are very wide, and you get a stable image with none of the colour shimmer that can affect TN panels. Contrast is high too, for a standard IPS panel, measuring 1,148:1 in our tests. As such, there's a good depth and punchiness to the image.

Colour accuracy is good out of the box as well, if not quite perfect. The menu offers a host of image quality tweaking options, including seven colour temperature presets and five gamma options. By default, it's set to a 6,500K temperature and 2.2 gamma, which is what we'd expect, but in our tests its colour temperature was just a smidge off, registering 6,962K. Nonetheless, for gaming and the vast majority of other tasks, this display is good to go right out the box.

Meanwhile, the menus are packed with features and are easy to navigate thanks to the excellent mini joystick controls on the back. One setting you won't find, though, is Asus' ELMB sync mode, which allows for backlight-strobing blur reduction with G-Sync.

Instead, you just get Nvidia's ULMB mode, which doesn't work with G-Sync, and only works at up to 240Hz. Comparatively, the likes of the Asus VG279QM offer ELMB-sync at 240Hz, and 240Hz with backlight strobing is actually better for image clarity in fast motion than 360Hz without it.

Speaking of which, that 360Hz refresh rate is impressive in action. It's not a night and day difference compared with a 240Hz panel in real-world gaming, but there is an extra level of smoothness. However, you'll need some serious GPU power to get many games to run at that frame rate. Even the lowly CS:GO required us to drop most settings to Medium with no AA to regularly get above 300fps on a GeForce GTX 1080 Ti at 1080p, for example.

Meanwhile, the Nvidia Reflex Latency Analyzer technology is genuinely useful for optimising your games' latency. We were able to measure a noticeable difference in average total system latency between 360Hz and 240Hz (18.4ms vs 38.0ms), and between running a game with all the graphics settings turned down (18.4ms) and all of them turned up (26.3ms).

FULL CIRCLE

+ Exceptional gaming performance
+ Fantastic image quality
+ Genuinely useful latency analysing tool

ROUND THE TWIST

− Very expensive
− Lacks ELMB-Sync
− 360Hz is overkill for most

SPEC

Screen size
25in

Resolution
1,920 x 1,080

Panel technology
IPS

Maximum refresh rate
360Hz

Response time
1ms

Contrast ratio
1,000:1

Active sync
G-Sync

Display inputs
1 x DisplayPort 1.4, 1 x HDMI 2

Audio
Headphone jack

Stand adjustment
Height, pivot, rotation, tilt

Extras
100 x 100mm VESA mount, Aura Sync RGB lighting, 2 x USB 3 ports

HDR standard
DisplayHDR 400

Conclusion

The Asus ROG Swift PG259QNR can quite legitimately claim to be the ultimate performance gaming monitor, as it's the only one on the market to offer a 360Hz refresh rate – the next closest is 280Hz. It also offers excellent image quality, even if it is at a low resolution.

However, the lack of ELMB-Sync is a major detractor and the price is hard to swallow. At the very least, opting for the version without the latency analyser (PG259QN) will save you £100. If you want the very fastest gaming monitor at whatever cost, though, this is it.

EDWARD CHESTER

IMAGE QUALITY 23/30
GAMING 30/30
FEATURES 17/20
VALUE 10/20

OVERALL SCORE 80%

VERDICT

An astonishing gaming display, but plenty of competitors offer nearly as good performance for much less money.

27IN GAMING MONITOR

ALIENWARE AW2721D / £700 inc VAT

SUPPLIER dell.com

Alienware's AW2721D is built for fast-paced gaming, with a 2,560 x 1,440 resolution, a 240Hz refresh rate, a 3ms response time and Nvidia G-Sync Ultimate. It lives up to the hype, with no tearing or stuttering and noticeably improved responsiveness compared with 144Hz panels. We tested it in fast-paced games, including CS:GO, Rainbow Six Siege and Doom Eternal – and in BlurBusters' benchmarks – and it was crisp and smooth.

The 3ms response time can also be tightened to 2ms or 1ms with overdrive modes. However, these modes introduce noticeable inverse ghosting, so it's not worth using them.

The only way to get a much faster refresh rate is to switch to a 360Hz display (see the Asus display opposite), but most gamers will be sated by 240Hz. You can find 1ms or 0.5ms panels elsewhere if you're a particularly demanding esports player, but those displays don't have the features or quality of the Alienware. The only notable omission is motion blur reduction technology.

The panel's default brightness level of 235cd/m^2 is ample and the black point of 0.23cd/m^2 is reasonable for an IPS display. The contrast of 1,022:1 is solid – some other IPS displays are a little better, but it's only significantly improved on a VA panel. The delta E of 2.03, colour temperature of 6,458K and gamma level of 2.23 are great, and the Alienware rendered 99.8 per cent of the sRGB gamut at 136 per cent volume. Colours are punchy and vibrant, with decent depth.

Meanwhile, enabling HDR allows the Alienware to hit a maximum brightness of 663cd/m^2 and a black point of 0.1cd/m^2. The revised contrast level of 6,630:1 is great here, and this display exceeds DisplayHDR 600's requirements while rendering 95.5 per cent of the DCI-P3 gamut.

The Alienware does deliver a reasonable improvement in HDR games, but its relatively unsophisticated edge-lit dimming system means it lacks subtlety when compared with pricier DisplayHDR 1000 panels with full-array dimming. Nvidia's G-Sync Ultimate spec originally called for displays to hit 1,000cd/m^2 and use multi-zone backlighting, but Nvidia has relaxed those rules, so G-Sync Ultimate displays don't need to hit those marks any more. There are other minor considerations. While this screen uses 10-bit colour, it's restricted to 8-bit beyond 144Hz. FreeSync also only works over DisplayPort, and this display can't handle the Adobe RGB gamut.

The Alienware is impressive physically too. It's fully adjustable, robust and good-looking, with a monochromatic design, slim bezels and RGB LEDs. The OSD is navigated by a sturdy joystick, and the on-screen menu is slick. It also sports four USB 3.2 Gen 1 ports, but no USB Type-C.

SPEC

Screen size
27in

Resolution
2,540 x 1,440

Panel technology
IPS

Maximum refresh rate
240Hz

Response time
3ms

Contrast
1,000:1

Active sync
G-Sync Ultimate and FreeSync

Display inputs
1 x DisplayPort 1.4, 2 x HDMI 2

Audio
Headphone jack

Stand adjustment
Height, pivot, rotation, tilt

Extras
100 x 100mm VESA mount, RGB LEDs

HDR standard
DisplayHDR 600

Conclusion

The Alienware AW2721D delivers fast, crisp, and smooth gaming in high-end single-player titles and competitive games, and it's bolstered by good image quality, adjustability and design. The inverse ghosting in the overdrive modes, and the lack of motion blur reduction, may prompt the most demanding esports players to look elsewhere, though, and HDR fans also won't be sated by this display. For fast-paced gaming and esports, though, the Alienware is one of the best displays around – it's expensive, but it's delivered with superb features and execution.

MIKE JENNINGS

VERDICT

Fast, smooth, crisp and feature-packed, this attractive monitor is ideal for fast-paced gaming.

ROSWELL

+ Smooth, stutter-free operation
+ Great image quality
+ Attractive design

NOT WELL

– No motion blur reduction
– Inverse ghosting in overdrive modes
– HDR could be better

IMAGE QUALITY **26/30**

GAMING **27/30**

FEATURES **17/20**

VALUE **15/20**

OVERALL SCORE **85%**

PCSPECIALIST

CUSTOM GAMING
DESKTOPS AND LAPTOPS

CUSTOM BUILT TO YOUR SPEC

EASY TO USE CONFIGURATOR

CUSTOM PCS & LAPTOPS

AWARD WINNING SYSTEMS

COBALT PRO

Intel® Core™ i7-10700K
ASUS® TUF Z490-PLUS GAMING
16GB Corsair VENGEANCE 2666MHz
8GB GEFORCE RTX 2070 SUPER
256GB PCS 2.5" M.2 SSD
2TB SEAGATE BARRACUDA HDD
Genuine Windows 10 Home

This spec from
£1,541.99

OPTIMUS PRO

15.6" Matte Full HD 120Hz Screen
AMD Ryzen™ 7 Eight Core Processor 4800H
8GB Corsair 2400MHz DDR4
4GB GeForce GTX 1650 Ti
128GB ADATA SX6000 LITE M.2
Genuine Windows 10 Home

This spec from
£920.99

COBALT ELITE

Intel® Core™ i5-10600K
ASUS® PRIME Z490-P
8GB Corsair VENGEANCE 2400MHz
6GB GEFORCE GTX 1660 SUPER
256GB PCS 2.5" M.2 SSD
1TB SEAGATE BARRACUDA HDD
Genuine Windows 10 Home

This spec from
£934.99

ORDER ONLINE NOW AT
WWW.PCSPECIALIST.CO.UK

0333 011 7000

/PCSpecialist @PCSpecialist

GET A FURTHER £15 OFF WITH THIS EXCLUSIVE VOUCHER CODE: **CPC21**

* Prices are including VAT and are correct at the time of printing, but subject to change.

NAS ENCLOSURE

WD MY CLOUD EX2 ULTRA / £135 inc VAT

SUPPLIER shop.westerndigital.com

While having a countless choice of apps and features is useful on smartphones and tablets, when it comes to NAS enclosures, many of us just want the basics, such as shared folder access, media servers and cloud storage. Thankfully, there's plenty of basic units out there that don't bump up the price with needless bells and whistles running in the background, and WD's offerings are great examples, with the WD My Cloud EX2 Ultra even having the option of coming with hard disks pre-installed.

However, despite WD being the manufacturer of both the NAS and the hard drives themselves, you pay a lot more for pre-installation than the cost of buying them separately. It's much cheaper to buy your own drives and opt for the empty enclosure, which costs just £135 inc VAT. With a pair of 4TB WD Red hard disks, the whole setup will set you back around £320, but WD wants nearly £400 to sell you the same hardware, albeit preconfigured.

We know which option we'd pick, especially as setting it up is quick and painless, just requiring you to select the RAID option you want to use and leaving it for ten minutes while the NAS box sets itself up. The My Cloud EX2 Ultra has two pull-out trays that support either 3.5in or 2.5in drives, and under the hood sits 1GB of DDR3 memory and a dual-core 1.3GHz Marvell Armada 385 CPU – that's quite a modest spec compared with the competition from the likes of Synology.

Thankfully, the My Cloud EX2 Ultra has most of the features you need from a basic NAS. Its interface is simple and clear to use, and while there are apps you can download, it's a far smaller pool compared with the large catalogues offered by the likes of Synology and QNAP offer.

Importantly, though, you get a download manager that can handle BitTorrent, support for cloud storage services, including a Dropbox app, plus various media servers, including Plex, Twonky and iTunes. You can easily create shared network folders and file shares via its cloud service too. Meanwhile, there are two USB 3 ports on the rear, allowing you to easily add a backup drive or copy files onto the NAS without going over a network connection.

There's an interesting cooling configuration as well, with a notable lack of a cooling fan but plenty of ventilation. As such, the My Cloud EX2 remained quiet during testing, just exhibiting the usual hard disk grunts, but was free from rattles and clicks. Unlike the QNAP TS-231P3 (see opposite), the My Cloud EX2 is limited to Gigabit speeds, although that's not surprising for the price.

As such, 125MB/sec is the maximum you'll see in perfect conditions, and the AJA Video Systems benchmark returned read and write speeds of 102MB/sec and 103MB/sec respectively, with our video file copy test peaking at 112MB/sec. Dealing with folders filled with small image files saw these speeds fall to between 50-60MB/sec.

Conclusion

The WD My Cloud EX2 Ultra costs around £30 less than the Synology equivalent, but despite it offering fewer features and apps, is still an attractive proposition. It's simple, does its job very well and WD's documentation is easy to follow when it comes to delving into apps and networks shares.

Despite its lowly specifications, it coped well when dealing with our benchmarks, hitting near Gigabit-speeds with large files and still managing to maintain around 50MB/sec with folders of smaller ones. If you have the extra money, it's worth opting for a Synology or QNAP NAS for the added features and performance, but if you're strapped for cash and just need the basics, the My Cloud EX2 Ultra is definitely worth considering.

ANTONY LEATHER

SPARE RIBS

+ Good transfer speeds
+ Easy setup
+ Reasonable price

BROKEN RIBS

− Pre-configured units too expensive
− Limited apps and features
− No cooling fan

VERDICT

Simple, but fast enough and easy to set up. However, you'll want to buy your hard disks separately.

PERFORMANCE	29/35
FEATURES	28/35
VALUE	28/30
OVERALL SCORE	85%

NAS ENCLOSURE

QNAP TS-231P3

/ **£275** inc VAT

SUPPLIER ebuyer.com

If you're building a tiny PC and don't have room for several hard disks, or if you just want to house all your data in one enclosure that you and your family can access from anywhere, as well as offering the benefits of media servers, a NAS enclosure is a very useful tool.

We're familiar with these devices offering apps and supporting remote access and cloud functions, but there's a renewed push in boosting transfer speeds beyond the usual 1 Gigabit speeds that seem to have been stuck with us for eternity. QNAP has begun ushering in 2.5 Gigabit speeds into the lower echelons of its NAS range, meaning the dual-bay TS-231P3 has the theoretical potential to transfer data at up to 312MB/sec rather than 125MB/sec maximum you'd see from a typical Gigabit-limited NAS.

Of course, a lot of the resulting performance will depend on the storage you use too. Some NAS enclosures include caching, or the ability to install an SSD to boost transfer speeds, for example. However, while the TS-231P3 does have the ability to house an SSD and use it for caching, even including a tool to test different setups, you lose an entire hard disk bay in the process, making it a questionable course of action in this dual-bay NAS, especially as SSDs are still much pricier than hard disks.

Setting up the TS-231P3 is simple and is most easily achieved on your smartphone, where you scan the QR code on the side of the NAS and follow the instructions. It will then install the latest operating system and a basic set of apps. It's also simple to install more apps via a well-stocked app store, where you'll find a download manager that can handle BitTorrent downloads with its own scheduler, as well as its own music, surveillance and media servers, plus Plex support.

You get both 2.5 Gigabit and 1 Gigabit ports, plus a 70mm fan that remained quiet throughout testing, as well as three USB 3 ports with one on the front to allow fast copying from external storage devices. It also uses a 1.7GHz quad-core Annapurna Labs Alpine AL-314 (ARM Cortex-A15) CPU, along with 2GB of DDR3L RAM. Despite being extremely compact, the TS-231P3 also did a great job of minimising noise and vibration from the hard disks too.

For testing, we hooked up the NAS to a 2.5 Gigabit port on a Z490 motherboard, via a 2.5 Gigabit switch, which resulted in read and write speeds varying between 150MB/sec and 200MB/sec with single large file transfers, with a peak of 240MB/sec in CrystalDiskMark and the AJA Video Systems benchmark, using both 512MB and 1GB file transfer sizes.

These are all noticeably quicker than the maximum 125MB/sec speeds you'd see over a Gigabit connection, but due to bottlenecks elsewhere, namely the hard disks that were configured in a RAID 1 array, it was a little disappointing to see speeds fall well short of the 300MB/sec+ you could theoretically achieve.

Conclusion

The QNAP TS-231P3 is the fastest NAS we've ever tested, assuming of course that you have the network hardware to match. Testing it ultimately proved that you can see significant improvements in file transfer speeds by shifting from 1 Gigabit to 2.5 Gigabit, which these days may only require a switch costing around £100 if you have an appropriate motherboard.

Secondly, however, it also proved that there are plenty of bottlenecks, such as the hard disks themselves, so while the TS-231P3 is definitely worth considering if you already have 2.5 Gigabit hardware, if speeds are your priority, it's worth opting for 10 Gigabit-capable hardware (assuming you have a Cat6 cable installation), and/or a NAS that can offer a more elegant system for SSD caching. If your budget doesn't stretch that far, though, the QNAP TS-231P3 is a great buy if you want to increase speeds without spending over the odds.

ANTONY LEATHER

VERDICT

A decent NAS with better-than-Gigabit speeds, but your network will need an upgrade too.

CACHE

+ Quad-core CPU
+ Simple setup
+ Excellent transfer speeds

CRASH

− Other bottlenecks can reduce speeds
− SSD caching disables one bay
− 10 Gigabit NAS boxes available for not much more

PERFORMANCE **34/35**

FEATURES **32/35**

VALUE **22/30**

OVERALL SCORE **88%**

GAMING CHAIR

VERTAGEAR PL4500 / £359 inc VAT

SUPPLIER currys.co.uk

GEARS OF WAR

+ Good seat padding
+ Great value
+ Decent overall build quality

GEARS OF CAR

– Too narrow for a tall chair
– Poor lumbar support cushion
– Lacklustre styling

Vertagear's P-Line (PL) range of chairs is aimed at bigger and taller gamers than most chairs, with the base level PL1000 made for people measuring up to 6ft 2in and weighing 110kg, while the range-topping PL6000 welcomes bodies up to 6ft 8in tall and weighing 169kg. The PL4500 sits in the middle, made for users up to 6ft 6in tall, although it's only rated for up to 100kg of weight.

This apparent focus on taller, slimmer gamers comes through in the shape of this chair, as it's not overly generous with its width. While the likes of the noblechairs HERO accommodates larger sitters by flattening out the various protrusions at the side of the chair, the Vertagear PL4500 has quite severe shoulder, hip and leg wings to keep you securely wedged into place. As such, even my fairly slim 6ft 2in frame didn't have a lot of room to manoeuvre.

Thankfully, the cushioning on the seat is much more generous. It's still on the firm side, but with a little more spring than the likes of the noblechairs HERO or Corsair T3 Rush. The contouring is good too, with a reasonable drop off at the front that prevents it from digging into your thighs.

Elsewhere, the overall comfort level on this chair is middling, with the lumbar support cushion being too hard and having too severe edges. It also doesn't have a strap system to hold it in place. The head cushion is pleasant and soft though.

In terms of styling, the black and blue combination here lacks a certain finesse for our tastes, although that's a subjective assessment. It's neither outlandish enough to be fun nor staid enough to go unnoticed. The combination of materials is more successful though. The wings are finished in a hard-wearing faux leather that should help the more exposed parts to stand the test of time.

Meanwhile, the seat and back cushions have a soft fabric finish that feels pleasant when you're sitting on them. Plus, the covering prevents you from sticking to the chair while also gripping your clothing, so you don't slide down the chair.

The chair has an impressive feature set for the price as well. You get a quality tilt system that lets you lock the chair in a number of reclined positions, and the tilt system is a little better balanced than some offerings too, allowing you to tilt yourself back without having to prop up your feet, like on cheaper gaming chair. The base is also a heavy-duty solid metal affair, and the castors have a large diameter and roll freely, making it a doddle to move this chair.

As with the Vertagear SL5000, you can also add RGB lights to the PL4500. For a whopping $300 US (around £260 inc VAT), you can adorn the holes in the seat's back with RGB lighting that will sync up with your system's RGB lighting. There's even a kit for another $300 US that will add underlighting to the base. It seems to us more than a little silly to spend so much money on RGB lighting for a chair – even a streamer surely couldn't justify the base lighting, but the option is there if you really must have as much RGB bling as possible.

Conclusion

The Vertagear PL4500 is a real mixed bag of a gaming chair. Its pricing in the UK is very competitive, with few chairs below the £400 mark offering the same uprated tilt system used here. The seat cushioning is good too, and there are quite a few other decent features, such as the quality of the castors. However, the lumbar support system is poor and overall comfort is middling. Its constriction from the various side wings also dents its apparent appeal to big and tall gamers.

EDWARD CHESTER

COMFORT 15/25
DESIGN 15/25
FEATURES 21/25
VALUE 22/25

OVERALL SCORE 73%

VERDICT

A good-value chair that offers plenty of features and decent build quality for the price, but it's lacking in some key areas.

HackSpace

TECHNOLOGY IN YOUR HANDS

THE MAGAZINE FOR THE MODERN MAKER

SUBSCRIBE AND SAVE UP TO 35% on the cover price

ISSUE **#40**

OUT NOW

hsmag.cc

Available on the App Store

GET IT ON Google Play

GAMING CHAIR

RAZER ISKUR / £499 inc VAT

SUPPLIER razer.com

LUMBAR SUPPORT

+ Premium build quality
+ Striking design
+ Decent armrests

LUMBERED WITH IT

– Lumbar support doesn't work well
– Overly rounded shoulder support
– Castors don't roll

Razer's Iskur is the company's one and only gaming chair, and while for the most part it offers much the same sort of feature set as the chairs we reviewed in last month's Labs test, it has one feature that really sets it apart. Instead of relying on a cushion for lumbar support, or offering the welcome but modest support provided by simply firming up a portion of the seat's back padding (as with the noblechairs HERO and many car seats), the lower portion of the seat's back hinges forwards from the top.

The idea is that you can adjust this section so that it really nestles into the small of you back and offers some support. However, at least in our testing, it just doesn't work. The peak of the back's curve sits too low at around 6in, so it pokes you in the backside, rather than the lower back.

It's not too bad in its default position, but pulling on the lever to spring it forward just results in it pushing your bum off the chair. People with shorter backs might get on better with this design, but we also measured several other chairs we had to hand, where the lumbar support sits around the 9in mark, suggesting the Iskur's support is lower than the industry standard.

The comfort issues didn't stop there either. The shoulder wings actively pushed my shoulders forward, creating a rolled shoulder posture. This issue affects several of these racing seat-style gaming chairs, but this was the only one I've tested where it affected my posture so badly.

Again, shorter users will likely fare better, but a gaming chair should still accommodate a 6ft 2in height. Moreover, it just goes to highlight the problems with shoulder wings on a gaming chair – they're the definition of style over substance. We can only advise you, by whatever means you can, to try before you buy with this chair, to make sure it fits your frame.

It's not all bad news though. While the green stitching is a little in your face, the Iskur largely looks fairly smart, with its attractively stitched faux leather finish, and build quality is solid as well. The stand, armrest arms and the various knobs and dials all feel good quality. The seat padding is decent too, providing a firm support but with a pleasant bit of springiness in it too.

One particular plus point is the '4D' armrests, which have contoured pads that are softer than some we've tested, and they also lock firmly into position. The only let down in terms of build quality is the castors. They simply don't seem to turn. The chair drags rather than rolls along.

The tilt mechanism also has a premium feel, and it can float freely and lock into any position. However, it doesn't have a default position that you can quickly lock back into – you always have to guess the angle at which you want to keep the seat and lock it into place. As a point of comparison, the set-and-forget system of the noblechairs HERO is much easier. We also found the weighting of the tilt system to be fairly poor, with it proving difficult to get the chair to stay tilted back without resting our feet on an object to raise them up.

Conclusion

In terms of style and build quality, the Razer Iskur is a cut above many gaming chairs, assuming you don't mind the in-your-face green details. It also offers a decent number of features and plenty of adjustability. However, it falls short when it comes to overall comfort. Of course, other peoples' mileage may vary here, depending on your height and body shape, but we found the adjustable lumbar support and shoulder wings made this chair decidedly uncomfortable.

EDWARD CHESTER

VERDICT

Not quite style over substance but certainly style over comfort.

COMFORT 10/25

DESIGN 20/25

FEATURES 20/25

VALUE 17/25

OVERALL SCORE 67%

GAMING LAPTOP

ASUS ROG ZEPHYRUS DUO SE GX551 / £3,499 inc VAT

SUPPLIER overclockers.co.uk

ZEPHYR

- + Fantastic GPU
- + Huge CPU power
- + Impressive design
- + High-end components

HURRICANE

- – Poor keyboard and trackpad layout
- – GPU isn't 4K-capable
- – Some heat issues
- – Expensive

Asus' Zephyrus Duo SE GX551 is one of the first RTX 3080 laptops to come out the door, and Nvidia's Ampere-powered portable GPU has a fearsome specification, including 6,144 CUDA cores and a 1545MHz boost clock and even up to 16GB of GDDR6 memory in the version used here. The mobile RTX 3080 is 2,560 CUDA cores short of the desktop card, but it's still mighty for a mobile chip.

This laptop also uses AMD's latest Zen 3-powered Ryzen 9 5900HX laptop CPU, with eight SMT-enabled cores and 4.6GHz turbo peak. The GX551 has 32GB of 3200MHz DDR4 memory and a 2TB RAID 0 storage array, comprising a pair of 1TB Samsung PM981 NVMe PCI-E 3 drives. The array delivers stupendous read and write speeds of 6,961MB/sec and 5,499MB/sec, but its striped configuration means data isn't protected if one drive fails. Meanwhile, networking comes from dual-band Wi-Fi 6 and Gigabit Ethernet, but there's no 2.5Gbps Ethernet.

The Asus also has three USB 3.2 Gen 2 ports and a Type-C connector, plus several ports are installed at the rear, so cable tidying is easier when you're at a desk. The power connector sits awkwardly about halfway down the left-hand edge, though, and most of the USB ports sit towards the front, so cables could obstruct your mouse. It's also disappointing to see just a micro-SD card slot, not a full-sized SD reader, and there's no webcam either.

The Duo's defining external feature is the ScreenPad Plus, which is installed in the base and pitches upwards when the laptop is opened, to improve viewing angles and cooling. It sits below the main display, which is a 15.6in IPS panel with a 120Hz refresh rate, a 4K resolution and Pantone certification – alongside a 3ms response time.

The 3,840 x 1,100 touch-screen has a customisable shortcut dock, alongside dedicated apps for games such as League of Legends, Fortnite and CS:GO. The ScreenPad is useful in creative applications too – you can move timelines and controls to the touch-screen or use it for secondary apps.

The second screen and beefy internals mean the Duo's physical design is inevitably compromised though. The 21mm thickness and 2.5kg weight are decent considering what's on offer and the build quality is superb, but conventional laptops are slimmer and lighter. There's also no getting around the price for the second screen. Drop the ScreenPad and compromise on the CPU and you can find RTX 3080 machines from £1,999.

The biggest compromise concerns the keyboard and trackpad, which are both pushed to the front. The trackpad is too narrow, with soft buttons. The keyboard is cramped, and the buttons are fast but soft, while their 1.4mm of travel is mediocre. Asus tries to address layout issues by including a wrist rest, but it can't be secured to the laptop and it's too small. For mainstream use on a desk, the keyboard is passable, but more space and snappier typing would be preferable at this price.

Performance

The RTX 3080 scythed through games at 1080p – it returned 99th percentile minimums of between 43fps and 98fps in our core titles, as well as Metro Exodus with High ray tracing, and the frame rates remained playable with ray tracing and DLSS enabled at 2,560 x 1,440.

Sadly, though, the GPU doesn't have enough power to play demanding games at the screen's native 4K resolution. The RTX 3080 was only playable in Cyberpunk 2077 at Ultra

SPEC

CPU
3.3GHz AMD Ryzen 9 5900HX

Memory
32GB 3200MHz DDR4

Graphics
Nvidia GeForce RTX 3080 Mobile 16GB

Screen
15.6in 3,840 x 2,160 IPS 120Hz; 14in 3,840 x 1,100 IPS touch-screen

Storage
2 x 1TB Samsung PM981 PCI-E 3 NVMe SSDs in RAID 0 configuration

Networking
Dual-band 802.11ax Wi-Fi, Gigabit Ethernet, Bluetooth 5.1

Weight
2.5kg

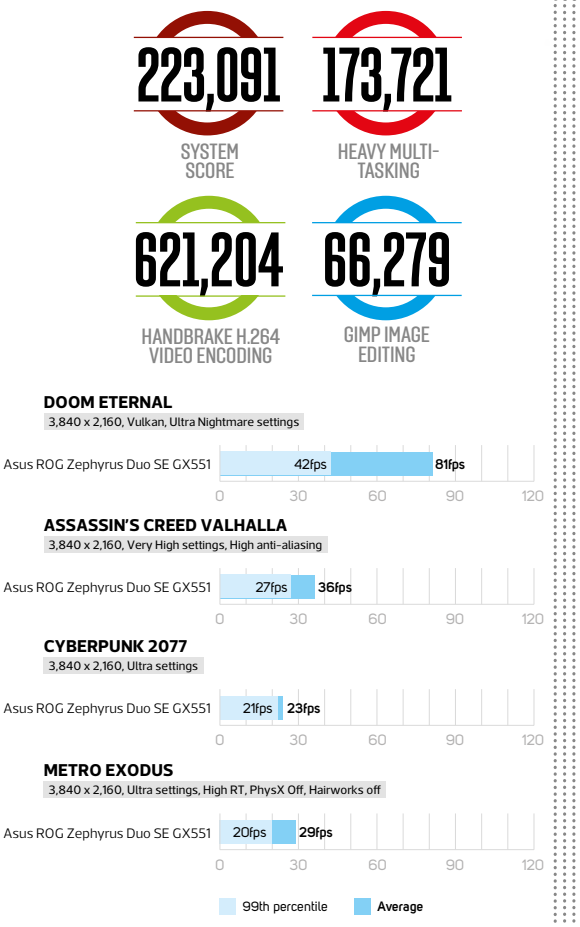
Ports
3 x USB 3.2 Gen 2, 1 x USB 3.2 Gen 2 Type-C/DisplayPort, 1 x audio, 1 x HDMI, 1 x micro-SD slot

Dimensions (mm)
260 x 268 x 21 (W x D x H)

Operating system
Windows 10 Home 64-bit

Warranty
One year parts and labour return to base

BENCHMARK RESULTS



settings if we enabled DLSS (without ray tracing), and its Assassin's Creed Valhalla minimums dipped below 30fps.

The new AMD CPU is a monster though. The single-threaded image editing score of 66,279 is almost 10,000 points beyond the results from any Intel laptop chip, and its Handbrake video encoding result of 621,204 trounces any competition. The Duo will handle 4K video work and other high-end content-creation tasks with ease.

The Asus produces fan noise when gaming, but it's no worse than other high-end laptops. During work tests, the processor hit a single-core peak of 4.5GHz and an all-core turbo peak of 4.1GHz. It attained a delta T of 72°C, which is the CPU's maximum temperature, but clock speeds never declined and there was never any instability.

The processor is limited to drawing 50W when the GPU is active, and this means the CPU throttles to 3.7GHz on all cores during graphical workloads. Asus has clearly had to do some work to keep the thermals balanced, but no matter what the task, the noise levels are reasonable and there's always enormous power available.

The biggest problem is heat. During gaming and CPU-intensive workloads, hot air is vented from the right of the machine and the underside becomes too hot to touch.

Thankfully, system stability never suffered, and this laptop will rarely leave a desktop anyway. Expect to be desk-bound because of the battery too. While the Duo lasted for three hours during work, it barely made it through an hour of gaming.

Meanwhile, the main panel has a 1,144:1 contrast ratio and a 6,740K colour temperature, and it renders 100 per cent of the sRGB and Adobe RGB gamuts. The only issue is the delta E of 4.33, which is good rather than great, but this display is generally bold, punchy, and excellent for gaming and work. The ScreenPad has lower contrast and poorer colours, but accuracy is more important on the primary panel. The two 4W speakers and two 2W tweeters are great too – they're loud and clear, with balanced bass and a crisp top end.

Conclusion

The Zephyrus Duo has more power than any other laptop we've tested. The dual-screen design can be useful in some scenarios, and the machine is surprisingly slim. The second screen is hardly an essential, though, and it hampers keyboard and trackpad quality. Also, the GPU can't handle demanding 4K gaming, and the Asus is expensive and sometimes hot and loud. If you've got money to burn and you'll benefit from the second screen, then the Asus is an impressive showcase of new technology, but most people will be better off saving a big chunk of money and buying a conventional laptop.

MIKE JENNINGS

VERDICT

World-beating power and innovative design, but it's also expensive and the design could be improved in some key areas.

PERFORMANCE **24/25**

DESIGN **21/25**

HARDWARE **23/25**

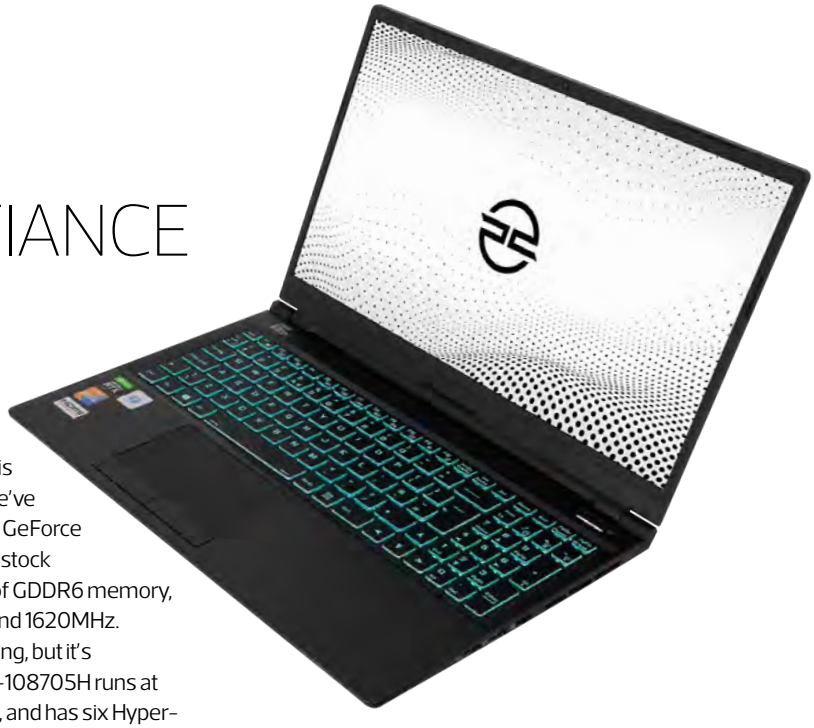
VALUE **13/25**

OVERALL SCORE **81%**

GAMING LAPTOP

PC SPECIALIST DEFIANCE VIII PRO / £1,499 inc VAT

SUPPLIER pcspecialist.co.uk



PC Specialist's Defiance VIII Pro is one of the cheapest laptops we've seen with Nvidia's new mobile GeForce RTX 3070, and in this case it runs with its stock specification of 5,120 CUDA cores, 8GB of GDDR6 memory, and base and boost clocks of 1100MHz and 1620MHz.

The rest of the spec isn't groundbreaking, but it's reasonable at this price. The Intel Core i7-10870H runs at 2.2GHz with a turbo speed of up to 5GHz, and has six Hyper-Threaded cores. There's also 16GB of dual-channel DDR4 memory clocked to a middling 2666MHz. Storage comes from a 1TB Samsung NVMe drive with solid read and write speeds of 3,520MB/sec and 3,070MB/sec, and networking is handled by Gigabit Ethernet and dual-band Wi-Fi 6.

The Defiance is also enormously customisable: you can choose from dozens of memory and storage options, downgrade or upgrade the graphics, improve the networking, and choose keyboards in different languages. The Defiance also comes with a three year labour warranty with a year of parts coverage, which is better than the one year deals included with most big-brand machines. It's possible to buy the Defiance as a 17.3in model as well.

The Defiance uses a chassis made by Taiwan-based Clevo. It excels in practical areas: it has three USB 3.2 Gen 1 ports and a faster USB 3.2 Gen 2 Type-C port that supports Thunderbolt. There are also mini-DisplayPort and HDMI outputs, a micro-SD card reader and two audio jacks, plus a webcam. Most rivals at this price only have single audio jacks, no mini-DisplayPort and no card readers – and many miss out on webcams too.

The Clevo chassis isn't always impressive. It looks plain, with a body made from matt black metal and no visual flair. Build quality is also mediocre, with too much movement in the keyboard deck, the underside and the back of the screen. On the plus side, it's easy to get inside the chassis – you don't need any Torx screwdrivers – and the pairs of SODIMM and M.2 connectors are accessible. The Defiance weighs 2kg and is only 21mm thick, which makes it lighter than most rivals.

The keyboard has a numberpad and a decent layout, and the keys have acceptable travel and speed, so they're fine for mainstream gaming and typing, although they're light and wobbly. The RGB LED lighting is also only single-zone, has no effects and only offers 15 shades. Meanwhile, the trackpad is fine for Windows use, but its buttons are soft and tall, so a USB mouse will be far better for gaming.

Performance

In our tougher game tests, such as Cyberpunk 2077 and Assassin's Creed Valhalla, the RTX 3070 delivered 1080p 99th percentile minimums of 45fps and 41fps with games at their highest quality levels, so you'll get smooth gameplay without compromise - only a few minor tweaks will get averages beyond 60fps. The Cyberpunk 99th percentile result didn't drop when we activated Medium ray tracing with DLSS either.

The RTX 3070 compares well with the older RTX 2070. In Shadow of the Tomb Raider, the Defiance's 99th percentile result of 32fps was 99fps beyond the last RTX 2070 laptop we reviewed. The Defiance impressed in the less demanding Doom Eternal too, where its 99th percentile minimum and average frame rates of 121fps and 183fps were around 10-30fps beyond the RTX 2070 – less demanding esports games should properly be able to take advantage of the 240Hz display.

