DESIGN YOUR DREAM PC

Building your own PC is easier than you think, cheaper than buying a pre-built system, and lets you tailor every component to your needs. Get started with this guide to the best parts to choose from, and how to put it all together for a machine to match your specific needs

While there are many great desktop PCs you can buy outright, there is an alternative to buying pre-made: one that's less expensive, more suitable for customising and ultimately more satisfying. It's choosing the individual parts, ordering them separately, and building the whole system yourself.

That might sound like a lot of work, involving some pretty valuable computer parts that could be intimidating to the unfamiliar, but building a PC is actually quite straightforward. Even a novice builder can put complete their first PC in an afternoon, and they'll have done so with components that reflect their specific personal needs and preferences. The cost savings aren't just pennies, either – a home-built PC can work out to be hundreds of pounds cheaper than if you bought an equivalently specced system from a large manufacturer or PC builder.

The most important thing is making sure you choose the right parts in the first place. To that end, we've prepared this guide: it will take you through the best available products in every component category, covering a range of price points. Simply pick out the ones that best suit you, and you'll have everything you need to build your perfect, custom-specced PC.

CONTENTS

CPUs PAGE 80

MOTHER-BOARDS PAGE 84

PSUs PAGE 88

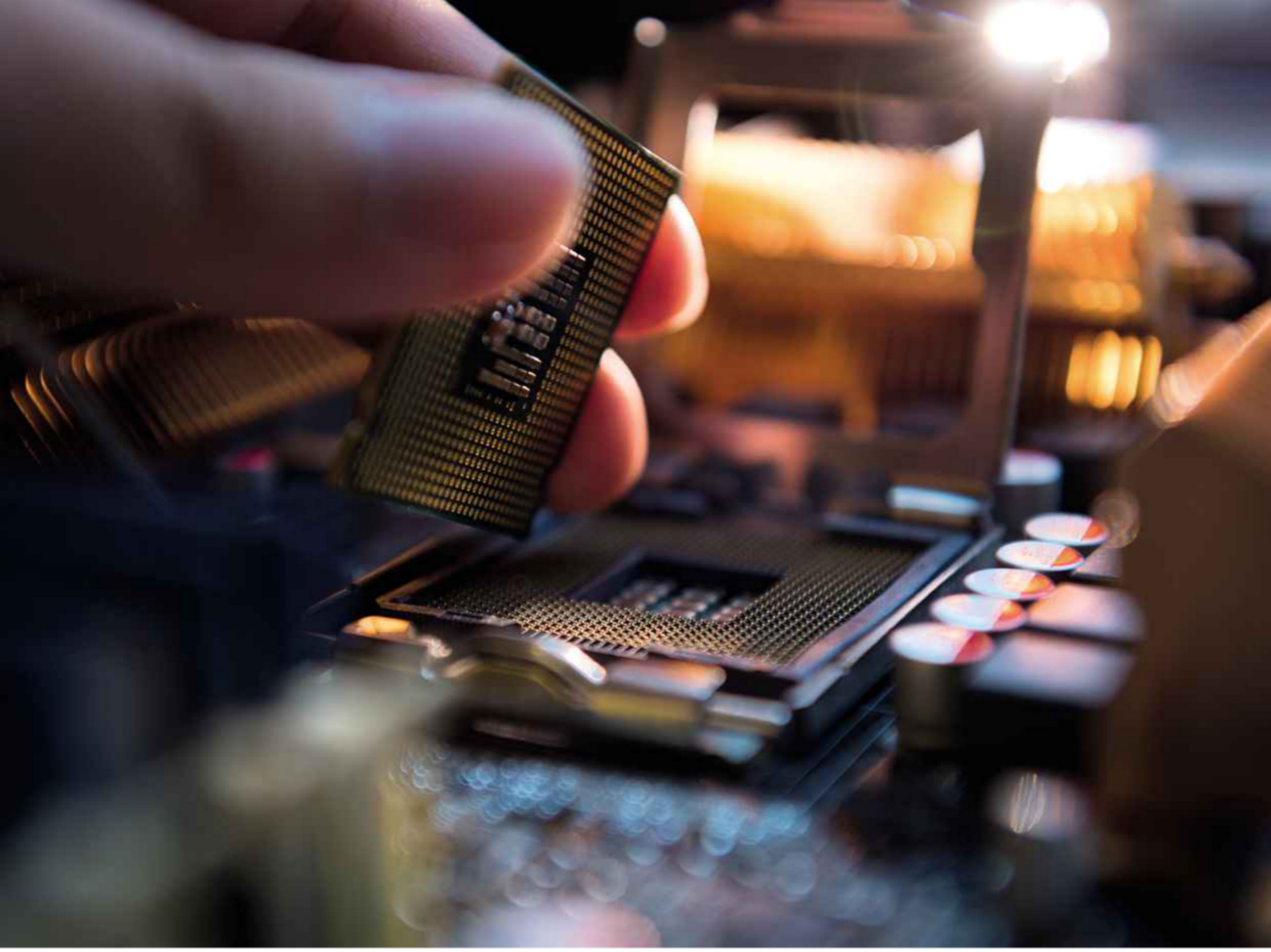
STORAGE PAGE 90

GRAPHICS CARDS PAGE 94

CPU COOLERS PAGE 100

CASES PAGE 104

THE IDEAL SPEC FOR YOUR PC PAGE 108



CORE BLIMEY

CPUs

At the heart of every PC is the central processing unit: the CPU. This little chip affects practically every area of performance, so picking one with enough power for your needs is essential

THE CPU IS a tiny component with a massive impact. Every input you make into your PC, and everything that appears on the monitor as a result, will pass through it as processes, and so it essentially has the last word in how well the PC will run. Even if you want to construct a monster gaming system with a cutting-edge dedicated graphics card, it will be the processor that will unleash the GPU's potential – or hinder it, if it's not fast enough to keep up.

In any case, choosing a CPU is all about getting as much performance as you can afford with your budget.

THREAD LIGHTLY

That performance is mainly derived through three things: the processor's cores, threads, and clock speeds. Cores are the physical processing units that exist on a CPU – most modern CPUs are multicore, meaning they have at least four cores, with each core being able to take on a task each. At least, that's the case if the number of threads is the same as the number of cores. Many CPUs support either Hyper-Threading (if it's an Intel model) or Simultaneous Multi-Threading (if it's an AMD model); these present virtual cores to the operating system, tricking it into thinking there are more available cores than there actually are. This can improve performance when multitasking, as there are more threads to share the load, or in programs

Choosing RAM

Random access memory (RAM) is tasked with making sure that any information the CPU has to process is readily at hand. Currently used data is stored in this ultra-fast form of memory to ensure it can be accessed by the CPU as quickly as possible. If the RAM fills up, however, then the CPU must spend additional time fetching new data from the PC's SSD or hard disk, slowing things down. This is why it's better to have more total RAM than less, especially if you're multitasking or using software that can utilise multiple CPU threads.

The lowest you should go for is about 8GB, while more performance-minded builds should aim for 16GB. Even 32GB wouldn't be excessive for a workstation-esque productivity PC, though this is where it starts to get really expensive. One of the best things about RAM is that it's easy to upgrade in the future, especially if you have a motherboard with spare slots.

Speaking of which, it's vital that the RAM you buy will fit in the motherboard's slots. All of the motherboard models we've included in this feature take regular DDR4 sticks, so all of the recommended RAM kits below will be compatible.

These also all happen to be 'dual channel' kits, meaning they come in sets of two identical sticks. By splitting the available memory between two channels, the data on them can be accessed more efficiently than with a single stick in a single channel, similar to the way in which more CPU threads can improve performance.

Lastly, there's the issue of clock speed; also just like a CPU, RAM is rated at a certain operation speed, which can be overclocked if desired. This particular spec isn't as important as the total RAM pool size, however – 3,000MHz kits won't be significantly faster than 2,400MHz kits for most uses.

PRODUCT NAME	PART CODE	SPEED	CAPACITY	PRICE	SUPPLIER
Corsair Vengeance LPX 8GB	CMK8GX4M2A2666C16	2,666MHz	8GB (2x 4GB)	£53	www.amazon.co.uk
HyperX Fury 8GB	HX424C15FBK2/8	2,400MHz	8GB (2x 4GB)	£55	www.ebuyer.com
Corsair Vengeance LPX 16GB	CMK16GX4M2A2400C16	2,400MHz	16GB (2x 8GB)	£85	www.amazon.co.uk
HyperX Fury 16GB	HX424C15FB2K2/16	2,400MHz	16GB (2x 8GB)	£89	www.amazon.co.uk
Corsair Vengeance LPX 32GB	CMK32GX4M2A2400C16	2,400MHz	32GB (2x 16GB)	£166	www.amazon.co.uk

with multicore/multithreading support, where a single application can take over several cores to keep running smoothly.

Clock speeds refer to how fast each core can complete processes. They're measured as cycles per second, with each cycle expressed as 1MHz, so a clock speed of 3.6GHz translates to 3,600 cycles per second. All CPUs have an advertised base clock speed, while others can have a 'turbo' feature, where the CPU dynamically raises its speed beyond the base clock in order to take advantage of unused thermal headroom (in other words, when a CPU is under lighter loads, it can afford to run harder and faster). The maximum speeds these chips can reach are expressed as a boost clock speed.

OFF THE CLOCK

In the past, clock speeds alone were a strong indicator of CPU performance – obviously it's going to be better for each core to complete more process cycles in less time – but things have become a bit more complicated with the rise of quad-core, hexa-core and even octa-core processors. A CPU with more cores and threads but lower clock speeds can easily outpace a quad-core CPU with high clock speeds, as the additional cores and threads will be completing more cycles at once.

At the same time, higher clock speeds can still be better in programs that only require one or two threads, such as games. As such, you should consider where you'll most need higher performance, and tailor your choice accordingly: a quad-core CPU with higher clock speeds is best for lower-budget PC builds (where you'll only be running basic software); hexa-core chips are a good compromise for all-around performance (with clock speeds remaining high enough for smooth gaming); and octa-core CPUs are best for heavy multitasking and productivity.

TIPPED OVER

There is one way to squeeze even more speed out of a processor: overclocking. This is when you manually raise clocks speeds so that the CPU will permanently target a value above the base number of cycles per second, and maybe even the boost clock speed, if you're really ambitious.

There are, to be very clear, a number of limitations and risks involved with overclocking. First, you'll need the CPU's clock speed to be unlocked, which in Intel's case is unusual rather than the norm – look out for the 'K' suffix on Intel CPUs to check if they're overclockable. Almost all AMD Ryzen CPUs are unlocked, but regardless of which manufacturer you go with, you'll also need to make sure that your motherboard's chipset enables overclocking as well.

It's also essential that the CPU is adequately cooled, as raising clock speeds also raises operating temperatures – if these get too high, the processor will either throttle itself (denying the performance increase you were after in the first place), cause the system to shut down, or just fail to boot entirely. A good liquid cooler is best – we've covered these on page 100 – but even these won't help if you push things too far.

Overclocking can be fussy, then, but it's also a way of boosting performance for no extra money. Our advice would be to start off raising the clock speed slowly, raising the target speed by 50MHz increments until the system starts crashing, at which point you should dial it back.

AS PER VISUAL

If you don't want or need a dedicated graphics card – which will likely be the case if you only want a system for basic home use or light office work – then it will be cheaper and easier to pick a CPU with integrated graphics. You can't go without some form of GPU entirely, but many chips will have their own onboard graphics processor, which will be enough to get Windows up on a display.

It's essential that the CPU is adequately cooled, as raising clock speeds also raises operating temperatures

Not every CPU has integrated graphics – we've detailed which of our recommendations do and don't in the table overleaf – but those that do will plenty suffice for pretty much everything outside of gaming and other, more intensive graphics-based software. Most image- and video-editing programs will run on integrated graphics, but these applications can often take advantage of GPU acceleration for even better performance, so we'd still recommend a proper graphics card for serious media editing and encoding.

Best for:
Maximum performance

The **Core i9-9900K** was Intel's first mainstream octa-core, 16-thread processor, but that alone isn't enough to make it a great CPU at a time when AMD has numerous 16-thread Ryzen chips in its arsenal. More impressive is the CPU's ability to hit a searing 5GHz boost speed straight out of the box, no overclocking required. Besides battering the top-spec AMD Ryzen 7 2700X in performance benchmarks, this helps mark the Core i9-9900K as a CPU that can cope with games as well as the intense loads typically handled by workstations.

Best for:
High-end AMD systems

Even if the Core i9-9900K is faster, the **Ryzen 7 2700X** is still a very powerful processor, and a lot cheaper than Intel's offering, too. This CPU marks the point where AMD finally caught up to Intel on gaming performance, and with eight cores and 16 threads, it's a mighty multitasker. There's not a lot of room for overclocking, but there's a good reason for that: AMD sets the clock speeds so high to begin with, but despite this, the Ryzen 7 2700X runs nice and cool. It's just about the complete premium package.

Best for:
High-end Intel systems

In some ways, the **Core i7-9700K** is a bit of an odd one. Despite it being only one step below the Core i9-9900K, Intel elected not to include Hyper-Threading, so the eight physical cores aren't assisted by virtual threads. Perhaps as a result, it's only about 10% faster than the old Core i7-8700K in our benchmarks. Nonetheless, we'd sooner recommend the newer chip anyway: the Core i7-8700K remains almost as expensive, and is slower. Besides, you can always overclock the Core i7-9700K for some extra horsepower.

Best for:
Mid-range systems

AMD's mid-tier Ryzen chips continue to leave Intel alternatives in the dust, especially the £185 **Ryzen 5 2600X**. It's cheaper than the £260 Core i5-9600K, and while the quad-core Core i5-8400 manages good gaming performance, it's no match for the hexa-core Ryzen 5 2600X elsewhere. As with the Ryzen 7 2700X, a simple increase in clock speeds works wonders for this CPU, making it an even better all-rounder than the previous Ryzen 6 1600X.

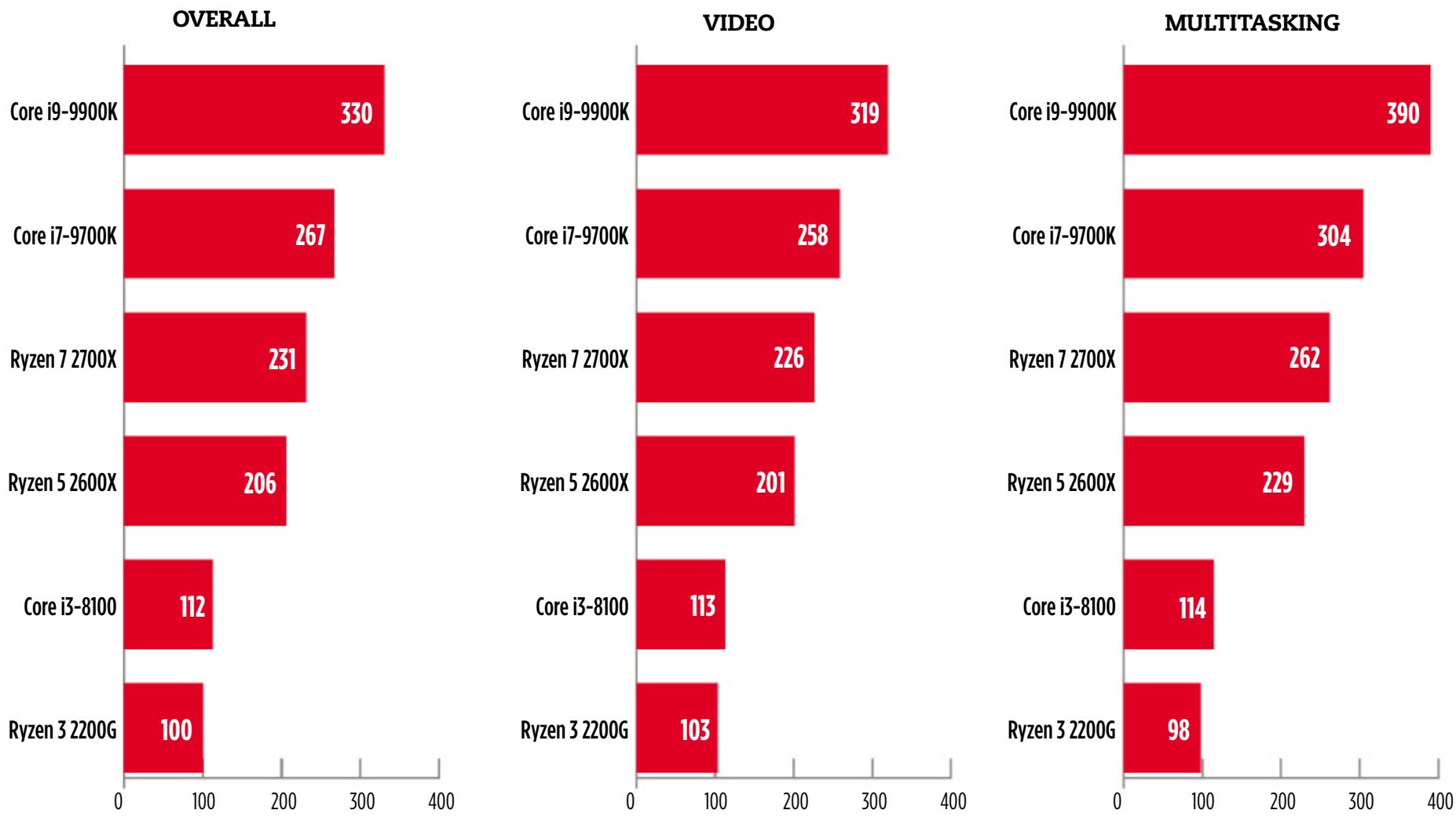
Best for:
Budget AMD systems

It may be over a year old now, but the lack of a replacement for the **Ryzen 3 2200G** isn't exactly a pressing matter. With four cores and a healthy 3.5GHz base clock speed, not to mention full overclocking capabilities (a rarity for cheap CPUs), it has more than enough power for a home office PC or even an entry-level gaming system. On that note, this is one of the few Ryzen chips with integrated graphics – namely AMD's Radeon Vega 8 – so if money's tight, you won't need a graphics card.

