Embedded systems

1.1.3 · Computer systems (Paper 1) · revision notes

An embedded system is a computer system built into a larger device to carry out a dedicated function. You need to know what embedded systems are used for, their characteristics and examples, and how they differ from general-purpose computers. Questions are usually short recall or 2 to 4 mark 'describe' and 'explain' items set in a scenario.

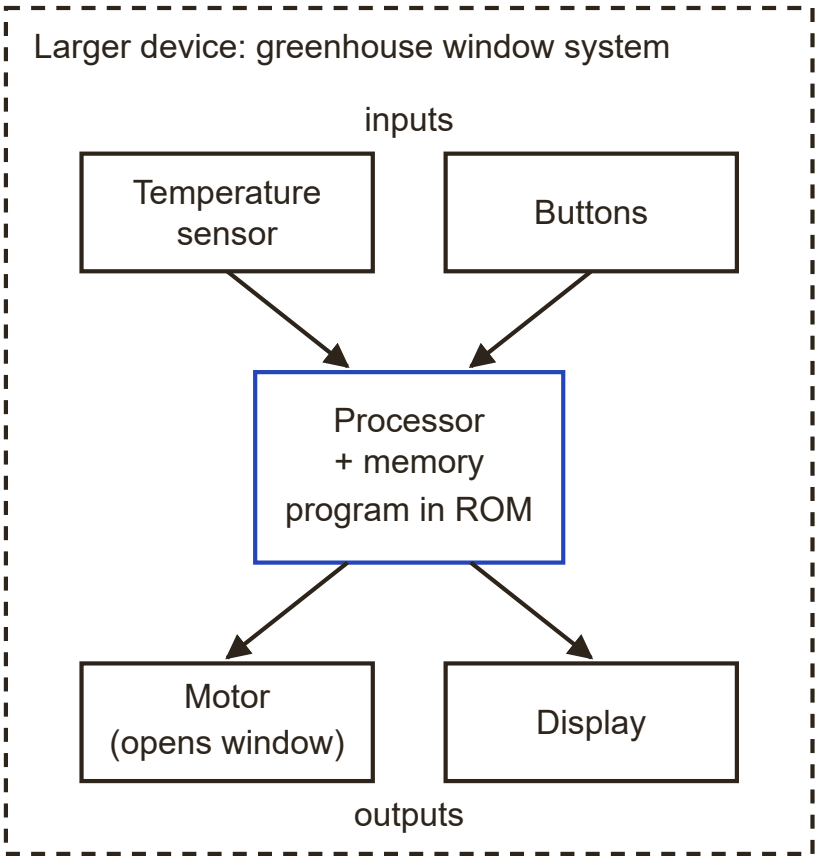
Key facts

- Embedded system: a computer system inside a larger device with a dedicated function
- Characteristics: dedicated, small, low power, low cost, reliable
- Simple or no user interface; inputs often come from sensors
- Examples: washing machine, microwave, thermostat, traffic lights, car engine management, fitness tracker
- Program stored in ROM or flash: non-volatile and not changed by the user
- General-purpose computer: runs many programs; the user can install software

Notes

What an embedded system is

- An **embedded system** is a computer system built into a larger device or machine to carry out a **dedicated function**: one specific task or a small set of related tasks.
- It has a processor, memory, and inputs and outputs, like any computer, but they are usually small and simple.



An embedded system: inputs, a dedicated processor with its program in ROM, and outputs, all built into a larger device

- Examples: washing machines, dishwashers, microwaves, central heating thermostats, traffic lights, digital cameras, fitness trackers, and car systems such as engine management and anti-lock brakes.
- Users often don't think of it as a computer: they just press buttons on the device.

Characteristics

- **Dedicated**: it runs one program to do one job, e.g. controlling a wash cycle.
- **Small**: it fits inside the device it controls.
- **Low power**: it can run from a battery for a long time, or costs very little to run.
- **Low cost**: it can be mass-produced cheaply for everyday products.
- **Reliable**: its simple, fixed program is well tested, so it can run for years without failing. Many respond to inputs immediately, e.g. a car's airbag controller.
- Its program is usually stored in **ROM** or flash memory, which is non-volatile, so the program is kept when the power is off and the user cannot easily change it.
- It often has a very simple interface (a few buttons and a small display) or none at all, and reads its inputs from sensors.

Embedded vs general-purpose computers

- A general-purpose computer, such as a laptop, can run many different programs. The user can install new software and often upgrade the hardware.
- An embedded system does one job. The user cannot install new programs and its hardware cannot be upgraded, although the manufacturer may send a software (firmware) update, e.g. to a smart TV.