SPEC

CPU
2.2GHz Intel Core i7-10870H

Memory
16GB 2666MHz DDR4

Graphics
Nvidia GeForce RTX 3070 8GB

Screen
15.6in 1,920 x 1,080 IPS 240Hz

Storage
1TB Samsung 970 Evo Plus M.2 SSD

Networking
Dual-band 802.11ax Wi-Fi, Gigabit Ethernet, Bluetooth 5.1

Weight
2kg

Ports
3 x USB 3.2 Gen 1, 1 x USB 3.2 Gen 2 Type-C/Thunderbolt, 2 x audio, 1 x HDMI, 1 x mini-DisplayPort, 1 x micro-SD slot

Dimensions (mm)
358 x 238 x 20 (W x D x H)

Operating system
Windows 10 Home 64-bit

Warranty
Three years labour, including one year parts and one month collect and return

BENCHMARK RESULTS

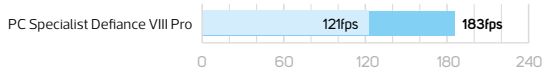
169,601 SYSTEM SCORE

166,939 HEAVY MULTI-TASKING

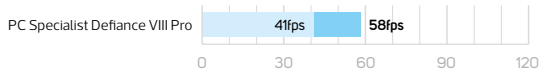
436,498 HANDBRAKE H.264 VIDEO ENCODING

49,714 GIMP IMAGE EDITING

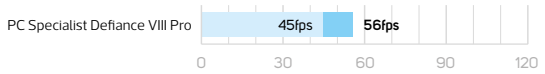
DOOM ETERNAL
1,920 x 1,080, Vulkan, Ultra Nightmare settings



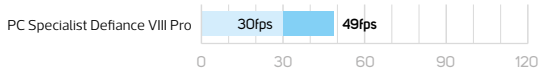
ASSASSIN'S CREED VALHALLA
1,920 x 1,080, Ultra High settings, High anti-aliasing



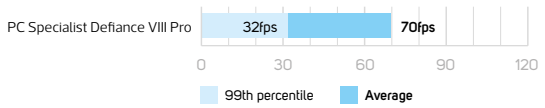
CYBERPUNK 2077
1,920 x 1,080, Ultra preset, no ray tracing



METRO EXODUS
1,920 x 1,080, Ultra settings, High RT, PhysX off, HairWorks off



SHADOW OF THE TOMB RAIDER
1,920 x 1,080, Highest settings, High RT shadows, TAA



That refresh rate isn't paired with active sync, but the Defiance's display still delivers smooth gameplay in fast-paced titles. The brightness of 308cd/m^2 is good enough for indoor use, and the contrast ratio of 1,062:1 delivers decent vibrancy and depth. The delta E of 1.6 is good and the sRGB coverage level of 95 per cent is solid, but the colour temperature of 7,272K is cool. That's not ruinous, though, and the PC Specialist's panel is easily good enough for everyday gaming and work – just don't expect it to hold up for colour-sensitive workloads.

Meanwhile, the processor is only ordinary these days – its overall result of 169,601 is outpaced by last year's AMD Ryzen 7 4800H, and laptops such as the Asus TUF Gaming A15 now come equipped with a Ryzen 7 5800H and an RTX 3070 for just £100 more at £1,599 inc VAT. The Core i7 CPU is still fine – it won't cause gaming bottlenecks and it will easily handle everyday workloads and photo editing, but it's now outclassed by the AMD competition.

The PC Specialist is mixed thermal performer too. When gaming, noise levels aren't bad – a headset will easily mask the moderate output – and the GPU regularly boosted to clock speeds beyond 1650MHz. The Defiance was quieter when handling both single- and multi-threaded workloads, too. The GPU's peak delta T of 51°C is fine.

However, the CPU ran a little hotter: during a multi-threaded work benchmark it peaked at 68°C and then slowly throttled to an all-core speed of 2.9GHz, which is short of the chip's theoretical all-core Turbo peak of 4.2GHz. In a single-threaded test, the CPU was faster, so the Defiance is clearly better suited to gaming and single-threaded tasks, rather than large multi-core workloads.

Don't expect much from the speakers either – they're loud, but tinny, with high-end distortion, little depth and no bass. The included SoundBlaster Atlas app has profiles for different game genres, but they make no real difference. A headset would be much better. Finally, when gaming, the battery lasted for just under two hours, and its lifespan extended to four hours when working, which is reasonable for a gaming laptop.

Conclusion

The Defiance has enough gaming power to handle any 1080p gaming scenario and it serves up a good display, solid connections and a low price. The lower price does mean an underwhelming case, CPU, and keyboard though – problems that could be solved by spending a bit more cash. We'd recommend splashing out a little more money if you can find it, but if not, the Defiance remains a decent option for affordable, unfussy mainstream gaming.

MIKE JENNINGS

VERDICT

Decent gaming speed, a solid display and a low price, but it's a bit rough around the edges.

DEFY

+ Solid 1080p gaming speed
+ Customisable spec
+ Very affordable

CAPITULATE

– Mediocre chassis
– Middling keyboard
– Terrible speakers

PERFORMANCE **19/25**

DESIGN **17/25**

HARDWARE **19/25**

VALUE **23/25**

OVERALL SCORE **78%**

AMD B550 GAMING PC

CYBERPOWER ULTRA 9 XT / £2,599 inc VAT

SUPPLIER cyberpowersystem.co.uk

It's not unusual to see a PC with an AMD processor, but a high-end rig all-AMD with Radeon graphics is rarer. CyberPower's Ultra 9 XT is the first system we've seen with the Radeon RX 6800 XT, and it sits alongside AMD's tremendous Ryzen 9 5900X Zen 3 CPU.

This chip has 12 SMT-enabled cores, alongside base and boost speeds of 3.7GHz and 4.8GHz. It's a muscular part for multi-threaded workloads, and the rest of the CyberPower's specification takes aim at creative tasks – there's 32GB of 3600MHz DDR4 memory, a PCI-E 4 SSD and a 4TB hard disk. The Corsair RM850x PSU is also a welcome addition, with its 80 Plus Gold certification and modular design.

Meanwhile, the Radeon 6800 XT is AMD's answer to the Nvidia GeForce RTX 3080, and it includes 4,608 stream processors. This MSI-made card has overclocked game and boost clocks of 2045MHz and 2285MHz respectively, and it includes 16GB of GDDR6 memory. That's 6GB more than the RTX 3080, but AMD's memory uses a narrower 256-bit interface. AMD's card supports ray tracing too, with 72 AMD Ray Accelerators – one for each Compute Unit, but the company doesn't have a hardware equivalent of DLSS.

It's all plugged into a basic Asus TUF Gaming B550-Plus motherboard, which concentrates on helpful features rather than hefty heatsinks and lighting. Its primary 16x PCI-E and M.2 connectors support PCI-E 4, and the board has 2.5Gbps Ethernet and loads of connectors, including a Thunderbolt header.

At the rear it has USB 3.2 Gen 2 Type-A and Type-C connectors, alongside six more USB slots of varying speeds. CyberPower has added dual-band 802.11ax Wi-Fi, and the board has an M.2 Key E connector if you'd like to add a Bluetooth module. It's a good board, but it does have some minor limitations. None of the other M.2 connectors or PCI-E slots supports PCI-E 4, for example, and there's no USB 3.2 Gen 2x2.

The sturdy Corsair 4000D that houses the hardware looks subdued thanks to dark tempered glass. At the top it has single USB 3 Type-A and Type-C ports, and on the inside, there's the usual PSU shroud. Corsair has included extra cable-tidying features, including loads of Velcro anchor points and channels, and CyberPower has done a great job keeping the interior tidy, including the tubes emerging from the 360mm Cooler Master cooler. Around the rear, there's one 3.5in drive bay and two 2.5in mounts, but the rear is a little untidy and there's no fan hub. More USB ports would be welcome on top of the case too.

CyberPower's rig is protected by a three year labour warranty with an impressive two years of parts coverage. In the wider market, though, its value can be questioned – at the time of writing, it's relatively easy to find equivalent machines for a little less money than the CyberPower, and you can also find PCs with this CPU and an RTX 3080 GPU for between £2,250 and £2,500.

SPEC

CPU
3.7GHz AMD Ryzen 9 5900X

Motherboard
Asus TUF Gaming B550-Plus

Memory
32GB Corsair Vengeance LPX 3600MHz DDR4

Graphics
MSI Radeon RX 6800 XT 16GB

Storage
500GB Seagate FireCuda 520 M.2 SSD, 4TB Seagate Barracuda hard drive

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

Case
Corsair 4000D

Cooling
CPU: Cooler Master MasterLiquid Lite 360 with 3 x 120mm fans; GPU: 3 x 90mm fans; rear: 1 x 120mm fan; roof: 2 x 120mm fans

PSU
Corsair RM850x 850W

Ports
Front: 1 x USB 3.2 Gen 1, 1 x USB 3.2 Gen 1 Type-C, 1 x audio; rear: 1 x USB 3.2 Gen 2, 1 x USB 3.2 Gen 1 Type-C, 4 x USB 3.2 Gen 1, 2 x USB 2, 1 x optical S/PDIF, 5 x audio

Operating system
Microsoft Windows 10 Home 64-bit

Warranty
Two years parts and labour, plus one year labour only. Six months collect and return, then return to base

Performance

The CPU's image editing score is around 7,000 points faster than the Intel Core i9-10900K that's often found in equivalent systems, and in the Handbrake test, the AMD chip scored 1,023,652 – over 250,000 points beyond those Intel CPUs and not far behind the 16-core Ryzen 9 5950X. The CPU's overall score of 378,724 is a superb result that's well beyond the performance of equivalent Intel CPUs.

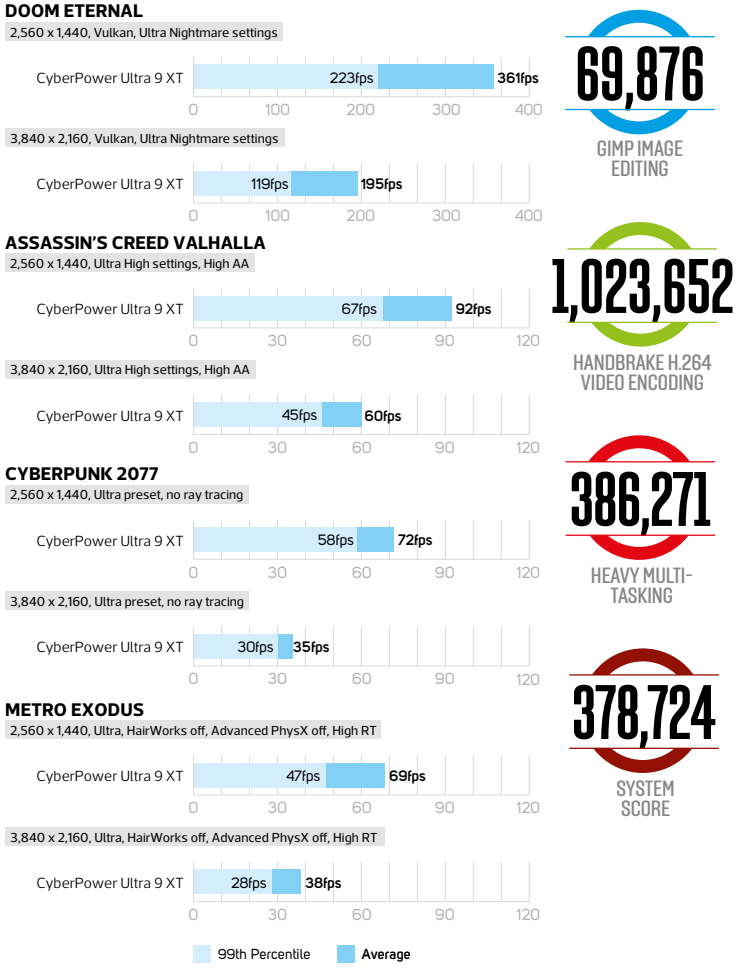
This CPU can do it all, from multi-threaded content creation to everyday single-threaded workloads. The CyberPower's productivity prospects are bolstered by excellent SSD read and write speeds of 4,987MB/sec and 2,543MB/sec.

The Radeon RX 6800 XT can't match the impressive CPU though. Happily, it did deliver superb frame rates in our standard game tests at 2,560 x 1,440, and it will happily play Assassin's Creed Valhalla and Doom Eternal at 4K too. However, it struggles with Cyberpunk 2077 at the latter resolution, and the Radeon's Metro Exodus performance shows that Nvidia has the upper hand with ray tracing, particularly if you enable DLSS. The RTX 2080 is more than 10fps faster in Cyberpunk and Metro Exodus at 4K with DLSS enabled.

In most games you'll be able to play games on this machine at 4K smoothly without reducing many graphics settings, though, and at lower resolutions you'll easily have the pace to handle high refresh-rate displays. There was little to choose between the 6800 XT and the RTX 3080 at 2,560 x 1,440.

The CyberPower was also inconsistent in thermal tests. It impressed when gaming, with low fan noise, but it was louder when handling CPU-based workloads. The noise levels aren't ruinous, but they can be distracting. During all-core CPU workloads, the chip ran at around 4.5GHz, which is impressive – only 300MHz behind AMD's quoted single-core boost speed. Temperatures were just about fine too: the CPU's delta T of 61°C is solid, and the GPU hit 68°C.

BENCHMARK RESULTS



69,876
GIMP IMAGE EDITING

1,023,652
HANDBRAKE H.264 VIDEO ENCODING

386,271
HEAVY MULTI-TASKING

378,724
SYSTEM SCORE

Conclusion

CyberPower's all-AMD rig is a solid machine that's undermined by a couple of missteps. The processor is fantastic for any workload, and the CyberPower serves up great memory and storage. The Radeon graphics card can't compete with the RTX 3080 with ray tracing enabled, though, and the CyberPower is also a little expensive for what you get. This is undoubtedly a good system for tough workloads, but we'd recommend shopping around for an RTX 3080 system at this price instead.

MIKE JENNINGS

REFRACT

- \+ Fantastic CPU
- \+ Sturdy, subtle chassis
- \+ Decent storage, memory and PSU

RETRACT

- – Nvidia GPUs faster at ray tracing
- – Loud during CPU tests
- – A little expensive

VERDICT

Great CPU speed and solid component choices, but the price is high and the GPU struggles with 4K ray tracing.

PERFORMANCE	22/25
DESIGN	21/25
HARDWARE	22/25
VALUE	18/25
OVERALL SCORE	83%

AMD B450 GAMING PC

PC SPECIALIST PRISM ELITE / £899 inc VAT

SUPPLIER pcspecialist.co.uk

ELITE

+ Great price
+ Fine for 1080p gaming
+ Spacious case

DEFEAT

– Entry-level components
– Loud in CPU-heavy workloads
– Few upgrade paths

PC Specialist's Prism Elite is an interesting proposition for these interesting times: a budget machine that hits the £899 mark by relying on older components that are readily available in our era of supply shortages. The machine's Turing-based GeForce GTX 1660 Ti doesn't have ray-tracing hardware, but it includes 1,536 stream processors and 6GB of memory. This card is made by Zotac, and it runs at its stock base and boost clocks of 1500MHz and 1770MHz.

The Prism's AMD Ryzen 5 3600 CPU is another older component, but it still has solid mid-range specifications, including six SMT-enabled cores and a 4.2GHz turbo clock. The lack of the X and XT suffixes mean the chip misses out on minor speed boosts, but it's still a decent CPU for the price. It's chilled by a PC Specialist FrostFlow air cooler with two 120mm fans.

The rest of the specification is middling. There's 16GB of dual-channel 3200MHz memory, and PC Specialist's own-brand NVMe SSD delivers read and write speeds of 2,014MB/sec and 796MB/sec – they're not record-breaking results, but they're enough. There's also a 1TB hard disk. It's all protected by PC Specialist's warranty, which is a three year labour deal with a year of parts coverage – but only a month of collect and return service.

There are areas where the PC Specialist is underwhelming, though, such as the Asus Prime B450-Plus motherboard, which only has one M.2 connector and entry-level Realtek ALC887 audio.

As it's based on the older B450 chipset, it lacks the PCI-E 4 support of B550 boards. At the rear it has two USB 3.2 Gen 2 ports, but the rest of its full-sized and Type-C connections are slower. There aren't any faster USB headers on the board either, and the number of fan and lighting connectors is limited.

The Corsair CV450 PSU is another entry-level component – the 80 Plus Bronze certification is fine, but it's non-modular and its 450W power limit means you'll have to buy a new PSU if you want to install any serious graphics or CPU upgrades. Likewise, the single-band 802.11n Wi-Fi card is basic compared with the dual-band 802.11ax cards found in many other machines.

PC Specialist has housed all the gear in its own-brand Prism-X chassis. The front panel has a mix of black mesh and gunmetal plastic, and its sturdy façade glows with the red and yellow light from the intake fans. There's a PSU shroud, the build is neat and there's room for 2.5in drives at the rear. It's large, measuring 490mm tall and 470mm deep, so there's plenty of room inside, but it's not ideal if you only have a small space for your system.

However, the roof and PSU shroud have middling build quality, there's no room for a second hard drive and the top only has one USB 3.2 Gen 1 port and no Type-C connector.

Of course, at £899, any PC will have compromise, but the PC Specialist does a decent job of balancing those budget issues against the wider market. Looking at other big companies reveals that the Prism's specification is usually only available at nearer to £1,000, and even then, systems often come with the slightly slower GTX 1660 Super GPU. If

SPEC

CPU
3.6GHz AMD Ryzen 5 3600

Motherboard
Asus Prime B450-Plus

Memory
16GB Corsair Vengeance LPX 3200MHz DDR4

Graphics
Zotac GeForce RTX 1660 Ti 6GB

Storage
512GB PC Specialist M.2 PCI-E 3 NVMe SSD, 1TB Seagate Barracuda hard drive

Networking
Gigabit Ethernet, single-band 802.11n Wi-Fi

Case
PC Specialist Prism-X RGB

Cooling
CPU: PC Specialist FrostFlow 150 with 2 x 120mm fans; GPU: 2 x 80mm fans; front: 3 x 120mm fans rear: 1 x 120mm fan; roof: 1 x 120mm fan

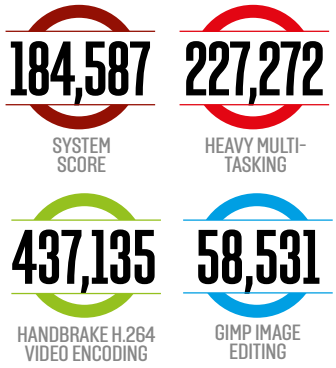
PSU
Corsair CV450 450W

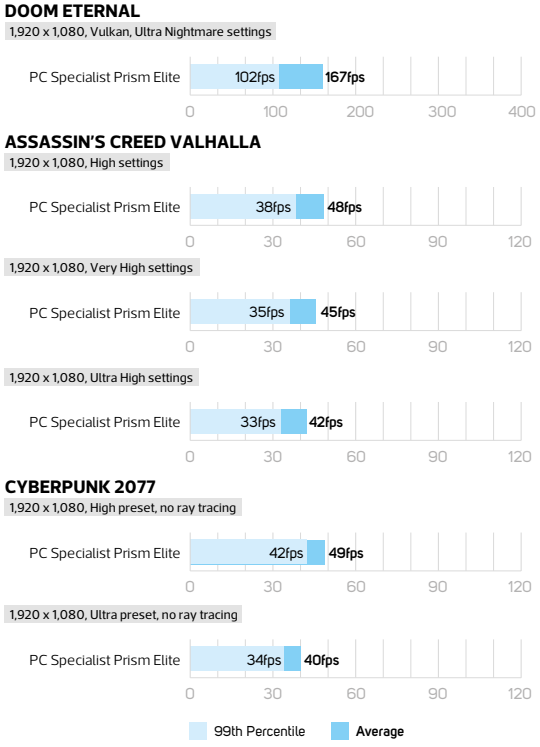
Ports
Front: 1 x USB 3.2 Gen 1, 2 x USB 2, 2 x audio; rear: 2 x USB 3.2 Gen 2, 1 x USB 3.2 Gen 1 Type-C, 2 x USB 3.2 Gen 1, 2 x USB 2, 1 x PS/2, 3 x audio

Operating system
Microsoft Windows 10 Home 64-bit

Warranty
One year parts and labour, plus two years labour only. First month collect and return, then return to base

BENCHMARK RESULTS





you'd prefer a GeForce RTX 3060 Ti and a Ryzen 5 5600X, then you can expect to pay more than £1,200, and it's also hard to find that GPU in stock anywhere.

Performance

The GTX 1660 Ti has the grunt to handle mainstream 1080p gaming. In Doom Eternal it delivered a 99th percentile minimum frame rate of 102fps, and in tougher games, it broke the 30fps barrier – the GTX 1660 Ti ran Assassin's Creed Valhalla with a 99th percentile minimum of 33fps, and Cyberpunk 2077 with a 99th percentile result of 34fps.

You'll be able to play today's big-name titles at 1080p, although you'll have to dial back the settings if you want to get smooth frame rates in most single-player games. Run Cyberpunk 2077 at High rather than Ultra settings and it

averages 49fp, while Assassin's Creed Valhalla will average 48fps at High settings.

If you want a new PC with more gaming power and ray-tracing support, you'll need an RTX 3060 Ti. Happily, the GTX 1660 Ti is more capable when it comes to esports: it will play any current game at beyond 100fps at 1080p, so it delivers the frame rates required for smooth competitive play in undemanding games.

Meanwhile, the Ryzen 5 3600X's overall score of 184,587 is reasonable. This CPU is fast enough to handle office tasks and photo editing, as well as some multi-threaded work. Compared with its successor, though, there's a gulf: the Ryzen 5 5600X scores around 245,000 in our benchmarks, representing a substantial upgrade.

The PC Specialist is a mixed thermal performer too. Positively, temperatures were never an issue – the CPU and GPU delta Ts of 52°C and 50°C are fine. The noise levels are easily manageable during gaming. A bigger concern is the PC's noise output when then CPU is stressed, with a very loud noise generated by the CPU cooler's two fans. You'll want to be in a different room if you set it running on a big video encoding task.

Conclusion

PC Specialist's Prism Elite can handle standard 1080p gaming and everyday computing for a reasonable price. However, it uses older components and entry-level hardware, and this rig also suffers from noisy operation in some tasks and a lack of upgrade paths. Spending a little more money will rectify those issues and net you more CPU and GPU power, but this is a reasonable entry-level system that can be built right now if you want to save some money.

MIKE JENNINGS

VERDICT

An affordable PC for 1080p gaming everyday computing, but there's limited scope for upgrading.

PERFORMANCE 16/25

DESIGN 18/25

HARDWARE 16/25

VALUE 23/25

OVERALL SCORE 73%

Custom kit

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

UNIM MUG WARMER / £16.99 inc VAT

SUPPLIER amazon.co.uk

The clue that the UniM Mug Warmer isn't messing about lies with the power supply – it uses the mains rather than a USB cable for power. It's one of those rare desktop mug warmers that takes its job incredibly seriously. The UniM Mug Warmer will warm your mug of tea of coffee. It will warm it a lot.

The plate on the UniM gets incredibly hot, so you're not gently warming your cup of tea to buy you an extra few minutes to drink it hot – instead, it's hot enough that, given enough time, you could probably reheat a cold cup of tea on it. This places the UniM in an awkward position.

It's a mug warmer, and it's very good at putting warmth into mugs, but the price you pay is having this unassuming-looking, yet extremely hot plate, on your desk. The UniM needs to be treated with a degree of caution more usually reserved for kitchen devices, not the rumble-tumble world of the desktop gadget. Oh Icarus, maybe just drink your tea before it gets cold.

Lukewarm ●●○○○ Luke Skywalker

NOKLEAD ALARM CLOCK

/ £16.14 inc VAT

SUPPLIER amazon.co.uk

In a time where the ubiquity of smartphones has mostly rendered the alarm clock redundant, the Noklead Alarm Clock has adopted an interesting strategy to remain useful. Rather than attempt to compete with smartphones, the Noklead has Qi charging capability, so you can recharge your phone on top of it, while also using it as an alarm clock.

The Noklead is USB-powered and simple to set up. Programming the time and setting the alarm involves the usual amount of awkward faffing for a device with only a few buttons to control its interface, but once it's working, it does exactly what you want.

The one design drawback is that the phone charges on top of the clock, and that's where you'd expect the snooze button to be positioned. Instead, the Noklead has the snooze button in the foot underneath, with the off switch at the back. It's not bad, but the positioning of these crucial controls feels a little inelegant, especially with a phone in the way of the top.

Lose ●●●○○ Snooze

PHISSION SOUNDBAR

/ £21.99 inc VAT

SUPPLIER amazon.co.uk

The Phission soundbar is a USB-powered speaker that uses a 3.5mm jack audio connector. Its relatively small size, combined with its simplicity of use, makes it a solid option for any system such as a laptop, or a basic office setup that benefits from having a reasonable ability to make noise, but where a heftier set of speakers isn't feasible.

The sound quality from the Phission is good enough for close quarters and clarity, but it's not going to make your home cinema pop or your music bring the house down. The styling is low-key and even the obligatory LED can be switched off. It's a decent option when you need some noise, but not much of it.

Fishion ●●●○○ Fission

TRUE UTILITY SHARKEY / **£8.99** inc VAT

SUPPLIER amazon.co.uk

The True Utility Sharkey has no business being this clever. A multitool designed to look like a shark that's small enough to fit on a key ring doesn't seem like it's going to be capable of much more than poking you through your pocket, and yet here we are.

Somehow, somebody found a way to achieve a unity of form and function between an array of simple tools and a tiny stainless-steel shark.

Every protrusion from the body, such as the fins or the jaw is put to use, usually as a screwdriver head, but the spaces in between are also used.

A dorsal fin hides a thread cutter, and the curve of the ventral fin into the tail is a bottle opener. Meanwhile, the jaws operate as a pry bar, a nail file and flathead screwdriver.

The small size mitigates any problems that might arise from having a collection of pointy protrusions on a key ring too – the Sharkey is approximately the same size as a house key, so it shouldn't stick out too much. In practical terms, the Sharkey is shaped well and strong enough to take a stab at many tasks for which it's designed, while also being convenient to carry around.

Fishy ●●●●● **Sharky**

HAMSWAN SC-G04 VR HEADSET / **£12.99** inc VAT

SUPPLIER amazon.co.uk

Paring back a smartphone VR headset to the bare essentials to make a cheaper, smaller, lighter and easier-to-use system seems like a great idea on paper, but when confronted by the reality of it in the form of the Hamswan VR headset, the situation turns out to be more complicated. The Hamswan does manage to be extremely compact, but the trade-offs are quickly apparent.

For example, there are no controls to interact with the smartphone you've installed. This means you need to use some sort of third-party Bluetooth device, or you need to start whatever you want to watch running on the phone before closing up the headset, adjusting it on your head and then watching it. The Hamswan also has a snug fit, so while it's comfortable, you can't wear it with glasses. It does have limited lens adjustment to compensate for myopia, which is considerate, if not ideal.

The sacrifices made to keep down the weight and size do make the Hamswan SC-G04 comfortable and easy to wear while looking around, which can be an issue for heavier, bulkier units that can be prone to instability. If you can work around the shortcomings, then it works fine, but it isn't a universally useful device.

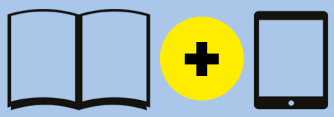
Virtual ●●○○○ **Actual**

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

ALL PRINT SUBSCRIPTIONS NOW COME WITH A

FREE DIGITAL SUB

PRINT + DIGITAL



- Free delivery of the print magazine to your door
- Exclusive subscriber-only covers
- Save up to 37% on the shop price of print issues
- Access to the digital edition on your iOS or Android device

CHOOSE YOUR SUBSCRIPTION OFFER

- **£5 for 3 issues**
  Renewing at £25 every 6 issues
  UK only
- **£5 Rolling subscription**
  UK only
- **£25 for 6 issues**
  UK only
- **£45 for 12 issues**
  UK only
- **£80 for 12 issues**
  EU
- **£90 for 12 issues**
  Rest of the world

SUBSCRIBE TODAY!

custompc.co.uk/subscribe

01293 312182 **custompc@subscriptionhelpline.co.uk**

Subscriptions, Unit 6 The Enterprise Centre, Kelvin Lane, Manor Royal, Crawley, West Sussex, RH10 9PE

Please allow 28 days for delivery.

LABS TEST

Titanic towers

What do you get if you spend over £100 on your PC's home? **Antony Leather** puts five of the latest and greatest cases to the test to find out

How we test

Our case testing method is simple. We use real, overclocked hardware in a standard system to see how cases perform in terms of air cooling. We use an Asus TUF B450M-Plus Gaming motherboard, along with a Ryzen 5 1600 overclocked to 3.8GHz using a vcore of 1.365V.

We also use a Palit GeForce GTX 1660 StormX with an open GPU cooler to better represent modern graphics cards, and we limit its fan speed to 60 per cent to prevent it from interfering with noise testing results, which we gauge with a sound meter. Meanwhile, our CPU is cooled by a Thermaltake Riing Silent 12 Sync 120mm cooler, but again, we've limited its fan speed using a 7V resistor cable to put more emphasis on each case's cooling.

One change to our usual testing is the addition of two Corsair ML120 Pro fans, which we add to cases where possible to see how they respond to additional airflow. This not only allows us to more sensibly test cases that come with no fans, but also lets us test whether it's worth adding more fans to cases that already include them.

We leave each case for 15 minutes, with the system running Prime95's smallest FFT test with AVX disabled (**mersenneforum.org**) to load the CPU, and Unigine's Valley benchmark (**unigine.com**) to load the GPU. Results are taken from Ryzen Master (**amd.com**) and GPU-Z (**techpowerup.com/gpuz**), and we subtract the ambient temperature from the results to give a delta T reading, which we can use to test in normal conditions across several days and varying temperatures.

Where fan controllers are included with a case, we test at the highest and lowest fan speeds to see what impact the different fan speeds on offer have on cooling. We score each case using weighted calculations for their cooling, design, features and value, to give an overall score.

Contents

BE QUIET! SILENT BASE 802 / £141 inc VAT

SUPPLIER overclockers.co.uk

While be quiet! is only a couple of generations into its case journey, the company has already gone from good efforts with pricey, flawed designs, to one of the most interesting and unique cases on the market. The Silent Base 802 is big, but packs a lot into its cavernous dimensions. It focuses on cooling and there are three 140mm Pure Wings 2 fans included, with two up front to create positive air pressure. There's space for four more 140mm fans too, with room for up to 420mm radiators in the front and 360mm radiators in the roof, with plenty of clearance for twin rows of fans or thick radiators.

The large accessory box includes replacement panels for the roof and front, which feature mesh rather than sealed panels to improve airflow – that's great for a case costing under £150. The front panel pops off easily too, sliding up vertically, although it also comes loose easily if you try to lift it, which caught us out with back-jarring consequences during testing.

SPEC

Dimensions (mm) 281 x 539 x 553 (W x D x H)

Material Steel, plastic, glass

Available colours Black, white

Weight 13.2kg

Front panel Power, reset, 2 x USB 3, 1 x USB 3.1 Type-C, 1 x stereo jack, 1 x mic jack, fan control

Drive bays 3 x 2.5/3.5in, 7 x 2.5in

Form factor(s) E-ATX (up to 275mm wide), ATX, micro-ATX

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

CPU cooler clearance 185mm

Maximum graphics card length 432mm (287mm with second hard drive cage)

The case itself is solid enough, with mostly steel construction, but the exterior does feature a lot of plastic – it doesn't feel cheap, but it lacks the finesse of the Corsair 5000D Airflow, for example. However, it has some fantastic side panels that pop off easily by pressing buttons at the rear of the case. Only the Fractal Design Meshify 2 is more elegantly engineered.

Building a PC into the case is straightforward, but we were disappointed with the minimal effort paid to cable tidying, which wasn't on par with the rest of the field. You do get a pre-connected PWM fan hub with six channels, which can also double as a two-speed manual fan controller, and there's the option of a vertically mounted GPU too. What's more, the top fan mounts are located in a slide-out tray, which makes installing extra fans and radiators here much easier. In addition, the motherboard tray can be rotated for an inverted layout.

Out of the box, there are three 3.5in mounts for hard disks and up to seven for SSDs, although you can expand these numbers to seven and 15 respectively by purchasing optional mounts.

In its stock configuration, the CPU delta T of 71°C was a few degrees off the pace, but not terrible and the GPU delta T was the lowest at 64°C. The best result, though, was the noise level, which was just 37dBA using the mesh panel. With the closed panel, the CPU delta T rose 2°C and the GPU delta T by 5°C, but the noise level stayed the same at our measuring point. Adding one and then two extra 120mm fans failed to improve the airflow, though, with just a single degree knocked off the CPU delta T with two fans installed in the roof and front sections.

SILENCE OF THE LAMBS

+ Good cooling
+ Intuitive features
+ Good expansion possibilities

HANNIBAL RISING

– Not quite as refined as the competition
– Average cable tidying
– Front panel can come loose when carried

Conclusion

The Silent Base 802 nearly hits the nail on the head, and is worth considering if low noise is a top priority. It has good cooling, plenty of room for expansion, highly useful features and very quiet operation. Its mediocre cable-tidying setup means it just misses out on an award, but it still comes recommended.

VERDICT

Superb in many departments, but a lacklustre cable-tidying system means it doesn't quite top the field.

COOLING	FEATURES	OVERALL SCORE
28/30	17/20	88%
DESIGN	VALUE	
26/30	17/20	

CORSAIR 5000D AIRFLOW / £135 inc VAT

SUPPLIER overclockers.co.uk

Case manufacturers are often releasing several variants based on one design at the moment, and the new Corsair 5000D Airflow is, as its name suggests, the high-airflow version of its latest mid-tower premium case. Other versions include the iCUE 5000X RGB, which includes a trio of RGB fans, while the more basic 5000D has a closed front panel instead of the attractive vented panel here.

At £135, it's reasonably priced, although you only get two fans included, which is fewer than you get with the Fractal Design Meshify 2 and be quiet! Silent Base 802. For such a big chassis, we'd prefer to see more fans included, but we can appreciate that Corsair likely assumes customers would want to add their own. The case certainly looks good, with its precise, clean lines making it look smart. It lacks the visual flair of the NZXT H510 Elite, but the 5000D Airflow also has a lower price and a vastly superior feature set in its favour.

For some reason Corsair has opted for both pop-on and thumbscrew side panel securing mechanisms, but we suggest leaving the screws loose and just using the pop-on pins to make life easier. The front and roof panels are easily removable, and reveal large dust filters beneath. In terms of maintenance, no other case here gets close in terms of ease of use. The front panel lacks any lighting or fan control, but it does include a full-fat Type-C USB port as well as two USB 3 ports, plus a single-pole audio jack.

Inside, Corsair has also made some interesting additions to the case's feature set, including a large cable cover, cable-routing channels and large Velcro anchors, making it easy to keep the case spaghetti-free. It also has a 6-channel PWM fan hub, with both the included fans already wired up to it.

Next to the motherboard tray is one of three possible locations for a 360mm radiator, with the fans here exhausting out the side panel. You can also mount one in the roof and front section, so there's plenty of scope for handling some seriously high-end hardware. The only exception is storage, with only a measly pair of 3.5in hard disk mounts is included.

With its two fans, the Corsair's CPU delta T of 48°C was generally warmer than the competition, but only by a couple of degrees. The same was true for the GPU delta T, but again this was only 1°C behind the top spot thanks to the lone front fan pointing directly at our graphics card. Adding another fan to the front saw the CPU delta T drop 1°C and a further 2°C with an additional fan in the roof of the case. The GPU delta T failed to budge though. Noise increased steadily as we added more fans, though, with the Corsair being a sizeable 5dBA louder than the be quiet! Silent Base 802. However, it was still significantly quieter than the NZXT 510 Elite when the latter was at full fan speed.

SPEC

Dimensions (mm) 245 x 520 x 520 (W x D x H)

Material Steel, plastic, glass

Available colours Black, white

Weight 13.8kg

Front panel Power, reset, 2 x USB 3, 1 x USB 3.1 Type-C, 1 x stereo/mic jack

Drive bays 2 x 2.5/3.5in, 4 x 2.5in

Form factor(s) ATX, micro-ATX

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

CPU cooler clearance 170mm

Maximum graphics card length 420mm

GO PRO

+ Good cooling
+ Great water-cooling support
+ Easy maintenance

GO AWAY

– Only two hard disk bays
– Lacks visual flair
– Side panels not as elegant as the competition

Conclusion

While the Fractal Design Meshify 2 has a better overall balance of features for the price, the Corsair 5000D Airflow still ticks a lot of boxes. If you prefer its clean, elegant design to the rather bland offerings from Fractal Design, be quiet! and Phanteks this month, you certainly won't be disappointed.

VERDICT

A well thought-out, modern case with a clean, attractive design.

COOLING	FEATURES	OVERALL SCORE
28/30	15/20	89%
DESIGN	VALUE	
28/30	18/20	

FRACTAL DESIGN MESHIFY 2 / £129 inc VAT

SUPPLIER scan.co.uk

As the cheapest case on test this month, the Fractal Design Meshify 2 might appear to be at a disadvantage when it comes to features, but this unassuming case is sizzling with useful bits and pieces that will both aid your build process and help you create a cool, tidy PC. It's much more grown up than its aging predecessor – the original Meshify – and the first feature we loved about it was the pull-open mesh door on the front, which reveals a filter and fan mounts behind it for easy access.