Best for:
Budget Intel systems

Another holdout from a previous generation, this time from Intel, the **Core i3-8100** is no less a capable budget option. It's actually a little faster than the Ryzen 3 2200G, except in games, where its integrated Intel UHD Graphics 630 have the disadvantage. It also can't be overclocked, although that's far less of a concern at this price. What you're left with is a simple, reliable quad-core workhorse that could form the basis of a variety of different PC builds.

BENCHMARK RESULTS



Manufacturer	AMD	AMD	AMD	INTEL	INTEL	INTEL
Model	Ryzen 3 2200G	Ryzen 5 2600X	Ryzen 7 2700X	Core i3-8100	Core i7-9700K	Core i9-9900K
HARDWARE						
Socket	AM4	AM4	AM4	LGA 1151	LGA 1151	LGA 1151
Cores	4	6	8	4	8	8
Frequency (boost)	3.5GHz (3.7GHz)	3.6GHz (4.2GHz)	3.7GHz (4.3GHz)	3.6GHz	3.6GHz (4.9GHz)	3.6GHz (5GHz)
Multiplier	x35 (unlocked)	x36 (unlocked)	x37 (unlocked)	x36	x36 (unlocked)	x36 (unlocked)
External bus	100MHz	100MHz	100MHz	100MHz	100MHz	100MHz
Process	14nm	12nm	12nm	14nm	14nm	14nm
Level 1 cache	384KB	576KB	768KB	256KB	512KB	512KB
Level 2 cache	2MB	3MB	4MB	1MB	2MB	2MB
Level 3 cache	4MB	16MB	16MB	6MB	12MB	16MB
Supported memory type	DDR4	DDR4	DDR4	DDR4	DDR4	DDR4
Power rating (TDP)	65W	95W	105W	65W	95W	95W
Integrated graphics	AMD Radeon Vega 8	None	None	Intel UHD Graphics 630	Intel UHD Graphics 630	Intel UHD Graphics 630
Cooler	Yes	Yes	Yes	Yes	No	No
BUYING INFORMATION						
Price	£82	£185	£295	£108	£390	£475
Warranty	Three years RTB	Three years RTB	Three years RTB	Three years RTB	Three years RTB	Three years RTB
Supplier	www.amazon.co.uk	www.scan.co.uk	www.amazon.co.uk	shop.bt.com	www.scan.co.uk	www.ebuyer.com
Details	www.amd.com	www.amd.com	www.amd.com	www.intel.com	www.intel.com	www.intel.com
Part code	YD2200C5FBBOX	YD260XBCAFBOX	YD270XBGAFBOX	BX80684I38100	BX80684I79700K	BX80684I99900K

Prices correct at time of going to press

PERFECT CIRCUIT
Motherboards

A PC may come in a case, but it's the motherboard that really holds everything together. Choose carefully, as your system's connectivity and upgrade potential may depend on it

NOW YOU HAVE an idea of which CPU you want, it's time to pair it with a compatible motherboard, the part that allows all the other components to interact with one another. Making sure you get the right processor socket is just the first step. Motherboards are perhaps the most complex component in the entire system, in terms of the breadth of functions and features they offer, and the requirements they demand. Here, we'll start making sense of them.

UNFRIENDLY COMPETITION

When it comes to installing a CPU on to the motherboard, Intel and AMD chips will only fit into their respective sockets – typically the LGA1151 socket in Intel's case, and the AM4 socket in AMD models. There is no overlap or even any form of backwards compatibility when it comes to the physical socket – an AM4 CPU won't fit in AMD's older AM3 socket, for instance – so it's crucial that you make the match.

It's a similar story with each motherboard's chipset, the controller that actually manages how data is transferred between the system's components. A CPU will only be able to work with a handful of chipsets from their respective manufacturer, although since these vary by feature set and price, you have a degree of choice.

For example, on the Intel side, there's the budget H310 chipset, the mid-range B360, and the high-end Z370 and Z390. All the Intel

CPUs we recommended in the previous section will be compatible with any of these, but you should still tailor your choice according to what you want from your PC. If you want overclocking support, you'll need a Z370 or Z390 motherboard; if you don't, you can save money on a H310 model, although B360 boards tend to be much better equipped for ports and expansion slots.

As for AMD, there's a greater range of overclocking-compatible chipsets: our Ryzen recommendations will work with the enthusiast X370 and X470 chipsets as well as the more middling B350 and B450. Only the very cheapest A300 and A320 motherboards don't permit overclocking, although these are also compatible with the CPUs we've covered so far.

PORTS DIRECT

Besides pricing and overclocking support, chipsets will differ in the range of connectivity ports they include, and how much internal hardware can be added to the system through expansion slots and ports (although both of these can also be influenced by form factor, which we'll come to shortly). Those USB and audio ports you see at the back of every PC? They're part of the motherboard, so if you want a higher degree of connectivity, be prepared to pay more for a better board.

Faster USB3, USB3.1 and USB Type-C ports are preferable to the older, slower USB2 standard, and many motherboards offer upgraded audio outputs so you can connect to a soundbar or surround-sound system. If you're planning to use integrated graphics, you should also take note of which video outputs ports are on the rear I/O panel; if you're getting a dedicated graphics card, on the other hand, you'll be connecting your monitor to the back of the card instead.

Integrated Wi-Fi and Bluetooth modules are also a nice little luxury, and can most often be found on motherboards with higher-end chipsets. All models should have an Ethernet port as standard, but onboard Wi-Fi can save you both the need to have a cable from your router to your PC, as well as having to use up a USB port (or internal PCI-E slot) installing a separate wireless receiver.

LAYING THE FOUNDATIONS

Since the motherboard is where all the internal components of a PC are eventually plugged in, it's the motherboard that determines things such as how many RAM sticks can be installed, how many PCI-E devices (graphics cards, Wi-Fi cards, sound cards and capture cards) can be added, and how many storage drives can be used at once.

For basic system builds, this might not be much of a concern at all. Even the smallest, cheapest motherboards will cover the essentials, such as two RAM slots, a single PCI-E x16 slot (you can also install smaller PCI-E x1 devices in this slot as well) and at least a couple of SATA ports, for hooking up hard disks and SSDs.

However, more generously equipped motherboards are better both for high-end builds and for adding upgrades in the future. After all, one of the best things about PC ownership is being able to add individual parts to it later, customising your system as your needs evolve. Four RAM slots and a mix of PCI-E x1 and x16 slots are therefore good to aim for, space allowing. It's also worth getting one or two M.2 slots – these can hold NVMe SSDs, which can run much faster than 2.5in SATA SSDs, and don't need any additional power or data cables.

GOT FORM

Before you get too far thinking about all the drives and cards you can add in, however, remember that the choice of CPU isn't the only thing that affects which motherboard you can have. The other is the size of the system itself or, more specifically, the case.

Simply put, not every chassis supports every size of motherboard, of which there are several. The largest, and perhaps most common, is ATX, which is a little larger than a sheet of A4 paper. ATX motherboards can be a little pricier than their smaller brethren, but are easily the most versatile when it comes to the range of internal slots and ports.

MicroATX motherboards sit in the middle, and sometimes look like ATX motherboards with a chunk of the bottom looped off. As such, they won't have as many PCI-E slots, and perhaps only one M.2 slot, but can still provide a degree of upgrade potential.

Mini-ITX motherboards are the smallest, about the width of an outstretched hand. As such, they're the hardest to make changes to: with likely just a single PCI-E x16 slot and two RAM slots, you'll struggle to add new hardware without also having to remove what's already installed. They are, however, the cheapest of the three.

Larger cases are usually compatible with a range of motherboard sizes, so if you want a full-size chassis but don't need a lot of upgradability, then you could install a microATX or Mini-ITX motherboard in an ATX-compatible case. Smaller cases will only be able to hold smaller motherboards, so keep that in mind. The good news is that size doesn't really affect external connectivity, as every I/O panel is the same size.

Those USB and audio ports you see at the back of every PC? They're part of the motherboard, so if you want a higher degree of connectivity, be prepared to pay more

WHO'S THE BIOS

We've mentioned overclocking a few times, and this is something that has almost as much to do with the motherboard as it does with the processor.

In fact, not only is the motherboard what enables you to actively tweak CPU clock speeds, but it lets you do the same with RAM speeds, too. Unless you're using AMD's Ryzen Master software, this is done in the BIOS (or to use its more recent name, the UEFI), a set of menus that essentially acts as a user interface for the motherboard. You can access it at startup, granting yourself incredibly fine control over various aspects of your PC.

Much of what you'd find in a BIOS might seem like gibberish if you've never poked around in one before, but most motherboard manufacturers also include a simplified Easy (or 'EZ') mode, which lets you perform basic but fundamental tasks like setting the booting order of the storage drives in your system. You might have to do this in the course of building your PC, as you'll need to boot from whatever drive you're installing Windows from, but don't worry – it's a simple process.

Best for: High-end AMD systems

A lavish motherboard even by premium standards, the **Gigabyte X470 Aorus Gaming 7 WiFi** is dripping with customisable RGB lighting and eye-catching heatsinks. It's the functionality that makes it great, however: from the terrifically well-featured I/O panel to integrated 802.11ac Wi-Fi and Bluetooth 5.0, there are plenty of useful features even if you're not inclined to do much internal tinkering. If, conversely, you've got grand plans for customisations, there are expansion slots in abundance.

Best for: High-end Intel systems

The **MSI MPG Z390 Gaming Edge AC** has all the trappings of a proper top-end motherboard. There's the very latest Intel chipset, multiple PCI-E x16 slots with dual GPU support, two M.2 slots, hi-fi-friendly audio outputs and integrated 802.11ac Wi-Fi, along with Bluetooth 5.0. Despite all this, it's priced extremely aggressively, ending up only a few pounds more than most ATX B360 motherboards. You can also take advantage of MSI's BIOS, the most user-friendly of any we've tried.

Best for: Mid-range AMD systems

The **Asus TUF B450M-Plus Gaming** could be said to be nearer the budget end of the motherboard spectrum – it's even cheaper than the ASRock Fatal1ty AB350 Gaming-ITX/ac, as a matter of fact – but that doesn't stop it from being a good choice for PC builds that aim a little higher than the low end. It's kitted out rather well for an affordable microATX board – M.2 connectivity hasn't been lost, for instance – and with fast USB3.1 and USB Type-C ports on the back, it's competitive on connectivity.

Best for: Mid-range Intel systems

There aren't many thrills to be had from the **Gigabyte Z370P D3**, but then there's a lot of motherboard here for £100. Literally – it's a full-size ATX board, which means you get additional PCI-E x1 and x16 slots, with plenty of room for a full four RAM slots and an M.2 drive. The down-to-basics approach is less well hidden by the rear ports, which total a very average six, but most of these are USB3 rather than USB2. Being a Z370 model, overclocking is supported, too.

Best for: Budget AMD systems

The **ASRock Fatal1ty AB350 Gaming-ITX/ac** is actually quite pricey for an older AMD B350 motherboard, and a Mini-ITX one at that, but it's still below the £100 mark, making it relatively affordable in the grander scheme, and you do get plenty for your cash. 802.11ac Wi-Fi is the main attraction, but there's also the rear I/O port, which – with USB Type-C, optical S/PDIF and dual HDMI outputs – wouldn't look out of place on an X470 model, and the rear-mounted M.2 slot is a genius space-saving touch.

Best for: Budget Intel systems

The **Asus Prime B360M-K** is more of a true budget motherboard than the Fatal1ty AB350 Gaming-ITX/ac, aiming for the lowest possible cost at the expense of more plush features. As such, you shouldn't expect any fancy external connections, and you'll have to make do with just two RAM slots and DVI (instead of HDMI or DisplayPort) for video output, but the Prime B360M-K does succeed in delivering a degree of internal upgrade potential that sets it apart from more undesirable bargain-basement fare.

	AMD			INTEL		
Manufacturer	**ASROCK**	**ASUS**	**GIGABYTE**	**ASUS**	**GIGABYTE**	**MSI**
Model	Fatal1ty AB350 Gaming-ITX/ac	TUF B450M-Plus Gaming	X470 Aorus Gaming 7 WiFi	Prime B360M-K	Z370P D3	MPG Z390 Gaming Edge AC
HARDWARE						
Processor socket	AM4	AM4	AM4	LGA1151	LGA1151	LGA1151
Form factor	Mini-ITX	MicroATX	ATX	MicroATX	ATX	ATX
Dimensions	170x170mm	244x244mm	305x244mm	226x185mm	305x244mm	305x244mm
Processor support	AMD Ryzen, 7th-gen AMD A-series/Athlon X4 processors	AMD Ryzen, 7th-gen AMD A-series/Athlon X4 processors	AMD Ryzen, 7th-gen AMD A-series/Athlon X4 processors	Intel 8th- and 9th-gen Core processors	Intel 8th- and 9th-gen Core processors	Intel 8th- and 9th-gen Core processors
Processor external bus	100MHz	100MHz	100MHz	100MHz	100MHz	100MHz
Chipset	AMD B350	AMD B450	AMD X470	Intel B360	Intel Z370	Intel Z390
Supported memory type	DDR4	DDR4	DDR4	DDR4	DDR4	DDR4
Maximum memory speed	3,466MHz	3,200MHz	3,600MHz	2,666MHz	4,000MHz	4,400MHz
Memory slots	2	4	4	2	4	4
Maximum memory	32GB	64GB	64GB	32GB	64GB	64GB
Motherboard power connectors	1x 24-pin ATX, 1x 8-pin 12V	1x 24-pin ATX, 1x 8-pin 12V	1x 24-pin ATX, 1x 8-pin 12V, 1x 4-pin 12V	1x 24-pin ATX, 1x 8-pin 12V	1x 24-pin ATX, 1x 8-pin 12V	1x 24-pin ATX, 1x 8-pin 12V, 1x 4-pin 12V
PCI-E x16 slots	1	2	3	1	3	3
PCI-E x4 slots	0	0	0	0	0	0
PCI-E x1 slots	0	1	2	2	3	3
PCI slots	0	0	0	0	0	0
M.2 slots	1	1	2	1	1	2
Fan/cooling headers	3	3	8	2	4	7
SATA II ports	0	0	0	0	0	0
SATA III ports	4	4	6	6	6	6
RAID support	0, 1, 10	0, 1, 10	0, 1, 10	None	0, 1, 5, 10	0, 1, 5, 10
Networking	Gigabit Ethernet, 802.11ac Wi-Fi	Gigabit Ethernet	Gigabit Ethernet, 802.11ac Wi-Fi	Gigabit Ethernet	Gigabit Ethernet	Gigabit Ethernet, 802.11ac Wi-Fi
Motherboard sound (ports)	Realtek ALC1220 (line in, line out, mic in, rear speaker out, S/PDIF, C/SUB)	Realtek ALC887 (line in, line out, mic in)	Realtek ALC1220-VB (line in, line out, mic in, rear speaker out, S/PDIF, C/SUB)	Realtek ALC887 (line in, line out, mic in)	Realtek ALC887 (line in, line out, mic in)	Realtek ACL1220P (line in, line out, mic in, rear speaker out, S/PDIF, C/SUB)
USB ports	2x USB2, 3x USB3, 1x USB Type-C	2x USB2, 2x USB3, 1x USB3.1, 1x USB Type-C	2x USB2, 4x USB3, 2x USB3 DAC-UP, 1x USB Type-C	2x USB2, 2x USB3, 2x USB3.1	2x USB2, 4x USB3	2x USB2, 2x USB3, 1x USB3.1, 1x USB Type-C
USB headers	1x USB2, 1x USB3	4x USB2, 2x USB3	4x USB2, 4x USB3, 1x USB Type-C	4x USB2, 2x USB3	4x USB2, 2x USB3	2x USB2, 2x USB3, 1x USB Type-C
Video outputs	2x HDMI	1x HDMI, 1x DVI-D	None	1x DVI-D, 1x VGA	1x HDMI	1x HDMI, 1x DisplayPort
Other ports	1x PS/2	1x PS/2	None	2x PS/2	2x PS/2	None
Motherboard clock adjustment	CPU/RAM	CPU/RAM	CPU/RAM	None	CPU/RAM	CPU/RAM
Motherboard voltage adjustment	CPU/RAM	CPU/RAM	CPU/RAM	None	CPU/RAM	CPU/RAM
BUYING INFORMATION						
Price	£95	£88	£233	£70	£100	£140
Warranty	One year RTB	Two years RTB	Three years RTB	Two years RTB	Three years RTB	One year RTB
Supplier	www.cclonline.com	www.ebuyer.com	www.scan.co.uk	www.ebuyer.com	www.cclonline.com	www.scan.co.uk
Details	www.asrock.com	www.asus.com	www.gigabyte.com	www.asus.com	www.gigabyte.com	www.msi.com
Part code	90-MXB5P0-A0UAYZ	TUF B450M-PLUS GAMING	X470 Aorus Gaming 7 WiFi	PRIME B360M-K	Z370P D3	MPG Z390 Gaming Edge AC

Prices correct at time of going to press

POWER UP
PSUs

PSUs do more than just provide power, and making the right choice today can affect your PC tomorrow

WE'VE COME A long way with power supply units (PSUs). A few years ago, the market was awash with cheap, non-branded supplies that couldn't deliver the power they claimed and were as likely to pop as make your computer work. Today, branded power supplies are the majority and, what's more, they've all been tested under the 80 Plus certification, giving you the confidence that the PSU will last.

