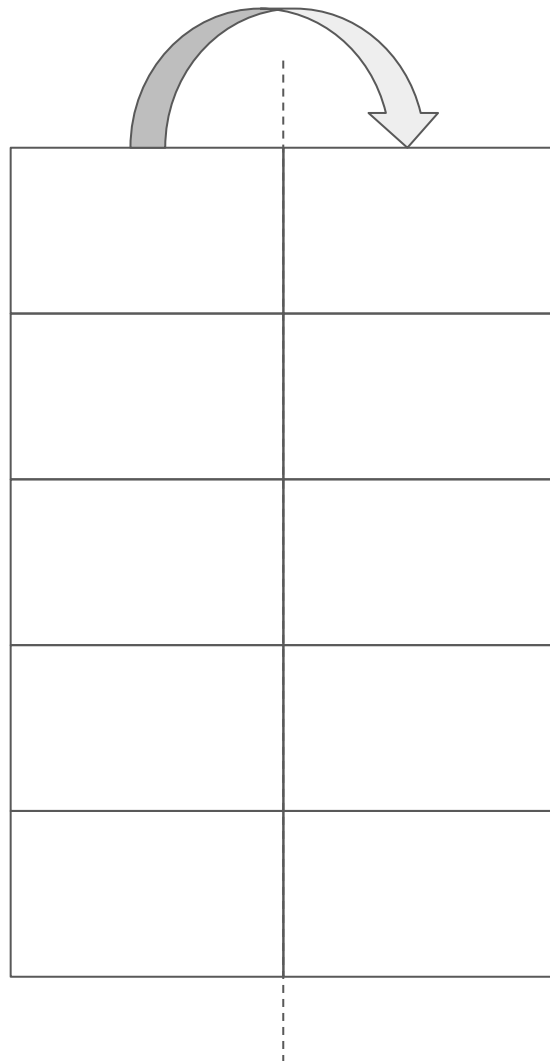


Instructions

- Print as one page per sheet
- Fold and glue together
- Cut out individual cards



**Power of Two
1 KB?**

$$1 \text{ KB} = 2^{10} \text{ bytes}$$

**Power of Two
64 KB?**

$$64 \text{ KB} = 2^{16} \text{ bytes}$$

**Power of Two
1 MB?**

$$1 \text{ MB} = 2^{20} \text{ bytes}$$

**Power of Two
1 GB?**

$$1 \text{ GB} = 2^{30} \text{ bytes}$$

**Power of Two
4 GB?**

$$4 \text{ GB} = 2^{32} \text{ bytes}$$

**Power of Two
1 TB?**

1 TB = 2^{40} bytes

**Time
L1 Cache Reference**

0.5 ns

**Time
Branch Mispredict**

5 ns

**Time
L2 Cache Reference**

**7 ns
(14x L1)**

**Time
Mutex lock/unlock**

100 ns

Time Main Memory Reference	100 ns (20x L2, 200x L1)
Time Compress 1 KB with Zippy	10,000 ns 10 us
Time Send 1 KB over Gbit network	10,000 ns 10 us
Time Read 4 KB randomly from SSD	150,000 ns 150 us
Speed Round trips within same data center per second?	Speed Round trips within same data center per second?

Time Read 1 MB sequentially from memory	250,000 ns 250 us
Time Round trip within same datacenter	500,000 ns 500 us
Time Read 1 MB sequentially from SSD	1 ms (4x memory)
Time Disk seek	10 ms (20x data center roundtrip)
Time Read 1 MB sequentially from Gbit network	10 ms (40x memory, 10x SSD)

<p>Time Read 1 MB sequentially from disk</p>	<p>30 ms (120x memory, 30x SSD)</p>
<p>Time Round trip CA-AMS-CA</p>	<p>150 ms</p>
<p>Power of ten? ns / us / ms</p>	<p>ns = 10⁻⁹ s us = 10⁻⁶ s ms = 10⁻³ s</p>
<p>Speed Read sequentially from disk</p>	<p>30 MB/s</p>
<p>Speed Read sequentially from Gbit network</p>	<p>100 MB/s</p>

**Speed
Read sequentially
from SSD**

1 GB/s

**Speed
Read sequentially
from memory**

4 GB/s

**Speed
World-wide round trips
per second?**

**6-7 world-wide round trips
per second**