We were also glad to see the return of the lift-out roof section we saw with the Define 7, which makes installing your hardware incredibly easy. Here, the roof section pops off with minimal force, again revealing a large removable filter and fan mounts. However, as its name suggests, there are no solid swap-out panels here, as this case is all about mesh and airflow. The side panels are also pop-off and are tool-free, bettering every other case on test in terms of their simplicity.

Three 140mm fans are included, with two in the front and one at the rear – that's easily enough fans to handle a high-end system. However, if you plan on water-cooling your PC, there's space for up to 360mm radiators in the roof and front, plus either a 240mm or 280mm radiator in the base, making it one of the most water cooling-friendly cases on test.

CPU cooler height is ample at 185mm, and if you're happy with a pair of hard disks in the base and a third secured using a bracket that can also secure pumps and SSDs, there's space for up to 467mm-long graphics cards, with this figure shrinking to 315mm if you employ the quartet of hard disk trays that mount next to the motherboard. The latter brings the total of 2.5in/3.5in mounts to an impressive seven in addition to two dedicated 2.5in mounts.

Cable tidying is excellent, with numerous large Velcro anchors with guides and plenty of routing holes too. Fractal Design also includes a fan hub that offers six 3-pin fan headers and three 4-pin PWM headers powered by your motherboard, making it straightforward to build a tidy system, although it could do with more 4-pin connectors here.

The Meshify 2 also did a good job of containing noise, and despite our additional fans being installed in identical locations, it was 3dBA quieter than the Corsair 5000D Airflow, although it still couldn't match the be quiet! Silent Base 802 here. Cooling was exemplary, though, being only one of two cases to dip under a CPU delta T of 47°C and posting consistently good GPU delta Ts too. However, as there are already two front 140mm fans, our two additional fans failed to improve cooling any further.

Conclusion

Apart from slightly bland aesthetics, the Fractal Design Meshify 2 strikes an excellent balance of price, features and cooling. It maintains Fractal Design's superb form following on from the awesome Define 7 and Define 7 Compact, and it also packs a punch considering it's one of the smaller cases here. If you have around £130 to spend on a PC case, it's a great choice whether you plan on water-cooling or air-cooling your PC.

FRACTAL

- \+ Simple hardware installation
- \+ Great water-cooling support
- \+ Plenty of storage options

FRACTIOUS

- – Comparatively bland design
- – Only three 4-pin ports on fan hub

SPEC

Dimensions (mm) 240 x 542 x 474 (W x D x H)

Material Steel, plastic, glass

Available colours Black

Weight 13.8kg

Front panel Power, reset, 2 x USB 3, 1 x USB 3.1 Type-C, 1 x stereo jack, 1 x mic jack

Drive bays 7 x 2.5/3.5in, 2 x 2.5in

Form factor(s) E-ATX (up to 285mm wide), ATX, micro-ATX

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

CPU cooler clearance 185mm

Maximum graphics card length 467mm (315mm with optional hard disk mounts)

VERDICT

A brilliantly designed, feature-rich case for both air-cooled and water-cooled systems.

COOLING	FEATURES	OVERALL SCORE
28/30	17/20	93%
DESIGN	VALUE	
29/30	19/20	

NZXT H510 ELITE / £150 inc VAT

SUPPLIER overclockers.co.uk

The H510 Elite certainly isn't new, but it sure is beautiful and remains NZXT's flagship premium mid-tower case. At £150, despite it being the smallest case on test, it's also the most expensive, but there are some good reasons for the high price. It has front and side tempered glass panels, it's beautifully made, and it's also the only case on test to include software fan and light control, courtesy of its Smart Device V2 feature – a USB-controlled fan and lighting hub that's already wired up and ready to go.

You just need to install your hardware, and the fans and RGB lighting automatically fire up, ready to be controlled using NZXT's CAM software, which worked fine first time in our tests.

Here, you can tweak the fan profiles – for our testing, we switched between silent and performance modes to get an idea of noise levels and cooling performance.

There is a downside the H510 Elite's supremely compact design, however, and that's the limited expansion possibilities. There's space for just two hard disks, which is paltry compared with the monstrous offerings elsewhere in this month's Labs test, although it's also the only case to occupy all of its fan mounts out of the box, with rear, top and dual front fans included as standard. However, that's still far fewer fan mounts than the rest of the field this month, and you're limited to a single 280mm radiator too, which is barely enough to deal with a high-end overclocked CPU and GPU in one loop.

The interior is certainly snug, but a smattering of Velcro cable anchors, as well as a cable cover, help to keep the insides tidy. The CPU area cut-out is large, so installing your cooler while the motherboard is installed is simple enough. Plus, with the two front AER RGB 140mm fans, 140mm roof fan and 120mm rear fan all wired up out of the box, it then doesn't take long to build your PC.

However, bear in mind that the CPU cooler height limit is adequate at 165mm, but not exceptional, and any attempt to install a front radiator could see the graphics card clearance cut to less than 320mm, which will result in longer cards struggling for space.

The H510's sound reading of 48dBA with the fans at full speed was by far the highest on test, but despite the lack of ventilation, this setting also netted the joint lowest CPU delta T on test, and the GPU was kept within a degree of the best result too. Switching to the Silent fan profile saw the CPU delta T rise from 69°C to 72°C and the GPU delta T stay the same, but the noise was a far more pleasant 42dBA.

Conclusion

There's no denying that the NZXT 510 Elite is a stunning premium case, and it's very well put together. Its software control works well, and the fact it's pre-wired with fans and lighting out of the box is very welcome. However, it's very limited in terms of expansion and you get a lot more for your money from every other case we reviewed this month, all of which cost less money too. The H510 Elite isn't quite all form over function, but it's only worth considering if you can accept these limitations and aesthetics are at the top of your priority list.

SPEC

Dimensions (mm) 210 x 428 x 460 (W x D x H)

Material Steel, plastic, glass

Available colours Black, white

Weight 7.5kg

Front panel Power, reset, 1 x USB 3, 1 x USB 3.1 Type-C, 1 x stereo/mic jack

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

Form factor(s) ATX, Micro-ATX

Cooling 2 x 120/140mm front fan mounts (2 x 140mm fans included), 1 x 120mm rear fan mount (fan included), 1 x 120/140mm roof fan mount (1 x 140mm fan included)

CPU cooler clearance 165mm

Maximum graphics card length 369mm

VERDICT

Cramped, limited and pricey, but it's well built and undoubtedly the best-looking case on test.

COOLING	FEATURES	OVERALL SCORE
29/30	14/20	81%
DESIGN	VALUE	
23/30	15/20	

ELITE

+ Good cooling
+ Software-controlled lighting and fans
+ Looks fantastic

ELITIST

– Noisy at full speed
– Limited expansion
– Large CPU coolers won't fit

PHILIPS

Monitors

get in the moment

innovation you

Momentum 32” 4K UHD, LCD display with Ambiglow
326M6VJRMB

4K Ultra HD

VESA CERTIFIED DisplayHDR™ 400

UltraWideColor

Adaptive Sync

Available at:

amazon ebuyer.com SCAN

PHANTEKS ENTHOO PRO 2 / £134 inc VAT

SUPPLIER overclockers.co.uk

The Phanteks Enthoo Pro 2 offers by far and away the most extensive, flexible PC building space this month, while also being one of the cheapest cases on test. It's certainly not small, towering to nearly 60cm high and 56cm deep, but it can offer a home to two 420mm radiators, with one in the front and another in the side expelling air through a vent in the side panel. As if this wasn't enough, there's space for 360mm radiators in the roof and base too.

You don't need to let the extensive storage options get in the way of your water-cooling gear either, as the four individual hard disk trays included can be mounted beneath your graphics card, so they don't interfere with the front radiator mounts. As well as these trays, there are mounts for a further eight drives in the side fan mounts using optional trays so. There's scope here to go all-out with RAID arrays, water-cooling systems or a mix of the two.

SPEC

Dimensions (mm) 240 x 560 x 580 (W x D x H)

Material Steel, plastic, glass

Available colours Black

Weight 13kg

Front panel Power, reset, 2 x USB 3, 1 x USB 3.1 Type-C, 1 x stereo jack, 1 x mic jack, lighting control

Drive bays 4 x 2.5/3.5in (up to 12 optional), 11 x 2.5in

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

Cooling 4 x 120mm/3 x 140mm front fan mounts (fans not included), 1 x 120/140mm rear fan mount (fan not included), 3 x 120/140mm roof fan mounts (fans not included), 3 x 120mm/1 x140mm base fan mounts (fans not included)

CPU cooler clearance 195mm

Maximum graphics card length 503

The case can also house a second mini-ITX system in addition to a standard-sized rig, as well as a second power supply should you wish to game and create content on separate rigs. While there's no riser cable in the box, you can also mount your graphics card vertically. Unlike the be quiet! Silent Base 802, there are no swap-out panels here, though, with the Pro 2 using Phanteks' mesh fabric to improve airflow.

Cable tidying is pretty decent, with a few extra-long Velcro anchors and a huge stowage hole in front of the PSU, although it would be better to have a little more clearance between the side panel and motherboard tray. There's also no USB 3.1 Type-C support, only a USB 3 Type-C port, and no fan hub either, although you do get a splash of RGB lighting on the PSU cover.

No fans are included in the box, so we only tested with one and two additional fans. With the former located in the front of the case, the CPU delta T of 71°C was on par with the rest of the field, despite an airflow deficit. However, the GPU delta T of 69°C was noticeably warmer, sitting 5°C higher than the best result.

With two fans installed, the added airflow saw an improvement, with the CPU delta T falling by 1°C and GPU delta T by 2°C, but you'd need at least another couple of fans to match the best-performing cases on test. Noise-wise, the Pro 2 kept the decibels to a minimum without fans installed, topping out at 40dBA, which was a match for the be quiet! Silent Base 802.

Conclusion

The Phanteks Enthoo Pro 2 is a blank canvas for cooling, with its lack of fans and extensive water-cooling support offering the ability to fully customise your rigs instead of spending money on fans that might end up in the bin. It's simple and maybe even a bit clunky, but its storage and cooling expansion potential are phenomenal for the price.

While the Phanteks isn't up to much out of the box, it still comes recommended if you're looking for an affordable case to cram full of hardware. CPC

PHANTEKS OF THE OPERA

+ Massive water-cooling potential
+ Plenty of hard disk mounts
+ Affordable

THE PHANTEKS MENACE

- No USB 3.1 Type-C
- No fan hub
- No fans included

VERDICT

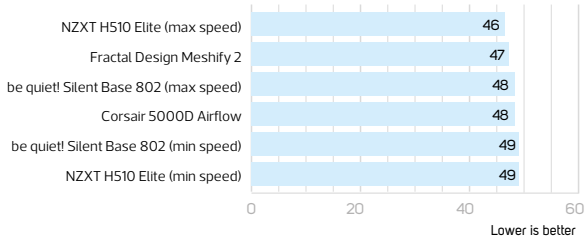
Offers huge potential for a massive machine crammed with hardware, although you'll need to spend a bit of money on extra fans.

COOLING	FEATURES	OVERALL SCORE
27/30	19/20	88%
DESIGN	VALUE	
24/30	18/20	

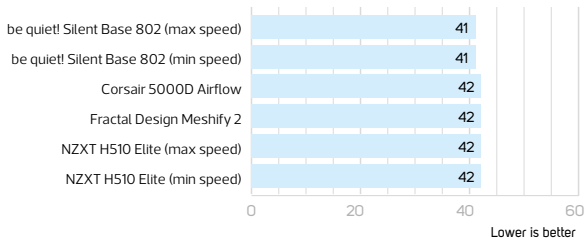
CASE LABS AIR COOLING RESULTS

STOCK CONFIGURATION

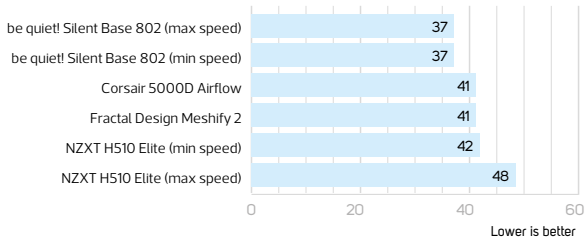
CPU Delta T (°C)



GPU Delta T (°C)



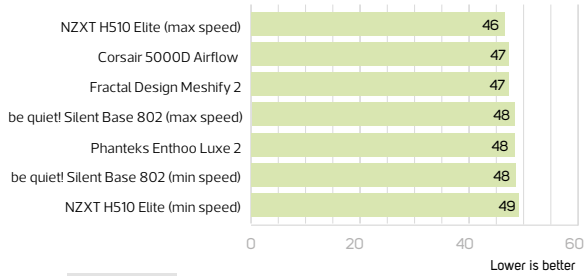
Noise (dBA)



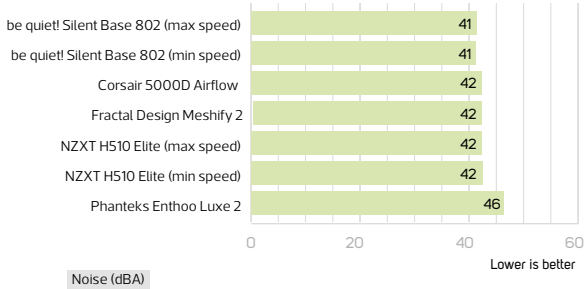
The Phanteks Enthoo Luxe 2 is missing from these results as it has no fans out of the box

ONE EXTRA FAN

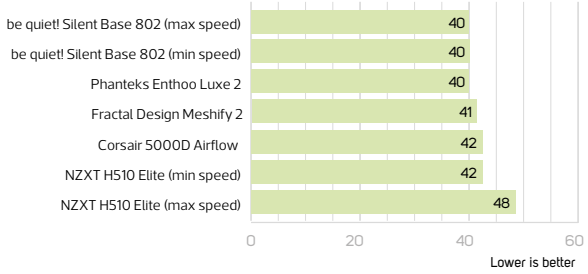
CPU Delta T (°C)



GPU Delta T (°C)



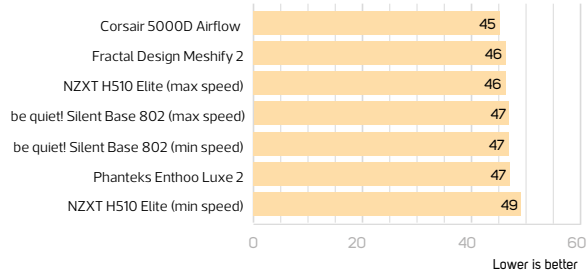
Noise (dBA)



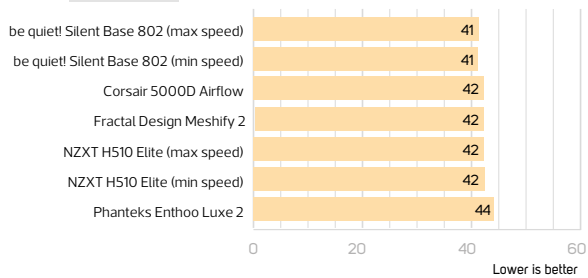
The NZXT H510 Elite was already full of fans out of the box, and is only included in these results for comparison (with no extra fans)

TWO EXTRA FANS

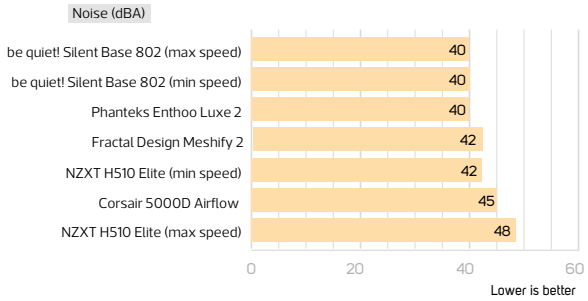
CPU Delta T (°C)



GPU Delta T (°C)



Noise (dBA)



The NZXT H510 Elite was already full of fans out of the box, and is only included in these results for comparison (with no extra fans)

LABS TEST

Mechanical animals

Edward Chester puts eight of the latest high-end mechanical gaming keyboards to the test

How we test

Whether you're after a feature-packed game controller or a rugged typing tool, there's a mass of choice available when it comes to mechanical keyboards. We've picked out eight of the more premium models available to gauge your options if you're prepared to splash out.

The first test of our assessment concerns style and build quality. While some keyboards opt for a basic design but solid build, others pack in all the bells and whistles but can sometimes come up short in terms of heft and solidity. Many people value weight and rigidity above other factors, while others might prefer a more portable option.

Other build quality factors include the overall fit and finish of the board and the type of keycaps – cheaper boards use thinner, less wear-resistant ABS plastic with the key legends painted onto them. More expensive keyboards use doubleshot keycaps made from more wear-resistant plastic, so the key legends don't wear away.

Next up, we look at what features the board offers. Some are pretty basic in this respect, while others include features such as a USB port for connecting other peripherals or USB dongles, a dedicated volume wheel and other multimedia controls, as well as sometimes whole rows of extra keys for convenient triggering of gaming macros. Some keyboards also include several extras in the box, such as a wrist rest, a tool for removing keycaps and even spare keycaps.

Next, we look at the switches. We fully explore and explain the various options available when it comes to switches in our guide on p82, but the short version is that some are better for gaming and some better for typing, while there are various other factors such as feel, noise and compatibility with other keyboards and keycaps to consider. We've noted the switch force, actuation point and bottoming out point in each review (in the format xxxg, xxxmm, xxxmm).

We used each mechanical keyboard over a period of several days for both everyday typing and gaming duties, in order to assess their comfort levels, typing speed and ease of use for gaming. We also performed several typing speed tests on each board to gauge any typing benefits of the switches.

Contents

COOLER MASTER CK550 V2 / £95 inc VAT

SUPPLIER amazon.co.uk

Cooler Master's CK550 V2 is the latest addition to the company's keyboard range, and it includes RGB lighting and plenty of programmability. It has an attractive design with a smart, brushed aluminium-topped casing. The top folds over the edges in a similar way to the Ducky Shine 7, making for a slightly larger footprint than necessary, but it gives the keyboard a more interesting, angular look than usual.

A welcome design touch is that the lock key indicator lights in the top right have RGB LEDs, so you can control their colour and brightness along with the rest of the keyboard. What this keyboard can't really claim, though, is to have particularly high-end build quality. It weighs in at just 852g, and although the build is reasonably stiff, it clearly doesn't have the hefty core of some of the keyboards on test. Pop off the keycaps and you can clearly see they're not doubleshot either, so the black paint that outlines the legends will eventually wear through.

You also miss out on a lot of extra features, such as a USB pass-through or extra gaming keys. You do, however, get a keycap removal tool in the box and a large, padded wrist rest. The latter is essentially like a slice of very thick (15mm) soft mouse mat, with a rubberised bottom, foam middle and fabric top. It's a clever addition, as it's much more comfortable to use than most included wrist rests, yet it's also no doubt affordable to make and include in the bundle.

SPEC

Dimensions (mm) 460 x 135 x 32-40 (W x D x H)

Weight 852g

Format Standard 105 keys

Connections USB

Switch type Cooler Master mechanical (Blue, Brown or Red)

Switch life 50+ million keystrokes

Backlighting RGB

Extras Keycap removal tool, foam wrist rest

The key layout is entirely standard, with no extra keys, but you do get masses of secondary functions built into the keys' functions, with labelling for them on the keycaps. Hitting Fn with the F keys controls all the lighting settings, switches on the Gaming mode (Windows key lock) and also controls macro recording.

The Home/End cluster has media playback and volume controls, the cursor keys add further macro control and the 1-4 keys switch the keyboard profiles. It will take some time to learn all the combinations, but it's handy to have all that extra control built into the design and clearly labelled.

Cooler Master's MasterPlus+ software makes setup easy as well, with full control of backlighting, key mapping and macros. Unfortunately, the software also ruined our review sample, when it failed to install a firmware update (this broke the backlighting and extra functions, although typing still worked), though a later update fixed this.

At the top of Cooler Master's current keyboard stack is the company's MK850 (reviewed in Issue 193), which features key switches that have an analogue response. The further you press down the key, the higher the response in-game, just like the triggers on a control pad. The MK850 is also equipped with real Cherry MX switches.

Comparatively, the CK550 V2 uses an MX clone switch without the analogue response, although they're available in exactly the same blue, brown and red configurations as the Cherry ones, with a 50+ million lifespan. We tested the red version and it felt just as good as using conventional Cherry MX red switches.

Conclusion

The CK550 V2 is a great value mid-range mechanical keyboard. It offers a stylish aluminium-topped design, fully programmable RGB backlighting and key functions, and it all comes in at a very modest price of under £100. It doesn't have the high-end heft of more expensive models, or much in the way of extra features, but it delivers if you just want the basics in an attractive package.

MASTERY

+ Stylish design
+ Good value
+ Even lock key lights are RGB
+ Nice foam wrist rest

MYSTERY

– A touch
– Firmware update bricked it
– Few extra features

VERDICT

Stylish and capable, if not the most ruggedly built, this is a decent-value mechanical keyboard.

DESIGN	FEATURES	OVERALL SCORE
20/25	15/25	78%
PERFORMANCE	VALUE	
20/25	23/25	

CORSAIR K100 RGB / £229 inc VAT

SUPPLIER scan.co.uk

We first looked at the Corsair K100 in a standalone review back in Issue 208, where we were impressed by its combination of premium features and impressive performance. Stacked directly up against the very best competitors, though, does it still impress?

Perhaps most obviously, this keyboard has quite a few extras that put it above many of the others on test. Down the left edge of the keyboard is a column of six extra gaming keys, which are ideally positioned for firing off macros and other extra game commands. Then, in the top left corner, there's a dedicated button and dial that works in conjunction with Corsair's iCUE software to provide extra features, such as backlighting brightness control, skipping music tracks and switching apps.

In this location there are also buttons for switching profiles and locking the Windows keys. In the top right, there's a handy volume wheel and mute button, while at the back is a shiny black plastic section that hides the indicator lights for the Windows key, Scroll, Caps and Num lock buttons. At the back of the keyboard is a USB pass-through, although it's only USB 2.

SPEC

Dimensions (mm) 471 x 165 x 40 (W x D x H)

Weight 1.35g

Format Extended – 111 keys

Connections USB

Switch type Corsair OPX or Cherry MX Speed Silver

Switch life 50+ million keystrokes

Backlighting RGB

Extras USB 2 pass-through, 44-zone RGB lighting strip, multimedia buttons, six gaming keys

All told, it's quite a useful selection, although the quality of the buttons along the top edge is a bit disappointing – they're akin to mouse buttons, with a very shallow clicky feel that feels slightly out of place against all the heavy-duty mechanical keyboard switches.

The gaming keys on the edge also have pros and cons. They're undeniably useful as extra keys, but they're not really close enough to be practical to hit mid-game while still trying to keep your hand largely hovered over the WASD zone. I also found that, even after prolonged use, I'd occasionally place my left hand too far to the left, as my little finger would head for the gaming keys rather than the left Ctrl key, which is the usual reference point for placing my hand during gaming.

Elsewhere, this is a stylish and well-built keyboard, with its brushed aluminium top giving it a premium feel, although it can't quite match the look of previous Corsair keyboards with their even thicker slab of aluminium, even if the new design has a much smoother finish. You also get masses of RGB lighting, with all the keys backlit, in addition to a 44-zone strip of lighting around the rear and side edges of the board.

For key switches, Corsair offers its own OPX optical mechanical switches, which have a very light and tight 45g actuation force and 1mm actuation point (3.2mm total travel), or you can get Cherry MX Speed Silver switches that are similarly fast (45g, 1.2mm, 3.4mm).

We tested the OPX switches and we found them a touch too light at first – they're rather unforgiving of even the lightest accidental touch, but they're clearly very fast and ideal for gaming. Plus, once we got the feel for the keys, they proved very speedy in our typing tests, though not meaningfully quicker than other more tactile alternatives. Finishing off the premium feel, the keycaps here are doubleshot and use PBT plastic, so they should last a lifetime.

KEYLESS CAR

+ Good build quality
+ Stylish design
+ Loads of extra features
+ Very fast optical switches

KEYED CAR

– Expensive
– Light switches are divisive

Conclusion

This is a premium keyboard in all the ways you'd expect, with a solid, attractive design, RGB lighting and plenty of extra features. But then you'd expect that for a non-custom keyboard costing £230. At that price, it's hard to call this keyboard a bargain, but when keyboards that still cost the better part of £150 offer just a basic set of keys, this board certainly doesn't offer bad value either.

VERDICT

With its style, features and blistering typing speed, this is a capable if pricey keyboard.

DESIGN	FEATURES	OVERALL SCORE
22/25	21/25	82%
PERFORMANCE	VALUE	
21/25	18/25	

DUCKY SHINE 7 RGB / £180 inc VAT

SUPPLIER overclockers.co.uk

If you like the idea of the customisation aspect of a custom-made mechanical keyboard, but can't afford (or don't have the time) to build one from scratch, it's worth having a look at what Ducky has to offer. The company produces a vast range of mechanical keyboards with multiple keyboard sizes, switch types and keycap sets available. UK retailer **overclockers.co.uk** lists 111 different flavours of Ducky keyboard. The keyboard brand with the next most numerous options at the same retailer is Vortex, with 30 options.

The Shine 7 is Ducky's flagship keyboard, with a full-sized layout, RGB backlighting and a design that's capped by a beautiful thick slab of zinc alloy. The overall simplicity of the design makes for an attractively minimalist appearance, as does the fact that the keys are sunken into the metal surround, which gives the Shine 7 a less gangly appearance than keyboards with the switches mounted on the surface.

DAZZLING

- \+ Great build quality
- \+ Stylish design
- \+ Real Cherry MX switches
- \+ Doubleshot PBT keycaps

DULL

- – Expensive
- – Modest feature set
- – Overly bright lock key lights

SPEC

Dimensions (mm) 458 x 134 x 38 (W x D x H)

Weight 1.44g

Format Standard 109 keys

Connections USB Type-C socket

Switch type Cherry MX – all types

Switch life 50+ million keystrokes

Backlighting RGB

Extras Detachable USB Type-C cable, extra pink keys, keycap removal tool

This sense of build quality runs to other areas as well. The whole keyboard has a real heft to it – it weighs a group test-topping 1.44kg, which in turn provides plenty of rigidity. You also get a removable cable, with the 1.6m cable plugging into a USB Type-C socket at the back of the board. Sadly, there's no USB pass-through though.

Elsewhere, however, this board isn't as fully featured as some models on test. You do get an extra count of four proper mechanical switches in the top right corner, which by default are dedicated to mute, volume control and opening the calculator app, of all things. Otherwise, there are no extra gaming keys or other multimedia features.

When it comes to programmability, Ducky provides software for changing the lighting effects, with plenty of options included, although annoyingly the overly bright lock key indicator lights can't be controlled. There's no option for changing key functions and programming macros either. Instead, there are loads of (unlabelled) default secondary functions, and you can program keys and macros via a series of key inputs.

On the underside, there's also a row of four DIP switches for changing the default mode of the keyboard. The first three assign the position of the Fn key (it can be programmed to sit on any of the seven keys that flank the spacebar), while the fourth switches between N-key rollover and 6-key rollover modes.

For switches, you get the choice of nearly all Cherry's MX range of switches, including standard red, blue and brown. We tested the brown switches, which are light and snappy enough for speedy typing and gaming, but with just a little bit of a tactile bump to inform when you've pressed the key.

As for keycaps, you only get the one choice by default, but Ducky sells a load of alternatives, in both standard Cherry profiles as well as the taller SA profile. The included caps are doubleshot and made with PBT plastic, so they should last a long time as well. A plain black spacebar is included too.

Conclusion

The Ducky Shine 7 RGB isn't a cheap keyboard and you don't get masses of extra features for the high price, but what you do get is plenty of quality. From the premium metal-topped design, to the solid overall feel of the keyboard, the real Cherry MX switches and the high-end keycaps, it feels like a step towards a much higher grade of keyboard than most of the others on test. It's just a shame about the limited programmability and overly bright lock key indicator lights.

VERDICT

A superb quality keyboard that's about as close to a custom mechanical keyboard as you can get without really splashing the cash.

DESIGN	FEATURES	OVERALL SCORE
22/25	20/25	84%
PERFORMANCE	VALUE	
20/25	22/25	

FILCO MAJESTOUCH-2

£125 inc VAT

SUPPLIER keyboardco.com

Sitting at the more affordable end of the mechanical keyboard scale than some of the models on test this month, the Filco Majestouch-2 is a solid, reliable, full-sized keyboard that's available with a wide range of Cherry MX switches. It's a no-frills keyboard, but its price and build quality will make it a tempting option for some people.

The most obvious downside of this keyboard, though, is that the vanilla model isn't much of a looker. Its all-black design is certainly unobtrusive, but there's not a lot of finesse here – it looks more mundane than minimalist. You can buy the Majestouch-2 in a few more whacky variants though.

There's one that has a case adorned with luminous skulls, with purple lock key indicator LEDs, a fully pink variant and one with bright yellow keys, among others.

You can also get versions with 'ninja' keycaps, where the tops are blank and the legends are written on the side – that's certainly one way to prevent the legends from wearing away.

YOUR MAJESTY

- \+ Good build quality
- \+ Modest price
- \+ Real Cherry MX switches

YOUR MATE

- – Expensive for no backlighting
- – Modest feature set
- – No backlighting

SPEC

Dimensions (mm) 440 x 135 x 40 (W x D x H)

Weight 1.18kg

Format Standard 105 keys

Connections USB (PS/2 adaptor included)

Switch type All Cherry MX types

Switch life 50+ million keystrokes

Backlighting None

Extras USB to PS/2 adaptor

Back to this plain version of the Majestouch-2, though, this model makes up for its looks with its build quality. Despite having an all-plastic exterior with none of the metal top plates of other keyboards on test, it still weighs in at 1.35kg and feels strong and sturdy. It's not quite up there with the Shine 7 or indeed the tank-like build you'll get on some custom keyboards, but it's impressively solid for the price.

There's no backlighting, though, which is an obvious cost-cutting area. While RGB backlighting is a more frivolous addition, single-colour backlighting can be useful for instantly allowing you to see key legends in a darkened room. That said, even just the light from our monitor was sufficient for us to make out the white-on-black legends on these keys.

Even then, though, the keycaps aren't doubleshot – the white is just printed onto the surface, and the caps are made from cheaper ABS plastic than the PBT plastic used on some models. They'll last a good few years, but they won't have the hardcore longevity of doubleshot PBT keycaps.

Meanwhile, for extra features, you get basically nothing. There's no USB pass-through, no extra keys, no extra keycaps in the box and no keycap removal tool or wrist rest either. The cable is also fixed, relatively slim and unbraided. You do, however, get a USB to PS/2 adaptor in the box, so you could use this keyboard with an older machine.

We opted to try the Cherry MX Silent Red switch-equipped version of this keyboard. These switches incorporate tiny rubber patches in the sliding mechanism of the switch, which soften the down and up hits of the switch, significantly reducing the overall clatter of keys. In our testing, the other keyboards averaged between 61.5dB and 70.3dB, whereas this board hit just 56.3dB.

They have a linear action with a 45cN operating force (1.9mm/3.7mm travel); combined with the soft landing, this makes for a surprisingly soft and spongey feel compared with many mechanical switches. It's a little disconcerting at first, but while the action feels a little mushy and lacks feedback, it still has the responsiveness and reliability of other mechanical switches.

Conclusion

A relatively low price makes this keyboard a decent option for those seeking a simple but solid workhorse mechanical keyboard. With this version's Cherry MX Silent Red switches, it's an impressively quiet option too, although it will take a while to get used to the feeling of the switches. The very basic feature set and lack of backlighting are disappointing for the price though.

VERDICT

A capable, well-built mechanical keyboard, but its lack of extras lets it down, even at its modest price.

DESIGN	FEATURES	OVERALL SCORE
17/25	12/25	75%
PERFORMANCE	VALUE	
23/25	23/25	

LOGITECH G915 TKL / £199 inc VAT

SUPPLIER logitech.com

We first looked at the Logitech G915 TKL back in Issue 208 in the context of wireless mechanical keyboards, and were impressed by its design, compactness and features. However, now seemed like a good time to put it up against the thoroughbred typing tools tested elsewhere this month.

The G915 TKL, along with its full-sized non-TKL siblings, represents the company's flagship keyboards. Unlike the very pared-down feel of the Logitech G Pro X (see p56), this one is packed with extras. Along the top edge you get four buttons for switching between wireless and Bluetooth modes, turning on Gaming mode and adjusting backlight brightness. Four more buttons provide media playback control and a mute button, while a lovely grooved metal volume wheel sits at the top of the keyboard.

On the back edge, you'll find the micro-USB connection/charging port, as well as an on/off switch, while the underside is home to a slot to stow the wireless dongle, along with two-stage flip-down legs. It really does make for a stark contrast to how little you get with the G Pro, although you'd hope that a keyboard costing close to £200 would indeed be packed full of features.

In terms of styling, the G915 looks fantastic, especially in this TKL form factor. The brushed aluminium plate that wraps around the chassis looks superb set against the white keys. You might expect this lighter-coloured keyboard to get noticeably dirty, but we've been using this sample repeatedly since our original review, and we're pleased to report that it hasn't noticeably become any dirtier than darker-coloured keyboards.

It's also surprisingly dense and rigid, despite its slim design. It exhibits very little flex and weighs in at 880g, which isn't far shy of its much chunkier sibling. This arguably affects its portability – if that's actually a concern – but this isn't really a keyboard that's made compact for the sake of travel.

When it comes to typing, however, and when this keyboard is set against the best typing tools available, the low-profile Logitech GL switches and the G915's wide, flat keycaps are rather shown up. In our typing tests, we could still operate at a reasonable speed, but the lack of distinction between the keycaps made mistakes more likely (average accuracy of 92 per cent vs 94 per cent plus for the other keyboards) and kept our maximum typing speed some 30 characters per minute slower than most other boards.

The switches are available in linear, clicky and tactile flavours, and we tested the tactile version. They have a fairly pronounced bump and relatively short travel distance (60g, 1.5mm, 2.7mm), but they can become tiring to use with prolonged use.

The tactile bump feels much stiffer than Cherry MX Brown-style switches, and the keys have an almost creaky quality to them – as if they could do with a bit of lubrication. The linear version may improve on this, but full-sized Cherry MX Brown switches are so much quicker, easier and less fatiguing for typing.

Conclusion

The Logitech G915 TKL is a very impressive, versatile keyboard. It's stylish, portable, has a lightning-quick wireless connection and it's packed with features. However, as a pure typing tool it can't compare with the chunkier units on test – there's a reason why big, bulky mechanical keyboards are so beloved by enthusiasts. The G915 TKL is fine for gaming, but its low-profile keys and switches are easily outclassed by larger options when it comes to everyday typing.

SPEC

Dimensions (mm) 369 x 150 x 23 (W x D x H)

Weight 880kg

Format TKL – 87 keys

Connections USB, Bluetooth, Wireless

Switch type Logitech GL (linear, tactile or clicky)

Switch life Unspecified

Backlighting RGB

Extras 1.8m micro-USB cable, USB dongle

LOW PROFILE

+ Stylish, compact design
+ Wireless convenience
+ Plenty of features

FLAT AS A PANCAKE

– Key switches could be better
– Keycap shape and size makes mistakes easier
– Expensive

VERDICT

A fantastically versatile keyboard, but it can't compare for comfort and speed with full-sized mechanical keyboards, and it's rather pricey.

DESIGN	FEATURES	OVERALL SCORE
22/25	23/25	74%
PERFORMANCE	VALUE	
15/25	14/25	

LOGITECH G PRO X / £110–£130 inc VAT

SUPPLIER logitech.com

The latest addition to Logitech's keyboard line-up is, like the company's other G Pro peripherals, a hyper-focused gaming tool first and foremost, or at least that's what Logitech would have you believe. In practice, the G Pro is simply a compact tenkeyless (TKL) keyboard with very little in the way of extra features, but crucially, it also comes with a surprisingly modest asking price.

One area where this keyboard strongly nods towards its gaming peripheral siblings is that its removable cable has the same micro-USB plug on the end that fits into the G Pro Wireless mouse, so in theory, you can use the same cable to charge and use the mouse. However, the keyboard isn't battery-powered, so if you unplug it to use the mouse, the keyboard is useless. With this in mind, it seems like a strange design decision, rather than just providing a normal micro-USB socket and cable (or, even better, a Type-C socket). You also miss out on a USB pass-through port.

Elsewhere, the keyboard sports a very simple set of features, with the TKL layout joined by only two buttons in the top right for switching the backlighting on and off (it doesn't even adjust between brightness levels like some keyboards) and a Gaming mode button, which locks the Windows key. They're undeniably two very useful one-touch buttons for gaming, but there's not much else – there are no dedicated macros keys here, for instance.

SPEC

Dimensions (mm) 361 x 153 x 34 (W x D x H)

Weight 990g

Format TKL – 87 keys

Connections USB

Switch type Logitech GX (linear, tactile or clicky)

Switch life Not specified

Backlighting RGB

Extras Keycap removal tool, key removal tool, 1.8m micro-USB cable

The rest of the keyboard is a modest affair, with a simple all-black plastic chassis surrounding the slightly sunken keys. It's a smart, attractively designed board with a reasonable heft and rigidity to it, but it lacks any of the premium touches of some of the other options on test this month. The TKL layout does make for more room for your mouse, though, meaning you can get into a more comfortable position for using both your keyboard and mouse together.

