Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

offset: the low 12 bits, `0x345`

page number `0x12`

2.2

page 2, offset `0xF10`

frame 5: `0x5F10`

2.3

1, 2, 3 fault; 1 hits

4 evicts 2; 2 evicts 3; 5 evicts 1

6 faults

2.4

hit: $1 + 100 = 101$ ns; miss: $1 + 100 + 100 = 201$ ns

$0.98 \times 101 + 0.02 \times 201$

$=$ **103** ns

3.1

(a) 7, 0, 1, 2 fault; 0 hits; 3 evicts 0; 0 evicts 1; 4 evicts 2: **7**

(b) 2 evicts 7; 0 hits; 3 evicts 1; 0 hits; 4 evicts 2: **6**

(c) 2 evicts 7 (never used again); 3 evicts 1; 4 evicts 2 or 3: **6**

(d) Belady's anomaly

3.2

(a) $(1 - p) \times 100 + p \times 10^7 \leq 110$ ns; $p(10^7 - 100) \leq 10$; $p \leq \mathbf{1 \times 10^{-6}}$: one fault in a million accesses

(b) the processes together need more pages than there are frames, so pages are evicted and faulted back in again and again, and little work is done; suspend some processes (or swap them out) so the rest fit in memory

3.3

(a) $2^{48-12} = 2^{36}$ entries; $\times 8$ B $= 2^{39}$ B $=$ **512 GiB**: far too large

(b) $4 \times 9 + 12 = 48$ bits; each table has $2^9 = 512$ entries $\times 8$ B $=$ **4 KiB**, one page

(c) 64×4 KiB $=$ **256 KiB**; 64×2 MiB $=$ **128 MiB**

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(d) yes: with 4 KiB pages almost every access to a 100 GB cache would miss the TLB and need a 4-level walk; huge pages cover 512 times more per entry and need one fewer level