You may think there's nothing left to choose and any model will do the trick. Not quite: we'll take you through the choices you need to make to deliver the power you need.

MAX POWER

Your first choice is to find a PSU that's powerful enough for your system. It's not worth buying the biggest PSU you can afford, as you'll waste a load of money doing so. You may also end up with a PSU that's not running at its maximum efficiency.

All PSUs waste some power as heat, but the more efficient a PSU is (measured in percentage), the more input power makes it through as output power to your computer. All PSUs have efficiency ratings under the 80 Plus scheme, rated at Bronze, Silver, gold, Platinum and Titanium ratings (see table).

PERCENTAGE OF RATED LOAD				
	10%	20%	50%	100%
80 Plus		82%	85%	82%
80 Plus Bronze		85%	88%	85%
80 Plus Silver		87%	90%	87%
80 Plus Gold		90%	92%	89%
80 Plus Platinum		92%	94%	90%
80 Plus Titanium	90%	94%	96%	94%

Supplies tend to be most efficient between 50% and 100% load, and higher-efficiency supplies save you money. For example, a 500W power supply that is 85% efficient would need to draw 394W to power a 335W PC. By comparison, a 94% efficient PSU would need to draw 356W – 38W less to power the same PC, and it will also generate less heat.

Don't buy a PSU based on energy savings alone, as it may take years to recoup the cost of a more expensive and more efficient supply.

One of the easiest ways to work out what type of PSU you need is to use the eXtreme Power Supply Calculator (*outervision.com/power-supply-calculator*). Just enter the components that you have (or will be buying), and the calculator tells you how much power your computer will draw and make a PSU recommendation.

DE-RAILED

PSUs output their power on different rails that run on different voltages and have a rating in amps that shows the total current they can pull. To work out the total in Watts, multiply the current (Amps) by voltage.

It's possible to buy PSUs that use a single or multiple 12V power rails. Cheaper supplies tend to use one rail, while more expensive ones use multiple rails. The total power for the rails combined may exceed the total output of the PSU, so you can't use each rail to its max. What's the real difference, then, between single and multiple rail PSUs?

It's all down to over current protection (OCP). If a device draws more current from a

Best for: BUDGET PCs

CORSAIR TX550M

£65 • From www.scan.co.uk

The Corsair TX550M replaces our previous budget choice, the Corsair RM550X, maintaining the quality we've come to expect from the company and at a great price. This model is semi-modular, with the motherboard connectors fixed into place.

There are enough other connectors to power a modern build, however. Power is supplied via a single 12V rail. This is not a semi-passive PSU, although it is very quiet under very low loads and you shouldn't hear a lot of noise through a PC case.

If you want a more powerful PSU, then there are 650W, 750W and 850W models available. A great choice for most builds, it's hard to get better quality at this price. Look for one of the more expensive models here if you want a fully modular supply or something more efficient.

SPECIFICATIONS

5x SATA • 1x floppy and 2x 6+2 pin PCI-E connectors • 80 Plus Gold certification

Best for: MID-RANGE PCs

CORSAIR RM750i

£130 • From www.scan.co.uk

The 80 Plus Gold-certified 750W Corsair RM750i is a step up from the entry-level RM550X. By default, it's configured with five 12V rails, giving your devices separation and protection, which could be good in mid-range builds. You can switch the supply back to a single rail, although there are no practical downsides to the multi-rail approach, so we wouldn't bother.

A semi-passive PSU, the RM750i is silent under low utilisation, with the fan picking up under load; however, it's still a very quiet PSU.

Using a fully modular design, you need only connect the cables that you require. There are plenty of connectors on offer to handle up to two graphics cards and tons of peripherals. There are also 650W, 850W, 1,000W models available for different builds.

SPECIFICATIONS

7x Molex • 8x SATA • 2x floppy and 4x 6+2 pin PCI-E connectors • 80 Plus Gold Certification

Best for: HIGH-END PCs

BE QUIET! Dark Power Pro 11 850W

£180 • From www.scan.co.uk

If you need both power and high efficiency, the Be Quiet! Dark Power Pro 11 850W is the model for you. An 80 Plus Platinum supply, it's supremely efficient, which means you'll get less heat wafting around your PC.

This model has four 12V rails, giving you extra protection, so you can separate different components. It's a modular PSU so you need only install the cables you're using. And there are enough connectors for any computer.

At low power consumption, the fan barely spins, making this PSU effectively silent. Even under heavy load, the fan is never noisy so that you can use this PSU in a quiet room.

For big builds or where you want the best, this is the supply to get. It's also available in 550W, 650W, 750W, 1,000W and 1,200W versions.

SPECIFICATIONS

8x Molex • 8x SATA • 1x floppy and 4x 6+2 pin PCI-E connectors • 80 Plus Platinum certification

rail than is allowed, the PSU's OCP shuts the PSU down. With a single rail, the OCP is set high, so a single device failing may pull through a lot of power damaging multiple components. With multiple rails, each has their own limits, so OCP is triggered at a lower level. As devices are separated, you get better protection and, for example, a failing hard disk may not affect your graphics card.

Standard builds are fine with single rail, but go with multiple rails if you've got an overclocked system with multiple graphics cards.

PASSIVE AGGRESSIVE

The vast majority of PSUs have cooling fans to help dissipate heat. These can add to the overall noise of your computer. While you can buy passively cooled models that are completely silent, these models tend to be expensive and top out at lower power levels.

Instead, look for a semi-passive PSU. These models stop the fan when the PSU's not under a lot of load; when your computer ramps up to do something more powerful, such as playing games, the PSU fan spins into life. The advantage of such PSUs is that your computer is much quieter during day-to-day tasks.

GET CONNECTED

Next, you need to think about the connections that you need on your PSU. We recommend buying a modular or, at the very least, a semi-modular PSU to keep things tidier inside your case. The difference between the two is that a fully modular PSU lets you remove all of the cables; a semi-modular PSU has fixed cabling for the motherboard, but the other connectors are plug and play.

Given that you need the motherboard connectors in any case, a semi-modular PSU isn't such a disadvantage, but a fully modular supply can make running cables a little easier, as you can detach either ends of the cable.

Make sure that you've got enough connectors to run your system. For an entry-level graphics card, a six/eight-pin PCI-E connector is required, although you'll need two of these for high-end GPUs. If you want to run two powerful graphics cards, then you'll need a PSU with four such connectors.

Look out for enough SATA connectors to power your hard disks, optical drives and 2.5in SSDs. If you have an SSD that fits in the motherboard's M.2 slot, this won't need any additional power cables.

Older Molex connectors can be useful if you have an old drive or fan that's powered this way; the same goes for floppy connectors. Both of these connectors are becoming far less popular, so the benefit of a modular supply is that you don't fill your case full of cables that you'll never use.

DRIVE TIME
Storage

Every PC needs somewhere to store the operating system, as well as all your data and programs. This guide will help you decide if you need a fast SSD, spacious hard disk or a combination of the two

DESKTOP PCs AREN'T Chromebooks – their strength is being able to store everything you need locally, available to access immediately and regardless of network connectivity. As such, speccing your PC with some quality storage is strongly advised.

It's not simply a case of buying as many gigabytes as you can afford, however. Capacity is important, but you should also be thinking about the performance of your installed drives, as well as the form factor those drives come in: not every PC build can take every kind of drive.

HARD LINES

The first thing to know is what your options are: namely, hard disks and solid-state drives (SSDs). Hard disks have long been a staple of PC storage, something that's reflected in their relatively old-fashioned design. They consist of a mechanical arm, holding read/write heads, and one or more spinning platters, which contain your data. When in use, the arm moves both heads across the surface of the platters to read or write information.

There are a few downsides to hard disks. First, they're slower than SSDs as they rely on the completion of a mechanical process. Second, they're more fragile, and should a PC containing hard disks take a knock, it could damage the arm of the platters and cause errors, or even render the drive unusable. Lastly, they're bulky: you can get hard disks

that use the 2.5in form factor, the same as some SSDs, but most come in 3.5in sizes that need more space in your case.

This might already make hard disks seem like a bad choice, but they have significant advantages, too. Mainly, this comes down to value: hard disks are much cheaper per-gigabyte than SSDs, and as a result will usually have larger capacities available at much lower prices than an equivalent SSD.

AN EASY CELL

SSDs, then, are the exact opposite of hard disks: they're pricier, and therefore mainly sold with smaller capacities, but are smaller in size, more high-tech and faster.

There are no moving parts within an SSD. They use stacks of NAND flash memory cells, similar to what you have in your smartphone, and can read and write data straight from or to the cell layers in these stacks. The memory can be classified according to how many bits of data are stored in each cell: single-level cell (SLC) NAND obviously contains one bit per cell; multi-layer cell (MLC) NAND can hold two; and triple-layer cell (TLC) can hold three.

The fewer bits in each cell, the faster (in theory) it should be, as stuffing in more means the SSD takes longer to search through each cell to find the data it's looking for. On the other hand, having more bits per cell means higher capacities and lower costs, hence why the majority of consumer-grade SSDs use TLC or MLC NAND, perhaps with a small SLC cache for a modest performance boost.

Speaking of which, SSD speeds are a very compelling reason to choose them over mechanical storage. Even the very fastest hard disks have only about half the read and write speeds of a decent SSD, even if both are using the SATA connection standard. If you get a motherboard with an M.2 slot, you also have the option of non-volatile memory express (NVMe) SSDs, which are even quicker than SATA models: a SATA SSD's read speeds might max out around 560MB/s, but NVMe drives can reach 3,000MB/s and higher. You can also get M.2-compatible SSDs that use the SATA standard, but it wouldn't really be taking advantage of what the port can do.

The most obvious benefit here is faster file transfers, but using a faster storage drive will help boost your PC's performance more generally, too. If you have Windows installed on an SSD, for instance, it will boot to the desktop in far less time than if it were installed on a hard disk – a few seconds, rather than a minute or so. Applications and large files will open faster, too, and loading times in games will be shortened.

POWERS COMBINED

Still, the higher pricing and lower capacities of SSDs make them unsuitable to act as the sole storage drive in a PC, unless you have hundreds and hundreds of pounds to spare; we don't recommend your total system capacity going below 1TB, and SSDs of that size are immensely expensive.

The ideal solution, we feel, is to just have both. Use a smaller SSD as your primary drive, using it for your Windows install and a few choice programs, but keep a larger hard disk as well, for storing anything that doesn't gain so much from an SSD's speed: photos, music and the like.

Of course, depending on your chassis (and motherboard), you can always add additional drives in the future, and you should feel free to tweak your storage setup depending on how you use your PC – if you're a photographer, for instance, you may wish to buy a second, identical hard disk, and run them in RAID 1 mode so that any photos you save on one drive are automatically backed up on the other.

The only time you should try to get away with a single drive is if you're building your PC on a tight budget. That's fine, and in this case we'd even recommend resisting the allure of SSD speeds and just getting a single hard disk of at least 1TB. For the same money, you'd probably only be able to afford a tiny 128GB SSD, which would fill up extremely quickly once you'd installed Windows and even just a few essential bits of software.

GIVEN THE BOOST

There is one way of ramping up hard disk performance, and if you're starting off with a solo mechanical drive, it might be worth keeping in mind for the future. Intel Optane Memory drives are essentially add-on SSD caches, which you can install in an M.2 slot (like an NVMe SSD) to accelerate your hard disk. The results can be pretty dramatic: we tested the 32GB model (£55) on a fully mechanical Seagate Barracuda hard disk, and combined read and write speeds leapt from 182.9MB/s to 1,548MB/s.

Why, then, would you not just get a hard disk and Optane drive combo in the first place? For starters, it's not quite the magic bullet those figures make it seem: performance gains will depend on whether files are cached or not, and only Intel motherboard chipsets will enable Optane Memory drives to work at all, so AMD CPU owners will be out of luck. Most of all, it's ultimately better – if you've got the cash up front – to put that £55 towards an SSD, which will give you more consistent performance and greater total capacity.

Instead, where Optane makes most sense is as a future upgrade to budget PC builds – for when you might have grown tired of your hard disk's slower performance, and just want an inexpensive way of giving it a push – without the hassle of having to reinstall Windows and all your files on a new, conventional SSD.

HOW WE TEST

All the hard disks and SSDs we test go through a series of benchmarks, including the widely available CrystalDiskMark, as well as our own custom tests. These use a script that copies files of varying sizes to and from the drive, measuring the time taken for each transfer. We also copy the files to the drive from the system memory, using RAMDisk to turn a portion of RAM into a disk drive; this helps make sure that the results aren't unduly lowered, as RAM is faster than any hard disk or SSD, so won't impede the results beyond what the tested drive is capable of.

Splitting these file transfer tests into Huge, Large and Small file size tests also gives a clearer picture of how each drive can cope with different types, and batch sizes, of files. The Huge test, for example, involves copying a single video file, while the Small test involves copying a massive library of photos, and the Large test covers a handful of music files. We've included results for the Large file test on page 93, to give you an idea of how each of our recommendations can perform in real-life conditions.

Best value SSD

ADATA
XPG SX8200 Pro

There are plenty of 'cheap' NVMe SSDs, but the Adata XPG SX8200 Pro is special: it's both affordable, and genuinely competitive with high-end drives on performance and features. Available in 256GB, 512GB and 1TB versions, this TLC-based SSD kept up with its very fastest rivals, especially on read speeds – CrystalDiskMark put its peak beyond 3,500MB/s.

The XPG SX8200 Pro is also extremely durable, with TBW ratings (how many terabytes can be written to the drive before it wears out) ranging from 160TBW on the 256GB model to 640TBW on the 1TB model. To top things off, you get a neat little heat spreader, which is easily attached via the pre-applied thermal compound.

Best performance SSD

SAMSUNG
970 Evo Plus

We were disappointed by the original 970 Evo, but this update puts Samsung back on top of the NVMe pile for sheer speed. Write speeds are a particular strength, which is a rarity in itself, but read speeds also proved fiercely high in our benchmarks.

You can expect to pay more for this level of performance, but then the 970 Evo Plus isn't a rip-off either. It launched at lower prices than the original 970 Evo did, and is affordable enough to be a viable option for first-time system builders and PC enthusiasts alike.

Best SATA SSD

SAMSUNG 860 Evo

The 860 Evo is kind of a 2.5in SATA equivalent of Samsung's 970 Evo Plus: a chart-topping performer with a price that's not amazingly low, but not too high either. There's an even wider choice of capacities, too, including 250GB, 500GB, 1TB, 2TB and even 4TB.

So quick is the 860 Evo that it leaves you wondering where SATA SSDs could possibly go next – its read speeds, especially, are pushing the SATA interface to its absolute limits. It's a fantastic choice if your motherboard doesn't have M.2 support.