All the keys, extra buttons and the Logitech logo in the top left are RGB backlit, so you can sync up the whole lot. Logitech's software provides options for per-key lighting, grouped key lighting, built-in whole-board effects or even creating your own custom effects. You can also specify which keys are disabled when the Gaming button is pressed, as well as create macros and custom key binds. However, binds can only be assigned to the F1–F12 keys.

The G Pro keyboard is equipped with Logitech's latest Cherry MX keycap-compatible GX switches – a change from the company's previous proprietary switches. Moreover, the switches are hot-swappable, so you can mix and match the three switch types (linear, tactile, clicky). This will no doubt have niche appeal, but key sets are only £43 and it's handy to at least have the option. We tested the linear switches and they felt great. They're slightly stiffer than Cherry MX Red, with stats of 50g, 1.9mm and 4mm, but they felt every bit as comfortable for typing and gaming.

LOGICAL ARGUMENT

+ Simple, compact design
+ Cable works with G Pro mouse too
+ Modest price

LOGICAL FALLACY

– Basic feature set
– Plastic build
– No wrist rest

Conclusion

The G Pro X is a well thought-out, gaming-focused mechanical keyboard. However, complicating our verdict is the fact that Logitech lists both the G Pro X and G Pro on its website, despite there being no difference between the two. The G Pro can be had with clicky switches for £110 with a UK layout (with stock widely available) but the G Pro X with choices of all three switches costs £130, doesn't have a UK layout option and is only available from Logitech. At £110, it's a decent buy but £130 is pushing it.

VERDICT

A great little keyboard for gamers, but don't pay over the odds for it and make sure it's in stock.

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

Wireframe

Join us as we lift the lid on video games

Visit **wfmag.cc** to learn more

RAZER BLACKWIDOW V3 / £139 inc VAT

SUPPLIER razer.com

The Razer BlackWidow V3 is the company's latest conventional mechanical keyboard, by which we mean it does without the wireless connection of the BlackWidow V3 Pro (Issue 208), or the optical switches of the Hunstman range (Issue 193). What it lacks in fancy extras, though, it makes up for in value, style and performance.

It's a great-looking keyboard, with a slick, all-black look and an aluminium plate on the top finishing off the premium feel. It has a similar vibe to the similarly dark and moody Corsair K100, but just takes the win for style in our eyes. It isn't the heftiest keyboard, though, lacking the weight and rigidity of the Filco and Ducky models on test.

For features, the BlackWidow V3 is a much less outstanding example though. It has a very aggressively knurled volume wheel in the top right (that also doubles as a mute button), and a multi-function media button that will play/pause, and skip forward and back tracks, depending on how many times it's pressed. A handful of the main keys also have secondary functions, such as adjusting backlighting brightness, engaging Gaming mode (disabling the Windows key) and switching profiles.

However, that's your lot. There's no USB pass-through, no gaming keys or any other extras than the included wrist rest. The latter is quite large, slim and made from hard plastic, so it doesn't offer the comfort of the padded wrist rest of the Razer BlackWidow V3 Pro, for instance.

One minor upside to the lack of a USB pass-through is that you get a slimmer, more manageable cable than that of the Corsair K100 and SteelSeries Apex Pro TKL. The Corsair's cable is fully 7mm thick, making it stiff and unwieldy. The BlackWidow V3's cable, though, is just 4mm thick yet is still braided and feels plenty durable enough.

Each key is RGB-backlit, along with the Razer logo on the front edge, making for a simple but attractive lighting array – it's a shame the wrist rest blocks the front logo though. The keycaps are also doubleshot, so the legends should last, but they're only ABS plastic, so will go shiny after a while.

In terms of action, the BlackWidow V3 uses Razer's own mechanical switches, which are essentially Cherry MX clones, but they have stabilising plastic surrounding the central cross on which the keycap sits. This means they should be compatible with most Cherry MX profile keycaps, but you'll need to check the exact measurements of the caps.

Oddly, the keyboard is only available with two switch types – a green clicky version (50g, 1.9m, 4mm) and a yellow linear version, with no tactile bump version, despite Razer making a tactile switch. We tested the clicky version (the only clicky board we tested) and it was certainly very clicky, putting out a typically cacophonous din that was really quite off-putting to our ears (70.3dB compared to around 63dB that was typical of the other boards) during heavy typing sessions.

In our typing test, the switches proved to be decent, but there was a small step down in speed from the fastest switches. We slightly underpressed the keys sometimes too – you can't use a light touch on these switches.

BLACK WIDOW

- \+ Stylish design
- \+ Some extra features
- \+ Decent value

MONEY SPIDER

- – Limited switch options
- – Clicky switches are very loud
- – Some flex in chassis

SPEC

Dimensions (mm) 451 x 154 x 42 (W x D x H)

Weight 1,006g

Format Standard 104 keys

Connections USB

Switch type Razer mechanical green (clicky) or yellow (linear)

Switch life 80 million keystrokes

Backlighting RGB

Extras Volume wheel/mute button, multimedia button

Conclusion

The BlackWidow V3 may not have many fancy features or the heft and rugged build quality of some more utilitarian mechanical keyboards, but it's still a decent keyboard. It looks great, it performs perfectly well and is competitively priced. It's just shame about the limited choice of switches.

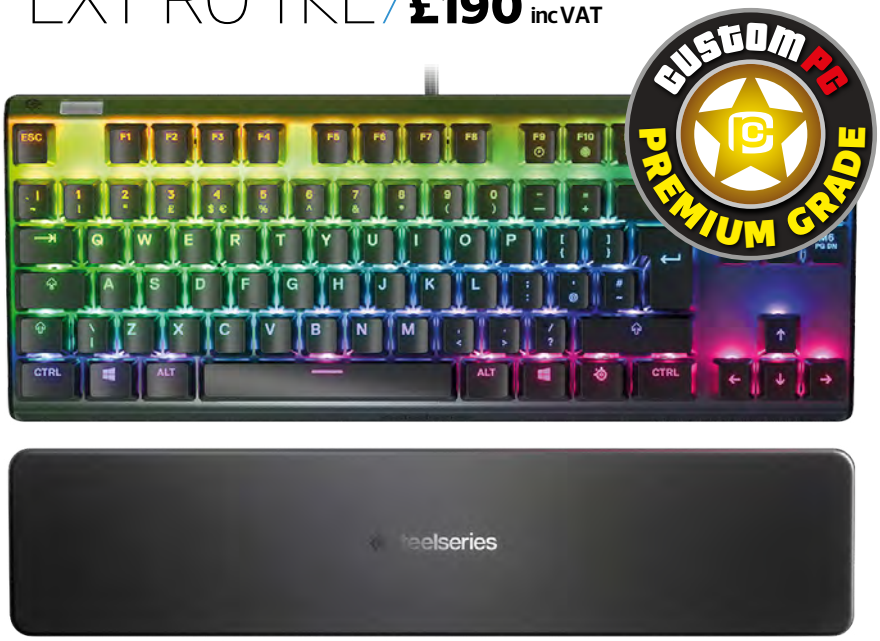
VERDICT

A narrow choice of switches limits the appeal of this keyboard, but it looks great, performs well and is priced sensibly too.

DESIGN	FEATURES	OVERALL SCORE
20/25	16/25	78%
PERFORMANCE	VALUE	
20/25	22/25	

STEELSERIES APEX PRO TKL / £190 inc VAT

SUPPLIER steelseries.com



There's so much packed into the SteelSeries Apex Pro TKL that it's hard to know where to start. SteelSeries' own adjustable OmniPoint switches? The built-in OLED display? The swish magnetic wrist rest? The illuminated USB socket? All are worthy candidates, but first impressions are so often what count, and it's the design of this keyboard that strikes the first chord.

The TKL layout helps here, as this more compact form factor always looks more appealing than the sprawling mess of full-sized models. The edges of the keyboard are also cleverly cut at various angles in order to slim down the overall look, although in practice the Apex Pro isn't significantly more low-profile than the other models on test. The top also includes a slab of aluminium, with a lovely sand-blasted and anodised finish, which attractively diffuses the RGB lighting that spills out onto it. Even the wrist rest adds to the overall premium and stylish impression, with its thick rubber top, sharp angles and magnetic attachment.

This keyboard isn't all about show either. There are practical additions, such as the inclusion of cable-routing options on the underside, so the cable can exit from the left, middle or right of the back of the keyboard. And yes, there's that illuminated USB pass-through socket we mentioned too.

Next up on the hit list is the top-right corner of the keyboard with its lovely tiny, knurled, metal volume wheel (which you can press to mute) and little play/pause button below it. Left of these controls sits the OLED display. Packing in 128 x 40 pixels, this black and white panel will show whatever image you like (including GIF animations) or you can sketch an image in SteelSeries' software.

The display can also be used to change settings, using the volume wheel and adjacent button. It's a little fiddly, and we didn't encounter any function that made it feel like an essential addition, but it's a neat extra feature.

The final big piece to the Apex Pro puzzle is its key switches. The main cluster (from the number row down and enter key left) all use SteelSeries' OmniPoint switches, which use a magnetic actuation technology, where the key senses the distance of the plunger from the magnet in the switch's base. This not only makes for a reliable switching system (with a 100 million+ actuation rating), but it also means the actuation point can be changed in software.

You can opt for one of ten settings that translate to an actuation distance of between 0.4mm and 3.6mm, making for either a very sensitive switch or one that requires a very deliberate press. The feel of the switch doesn't change, just the trigger point. Fans of very heavy, tactile or clicky switches need not apply though – the 50g linear action is the only option.

We didn't feel the need to change the actuation point from its default middle point, as this felt like a great keyboard for typing and gaming on from the off. The switches are compatible with Cherry MX keycaps, and although the ones included look good, they're basic ABS plastic with painted black legends.

Conclusion

The APX Pro TKL is a stunning keyboard. It's stylish, well-built, svelte and packed with useful and fun features – just about the only fault we can level is its use of basic keycaps. Plus, of course, it doesn't come cheap. At £200 for the full-sized version and with a saving of only £10 for the TKL version, this is a very pricey keyboard, but if you have the money you won't be disappointed. CPC

SPEC

Dimensions (mm) 355 x 139 x 32-38 (W x D x H)

Weight 685g

Format Standard 105 keys

Connections USB

Switch type SteelSeries OmniPoint (linear feel)

Switch life 100 million keystrokes

Backlighting RGB

Extras Keycap removal tool, foam wrist rest

APEX PREDATOR

+ Very stylish design
+ Packed with useful features
+ Adjustable typing experience

EASY MEAT

– Expensive
– Basic keycaps
– Limited switch options

VERDICT

It doesn't come cheap but the Apex Pro TKL delivers a truly premium experience.

DESIGN	FEATURES	OVERALL SCORE
25/25	22/25	84%
PERFORMANCE	VALUE	
22/25	15/25	

How we test

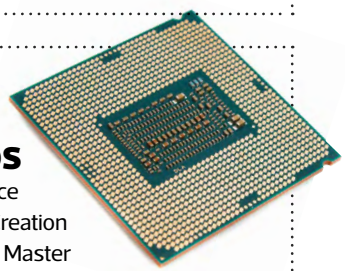
MOTHERBOARDS

TEST PROCESSORS

- **Intel LGA1200** Intel Core i9-10900K
- **Intel LGA2066** Intel Core i9-7900X
- **AMD AM4** AMD Ryzen 9 3900X
- **AMD TRX4** AMD Threadripper 3970X

Our test gear comprises a GeForce RTX 2070 Super Founders Edition and a 2TB Samsung 970 Pro SSD (or a PCI-E 4 1TB Corsair MP600 SSD on X570 and TRX40 boards). We also use Corsair Vengeance RGB 3466MHz DDR4 RAM – a 16GB dual-channel kit for mainstream systems, and a 32GB quad-channel kit for HEDT systems. 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 New Dawn on Windows 10 Home 64-bit. We also test the board's M.2 ports, and record the noise level and dynamic range of integrated audio using RightMark Audio Analyzer. Where possible, CPUs are overclocked and benchmarked again.



PROCESSORS

TEST MOTHERBOARDS

- **Intel LGA1200** MSI MEG Z490 Ace
- **Intel LGA2066** MSI MEG X299 Creation
- **AMD AM4** Gigabyte X570 Aorus Master
- **AMD AM4 (APU)** MSI X470 Gaming Pro Carbon
- **AMD TRX4** Asus ROG Zenith II Extreme

Our CPU test setup comprises a GeForce RTX 2070 Super Founders Edition (or an APU's integrated GPU), a 2TB Samsung 970 Pro SSD, and Corsair Vengeance RGB 3466MHz DDR4 memory – a 16GB dual-channel kit for mainstream systems, and a 32GB quad-channel kit for HEDT systems. A Corsair Hydro-X water-cooling loop, with two XR5 240mm radiators, an XD3 RGB reservoir and an XC7 RGB waterblock is also used.

We use Windows 10 Home 64-bit, and test with our RealBench suite, as well as Cinebench for 3D rendering and Adobe Premiere Pro for video export times. Far Cry New Dawn and Metro Exodus test gaming performance. Finally, we record the total power draw of the test PC. We run all tests at stock speed and at the highest stable overclocked frequency.

MONITORS

We test image quality with an X-Rite iDisplay Pro colorimeter and DisplayCal software to check for 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 responsiveness subjectively and then also use Blur Buster's excellent ghosting UFO test to check the sharpness of the display in high-speed motion.

CPU COOLERS

We measure the CPU temperature with CoreTemp, and subtract the ambient air temperature to give a delta T result, enabling us to test in a lab that isn't temperature controlled. We load the CPU with Prime95's smallfft test and take the reading after ten minutes.

TEST KIT
Fractal Design Meshify C case, 16GB of Corsair Vengeance RGB Pro memory, 256GB Samsung 960 Evo SSD, Corsair CM550 PSU, Windows 10 64-bit.

INTEL LGA1200
Intel Core i9-10900K CPU overclocked to 4.9GHz with 1.2V vcore, MSI MEG Z490 Tomahawk.

AMD AM4
AMD Ryzen 9 5900X overclocked to 4.5GHz with 1.25V vcore, MSI MEG X570 Unify motherboard.

INTEL LGA2066
Intel Core i9-7900X overclocked to 4.2GHz with 1.15V vcore, MSI X299M Gaming Pro Carbon AC motherboard.

AMD TRX4
AMD Threadripper 3960X overclocked to 4.2GHz with 1.265V vcore, 32GB of 3466MHz Corsair Vengeance RGB memory, Samsung 960 Pro SSD, Corsair RM850i PSU, ASRock TRX40 Taichi 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.

TEST KIT

Intel Core i7-8700K overclocked to 4.8GHz on all cores, 16GB of Corsair Vengeance LED 3000MHz DDR4 memory, Gigabyte Z370 Aorus Gaming 5 motherboard, Thermaltake Floe Riing 240 CPU cooler, Corsair HX750 PSU, Cooler Master MasterCase H500M case, Windows 10 Home 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 FrameView.

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

Metro Exodus Tested at Ultra settings with High ray tracing, and with Advanced PhysX and HairWorks disabled. We run the game's built-in benchmark, and report the 99th percentile and average frame rates.

Shadow of the Tomb Raider Tested at the Highest settings preset with High ray-traced shadows, with both TAA and DLSS if it's supported. We run the built-in benchmark and record the 99th percentile and average frame rates with OCAT.

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.

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.

Budget system with integrated graphics

Quad-core CPU, basic gaming

Needs a micro-ATX or ATX case.
We recommend a 350W 80 Plus power supply.

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 5 3400G	currys.co.uk	**#194** p20	£130
CPU COOLER	AMD Wraith air cooler included with CPU	N/A	**#194** p20	£0
GRAPHICS CARD	AMD Radeon RX Vega 11 integrated into CPU	N/A	**#194** p20	£0
MEMORY	16GB (2 x8 GB) Corsair Vengeance LPX Pro 3200MHz (CMK16GX4M2 Z3200C16)	scan.co.uk	**#204** p74	£83
MOTHERBOARD	Asus TUF B450M-Plus Gaming (micro-ATX)	cclonline.com	**#204** p74	£80
STORAGE	500GB WD Blue SN550 (M.2 NVMe)	scan.co.uk	**#204** p24	£55
		Total £348		

Budget gaming system

6-core CPU, 1080p gaming

Needs a micro-ATX or ATX case. We recommend a 450W 80 Plus power supply. See Issue 204, p74 for an example build guide.

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 5 2600	scan.co.uk	**#189** p46	£165
CPU COOLER	ARCTIC Freezer 7 X	scan.co.uk	**#202** p20	£18
GRAPHICS CARD	AMD Radeon RX 5600 XT	overclockers.co.uk	**#204** p74	£290
MEMORY	16GB (2 x8GB) Corsair Vengeance LPX Pro 3200MHz (CMK16GX4M2Z 3200C16)	scan.co.uk	**#204** p74	£78
MOTHERBOARD	Asus TUF B450M-Plus Gaming (micro-ATX)	cclonline.com	**#204** p74	£79
STORAGE	500GB WD Blue SN550 (M.2 NVMe)	scan.co.uk	**#204** p24	£55
		Total £608		

UPGRADES				
SWAP GRAPHICS CARD	Nvidia GeForce RTX 3060 Ti	overclockers.co.uk	**#211** p39	£450
SWAP STORAGE	1TB WD Blue SN550 (M.2 NVMe)	scan.co.uk	**#204** p24	£89

Entry-level RTX gaming system

6-core CPU, 2,560 x 1,440 gaming with real-time ray tracing

Needs an ATX case. We recommend a 550-600W 80Plus Bronze power supply (see Issue 210, p74 for an example build guide).

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 5 5600X	overclockers.co.uk	**#209** p30	£350
CPU COOLER	Antec Neptune 240	scan.co.uk	**#204** p16	£80
GRAPHICS CARD	Nvidia GeForce RTX 3070	overclockers.co.uk	**#211** p40	£650
MEMORY	16GB (2 x 8GB) Corsair Vengeance RGB Pro 3600MHz (CMW16GX4M 2Z3600C20)	scan.co.uk	**#210** p74	£99
MOTHERBOARD	MSI MPG B550 Gaming Carbon WiFi (ATX)*	cclonline.com	**#210** p74	£180
STORAGE	1TB Gigabyte Aorus NVMe Gen4 M.2 SSD (M.2 NVMe)	scan.co.uk	**#210** p74	£149
		£1,508		
UPGRADES				
ADD SECONDARY STORAGE	Western Digital Blue 4TB	overclockers.co.uk	**#166** p54	£95

***This motherboard may require a BIOS update in order to recognise the new CPU.**

Mid-range gaming system

8-core CPU, 2,560 x 1,440 and some 4K gaming with real-time ray tracing

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	AMD Ryzen 7 5800X	scan.co.uk	**#208** p16	£425
CPU COOLER	Antec Neptune 240	scan.co.uk	**#204** p16	£80
GRAPHICS CARD	Nvidia GeForce RTX 3080	overclockers.co.uk	**#211** p43	£830
MEMORY	16GB (2 x 8GB) Corsair Vengeance RGB Pro 3600MHz (CMW16GX4M 2Z3600C20)	scan.co.uk	**#210** p74	£99
MOTHERBOARD	Asus ROG Strix X570-E Gaming (ATX)*	overclockers.co.uk	**#193** p44	£290
STORAGE	1TB Sabrent Rocket NVMe 4.0	amazon.co.uk	**#208** p51	£159
		Total £1,883		
UPGRADES				
SWAP CPU	AMD Ryzen 9 5900X (12 cores)	overclockers.co.uk	**#208** p18	£600
ADD SECONDARY STORAGE	Western Digital Blue 4TB	overclockers.co.uk	**#166** p54	£95
SWAP CPU COOLER	Corsair H100i RGB Platinum (240mm AIO liquid cooler)	amazon.co.uk	**#185** p82	£121

***This motherboard may require a BIOS update in order to recognise the new CPU.**

Core component bundles cont ...

4K gaming system

12-core CPU, 4K gaming with real-time ray-tracing abilities

Needs an E-ATX case with room for a 240mm all-in-one liquid cooler. We recommend an 850W 80 Plus Gold power supply.

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 9 5900X	overclockers.co.uk	#208 p18	£600
CPU COOLER	Corsair H100i RGB Platinum (240mm AIO liquid cooler)	amazon.co.uk	#175 p20	£121
GRAPHICS CARD	Nvidia GeForce RTX 3090	overclockers.co.uk	#208 p24	£1,800
MEMORY	16GB (2 x 8GB) Corsair Vengeance RGB Pro 3600MHz (CMW16GX4M 2Z3600C20)	scan.co.uk	#210 p74	£99
MOTHERBOARD	MSI Prestige X570 Creation (E-ATX)*	overclockers.co.uk	#193 p48	£440
STORAGE	1TB Samsung 980 Pro	ebuyer.com	#208 p52	£204
	Total £3,264			
UPGRADES				
ADD SECONDARY STORAGE	4TB Western Digital Blue	overclockers.co.uk	#166 p54	£95
SWAP CPU	AMD Ryzen 9 5950X (16 cores)	overclockers.co.uk	#209 p31	£860

***This motherboard will require a BIOS update in order to recognise the new CPU.**

Heavy multi-threading workstation

Serious multi-threaded power, 1080p gaming

Needs an E-ATX case with room for a 280mm all-in-one liquid cooler. We recommend a 750W 80 Plus Gold power supply.

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Threadripper 3960X	scan.co.uk	#197 p18	£1,274
CPU COOLER	NZXT Kraken X63 (280mm AIO liquid cooler)	scan.co.uk	#207 p47	£130
GRAPHICS CARD	Nvidia GeForce GTX 1660 Super	currys.co.uk	#199 p44	£224
MEMORY	32GB (4 x 8GB) Corsair Dominator Platinum RGB 3600MHz	scan.co.uk	#197 p20	£275
MOTHERBOARD	ASRock TRX40 Taichi (E-ATX)	overclockers.co.uk	#198 p44	£470
STORAGE	1TB Samsung 980 Pro	ebuyer.com	#208 p52	£204
	Total £2,577			
UPGRADES				
SWAP GRAPHICS CARD	Nvidia GeForce RTX 3070 (2,560 x 1,440 gaming with real-time ray tracing)	overclockers.co.uk	#211 p40	£650
SWAP CPU	AMD Threadripper 3970X (32 cores - massive multi-threaded power)	scan.co.uk	#197 p19	£1,790
ADD SECONDARY STORAGE	4TB Western Digital Blue	cclonline.com	#166 p50	£95

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. We've also recommended a small PSU and a low-profile CPU cooler, if your chosen case requires them.

Mini-ITX

Motherboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
Intel Z490 (LGA1200)	Asus ROG Strix Z490-I Gaming	scan.co.uk	**#206** p40	£275
AMD B550 (AM4 budget)	Asus ROG Strix B550-I Gaming	scan.co.uk	**#206** p44	£197
AMD X570 (AM4 mid-range)	Asus ROG Strix X570-I Gaming	scan.co.uk	**#198** p20	£280

Cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
ALL-PURPOSE	Cooler Master MasterBox NR200P	overclockers.co.uk	**#206** p18	£100

CPU coolers

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
LOW-PROFILE	Noctua NH-D9L	amazon.co.uk	**#143** p17	£55

ATX cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET	Phanteks Eclipse P300 Glass	overclockers.co.uk	**#176** p28	£47
BUDGET QUIET	be quiet! Pure Base 500	scan.co.uk	**#196** p24	£75
SUB-£100	be quiet! Pure Base 500DX	scan.co.uk	**#202** p39	£99
COMPACT	Fractal Design Define 7 Compact	overclockers.co.uk	**#203** p32	£99
HIGH AIRFLOW	Fractal Design Meshify 2	scan.co.uk	**#212** p45	£129
MID-RANGE	Phanteks Eclipse P600S	overclockers.co.uk	**#202** p44	£139
SUB-£150	Fractal Design Define 7	overclockers.co.uk	**#204** p18	£140
PREMIUM	Phanteks Enthoo Evolv X	overclockers.co.uk	**#187** p24	£215

Micro-ATX

Motherboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
AMD X399 (TR4)	ASRock X399M Taichi	amazon.co.uk	**#179** p28	£310
AMD B550 (AM4)	MSI MAG B550M Mortar	ebuyer.com	**#204** p42	£130

Cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET	Fractal Design Focus G Mini	scan.co.uk	**#180** p46	£50
MID-RANGE	Fractal Design Define Mini C	scan.co.uk	**#161** p26	£75

Networking

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
ROUTER (WI-FI 6)	TP-Link Archer AX6000	overclockers.co.uk	**#196** p57	£250
MESH ROUTER (WI-FI 6)	Asus AiMesh AX6100	amazon.co.uk	**#196** p54	£350
WI-FI ADAPTOR	TP-Link Archer TX3000E	overclockers.co.uk	**#196** p58	£60
SINGLE-BAY NAS BOX	Synology DS118	box.co.uk	**#174** p34	£152
DUAL-BAY NAS BOX	Synology DS220j	box.co.uk	**#200** p22	£152
DUAL-BAY MEDIA NAS BOX	Synology DS218play	box.co.uk	**#174** p34	£220
2.5 GIGABIT DUAL-BAY NAS BOX	QNAP TS-231P3	ebuyer.com	**#212** p25	£275

Monitors

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

Up to 25in

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
24IN, 144Hz, TN, 1,920 x 1,080, F, G	AOC G2590FX	scan.co.uk	#190 p53	£178
24IN, 144Hz, VA, 1,920 x 1,080, F	AOC C24G1	ebuyer.com	#191 p28	£197
25IN, 240Hz, IPS, 1,920 X 1,080, F, G	Acer Predator XB253Q	currys.co.uk	#209 p57	£329
25IN, 360Hz, IPS, 1,920 X 1,080, F, G	Asus ROG Swift PG259QN	overclockers.co.uk	#212 p20	£700

Over 28in

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
31.5IN, 60Hz, VA, 4K, F	iiyama ProLite XB3288UHSU	scan.co.uk	#205 p43	£370
34IN, 144Hz, IPS, 3,440 x 1,440, W, F	iiyama G-Master GB3461WQSU	cclonline.com	#206 p53	£406
34IN, 144Hz, IPS, 3,440 x 1,440, W, F, G	LG UltraGear 34GN850	currys.co.uk	#206 p55	£949
38IN, 144Hz, IPS, 3,840 X 1,600, W, F, G, HDR	LG UltraGear 38GN950	currys.co.uk	#208 p30	£1,500
35IN, 200Hz, VA, 3,440 x 1,440, W, G, HDR	Asus ROG Swift PG35VQ	scan.co.uk	#198 p58	£2,499

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	£220
27IN, 240Hz, IPS, 1,920 X 1,080, F, G	Asus TUF Gaming VG279QM	scan.co.uk	#209 p60	£349
27IN, 240Hz, IPS, 1,920 X 1,080, F, G	Acer Nitro XV273	alza.co.uk	#204 p25	£378
27IN, 144Hz, IPS, 2,560 x 1,440, F, G	Asus TUF Gaming VG27AQ	overclockers.co.uk	#201 p54	£460
27IN, 240Hz, TN, 2,560 x 1,440, F, G	AOC AG273QZ	overclockers.co.uk	#202 p27	£540
27IN, 240Hz, IPS, 2,560 X 1,440, F, G	Alienware AW2721D	dell.com	#212 p21	£700

Non-gaming

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
27IN, 75Hz, IPS, 2,560 X 1,440, F	LG 27QN880	ebuyer.com	#210 p26	£388

Peripherals and audio

Gaming keyboards

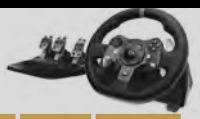
CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
MEMBRANE	Corsair K55 RGB	amazon.co.uk	#201 p45	£55
BUDGET TKL MECHANICAL	HyperX Alloy FPS Pro	amazon.co.uk	#201 p46	£62
MECHANICAL	Corsair K68 RGB	amazon.co.uk	#181 p53	£120
OPTICAL ESPORTS	Asus ROG Strix Scope RX	overclockers.co.uk	#209 p43	£125
MECHANICAL MMO	Corsair K95 RGB Platinum	overclockers.co.uk	#164 p26	£180
PREMIUM MECHANICAL	Corsair K70 Mk.2 Low Profile	scan.co.uk	#193 p56	£150
PREMIUM TKL MECHANICAL	SteelSeries Apex Pro TKL	steelseries.com	#212 p59	£190
LUXURY MECHANICAL	Ducky Shine 7 RGB	overclockers.co.uk	#212 p53	£180
LUXURY WIRELESS MECHANICAL	Razer BlackWidow V3 Pro	scan.co.uk	#208 p60	£230

Gaming mice

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET GAMING	Corsair M55 RGB Pro	amazon.co.uk	#200 p24	£45
FIRST-PERSON SHOOTER	SteelSeries Rival 600	box.co.uk	#184 p59	£65
MMO	Razer Naga Trinity	amazon.co.uk	#186 p52	£76
WIRELESS	Corsair Dark Core RGB Pro	amazon.co.uk	#202 p25	£90
PREMIUM WIRELESS	Razer Deathadder V2 Pro	scan.co.uk	#210 p28	£125
ULTRA LIGHTWEIGHT	Roccat Burst Pro	currys.co.uk	#211 p28	£50

Peripherals and audio cont ...

Game controllers



CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
RACING WHEEL	Logitech G29 Driving Force	currys.co.uk	#202 p50	£230
PREMIUM RACING WHEEL	Fanatec CSL Elite PS4 Starter Kit	fanatec.com	#202 p49	~£434
GAMEPAD	Microsoft Xbox One Wireless Controller	currys.co.uk	#191 p56	£55
BUDGET FLIGHT STICK	Logitech Extreme 3D Pro Joystick	currys.co.uk	#207 p52	£34
FLIGHT STICK	Thrustmaster T.16000M FCS HOTAS	thrustmaster.com	#207 p56	£140

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	£87
WIRELESS	Corsair Virtuoso RGB Wireless	ebuyer.com	#204 p50	£160
PREMIUM WIRELESS	Razer BlackShark V2 Pro	overclockers.co.uk	#211 p26	£180

Speakers

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
STEREO	Edifier R1280DB	amazon.co.uk	#192 p57	£120

Non-gaming keyboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
WIRELESS MULTI-DEVICE	Logitech K780	currys.co.uk	#203 p58	£80
WIRELESS TKL MECHANICAL	Keychron K2 Version 2	keyboardco.com	#208 p57	£84
TKL MECHANICAL	Filco Majestouch Convertible 2 Tenkeyless	keyboardco.com	#203 p55	£140

PCs and laptops

Pre-built PC systems

CATEGORY	NAME	CPU	GPU	SUPPLIER	ISSUE	PRICE (inc VAT)
ENTRY-LEVEL RTX	Wired2Fire Predator	AMD Ryzen 7 5800X	Nvidia GeForce 3060 Ti	wired2fire.co.uk	#211 p32	£1,413
8-CORE GAMING	Chillblast Fusion Commando 3060Ti	AMD Ryzen 7 5800X	Nvidia GeForce 3060 Ti	chillblast.com	#210 p34	£1,690
8-CORE RTX 3080 GAMING	PC Specialist Obsidian I	Intel Core i7-10700KF	Nvidia GeForce RTX 3080	pcspecialist.co.uk	#209 p40	£2,109
10-CORE RTX 3080 GAMING	CyberPower Infinity 910 RTX	Intel Core i9-10850K	Nvidia GeForce RTX 3080	cyberpowersystem.co.uk	#208 p42	£2,465
WATER-COOLED 16-CORE GAMING	Scan 3XS Absorbere	AMD Ryzen 9 5950X	Nvidia GeForce RTX 3090	scan.co.uk	#209 p46	£5,388
DREAM PC	Scan 3XS Barracuda	Intel Core i9-10980XE OC to 4.3GHz	Nvidia GeForce RTX 3090	scan.co.uk	#145 p58	£13,819

Laptops

CATEGORY	NAME	CPU	GPU	SCREEN	SUPPLIER	ISSUE	PRICE (inc VAT)
THIN AND LIGHT GAMING	Asus ROG Zephyrus G14 GA401IV	AMD Ryzen 9 4900HS stock speed	Nvidia GeForce RTX 2060 Max-Q	14in 2,450 x 1,440 IPS 60Hz	overclockers.co.uk	#202 p28	£1,800
HIGH-PERFORMANCE GAMING	Lenovo Legion 7i	Intel Core i7-10875H stock speed	Nvidia GeForce RTX 2080 Super Max-Q	15.6in 1,920 x 1,080 IPS 144Hz G-Sync	laptopsdirect.co.uk	#208 p40	£1,800

RICK LANE / INVERSE LOOK

A JOKE OF A FEATURE

Mistakes in game design are inevitable, but don't then joke about them. That's Rick Lane's job

This month I reviewed The Medium (see p72), the latest horror game I disliked from Polish developer Bloober Team. I've looked forward to every Bloober game I've reviewed, but never seem to get on with the final product. In the case of The Medium, I was nonplussed throughout, but there was a specific moment in the review process where my indifference turned to active distaste.

It involves a puzzle in which one of the player characters must navigate through a hedge maze. It's a dull puzzle, made worse by the game making you do it several times. But what really annoyed me wasn't the repetitiveness. During the final iteration of the puzzle, the player character exclaims, 'This is getting tedious!'

The problem isn't necessarily the game making the player perform a boring task. While it may seem boring to me, that might not be the case for other players. It's quite different, however, for a game to make you do a monotonous task while making a snarky comment about that exact monotony. The developer knew this part of the game was boring, and not only decided to keep it, but also hoped to mask the problem by ironically pointing it out.

Commenting upon the rubbish bits of your own game is depressingly common in the industry. You may have encountered an RPG forcing you to kill rats while talking about how killing rats is boring. Meanwhile, Deadpool and My Friend Pedro sarcastically comment about clichéd sewer levels, before making you run through yet another tedious sewer level.

> You can't resolve a problem simply by pointing at it and making a joke

Games can identify and engage with their own design tropes, of course, but it should be in a way that's interesting and improves the experience. If Deadpool and My Friend Pedro were creative with the tired old concept of sewer levels, that would be different.

An alternative example is the first Fighter's Guild Quest in The Elder Scrolls IV: Oblivion. Here, you're notionally sent on a mission to kill rats in a woman's basement, but it transpires she actually needs help protecting her pet rats from a marauding mountain lion.

Breaking the fourth wall is a storytelling mechanic, a counter-intuitive method of engaging the audience in the events being depicted. It's not a solution to a design issue. You can't resolve a problem simply by pointing at it and making a joke, otherwise surgery would be a lot easier. It smacks of both a lack of confidence and a dearth of imagination in the design. Worse still, it's duplicitous, hoping to pull a fast one over the player by making them think whatever poorly implemented activity you have them doing is a setup for a joke, rather than being poor design concealed by one.

Game development is a difficult and complex process, and sometimes that brilliant idea in your head doesn't turn out to be such fun in practice. Errors are an inevitable consequence of creativity, sometimes slipping through the net of even the best games. But it's important to own those mistakes. Wisecracking about them is amateurish and does a disservice to the players who spent money on your game. CPC

Rick Lane is Custom PC's games editor @Rick_Lane

Disjunction / £12.99 inc VAT

DEVELOPER Ape Tribe Games / **PUBLISHER** Sold Out

Stealth games are normally cautious affairs, where you're creeping carefully through the shadows past guard patrols and surveillance cameras, but Disjunction doesn't have time for such ponderous play. This top-down stealth game is all about speed and precision, as much inspired by Hotline Miami as Thief.

Set roughly 30 years in the future in a cyberpunk vision of New York, Disjunction sees you play as three characters – detective Frank Monroe; boxer and former convict Joe Murphy; and a female hacker known as Spider. They each become entangled in a conspiracy that begins with a local community leader being framed for the murder of a police officer.

It's a familiar cyberpunk tale, but it's well told. Both its plot and characters are acutely drawn through snappy, minimalist dialogue, while most conversations feature a range of choices that can affect the overall direction of the story. The storytelling is bolstered by the grungy yet vibrant pixel art, which makes excellent use of its cobalt and gold colour palette, while the action is underpinned by a buzzing synth soundtrack that brilliantly evokes the game's retro-futurist theme.

As a stealth game, Disjunction is broken up into short but often fiendish levels that typically involve breaking into secure locations to obtain vital pieces of evidence. Between you and that goal is a swarming hive of sentries and security measures, ranging from various human guards, to security cameras, laser turrets and even robotic spiders.

The result is a shifting maze of vision cones designed for you to slip through them swiftly and precisely. Disjunction isn't designed exclusively for stealth – you can blast your way through the levels if you want. However, the levels' arrangements, with sentries leaving tiny gaps in their patrols that can be exploited with the right abilities – a smoke grenade here, a holographic distraction there – indicate that stealth is the primary goal.

The slick and speedy stealth play makes for a refreshing change from the norm, and successfully navigating one of Disjunction's hyper-secure labyrinths is always satisfying. However, it can also be a frustrating experience, and not just because the game is designed to be difficult.

Certain issues, such as inconsistent checkpointing and the sentry vision cones often extending into the corridors separating rooms, mean the challenge can vary significantly between levels and even individual areas. Additionally, sometimes the game is simply cruel, hiding enemies behind doors or placing elaborate security setups beyond the limits of the low and non-adjustable camera.

Disjunction gets you back in the action quickly, but the design isn't quite tight enough to prevent irritation creeping into the experience. That said, the challenge is enjoyable more often than not, so Disjunction merits a recommendation for players seeking a slightly different take on stealth gaming.

