Digital Technologies @ Home
Unplugged activities for students

This activity is for: Years 9-10

LAN Party

This activity teaches...
- Subnet masks
- Basic local network configuration

The activity teaches students how IP addresses - the addresses that identify computers - determine the network a computer belongs to. It explains how a subnet mask is used to identify which part of the address belongs to the network, and which part identifies the computer itself. It also describes how a CIDR number can be used as a shorthand for writing the subnet of a network.

It is targeted towards secondary students in years 9 and 10 and addresses the expectations of the Australian Curriculum at that level. It assumes students have learned the content in the Year 7 and 8 band of the Digital Technologies curriculum, and understand both what an IP address is, and basic binary operations.

It should take about 1 hour.

You will need...
Pen and paper

Getting started (read this with your child):
Understanding how local networks are configured is important, from setting up a home network, to running an enterprise system. The fundamental knowledge remains the same, and central to that is understanding who can communicate with others in a local network.

Step by step
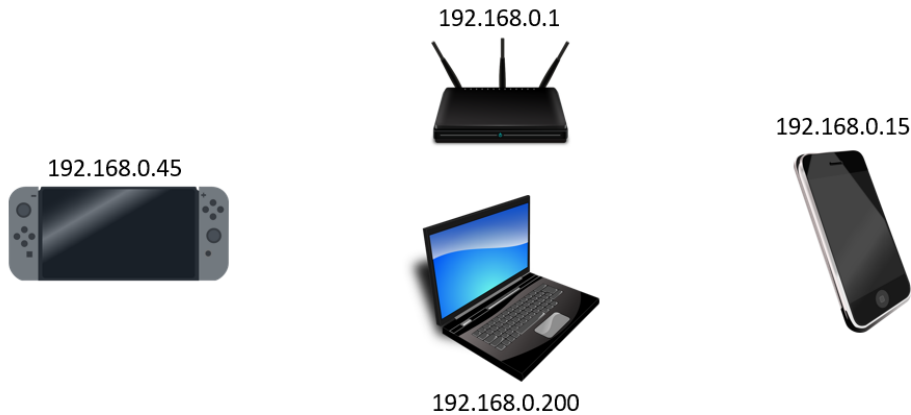Read the notes and answer the questions below.

LAN Party

Understanding subnet masks - who is visible on your network

LAN and subnet masks

Computers, smartphones, tablets and many other devices communicate in networks. The network you have at home is called a local area network (LAN), and it will look something like this:

192.168.0.1

192.168.0.15

192.168.0.45

192.168.0.200

So we can identify each device uniquely, it has an address assigned to it, just like different houses have addresses on the same street. These addresses are called IP addresses, because they use the Internet Protocol (IP). Because home networks are quite small, they use the IPv4 (version 4) protocol, and addresses using IPv4 look something like this:

192.168.0.1

The IP address is a series of 4 numbers between 0 and 255, and each can be represented as an 8 bit number.

Although it may not be obvious this address is made up of two parts - one part describes the network, and the other identifies the host. A host is a device on a network, like your router, laptop, phone, wireless printer or even a smart LED like the Philips Hue.

The subnet mask on a typical LAN is usually `255.255.255.0` If we convert the subnet mask into binary, we see something interesting:

Subnet mask	`255.255.255.0`
Subnet mask (binary)	`1111 1111 . 1111 1111 . 1111 1111 . 0000 0000`
Network/hosts	`|-----------network-----------|  |-hosts-|`

When we convert to binary, the network part is always at the front and is represented as a series of ones. The remaining part - the zeros, is set aside for the hosts. ***Once a zero appears in the subnet mask, no ones can be added after it***! The subnet mask dictates which devices are *visible* to other devices. It also dictates what addresses a *broadcast* message will go to (all hosts in the network).