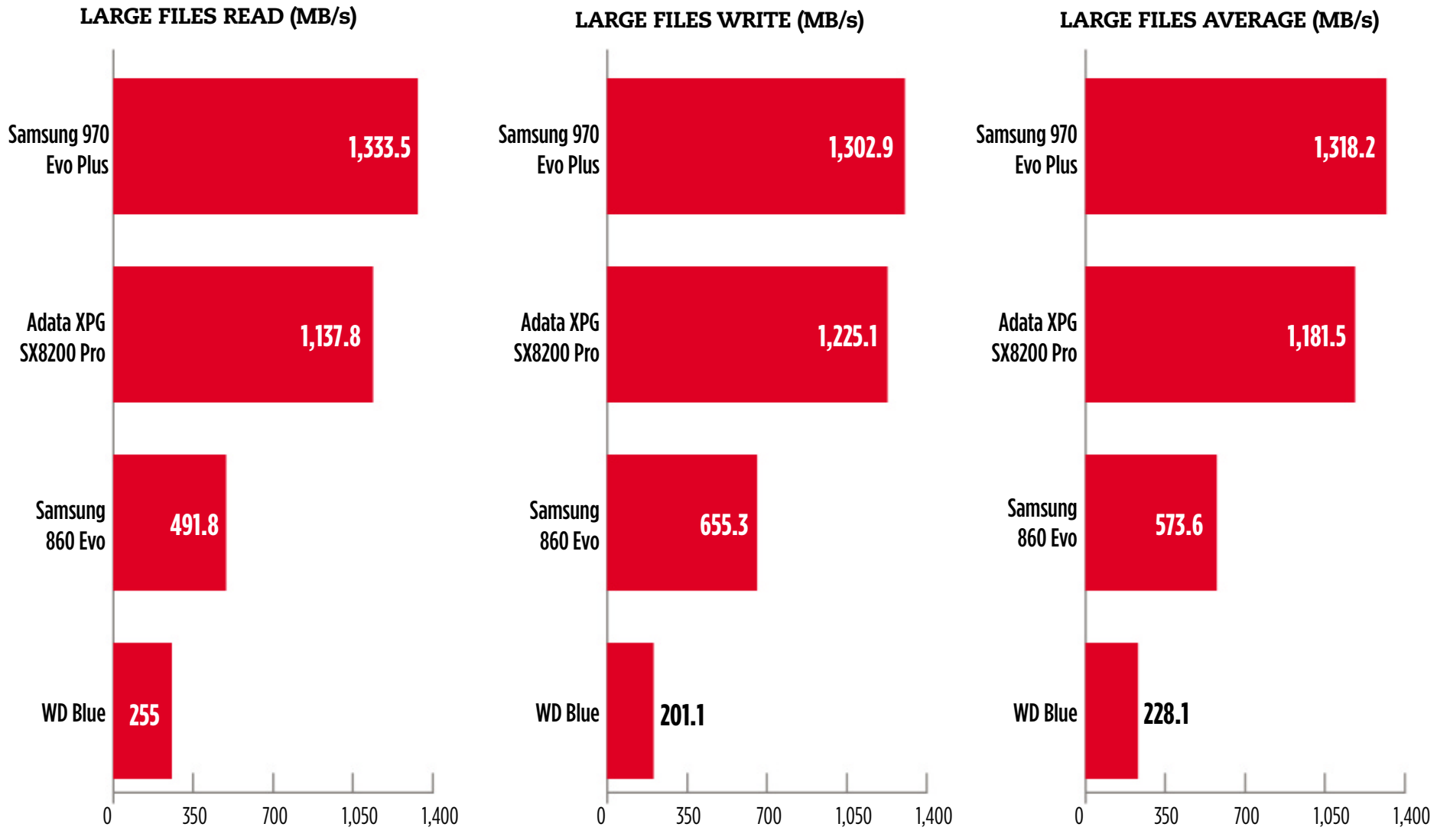
Best hard disk

WD Blue

An old favourite of ours, the WD Blue doesn't do anything flashy, but with big capacities available at low prices, it certainly plays to the strengths of mechanical hard disks. The 1TB model should be enough for everyday home use, but if you want or need more, then 2TB, 3TB, 4TB and 6TB models are also available, as well as a smaller 500GB option.

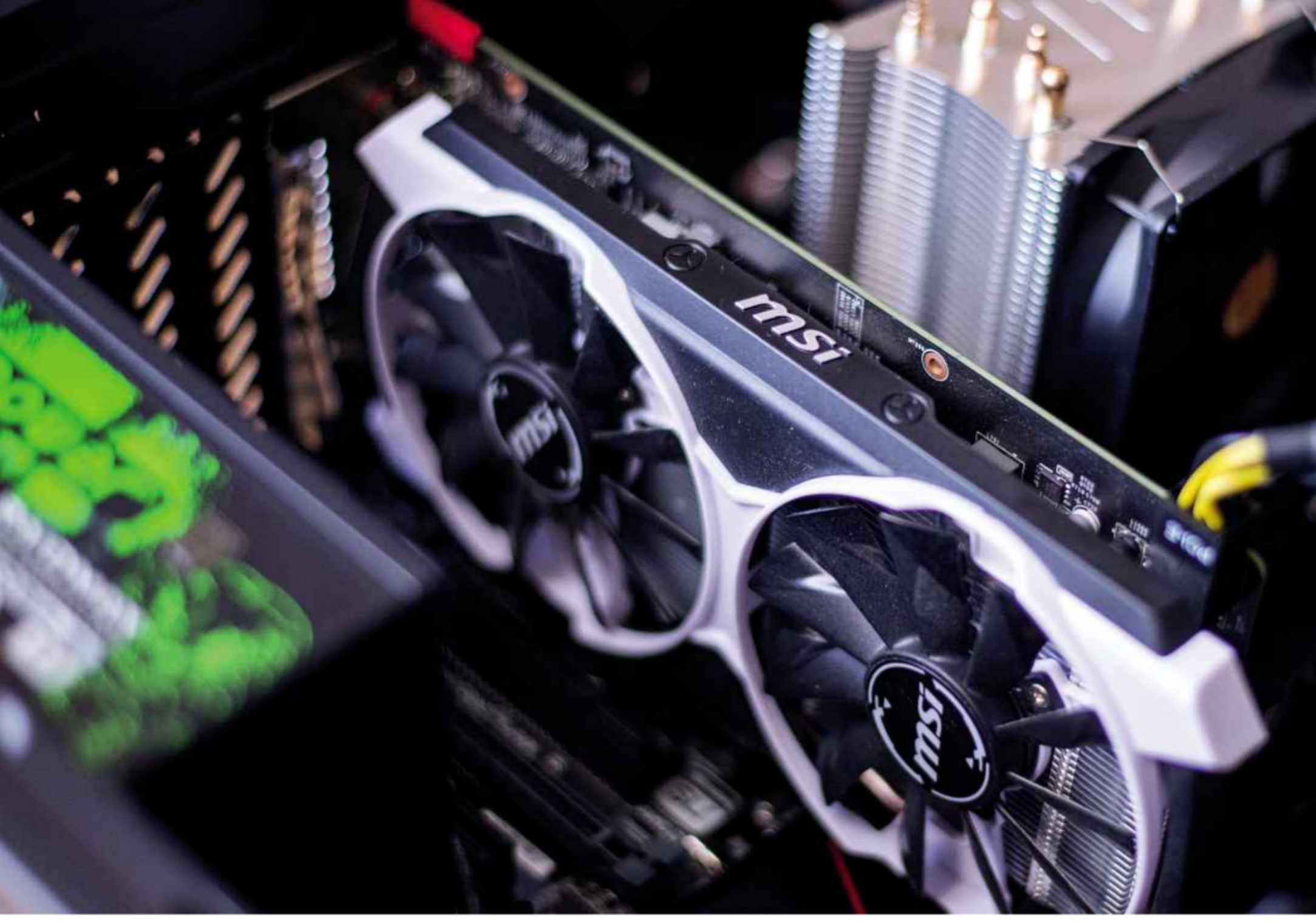
Naturally, it's no match for an SSD when it comes to performance, but as you can see from its benchmark results in the graphs opposite, it's rather quick by hard disk standards. Most mechanical drives, especially cheaper ones such as this, often struggle to reach 200MB/s at all.

BENCHMARK RESULTS



Manufacturer	ADATA	SAMSUNG	SAMSUNG	WD
Model	XPG SX8200 Pro	860 Evo	970 Evo Plus	Blue
HARDWARE				
Capacity	256GB/512GB/1TB	250GB/500GB/1TB/ 2TB/4TB	250GB/500GB/1TB	500GB/1TB/2TB/3TB/ 4TB/6TB
Interface	NVMe (M.2)	SATA3	NVMe (M.2)	SATA3
Claimed read	3,500MB/s	550MB/s	3,500MB/s	Not stated
Claimed write	3,000MB/s	520MB/s	3,300MB/s	Not stated
BUYING INFORMATION				
Warranty	Five years RTB	Five years RTB	Five years RTB	Two years RTB
Prices	£57 (256GB), £99 (512GB), £161 (1TB)	£53 (250GB), £83 (500GB), £141 (1TB), £287 (2TB), £571 (4TB)	£77 (250GB), £110 (500GB), £217 (1TB)	£38 (500GB), £39 (1TB), £53 (2TB), £78 (3TB), £91 (4TB), £157 (6TB)
Supplier	www.amazon.co.uk	www.amazon.co.uk	www.amazon.co.uk	www.ebuyer.com
Details	www.adata.com	www.samsung.com	www.samsung.com	www.wdc.com
Part codes	ASX8200PNP-256GT-C, ASX8200PNP-512GT-C, ASX8200PNP-1TT-C	MZ-76E250B/EU, MZ-76E500B/EU, MZ-76E1T0B/EU, MZ-76E2T0B/EU, MZ-76E4T0B/EU	MZ-V7S250BW, MZ-V7S500BW, MZ-V7S1T0BW	WD5000AZRZ, WD10EZRZ, WD20EZRZ, WD30EZRZ, WD40EZRZ, WD60EZRZ

Prices correct at time of going to press



THE BIG PICTURE
Graphics cards

Adding a dedicated graphics card to your system is essential for gaming, and can help with other kinds of software, too. Use this guide to make sure you're getting the graphical horsepower you need

UNLIKE MOST OF the components covered in these pages, you don't always need a graphics card to get a PC up and running. If your chosen processor has integrated graphics, you can connect your monitor directly to the motherboard and output video that way, even at higher resolutions.

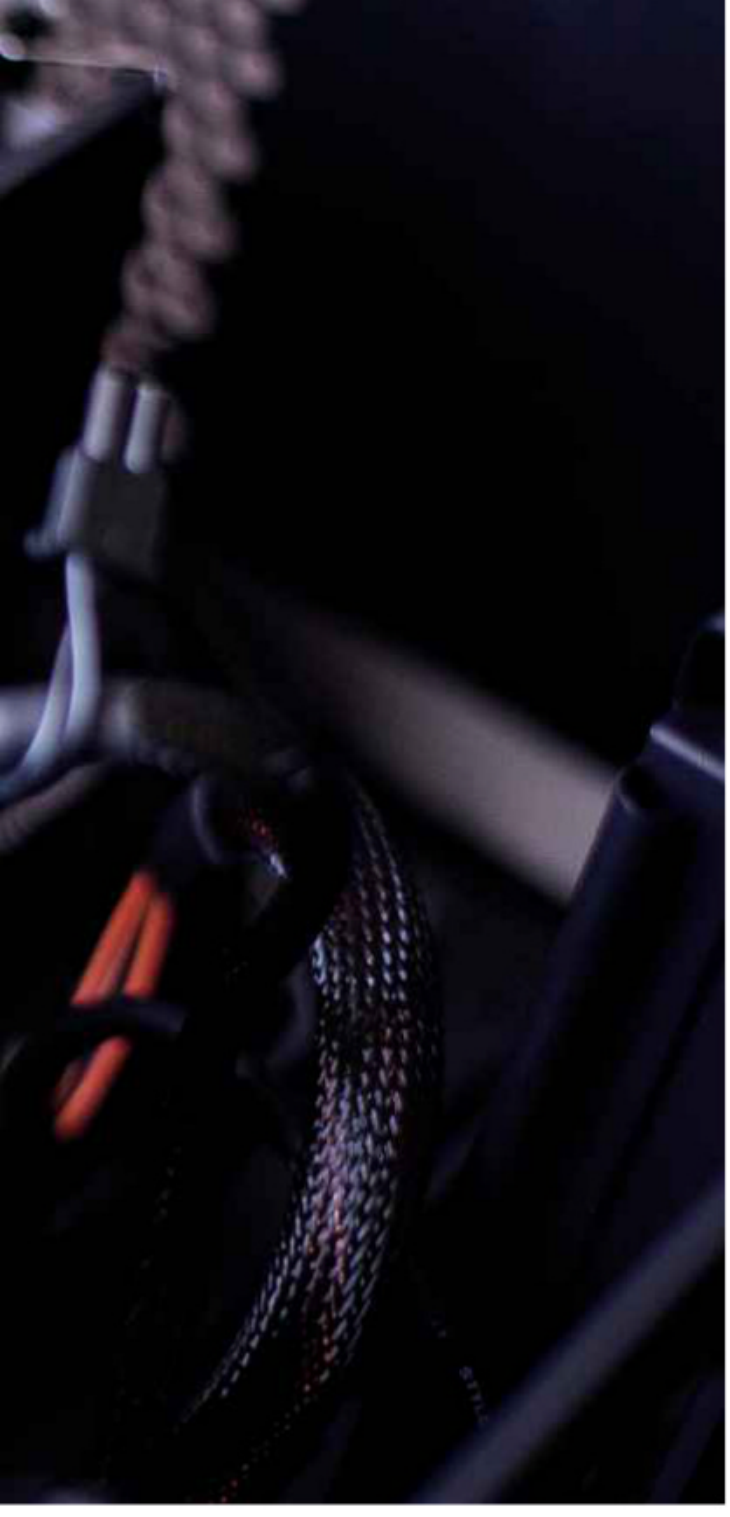
That's fine if you just want to use your system for basic things such as web browsing, writing emails and watching videos; a dedicated graphics card won't make these look any better, and you'd just be spending money on hardware that isn't being used to anywhere near its full potential. However, there are other PC uses where such a card isn't just preferable: it's a necessity.

The big one is gaming. Although modern integrated graphics can technically run basic or older AAA games, they can normally only reach playable frame rates if you use low quality settings and/or run them at a lower resolution, such as 720p. Even the most low-end graphics cards, by contrast, can handle most games at 1080p, and by spending more you can ensure smooth running at 1440p and even 4K resolutions.

There are other benefits to choosing a dedicated graphics processing unit (GPU) over integrated graphics. In this section we'll walk you through what they are, what to look for when buying a graphics card, and which are currently the best models on the market.

STRONGER SHADES

Fundamentally, GPUs don't function all that differently from CPUs, with perhaps the distinction that data is fed through the CPU before it reaches the GPU. This data, which specifically involves the mathematical and geometric calculations for rendering images, is simply processed by the GPU to create the images you see on the screen, whether it's a



scene in a game or a 3D model you're creating yourself. Colours, textures, lighting effects – they're all the result of a graphics processor converting data into visuals. The more powerful the processor, the more complex data can be processed, and at higher speeds.

Games are particularly trying on a GPU, including dedicated graphics cards, because they're constantly bombarding the system with real-time updates to what's on the screen – and that can be any combination of high-detail textures, level geometry information, physics simulations and lighting effects. The level of strain this puts on the PC will vary greatly by game, but the recommend specs of most AAA titles these day will suggest at least a mid-range graphics card.

Dedicated graphics will also help in more productivity-minded software, specifically that which involves rendering. Video-editing suites and 3D-modelling applications are key examples, but even 2D image-editing programs such as Adobe Photoshop can see a performance boost compared to using integrated graphics. If you're building a PC for design work, then, a graphics card is a wise inclusion even if you've no interest in games.

FORCED THROUGH

As with CPUs, the GPU market is a two-horse race, in this instance between Nvidia and AMD. To put it charitably, however, this rivalry is somewhat less competitive than Intel versus AMD: Nvidia doesn't just have a wider range of graphics cards, but they tend to be more powerful, more efficient or have more features than their closest AMD counterpoints. AMD's Radeon cards have had an edge on occasion, especially for value, but Nvidia's GeForce cards have generally been better-rounded components, especially in the two most recent generations.

That's not to say that you should buy an Nvidia card on brand alone, but don't be surprised if the most appealing options all share a certain green branding.

If you're already fairly familiar with graphics cards, you may also notice our recommendations stick to the gaming-focused Radeon and GeForce sub-brands, without AMD Radeon Pro or Nvidia Quadro models, which are designed more for professional software. That's partly because the latter tend to be a lot more expensive – the Quadro RTX 4000, for instance, is based on the GeForce RTX 2070, but is almost double the price – and 'gaming' GPUs are getting progressively better in productivity software anyway.

RAMMING SPEED

Yet another similarity with CPUs is that graphics cards perform their task with a number of processing cores, running at base and boosted clock speeds, although the video RAM (VRAM) they use is integrated, rather than being separate as it is in the PC's main system RAM.

GPU cores also number in the hundreds or thousands, which makes it trickier to make direct comparisons between cards on specifications alone, especially when you also factor in clock speeds. This is partly why VRAM is the more commonly used point of reference than core count, though this also should only ever be considered a rough guide. Entry-level cards reliably have 2GB to 4GB of VRAM, and mid-range cards at least 6GB, although 8GB is available to some mid-range cards and premium 4K-ready cards alike.

More is undoubtedly better here: because VRAM stores image data to get it on the screen faster, and because high-resolution textures and complex 3D meshes create more data to get through, having too little memory will slow down performance. A total of 6GB should be enough for good-quality gaming at 1080p, and even 2,560x1,440 in some cases, but 8GB should be considered the minimum for truly top-quality performance.

On the subject of clock speeds, many partner card manufacturers (in other words, those that use Nvidia or AMD's GPU and create their own version of a card) will add a factory-tested overclock that's ready to use immediately. There's nothing wrong with this, but temper your expectations: in our experience, factory-overclocked cards are only one or two frames-per-second higher than non-overclocked models in our test games.

WILLING AND CABLED

The more powerful a GPU is, the larger the chip and the more power circuitry is required on the circuit board, which ultimately means that graphics cards become physically larger as they become more capable. While some clever design can mean that, say, not every RTX 2070 will be bigger than every RTX 2060, you should be checking the length of your potential choices to make sure they'll fit in the case you've picked out. As with CPU coolers, most cases should fit most cards, but smaller chassis designs might not be able to cram in a massive high-end card. Not that this would be advisable even if they did: GPUs produce heat and, while every graphics card includes its own cooler, it's better to give it some space to breathe than to create a cramped little hotbox that could bring down performance across the entire system.

The only other concerns regarding installation are making sure you have a spare PCI-E x16 slot on the motherboard (if you have more than one, always install a graphics card in the topmost slot, as it will be the fastest), and any requisite 6-pin and/or 8-pin power connectors, as detailed in the PSUs section (page 88). Luckily, even the tiniest motherboards have at least one PCI-E slot, and the power cables should come included with any decent PSU. Some lower-end cards might not even need any power cables, if they're efficient enough to draw all the power they need straight from the PCI-E slot.