RICK LANE

DISJUNCTION

+ Great presentation
+ Good story
+ Fast-paced, challenging stealth

DISAFFECTION

– Can be extremely frustrating
– Inconsistent checkpointing

/ VERDICT

Disjunction's quickfire stealth is thoroughly entertaining, when it isn't making you want to tear out your hair.

OVERALL SCORE

72%

Hitman 3 / £49.99 inc VAT

DEVELOPER IO Interactive / **PUBLISHER** IO Interactive

IO Interactive has chased the dream of perfecting the professional murder simulator for 20 years, and from the highs of Blood Money to the lows of Absolution, its success has been decidedly uneven. However, the studio finally nailed it with 2016's Hitman, which offered some of the most majestic and elaborate sandboxes ever designed.

Since then, it's all been gravy for Agent 47. Hitman 2 was a fantastic follow-up to that experimental first game, and Hitman 3 is the culmination of all that effort. It provides six more assassination adventures that sees IO at the height of its programming powers. Well, mostly. We'll get to that later, but let's focus on the good for now, as there's plenty of it.

Hitman 3 kicks off in Dubai, where Agent 47 infiltrates the world's tallest building (the Burj Al-Ghazali) on a mission to assassinate the leaders of Providence – a secret society of horrible rich people who control the world from the shadows. Hitman 3's story is just as absurd and nonsensical as that of the previous two games, although it adds some personal stakes that make a few of its twists more interesting.

Fortunately, Hitman has never been about plot. It's about tracking down your quarry and using one of the environment's innumerable opportunities to kill them. Mechanically, Hitman 3 is virtually identical to the previous games. The biggest new feature is a camera that doubles as a hacking device, which is useful in certain circumstances, but doesn't alter the core game much. That's good, because the core game works just fine. Rather, the appeal of Hitman 3 is its levels, and how they elaborate upon the conventions established in the previous two games.

To this end, Dubai provides an excellent reintroduction to Hitman's play. Occupying the top three floors of the Burj Al-Ghazali, the area is perfectly sized for warming up your murder muscles – it's large enough to accommodate some freedom of choice, but small enough that you don't feel overwhelmed by the opportunities available. It also perfectly encapsulates the tone of Hitman, with the Burj's overwhelming opulence acting as a screen for more sinister ongoings beneath the surface.

After completing his mission in Dubai, 47 then jets off to sunny Dartmoor, where the last of Providence's leaders, the matriarchal Alexa Carlisle, awaits her fate in her sprawling family estate. This is where Hitman 3 starts to show off. Dartmoor dedicates most of its resources to an elaborate and hilarious set-piece as it turns out Agent 47 isn't the only killer on Dartmoor. Someone has murdered Alexa's reclusive brother the previous night, and as a way of getting to his target, Agent 47 can assume the identity of the detective assigned to the case, before trying to solve it.

What results is by far the most playful and involved of Hitman's Mission Stories, offering a genuinely well-constructed mystery that plays out like a twisted take on a Poirot novel. Prowling around the mansion's many eccentric rooms, ferreting out clues and interrogating suspects is buckets of fun. You can even choose how to close the case – whether to point out the real murderer to Carlisle, or frame someone else.

Meanwhile, the game's third mission in Berlin is set in a pulsing nightclub situated on the industrial fringes of Germany's capital, where Agent 47 finds himself hunted by 11 rival assassins. Berlin is both Hitman's ultimate test and the ultimate playground. It ditches the guided mission stories entirely, leaving the how and why of approaching your targets up to you. In addition, at the outset of the level, you don't know what your targets look like, but they know what you look like. Hence, you need to explore the nightclub carefully, using your camera to identify targets but without being recognised yourself.

Together, Berlin and Dartmoor represent Hitman at its most thrilling extremes. The next level, Chongqing, mixes up the formula again. In this rainy, neon-lit Chinese suburb, Agent 47 must hack into the data facility of the ICA – the organisation for which he's been working since the original game. The primary challenge here is accessing the data centre, one of the most secure locations in the whole Hitman series. The two assassination targets are almost incidental, forming part of the security measures for the data centre itself.

After Chongqing, Hitman 3 returns to classic form in Argentina, where he must assassinate two targets at a party in a sun-drenched vineyard. Mendoza is the least spectacular of Hitman's six missions, but its subtler nature doesn't equal a lack of quality. Mendoza offers a wealth of approaches, including some of the best mission stories outside Dartmoor. One involves tricking a sniper guarding the vineyard into doing the dirty work for you, while another sees 47 make creative use of a winepress. All told, IO couldn't have picked a better location to draw a close to Agent 47's adventures.

Technically, there's another mission after Mendoza that acts as the official finale, but it's frankly dreadful. In fact, it isn't really a mission at all, but a highly linear action sequence that's at odds with every other level in the trilogy. Being generous, IO Interactive likely wanted to allow the player a chance to let rip with 47's murder skills after 20 missions of careful restraint. However, after such a fantastic run of experiences in the rest of the game, the final mission ends up deeply anticlimactic, an unwelcome reminder of Hitman: Absolution's mediocrity.

It's a shame that such a wonderful project to watch unfold ends on a down note, but don't let that put you off. Hitman 3 remains largely a fantastic send-off for 47. And combined, the three games represent some of the best sandbox gaming in the history of the medium.

RICK LANE

HITMAN

+ Five fantastic missions

BINMAN

– One rubbish mission

/ VERDICT

Despite a weak final act, Hitman 3 further expands one of the best sandbox experiences around.

OVERALL SCORE

86%

THE MEDIUM / £41.99 inc VAT

DEVELOPER Bloober Team / **PUBLISHER** Bloober Team

MEDIUM

+ Looks great
+ Split-screen mechanic has potential

MEDIOCRE

- Dull story
- Awkward outside of puzzling
- Doesn't know what to do with its core idea

As a thoroughly middling horror game, The Medium is at least aptly named. It's a classically styled horror adventure with an intriguing split-screen gimmick that sees you exploring two worlds at once. Set in Poland in 1999, players assume the role of Marianne. A young woman gifted (or cursed as she would put it) with psychic powers, Marianne commences the game preparing for the funeral of her foster-father.

Yet the game dispenses with this setup almost immediately after Marianne receives a call from a man named Thomas, requesting her help at an abandoned Soviet holiday resort called Nisa. Despite not knowing anything about the man or the resort, she immediately abandons her funereal preparations and drives deep into the Polish forest.

The Medium's whole approach to storytelling is generally messy. Its characters are inertly written and overacted, while the tone veers from superficially maudlin to weirdly comical. The game does look fantastic, however.

From the foreboding concrete bulk of the Nisa resort, to the eerie, brownish architecture of the spirit realm, the environments are always intriguing to explore. The Medium's stylistic qualities are aided by two key features. The first is its camera and control scheme, which hark back to classic 1990s horror games such as Resident Evil and, particularly, Silent Hill. The second is its unique split-screen mechanic, where you control versions of Marianne both in the material and spirit realms.

The setup works well when The Medium sticks to being a spooky puzzler. Marianne's spirit form can access areas that her physical form cannot, and can perform certain actions, such as rebooting electrical generators. These are used to create some gently engaging navigational puzzles, which blend well with the general atmosphere of tension.

Whenever The Medium steps away from puzzling, though, it begins to struggle. In between the puzzles are multiple stealth sections and chase sequences, neither of which are fun to play with the antiquated control scheme. The former are particularly underwhelming – the enemy AI is so poor that you can stand right next to monsters without them spotting you.

The Medium's biggest problem is that it doesn't know what to do with its core mechanic. The split-screen concept never evolves much beyond the abilities you're given in the game's first third of the game. Moreover, it constantly strays away from the split-screen concept. Large portions of the game are played in single-screen form in one of the two realms, at which point the façade crumbles away, leaving a simplistic, rather tedious puzzle game and not much else.

If The Medium focused on its key idea and elaborated on it properly, it could be a fantastic experience. Sadly, instead you get a trite and ponderous horror game that occasionally toys with innovation.

RICK LANE

/ VERDICT

You don't need to be psychic to see that The Medium is a disappointment.

OVERALL SCORE

50%

WEREWOLF: THE APOCALYPSE – EARTHBLOOD / £35.99 inc VAT

DEVELOPER Cyanide Studio / **PUBLISHER** Nacom

Coming at you direct from 2007, Werewolf: The Apocalypse – Earthblood is a bafflingly dated action game based on the White Wolf tabletop RPG of the same name. It puts you in the hide of Cahal, a werewolf who, along with his fellow lycanthropes, wages a secretive war against an oil company named Endron.

The plot is bolstered by heaps of back-story and lore from the aforementioned tabletop RPG, but you'll struggle to care about any of it. The storytelling is rote and humourless, while Cahal has the personal charisma of a Bonio.

This lack of personality extends to the general presentation. Aside from the dated graphics, Earthblood is stylistically grey and featureless. Nearly every mission involves infiltrating one of Endron's facilities, which all look indistinguishable whether it's a power plant or a training area for Endron's private military. The heavy-metal soundtrack that kicks off whenever you enter combat is a nice touch, but that's as close as Earthblood gets to personality.

It's slightly more interesting at a systems level. Play is split equally between stealth and grisly werewolf combat, and Cahal can assume three different forms – human, regular wolf and werewolf. The first two are primarily used in stealth – the former lets you interact with the environment and quietly eliminate enemies, while the latter makes it quicker to move and easier to hide.

Stealth play is half-decent, striking a pleasing balance between challenge and pacing. One of Werewolf's neater touches is that Cahal can sabotage doors that spawn enemy reinforcements, meaning they enter combat at half-health. Unfortunately this feature, and stealth in general, is made redundant by the combat.

If detected, Cahal can erupt into his most powerful form – an 8ft, befanged monster, and tear through Endron's private army like a toddler through a toy shop. At first glance, the combat system looks impressive.

You have two combat stances, four special abilities and a 'Frenzy' meter that, when filled, lets you perform extra-powerful attacks.

In practice, though, you end up frantically mashing the buttons, occasionally pausing to dodge the attacks from one of the few enemies that can do meaningful damage.

In short, combat is far too easy, which would be less of a problem if it felt satisfying. While tearing through your human adversaries will spill lashings of blood, your attacks have little sense of impact, while dead enemies bounce around combat arenas as if made of rubber. The fact you can grab and throw weaker enemies is fun, but again, there's no weight to the act of throwing.

The result is a combat system's that's too effective to be ignored, but not satisfying enough to be engaging. This, combined with the shoddy production values and general lack of style, means Earthblood is a bit of a howler.

RICK LANE

LYCANTHROPE

+ Decent stealth play
+ Transforming gimmick is cool

MISANTHROPE

– Graphically antiquated
– Stylistically dull
– Combat lacks impact

/ VERDICT

Dated, tedious and poorly balanced, Werewolf: The Apocalypse – Earthblood shows players its full moon.

OVERALL SCORE

43%

REALITY CHECK

Dinos, Doom and sci-fi road trips. **Rick Lane** rounds up the latest happenings in the world of VR

NEWS

QUESTZDOOM

Doom has been ported to every electronic device imaginable, from calculators to pregnancy tests, and now the Oculus Quest, thanks to the unofficial QuestZDoom mod.

It adds support for fully immersive stereoscopic 3D, 6-DOF head-tracking, teleported movement and even touch controls, converting the game's weapons into 3D objects that you can manipulate with your hands. In other words, it transforms Doom into a fully functional VR game.

And it doesn't just run Doom either. Currently, the list of supported games includes Doom II, Final Doom, Wolfenstein 3D, Hexen, Heretic and Strife. It also includes free versions of certain games as part of the package (such as FreeDoom), and even features support for mods such as Brutal Doom and Maps of Chaos.

To install QuestZDoom on your headset, first you need to install SideQuest, another third-party app that enables you to sideload non-Oculus-approved software onto the device. After that, you'll need to install two further applications – the QuestZDoom launcher and the QuestZDoom engine.

Once completed, Doom WADs can then be uploaded directly to QuestZDoom. You can play the free versions of Doom, Wolfenstein and so on right away, but if you want to play the official versions, you'll need to own them separately.

REVIEW

JURASSIC WORLD: AFTERMATH / £18.99 inc VAT

DEVELOPER Coatsink / **PUBLISHER** Oculus Studios

Taking place two years after the events of the middling 2014 film, Jurassic World: Aftermath sees you play as Sam, a mercenary who joins a small expedition returning to the abandoned park on Isla Nublar to retrieve valuable research materials from the Park's main compound. However, after your plane is brought down by aggressive Pterodactyls, the mission turns into an urgent fight for survival.

Aftermath is primarily notable for achieving a lot with relatively little, starting with the presentation. A Quest-exclusive title, the game deftly sidesteps the headset's limited rendering power by adopting a highly stylised cel-shaded aesthetic. The result is one of the sharpest-looking games on the platform, with hyper-vibrant colours and crisp, cleanly drawn lines, all packaged into a file just over 600MB in size.

Presentational quality doesn't end there either. Aftermath offers a tense, low-key survival story that's compellingly written and superbly acted. Actress Laura Bailey excels as Amelia Everett, a geneticist and your primary companion, guiding you through the compound's maze-like layout via remote link. Bailey is crucial in selling the game's story, adding drama to even the most mundane processes of getting the park's basic systems up and running.

In play, Aftermath takes its primary cues from Alien: Isolation, replacing the latter's Xenomorph with a prowling velociraptor that hunts you dynamically through large portions of the game. Although the raptor isn't as coherently simulated as the Xenomorph, Aftermath does a good job of making its behaviour lifelike. It will investigate noises you make, search for you under desks and, when it's not on screen, you can hear it clunking around in the compound's ventilation shafts.

These bouts of dino-evasion are coupled with some light puzzle solving. In a nod to Half-Life: Alyx, doors, computers and other electronic items require you to solve a range of holographic puzzles in order to access them. Doing this while also watching for the Raptor is one of the main drivers of the game's tension. You can hide in a cupboard for safety, and you can also distract the dinosaur by remotely activating certain electronic equipment.

Aftermath does an impressive job of creating a compelling experience out of a handful of systems, although it does err on the side of being too slight. For example, you can't throw

items to distract the raptor, which would be both more engaging and more practical than relying on the limited number of electronic devices in each room. A bigger problem, however, is that the game ends abruptly after around four hours, with the next part gated off as paid DLC.

Like Star Wars: Tales from the Galaxy's Edge, overly monetising already-brief VR games is an unsavoury practice, and it means Aftermath ends on a rather sour note. However, while it's unfortunate that developer Coatsink doesn't feed you the whole dinosaur pie, Aftermath is otherwise a smart, atmospheric and impressively efficient experience.

JURASSIC PARK

- \+ Looks splendid
- \+ Fun dino-based stealth
- \+ Does a lot with just a handful of systems

THE LOST WORLD

- – Oversimplifies things too much
- – Ending appears to have been cut off for DLC

VERDICT

Despite a questionable pricing structure, Jurassic World: Aftermath is a fun ride while it lasts.

OVERALL SCORE

72%

NEWS

VANISHING GRACE

One of the more original VR releases coming in 2021, Vanishing Grace is a sci-fi road trip adventure game. Vanishing Grace puts you in the role of Joel on a mission to track down his friend Grace, who disappeared in the desert while travelling. The game involves following Grace's trail in your sand-skimming hovercraft, gradually piecing together what happened to her.

Aside from its distinctive setting, which is partly inspired by Campo Santo's gripping narrative adventure Firewatch, what makes Vanishing Grace interesting is its approach to systems and interaction. Much of the game revolves around the hovercraft itself, which you need to drive, maintain and power. This latter mechanic is especially unusual, as you need to collect resources by throwing a boomerang at strange, hovering rocks. Yes, you read that correctly.

Our one concern about Vanishing Grace revolves around the story's delivery. In the trailer, the voice acting for Grace isn't especially convincing. Given that Grace's voice is the most prominent in the story (delivered via the tried and tested method of audio-logs) this has potential to undermine the narrative, which is a big part of the game's appeal. No specific release date has been announced at the time of writing, but the developer intends it to be soon, so expect a review within the next few issues. CPC

BUILD A FIRST-CLASS WATER-COOLED GAMING PC

ANTONY LEATHER SHOWS YOU HOW TO BUILD A POWERFUL WATER-COOLED PC TO PLAY THE LATEST GAMES AT MAXIMUM SETTINGS

We can't wait for stock levels to get back to normal so we can start tinkering with hardware and planning future PC builds. It's a fantastic time to be a PC enthusiast too. There are compelling, competitive products in both the CPU and GPU arenas, water-cooling gear is more varied and easier to use than ever and SSDs are available in big capacities with ridiculous speeds and low prices. Cases are better than ever as well, with fantastic features to keep your PC cool and make the build process intuitive and simple.

Whether you plan on building a £600 budget-conscious rig or an all-out monster costing several thousand pounds, your hardware choices are important. The more expensive the build, though, the larger the consequences of poor choices will be. If you're planning your dream PC then it definitely pays to pore over every detail to make sure it not only performs as it should, but looks great too.

This month we're building a droolworthy system using high-end kit. There's custom water cooling, ray-traced gaming capable graphics, RGB lighting and plenty of multi-threaded grunt for streaming and content creation, as well as tips on alternative hardware to plan your own mega build.

OUR TOP HARDWARE PICKS

CPU

AMD Ryzen 9 5900X

£599 inc VAT

overclockers.co.uk

There's a huge amount of choice out there right now when it comes to CPUs, for the simple reason that AMD has a full stack of winning models from the Ryzen 5 5600X all the way up to the Ryzen 9 5950X. In a reversal of roles, Intel is now dropping prices to remain competitive and the likes of the Core i5-10600K, Core i9 10850K and Core i9-10900K are suddenly a whole lot more competitive than they were a few months ago. They're available too, which can't be said for many of AMD's CPUs, including the Ryzen 9 5900X that we're using in this build. However, we've been reassured by retailers that it should be available soon – hopefully by the time you read this magazine.

The Ryzen 9 5900X strikes a great balance of excellent multi-threaded performance paired with superb lightly threaded grunt that propels it to the top of graphs in games compared with nearly every other CPU except AMD's own Ryzen 9 5950X. It's a great choice if you plan on doing a range of tasks with your PC such as streaming and video editing, as well as gaming, as it has 12 cores and 24 threads too.

Alternatives

Things get a tad complicated when you consider other CPUs for a build of this calibre, as there are several from both AMD and Intel. To start with, if you need more multi-threaded grunt, the logical choice is the Ryzen 9 5950X. With its 16 cores and 32 threads, it's a CPU that will demolish just about any multi-threaded tasks that you'll likely encounter on a desktop PC, and it's a dab hand at gaming too. However, it will cost you another £250, so you'll need to carefully consider if it's worth it.

At the time of writing, the 5950X was also out of stock, but not our next choice, the Ryzen 7 5800X. With eight cores and 16 threads, you certainly won't see any performance drop in games compared with its more expensive siblings and it costs £440 too, saving you over £150.

However, it was also our least favourite of AMD's Ryzen 5000-series CPUs. The cheaper Ryzen 5 5600X was just as quick in games and the Ryzen 9 5900X offers a huge amount more multi-threaded performance leaving the 8-core 5800X in a tricky spot. However, if you're dead set on having more than six cores and don't need the added grunt or cost of the 12-core Ryzen 9 5900X, then the Ryzen 7 5800X might be a good option, especially if the others are still out of stock.

While we'd have advised against it a few months ago, the fact that Intel's 10-core 10th-gen CPUs can be had for far less now and are actually available, makes them viable alternatives to AMD's Zen 3 CPUs. The Core i9-10850K costs just £380, which is £60 less than the Ryzen 9 5800X, but has an additional two cores and four more threads and isn't far behind in lightly threaded applications either.

With Z490 motherboards available for less than £160, an overclocked Core i9-10850K could be a cheaper option than AMD equivalents and it's still a great CPU for games and content creation, albeit without the finesse of AMD's 7nm Zen 3 architecture.

MOTHERBOARD

MSI MEG X570 Unify

£265 inc VAT

scan.co.uk

As we're opting for a Zen 3 Ryzen CPU, it makes sense to go for either an X570 or B550 chipset motherboard. Both should now support Zen 3 Ryzen CPUs out of the box, but in the rare event they don't, our chosen motherboard also supports USB BIOS Flashback, allowing you to update the BIOS to a newer version without turning on the PC.

We've picked the MSI MEG X570 Unify, as it has an impressive specification including a USB 3.1 Type-C header to match our chosen case, power, reset and clear-CMOS buttons to aid with testing and overclocking – plus 802.11ax Wi-Fi and 2.5 Gigabit LAN. MSI has also teamed up with Corsair to offer an RGB lighting connector to control Corsair's components, some of which we'll be using in this build, giving us the option of using Corsair's iCUE software or MSI's alternative. For a premium X570 motherboard, the MSI MEG X570 Unify is also reasonably priced at £265, plus it's one of the more colour-neutral motherboards out there too.

Alternatives

We're avoiding RGB lighting on our motherboard with this build, as plenty of other components have it. However, if you fancy some additional eye candy, the Asus ROG Strix X570-E Gaming is a great choice, sporting similar features except with a generous helping of RGB. It will set you back an extra £50 or so.

GPU

Nvidia GeForce RTX 3080 Founders Edition

£649 inc VAT

nvidia.com

While AMD's RX 6800-series cards are compelling and recent driver tweaks have resulted in sizeable performance improvements, Nvidia's RTX 3000-series is still hard to beat for an all-round frame rate-fest that includes the latest ray-traced titles. With the benefit of DLSS, Nvidia has an edge here, but none of this matters.

Stock levels continue to be dire with plenty of scalping going on at some retailers and especially at auction websites, which are currently best avoided. Nvidia has generally had slightly better stock levels for the past few weeks, but we're still talking stock that's gone in a flash. Again, we're hoping this will improve and if it does, our pick for a build such as this would be the RTX 3080.

There are plenty of models from which to choose, but if you're water-cooling it, which we are, there are usually plenty of options for Founders Edition models and the RTX 3080 is no exception. EK has at least two blocks available for this model in a range of colours and most waterblock manufacturers have models for it available or in the works too. The trouble, as usual, is getting hold of it, especially as the RTX 3080 Founders Edition is one of the cheaper models out there. Alternatively, there are waterblocks available for other models too, so be sure to check the compatibility tables from the likes of Corsair, EK and Alphacool before you splash out on a card you find in stock.

Alternatives

Sadly, stock levels are poor across the spectrum right now, but if ray tracing and high-resolution gaming are your thing then Nvidia is the one to go for with its RTX 3000-series. The RTX 3070 is a worthy alternative if your budget is tighter. It will still provide ample performance for gaming at up to 1440p, with the addition of DLSS, and it can handle plenty of titles at 4K too.

The Radeon RX 6800 XT doesn't have quite as well-rounded a feature set and performance range compared with the RTX 3080, but recent driver updates have improved performance and at the moment, it certainly pays to keep your options open if you happen to find one in the wild.

If you need the ultimate performance and game predominantly at 4K or above, then the RTX 3090 is the clear option. It's an absolute monster for performance, but sadly for your wallet, it has a monster price tag too.

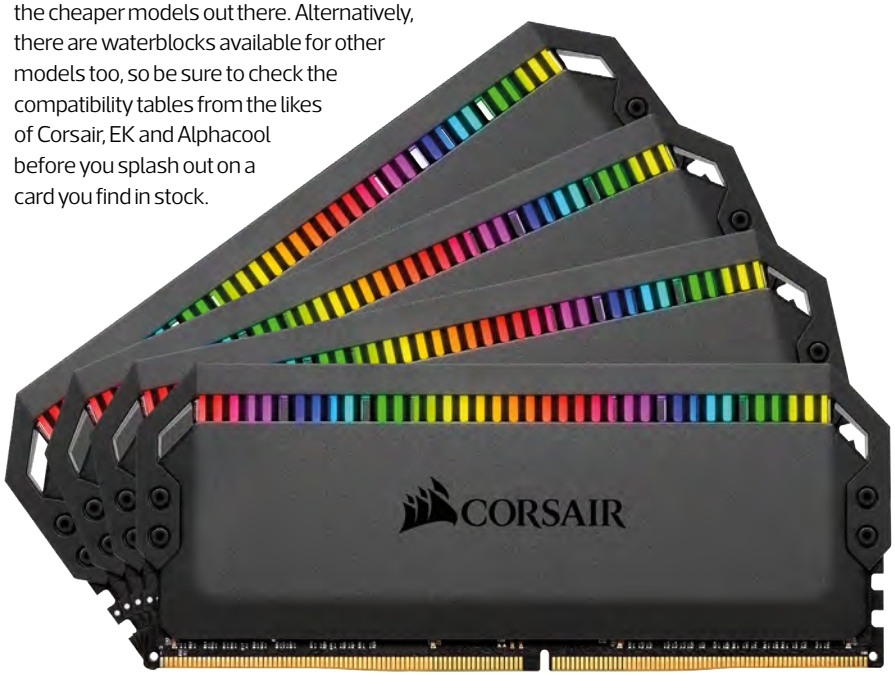
MEMORY

32GB Corsair Dominator Platinum RGB White 3600MHz

£273 inc VAT

scan.co.uk

As we're splashing out with this build, a four-module kit was in order and for a couple of reasons. Firstly, when it comes to RGB lighting, filling all available slots simply looks better. It's one reason why companies such as Corsair make dummy modules, allowing you to just buy two expensive real modules, but fill the vacant slots with much cheaper dummy sticks. If you can afford it, though, simply going with a four-module kit will mean you won't need to worry about upgrading in future and there are other benefits too.



The second reason is that, due to the design of AMD's Zen 3 Ryzen CPUs, they actually perform better when they have access to four modules as opposed to two, with all other factors being equal. As a result, if you're keen on maximising the performance of your PC, opting for a four-module kit as opposed to two modules is another way to eke out a little more performance. It not always worth spending the extra money, as investing the cash in a better GPU will have more benefit, but as the next step up is a hugely more expensive RTX 3090 card, we decided to grab a four-DIMM kit.

Our chosen kit is Corsair's 32GB Dominator Platinum RGB in white, with a rated speed of 3600MHz. This is maybe a tad overkill in terms of capacity, but if you're mixing content creation with gaming and leave software open as you switch between tasks, you'll be thankful for a little extra breathing room as well as the extra performance having four sticks brings.

CASE

Corsair iCUE 5000X RGB

£170 inc VAT

scan.co.uk

Our premium case Labs this month featured several exciting new cases that wowed us with features and cooling. However, for this build, we wanted a little more visual pizzazz mixed with excellent water-cooling credentials and none really fitted the bill. However, one of the runners-up – Corsair's 5000D airflow, has a sibling that's perfect for the job.

The iCUE 5000X RGB uses the same chassis, but with all-around glass, RGB fans, and comes in a gorgeous white and grey finish. It doesn't have the same large vented exterior, with the front and roof instead sheathed in tempered glass, but these areas are still designed to allow air to pass through. There are plenty of other places to put fans and radiators, though, including the side panel, so it remains a great case to water-cool and is much better-looking than the cheaper model too.

Alternatives

The storage options in our chosen case are rather limited, plus you might prefer something a little more understated. In which case, this month's case Labs test winner is a great choice. Fractal Design's Meshify 2 is superb, leaving you with plenty of change from £150 but still providing great out-of-the-box cooling and oodles of water-cooling potential.

COOLING

Corsair Hydro X components

£100 inc VAT

scan.co.uk

As the RTX 3080 has been out for a few months, waterblock manufacturers have had ample time to measure up and create their wares and there's a number of waterblocks available. We've gone for Corsair's Hydro X XG7 RGB, which is specifically made for the RTX 3080 Founders Edition, but it offers models for plenty of partner card examples too.

We've also gone for Corsair's XC7 CPU waterblock to cool our Ryzen 9 5900X, as well as a pair of its XR5 360mm radiators and ML120 Pro RGB fans to keep our PC cool and quiet. We're also using 12/10mm flexible tubing, cut to length with angled Corsair chrome fittings to route it around the PC. Finally, we're using Corsair's XD5 RGB reservoir, which includes a D5 pump. We'll also be using red clear coolant. The total for the entire cooling system is £660.

PSU

Corsair RM850i

£168 inc VAT

novatech.co.uk

While the RTX 3080 is a monster GPU, it has some fairly hefty power requirements. We haven't seen power draw above 500W from any of our in-house RTX 3080 PCs, but it's come close. As a result, you'll want to factor in at least another 50 per cent on top of that – more if possible, so a minimum of 750W. We've opted for an 850W PSU in the form of Corsair's RM850i. It has fully modular cables, which we've replaced with Corsair's custom white cable set, and with 850W of power, it should be more than enough for our system.

STORAGE

Corsair 2TB MP600

£159 inc VAT

overclockers.co.uk

We're not quite at the point of replacing our hard disks with SSDs, as 8TB of the former still costs a lot less than the latter. However, with many of us using the cloud or a NAS enclosure to house mass data, getting a single big M.2 SSD is still a great way to have nearly all you need on a single drive. It saves cables and with the Corsair iCUE 5000X RGB case, removing the hard disk cage provides a handy cable stowage area under the PSU cover too. We've gone for Corsair's 2TB MP600 SSD and removed its heatsink, so it can sit under the included motherboard M.2 heatsink.

TOTAL
2,943 INC VAT

BUILDING THE PC

YOU DON'T WANT TO SPEND A WEEKEND BUILDING YOUR WATER-COOLED PC ONLY TO FIND YOUR GRAPHICS CARD IS FLAKY

1 INSTALL COMPONENTS ON MOTHERBOARD

Fit as much as you can on your motherboard before you install it in the case. Once you've installed it, everything else becomes harder to fit, especially once you've installed your water-cooling system, as getting at the ports and heatsinks will be fiddly. So, start by installing the waterblock mounts, the CPU and memory. The Corsair waterblock we've used handily comes with thermal paste pre-applied.

2 TEST HARDWARE

It's a very good idea to test your hardware out of the case to make sure it works. Dead-on-arrival components are rare, but you don't want to spend a weekend building your water-cooled PC only to find your graphics card is flaky. Place the motherboard on its box, connect the power cables and graphics card, and connect it to your monitor.

Then install the waterblock, but don't plumb it in. We'll only be turning on the PC for a few moments to make sure we get a display output and the CPU will not overheat in this time. Unfortunately, AMD doesn't include a cooler with the Ryzen 9 5900X, so the waterblock is required at this stage. Switch on the PC, wait for a display and then switch it off straight away.

3 INSTALL SSD

Remove the SSD's heatsink. We'll be using the motherboard's own M.2 heatsink, but you're welcome to leave the latter in the box and use the one the SSD came with too. The choice is yours. Install the SSD using the screws provided. Ideally, you want to use a slot away from your graphics card, as the exhaust air can heat it up and potentially cause it to throttle.

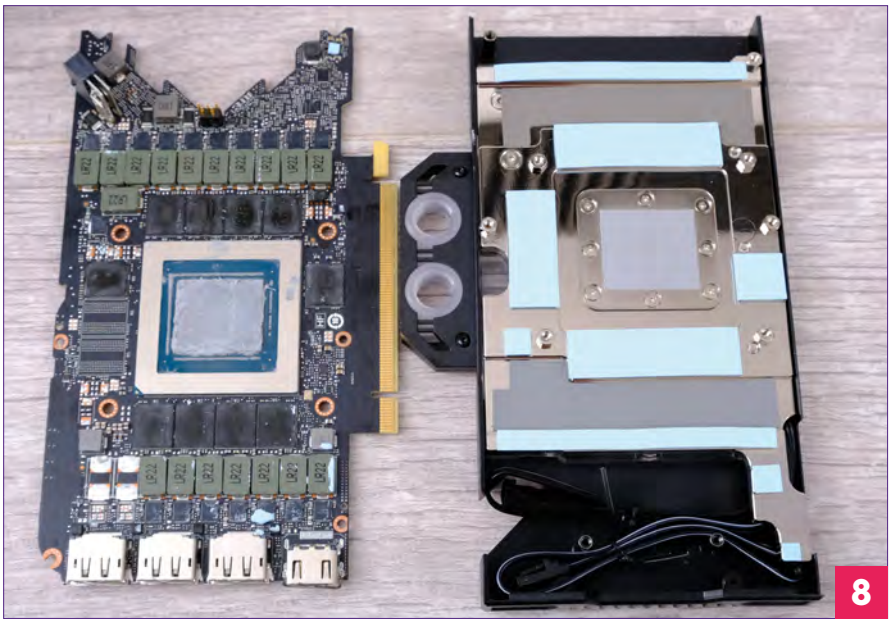
4 INSTALL MOTHERBOARD IN CASE

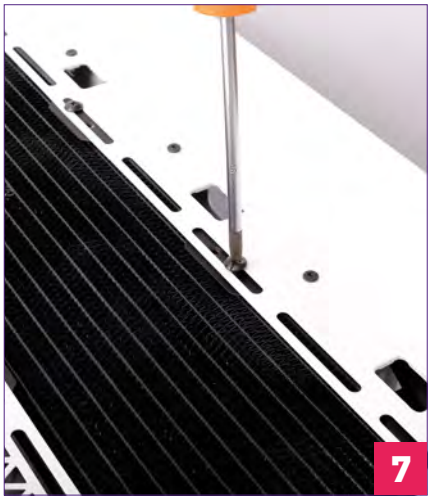
Go ahead and install the motherboard into the case. If you haven't decided on your tubing routes, now's a good time to get an idea of how things might play out, and you can test-fit other components such as radiators and reservoirs at the same time.

5 INSTALL RADIATOR FANS

You need to check a few things here. Firstly, you need to make sure the power and lighting


6


8


7


9

cables are all facing the same and correct way, so that they face the motherboard tray once the radiator is installed. This will enable you to feed the cables directly through the cable-routing holes and minimise any unsightly cable spaghetti. You also need to make sure the fans are on the correct side of the radiator.

6 REMOVE REDUNDANT CASE PANELS

A lot of cases now include optional panels and other components that you can chop and change depending on the style of your build. This is a good stage to make sure your case is setup how you want, as you don't want find after installing most of your cooling system that you've blocked a panel that needs to come out, meaning you need to remove everything to get at it. Areas to look out for include sections of the PSU cover that make way for radiators or, in our case, a cable cover that reveals the side-mounted radiator location.

7 INSTALL RADIATORS

To install the radiators, you'll need the right screws. Mounting a radiator so that it exhausts from your case usually requires the shorter screws, as you're just bolting the radiator to your case. That's what we're doing here, as we're placing radiators in the roof and side mounts, shifting air out of the case.

8 REMOVE GPU COOLER

You can see last issue's guide for more details on how to dismantle the RTX 3080 Founders Edition, but we recommend duct tape or 3M mounting tape to remove the magnetic screw caps in the casing. After this, dismantling the card is straightforward. The Corsair waterblock we've used has its pads and paste pre-applied, which saves a lot of time.

9 FIT GPU WATERBLOCK

All you need to do is clean the GPU core and memory modules, remove any stray thermal pads and place these back onto the original heatsink; then place the waterblock on top. Follow the instructions on how to secure it and the backplate. Once it's mounted, go ahead and install the graphics card. We've used a riser cable to mount our graphics card vertically, so it's visible through the side window.


10


11


13

WE'VE USED A PCI-E RISER CABLE TO MOUNT OUR GRAPHICS CARD VERTICALLY, SO IT'S VISIBLE THROUGH THE SIDE WINDOW


12


14


15

10 FIT RESERVOIR AND PSU COVER

The Corsair iCUE 5000X RGB includes a replacement panel for the front section to seal the PSU cover and smarten up this end of the case. Fit this first and then install the reservoir in one of the front fan mounts using the included adaptors.

11 PLAN YOUR TUBING

The tube routes are down to personal preference, but there's logic in using as little tubing as possible. We ended up having the coolant come into the top of the reservoir and having the outlet pointing at the GPU rather than what you see pictured, which ended up trailing tubing up to the roof radiator.

12 CUT AND FIT TUBING

Connect the tubing to your fittings and run it to the next fitting, marking the cutting point where the end of the tube should reach onto the fitting barb. You can then use tube cutters to create a straight cut. Using flexible tubing can still look great and is a massive time and money-saver too. It doesn't matter on the order of components. Just connect them in the most efficient way to use the least tubing. The coolant temperature tends to even out around the loop, so there's little to no benefit having a radiator before your CPU waterblock, for example.

13 ADD ANGLED PIPE FITTINGS

Connecting two nearby radiators can be a challenge, but using angled rotating fittings can mean you avoid kinks and save connecting them to other components instead, wasting tubing and making the route less efficient.

It's worth a few minutes of tinkering to connect them to each other. Even if you're using use rigid tubing, it's easier to use flexible tubing in out of sight areas like this.

14 CHECK FOR UNUSED PORTS

Once you've connected your fittings, do a check of all components for spare ports that need to be plugged. The graphics card has at least two, and the pump and radiators might do as well. Most waterblocks and reservoirs come with blanking plugs to cap off any unused ports like this.

15 CONDUCT A LEAK TEST

Of course, if you do miss one, or haven't tightened a fitting properly, then you'll find out at this step. A leak tester is an essential bit of kit for a water-cooling system, as it can find leaks before you even add a drop of coolant.

Connect it to a spare port, for example on the graphics card, and aim for 0.3bar if you're testing an entire loop. From here, cap off the tester and leave it for ten minutes. If the pressure gauge remains constant then you're good to go. If not, tighten all your fittings and try again.