Reserved addresses - broadcasting and the network address

*In this scheme, a host can have addresses from **1 to 254**. The number 255 is used for broadcasting a message to everyone, and 0 is reserved for describing the network without specifying a host.*

When we combine this info with the IP address (**192.168.0.1**) , it tells us the network address and the possible range of IP addresses that can be given out to devices on the same network.

How does a device know what other hosts are visible

A host knows which other hosts it can communicate with by performing the AND operation between the destination IP address and the subnet mask to find the network address..

Subnet mask (binary)	**1111 1111 . 1111 1111 . 1111 1111 .** 0000 0000
Network/hosts	**|-----------network-----------|**　　|-hosts-|
IP address (binary)	**1100 0000 . 1010 1000 . 0000 0000 .** 0000 0001
Network address (binary)	**1100 0000 . 1010 1000 . 0000 0000 .** 0000 0000
Network address	**192.168.0.**0
Host range	**192.168.0.**1 - **192.168.0.**254

All computers that can communicate will have the same network address. Different devices will have a different *host* number.

Communicating outside the network

*Communicating outside the network requires a **router** to forward the packets (chunks of data) to the correct location. A host can specify the **default gateway** to be the IP address of the router, and if the destination is outside the network the packets are forwarded by the router.*

What does this have to do with subnets?

IP addresses take the general form of `<network><host>`. Sometimes you want to separate some devices on your network from others, like you might in a guest network where visitors shouldn't get access to your network drive. In this situation, you might consider breaking your network into smaller networks - or ***subnets***. When we do this, we use the last part of the `<network>` part of the address to define separate subnets.

Subnet addresses	192.168.**0**.0, 192.168.**1**.0, 192.168.**2**.0, ..., 192.168.**255**.0
Subnet mask (binary)	1111 1111 . 1111 1111 . **1111 1111 .** 0000 0000
Network/hosts	|------network-------|　**|subnet-|**　|-hosts-|
Host ranges	192.168.**X**.1 - 192.168.**X**.254　(where **X** is anything from 0 - 255)

Let's take a look at an example network, where two townhouses are sharing an internet connection on the same network. Each device in the picture (that isn't a router) has a subnet mask of `255.255.255.0`.

Let's look at some of these devices, all of these devices in the house have the same subnet, which means they can communicate to other devices in the same network. But the devices in the separate townhouses can't communicate with each other.

Device	Left house - IP addresses			Right house - IP addresses		
	Network	Subnet	Host	Network	Subnet	Host
Router	192.168	**30**	1	192.168	**20**	1
Computer	192.168	**30**	154	192.168	**20**	12
Smart TV	192.168	**30**	132	192.168	**20**	46
Smart light	192.168	**30**	118	192.168	**20**	87
Google home	192.168	**30**	90			
Phone				192.168	**20**	32
Smart fridge				192.168	**20**	125

A shorthand notation

*There is a shorthand way to specify an IP address and the associated subnet masks. For example: 192.168.1.33**/24**. The "/24" indicates there are 24 1s in the subnet mask. In other words, it's saying the subnet mask is*

$$1111\ 1111\ .\ 1111\ 1111\ .\ 1111\ 1111\ .\ 0000\ 0000$$

*which is our old friend **255.255.255**.0.*

Since subnet masks always start with 1s, this shorthand notation just says how many 1s there are in the subnet mask - that's it! This is called Classless Inter-Domain Routing (or CIDR)
https://en.wikipedia.org/wiki/Classless_Inter-Domain_Routing.

Questions

Question 1
The network address is `172.10.45.22/16`, what is the subnet mask?
** Find the answer in the box titled **A shorthand notation***

Question 2
Take a look at the image in the ***What does this have to do with subnets*** section. A pair of townhouses are sharing an internet connection, but each have their own routers and networks.

    a)   Why is it useful for them to be on separate networks?

_____

_____

** Find the answer in the section **What does this have to do with subnets***

    b)   One of the devices has a problem. It still connects to the internet, but it can't connect to the smart TV in the same house. What is the problem, and which device is it?