GOING OUT

One of the lesser-appreciated benefits of having a dedicated graphics card is that they provide a more varied range of display outputs than you'd get on a motherboard's I/O panel. This makes them ideal for desktop setups that include multiple monitors, and you'll have a much better chance of being able to use DisplayPort and HDMI (which have better resolution and refresh rate support) instead of older DVI and VGA connectors.

Monitors aren't the only things that can be plugged into the back of a graphics card, either. This is also where you'd need to hook up a VR headset. These often use HDMI connectors, so it can make things easier if your monitor is connected via one of the other ports, to keep the HDMI slot free. Newer headsets might also use VirtualLink, a new standard based on USB Type-C. Nvidia's GeForce RTX cards are the only ones we've seen so far that include a dedicated VirtualLink Type-C port.

If you're building a PC for design work, a graphics card is a wise inclusion even if you've no interest in games

Best for budget PCs

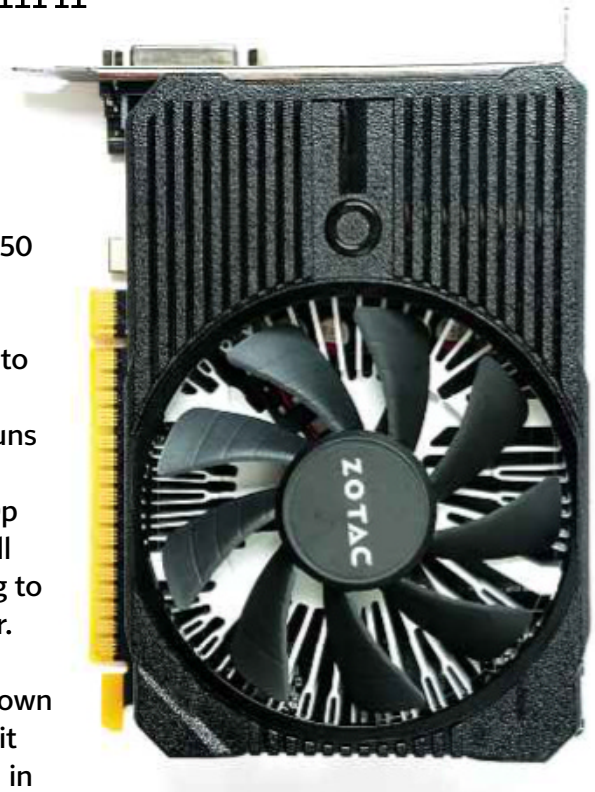
GIGABYTE GeForce GTX 1050 D5 2G

A tiny but peppy graphics card, Gigabyte's take on the 2GB GTX 1050 is brilliant for home PCs that might only dabble in the occasional spot of 1080p gaming. Less graphically intensive games will run fine even at maximum settings, while with more demanding titles you'll at least avoid having to turn everything down to a minimum.

That's not a bad showing at all for something with only 2GB of VRAM that costs just **£125**. Its frugal nature extends to its power efficiency, too: consumption is rated at 75W, and we measured it using only up to 94% of that. It can therefore be powered entirely through the PCI-E x16 slot, saving on cables.

Best for budget PCs

ZOTAC GeForce GTX 1050 Ti Mini



If money is tight, but you want a little more than the bare minimum performance, then the GeForce GTX 1050 Ti Mini is perfect. Despite the GPU's apparent closeness to the GTX 1050, it's a clear step up, and runs noticeably better in games at both 1080p and 1440p. We'd still recommend sticking to the former, however.

This particular model is a shrunk-down version that makes it ideal for installation in smaller cases. These single-fan cooler designs can sometimes have a hard time keeping down temperatures without also creating a racket, but the GeForce GTX 1050 Ti Mini never seems to be whirring out of control.

Best for mid-range PCs

ASUS ROG Strix RX 570 OC

Asus' twin-fan Radeon RX 570 variant is an even bigger bargain than Zotac's GTX 1050 Ti, currently costing a few pounds less despite offering even greater performance. The pricing of Radeon cards is extremely volatile due to demand from cryptocurrency miners, however, so we don't know how long it will stay this cheap for.

In any case, the RX 570 is supposed to bridge the gap between entry-level cards and the 'true' mid-range, occupied by the likes of the RX 590 and Nvidia's new GTX 1660 Ti. It will therefore comfortably play even the more GPU-punishing games at 1080p with High or Very High settings, and can dabble in 1440p and VR much more effectively than any budget card.

Best for mid-range PCs

MSI GeForce GTX 1660 Ti Gaming X 6G

This is the newest graphics card of the bunch, a surprise release following the RTX 2060, which initially seemed to be the only successor to the stalwart GTX 1060. This doesn't quite have the core performance of the RTX 2060, but it's still a good bet if you want a competent mid-range card and don't care so much about the ray-tracing and machine-learning-assisted anti-aliasing that the RTX family provides.

To make up for this, the GTX 1660 Ti is cheaper than the RTX 2060, while also delivering decent performance improvements on the old GTX 1060. Crucially, it also outperforms the Radeon RX 590, AMD's closest equivalent.

Best for mid-range PCs

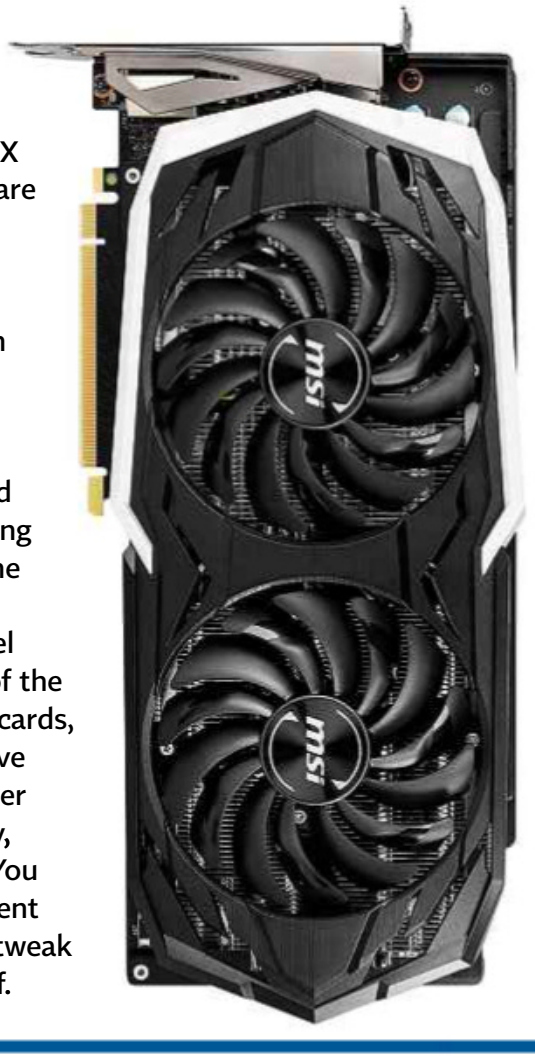
NVIDIA GeForce RTX 2060 Founders Edition

The RTX 2060 isn't just an excellent 1080p/1440p card: it's the most affordable option for getting Nvidia's latest big ideas – ray-tracing and Deep Learning Super-Sampling (DLSS) – in your PC. The former is the first meaningful attempt to get CGI movie-quality lighting effects in games, and the latter is an exciting new form of anti-aliasing that does all the edge-smoothing with far lower performance impact.

It's pretty pricey for a mid-ranger, to be sure – it costs £329, far more than the GTX 1060's launch price – but we think it's worth it, especially considering how much better core performance is than the previous generation. A lot of games will even run at 4K, with respectable quality settings.

Best for high-end PCs

MSI GeForce RTX 2070 Armor 8G



All three of the top RTX GPUs – the RTX 2070, RTX 2080 and RTX 2080 Ti – are mighty powerful, but the RTX 2070 is the only one that doesn't require an enormous bundle of cash to buy. It's no more expensive than the last-gen GTX 1080, but performs even better, and has all the same ray-tracing and DLSS trappings as the rest of the range.

MSI's Armor 8G model also happens to be one of the more affordable partner cards, despite adding an effective (and quiet) twin-fan cooler design as well as a sturdy, eye-catching backplate. You can also use MSI's excellent Afterburner software to tweak the clock speeds yourself.

Best for high-end PCs

NVIDIA GeForce RTX 2080 Ti Founders Edition

We were hoping that the RTX 2080 Ti would have dropped in price since launching late last year, but at £1,100 it's still not exactly a 'sensible' purchase, even for playing at 4K – an RTX 2070 can handle that for much less.

Nevertheless, it's hard not to covet Nvidia's top-of-the-line GPU. It's phenomenally fast in every possible game you can throw at it, and it's perfectly capable of getting serious work done in professional design software as well. The hefty 11GB of VRAM no doubt helps, and while the RTX 2080 Ti is generally overkill for most, there's no shame in saving up for one if you demand the best of the best.

HOW WE TEST

We test every graphics card by installing it in our usual benchmarking PC (which includes a fast Intel Core i7-4770K CPU) and running several different games, which provides an overview of how well each card performs with titles of varying graphical intensity.

Dirt Showdown, for instance, is very easygoing on GPUs, but is particularly reliant on the CPU to run well. As such, it will easily run well on a range of hardware, but might not always show the best of what a graphics card can do.

Metro: Last Light Redux is far more demanding; few games make it past the hallowed 60fps mark except at 1080p, and only the most powerful and expensive cards can cope at all with 4K.

Tomb Raider is less intensive than Metro, but also scales with hardware better than Dirt. It's a good indication of how each card will perform in a relatively detailed but well-optimised AAA game.

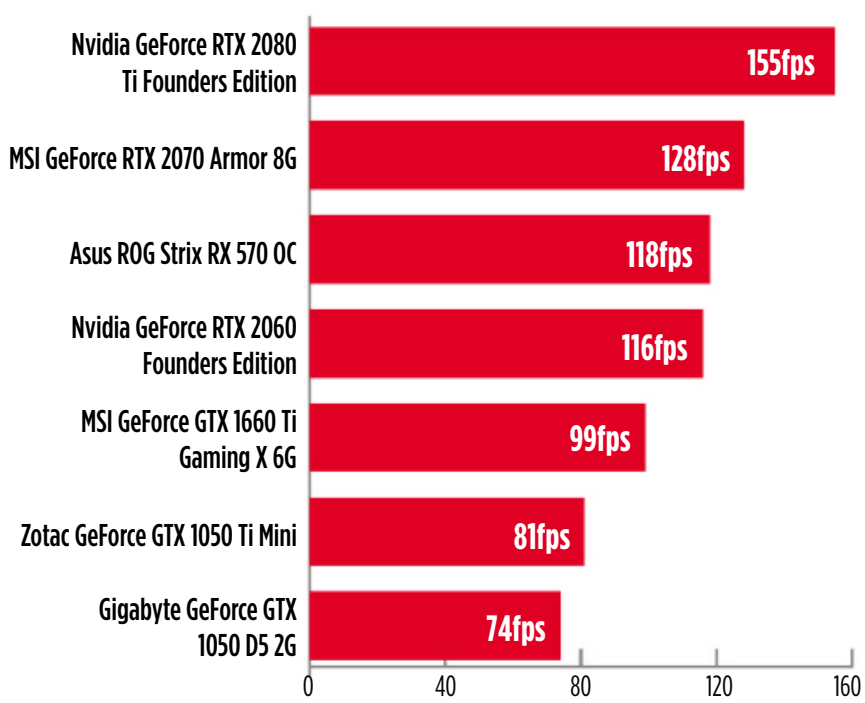
We also run Valve's SteamVR Performance Test benchmark, which measures how well each graphic card can run virtual-reality content. It grants scores from 0 to 11 based on how far you'd need to turn down quality settings to get a consistent 90fps – the higher the score, the higher your settings could be.

Manufacturer	ASUS	GIGABYTE	MSI	
Model	ROG Strix RX 570 OC	GeForce GTX 1050 D5 2G	GeForce GTX 1660 Ti Gaming X 6G	
HARDWARE				
Rear slots taken up	2	2	2	
GPU	AMD Radeon RX 570	Nvidia GeForce GTX 1050	Nvidia GeForce GTX 1660 Ti	
GPU cores	2,048	640	1,536	
GPU clock speed	1,300MHz	1,379MHz	1,500MHz	
GPU clock boost speed	1,310MHz	1,493MHz	1,875MHz	
Memory	4GB GDDR5	2GB GDDR5	6GB GDDR6	
Memory interface	256-bit	128-bit	256-bit	
Max memory bandwidth	224GB/s	112.1GB/s	288.1GB/s	
Graphics card length	240mm	172mm	247mm	
DVI outputs	2	1	0	
D-sub outputs	0	0	0	
HDMI outputs	1	1	1	
Mini HDMI outputs	0	0	0	
DisplayPort outputs	1	1	3	
USB Type-C outputs	0	0	0	
Mini DisplayPort outputs	0	0	0	
Power leads required	1x 8-pin	None	1x 8-pin	
Maximum power draw	200W	75W	130W	
Cooling	2x open air fans	1x open air fan	2x open air fans	
Monitor syncing support	AMD FreeSync	Nvidia G-Sync	Nvidia G-Sync	
Multiple GPU support	AMD Crossfire	None	None	
BUYING INFORMATION				
Price	£145	£115	£300	
Warranty	Two years repair and replace	Three years repair and replace	Three years repair and replace	
Supplier	www.box.co.uk	www.scan.co.uk	www.scan.co.uk	
Details	www.asus.com/uk	www.gigabyte.com	wwww.msi.com	
Part code	ROG-Strix-RX570-O4G-Gaming	GV-N1050D5-2GD	RTX 1660 TI Gaming X 6G	

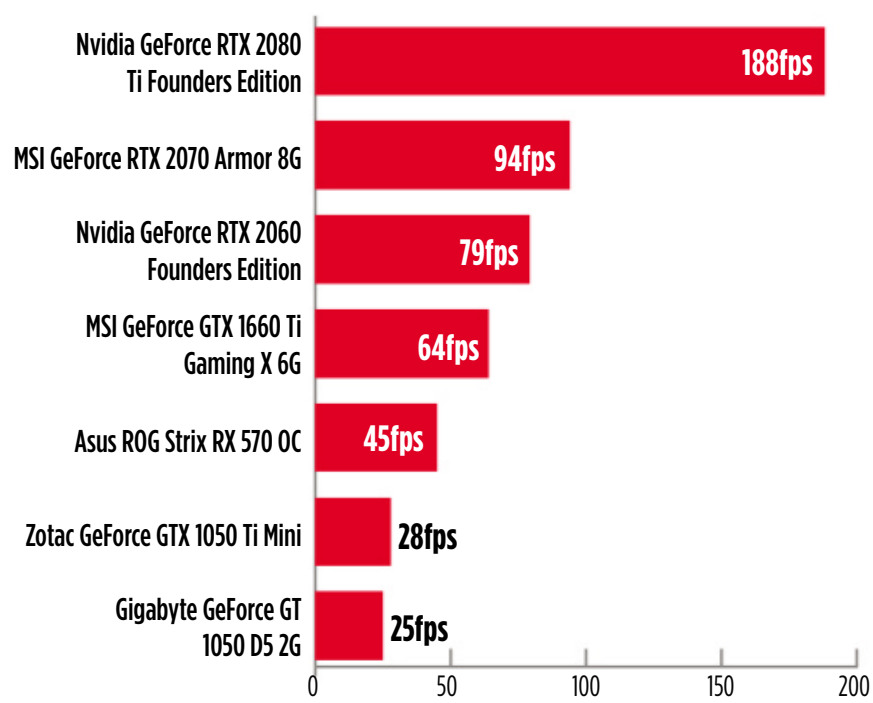
Prices correct at time of going to pres

BENCHMARK RESULTS

DIRT SHOWDOWN
(1,920x1,080, Ultra quality, 4x MSAA)

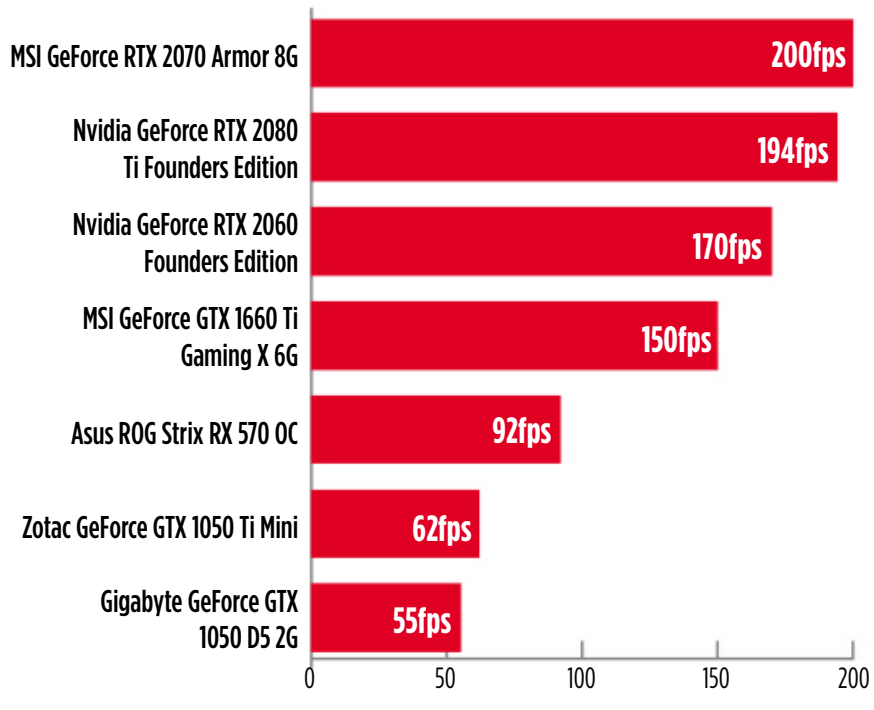


METRO: LAST LIGHT REDUX
(1,920x1,080, Very High Quality, SSAA)

