Network speeds and transmission time

4.1.5 · Networks · revision notes

Network speeds are measured in bits per second, using kilobits, megabits and gigabits. You need to convert between units and, because Paper 1 is taken without a calculator, construct expressions that link file size, transmission rate and time. Expect short 'Calculate' and 'Construct an expression' questions.

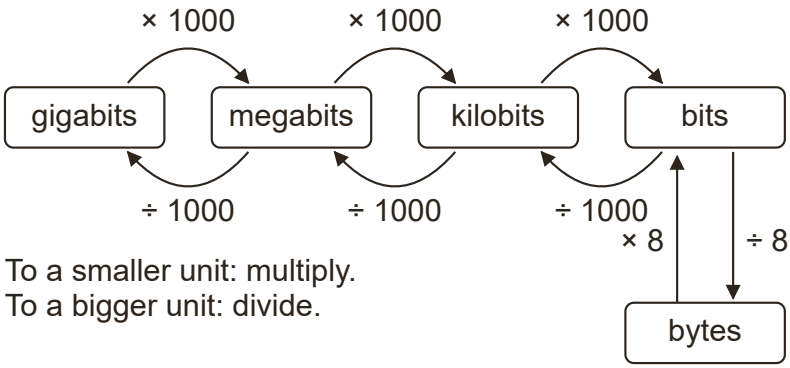
Key facts

- Network speed is measured in bits per second (bps)
- 1 byte = 8 bits
- time = file size ÷ transmission rate
- transmission rate = file size ÷ time
- 1 kilobit = 1000 bits; 1 megabit = 1000 kilobits; 1 gigabit = 1000 megabits
- 1 KiB = 1024 bytes; 1 MiB = 1024 × 1024 bytes; 1 GiB = 1024 × 1024 × 1024 bytes
- file size = transmission rate × time
- minutes = seconds ÷ 60

Notes

Units of network speed

- Network speed (transmission rate) is measured in **bits per second (bps)**.
- 1 kilobit = 1000 bits; 1 megabit = 1000 kilobits = 1,000,000 bits; 1 gigabit = 1000 megabits = 1,000,000,000 bits.
- So 1 kbps = 1000 bits per second, 1 Mbps = 1,000,000 bits per second and 1 Gbps = 1,000,000,000 bits per second.

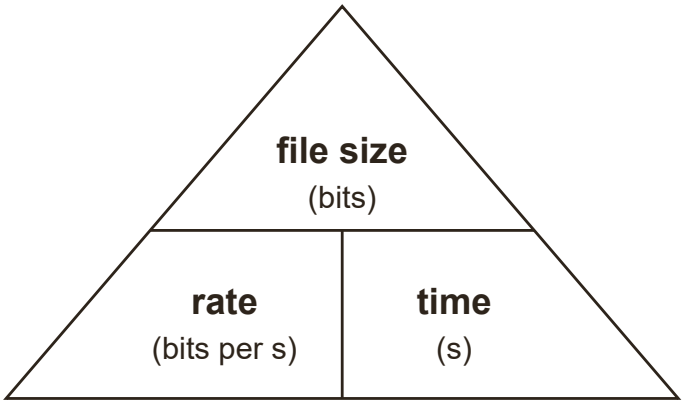


Each step between network units is × 1000 or ÷ 1000. 8 bits make 1 byte.

- File sizes are usually given in bytes, and 1 byte = 8 bits. Storage units go up in powers of 2, e.g. 1 KiB = 1024 bytes and 1 MiB = 1024 × 1024 bytes.
- Exam questions usually tell you which conversions to use. Always use the ones given.

The formula

- **time = file size ÷ transmission rate**
- Rearranged: **file size = transmission rate × time** and **transmission rate = file size ÷ time**.



Cover the one you want: time = file size ÷ rate

file size = rate × time. Cover the quantity you want to find to see the formula.

- The file size and the rate must be in matching units, usually bits and bits per second. The time then comes out in seconds.
- To give a time in minutes, divide the number of seconds by 60.

Method for a transmission time

- 1. Convert the file size to bits, e.g. for MiB: × 1024 × 1024 × 8.
- 2. Convert the rate to bits per second, e.g. for Mbps: × 1,000,000.
- 3. Divide the file size in bits by the rate in bits per second.
- Example: a 5 MiB file sent at 10 Mbps takes 5 × 1024 × 1024 × 8 ÷ (10 × 1,000,000) seconds, which is about 4.2 seconds.
- Real transfers take longer than this: the bandwidth may be shared with other users, wireless signals suffer interference, packet headers add extra data and lost packets have to be resent. Grade 7+ only

How to answer each type of question

Convert between units

1 mark | Grade 4

1. Bytes to bits: × 8. Bits to bytes: ÷ 8.
2. Up one prefix (bits → kilobits → megabits → gigabits): ÷ 1000. Down one prefix: × 1000.

Example. (a) A connection has a transmission rate of 25 megabits per second (Mbps). State this rate in bits per second. (1)
(b) A message is 6000 bits long. State its size in bytes. (1)

Model answer.