        Problem: _____

        Problem device IP address: _____

** Use the image in the section **What does this have to do with subnets***

Question 3
`255.255.115.0` - Is this a valid subnet mask?
** Find the answer in the section **LAN and subnet masks***

Question 4
A device has an address of `192.160.33.5/24`. What address would you use to broadcast a message to everyone on the same subnet?
** Find the answer in the box titled **Reserved addresses - broadcasting and the network address***

Question 5

The printer is at `10.0.160.5/20`. Which devices can print on the printer?
** Find the answer in the section **What does this have to do with subnets***

Laptop 1 - `10.0.162.6`
Laptop 2 - `10.0.172.5`
Laptop 3 - `10.10.3.165`
Laptop 4 - `10.0.159.240`
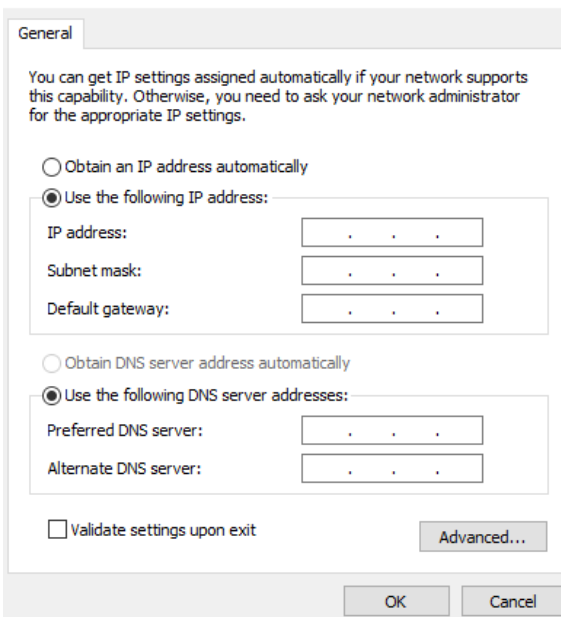Laptop 5 - `10.0.160.25`

Question 6

You have invited 2 other friends over for a LAN party to play games, and are configuring the 3 devices. Unfortunately you find the router you have is broken, but you still want to be able to play. Luckily, you have a network switch and can plug everything in. What do you put in each field so the devices can communicate? (You can specify your own network configuration)

Ignore the DNS settings, you don't need them.

Computer 1

Internet Protocol Version 4 (TCP/IPv4) Properties   ✕

General

You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.

○ Obtain an IP address automatically
◉ Use the following IP address:

IP address: .   .   .
Subnet mask: .   .   .
Default gateway: .   .   .

○ Obtain DNS server address automatically
◉ Use the following DNS server addresses:

Preferred DNS server: .   .   .
Alternate DNS server: .   .   .
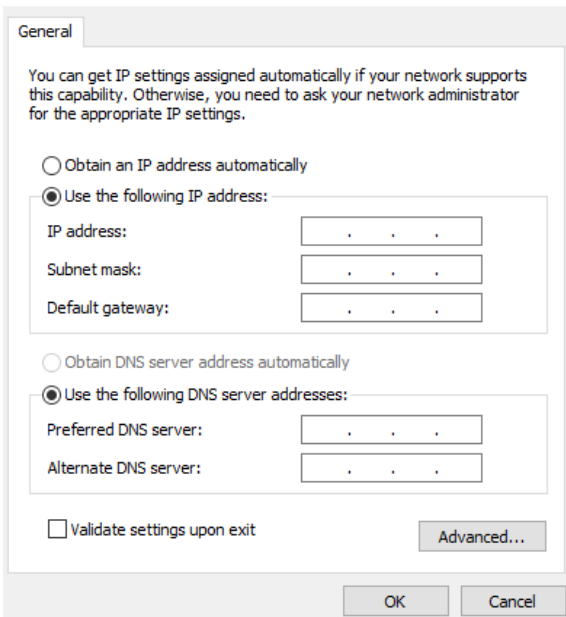
☐ Validate settings upon exit   Advanced...