16 ADD RGB LIGHTING

We've gone all-out with RGB lighting in this build and the next step is to connect it all. The waterblocks come with leads that can connect to Corsair's own components or directly to an RGB header on your motherboard using an included adaptor, so you don't have to be tied in to Corsair's RGB ecosystem.

Unfortunately, this will always add more spaghetti, but the end result will be worth it. We're expecting a higher degree of PC-building proficiency here, so we won't be covering the usual steps such as attaching front panel cables and the like.

17 CONNECT FAN AND LIGHTING CONTROLLER

One way to make your PC building life easier is to use Corsair's Commander Pro fan and lighting hub. This allows you to connect up to six fans directly, as well as power two Lighting Node Pro LED hubs, which power the lighting on the ML120 Pro fans we've used. This connects to your motherboard to allow you to control everything using Corsair's iCUE software. You can even wire in temperature sensors.

18 POP IN THE POWER SUPPLY

The power supply has plenty of connectors, but we only need half of them, so ditch any unwanted cables and just connect the ones you'll need. Feed the PSU into the case and secure it, then feed the cables around the case, connecting your hardware and making sure to put the Corsair case's cable-routing system to good use. Corsair includes a bunch of large Velcro cable ties as well as hefty anchor points, so it's simple to create a tidy PC.

19 FILL THE WATER-COOLING LOOP

With leak testers there's generally less of a need to power on the pump separately using an ATX jumper, as any leaks will have surfaced already, so we can skip this step. Instead, go ahead and fill your reservoir and then switch on the PC.

Expect the system to be noisy and there to be lots of bubbles in the loop until you've filled it and it's bled itself of air. This can easily take an hour depending on the loop and sometimes even longer.

20 FINISHING TOUCHES

Before you start meticulously tidying away all your system's cables, fire up Windows and check all the RGB lighting is working as it should. Then, skip the meticulous tidying anyway because the large door on this case hides everything underneath the side panel.

If your case is less accommodating, cable ties and Velcro straps are your friends. Secure down any errant cables to prevent them from interfering with any fans, blocking airflow and of course keep your system looking tidy.

PERFORMANCE AND OVERCLOCKING

There are a few ways to overclock your PC, especially when it comes to the CPU, but we'll be covering the easiest and quickest ways to get more performance, especially as heat is far less of an issue with a water-cooled PC. To start with, you'll need a copy of MSI Afterburner (**guru3D.com**) and AMD Ryzen Master (**amd.com**). You'll also need a copy of Prime95 (**mersenne.org**).

Starting with the latter plus AMD Ryzen Master, run the smallestFFT test in Prime95 with all AVX options disabled and monitor the temperature through Ryzen Master. Your CPU should be well below 80°C to give you headroom for overclocking. Our Ryzen 9 5900X stayed below 65°C after five minutes of this test, giving us plenty of space for an overclock.

We're tending to move away from raw manual overclocks with Zen 3 Ryzen CPUs for the simple reason that their all-core boost speeds aren't usually that much behind what the CPU can achieve by itself, but you lose the lightly threaded boost frequencies too.

However, AMD has Precision Boost Overdrive and Automatic Overclocking to help bridge the gap and this is what we'll be using here. It has a new curve optimiser to help reduce power and thermals, but we found it to be unstable and required significant tweaking, so for now we're sticking to the tried and tested method. You may want to investigate this further.

Head into the BIOS, and make sure you've enabled the XMP profile. This will set the correct memory speed and timings. If you're using a riser cable, you'll need to switch the PCI-E primary slot to Gen 3 mode if it's a PCI-E 3 cable – this can cause stability issues. Do this as soon as you power on your PC from the get-go, even before you install Windows.

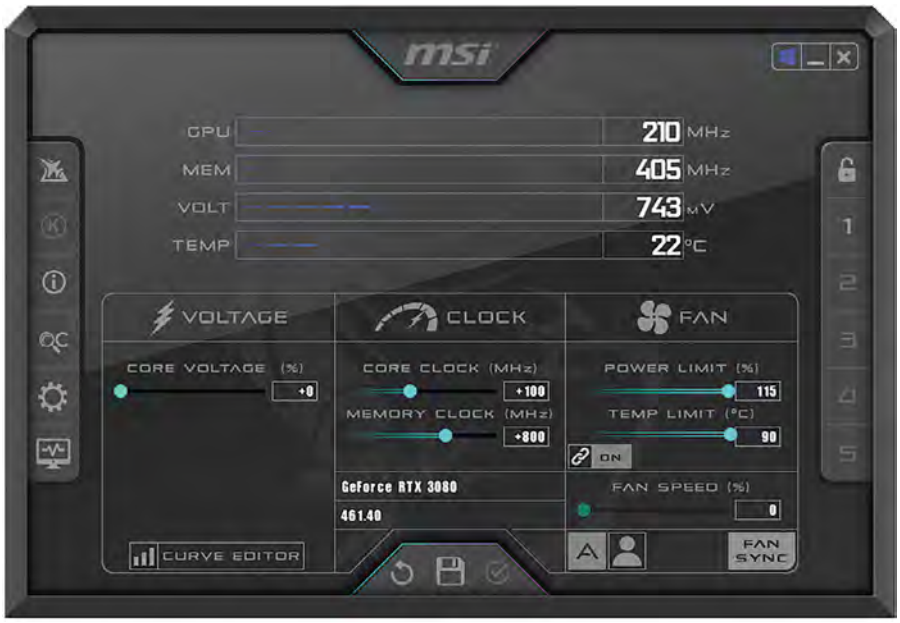
After you've done that, head to the Advanced section and find the options for AMD overclocking. Here you'll see the Precision Boost Overdrive options.

You'll want to allow your motherboard to control the power limits, but set a 10x scalar and 2000MHz boost clock override. This will provide a bump to single and multi-threaded workloads.

Apply your settings and then go back to Windows and perform another stress test. Here, our CPU temperature hit 83°C after

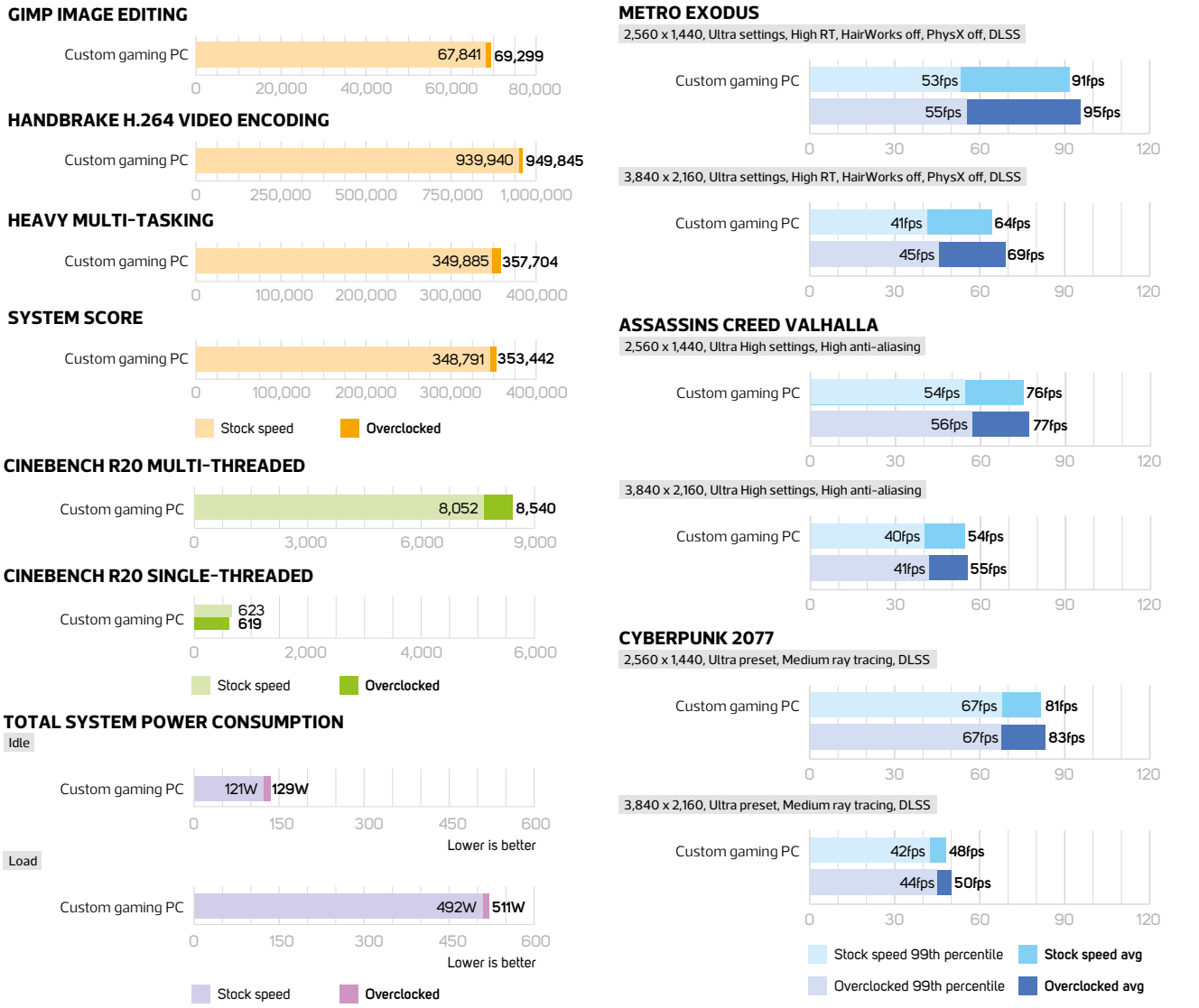
It's now easier to overclock using Precision Boost than dialling in the settings manually

Ensure the XMP profile is enabled in the BIOS, and switch to PCI-E Gen 3 mode if you're using a PCI-E 3 riser cable



MSI Afterburner is our GPU overclocking tool of choice – we increased the core clock by 100MHz and memory by 800MHz

BENCHMARK RESULTS



ten minutes, which is a big jump but still fine. The result of this was an increase in the Cinebench score from 8,052 to 8,540, which is actually higher than a test manual overclock managed at 8,430, but unlike our manual overclock, we barely lost any single-core performance. It also added nearly 4,000 points to the overall system score in Realbench.

Next, we'll deal with your graphics card. The RTX 3080 is a little easier to overclock and we've simply applied a 100MHz Core overclock and 800MHz memory overclock in MSI Afterburner.

Combined with our CPU overclock, this saw a 10 per cent increase to the 99th percentile minimum frame rate in Metro Exodus at 4K and a 5 per cent boost at the same resolution in Cyberpunk 2077.

ADDITIONAL OVERCLOCKING STEPS

Overclocking can get quite complicated very quickly once you delve into the finer details. However, there are a couple of tools at your disposal with an RTX 3000 graphics card and Zen 3 Gen Ryzen CPU that are worth exploring.

Firstly, as we already mentioned, there's AMD's Precision Boost Overdrive 2 with its curve optimiser. Here you can potentially lower the voltages at certain frequencies, while also achieving higher frequencies than stock speed. This can be processor-specific too, so it's likely you'll need to fine-tune the settings to your PC, while our use of Automatic Overclocking and Precision Boost Overdrive in this guide should work on any Zen 3 Ryzen CPU.

MSI Afterburner also has additional tools, including OC Scanner, which is a new Nvidia feature that allows you to automatically overclock your graphics card. However, it's not usually as beneficial as a manual overclock. You can also manually adjust the voltage/frequency curve using the curve editor tool to lower the peak voltage, which can cut temperatures in games. CPC

MECHANICAL KEYBOARDS EXPLAINED

EDWARD CHESTER TEACHES YOU ALL YOU NEED TO KNOW ABOUT MECHANICAL KEYBOARD SWITCHES

Mechanical keyboards are well established as the premium option for PC buyers, but just what is supposed to be so good about them and which model is right for you? With all the dozens of keyboard layouts, switch types, keycaps and other extra features to consider, the choice can seem overwhelming. Thankfully, though, armed with just a few key bits of information, you can much more easily whittle down your options.

Membrane switches

So-called mechanical keyboards are essentially those that use any sort of switch underneath the key other than rubber dome membrane switches. The latter are the cheapest sort of keyboard switch that you'll find, and are used in the keyboards you can buy for well under £10.

When the key is pressed, it pokes against a little dome of rubber that in turn buckles and presses against a thin sheet of plastic with a circuit printed on it – the titular membrane. The dome will then either connect two parts of the circuit via a conductive pad on its underside, or press one printed circuit sheet against another to join the circuit. The dome provides an initial resistance to being pressed then collapses, providing a degree of tactile feedback – you can feel when the dome gives – and it then acts as the spring to return the key to its starting position.

It's a clever system, and membrane keyboards can be incredibly cheap to manufacture, but generally, they suffer from several major drawbacks. The first is that having a little rubber dome that collapses when pressed doesn't make for a particularly consistent feeling movement. In order to produce keyboards at the scale required to make them so cheap (most of the time), the rubber domes aren't manufactured to a high tolerance, so the keys of a cheap keyboard can feel inconsistent.

The second problem is that the switch is required to bash down on the circuit below it in order to register a press. This means you always have to bottom out the switch, requiring a certain amount of force. In contrast, mechanical switches are generally triggered before the key bottoms out, allowing you to type with a lighter action, although many users actively prefer mechanical switches that are quite hard to press.

This requirement in turn means there's really only one type of feel to these sorts of switches – an initial resistance then a mushy release. Meanwhile, mechanical switches can offer all sorts of different actions, from smooth, light and linear, to stiff, tactile and clicky.

The final major issue is that membrane designs generally wear out much more quickly than mechanical switches. The contact pads tend to be very thin and wear through quite quickly, while the rubber itself can deteriorate. It's not uncommon for a rubber membrane keyboard to start to feel a little unresponsive after just a few months, and cheaper ones can be worn out after just a couple of years. Mechanical switches solve all these problems.

Rubber dome membrane keyboards are cheap to produce but their thin plastic sheets and rubber domes wear out quickly

Mechanical movement

Mechanical switches, then, are any switches that ditch the thin, easily worn-out membrane contact system and instead use individually engineered switches for each key. Most of these also ditch the rubber dome spring system and use metal springs instead, but there are some models that use individual rubber dome switches.

For a start, there are the scissor switches used in most laptops. These essentially just change the housing and mounting system to a very compact scissor hinge, rather than the plunger in a plastic housing of a full-sized keyboard, but underneath the hinge is generally a rubber dome providing the spring. The exact quality and type of switch can vary greatly between laptops. Low-profile scissor switches were also popular on desktop keyboards for a while – SilverStone made a particularly good model back in the day – but they're far less common these days, outside of portable and cheap units.

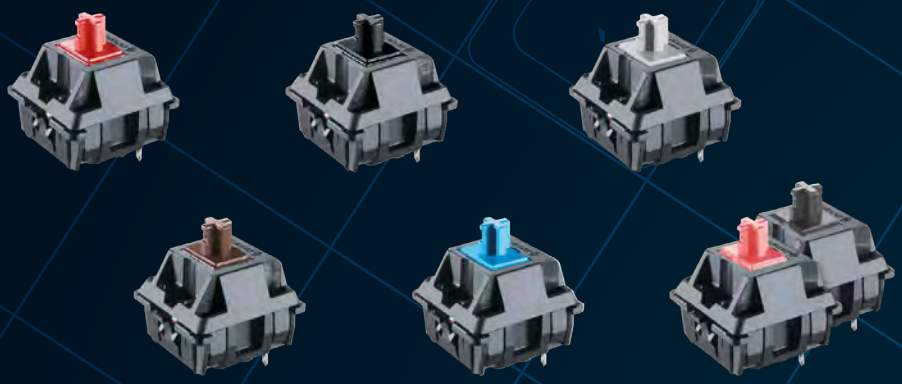
As for other rubber dome desktop keyboards, the most popular versions are made by a company called Topre. These switches use a magnet mounted in the rubber dome to trigger a response, so the switch doesn't need to bottom out, as with membrane keyboards. They also incorporate a spring under the membrane, so the tension in the system isn't just managed by the buckling of the rubber itself. They last much longer and they're more consistent than normal membrane rubber dome switches – and are quieter than many other mechanical switches – but they remain a niche option.

Cherry switch action

The most basic Cherry MX switch (Red) has a smooth slope pushing against the switch contact

A bump on the side of the Cherry MX Brown's plunger adds tactile feedback

A second plastic piece (white) slides over the main plunger, snapping back and forth to create the click of Cherry MX Blue keys



Cherry alone makes dozens of variants of its MX switch design, with different combinations indicated by the colour of the stem

There are only a handful of keyboards available that use them and most are dull, utilitarian objects, the cheapest of which costs well over £200. The main purveyor of them is RealForce – a sub-brand of Topre – while one of the most popular options is the Happy Hacking KeyBoard (HHKB), which costs £260 and still uses a tiny 60 per cent form factor with no numpad, cursor or function keys. You can buy 60 per cent keyboards with more popular mechanical switches for a quarter of the price.

being a clone of the IBM Model M made by a company called Unicomp. It's cheaper than the Topre boards – just $104 US (approx £76 inc VAT) for a full-sized keyboard, but backlighting isn't available, there are no meaningful options for feedback type and there are relatively few keycap options.

The Cherry on the cake

All of which brings us to the single most popular and recognisable incarnation of the mechanical keyboard switch: the Cherry MX.

THE SPRING SIMPLY PROVIDES TENSION, WITH THE TACTILE BUMP FEEDBACK AND CLACKING NOISE PROVIDED BY SEPARATE COMPONENTS WITHIN THE SWITCH

Spring forth

Finally, then, we come to what most people imagine when they talk about mechanical switches: those that use springs instead of rubber domes. There are chiefly two types. The first is called a buckling spring, which is a much older style popularised by the IBM Model M keyboards of the 1980s.

These switches rely on an internal spring buckling under pressure from your finger, the sideways movement of which tilts the metal contacts together. In some ways, they're similar to rubber dome switches in that the physical feedback of an initial pressure, then a release as the spring gives way, is based on the collapse of the spring-medium itself, rather than a secondary system providing that tactile feedback.

Much like with Topre switches, buckling spring switches are a niche option, with the only readily available keyboard to use them

These switches – and the main copycats and clone versions available – incorporate several key features that make them so enduringly popular.

The most fundamental advantage of the Cherry MX switch design is that the spring action and feedback are decoupled. In these switches, the spring simply provides tension, with the tactile bump feedback and clacking noise (that's inherent to switches with a buckling spring) provided by separate components within the switch. Similarly, the contact actuation isn't caused by the spring but by other components.

Specifically, inside the outer housing of each switch is a plastic plunger that connects to the keycap, and under the plunger is the spring that provides the tension. A small sloping plastic piece on the side of the plunger pushes against a metal contact in the housing of the switch. In its 'up' position the plastic piece keeps the metal contact open, but when pressed, the contact can slide down the plastic slope until it touches the other contact.

In its simplest form, this switch provides what's called linear feedback, with the switch and its metal contact smoothly gliding up and down. The only feedback to tell you that you've pressed the key is the action appearing on the screen, or the key bottoming out.

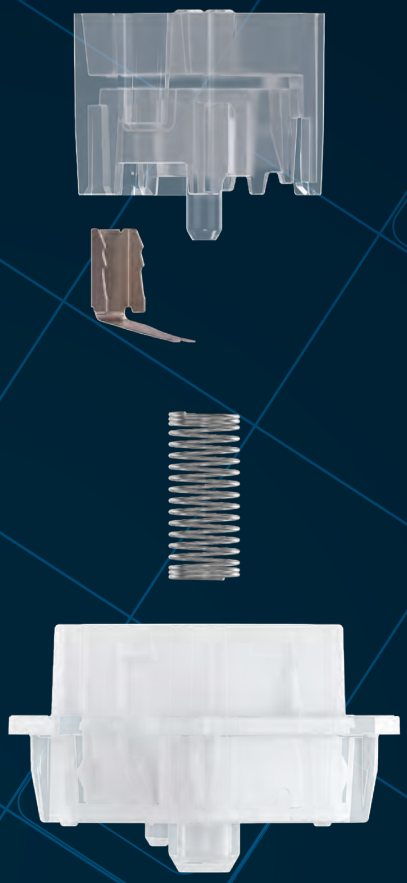
However, in other switch designs, the little plastic slop on the plunger can incorporate a bump that initially makes it a little harder to press the switch until the bump has been passed. This slight tension and release provides some tactile feedback to the user. These are, funnily enough, known as tactile switches.

The third of the most popular variants has a similar bumped slope as the tactile switch. However, here the bump is formed on a completely separate piece of plastic that floats freely around the main shaft of the plunger. When pressed, the plunger pushes down on the floating section until the bump is passed, at which point the floating piece snaps downwards from the force of the sprung metal contact. This creates a very noticeable tactile and audible feedback that gives this type of switch its name: clicky.

The main advantage of this design is that the separation of components means you can tweak each aspect of the switch individually. You can opt for stiffer or lighter springs, differently profiled bumps or add other components such as rubber dampeners, where one change won't affect the operation of the other.

More recently we've also seen companies offer switches where the actual switch detection is performed electromagnetically, or by breaking a beam of light. Technically,

Kailh's Box switches are one of the popular alternatives to straight Cherry MX clones



Cherry's new budget Viola mechanical switches have a simplified mechanism but are less easy to customise

some of these tweaks are possible on other switch designs, but it's a lot trickier to offer the sheer breadth of options.

Customisation

With Cherry MX having led the charge with the recent popularity of mechanical keyboards, we now have many compatible components. You can buy hundreds of different compatible keycaps, with different profiles (shapes), types of plastic and more. Cherry itself now offers over a dozen different Cherry MX switch variants and there are dozens more from other brands (such as Gateron, Kailh and TTC), that are compatible with both the keyboards into which Cherry MX switches fit and the keycaps that sit on top.

As we explored in our guide to building your own keyboard (see Issue 203), you can easily (though seldom cheaply) build your own keyboard from scratch, choosing any number of circuitboards, cases, switches and keycaps. In fact, in the mechanical keyboard enthusiast market, Cherry MX's switches aren't necessarily considered to be the best – the clones are often preferred. You can even get hot-swappable switches, so you can have different switch types in the same board – a stiffer-sprung Spacebar switch is a classic tweak.

Left: A doubleshot, thick-walled PBT keycap. Right: A cheap, painted, ABS keycap

THE ABILITY TO SWAP OUT KEYCAPS IS ONE OF THE MOST FUN AND COST-EFFECTIVE ASPECTS OF TINKERING WITH MECHANICAL KEYBOARDS

It's this level of customisation that has also led to an interesting trend in many big keyboard manufacturing brands.

A few years ago, as the mechanical keyboard market was hitting big, the likes of Logitech, Razer and SteelSeries embarked on creating their own switches, in order to save money, improve performance and control their supply chain. However, not all these switches were compatible with Cherry MX keycaps, and to a lesser extent, they weren't always compatible with Cherry MX switches as a whole.

Now, realistically, many of us will go the entire life of a keyboard without ever upgrading the keycaps, and we're even less likely to unsolder a duff key switch and solder in a new one. However, it's reassuring to have the option. By travelling the proprietary route, all these manufacturers put a major black mark on their products.

A few years later, nearly all the major keyboard brands have changed tack, and although they're still producing their own switches (or at the very least buying from third-parties other than Cherry), the switches are generally at least compatible with Cherry MX keycaps and many are essentially direct clones. In our Labs test on p50, all the keyboards have keycaps that can be swapped between each other, other than the low-profile Logitech G915.

The main overarching variant you'll see on the Cherry MX formula (other than the obvious RGB lighting and newer optical switching systems) is that, instead of the simple cross stem keycap mount, they use a wider 'box' stem that has extra support pieces around the cross. These supports provide a slightly more stable base for the keycap, which some users prefer. They're still compatible with Cherry MX keycaps, and vice versa, though.

Cherry has also just recently released a new low-cost mechanical switch called Viola – as seen in the Corsair K60 RGB Pro, reviewed in Issue 20, which simplifies the switch design and allows for hot-swap capability. It fundamentally lacks some of the potential for tweaking that's inherent in the MX design, however, so it remains to be seen if it's taken up by the enthusiast market.

Keycaps

The ability to swap out keycaps is one of the most fun and cost-effective aspects of tinkering with mechanical keyboards. With Cherry MX cross stem-compatible switches being so commonplace, there are thousands

Companies such as Ducky produce a vast range of wild and whacky keycaps, as well as sensible ones

of options available, and you just need a simple keycap removal tool (or a strong grip) to mix and match them. However, not all keycaps are created equal. There are several factors you'll need to consider when both looking for a keyboard to buy in the first place, and when looking to upgrade keycaps.

The first is the keycap's profile – its shape and size. Most have the same profile as Cherry's standard keys, but there are dozens of others. The second most popular profile is SA, with much taller keys that narrow to a smaller pad at the top, or there are shorter ones such as DSA. You can mix and match to your heart's content, but be aware that varying the profile for a single keyboard will potentially mean big differences in key height.

The next factor to consider is the type of plastic used to construct the caps. ABS is the most common, but it tends to wear to a shiny finish quite easily, and these caps can also be quite thin and hollow-feeling. PBT is the preferred premium option, as it's harder-wearing and has a weightier, less clackity feel.

Next up is the font and type of legend (the letters) that's applied to the keys. There are thousands of available fonts and logo sets from which to choose, and it comes down to personal preference. However, some legends are just painted onto the caps – whether as writing on coloured keys or black paint on clear keys through which backlighting glows – which means they can wear off over time.

For more longevity, keys can be made via a doubleshot method, where the legend is made by a second layer of plastic being applied to the whole key, which is much harder-wearing. We've found doubleshot key legends can look slightly less crisp – particularly backlit ones with fine writing, but the quality will vary between manufacturers.

The key stats

We've mentioned the fact that there are many different brands of Cherry MX-style switch, and people who are really into their keyboards will swear by certain brands – or even certain combinations of components from different brands. However, to a large extent, these MX-type switches can be considered interchangeable (if you stick to the same type), as long as you pay attention to the main stats of each key.

The first number to check is the operating force, which is the overall tension of the spring and is usually measured in centinewtons (cN). This generally ranges from 35cN (often just written as 45g) to 80cN. Cherry's most popular (and most cloned) trio of Blue, Brown and Red switches have operating forces of 60cN, 55cN and 45cN respectively.

In general, the heavier-force switches are preferred for typing – especially by people used to older mechanical keyboards – as the higher force required is more forgiving of slight finger-placement mistakes when you're quickly bashing out words. Meanwhile, lighter switches are preferred for gaming, where you're spending many hours holding down keys, and where accuracy across a wide range of keys is less important than a simple rapid response.

This same divide often marries up with the next most important stat, which is the pre-travel distance. This is the distance from the top of the key's travel to the point at which the switch is activated, and where any tactile/audible feedback is triggered. Technically, the feedback response is often not exactly

SteelSeries' new OmniPoint switches use magnets to trigger the switch, allowing the pre-travel distance to be adjusted in software

Keyboard typing tests

KEYBOARD MODEL	SWITCH TYPE	ACCURACY (PER CENT)	NOISE (DB)
Microsoft Bluetooth	Scissor rubber dome	87	55.7
HP K2500 Wireless	Rubber dome	93	60.2
Cooler Master CK550 V2	Cooler Master Red (linear)	97	64.8
Corsair K100 RGB	Corsair OPX (optical linear)	96	63.1
Ducky Shine 7 RGB	Cherry MX Brown (tactile)	94	61.5
Filco Majestouch-2	Cherry MX Silent Red (linear silent)	96	56.3
Logitech G915 TKL	Logitech GL Low-Profile (tactile)	92	59.3
Logiteh G Pro X	Logitech GX (linear)	96	62.5
Razer BlackWidow V3	Razer Green (clicky)	95	70.3
SteelSeries Apex Pro TKL	SteelSeries OmniPoint (linear)	96	63.6

HEAVIER-FORCE SWITCHES ARE PREFERRED FOR TYPING, AS THEY'RE MORE FORGIVING OF SLIGHT FINGER-PLACEMENT MISTAKES WHEN YOU'RE QUICKLY BASHING OUT WORDS

aligned with the switch response, but it's generally close enough to be considered the same.

This pre-travel range can be as low as 1mm and go up to 2.2mm, with the longer press generally used with tactile and clicky switches preferred by typists, and the shorter distances use in linear switches preferred by gamers.

Another consideration is the total travel distance, which is how far the plunger goes before it hits the bottom of the key. Generally, this is a much shorter range of 3.7-4mm, although it can be as short as 3.2mm for low-profile mechanical switches. This has much less of an effect on the overall feel of a key, but a longer travel distance does allow for a greater chance of not bottoming out the key and then smacking into the bottom of the board, increasing finger strain and noise.

Switch types compared

We've touched on the overarching differences between different switch types, but how do they actually compare? We grabbed a handful of the latest options for our group test, along with some cheaper rubber dome membrane keyboards, to see how each type performed in terms of typing speed, accuracy, overall feel and noise levels.

As well as all the keyboards featured in our group test, we also grabbed an HP K2500 (£18 inc VAT) membrane keyboard to represent standard cheap keyboards, along with a Microsoft Bluetooth keyboard (£40 inc VAT) to demonstrate a slightly pricier and low-profile, scissor switch membrane keyboard. Of the keyboards in our group test, five use a linear switch (showing the clear preference for this switch type for gaming brands), two use a tactile switch and one has a clicky switch.

Starting with a typing speed test, I quickly established that I was simply not a fast enough typist to really strain most of these keyboards. At best I could hit up to 300 characters per minute (CPM) or around 70 words per minute (WPM), with scores generally varying between around 260CPM and 310CPM, depending on my ability in the moment.

However, my testing did reveal some definite trends. The only consistently troublesome mechanical keyboard in terms of accuracy was the low-profile Logitech G915 TKL. Its wide, flat, less distinct keys and slightly stiff key action felt like it slowed me down a little and resulted in more mistakes, and sure enough, it was the lowest scoring of the mechanical keyboards tested in terms of speed and accuracy.

Conversely, the cheap HP rubber dome keyboard put in impressive numbers, slightly outclassing the G915 for words per minute and accuracy. Experience shows that it won't maintain this level of responsiveness for long, but a cheap keyboard can get the job done when it's fresh out of the box.

However, the slightly more expensive, but very low-profile, Microsoft Bluetooth keyboard was by far the worst tested. This was mainly due to the very flat keys and mushy key feeling, which made it difficult to discern one key from another at speed, making for more mistakes and a slower pace.

As for noise, it was no surprise that the clicky switches of the Razer BlackWidow V3 were far and away the loudest. At 70.3dB, measured from a distance of 20cm, it was nearly 6dB louder than the next loudest board (the Cooler Master). Meanwhile, the Ducky Shine 7 with its tactile Cherry MX brown switches was comparatively quiet at just 61.5dB, while most of the rest of the keyboards with linear switches hit between 62dB and 64dB.

Showing just why some people like them, though, was the whisper-quiet performance of the two rubber dome keyboards. The HP hit just 60.2dB and the Microsoft Bluetooth keyboard hit just 55.7dB.

In terms of overall feel for both typing and gaming, the speed and smoothness of linear mechanical switches is definitely good for gaming, where you want as frictionless an experience possible between moving your fingers and responses happening on the screen.

However, for typing, a little bit of tactile feedback really helps. The noise from Razer's clicky switches went a touch too far here for our liking (and anyone in the same room as you won't thank you either), but that's also a matter of taste.

As a general happy medium, we've come to prefer the Cherry MX Brown style of tactile switch for a general-purpose keyboard. They provide a good compromise between the speed of response and quietness of a linear switch, and the more direct feedback and forgiving feel of a clicky switch. CPC

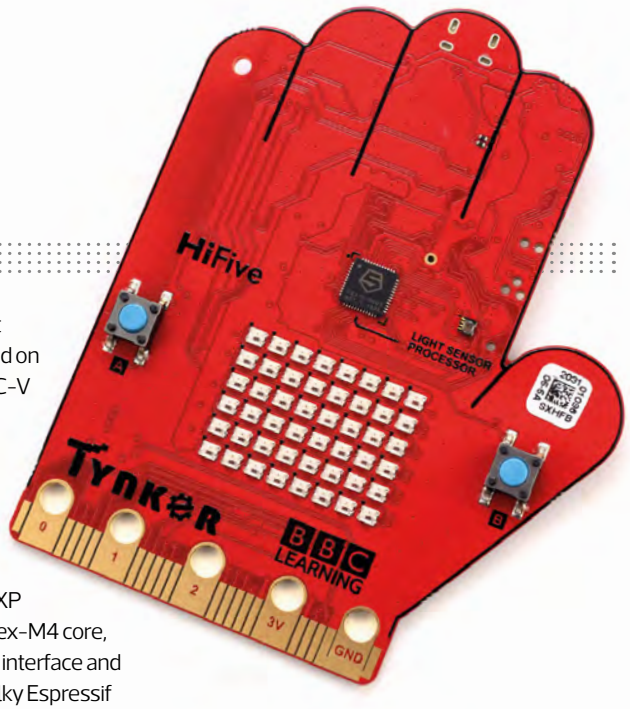
GARETH HALFACREE'S

Hobby tech

The latest tips, tricks and news in the world of computer hobbyism, from Raspberry Pi, Arduino, and Android to retro computing

REVIEW

BBC Doctor Who HiFive Inventor Coding Kit



It's not hard to see the BBC micro:bit's influence in the HiFive Inventor's design, despite the hand-shaped PCB

Regular readers will remember the launch of the BBC micro:bit (see Issue 154), a low-cost education-focused microcontroller board that formed the centre of a revived computer literacy programme at the nation's oldest broadcaster. The rather clunkily named BBC Doctor Who HiFive Inventor Coding Kit is not, surprisingly, a new BBC micro:bit pack, but an entirely new device – based unabashedly on its seemingly departed predecessor.

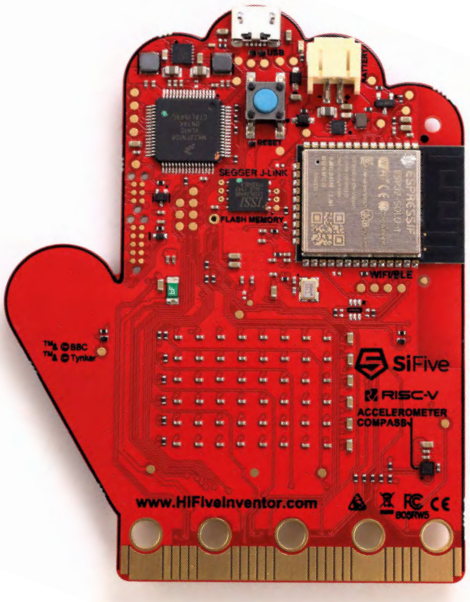
Like the micro:bit, the HiFive Inventor – put together by SiFive – has two front-facing tactile buttons and an LED matrix, as well as an accelerometer, magnetometer and thermometer as embedded sensors. The spec has had a bit of an upgrade though: the 5x5 red LED matrix of the BBC micro:bit is now a 6x8 RGB matrix; the radio now supports Bluetooth 4.2, Bluetooth Low Energy (BLE) and Wi-Fi; and there's a real light sensor, rather than relying on a hack with the LEDs.

There's also a new processor. The heart of the amusingly hand-shaped board is a SiFive FE310, which packs two 32-bit 150MHz processor cores based on the free and open-source RISC-V instruction set architecture. There's also 64KB of static RAM (SRAM) and 512KB of QSPI flash.

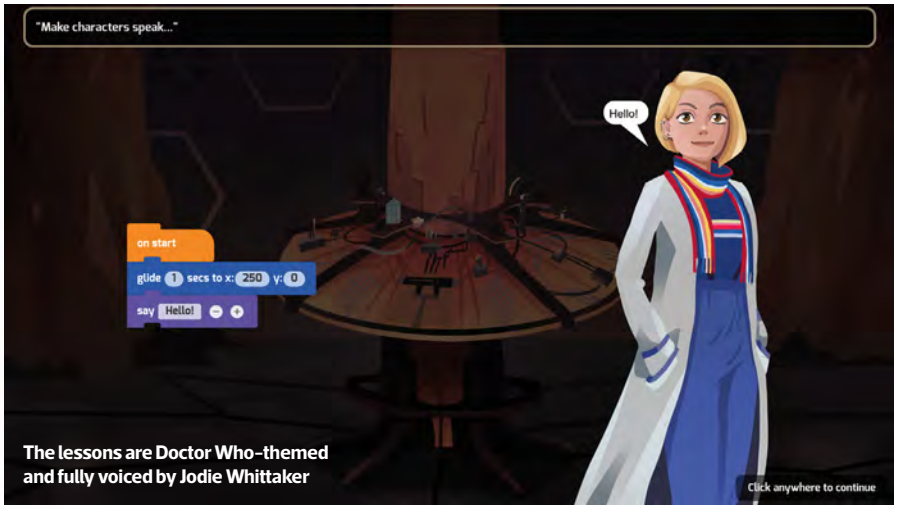
The FE310 isn't the only processor though. Flipping over the Inventor reveals an NXP Kinetis K22F with an Arm Cortex-M4 core, which handles the micro-USB interface and debugging. Next to that is a bulky Espressif ESP32-SOLO-1 module, which provides 802.11b/g/n Wi-Fi and Bluetooth, while bringing across its own single-core Xtensa processor – and considerably more SRAM and flash than you'll find on the main board itself.