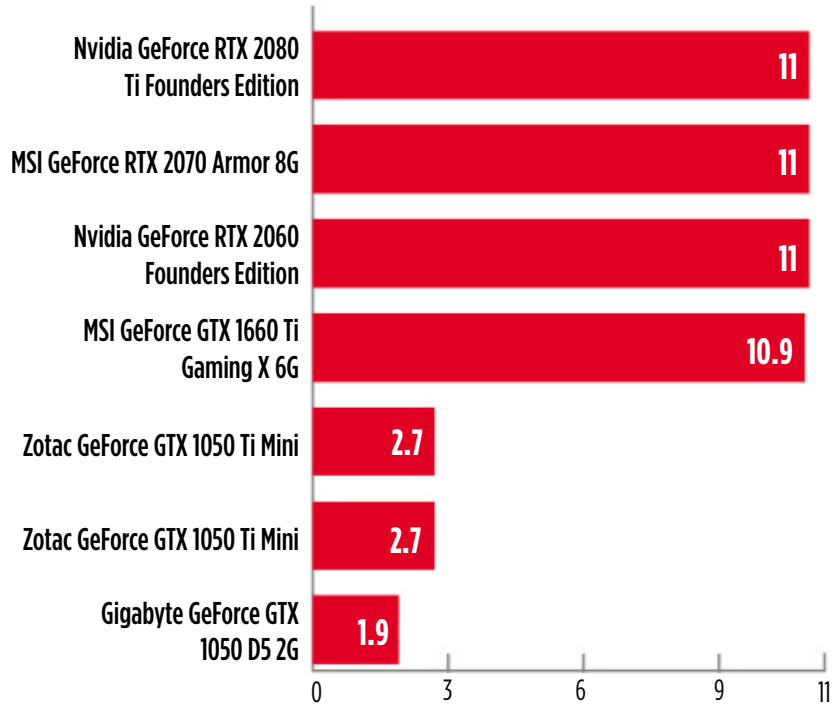


	MSI	**NVIDIA**	**NVIDIA**	**ZOTAC**
	GeForce RTX 2070 Armor 8G	GeForce RTX 2060 Founders Edition	GeForce RTX 2080 Ti Founders Edition	GeForce GTX 1050 Ti Mini
	2	2	2	2
	Nvidia GeForce RTX 2070	Nvidia GeForce RTX 2060	Nvidia GeForce RTX 2080 Ti	Nvidia GeForce GTX 1050 Ti
	2,304	1,920	4,352	768
	1,410MHz	1,365MHz	1350MHz	1,303MHz
	1,620MHz	1,680MHz	1,635MHz	1,417MHz
	8GB GDDR6	6GB GDDR6	11GB GDDR6	4GB GDDR5
	256-bit	192-bit	352-bit	128-bit
	448GB/s	336GB/s	616GB/s	112.1GB/s
	309mm	229mm	267mm	145mm
	0	1	0	1
	0	0	0	0
	1	1	1	1
	0	0	0	0
	3	2	3	1
	1	1	1	
	0	0	0	0
	1x 6-pin, 1x 8-pin	1x 8-pin	2x 8-pin	None
	175W	160W	260W	75W
	2x open air fans	2x open air fans	2x open air fans	1x open air fan
	Nvidia G-Sync	Nvidia G-Sync	Nvidia G-Sync	Nvidia G-Sync
	None	None	Nvidia SLI	None
	£460	£329	£1,100	£149
	Three years repair and replace	Three years RTB	Three years RTB	Five years RTB
	www.ebuyer.com	www.nvidia.com	www.nvidia.com	www.amazon.co.uk
	www.msi.com	www.nvidia.com	www.nvidia.com	www.zotac.com
	RTX 2070 Armor 8G	GeForce RTX 2060 FE	GeForce RTX 2080 Ti FE	ZT-P10510A-10L

TOMB RAIDER
(1,920x1,080, Ultimate quality, FXAA)



STEAMVR PERFORMANCE TEST



SERVE CHILLED
CPU coolers

Even if your CPU comes with its own cooler, investing in a superior model can help your PC run quieter and faster – especially if you want to try overclocking

MANY OF A PC'S components run hot enough to require active cooling, but while graphics cards and power supplies have their own built-in fans, the CPU's cooler must be installed separately.

To make things easier, a lot of processors come with a stock cooler unit included in the box. Intel tends to do this only with its lower-end chips, but AMD is somewhat more generous in bundling its Wraith brand coolers across the entire Ryzen range. These coolers will do the job if you just want to get up and running right away, but remember that they're designed to be freebies, and as a result are seldom going to be the most efficient, or have the quietest operation.

That's why, unless you're happy with the most basic of systems, we recommend buying a separate CPU cooler as part of your spec. You'll have to do this anyway if your chosen CPU doesn't include a stock cooler (see the table on page 83 to see which of our recommendations do and don't), but even if you get one bundled in, it's usually worth upgrading regardless.

WATER FEATURE

There are two types of CPU coolers to choose from: air coolers and liquid coolers, often called watercoolers. Air coolers are smaller, simpler and more affordable, which is partly why stock coolers adopt this design: a copper

plate sits on top of the CPU, and conducts heat via pipes up to a radiator. One or two fans, attached to the radiator, draw air across the radiator to keep it from getting too hot, and to disperse the resulting hot air into the PC's case, where it (ideally) can be sucked out by an exhaust case fan.

Watercoolers use a flatter radiator shape, and connect it to a pump unit via two liquid-filled tubes. The pump unit, which has a copper plate on the underside, transfers CPU heat into the outflowing liquid in one of these tubes, which then directs to the radiator, dispersing heat with attached fans. Cooler water is then piped down the other tube, back towards the CPU, to repeat the cycle.

You can set up custom-designed 'open loop' liquid-cooling systems, where a separate reservoir supplies the liquid to cool the CPU and maybe even the GPU at the same time, but these take a lot of time, money, skill and knowledge. It's far easier to just get an 'all in one' (AIO) watercooler, which comes with the radiator, tubes and pump already attached to each other; all you have to do is add the fans to the radiator, install the pump on the CPU and mount the radiator/fan combo somewhere on the PC chassis.

RISING TIDES

If this still all sounds like a lot of work, air coolers might justifiably seem like a better option. Even the largest tower-style air coolers, which have large, bulky radiators, only need to have one or two fans clipped on before they can be attached to the motherboard.

Liquid cooling, however, is more efficient at transferring heat away from the CPU, making it better for high-performance systems, particularly when the CPU has a lot of cores huddled together. A good watercooler can let you overclock the CPU further than you could with a basic air cooler, as you'll have more thermal headroom before overheating kicks in, but on a similar principle, you can benefit even if you're not interested in manual overclocking at all. Remember how most CPUs have a turbo boost function, where clock speeds can rise automatically as long as they can do so without running too hot? The better your cooling, the more often your CPU will be able to reach these higher speeds.

In short, and from a purely performance-focused perspective, liquid cooling is likely preferable where budget allows. Being able to get higher CPU speeds from better cooling also applies to higher-quality air coolers, at least compared to stock coolers, so they're still often worth upgrading to, but gaming systems and pseudo-workstations should aim for the liquid solution. That said, performance – while important – is only one factor to consider when choosing a cooler.

SOCKET SCIENCE

For instance, you'll also need to be wary of size, and whether the cooler you want will fit in the case that you want. See the cases section on page 104 for more about capacities and clearances, but the main thing is that not every cooler will fit in every case, especially if it's a compact mini-tower or cube-style chassis. For air coolers, the issue tends to be with the height of the radiator – models more than 150mm tall can be a tight squeeze – while with AIO watercoolers, you're more dependent on needing the empty fan mounts required to install the radiator.

We don't want to overstate the issue, as the vast majority of mid-tower cases will easily have room for the vast majority of coolers, but it's something to be aware of. Similarly, the cooler will need to be compatible with the CPU socket of your chosen processor motherboard: each socket has its own mounting system, even if the differences ultimately come down to where precisely some holes are drilled in the motherboard.

Fortunately, most coolers (including the recommended models on the following page) are built to be platform-agnostic, meaning they'll include all the parts you need to install it on any of the major Intel and AMD sockets, and even change between them in the event that you ever switch processors. If a socket isn't supported out of the box, you can often register to receive a separate mounting kit free of charge. Manufacturers tend to offer this when a new socket is launched after the cooler does, and before the product itself is packaged with an updated mounting kit.

SPIN AND SONIC

It's unavoidable that a PC makes some noise, but it's better to live with the whirr of some fans than to have your system (and its valuable components) constantly overheating. What you can do is choose parts that do their job while making as little fan noise as possible, whether it's through impeccable build quality, or highly efficient cooling allowing the fans to spin at slower (and thus quieter) speeds.

You can make this easy for yourself by selecting from one of the recommended coolers on page 102, as we've used all of them and can attest to them keeping comfortably quiet, even when the system is under heavy load. Experience is the only truly reliable way to judge how loud a cooler might be, as despite the best efforts of manufacturer's marketing departments, you can't tell this just from the given specs. Even the form factor doesn't determine that much – logic would suggest that watercoolers are quieter, as they're generally more efficient at spreading heat around and thus shouldn't require such high fan speeds. Nonetheless, we've tested whisper-quiet air coolers such as the Arctic Freezer 33 eSports One, and have been irritated by the loud purring and poorly controlled vibrations of multiple AIO liquid coolers.

> Liquid cooling is more efficient at transferring heat away from the CPU, making it better for high-performance PCs

Thermal paste explained

Thermal paste, thermal compound, thermal grease – whatever it's called, this silvery goo is essential for keeping the CPU cool. It sits in a thin layer between the top of the processor itself and the cooler's contact plate, and serves to conduct heat between the two by eliminating spaces and air pockets that could prevent heat passing from the chip to the cooler.

If it looks like this, you've gone too far

Some coolers come with a single-use sachet or tube of thermal paste in the box, and others will even have it pre-applied to the contact plate, making installation quicker and easier. Still, we'd suggest buying some anyway, in case you don't get it right the first time. To apply it, squeeze a pea-sized ball on to the centre of the chip, then use the cooler to squash it down, spreading the paste evenly over the CPU's surface. You want full coverage over the processor, but only a thin layer – too much and it will insulate, rather than conduct.

We use Arctic MX-2 paste in the *Shopper* labs. A 4g tube costs £4 from *www.cclonline.com*, and will yield at least a couple of uses.

Best air cooler

ARCTIC
Freezer 33
eSports One

Arctic's Freezer 33 eSports One offers everything you could want from an air cooler: it's simple to install and cheap at just £28, but it still performs well and is extremely quiet. Even during the most intensive portion of our benchmark tests, it was never any louder than our PC's other case fans.

It's also a very good-looking cooler – the name evokes an overly ostentatious 'gamer' feel, but it's sharply designed, has a few different colour options to choose from and isn't too bulky. For about £14 extra you can equip it with a second fan, to create a more effective push-pull airflow, but we found a single fan to be sufficient.

Best RGB liquid cooler

COOLER MASTER
MasterLiquid
ML240R RGB

RGB lighting is an acquired taste, but that didn't stop almost every manufacturer slapping customisable LEDs all over their coolers last year. The best of these light-up liquid coolers that we tested was the MasterLiquid ML240R RGB, which also introduced an upgraded pump over Cooler Master's previous generation models.

The MasterLiquid ML240R RGB is highly customisable, at least with regards to how you can make it look, and it's compatible with a wide range of hardware syncing systems, so you can apply identical effects across other components and peripherals. Most importantly, it's very effective at keeping CPU temperatures down, including when overclocking.

Best-value liquid cooler

DEEPCOOL Castle 240 RGB

Coming in at £100, a little less than the MasterLiquid ML240R RGB, the Deepcool Castle 240 RGB is decidedly feature-rich for the price. There's customisable RGB lighting, obviously, but you also get extras such as built-in sound dampening pads on the radiator, a fan hub, lighting controller and extensive effect syncing support.

Performance-wise, it's about even with Cooler Master's AIO, often coming dead level or within 1°C in our CPU temperature tests. That's another good showing, although as with the MasterLiquid ML240R RGB, keep in mind that you'll need a motherboard with dedicated RGB headers to get the most out of its lighting features.

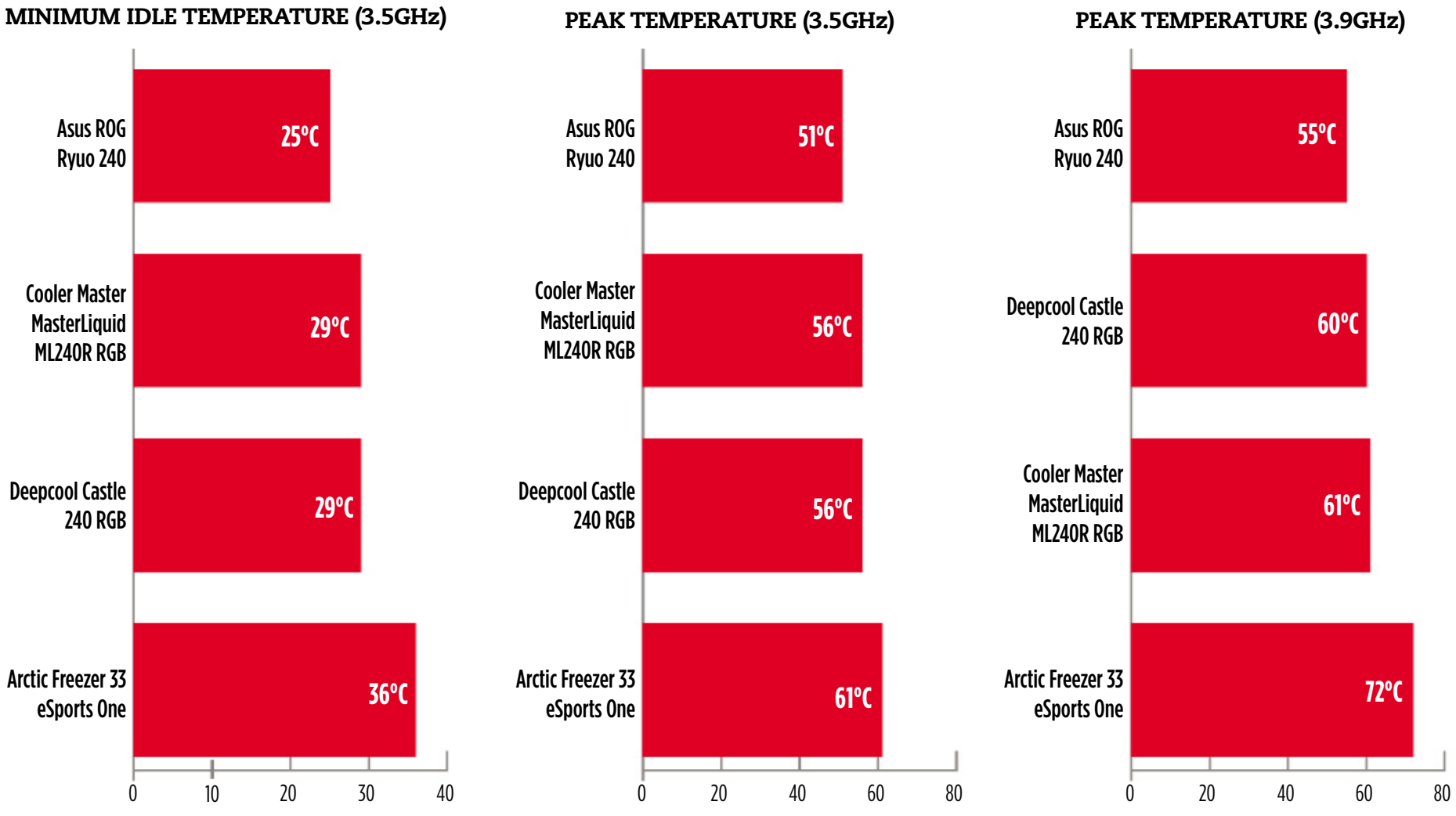
Best performance liquid cooler

ASUS ROG Ryuo 240

Asus would have you believe that the most noteworthy thing about the ROG Ryuo 240 is the OLED screen on the pump – an admittedly fun little feature that can display your choice of JPG or GIF images, even if GIF support was somewhat wonky when we tried it (even those that imported properly would play at reduced speed).

What's really impressive about this model, however, is how effectively it cools. The ROG Ryuo is an excellent performer, which helps make its high price a lot easier to stomach, especially if you're planning a high-end overclocked PC build. It's particularly easy to set up and install, too.

BENCHMARK RESULTS



We tested each cooler with our quad-core Intel Core i7-4770K processor, both at its stock base speed of 3.5GHz and overclocked 3.9GHz, and measured its core temperatures at idle and under the heavy load of our 4K CPU performance benchmarks.

