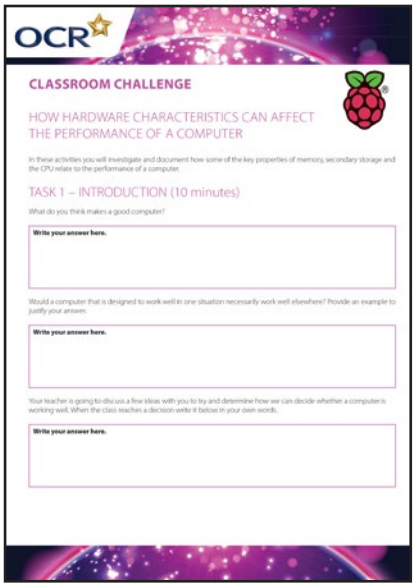
CLASSROOM CHALLENGE: INSTRUCTIONS AND ANSWERS FOR TEACHERS

HOW HARDWARE CHARACTERISTICS CAN AFFECT THE PERFORMANCE OF A COMPUTER

These instructions should accompany the OCR resource 'How Hardware Characteristics Can Affect the Performance of a Computer'.

This activity encourages learners to build on their prior experiential learning to understand how hardware characteristics such as CPU speed affect the performance of a computer. Learners will undertake a number of quantitative experiments where they adjust various hardware parameters and measure the resultant performance of the Raspberry Pi. These results are recorded and a number of ideas are given for how these may be documented.


CLASSROOM CHALLENGE

HOW HARDWARE CHARACTERISTICS CAN AFFECT THE PERFORMANCE OF A COMPUTER

In these activities you will investigate and document how some of the key properties of memory, secondary storage and the CPU relate to the performance of a computer.

TASK 1 – INTRODUCTION (10 minutes)

What do you think makes a good computer?

Write your answer here.

Would a computer that is designed to work well in one situation necessarily work well elsewhere? Provide an example to justify your answer.

Write your answer here.

Your teacher is going to discuss a few ideas with you to try and determine how we can decide whether a computer is working well. When the class reaches a decision write it below in your own words.

Write your answer here.

Expected approximate duration:

Task 1 - 10 minutes (30 minutes with extension task)

Task 2 - 30 minutes

Task 3 - 20–120 minutes dependent on option taken

It is recommended that learners are organized into small groups (pairs or threes) for these activities. Not only will this allow a synthesis of learning between more and less advanced students but they will be able to draw upon their own experiences when answering questions. In addition Task 2 requires actions to be timed which can be awkward if undertaken individually.

Finally, some follow-up areas (potentially for homework) are indicated at the end of this document.

To complete this activity the following resources are required:

- *Raspberry Pi model A or B (B recommended)*
- *Raspian Wheezy system image **on a variety of SD cards** (download: www.raspberrypi.org/downloads). A list of compatible SD cards can be found here - http://elinux.org/RPi_SD_cards. Note that the SD cards should have a stated capacity and speed (or class) written on them and it would be beneficial for a selection of both capacity and speed to be available*
- *HDMI or composite video cable and monitor*
- *Micro USB power supply – this should deliver 5volts and at least 900mA (note that the task of overclocking the CPU may increase this current requirement so it is worth investing in a supply able to provide 2A of current)*
- *Extra materials such as marker pens and paper may be needed dependent on how Task 3 is undertaken*
- *A way of taking photographs/videos – mobile phones work well here!*
- *A way of recording time – watch/stop-watch*

TASK 1

This task is designed to encourage students to think about what we (as consumers) want from a computer. This leads on to consideration about what factors will influence this.

Note that learners are expected to have knowledge of what the various pieces of hardware are together with basic scientific units such as Gb and MHz. It is recommended that this session is started with a plenary that recaps these topics.

Task flow is:

- Plenary to recap previous session(s). It would make sense that the previous session(s) looked at what the various pieces of hardware are and what they do.
- What do you think makes a good computer.
- Directed Question: "What do we mean when we say that a computer is working well?"
- Relay the question to other class members and write answers on dry-wipe board.
- Question for pairs to attempt: "What factors (things/characteristics) make a difference to how well a computer is performing?"
    - Get a member from each pair to write their ideas on the dry-wipe board.
    - This will lead to discussion of obvious factors like speed. The teacher may need to seed discussion about memory and storage media. For example "Why does the new Xbox 360 have 4GB of RAM? Can't we get away with just 2GB?"
    - There is no definitive answer for this. However quantity of RAM, CPU Speed, secondary storage capacity and speed are generally considered the 4 most important factors.
- Use this to create a class definition for a well performing computer.
    - The answer for this will depend on the context of use so possible answers may be "One that starts quickly so I can surf the Internet" or it might be "One that works reliably without me needing to check on it".

- Directed Question: "How can we test these factors to see what difference they make?"
    - The aim here is to guide discussions to the concept of benchmarking through controlled experiments to provide quantitative (measurable) results.
    - Use this as a way to introduce the tests to be undertaken in Task 2.