This piecemeal approach, which feels like it exists to make up for shortcomings in the FE310 chip and suggests the whole board may have been better off just running from the ESP32, is extended to the edge connector at the base. It duplicates the BBC micro:bit's version pin-for-pin, but only based on the original design. The indentations that help crocodile clips stay in place, for example, which were added to the latest BBC micro:bit revision, are nowhere to be seen – the same goes for the new touch sensor and microphone.

There's a simple explanation for this. The HiFive Inventor is actually the SiFive HiFive



An Espressif ESP32 module is stuck on the back to provide Wi-Fi and Bluetooth, but could easily run the board solo



The lessons are Doctor Who-themed and fully voiced by Jodie Whittaker

Learn Inventor, launched last year in a fetching black finish. After signing the deal with the BBC, SiFive took the original off the market – and now the hardware is only available as part of the Doctor Who bundle.

The whole package is themed around the latest incarnation of Doctor Who, as played by Jodie Whittaker. As well as the packaging, each bundle comes with a single-use code to register for an account with Tynker – a firm providing a Scratch fork by the same name – to run through a series of lessons based on the show, with Whittaker's voice acting.

It's undeniably neat, and helps to keep interest in the lessons. However, locking them behind a single-use code bundled with a hardware purchase is surprisingly stingy for the usually egalitarian BBC, especially given the presence of a simulated HiFive Inventor in the Tynker interface. On the plus side, a single parent account can register multiple 'student' accounts, each of which tracks its own progress through the course.

The initial puzzles are solved in Tynker's Scratch-based drag-and-drop visual programming environment, while a later series of tasks for older or more experienced children switches to MicroPython. If you've used a micro:bit in the past, it's all familiar – although there's no Microsoft Makecode this time.

The bundle is surprisingly expensive though. At the time of writing, the kits weren't available in the UK, but in the USA, the premium bundle, containing a HiFive Inventor board, micro-USB cable and three crocodile-clip jumper wires, plus a speaker, battery pack, clever clip-together case and single-use code to unlock the lessons, costs $74.95 (around £66 inc VAT). Meanwhile, a planned base bundle containing just the HiFive Inventor board, a micro-USB cable and single-use code, has yet to be released.

With the latest BBC micro:bit costing just £13.50 inc VAT, that's a big premium for the Whittaker-voiced lessons. Plus, if you have more than one kid in mind, there's currently no other way to buy a second HiFive Inventor without picking up the entire bundle.

That said, the lessons are well put together and engaging. Plus, when their novelty wears off, you can write your own programs in Tynker and MicroPython. The pin compatibility with the BBC micro:bit opens the door to a whole ecosystem of hardware add-ons too, but not all libraries have been ported to the HIFive Inventor, so double-check compatibility before buying. More information is available from **hifiveinventor.com**, along with a purchase link.

The case is clever, with access to the edge connector provided via a pop-off cap at the base

NEWS IN BRIEF

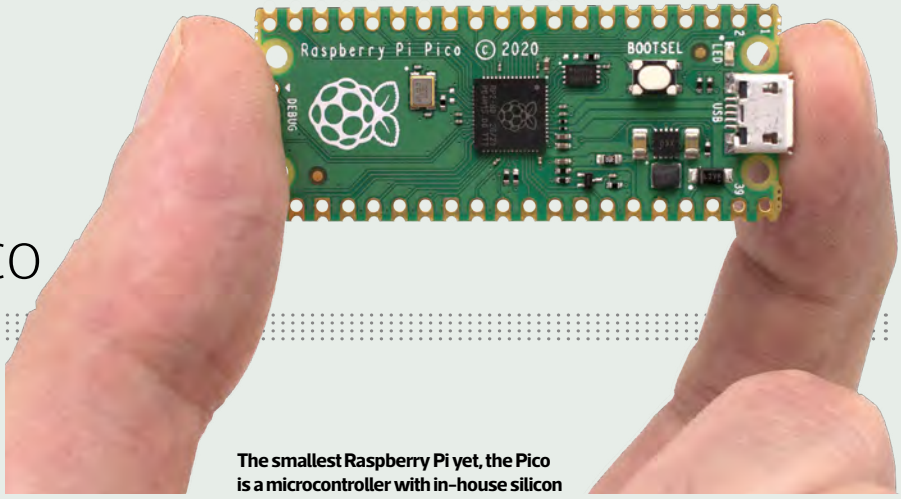
ClockworkPi announces DevTerm portable PC

ClockworkPi, the company behind the modular GameShell (reviewed in Issue 184), has announced a follow-up product: the DevTerm, a portable PC inspired by the TRS-80 Model 100. The A5-footprint DevTerm includes an ultra-wide 1,280 x 480 display and a 65 per cent keyboard with a miniature trackball. You have the choice of driving it from an in-house Arm-based system-on-module, or a Raspberry Pi Compute Module 3+.

A thermal printer module, which clips to the top of the system, is also bundled – just in case the device isn't retro enough already. The DevTerm is available to order from **clockworkpi.com** now, starting at $219 (around £192 inc VAT) for a version where you supply your own Compute Module.

REVIEW

Raspberry Pi Pico



The smallest Raspberry Pi yet, the Pico is a microcontroller with in-house silicon

The Raspberry Pi family of single-board computers has been a story of success, and in its current form spans the market from the ultra-low-cost Raspberry Pi Zero to the high-performance Raspberry Pi 4, as well as the recently launched Raspberry Pi Compute Module 4 for the embedded crowd. However, the Raspberry Pi Pico is not a new Raspberry Pi.

It's a new board from Raspberry Pi, yes, but it's not a single-board computer – for all that it computes, and its electronics fit on a single board. It's a microcontroller development board, marking Raspberry Pi's desire to replicate its success in the single-board computer market in the world of microcontrollers.

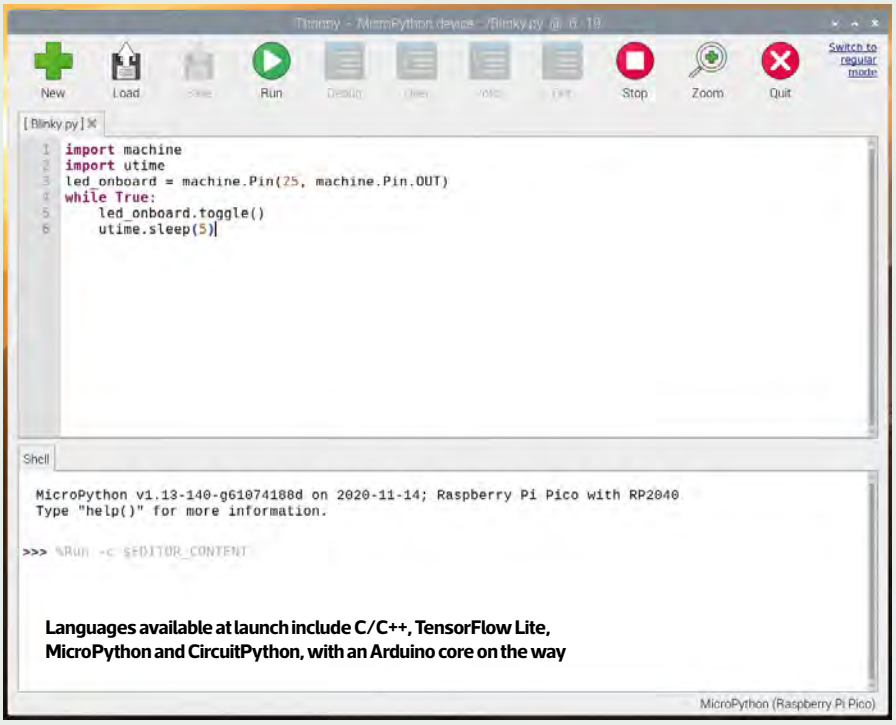
The Raspberry Pi Pico isn't just the first microcontroller board to come out of Raspberry Pi in Cambridge either. It also houses the company's first in-house silicon, RP2040. The first in a likely family of chips, RP2040 is a dual-core Arm Cortex-M0+ microcontroller running at 133MHz with 256KB of static RAM (SRAM), plus 2MB of external flash. The chip is both designed and taped-out by Raspberry Pi's own Application Specific Integrated Circuit (ASIC) team, in a first for the company.

The fact that Raspberry Pi has the talent to do in-house chip design should come as no surprise – many of the company's staff, including co-founder Eben Upton, came from silicon giant Broadcom. It's also logical that this move has begun with a microcontroller using Arm IP, despite Raspberry Pi having recently expressed interest in the free and open-source RISC-V instruction set architecture. The company has been using Arm chips since launch, and is intimately familiar with the technology.

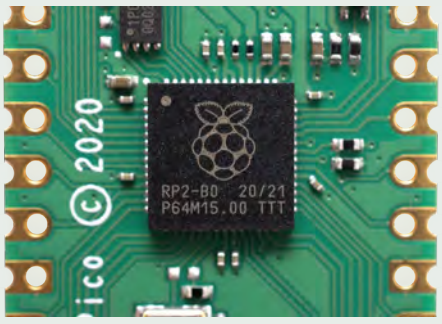
Still, the launch of the Raspberry Pi Pico and RP2040 brings a few surprises with it. The first is that the board design of the Pico is open source, unlike the Raspberry Pi SBC range, although the internal machinations of the RP2040 are being kept a closed secret. The second is that it straddles two markets: education and hobbyist at one side; industrial and embedded at the other.

A look at the Pico board, fresh from the package, reveals two notable areas. Firstly, the 2.45mm pin headers are unpopulated, meaning that the first step will be soldering pins into place – a relatively beginner-hostile move, and one that retailers are likely to fix by offering versions with pre-soldered headers, much like the Raspberry PI Zero H.

Secondly, the headers are also castellated, with indents along the outer edge. The reason



Languages available at launch include C/C++, TensorFlow Lite, MicroPython and CircuitPython, with an Arduino core on the way



The RP2040 is not only the first microcontroller from Raspberry Pi, but also the company's first in-house silicon

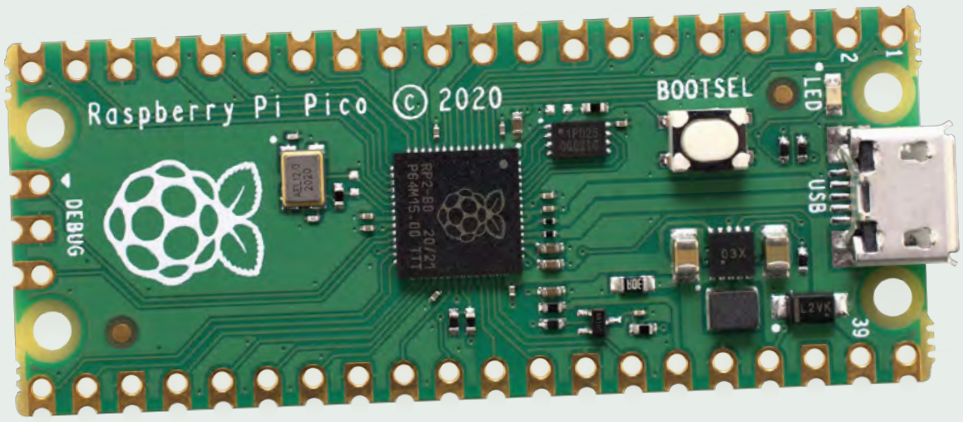
NEWS IN BRIEF

BeagleBoard.org and Seeed Partner for RISC-V BeagleV

Open hardware specialists **BeagleBoard.org** and Seeed Studio have partnered to design and launch an open-hardware Linux-capable, single-board computer based on the free and open-source RISC-V instruction set architecture, called the BeagleV.

Powered by a StarFive Jinghong 7100 chip, which houses two 64-bit SiFive U74 RISC-V cores, a single Nvidia Deep Learning Accelerator (NVLDA) and a neural network engine (NNE) accelerator, the board includes 8GB of memory – but not, in its first incarnation, a dedicated GPU.

The companies are taking applications at **beagle.seed.cc** for a pilot production run at $149 US (around £140 inc VAT) ahead of a mass-production run with an Imagination Technologies GPU later this year.



The board is castellated for use as a module, or you can solder pins for breadboard use

for this very deliberate design choice is the Pico board can be used as a module, soldered flat against a carrier board to power a finished design. For those using it as a module, there's a wealth of support – a detailed databook spans hundreds of pages, and comes alongside a C/C++ software development kit (SDK) with its own documentation.

However, Raspberry Pi hasn't forgotten the beginners. The Pico launches with an official MicroPython port, offering access to the majority of its features – USB 1.1 host/device modes and full internal clock functionality notwithstanding – in the beginner-friendly yet deceptively powerful Python language.

Hook up the Pico to a Raspberry Pi, or any other computer, drag and drop the MicroPython firmware, and you're away. The USB port includes a serial console with the MicroPython REPL already running, and the Thonny IDE boasts day-one support. There's also a version of Adafruit's CircuitPython, a MicroPython fork focused on education, and Google has ported its TensorFlow Lite machine learning framework, while a port of the Arduino core is promised.

The hardware on offer covers a lot of features. The 26 general-purpose input/output (GPIO) pins include hardware interrupts, three analogue inputs with a 12-bit resolution and 16 pulse-width modulation (PWM) channels.

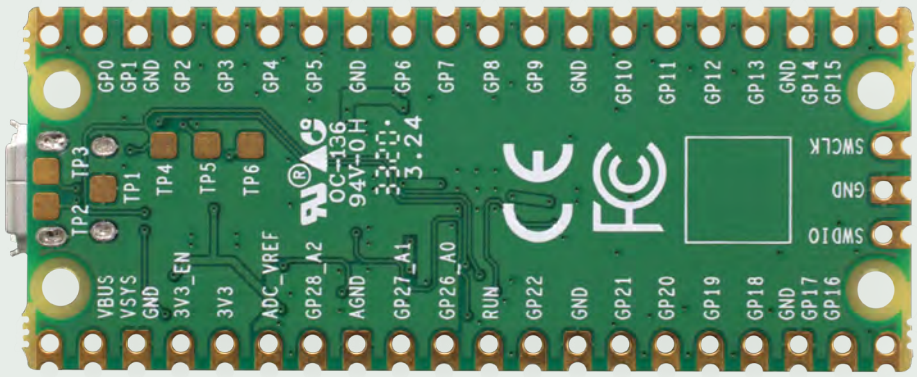
There are also two SPI, two I2C and two UART buses, plus an on-chip clock and timer with calendar, as well as a temperature sensor as an added bonus.

If that list isn't enough, the RP2040 at the heart of the Pico also includes eight programmable input/output (PIO) state machines. Using these, you can define your own hardware – either to add extra buses above and beyond those provided as standard, or to interface with hardware that isn't normally compatible. It's rare to see a microcontroller priced as aggressively as the Pico, but it comes with a reasonably steep learning curve.

The Pico doesn't tick every box though. A notable absence is any form of radio, whether Bluetooth or Wi-Fi. That's not surprising at the Pico's price point, but it may make the similarly priced ESP8266 a more tempting option.

The board's micro-USB port, used for data and power, is another odd choice – the Raspberry Pi 4 saw a move to the more modern USB Type-C, making the Pico's micro-USB port feel like a regression.

These are nitpicks though. At £3.60 inc VAT from **pimoroni.com** and other resellers, with unpopulated headers, the Raspberry Pi Pico offers impressive capabilities for its price. It's also going to be interesting to see what the community does with the PIO machines.



The bottom includes silkscreen labels for all pins – shame you won't see them when it's on a breadboard

REVIEW

Initiating Paraneon

Initiating Paraneon bills itself as a comic by hackers for hackers, in both the classic and modern senses of the word. It's the creation of Robert Willis, who works in information security but who would much rather be creating comics, especially ones that echo the materials he absorbed as a child.

Rather confusingly, it's not the first book in the Paraneon series – that will come later, Willis promises. Rather, it's three one-shot stories – Neon Skyline, The Hive Network and Portals – with shared characters that merge together at the end to serve as a kind of scene-setter and prequel to the series. At least, that's the idea.

In reality, Initiating Paraneon is a bit of a mess. The book starts with a six-and-a-frame-page infodump setting the scene on the primary character, Sudo – named, awkwardly, after the 'sudo' tool in POSIX-alike systems, which allows you to run a given command as a different user, usually the 'root' super-user. It's the equivalent of calling the character 'Run as Administrator', for those more versed in Windows.

A few pages later, Sudo – for ill-explained reasons – finds and activates a sex robot powered by a 'next-gen AI' who immediately falls into his arms in gratitude. Two pages later, they're on the run from the police and heading to Mars, and the pace only gets more breakneck from there.

There are hints of Willis' professional experience throughout the book, but they're few and far between. The network addresses of security cameras are usefully written on the outside, letting Sudo 'brute-force' the hardware, for example. Later, Sudo also overloads an attack robot with 'a verbal buffer overflow' – he screams at it, basically, and it obligingly collapses.

The comic borrows heavily from pop culture, as in this Matrix-inspired scene

Far greater in number than the infosec references are the pop-culture ones. All three stories wear their inspiration firmly on their sleeves. Delphi, an experimental cyborg dolphin, is taken from cyberpunk classic Johnny Mnemonic.

The titular Hive Network from the middle story owes its existence to The Matrix. It's not difficult to see Willis' entertainment preferences.

However, it's harder to see how the stories link together. The writing is, sadly, disjointed and clunky, and so is the art.

Willis decided to use three distinct art styles across four artists, rather than stick with a single style, leaving the resulting book feeling more like a collection of fan art than a cohesive whole. It's a stylistic choice Willis describes as 'a homage to independent comics', and one that will be wisely abandoned in favour of a single style for the upcoming series.

Billed as a comic 'by hackers for hackers', Paraneon fails to deliver

Initiating Paraneon is also violent, often aggressively so. The first activity of the cyber-dolphin Delphi after being attached to a robot body is gunning down the scientists – it takes place in a three-frame chest-exploding scene, revealing that someone involved in its creation is a fan of 2000 AD.

It also falls into the common trap of the author insert – Sudo is clearly Willis and is treated as an infallible expert whose skills are second only to Null, an android Sudo created 'to be the ultimate weapon: part hacker, part assassin, and an expert at both', with 'a great taste in music, compliments of his robotic brain being based on his creator'.

Initiating Paraneon isn't necessarily bad, but it's sadly not good either. The promise of 'by hackers for hackers' fails to shine through, and the teaser for Paraneon #1 at the end is unlikely to excite. Initiating Paraneon was crowdfunded on **kickstarter.com** for $10 US (VAT exempt); the book will be available at **afterlifecomics.com** to buy soon. CPC

Gareth Halfacree is a keen computer hobbyist, journalist, and author. His work can be found at **freelance.halfacree.co.uk** @ghalfacree

WIN

A NOBLECHAIRS HERO BLACK EDITION GAMING CHAIR

SPEC

- Newly developed PU leather covering with breathable micro-pores
- Infinitely adjustable lumbar support for lower back area
- Memory headrest for increased comfort
- Enlarged 4D armrests with cushioning
- Comfortable and breathable cold-foam upholstery
- Premium stainless-steel levers
- Designed for users weighing up to 330lbs

WORTH **£419**

How would you like to game in comfort, nestling in an amazing, top-of-the-line gaming chair? Well, here's an opportunity to really upgrade your gaming space, as our pals at noblechairs are kindly offering a superb HERO Black Edition chairs to one lucky **Custom PC** reader.

The HERO Black Edition won a Premium Grade award in our recent gaming chairs Labs test (see Issue 211, p54), where we praised its build quality, built-in lumbar support and decent reclining system.

When it comes to the design of the HERO series, noblechairs sought input from esports professionals. The result is an ergonomic and feature-rich leader in the gaming chair segment, a series that achieves unparalleled comfort even after long hours of working and gaming. The combination of breathable, soft PU leather and porous cold foam means that even the longest gaming sessions will be enjoyed with optimised ergonomics and comfort.

Chair manufacturer noblechairs is a multi-award-winning brand, headquartered in Berlin, with offices situated across the globe. The company is renowned for manufacturing gaming chairs with the focus on comfort, ergonomics and high-quality materials, for both the office and gaming space. Its products are recognised for consistent comfort and quality, even after prolonged use. For more information visit **noblechairs.com**

noblechairs

SUBMIT YOUR ENTRY AT **CUSTOMPC.CO.UK/WIN**

ANTONY LEATHER'S

Customised PC

Case mods, tools, techniques, water-cooling gear and everything to do with PC modding

PCI-E 4 riser cables are inbound

I've mentioned in my column before about the pitfalls of using a PCI-E 3 riser cable when both your motherboard and GPU support PCI-E 4. With both devices trying to communicate in PCI-E 4 mode, your system will go haywire when you use a PCI-E 3 riser cable. In fact, a couple of graphics cards I've tested recently, such as Palit's Game Rock RTX 3090, refused to output a display at all when used with a PCI-E 3 riser cable.

The only option in both cases is to force your PCI-E graphics slot back to Gen 3 in the BIOS. However, in the case of the RTX 3090 I was testing at the time, it wouldn't even let me do that – I had to use another GPU to get into the BIOS, as the Ryzen system I was using didn't have an on-board GPU. It's all a bit of a mess and it's caught out plenty of people, including me.

We'll have to live with this situation for the time being, but I've thankfully also heard from three companies this year that are working on their own PCI-E 4 riser cables. At the very least, we should be able to buy some PCI-E 4 options soon, although it may be a while until we see them being provided with PC cases.

PCI-E riser cables included with current PC cases are only compatible with PCI-E 3, but PCI-E 4 models are coming

Firstly, there's EK; alongside some very interesting water-cooling gear, the company told me during its CES online expo that it's working on its own cable. CableMod, which we've previously recommended in **Custom PC** for its excellent custom power supply cable design service, is also working on its own range of PCI-E 4

riser cables in various lengths to suit various different-use cases.

From short ATX setups to mini-ITX cases that require long riser cables to flip the graphics card behind the motherboard tray, such as the NZXT H1, Phanteks Evolv Shift 2 and Raijintek Ophion Evo, the company should have an option that suits most situations.

Finally, Thermaltake is also working on its own PCI-E 4 riser cable. The company is potentially the first case manufacturer to be doing so, although Thermaltake wouldn't give me any more information about it, so it remains to be seen whether or not this cable will be included with any of the company's future cases.

In the meantime, if you're desperate for a PCI-E 4 riser cable, a company called Linkup is offering them on Amazon. However, they're expensive and for now, there are no notable GPU performance gains from them in most situations, so I advise switching back to PCI-E 3 and waiting for prices to drop as more companies offer them.

Water cooling doesn't have to be expensive

I took great pleasure writing last month's feature about affordable water cooling (see Issue 211, p72). We all want the greatest hardware, but the fact remains that the best bang for your buck is rarely found in the very upper echelons of wallet-emptying purchases. The diminishing returns in terms of noise reduction and cooling performance mean you need to consider how much you spend on water-cooling hardware, as cutting-edge components rarely make your loop cooler or quieter.

It was amazing to see what you can achieve if you aim to have plenty of change from £200. For the same price as a high-end AIO liquid cooler, you can have a large 280mm radiator and full custom loop that can be expanded to include your graphics card at a later date. The feature was geared towards people who have an interest in water cooling, but find the prices of premium components a bit silly.

Premium manufacturers such as EK make some gorgeous kit, but it can be very expensive

I think this is important, because water cooling is beneficial and great fun. It enables you to really dial up the tinkering with your cooling system, but it's also just great to have a powerful, overclocked PC that's actually cool and quiet too. Thankfully, there are just as many components for lower budgets as the rest of the spectrum, so it's definitely worth hitting Google to check out some of the lesser-known manufacturers, or just the cheaper components on retailer's websites.

There are a few other places you can try too. I've found **aliexpress.com** and eBay to be handy tools for discovering brands such as Barrow and Bykski. The products might not always have the finesse of other brands, but there are huge ranges and I've used their parts in plenty of builds. However, do check reviews first, as some parts can leave a lot to be desired.

That said, I'm also liking a lot of the innovation I'm seeing from the usual premium players recently. I spoke to EK during its recent CES expo and it has some seriously cool products coming that are delightfully high-end and niche. Saving up and spending big, therefore, isn't likely to disappoint in terms of the sheer quality, engineering and eye candy departments, and I'm definitely not saying they should be avoided. Your PC will look fantastic with these parts, and most of them will last for years too – certainly longer than many people keep their processors or graphics cards.

They're also loaded with features that make your water-cooling experience easier and more rewarding. The latest mounts for pumps, reservoirs and distribution plates can make creating your own water-cooling loop easier than ever. It all means that water cooling is possible in a wider variety of cases than ever before – big and small. The cheaper stuff is rarely much less effective in terms of cooling and noise reduction, but premium kit certainly has its advantages.

Thankfully, there's enough water-cooling gear around now to suit nearly any budget, case size or heat load. If it's done properly, you're less likely to encounter leaks now than the old days too.

This didn't used to be the situation, and despite me fearing for the future of water cooling a while back, it's never looked stronger or more popular. CPC

Antony Leather is Custom PC's modding editor @antonyleather

How to Clean your waterblocks

Antony Leather shows you how to remove gunk from your waterblocks and make them shiny again

TOTAL PROJECT TIME / 2 HOURS

Over time, the waterblocks in water-cooling loop can lose their shine, and gunk can build up in their small heat-transferring fins. This not only causes them to lose performance, but also means they look far less attractive than when they were new.

Oxidation and residue build-up is unavoidable and very noticeable if you have a see-through top on your waterblock, but thankfully it can be fixed with a bit of elbow grease. However, you do need to be careful of certain plating materials, and be aware of the best tools to use for the job, so in this guide we'll look at the best way to get your waterblocks looking like new.

TOOLS YOU'LL NEED

Autosol Liquid Chrome Cleaner
amazon.co.uk

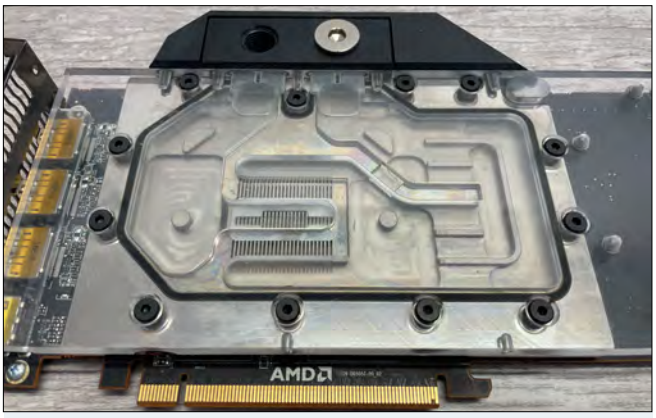
Microfibre cloth
Most hardware stores

Plastic polish
amazon.co.uk

Air duster
Most hardware stores

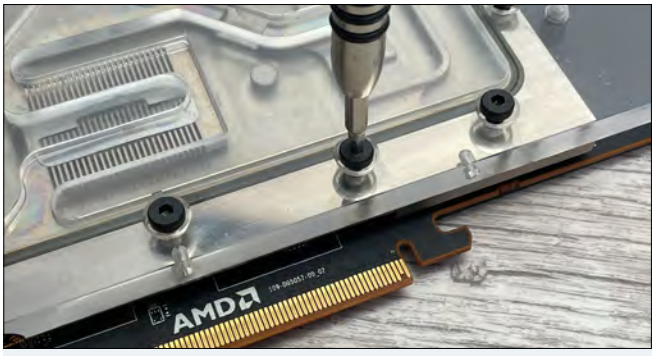
Plastic bristle brush
Most hardware stores

Hex tools or precision screwdrivers
Most hardware stores



1 / USE THE RIGHT CLEANER

Check your waterblock's metal finish. Copper is durable and can be cleaned with most metal polishes, but nickel plating requires a less abrasive polish, so make sure you know what materials you'll need to clean first.



2 / REMOVE SCREWS

Most waterblocks use a single top section, so they're usually easy to dismantle. Use the appropriate tool to remove the screws and keep them safe in a container, so you can reassemble the block later.

3 / DISMANTLE WATERBLOCK

Carefully lift the top away from the block and reseat any O-rings that come loose. Depending on how much gunk is inside the block, it may need to be prised away with a little force.

4 / USE BRUSHES AND AIR DUSTERS

The best tools to clear out any fine channels are plastic brushes and air dusters. Start with the latter and move on to the former if there are any stubborn particles trapped in the cooling fins.

5 / USE POLISH

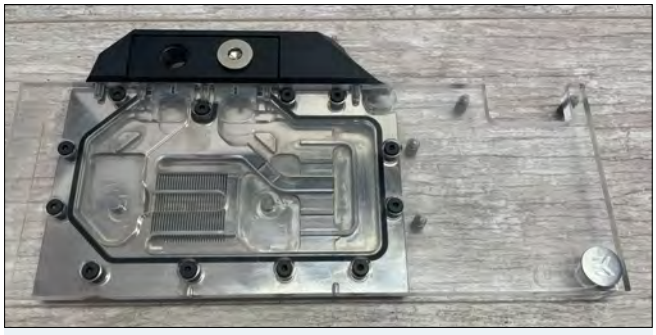
Exposed copper is durable enough to be cleaned with normal metal polish such as Autosol, but if there's a plating such as nickel, this is often quite thin, so you'll need a less abrasive cleaner. The same company makes a chrome polish, which is perfect, as chrome is also delicate.

6 / CLEAN BLOCK COOLANT CHANNELS

Use a plastic brush, along with some soap and warm water, to clean the waterblock, using the air duster or brush to clear the fine coolant channels over the core area.

7 / POLISH ACRYLIC

You can use a plastic polish to clean the acrylic. This will remove stains and minor scratches, so it's great for banishing coolant marks. Use a disposable cloth and rub the acrylic firmly with a good amount of pressure.



8 / REASSEMBLE WATERBLOCK

Give the areas you've polished a final wash with warm water and wipe them dry. Then clean your hands, as it's easy to leave fingerprints inside the waterblock that can be visible through the acrylic. Now reassemble the waterblock – you can consider using plastic gloves for this bit to avoid leaving any fingerprints.

9 / FLUSH WATERBLOCK

Finally, you'll need to flush your waterblock in order to remove any remaining residue inside it. You can use normal coolant or deionised water, but avoid using tap water, as this can leave marks on your freshly polished waterblock, even if it's only left for a few minutes.

How to Water-cool RTX 3000-series partner cards

Antony Leather shows you what's involved with water-cooling third-party RTX 3000-series cards, using an Asus GeForce RTX 3060 Ti model

TOTAL PROJECT TIME / 3 HOURS

Last month we showed you how to water-cool Nvidia's GeForce RTX 3080 Founders Edition, which was a very involved process, but in this guide we'll be using a different waterblock on a very different card. This time, we're dealing with the RTX 3060 Ti, but the card is part of the Asus ROG Strix range that encompasses the RTX 3060 Ti, 3070 and 3080 with similar PCBs.

As a result, unlike the Founders Edition waterblock we looked at last time, the Corsair block we're using this month fits all three of the aforementioned models of the Asus ROG Strix range. We'll show you how you how to identify the block you need for your model, how to remove the large triple-fan cooler and how to fit your waterblock.

TOOLS YOU'LL NEED

GPU waterblock
watercoolinguk.co.uk

Precision screwdrivers
amazon.co.uk

Thermal paste cleaner
overclockers.co.uk

Microfibre cloth
Most hardware stores

1 / IDENTIFY GRAPHICS CARD

While different tiers of RTX 3000-series cards within a specific range are often compatible with one specific waterblock, the same isn't true as you move across ranges, even from the same manufacturer, as PCBs can change slightly. Check online compatibility charts to identify the waterblock you need for your exact card.

2 / VERTICAL OR HORIZONTAL?

There are numerous waterblocks available, and some may be better suited to particular case layout orientations. Before you reach for your wallet, decide on your tubing routes and whether you want to mount your GPU horizontally or vertically.

3 / RUN A STRESS TEST

It's always fun to see the fruits of your efforts, so run a stress test first. Use a repeatable graphics benchmark, such as an in-game benchmark or Unigine Superposition (**benchmark.unigine.com**). Then use GPU-Z (**techpowerup.com**) to record the highest GPU temperature and boost frequency during the test.

4 / REMOVE BACKPLATE SCREWS

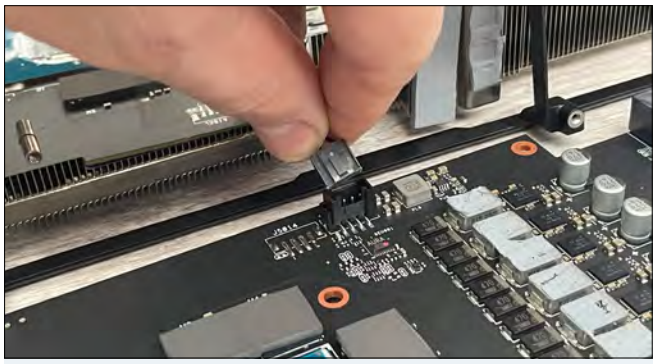
The backplate requires a mix of star-tool and crosshead bits, so you'll need an extensive micro screwdriver set to deal with them. Work your way around the edges, leaving the core area until last.

5 / REMOVE CORE SCREWS

The GPU core is easily identifiable on most cards, with four screws and often a support bracket. Dealing with these screws last will prevent the cooler from falling off and putting pressure on a screw at the edge, potentially damaging the GPU.

6 / REMOVE BRACKET SCREWS

The PCI-E bracket also secures to the cooler, and this will be the same on most models. The four screws above the lower video outputs can remain, but the rest need to be removed in order to release the lower heatsink support.

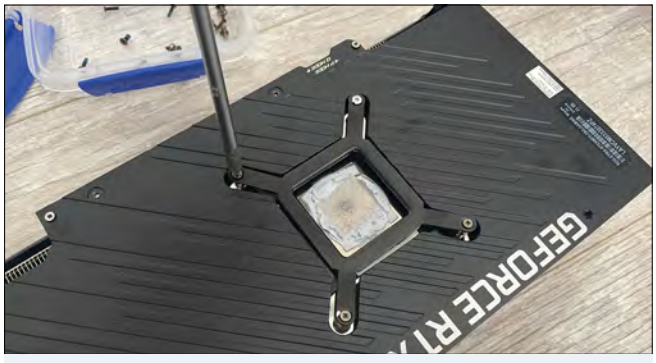


7 / DETACH CABLES

You need to deal with two cables here, which power the lighting and fan, but there may be other cables on your card. Lift the cooler high enough, so you can access them, but be extremely careful not to pull them, as they're very delicate. Pull from the connector, not the cable, and gently use a pair of needle-nose pliers if necessary.

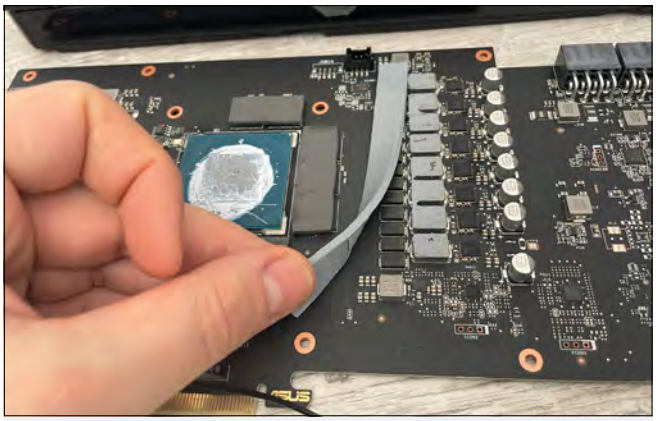
8 / REMOVE COOLER

The cooler should now lift off the card, so place your card with the PCB at the bottom. You can now lift up the cooler off the PCB, and also lift the backplate off the back if you haven't done so already.



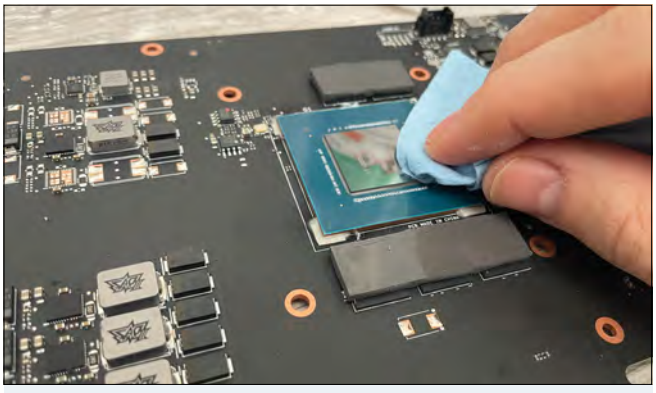
9 / FIT SCREWS TO COOLER

It's important to keep the screws safe, and the best way to do this is to place them back into the original cooler and backplate in the holes from which you removed them. You can then leave the cooler in the card's original box, so you can easily reassemble it if you want to sell it later.