Manufacturer	ARCTIC	ASUS	COOLER MASTER	DEEPCOOL
Model	Freezer 33 eSports One	ROG Ryuo 240	MasterLiquid ML240R RGB	Castle 240 RGB
HARDWARE				
Technology	Open air	Closed loop liquid	Closed loop liquid	Closed loop liquid
Fans	1x 120mm	2x 120mm	2x 120mm	2x 120mm
Maximum fan speed	1,800rpm	2,500rpm	2,000rpm	2,000rpm
Supported sockets	Intel LGA2066/ 2011-3/2011/1151/ 1150/1155/1156, AMD AM4	Intel LGA2066/ 2011-3/2011/1151/ 1150/1155/1156/1366, AMD AM4	Intel LGA2066/2011-3/ 2011/1151/1150/1155/ 1156/1366/775, AMD AM4/ AM3+/AM3/AM2+/AM2/ FM2+/FM2/FM1	Intel LGA2066/2011-3/ 2011/1151/1150/1155/ 1156/1366, AMD TR4/ AM4/AM3+/AM3/ AM2+/AM2/FM2+/ FM2/FM1
Radiator dimensions	153x123x88mm	121x272x27mm	120x277x27mm	120x274x27mm
LED lighting	None	RGB	RGB	RGB
Includes thermal paste	Yes	Yes (pre-applied)	Yes	Yes
BUYING INFORMATION				
Warranty	Ten years RTB	Three years RTB	Two years RTB	One year RTB
Price	£28	£160	£110	£100
Supplier	www.scan.co.uk	www.scan.co.uk	www.scan.co.uk	www.scan.co.uk
Details	www.arctic.ac	www.asus.com	www.coolermaster.com	www.gamerstorm.com
Part code	ACFRE00043A	90RC0040-M0UAY0	MLX-D24M-A20PC-R1	DP-GS-H12L-CSL240RGB

Prices correct at time of going to press

TAKING SHAPE

Cases

A good chassis isn't just a crate for holding PC parts: it can keep the system cool, display your build as a work of art and open up new routes for future upgrades

THE IMPORTANCE OF choosing the perfect PC case is to be underestimated at your peril – or, at least, at your inconvenience. While it understandably doesn't stand alongside components such as the CPU, graphics card or storage in determining performance and capability, the case is similar to the motherboard in how it ties into the system's other individual components. It has the potential to enable all manner of upgrades and high-end hardware, but if you pick one that doesn't suit your needs, you could also find the case to be a source of frustrating limitations.

This is complicated by the fact that there are thousands of different cases to choose from, each with different designs, capacities and features. However, we've narrowed this down to a handful of our top picks on page 106, and by understanding what exactly a case can offer (besides just holding parts), you can make the right choice.

MATERNAL INSTINCTS

If you've been reading this guide in strict order, you may have already picked out a CPU and motherboard – but before you decide on a case as well, you'll need to make sure that the motherboard will fit. As mentioned, smaller cases have the benefit of taking up less space on your desk, floor or AV cabinet, but they might only be able to hold microATX or Mini-ITX motherboards. For full-size ATX boards, a mid-tower style chassis is likely the way to go.

Remember, also, that larger cases routinely offer support for motherboard sizes below their maximum. That's another good argument for choosing a tower: even if you're starting off with a smaller motherboard, such as for budget reasons, you'll have the freedom to upgrade to a bigger, more fully

featured board without also needing to replace the entire case (and, in the process, completely rebuild the system).

Size matters for other components, too. Each case will have maximum clearances for CPU coolers and graphics cards: height and length respectively. More spacious cases will naturally be able to hold taller coolers and longer graphics cards, while compact cases will have less room internally. It's not impossible to find high-quality, high-performance components that are small enough to fit into a relatively tiny chassis, but be warned that packing the case too tightly will impede airflow and increase operating temperatures.

STORING STORAGE

The case is also the most significant determining factor in how much internal storage you can have, besides your budget. Look for the number of drive bays, trays and mounts each case has: 3.5in trays typically come stacked in cages and can usually hold both 3.5in hard disks and 2.5in SSDs, though it's also common to have one or more 2.5in mounting points dotted around. Cases also used to regularly include 5.25in trays, for optical drives rather than storage drives, but with falling interest in CDs and DVDs, these are much rarer nowadays.

There's no objectively ideal capacity when it comes to storage bays, as their importance will vary by owner: for a simple home PC, you might well never need more than just one hard disk and one SSD, while those who do a lot photo or video editing might need large cages full of hard disks to store all their material and backups. Then again, it's good to have at least a couple of 3.5in and 2.5in bays apiece: this provides both a solid foundation for an initial build, with room to easily add more when you run out of room.

The rise of M.2 slots on motherboards has also taken a share of the burden away from the case, at least when it comes to holding SSDs. For every M.2 slot your motherboard has, you can probably get away with one fewer 2.5in mount.

GO WITH THE FLOW

We've already covered CPU coolers, and graphics cards come with their own fans, but your case plays an important role in keeping the system chilled as well. In tower-style models, there will be fan mounts positioned at the front and back, possibly with more in the roof and base; this is where chassis fans can be installed. These are tasked with drawing cool air in from outside the case, sending it over the hot components, then venting out the resulting hot air. This constant, cyclical airflow prevents heat from building up inside the case, including that being shunted around by individual component coolers.

As such, it's best to have one fan at the rear (an exhaust) and at least one at the front (an intake), and it's particularly desirable to have these fans pre-installed by the manufacturer. Not all of them will be, however. If your case lacks an intake fan, for instance, it shouldn't be a deal-breaker, but you should consider buying and installing one yourself, which is easy to do. Some compact cases might not have room for more than one exhaust fan; this can still work, but we'd recommend sticking with low- or medium-powered internals that don't get too hot.

The number and size of fan mounts should also be noted if you want to install a watercooler, as these involve radiators designed to be installed where the fans would normally be. With a 240mm radiator, for example, you'll need two 120mm fan mounts positioned next to each other, which would typically be at the top or rear of the case.

PACKING NEAT

There will inevitably be a lot of cables running though your PC once it's built: PSU cables, I/O panel cables, SATA cables and so on. Leaving this in an unsorted mess isn't just unsightly, making it difficult to sort through at a later stage, but can reduce the effectiveness of that all-important airflow by leaving chunky wires in the way of the fans.

That's why it's worth taking a few minutes at the end of the building process to engage in a little cable management. At its most basic, this can just involve using cable ties (often included with the case) to bundle clumps of cables together into less chaotic strings, but a quality chassis will include dedicated tools to get the wiring out of sight, out of mind and out of the way of airflow. Use channels and routing holes to ensure that any cables going into the motherboard approach from behind its tray, and if there are any included straps, use these to tie down lose cables originating from the front I/O panel.

Tower-style cases will also often include a PSU shroud, which is simply a metal cover that runs across the entire main chamber and over the power supply. Feel free to stash any leftover cables under here, as the PSU cools itself and there won't be any other airflow to block anyway.

SLOT MACHINES

Since most external ports – including USB ports and audio jacks – will be on the motherboard's rear I/O panel, you shouldn't base case-buying decisions entirely on what's on each chassis' own, front-facing I/O panel. Still, this can be a source of useful functionality. Having easy access to two or even three or four USB ports on the front will always be preferable to having to crawl around the back every time you need to insert a thumb drive. As ever, faster USB3 ports are better than USB2, while the speediest USB3.1 and Type-C ports are very rare.

Also be included on the front panel as standard will be 3.5mm mic and headphone jacks. There's no real drawback to using these instead of the rear ports unless you also have a dedicated sound card installed. SD card slots are another possible, though less common, inclusion: since the only alternative would be to buy an SD-to-USB adaptor, these can be very useful to keen camera owners.

KEEPING UP APPEARANCES

Lastly, there's no shame in letting looks influence your choice of case; indeed, we like to think that none of our recommendations is particularly ugly. While functionality is king, this is ultimately something that you're going to have in your house or office for (probably) many years, so you won't want to get sick of the sight of it.

If you're particularly design-minded, consider a chassis with a side window, made from acrylic or tempered glass. These let you peer into the case's main chamber and spy the components and fans all ticking along – an optional but admittedly satisfying show-off feature for your handcrafted build.

The case is the most significant determining factor in how much internal storage you can have, besides your budget

THE BEST PC CASES

THERMALTAKE View 37

This is about as spacious as mid-tower cases get without crossing into full-tower territory, but the size isn't what's appealing about the View 37. That would mainly be its 'gullwing' side window, which curls around the top to become something of a PC skylight as well. Besides giving unobstructed views into the PC, this window – when removed – gives you far more light and space to build and customise. There's also loads of room for hard disks and SSDs, a well-equipped I/O panel and support for watercooling radiators up to 420mm in length.

COOLER MASTER MasterBox K500

Besides looking great – it's not the simplest or most subtle design, but it is sharp and thoroughly modern – the MasterBox K500 is simply a finely crafted all-rounder at an approachable price. Capable of taking motherboard sizes up to ATX, two 3.5in drives and three 2.5in drives, it covers all the essentials for a mid-tower and then adds in some very good cooling support, including six 120mm fan mounts and space for a 280mm radiator. Best of all are the two pre-installed intake fans, which provide improved airflow as well as a touch of visual flair.

NZXT Source 340 Elite

This is an older case, at least compared to the others here, but then the Source 340 Elite does leave a lasting impression. It can hold more storage drives than the MasterBox K500, its similarly priced mid-tower rival, and although its cooling capacity is lower, it has some unique tricks. One is the magnetic headphone puck, which sticks to the front panel and can be used as a combined headset hook and cable storage device, and the other is an HDMI extender, which handily lets you plug in VR headsets at the front I/O panel while still receiving a signal from a graphics card.

COOLER MASTER MasterBox Lite 3.1

This is a great option for having the ease and flexibility of a tower layout, but in a more compact (and cheaper) form. Despite essentially being a shrunk-down MasterBox Lite 5, it has the GPU and cooler clearances of a much larger mid-tower, although the largest motherboard size it can manage is microATX. With multiple drive bays and fan mounts, it's still ready and able to contain a potent PC system, although we'd suggest buying a 120mm intake fan to add in, as you only get an exhaust fan pre-installed.

KOLINK Satellite Plus

Small and affordable but with a smart aluminium finish, the Satellite Plus is perfect for living-room PCs that need only basic components and cooling. That's partly down to how its limited capacity for fans, big coolers or long graphics cards makes it difficult to square as a performance chassis, but there are plenty of other models if that's what you want. Good cube cases are altogether harder to find, but with its handsome, ultra-compact design and space for multiple hard disks, this is one of them.

THERMALTAKE Level 20 VT

Here's something a little different: a cube-style chassis that's neither very cheap nor very small, but still manages to be an attractive leftfield possibility. The Level 20 VT is distinguished by its ability to swap around the base and side panels, effectively letting you rotate the entire thing for different layout and looks – and with almost all the panelling being tempered glass, you'll be able to see every inch of your building work. More practically, it's stuffed with storage support, and the huge 200mm intake fan can shift plenty of air all by itself.

Manufacturer	COOLER MASTER	COOLER MASTER	KOLINK	NZXT	THERMALTAKE	THERMALTAKE
Model	MasterBox K500	MasterBox Lite 3.1	Satellite Plus	Source 340 Elite	Level 20 VT	View 37
HARDWARE						
USB2 ports	0	1	0	2	2	2
USB3 ports	2	1	2	2	2	2
Mic and headphone jacks	Yes	Yes	Yes	Yes	Yes	Yes
Front panel extras	Reset button	None	Reset button	1x HDMI out	Reset button	Reset button
Case type	Mid-tower	Mini-tower	Cube	Mid-tower	Cube	Mid-tower
Motherboard compatibility	ATX, microATX, Mini-ITX	MicroATX, Mini-ITX	Mini-ITX	ATX, microATX, Mini-ITX	MicroATX, Mini-ITX	EATX, ATX, microATX, Mini-ITX
Fan mounts	6x 120mm, 2x 140mm	3x 120mm	1x 120mm	1x 120mm, 3x 140mm	4x 120mm, 3x 140mm, 1x 200mm	7x 120mm, 7x 140mm, 2x 200mm
Supplied fans	3x 120mm	1x 120mm	1x 120mm	2x 120mm	1x 200mm	2x 140mm
Max 2.5in drive bays	3	1	4	4	6	7
Max 3.5in drive bays	2	2	3	3	3	11
Max 5.25in drive bays	0	0	0	0	0	0
PCI slots	7	4	2	7	5	10
PSU size	ATX	ATX	ATX	ATX	ATX	ATX
Max CPU cooler height	160mm	158mm	165mm	161mm	185mm	180mm
Max graphics card length	400mm	380mm	280mm	364mm	350mm	410mm
Dimensions	455x210x491mm	208x456x381mm	190x260x280mm	203x432x474mm	348x330x430mm	525x261x538mm
Weight	6.2kg	4.4kg	2.1kg	8.1kg	8.7kg	11.8kg
BUYING INFORMATION						
Price	£75	£37	£38	£80	£90	£108
Warranty	Two years RTB	Two years RTB	One year RTB	Two years parts and labour	Three years RTB	Three years RTB
Supplier	www.scan.co.uk	www.novatech.co.uk	www.cclonline.com	www.scan.co.uk	www.scan.co.uk	www.ebuyer.com
Details	www.coolermaster.com	www.coolermaster.com	www.kolink.hu	www.nzxt.com	www.thermaltake.com	www.thermaltake.com
Part code	MCB-K500D-KGNN-S00	MCW-L3B3-KANN-01	CA-02F-KK	CA-S340W-B3	CA-1L2-00S1WN-00	CA-1J7-00M1WN-04

Prices correct at time of going to press

THE IDEAL SPEC for your PC

Still unsure which graphics card, case or cooler is right for your dream machine? Here's our handy guide for four of the most popular PC types

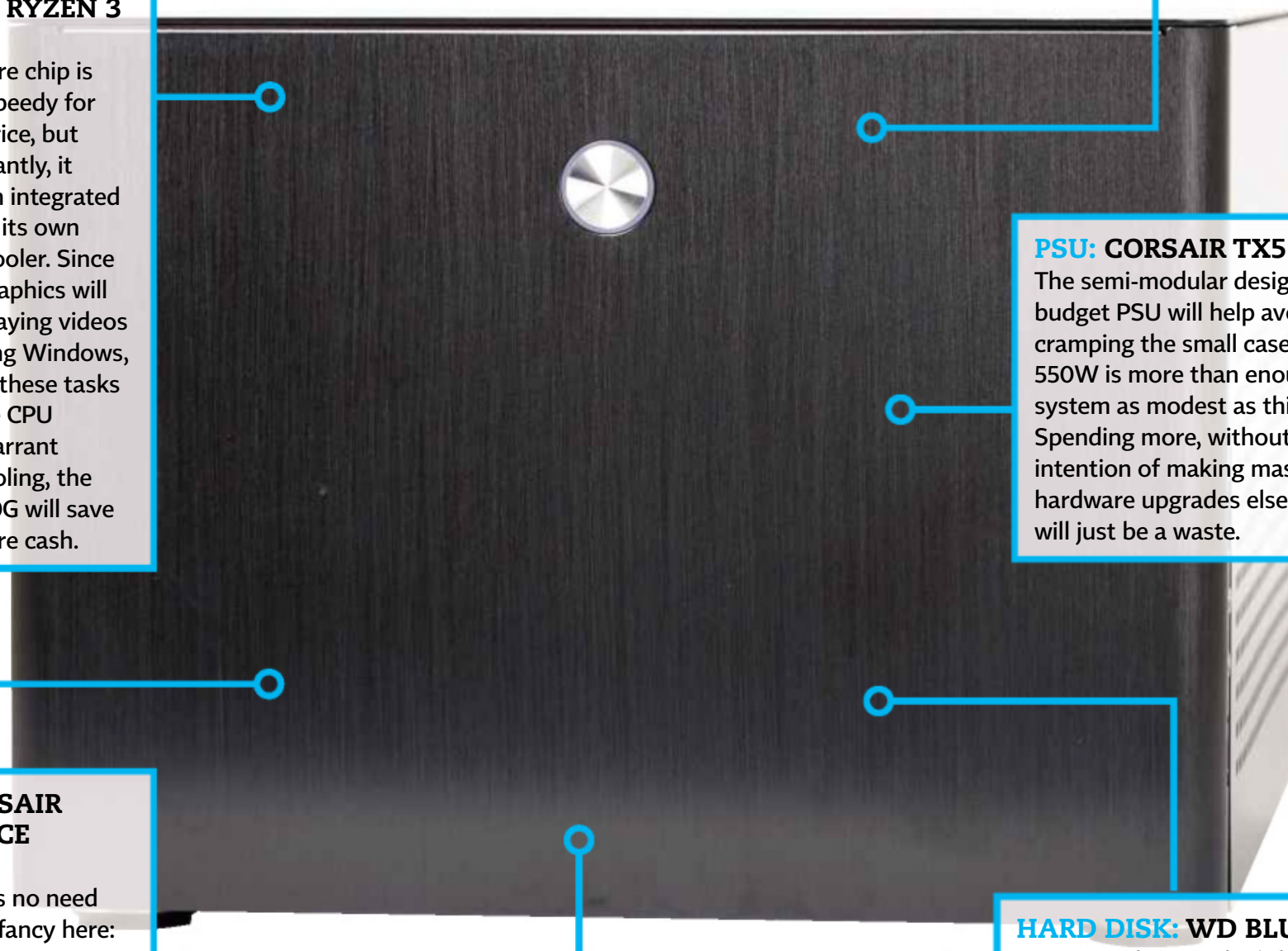
COMPACT MEDIA PC

TOTAL COST: £372

Bring Windows into your living room with a media PC – you don't need to spend big money on components, and can fit everything into a smaller, sleeker chassis that sits beneath your TV

CPU: AMD RYZEN 3 2200G
This quad-core chip is reasonably speedy for such a low price, but more importantly, it includes both integrated graphics and its own low-profile cooler. Since integrated graphics will be fine for playing videos and navigating Windows, and because these tasks won't tax the CPU enough to warrant upgraded cooling, the Ryzen 3 2200G will save you even more cash.