- Extension task: Students could design their own benchmark tests that investigate the importance of CPU speed, SD card properties and memory allocation.

TASK 2

Students are to carry out a series of benchmark tests that investigate the impact of varying CPU speed, memory allocation and using different types of memory card.

The learner instructions include details of how to carry out these tests together with tables for recording the results.

These instructions use the system boot time as the measurable benchmark. Whilst this is a test that can be undertaken by everyone it may not be overly engaging for some learners. As such, it is recommended that the teacher gives consideration to alternative tests that are in accordance with the context of the learners together with school policies. Possible examples include record the time taken to encode MP3 files or noting the frame-rate in games.

If an alternative benchmark is used then it will be necessary to edit the learner instructions accordingly (amendments will need to be made on pages 6–9).

Learners are expected to record benchmark times. In addition they may want to generate visual evidence (photograph or film) of their experiments. This would be particularly useful if they are going to be creating a video to document their findings.

Expected results are that:

- Performance increases with CPU speed.
    - This is because the computer can process instructions more quickly.
- Performance increases with memory allocated to RAM up to a point and then decreases.
    - This is because being able to store information in RAM is much faster than utilising secondary storage. However, allocating too much memory to RAM means that not enough is available for Graphics display which leads to graphics data utilising slow secondary storage instead!
    - The ideal balance varies between systems but allocating between 64MB and 128MB to graphics memory and the rest to traditional RAM is common.
- The stated "speed" of a memory card has an unpredictable impact on performance.
    - This is because there is no generally agreed standard for determining memory card performance. This means that manufacturers are free to use their test data in a manner that promotes their product in the best possible light.
    - For example a card could be sold as high-speed because it is particularly efficient at transferring large files. It may, however, suffer from particularly long access times which make it very slow when needing to work with multiple small files.
- The stated capacity of a memory card has little impact on performance provided that there is enough room for it to hold the operating system.

Sample answers to questions asked of students in relation to Task 2:

CPU INVESTIGATION

What do you think are the benefits of having a faster CPU?

- Ability to execute programs more quickly.

Are there any disadvantages?

- Yes – including that they tend to be more expensive; require a higher current from the power supply; and can get very hot.

Can you spot a pattern in the results?

- Yes – the time to boot up decreases as the CPU frequency increases.

SECONDARY MEMORY CAPACITY AND SPEED

Why do you think the inventors of the Raspberry Pi chose to use SD cards for secondary memory?

- One possibility is that they are readily available and the components needed to connect them to the rest of the computer are cheap.

What difference does having different capacity memory cards make to the time taken?

- Almost certainly no difference provided that the memory card is large enough to handle the task assigned to it. There is a chance that large capacity cards could suffer from excessive file fragmentation which would make them slower to use but this is unlikely in this scenario.

What difference does having different class/speed memory cards make to the time taken?

- In general systems using the higher class/speed memory cards should take less time than those using lower class/speed memory cards. It is worth noting, however, some of the comments in the verified list of Raspberry Pi peripherals indicate that some higher class cards do not perform particularly well. In addition it is not unknown for unscrupulous vendors to provide SD cards which are not of the quality advertised.

MEMORY ALLOCATION

What sort of programs do you think would require more video RAM to be available to them?

- Anything graphically intensive such as HD video playback or 3D games.

What would happen if that RAM was not available?

- Performance would degrade. In the case of video playback it would result in lost frames and choppiness. For 3D games it might mean that the game needs to be played at a lower resolution in order to be playable.

Can you see any patterns in your results? Which configuration worked best for you? Why do you think this was?

- The student answers will be dependent on the benchmarks being taken. Performance will be poor with very low video RAM allocation and will peak at either 64MB or 128MB. Justifications will relate to the graphical intensity of the benchmark compared to amount of processing being undertaken.

TASK 3

The final task is for learners to document their findings in a way that would be of benefit to non-IT experts. Three possible means are suggested.

1. In their groups students create a poster with no words on it to explain one of the changes they made and how it impacted performance.

   Posters are then pinned up around the class room and peers provide feedback in terms of a smiley face for the posters they understand and a question mark for those that they do not.

   It is recommended that students do not have access to the internet for this task. This makes them discuss their finding and to think about how to represent them rather than just doing a quick "Google images" search!

2. Groups/individuals write a user guide explaining how to improve the performance of your Raspberry Pi. If this approach is taken then students should be encouraged to take photographs in Task 2 which can be included here.

3. Groups use the photographs and film footage they created during Task 2 as the basis for an instructional video that explains how to improve the performance of a Raspberry Pi.

The created videos are shown to the class for peer feedback.

Task 3 will enable learners to reflect on and reinforce their learning. It also enables the teacher to verify that the students' understanding (schemas) is valid.

ADDITIONAL ACTIVITIES

Some elements cannot be addressed experimentally and will need an alternative approach. These could be assigned as research activities for homework. In particular you will want to consider:

- How cache size and number of cores affect performance.
- Why portability, durability and reliability of storage media/devices may be important to us.