How to answer each type of question

State what an embedded system is and identify examples 1 to 3 marks **Grade 3**

1. Define it using both ideas: inside a larger device, with a dedicated function.
2. For examples, pick everyday devices that do one job, not laptops, desktop PCs or tablets.

Example. (a) State what is meant by an embedded system. [1]
(b) Identify **two** devices in a home that are likely to contain an embedded system. [2]

Model answer.

(a) A computer system built into a larger device to carry out a dedicated function (1).

(b) Any two, e.g. a microwave oven (1), a smart thermostat (1). Also accept dishwasher, washing machine, fridge, burglar alarm, TV. Do not accept laptop, desktop PC or tablet.

Describe characteristics that make embedded systems suitable

2 to 4 marks | Grade 5

1. Name a characteristic (1 mark).
2. Expand it with a reason linked to the device in the question (1 mark).
3. Repeat for the number of characteristics asked for.

Example. A fitness tracker worn on the wrist contains an embedded system.
Describe **two** characteristics of embedded systems that make them suitable for a fitness tracker. [4]

Model answer. Low power consumption (1), so the tracker's small battery lasts several days between charges (1). Small in size (1), so it fits inside a device worn on the wrist (1). Also accept: dedicated function, so it only needs to count steps and measure heart rate; reliable, so it runs all day without crashing; low cost, so the tracker is affordable.

Compare an embedded system with a general-purpose computer

4 marks | Grade 6

1. Make every point a direct comparison: 'the embedded system…, whereas the computer…'.
2. Cover different features: purpose, software, interface, size, cost and power, upgrades.
3. One comparison per mark.

Example. Compare the embedded system in a microwave oven with a desktop computer. [4]

Model answer. The microwave's system has one dedicated function (controlling the power and timer), whereas a desktop runs many different programs (1). The microwave's program is fixed in ROM, whereas the user can install and change software on a desktop (1). The microwave has a simple interface of buttons and a small display, whereas a desktop has a keyboard, mouse and large screen (1). The microwave's system is small, cheap and low power, whereas a desktop is larger, more powerful and more expensive (1).

Describe how an embedded system controls a device

3 marks | Grade 7

1. Start with the input: what it reads, and that it reads it repeatedly.
2. Describe the decision: what it compares the reading with.
3. Describe the output: what it switches on or off in each case.

Example. A greenhouse window is controlled by an embedded system connected to a temperature sensor. The window should be open when the temperature is above 28 °C.
Describe how the embedded system controls the window. [3]

Model answer. It repeatedly reads the temperature from the sensor (1). It compares the reading with 28 °C (1). If the temperature is above 28 °C it sends a signal to open the window; otherwise it closes the window or keeps it closed (1).

Don’t lose marks

- Giving a laptop, desktop PC or tablet as an example. These are general-purpose computers.
- Just listing characteristics ('small, cheap') when the question says 'describe' or 'explain'. Add why each one matters for the device.
- Saying embedded systems have no CPU or no memory. They have both, just smaller and simpler.
- Saying the program is stored in RAM. It is stored in non-volatile memory (ROM or flash) so it is kept when the power is off.

More tips

Memory tricks

- Quick test: does it do one job inside a bigger device, with no way for the user to install new apps? Then it is embedded.
- Characteristics: 'Does Sam Like Lemon Rolls?' = Dedicated, Small, Low cost, Low power, Reliable.
- Characteristic + 'so' + a link to the device = 2 marks.

Exam technique

- Always use the device in the question: 'low power' earns more with 'so the smoke alarm's battery lasts for years'.
- In comparisons, use 'whereas' so every point mentions both systems.
- Use the phrase 'dedicated function' in definitions: examiners look for the idea of one specific task inside a larger device.

What each grade needs

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

Grade 3 — **Define an embedded system**
A computer system inside a larger device that carries out a dedicated function.

Grade 3 — **Give examples of embedded systems**
E.g. the controller in a washing machine or microwave, a smart thermostat, or a car's engine management system.

Grade 4 — **State the characteristics of embedded systems**
Dedicated function, small, low power, low cost, reliable, with the program usually stored in ROM.

Grade 5 — **Explain why a device uses an embedded system**
Link each characteristic to the device, e.g. low power, so a fitness tracker's battery lasts for days.

Grade 6 — **Compare embedded and general-purpose computers**
A laptop runs many programs that the user can change; an embedded system runs one fixed program.

Grade 7 — **Describe how an embedded system controls a device**
Describe the inputs (e.g. sensors), the decision it makes and the output it controls in an unfamiliar device.

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