(a) 25,000,000 bits per second (1)
(b) 6000 ÷ 8 = 750 bytes (1)

Calculate a transmission time

2 marks | Grade 5

1. Write down the formula: time = file size ÷ transmission rate.
2. Make sure both values use matching units, e.g. megabits and megabits per second.
3. Divide, and give the unit (seconds).

Example. A file of 720 megabits is downloaded over a connection with a transmission rate of 60 megabits per second (Mbps).
Calculate the time taken, in seconds, to download the file. (2)

Model answer. 720 ÷ 60 (1) = 12 seconds (1)

Construct an expression for the transmission time

2 to 3 marks | Grade 6

1. Convert the file size to bits (e.g. × 1024 × 1024 × 8 for MiB).
2. Divide by the rate in bits per second (e.g. Mbps × 1,000,000), using brackets.
3. If the time is wanted in minutes, divide by 60 at the end.
4. Do not work out the answer if the question says you do not need to.

Example. A 64 MiB file is uploaded over a connection with an upload speed of 16 megabits per second (Mbps). 1 MiB = 1024 × 1024 bytes and 1 megabit = 1,000,000 bits.
Construct an expression to calculate the time, in minutes, to upload the file. You do not need to do the calculation. (3)

Model answer.

64 × 1024 × 1024 × 8 ÷ (16 × 1,000,000) ÷ 60
64 × 1024 × 1024 × 8, the file size in bits (1)
÷ (16 × 1,000,000), the rate in bits per second (1)
÷ 60, to change seconds into minutes (1)

Calculate the amount of data sent, or the rate

2 marks | Grade 7

1. Rearrange the formula: file size = rate × time, or rate = file size ÷ time.
2. Change the time into seconds first (minutes × 60).
3. Convert the answer into the unit asked for.

Example. A video call uses data at an average rate of 2 megabits per second (Mbps).
Calculate the amount of data used by a 30-minute call. Give your answer in gigabits. (2)

Model answer.

30 × 60 = 1800 seconds, and 2 × 1800 = 3600 megabits (1)
3600 ÷ 1000 = 3.6 gigabits (1)

Give reasons why the actual time is longer

1 to 2 marks | Grade 7

1. Think about what else is using or affecting the connection.
2. Give specific reasons, not just 'the internet is slow'.

Example. A student calculates that a file should download in 8 seconds, but it actually takes 11 seconds.
Give **two** reasons why the download took longer than calculated. (2)

Model answer. Any two from: other devices were sharing the bandwidth (1); interference or a weak wireless signal (1); packet headers add extra data that must be sent (1); lost or damaged packets had to be resent (1); the server could not send the data at the full rate (1).

Don’t lose marks

- Forgetting to multiply bytes by 8, which makes the time 8 times too small.
- Dividing by 1024 for network speeds. Kilo, mega and giga in bits per second use 1000, unless the question says otherwise.
- Using the download speed when the question is about uploading, or the other way round.
- Dividing the rate by the file size instead of the file size by the rate.
- Leaving the answer in seconds when the question asks for minutes.
- Working out a long answer when the question only asks for an expression: there are no extra marks, and a slip could cost you.

More tips

Memory tricks

- Speeds are in bits (small b); file sizes are in bytes (big B). Mbps is not the same as MBps.
- Formula triangle: file size on top, rate and time on the bottom. Cover the one you want.
- Sense check: a byte is 8 bits, so an 8 Mbps connection moves only 1,000,000 bytes each second.
- Minutes: seconds ÷ 60. Hours: seconds ÷ 3600.

Exam technique

- Build your expression step by step and label each part, e.g. '(file size in bits)', so that method marks can be awarded.
- Put brackets around the rate, e.g. ÷ (16 × 1,000,000), so the expression can only mean one thing.
- Always use the unit conversions given in the question.
- Give units with every numerical answer: seconds, bits, Mbps.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 — **State the unit of network speed**
Network speed is measured in bits per second (bps), with kbps, Mbps and Gbps for larger rates.

Grade 4 — **Convert between bits and bytes**
Multiply a number of bytes by 8 to get bits, and divide a number of bits by 8 to get bytes.

Grade 5 — **Convert between kilobits, megabits and gigabits**
Multiply or divide by 1000 for each step, e.g. 3 Mbps = 3,000,000 bits per second.

Grade 5 — **Calculate time from file size and rate**
Use time = file size ÷ transmission rate, with the file size and the rate in matching units.

Grade 6 — **Construct an expression for transmission time**
For example, 20 × 1024 × 1024 × 8 ÷ (40 × 1,000,000) seconds for a 20 MiB file at 40 Mbps.

Grade 7 — **Rearrange the formula for size or rate**
Use file size = transmission rate × time, or transmission rate = file size ÷ time.

Grade 7 — **Explain why real transfers take longer**
Shared bandwidth, interference, packet headers and resent packets all add to the time taken.

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