CASE: KOLINK SATELLITE PLUS
A suitably small chassis, and one that wouldn't look out of place in an AV cabinet, either. It's just the right size for that ASRock Mini-ITX motherboard and, should you ever find yourself short on hard disk space, it's easy enough to add a second one. There's only one pre-installed fan, at the rear, but that's fine as this system should produce relatively little heat.



PSU: CORSAIR TX550M
The semi-modular design of this budget PSU will help avoid cramping the small case, and 550W is more than enough for a system as modest as this one. Spending more, without the intention of making massive hardware upgrades elsewhere, will just be a waste.

RAM: CORSAIR VENGEANCE LPX 8GB
Again, there's no need for anything fancy here: just 8GB to keep Windows running smoothly. Corsair's Vengeance LPX kits are currently the best-value going, even though they're not particularly low-spec.

MOTHERBOARD: ASROCK FATAL1TY AB350 GAMING-ITX/AC
There are more affordable Mini-ITX motherboards, but this has everything you need for a living-room system. There are two HDMI outputs, for easy connection to a TV, an optical S/PDIF sound jack for a soundbar, and onboard Wi-Fi, so you don't need to trail an Ethernet cable across the floor.

HARD DISK: WD BLUE 1TB
Movies and music don't benefit so much from an SSD's superior speed, so a single hard disk will do the job here. Just make sure you have sufficient capacity – any lower than 1TB, and you may find yourself running out of space sooner than you think.

HOME OFFICE PC

TOTAL COST: £667

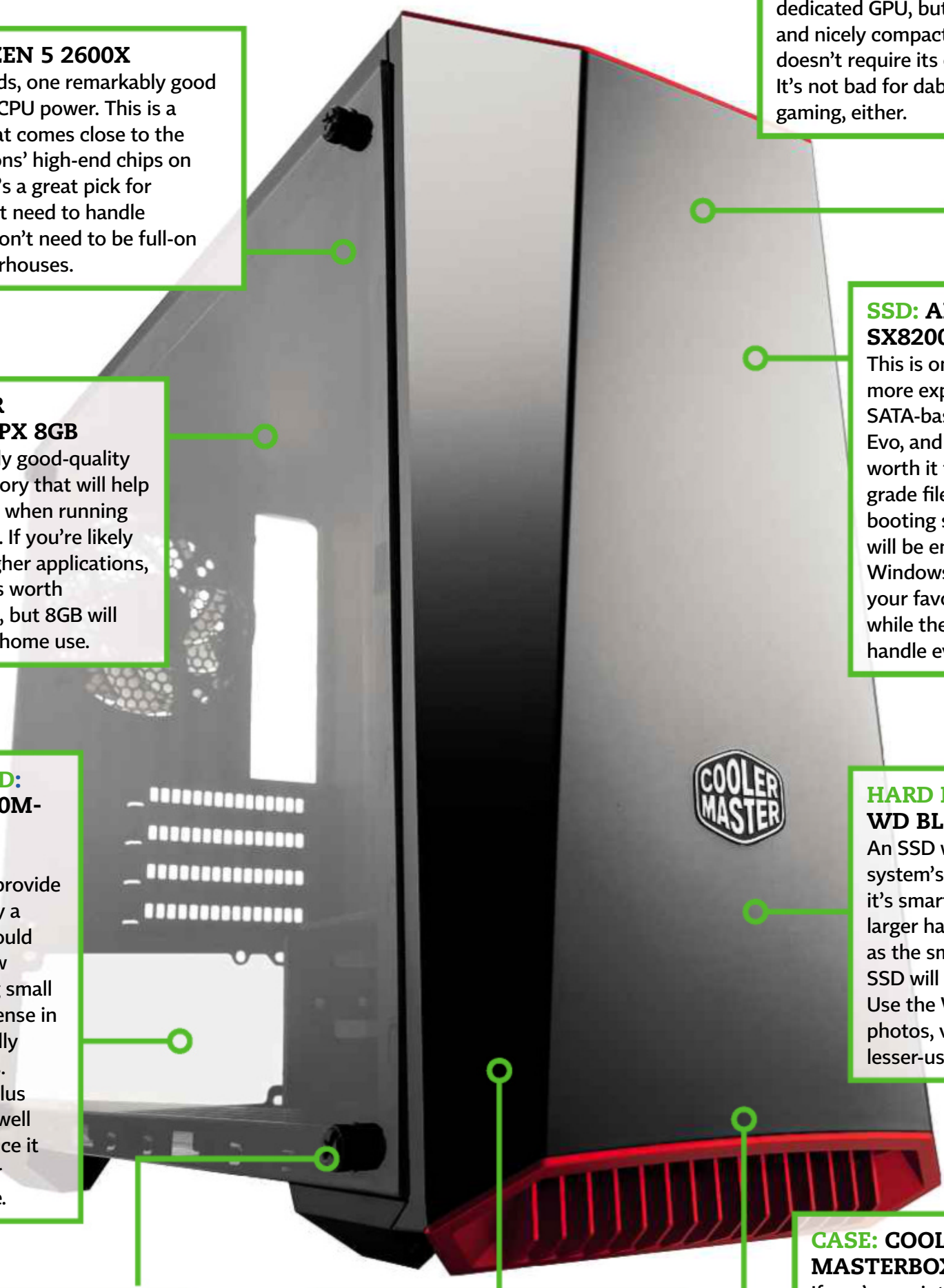
Need to do the odd spot of work at home, or just want something that stays swift when loaded with browser tabs? This system hits the sweet spot between affordability and everyday performance

CPU: AMD RYZEN 5 2600X
Six cores, 12 threads, one remarkably good price for so much CPU power. This is a mid-range CPU that comes close to the previous generations' high-end chips on performance, so it's a great pick for systems that might need to handle multitasking but don't need to be full-on professional powerhouses.

GRAPHICS CARD: GIGABYTE GEFORCE GTX 1050 D5
The lack of integrated graphics on the Ryzen CPU necessitates a dedicated GPU, but this is a cheap and nicely compact option that doesn't require its own PSU cables. It's not bad for dabbling in 1080p gaming, either.

RAM: CORSAIR VENGEANCE LPX 8GB
Again, this is simply good-quality dual-channel memory that will help prevent slowdown when running multiple programs. If you're likely to be running tougher applications, like Photoshop, it's worth upgrading to 16GB, but 8GB will suffice for regular home use.

SSD: ADATA XPG SX8200 256GB
This is only a few pounds more expensive than a SATA-based Samsung 860 Evo, and it's absolutely worth it to get NVMe-grade file-transfer and booting speeds. 256GB will be enough for Windows and a few of your favourite programs, while the hard disk can handle everything else.



MOTHERBOARD: ASUS TUF B450M-PLUS GAMING
A microATX motherboard will provide all the connectivity a system like this would demand, plus a few extras, while being small enough to make sense in a more desk-friendly mini-tower chassis. The TUF B450M-Plus Gaming will serve well here, especially since it has an M.2 slot for faster SSD storage.

HARD DISK: WD BLUE 1TB
An SSD will act as this system's main drive, but it's smart to keep a much larger hard disk in reserve, as the smaller-capacity SSD will fill up faster. Use the WD Blue for photos, videos and lesser-used applications.

CPU COOLER: ARCTIC FREEZER 33 ESPORTS ONE
Even if you're not going to be pushing the processor to its limits, for home use it's worth dropping an extra £28 to get this superior air cooler – if mainly for the fact that it's so quiet.

PSU: CORSAIR TX550M
Since none of the components here is massively power-hungry, it's fine to stick with Corsair's 55W power supply. This will keep costs down and allow you to remove cables you're not using, such as the 6- and 8-pin graphics card cables.

CASE: COOLER MASTER MASTERBOX LITE 3.1
If you've no intention of one day transforming this straightforward rig into a tricked-out premium desktop, then a mini-tower like this is just fine. In fact, Cooler Master's microATX-sized chassis is rather nice, with a big side window and a user-friendly internal layout.

GAMING PC

TOTAL COST: £1,369

There are uncountable configurations that would produce a quality gaming system, depending on which games you'd play, which display resolution you'd use and which quality settings you'd be happy with, but this system will ensure smooth running in most games at 1440p and below

CASE: COOLER MASTER MASTERBOX K500
Since this spec includes some costly components, the MasterBox K500 appeals as something that's well featured but very reasonably priced. Its sharp looks and three pre-installed fans make it even more suitable for a gaming system specifically.

CPU: INTEL CORE i7-9700K
The AMD Ryzen 5 2600X would also be decent here, but as graphics cards become more powerful, CPUs must also be able to unleash their capabilities without bottlenecking. Therefore, the high-end Core i7-9700K is a worthwhile investment.

CPU COOLER: COOLER MASTER MASTERLIQUID ML240R RGB
That Intel CPU is a bit of a beast, especially if you elect to overclock it. A good liquid cooler would be just the thing, and this is one of the best: effective, quiet, fairly easy to set up and slathered in highly customisable lighting.

RAM: CORSAIR VENGEANCE LPX 16GB
8GB is no longer enough to get AAA games running consistently at their best, especially if you've got other programs running in the background. A healthy 16GB of Corsair's dual-channel memory will help keep up performance.

GRAPHICS CARD: NVIDIA GEFORCE RTX 2060 FOUNDERS EDITION
This is the big one. We've gone for the RTX 2060 as it will run any game very well at the most common resolutions, but you can swap in something else to cater to your tastes. The much more affordable RX 570 might be better if you only want 60fps at 1080p, for instance, while the RTX 2070 is much better at 4K.

MOTHERBOARD: MSI MPG Z390 GAMING EDGE AC
Full CPU overclocking support and heaps of other features, all in a motherboard that doesn't cost massively more than a lot of mid-rangers. The MPG Z390 Gaming Edge AC is our favourite ATX board for Intel chips, and for good reason.

SSD: ADATA XPG SX8200 256GB
There's no real need to upgrade to an even faster SSD than Adata's champion. This won't just make sure Windows boots to the desktop quickly: it will also drastically reduce in-game loading times compared to a hard disk.

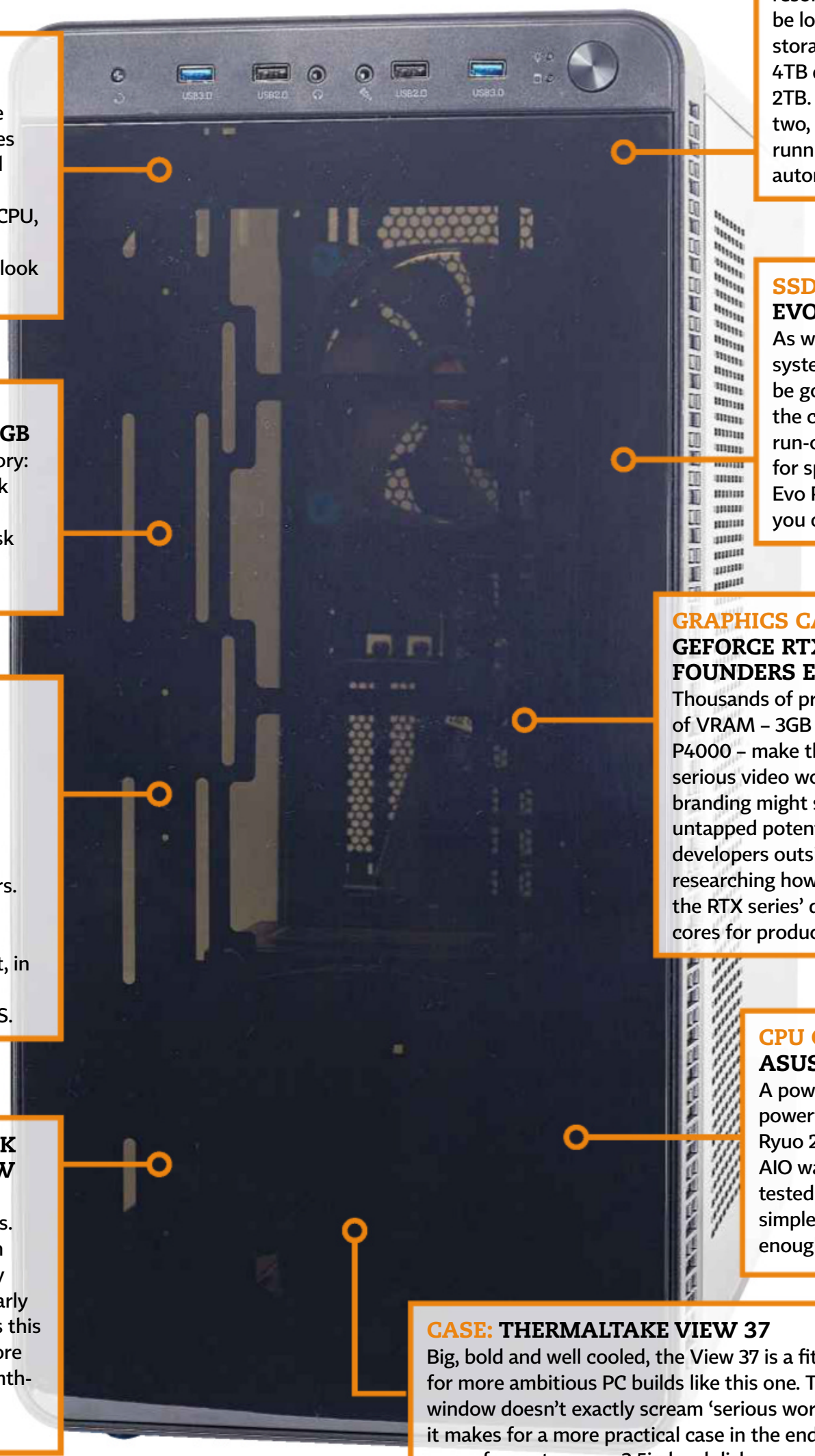
PSU: CORSAIR RM750I
Gaming-ready CPUs and graphics cards mean it's time to raise the bar for PSUs. This model has all the convenience of a fully modular design, plus power to spare and even a semi-passive fan, so when you're not playing, or otherwise putting load on the system, it will run completely silently.

HARD DISK: WD BLUE 2TB
A 1TB disk would also be a good start if you're keen to shave off some expenses, but 2TB offers far better future-proofing for a gaming PC in particular. With many new releases requiring several tens of gigabytes, a larger hard disk means more games to play without needing to uninstall others.

MULTIMEDIA EDITING PC

TOTAL COST: £2,621

This no-expense-spared system will make light work of the toughest media-editing and encoding programs, giving you a workstation in your own home



CPU: INTEL CORE i9-9900K
Wielding both a high core count (eight physical cores with 16 total threads) and Intel's fastest-ever clock speeds on a mainstream CPU, the Core i9-9900K makes even AMD Ryzen 7 chips look like weak multitaskers.

RAM: CORSAIR VENGEANCE LPX 32GB
Don't skimp on the memory: time spent unable to work properly because a single encoding or rendering task is hogging the RAM is, ultimately, time wasted.

MOTHERBOARD: MSI MPG Z390 GAMING EDGE AC
Yes, it's the same motherboard as used in our gaming PC spec, but you're unlikely to need more than what this offers. Maximum memory is a lofty 64GB, and there's respectable RAID support, in addition to overclocking potential and a great BIOS.

PSU: BE QUIET! DARK POWER PRO 11 850W
This is a perfect PSU for more hardware-heavy PCs. Besides providing enough power for all these thirsty components, it's particularly efficient in how it delivers this power, so it won't add more heat into an already warmth-inclined system than it absolutely has to.

HARD DISK: WD BLUE 4TB (x2)
When working with video projects and/or high-resolution images, you should be looking to maximise storage capacity, hence the 4TB drives instead of 1TB or 2TB. It's also advisable to get two, so you can have them running in a RAID 1 array for automatic backups.

SSD: SAMSUNG 970 EVO PLUS 500GB
As with the hard disks, for a system like this you should be going above and beyond the capacities of more run-of-the-mill PCs. That goes for speeds, too, and the 970 Evo Plus is one of the fastest you can get in this regard.

GRAPHICS CARD: NVIDIA GEFORCE RTX 2080 TI FOUNDERS EDITION
Thousands of processor cores and 11GB of VRAM – 3GB more than the Quadro P4000 – make this a better tool for serious video work than its gaming branding might suggest. There's untapped potential, too – software developers outside of games are already researching how to take advantage of the RTX series' deep-learning Tensor cores for productivity purposes.

CPU COOLER: ASUS ROG RYUO 240
A powerful CPU demands powerful cooling, and the ROG Ryuo 240 is the most effective AIO watercooling unit we've tested. It's also extremely simple to set up, and quiet enough to avoid distractions.

CASE: THERMALTAKE VIEW 37
Big, bold and well cooled, the View 37 is a fitting chassis for more ambitious PC builds like this one. The bendy side window doesn't exactly scream 'serious workstation', but it makes for a more practical case in the end, and with space for up to seven 3.5in hard disks, you won't be left wanting for storage.