



A9.1 Hardware, software and the stored program

Computer architecture · A level · OCR H446 1.1.1, AQA 7517 4.6.1.1,
Eduqas A500QS 2.1 · about 20 min

What this lesson is about

Internal components, the three buses and their widths, I/O controllers, the stored program concept, and von Neumann against Harvard.

- Hardware and software
- The internal components
- The stored program concept
- Von Neumann and Harvard
- The robot's processor

Questions

6 marks in all

1. Which bus is unidirectional, carrying signals only from the processor? [1 mark]

- ☐ A Address bus
- ☐ B Data bus
- ☐ C Control bus
- ☐ D All three

Answer: A. The processor puts addresses on the address bus; data and control lines carry signals both ways.

2. A processor has a 20-bit address bus. How many different memory addresses can it use? [1 mark]

Answer: 1048576. 2 to the power 20 is 1,048,576.

3. Which statement is the stored program concept? [1 mark]

- ☐ A Machine code instructions are stored in main memory and fetched and executed serially by the processor
- ☐ B Programs are stored on secondary storage so they survive power loss
- ☐ C Instructions and data are kept in separate memories
- ☐ D A program is set up by wiring the processor for each job

Answer: A. The program sits in main memory with its data and is fetched and executed one instruction at a time.

4. Where is the Harvard architecture typically used?

[1 mark]

- ☐ A Embedded systems and digital signal processors
- ☐ B Desktop PCs running many applications
- ☐ C Web servers
- ☐ D Spreadsheet software

Answer: A. Separate instruction and data memories suit fixed programs in flash and fast, predictable timing.

5. What is the job of an I/O controller?

[1 mark]

- ☐ A To connect a device to the buses and translate between the processor's signals and the device's
- ☐ B To store the program while it runs
- ☐ C To decode instructions
- ☐ D To add numbers for the processor

Answer: A. The processor reads and writes the controller like memory; the controller handles the device.

6. How does hardware relate to software?

[1 mark]

- ☐ A Software is instructions that only do something when run on hardware, and hardware needs software to tell it what to do
- ☐ B Software is the physical parts and hardware is the programs
- ☐ C Hardware can do useful work without any software
- ☐ D Software is only the operating system

Answer: A. Each is useless without the other; software is ultimately machine code for the hardware's instruction set.

The task: bus widths

Work out what a bus of a given width can carry. - For each address bus width in [12, 16, 24, 32] bits, print how many different addresses it can make, as a whole number with no commas, in the form address bus 16 bits: 65536 addresses . - For each data bus width in [8, 16, 32] bits, print the smallest and largest unsigned whole number it can carry, in the form data bus 8 bits: 0 to 255 . Print the seven lines in that order. The robot does not move.

```
# the two lines every program starts with: the commands, then the robot
from bugbot import *
connect()

address_widths = [12, 16, 24, 32]
data_widths = [8, 16, 32]
```

The hint students can ask for: Each wire carries one bit, so ask how many different patterns a given number of bits can make. The smallest unsigned value is all zeros; the largest is all ones, which is one less than the number of patterns.

A solution

```
from bugbot import *
connect()
address_widths = [12, 16, 24, 32]
data_widths = [8, 16, 32]
for n in address_widths:
    print(f"address bus {n} bits: {2 ** n} addresses")
for w in data_widths:
    print(f"data bus {w} bits: 0 to {2 ** w - 1}")
```

Any program that meets the task's checks is marked correct in the simulator; this is one way, not the only way.