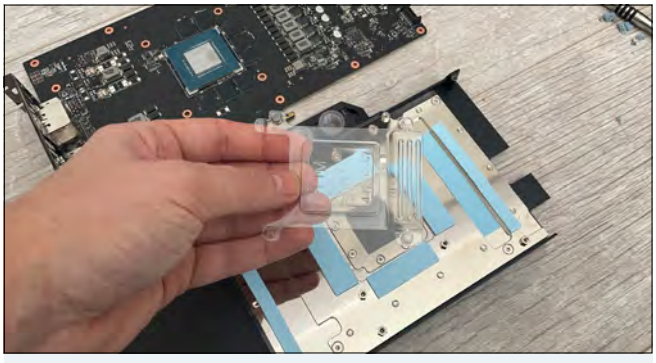
10 / REPLACE THERMAL PADS

Occasionally, some VRM or memory thermal pads can detach from the original cooler's heatsink and stick to the PCB. You won't need these, so carefully lift them off and place them back on the cooler's heatsink to use later.



11 / CLEAN THE GPU

You'll need to clean the GPU core ready for new thermal paste, so use a thermal paste cleaner or isopropyl alcohol and a microfibre cloth to clean it. The solutions aren't essential, but will make your life easier, as they break up the paste and reduce the amount of rubbing needed.



12 / REMOVE PROTECTIVE CAP

The Corsair waterblock we're using comes with thermal pads and paste pre-applied, which is extremely useful, but some require you to apply your own paste. Make sure you remove the cap protecting the thermal paste. Only remove it when you're ready to fit the waterblock.

13 / ATTACH WATERBLOCK

Place the waterblock face down on a raised platform, such as a small sturdy box, so the PCI-E bracket can dangle down and allow the two parts to meet. Line up the screw holes, and then check the waterblock instructions to see whether some screws need to be installed before you fit the backplate.

14 / INSTALL THE BACKPLATE

The backplate in this case houses all the screws that go through the card to secure the waterblock, so go ahead and remove the protective film on the thermal pads before securing it using the included screws.

15 / CONNECT TO YOUR LOOP

Attach your fittings and allow the loop to fully bleed of air. Once there are no air bubbles left, perform the stress test again. We found the GPU temperature fell from 58°C to 48°C when using the waterblock compared with the original Asus air cooler. CPC

Folding@home

Join our folding team and help medical research

ACTIVE USER MILESTONES

USERNAME	POINTS MILESTONE
kcanti	1,000,000,000
sonic_vortex	700,000,000
BurnedFastfood	600,000,000
Votick	400,000,000
gKitchen	200,000,000
TrekkieStu	100,000,000
Origami_Tsuki	100,000,000
Curtis.Perdue	100,000,000
dis80786	100,000,000
Bedders	90,000,000
bytemarq	90,000,000
Count_Stex	90,000,000
peete	90,000,000
jonesd98	80,000,000
GreenPig	60,000,000
YCDCN22	60,000,000
filreed	50,000,000
Wibb	40,000,000
Manda_Chuva	40,000,000
paul_warden	40,000,000
TokerRizla	30,000,000
Pennine_Lad	20,000,000
Mikloid	20,000,000
G4zm4n	20,000,000
sparrowm7	20,000,000
TheRepublicofKirkup	10,000,000
leeoliver24	10,000,000
TheLimey	10,000,000

USERNAME	POINTS MILESTONE
StevieTM	8,000,000
Pausanias828	8,000,000
ausnic83	8,000,000
leusenberger	7,000,000
Peanut.Rec.	5,000,000
Philhasnoidea whathe'sdoing	5,000,000
Bazil	2,000,000
Trotski	2,000,000
Lewisifer	2,000,000
PendragonOrion_ ALL_1Gpy...	2,000,000
Cole	2,000,000
Syfer	1,000,000
Wenna	1,000,000
mjgray87	1,000,000
raptor4216	1,000,000
Thunder	800,000
ROric	700,000
Team_DS-WHS2011	500,000
Ian_Beales	500,000
Luke-Ac3Mast3r	400,000
neo-internalforce	400,000
bughyz	300,000

WHAT IS FOLDING?

Folding@home uses the spare CPU and GPU cycles for medical research, with a current focus on COVID-19. You can get the client from **foldingathome.org/start-folding** and our team's ID is 35947. Once you pass a significant milestone, you'll get your name in the mag – we'll print all the milestones we can fit on the page. You can discuss folding with us and other readers online at the bit-tech forums (**custompc.co.uk/FoldingForum**).

TOP 20 PRODUCERS

RANK	USERNAME	DAILY POINTS AVERAGE	OVERALL SCORE
1	DocJonz	16,773,398	14,662,395,771
2	Desertbaker	8,893,027	3,717,700,246
3	tarka_dahl	6,953,358	1,686,038,934
4	Slavcho	6,670,740	3,850,844,850
5	Lordsoth	6,235,348	5,313,664,388
6	TrekkieStu	4,008,754	150,160,260
7	PC_Rich	3,626,249	6,552,036,136
8	Votick	2,751,279	449,435,434
9	KevinWright	2,283,443	1,378,364,960
10	madmatt1980	2,272,789	899,014,559
11	kcanti	2,160,692	1,019,340,664
12	Neku	1,790,592	174,461,264
13	peete	1,526,768	96,536,676
14	Bloo_Toon	1,510,413	381,922,505
15	Dickie	1,471,374	1,226,774,928
16	BurnedFastfood	1,437,678	605,334,250
17	Little_Willie	1,299,564	450,031,774
18	Simlec	1,256,636	337,588,178
19	sonic_vortex	1,255,386	725,643,097
20	gKitchen	1,252,864	201,961,183

TOP 15 OVERALL

RANK	USERNAME	POINTS	WORK UNITS
1	DocJonz	14,662,395,771	340,194
2	PC_Rich	6,552,036,136	164,869
3	Lordsoth	5,313,664,388	180,636
4	Shirty	5,266,143,058	39,848
5	Nelio	4,638,586,520	523,610
6	Slavcho	3,850,844,850	72,723
7	Desertbaker	3,717,700,246	68,261
8	HHComputers	3,544,050,839	85,007
9	Dave_Goodchild	3,069,605,174	160,184
10	piers_newbold	2,703,256,197	107,638
11	Scorpuk	2,565,487,007	57,788
12	clanseven	2,223,720,446	33,156
13	Unicorn	1,753,462,654	57,079
14	tarka_dahl	1,686,038,934	24,341
15	daxchaos	1,637,104,710	41,302

Retro tech

INTEL PENTIUM 4

Huge clock speeds, hot running and rubbish performance. **Ben Hardwidge** looks back to the time when Intel got it catastrophically wrong

Like that Simpsons episode where the director's commentary for The Postman is just Kevin Costner repeatedly apologising into his microphone, there needs to be a monument to the Pentium 4 somewhere at Intel's HQ to remind people how badly you can get it wrong. You might think Intel is behind the competition now, being stuck on a 14nm node and a lack of cores compared with AMD, but at least Comet Lake is a half-decent microarchitecture. You'd struggle to say the same for the Pentium 4.

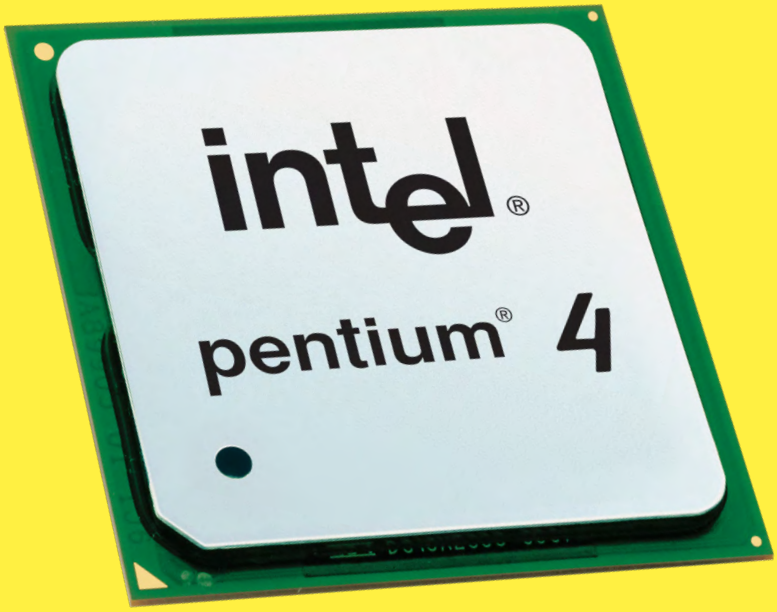
It would leave existing CPUs looking like relics. At least, that was the idea

Let's put the Pentium 4 in its historical context. Intel came up with the Pentium brand to distinguish its processors from the competition in the post-486 era, and it had worked. People looked for the Pentium brand as a seal of quality, and that had largely continued throughout the Pentium II era. Then, soon after the launch of the Pentium III, AMD brought out its first premium CPU brand, the Athlon.

There were teething problems with Athlon, as you might expect, but it showed that AMD could beat Intel in terms of performance. Not only that but, to Intel's shame, AMD's Athlon later beat the Pentium III to the 1GHz finish line at the end of 1999.

FIRST MISSTEPS

There were some clues to what was to come with Pentium 4 in the latter days of the mainstream Pentium III, when Intel introduced a 133MHz front side bus (FSB). Now, the 133MHz FSB was a great idea, as it not only bumped up the CPU speed, but also the I/O speed between the CPU and the motherboard chipset's Northbridge – if you used 133MHz memory with it, you got a load more bandwidth.



An Intel Pentium 4 in its dinky Socket 478 packaging

The problem was that Intel's two chipsets for it were both flawed in crucial ways. At the top end was 820, with pricey motherboards and the need for a new type of memory made by Rambus called Rambus Dynamic RAM (RDRAM). While SDRAM was generally running at up to 133MHz, RDRAM could run at 400MHz. Not only that, but by transferring data on the rise and fall of the clock, much like DDR memory today, it effectively ran at 800MHz.

It wasn't quite that simple though. At this time, RDRAM had a 16-bit bus, compared with the 64-bit bus used for SDRAM, and it also had much higher latency. RDRAM still had higher bandwidth by the end of it, but it wasn't quite the trouncing people expected. Also, all that bandwidth didn't make a massive difference when the front side bus

only ran at 133MHz anyway. More to the point, RDRAM was much more expensive than SDRAM – around three times the price, in fact.

Intel had another option, the cheaper 810 chipset, which supported 133MHz SDRAM, but again had a crucial flaw – there was no AGP slot, so you couldn't run the latest graphics cards on it. If you were a gamer, you had to buy into 820 and, needless to say, we were more inclined to buy a cheaper SDRAM-based Athlon system instead, or to overclock an Intel 440BX motherboard from the last generation. Intel later addressed this with the SDRAM and AGP-supporting 815 chipset, but by this time it was too late to stop the Athlon onslaught.

Intel needed an answer, and it had one in the works – a brand-new CPU microarchitecture that rewrote many of the previous rules and could be clocked to high heaven. The Pentium 4 would be built on several new technologies and principles, and leave existing CPUs looking like relics of yesteryear. At least, that was the idea.

NETBURST FORTH

Intel called its new microarchitecture NetBurst, and it represented a very different approach to the Pentium II and III, which had been largely based on the earlier Pentium Pro's P6 core. At this time, all CPUs had just the one core, and clock speed was the primary indicator of a CPU's performance. There were no model numbers like we have today – you bought a 1GHz Pentium III, for example, or an 800MHz Athlon.

This is where NetBurst could beat previous CPU microarchitectures, as it was built to be scaled up to super-high clock speeds. In fact, at the Pentium 4 launch in 2000, Intel said it expected the architecture to scale up to 10GHz as fabrication processes were refined over the years. Yes, really.

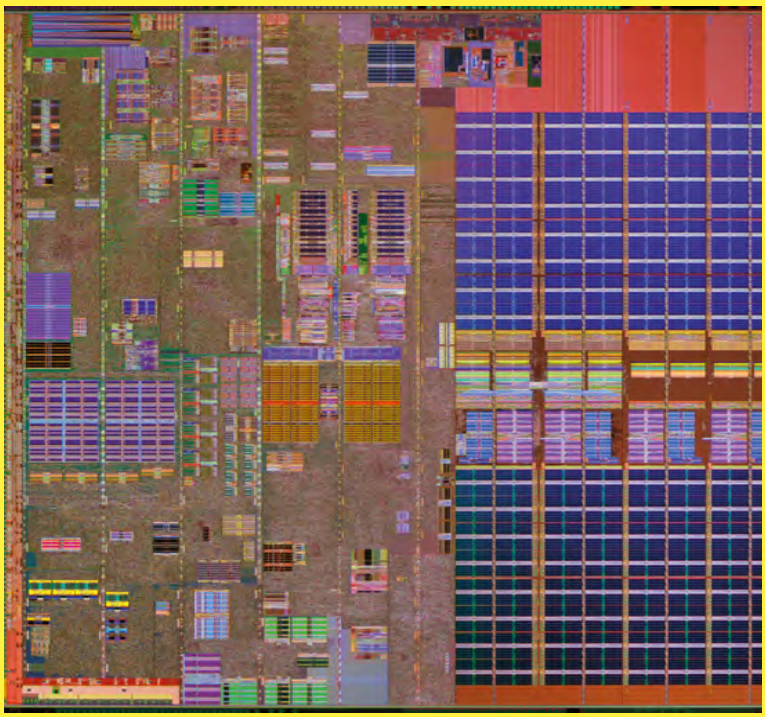
That didn't happen, as we now know, but NetBurst *could* hit very high clock speeds for the time, despite the first 'Willamette' chips being built on the same 180nm process as the previous 'Coppermine' Pentium III chips. They launched at 1.4GHz and 1.5GHz, with a 1.7GHz model arriving a few months later and a 2GHz model coming out in the summer of 2001.

STUCK IN THE PIPELINE

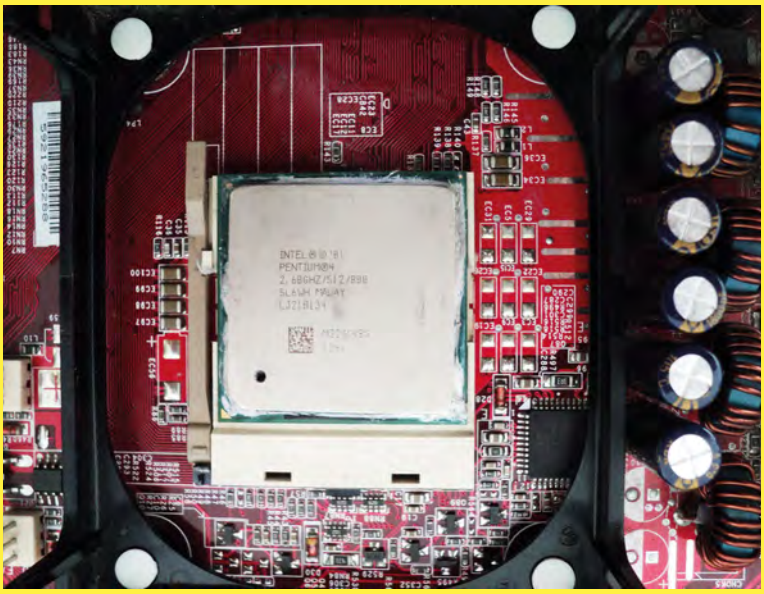
That sounds amazing, you might think. Intel had gone from 1GHz to 2GHz in under two years, and its new microarchitecture was clearly built for high-frequency operation. However, achieving that high clock speed required some fundamental changes to the structure of the microarchitecture, one of which was a large increase in the number of stages to the execution pipeline – with the pipeline split over more stages, Intel could devote fewer transistors to each specific stage, enabling it to increase the clock speed.

The first Willamette Pentium 4 CPUs had 20 pipeline stages, which increased to a massive 31 stages in the later Pentium 4 CPUs, codenamed Prescott. As a point of comparison, the Pentium III had 14 pipeline stages, the first Athlon 64 CPUs had 12 pipeline stages – even Intel's latest Comet Lake cores have fewer than 20 stages. NetBurst had a *long* pipeline, especially for the time.

There are two main problems with a long pipeline – the first is that they require a higher voltage than a shorter pipeline, and therefore the CPU generates more heat, especially in conjunction with the high clock speeds.



A die shot of a Prescott Pentium 4, which had a colossal 31-stage pipeline



A relic from Custom PC's past – the Beat the Office CPU was an overclocked 2.6GHz Northbridge Pentium 4C attached to a Vapochill phase change system at -22.5°C – we had it running stably at 3.54GHz

The Pentium 4 was the first CPU to really require the large heatsink-and-fan assemblies that we still use today, with some of the first Pentium 4 PCs being equipped with wind tunnels to link the CPU cooler with the case's exhaust fan.

The second problem is that it makes a CPU very inefficient at processing code with unpredictable branches. Intel's plan to get around the latency created by the many-stage pipeline was to make use of advanced branch prediction techniques. If a CPU was performing a task that repeatedly used predictable code branches, such as video encoding, then the CPU could efficiently predict what it needed to do. Loops of code could be handled quickly too, thanks to Intel's new L1 Trace Cache system, which moved the L1 cache to a position after the decode unit, so any microinstructions held in it would already be decoded.

For these reasons, Pentium 4 CPUs usually excelled in software with predictable instructions. The problem was that a lot of code didn't behave this predictably, particularly if you were running lots of legacy applications at once. If the CPU got it very wrong, the pipeline would have to be flushed and start again. That's not a massive problem if a CPU has a short pipeline, but it quickly makes the CPU inefficient if it has a long pipeline.

The result was that the Pentium 4 could process fewer instructions per clock (IPC) than the Pentium III in a lot of standard software, negating the benefits of those huge clock frequencies.

MISSING THE BUS

Another key difference between the Pentium 4 and its predecessors was its front side bus. As we mentioned earlier, there was a large disparity between the 133MHz Pentium III FSB and the massive bandwidth of RDRAM. Intel aimed to fix this with the Pentium 4 by introducing a quad-pumped FSB, where four signals are sent per clock cycle. The FSB still fundamentally ran at 100MHz, but it had an effective frequency of 400MHz. Intel launched the Pentium 4 with the 850 chipset, which only supported RDRAM, but the Pentium 4 could now take advantage of all that extra memory bandwidth.

Again, though, RDRAM was expensive, and not many people already had RDRAM sticks in their old PCs that they could simply transfer to a new system. Intel started bundling RDRAM with the CPUs in an effort to get people on board, but it was a tough ask.

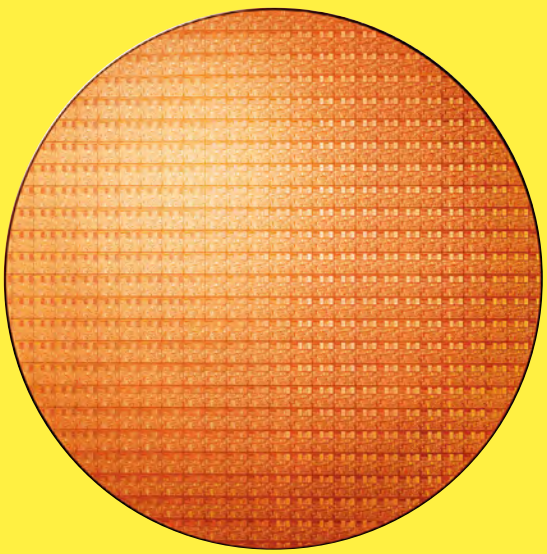
With disappointing sales and reviews for the Pentium 4, Intel backtracked and launched a new SDRAM-supporting chipset for the Pentium 4, called 840. The performance was dreadful without the extra memory bandwidth, but it

Intel backtracked and launched a new SDRAM-supporting chipset

did show that Intel's combination of RDRAM with a quad-pumped FSB worked – the Pentium 4 really needed to be paired with fast memory.

The magic bullet finally came with Intel's 845 chipset, which supported DDR memory running at 133MHz (266MHz effective). DDR memory was significantly cheaper than RDRAM, and it provided a very sensible compromise over Rambus in terms of bang per buck.

The last gasp for Rambus came with the later 850E chipset, which could run RDRAM at an effective frequency of 1066MHz, but had no native support for USB 2 and was pretty much dead in the water on launch. Intel then put all its work into supporting DDR, with the E7205 'Granite Bay' chipset supporting dual-channel memory, where two memory sticks interleave to create more bandwidth.



An Intel Pentium 4C wafer – the 'C' denoted that the processor had an 800MHz front side bus

Intel introduced Extreme Editions for enthusiasts, with high clock speeds

Then, the later 865 and 875 chipsets went on to support 200MHz (400MHz effective) DDR memory in dual-channel mode, which went well with Intel's latest Pentium 4C chips, which had an 800MHz FSB. RIP RDRAM.

THE 64-BIT QUESTION

Intel had dropped the ball with the Pentium 4, and it had taken several years to get to the point where it had affordable memory and decent performance. That would be fine if AMD had been resting on its laurels, but in late 2003 AMD unleashed its AMD64 architecture, resulting in its famous Athlon 64 desktop CPUs.

The headline was 64-bit computing. However, it's worth remembering that, at this time, there was no 64-bit version of Windows XP, and that it would take a good few years before 64-bit Windows became a standard. AMD had also removed the front side bus from its CPU design, introducing an integrated, on-die memory controller, which reduced latency. The first Socket 754 Athlon 64 CPUs only supported single-channel memory, but the Socket 939 CPUs in 2004 supported dual-channel memory.

While the integrated memory controller and 64-bit instructions are often touted as the benefits of the Athlon 64 over NetBurst, the main difference when it came to performance was that AMD64 had a much shorter pipeline, with just 12 stages. Intel would later add support for 64-bit instructions to some of its Pentium 4 CPUs, but AMD64 CPUs were just massively more efficient in terms of instructions per clock, thermals and power consumption.

LATER REVISIONS

There were several iterations of Pentium 4 over the years, starting with a die shrink from the 180nm Willamette to the 130nm Northwood core, along with a new dinky package called Socket 478. The top-end Northwood Pentium 4 HT CPUs also brought us an idea that we still use today, which is executing more than one thread simultaneously on one core, with the HT standing for Hyper-Threading.

The way Hyper-Threading works has changed a bit since then, but the principle is the same – Windows saw a Pentium 4 HT CPU as two processors, with the CPU splitting its one core's resources to create a virtual second core. Hardly any desktop software was properly multi-threaded at this point, but it worked well in software optimised for dual-CPU setups, such as Lightwave.

Next came Gallatin, which introduced the Pentium 4 Extreme Edition with Hyper-Threading and a 3.2GHz clock speed for enthusiasts. Until this time, Pentium 4 CPUs had maintained the 20-stage pipeline, but then came Prescott with its 31 stages, fabricated on a 90nm process, and clock speeds of up to 3.8GHz. By this time, the thermal and power demands of Pentium 4 were looking utterly ridiculous.

NETBURST, AHEM, BURSTS

By the time Prescott was launched, the power and thermal demands of NetBurst had already made it redundant in the laptop world. Intel had introduced the Pentium 4-M, but its thermal demands had resulted in thicker laptops and slow performance. Not surprisingly, the first part of Intel to backtrack on NetBurst was its mobile division in 2003, with the introduction of the Pentium-M.

It was fabricated on a 130nm process, and took some of the good ideas from Pentium 4, such as the front side bus and improved branch prediction, but attached them to a core based on the P6 core from the Pentium Pro days, with a much shorter pipeline and a massive load of cache.

The result was a really good mobile CPU, with great performance and decent battery life. People started saying that Intel needed to do the same on the desktop, but Intel had sunk so much investment into NetBurst on the desktop at this point, and it doggedly stuck by NetBurst 4 for a few more years, bringing it into the dual-core era and dropping the '4' from the end of the Pentium brand.

It wasn't until 2006 that Intel finally threw in the towel on NetBurst. There were rumours flying around the Internet on the day before it happened. I phoned Intel's UK PR rep the next morning and asked him if there was any truth in them, and he laughed at the very idea of it. A few hours later he called me back, sheepishly confirming that Intel was indeed about to completely overhaul its desktop strategy.

NetBurst was in the bin, and so was the Pentium brand as a sign of premium quality. Intel's next desktop CPUs would feature the Core 2 brand, and would again be based on the P6 core Intel had abandoned years earlier. We'd learned that there was more to CPUs than clock frequency, and that you don't necessarily have to reinvent the wheel to get ahead in tech. CPC

Readers' drives

Cyberpunk Two 077

Dystopian fiction fan Richi Bowzer spent a year creating this stunning Cyberpunk 2077-inspired PC, which can boot into two PCs for two-player gaming, and has an incredible amount of custom paintwork, as well as a nifty screen on the PSU shroud

/MEET THY MAKER

Name Richard Bowzer

Age 44

Occupation Web developer

Location Kent

Main uses for PC Graphic design, web development, gaming, dual-gaming and learning videography

Likes Any dystopian shows and films, gaming, tech, PCs, football and airbrushing/painting

Dislikes Musicals, curry and heights. I will go up to high places, but I won't be happy about it!

CPC: What inspired you to build this Cyberpunk 2077 PC?

Richi: I've been a fan of the whole dystopian theme for a long time – I even enjoyed the updated Blade Runner film! I read the Bruce Bethke books when I was younger, and for me he is the founder of the whole dystopian future idea. I also have a huge collection of cyberpunk and dystopian future wallpapers, so when the game was announced, a mod on this theme was always in the works.

I wanted to include a screen as well, but too many modders are rocking the 7in ones now, so I went on **aliexpress.com** and found a 14in 1,280 x 390 mini ultrawide screen, and decided to go down that route. As soon as I found it, I thought it would make a good custom rain meter or monitoring screen, then the game came out with ultrawide adverts, so I chose to display them on the screen instead.

My design cues were quite simple – I wanted to make it look dystopian, and not follow the yellow and blue theme inside the case, as it was already on the outside. I just wanted to create a dystopian/cyberpunk look inside. I pictured it in my head and it came out almost 90 per cent how I imagined it. I also wanted to get a whole external lighting right around the setup, using a Philips Hue setup around the monitors and desk.

CPC: That's an amazing paint job. Take us through your painting process.

Richi: I get a bit silly when it comes to painting. Firstly, I measured the panels, which of course meant stripping off the panels off including the front one – that was luckily a simple task with the Lian Li Dynamic O11XL, as it has screws holding it in place rather than rivets. I then wet-sanded all the panels with 800-grit sandpaper, so the etching primer could bite into it.

For the back panel, I made a stencil (I make all my stencils with a Silhouette Cameo 3D printer – one of the best investments I've ever made), to mask the design. The panel was then coated with two coats of Createx Pearl Silver, Pearl White and then Pearl Red. After the paint hardened, I sanded the panel with 1,400-grit sandpaper to scuff the image and give it a worn look and feel – I even sanded a bit of the anodised aluminium around the paint to add to that effect. The other panels were first coated in yellow with a hint of lime 2K paint, then two coats of lacquer to protect it.

I custom-designed the stencils in my very old copy of Photoshop, then used my Cameo to plot them out. I laid out the stencils, and then put down my own mix of Createx Pearl Green, Pearl White and Pearl Blue, again then sanding them down with 1,400-grit sandpaper to make

them look worn – I sanded away edges and complete lines of paint. After this, I used 3,000-grit paper with water to flatten it down, and then used some 400-grit paper to sand the edges of the top panel back to silver.

One of the hardest parts was jamming a small screwdriver into the edges of the front I/O ports, as I wanted though to chip off the paint around the ports to give them the whole worn vibe. This was then all finished off with four coats of 2K lacquer and compound rubbing (by hand), and then polished.

It was a lot of work, and it's hard to see it all, but I know I've done it and that sits right with me. The panel paint in studio light and standard lighting just shows up a green sort of colour, but it changes to blue under really bright light, with a sparkle to it. The main painting advice I would give is to prepare well, and then put loads of sweat and elbow grease into the colour sanding, as well as the compound rubbing-down of the finished lacquered product.

CPC: How did you go about making the glowing adverts on the GPU backplate?

Richi: The plate was made up for me by Ricardo at **coldzero.eu** on his UV printer, which allows semi-transparent prints. The design is my own, although I took some adverts from the game and made another to representing the fact that the GPUs are made by Nvidia – I designed an advert around that and adapted it to fit the futuristic theme.

CPC: That screen on the PSU shroud! How does it work?

Richi: I love this screen – it's hooked up to a Gigabyte GeForce GTX 1650 Super card behind the motherboard tray, as well as one of the main GeForce RTX 2080 Ti GPUs. It plays a video of advertisements from the actual game – I had to drive around the game and screenshot all the ultrawide adverts, then mix them up with some video adverts from the game (the videos were ripped from game files). I think I overdid it, though, as the total length of the advert loop is seven minutes.

> It plays a video of adverts from the game – I had to drive around the game and screenshot all the ultrawide ads

It serves a dual purpose too, as it's also connected to an UnRAID boot drive.

The machine has two different setups to boot – one regular one using all the hardware, and the second via UnRAID has two virtual machines (each one is separated into ten cores, 16GB of memory and a GeForce RTX 2080 Ti each). It's quite complex, and there was quite a bit of trial and error involved in getting it to work this way. However, it means I can boot up a separate mode that allows two gamers to play on the one rig.

CPC: Where did you get the Keanu Reeves model?
Richi: This was probably the cheapest product in the whole setup – it was £22 on Amazon – a bargain if you ask me.

CPC: There are some substantial curves in the tubing down the bottom. What tubing did you use, and how did you cut and bend it?
Richi: It's 14mm Bitspower Crystal Link Tube, and I'm probably going to upset a few people now, but my bending tools just involve a hacksaw, a tube insert, a reamer, some sandpaper, a heat gun and some Mayhems silicon cord bending spray – no mandrels are needed.

With acrylic, I like to heat a substantial amount of the tube, then I bend it, lay it flat on a clean surface and do any minor adjustment while it cools. I work by sight with my bends and don't measure, say, the curves at the bottom. I start with a bigger piece than I need, get the bend as tight as possible, then cut it down before finishing it off with a reamer and sandpaper. Good-quality tubing is the key to getting good curves.

CPC: The magenta and cyan lighting really helps this machine to stand out. How did you plan the lighting setup in the PC?
Richi: I just wanted a whole dystopian feel inside the rig, and blues, reds and magenta are at the forefront of that style, so it was a natural choice. The GPU waterblock's lights, as well as the upper and case lights, are all

SYSTEM SPECS

CPU Intel Xeon W3275

Case Lian Li PC011 Dynamic XL with Razer Chroma, Gigabyte Fusion and Philips Hue lighting

GPU 2 x Gigabyte Gaming OC GeForce RTX 2080 Ti, 1 x Gigabyte Gaming GeForce GTX 1650 Super

Storage 2 x 2TB Kioxia Excercia Plus NVMe SSD RAID array in U.2 enclosure, 2 x 960GB 2TB Kioxia Excercia SATA SSDs, 2 x 240GB Kioxia Excercia SATA SSDs in RAID array

Memory 6 x 8GB (48GB total) G.Skill Trident Royal 3200MHz 14-14-14-34

Motherboard Gigabyte C621 Aorus Xtreme

PSU 2 x Seasonic Prime Platinum Modular PSU

Cooling Bitspower D5 pump with Crystal Clear Reservoir, Bitspower Summit LGA3647 CPU waterblock, Bitspower Gigabyte C621 Aorus Xtreme Mos Block, Bitspower Lateral VGA waterblock for Nvidia, 2 x Bitspower 360mm Slim Radiators, 1 x Bitspower 240mm Slim Radiator, Bitspower 14mm Carbon Black Fittings, Bitspower 14mm Crystal Link tube, 9 x 120mm Lian Li UNI fans

connected to the motherboard via a Bitspower DRGB hub.

The GPU backplate, CPU block, MOSFET block and two front window lights are connected to a Razer Chroma ARGB controller, which of course allows individual LED colour choices.

This helps with the GPU backplate, as it allows me to select the LEDs under the panel to match the colour of the actual images with which they line up, enabling them to pop a bit more.

CPC: What specs did you use, and can the PC actually run Cyberpunk 2077 at decent settings?
Richi: There's a 28-core Xeon with two GeForce RTX 2080 Ti cards and a GeForce GTX 1650 Super. And yes, it plays great with ray tracing at decent settings. The settings are toned down slightly for the dual-system mode, but it still runs great.

CPC: Did you come across any difficulties?
Richi: Setting up an UnRAID system to run two virtual gaming machines was pretty tough, as I was a noob to it all. I tried the GPU pass-through route and got it working, but the VM using the pass-through kept stuttering and crashing. Setting it up as a dual-boot system was a pain as well – I ended up with two drives for UnRAID and virtual machines, and then two drives for the single Windows cold boot and a lot of partition drives. I'm sick to death of creating RAID arrays, then deleting them to get the right balance!

CPC: How long did it take you to complete this build?
Richi: I wouldn't like to guess the number of hours, but I did start planning it properly over a year ago – the pandemic had a big effect on the time, though, as it's not easy to mod (even with a shed in the garden) with a four-year-old (now five) at home.

> I start with a bigger piece than I need, get the bend as tight as possible, then cut it down before finishing it off

CPC: Are you completely happy with the end result?
Richi: I love the end result. The only part I would change if it was possible would be a bigger case. The motherboard fills all but maybe 2in or so to the right of the inside of the case if you look at it from the side – it was tough getting all the gear into the case with three radiators and fans on them, but then that's the fun of modding I suppose. CPC

WIN CORSAIR HYDRO X WATER-COOLING GEAR

CORSAIR

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 the AM4/LGA1151 or LGA2066 version.

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

DON'T COUNT OUT INTEL YET

James Gorbold discusses how Intel's road map to success is full of potential pitfalls and opportunities

If you only ever read product reviews it would easy to believe that AMD is currently giving Intel a thrashing in the desktop CPU market. However, while AMD's Ryzen CPUs do lead the way in most benchmarks, there's a lot more to success and failure than simple benchmark results.

Price is a major factor, and a tricky one. Right now, there's an approximate £100 price difference between the two best-selling high-end CPUs, the Ryzen 9 5900X and Core i9-10900K. On paper, the 5900X, with its two extra cores and outstanding multithreaded performance offers far better value for money.

For gaming, however, the GPU is far more important when it comes to performance – you'd arguably be better off putting that £100 towards a faster GPU. The 5900X's ongoing supply problems don't help either. As such, it's no surprise to me that many gamers are still opting for a Core i9 over a Ryzen 9.

It's no surprise to me that many gamers are still opting for a Core i9 over a Ryzen 9

Looking forward, it won't be long until Intel's next-gen Rocket Lake processors hit the market. I've seen lots of speculative press coverage dismissing these upcoming processors for having two fewer cores than the current flagship Comet Lake CPUs, but this could turn out to be a smart move by Intel for the gaming market.

After all, how many games really need more than 8 cores and 16 threads? I'm not arguing that Rocket Lake will be a game changer, but I don't think its right to count it out of the fight simply based on its core count. CPUs need to be smart to win, not just packed full of largely idle cores.

Later this year Intel has an even bigger roll of the dice planned with Alder Lake. With a combination of high-performance and low-power cores, and potentially with PCI-E 5 and DDR5 along to help, Alder Lake could prove very potent if it's done right.

However, I suspect Alder Lake may sink or swim depending how the Windows Task Scheduler divides up threads between the two types of core. Because of this challenge, I suspect Alder Lake might turn out to be an evolutionary dead end, or at least a shaky start that needs more time for software to take advantage of it, or another CPU generation to get right.

Whether Alder Lake is successful or not, I welcome the fact that no one company has a clear-cut lead in the processor market. The situation now, where Intel is leading one generation and AMD leads the next, is reminiscent of the PC industry in the 1990s. Many people are used to thinking one company is all-conquering, as has been the way the past decade, but back then, fierce competition led to each company putting a real focus on R&D and innovation in an attempt to leapfrog the other.

While not every gambit paid off, such as Intel NetBurst (see p106) and AMD Bulldozer, for each of these failures, there were also successes, such as Intel Core and AMD Athlon 64.

And while AMD has hit hard with Zen and its successors, the next few years could see a resurgence in processor innovation from both Intel and AMD. Nvidia could even make something really interesting if it gets the keys to ARM – it's already announced a range of DPUs, an interesting new type of smart NIC with an on-board processor. And now that Intel has the extremely experienced Pat Gelsinger at the helm, I really wouldn't count it out yet. The next few years will be bumpy, but certainly fun to watch. **CPC**

James Gorbold has been building, tweaking and overclocking PCs ever since the 1980s. He now helps Scan Computers to develop new systems.

G-MASTER™
#MONITORS4GAMERS
by iiyama

UNLEASH YOUR FULL GAMING POTENTIAL

Get the competitive edge you need to unleash your full gaming potential with the 24'' and 27'' G-Masters offering 0.8ms MPRT and 165Hz refresh rate. Armed with FreeSync Premium you can make split second decisions and forget about ghosting effects or smearing issues. The ability to adjust brightness and the dark shades with the Black Tuner delivers greater viewing performance in shadowed areas and the IPS panel technology guarantees superb image quality.

165 Hz | FAST IPS | 0.8ms MPRT | BLACK TUNER | HDMI DISPLAY PORT | USB HUB

Fixed stand versions:
24'' G2470HSU-B1 & 27'' G2770HSU-B1

Version with height adjustment:
24'' GB2470HSU-B1 & 27'' GB2770HSU-B1

Find your match at
gmaster.iiyama.com

XS SYSTEMS PRO GAMING

You dream it. We build it.

PCs designed and custom-crafted for a totally individual look in your home

Scan recommends Windows 10

Contact the Custom Build Team

scan.co.uk/3xs/custom-shop • 01204 47 47 47

SCAN