OK   Cancel

Computer 2

Internet Protocol Version 4 (TCP/IPv4) Properties   ✕

General

You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.

○ Obtain an IP address automatically
◉ Use the following IP address:

IP address: .   .   .
Subnet mask: .   .   .
Default gateway: .   .   .

○ Obtain DNS server address automatically
◉ Use the following DNS server addresses:

Preferred DNS server: .   .   .
Alternate DNS server: .   .   .

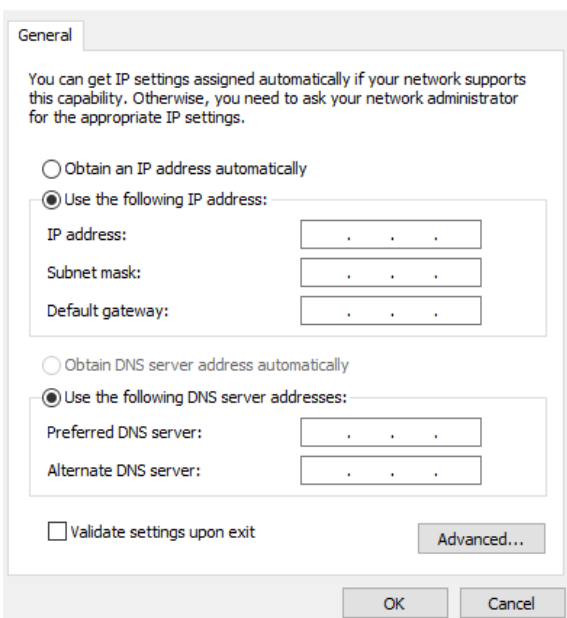☐ Validate settings upon exit   Advanced...

OK   Cancel

Computer 3

Internet Protocol Version 4 (TCP/IPv4) Properties   ✕

General

You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.

○ Obtain an IP address automatically
◉ Use the following IP address:

IP address: .   .   .
Subnet mask: .   .   .
Default gateway: .   .   .

○ Obtain DNS server address automatically
◉ Use the following DNS server addresses:

Preferred DNS server: .   .   .
Alternate DNS server: .   .   .

☐ Validate settings upon exit   Advanced...

OK   Cancel

Answer key

Choose if you want to print this for your kids
or keep it to yourself!

Answer 1

The network address is `172.10.45.22/16`
Subnet mask is:
`255.255.0.0`
Since the end is /16, we know there are 16 1s in the subnet mask.

Expanding the above into binary

```
1111 1111 . 1111 1111 . 0000 0000 . 0000 0000
   255    .    255    .    0      .    0
```

Answer 2

a) They should use separate subnets so that their devices are separated. If not, they could access their neighbors printer, smart TV, or Google home, which is undesirable.
b) The left house's laptop is configured wrong. It's on the neighbours network!
It's IP address is `192.168.20.233`

Answer 3

No - 255.255.115.0 is not a valid subnet mask. Converting it to binary it looks like this:
1111 1111 . 1111 1111 . **01**11 **001**1 . 0000 0000

Since there is a mix of 1s *after* 0s, it is not a valid subnet mask.

Answer 4

192.160.33.255 - since 255 is reserved for broadcast messages to everyone on that subnet.

Answer 5

The subnet mask becomes:
```
255.255.240.0
11111111.11111111.11110000.00000000
```
So we can see that any devices with the same first 20 digits of their IP address will be on the same network.

The printer is at:
```
10.0.160.5
00001010.00000000.10100000.00000101
```

So any device whose IP address starts with `00001010.00000000.1010` is on the same network.

To check this, convert each address to binary, and compare their initial numbers to the printers'.

	IP Address	Binary IP Address	Matches printer?
Laptop 1	10.0.162.6	0000 1010 . 0000 0000 . 1010 0010 . 0000 0110	**Yes**
Laptop 2	10.0.172.5	0000 1010 . 0000 0000 . 1010 1100 . 0000 0101	**Yes**
Laptop 3	10.10.3.165	0000 1010 . 0000 1010 . 0000 0011 . 1010 0101	**No**
Laptop 4	10.0.159.240	0000 1010 . 0000 0000 . 1001 1111 . 1111 0000	**No**
Laptop 5	10.0.160.25	0000 1010 . 0000 0000 . 1010 0000 . 0001 1001	**Yes**

Answer 6

This is a screen that has often faced students who want to set up their LAN party. There are *millions* of different answers here. Since there are only 3 devices, we want to have a small subnet, 255.255.255.0 is a sensible default choice. Any host number between 1 and 254 will work, as long as there are *no conflicts*. You can add more bits to the mask, if you like. The IP addresses should be narrow accordingly.

The default gateway field is not used, since there is no external communication. **So you can leave that field empty**, or just put in a number that doesn't conflict like 192.168.0.1 as a default (even though it doesn't exist). Either will work.

This page is for

Internet Protocol Version 4 (TCP/IPv4) Properties ✕

General

You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.

○ Obtain an IP address automatically
◉ Use the following IP address:

IP address: 192 . 168 . 0 . 5
Subnet mask: 255 . 255 . 255 . 0
Default gateway: 192 . 168 . 0 . 1

○ Obtain DNS server address automatically
◉ Use the following DNS server addresses:

Preferred DNS server: . . .
Alternate DNS server: . . .

☐ Validate settings upon exit   Advanced...

OK   Cancel

Internet Protocol Version 4 (TCP/IPv4) Properties ✕

General

You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.

○ Obtain an IP address automatically
◉ Use the following IP address:

IP address: 192 . 168 . 0 . 50
Subnet mask: 255 . 255 . 255 . 0
Default gateway: 192 . 168 . 0 . 1

○ Obtain DNS server address automatically
◉ Use the following DNS server addresses:

Preferred DNS server: . . .
Alternate DNS server: . . .

☐ Validate settings upon exit   Advanced...

OK   Cancel

Internet Protocol Version 4 (TCP/IPv4) Properties ✕

General

You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.

○ Obtain an IP address automatically
◉ Use the following IP address:

IP address: 192 . 168 . 0 . 150
Subnet mask: 255 . 255 . 255 . 0
Default gateway: 192 . 168 . 0 . 1

○ Obtain DNS server address automatically
◉ Use the following DNS server addresses:

Preferred DNS server: . . .
Alternate DNS server: . . .

☐ Validate settings upon exit   Advanced...

OK   Cancel

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Developed by the Australian Computing Academy, the University of Sydney.
Find out more: aca.edu.au, get help: help@aca.edu.au

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Want more?

Here are some further activities, online resources, assessment ideas and curriculum references.

This is just the start of networking

Once students understand how local networks operate, you can extend into routing, how IP addresses are allocated, types of data packets and more!

There's a whole lot more to networking than what was covered here! A few topics to investigate:

1. DHCP - how devices get assigned IP addresses automatically
2. DNS - how words (like google.com) are converted into a destination IP addresses
3. TCP - what is put inside a data packet so information can be sent back and forth reliably

Keep the conversation going

- What's the purpose of subnet masks?
- What would happen if any host could communicate with a wider range of IP addresses?
- What happens if we run out of addresses?

Keep learning

For High School students interested in learning more about how computers communicate, try this course: cmp.ac/networksec

Linking it back to the Australian Curriculum: Digital Technologies

Digital Systems
Investigate the role of hardware and software in managing, controlling and securing **the movement of** and access to **data in networked digital systems**. (ACTDIK034 - see cmp.ac/systems)

Refer to aca.edu.au/curriculum for more curriculum information.