270011 - SO - Operating Systems

Coordinating unit: 270 - FIB - Barcelona School of Informatics
Teaching unit: 701 - AC - Department of Computer Architecture
Academic year: 2019
Degree: BACHELOR’S DEGREE IN INFORMATICS ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)
BACHELOR’S DEGREE IN ENGINEERING PHYSICS (Syllabus 2011). (Teaching unit Optional)
ECTS credits: 6
Teaching languages: Catalan, Spanish, English

Teaching staff

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Prior skills

The student must have the technical capabilities that will confer the subjects studied previously and a minimum level of technical English (to read a documentation). In terms of technical capabilities could be summarized as:
- In terms of structure of computers: Understanding the main elements of a computer, these elements relate to each other, internal representation of data and basic knowledge of machine language.
- In terms of programming: Ability to program from scratch to include definition of data types, design a program more or less complex in different functions (which may be more than one file) and phases of creation an executable.

Requirements

- Prerequisite EC
- Prerequisite IC

Degree competences to which the subject contributes

Specific:
CT2.3. To design, develop, select and evaluate computer applications, systems and services and, at the same time, ensure its reliability, security and quality in function of ethical principles and the current legislation and normative.
CT3.6. To demonstrate knowledge about the ethical dimension of the company: in general, the social and corporative responsibility and, concretely, the civil and professional responsibilities of the informatics engineer.
CT6.1. To demonstrate knowledge and capacity to manage and maintain computer systems, services and applications.
CT6.2. To demonstrate knowledge, comprehension and capacity to evaluate the structure and architecture of computers, and the basic components that compound them.
CT6.3. To demonstrate knowledge about the characteristics, functionalities and structure of the Operating Systems allowing an adequate use, management and design, as well as the implementation of applications based on its services.
CT7.1. To demonstrate knowledge about metrics of quality and be able to use them.
CT7.2. To evaluate hardware/software systems in function of a determined criteria of quality.

CT7.3. To determine the factors that affect negatively the security and reliability of a hardware/software system, and minimize its effects.

CT8.4. To elaborate the list of technical conditions for a computer's installation fulfilling all the current standards and normative.

**Generic:**

G8. APPROPRIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a wide vision of the possibilities of the career in the field of Informatics Engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.

**Teaching methodology**

The course will mainly have two types of class: Theory and laboratories. The theory classes are mainly oriented to generic or to explain concepts applied to the particular case of Linux. These classes will be supported by slides. The laboratory classes are weekly and include work performed prior to the student, in class exercises to do individually and some questions that must be delivered at the end of class. Although all the sessions will include these questions to deliver, not all of them will be evaluated, only those that are marked as such. The rest will be used to track students and monitor the implementation of previous work and attitude of students in class. Especially in laboratory classes will be assessed issues such as student punctuality and positive attitude to the subject.

**Learning objectives of the subject**

1. Know the main functions of an OS and because of its necessity (abstraction / virtualització hardware, security, efficiency)
2. Understanding how the OS manages and provides its services and capabilities internally through data representation and management of resources, algorithms and hardware support
3. An overview of information systems: know the different interfaces and components that interact with the OS (hardware, system libraries, libraries + language user programs)
4. For each basic functionality of the system (process management, memory and I/O) know influencing basic aspects of the different architectures and environments that can support operating systems
5. For each basic functionality of the system (process management, memory and I/O): Understanding the hardware element that we want virtualizing
6. For each basic functionality of the system (process management, memory and I/O) know and be able to use the basic functionality offered by the system to the user.
7. For each basic functionality of the system (management processes, memory and I/O) know the basic elements of design (data types, data management structures and management algorithms) to offer this functionality.
8. For each basic functionality of the system (process management, memory and I/O): to know the basic architecture of the basic design elements in SO
9. For each basic resource which manages the OS (processes, virtual memory and I/O): to know the basic metric to assess service system and be able to apply the theoretical level.
10. For each basic resource which manages the system (processes, memory, I/O), know and be able to use basic tools to analyze a system's implementation and to monitor the state of the system to detect potential problems.
11. Understanding the implications, from the viewpoint of system and user of a multi-user parallel system.
12. Being able to participate in proactive professional development, demonstrating attendance, punctuality and respect
13. Being able to show motivation for quality and continuous improvement
### Study load

<table>
<thead>
<tr>
<th>Total learning time: 150h</th>
<th>Hours large group: 30h</th>
<th>20.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hours medium group: 0h</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>Hours small group: 30h</td>
<td>20.00%</td>
</tr>
<tr>
<td></td>
<td>Guided activities: 6h</td>
<td>4.00%</td>
</tr>
<tr>
<td></td>
<td>Self study: 84h</td>
<td>56.00%</td>
</tr>
</tbody>
</table>
## Introduction to Operating Systems

**Degree competences to which the content contributes:**

**Description:**
This chapter will give an overview of what is an OS that manages hardware resources, what are the services, functions etc.. We also introduced different types of users and applications that interact with the OS and the various forms of access.

## Process Management

**Degree competences to which the content contributes:**

**Description:**
This chapter will address the following points: concept of process. Context of a process. The life of a process. Concept planning processes. Mechanism of change of context. Management of events (signals). Concept of thread. Concept of concurrency. Issues related to concurrency. Inter-process communication: shared memory and message passing (only in terms of concept). Basic services for process management: Calls to system and management efficiency, security between users, reliability, etc.. Idea / Context: registros, stack, memory (address space) / Member / signals / users / environment variables. Representation of internal processes in Linux as well as the Round-robin scheduling algorithm to illustrative mode.

## Memory management

**Degree competences to which the content contributes:**

**Description:**
This chapter will address the following points regarding memory requirements of a general purpose system (definition of address space of a process and need for virtual memory). Basic services offered by the memory management system: support for address translation, protection of processes, loading processes, dynamic memory management, virtual memory, etc.. Structures and algorithms for management in virtual memory.

## Management of input / output

**Degree competences to which the content contributes:**

**Description:**
This topic will address the following points: Characteristics and types of devices. Concept of independence of devices. Relationship between the management of input / output and process management: operations blocking operations. Type of logical devices: pipes, console, sockets and files. Basic services and data structures necessary. Management namespace. Internal representation and algorithms to support the efficient management of devices (buffering, spooling, caching, locking). Concept of File System (FS) and services offered by it. Layered architecture of SF. Introduction to the VFS. Different types of files and utilities associated with files. Internal organization in Linux directories, i-nodes.. Organization of the disk space: fragmentation, partitions, services associated with SF's, space management free / busy. Reliability for SF's.
### Planning of activities

<table>
<thead>
<tr>
<th>Development of the subject Introduction to OS</th>
<th>Hours: 5h</th>
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</thead>
<tbody>
<tr>
<td>Description:</td>
<td></td>
</tr>
<tr>
<td>During this activity students will be an overview of what is an OS, what are their functions and services which are the main components of the system will develop during the course.</td>
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<tr>
<td>Specific objectives:</td>
<td>1, 2, 3</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Overview of the execution environment</th>
<th>Hours: 4h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td></td>
</tr>
<tr>
<td>During this activity, we will use basic commands to work with a Linux working environment, especially working from the command line but also understand the relationship with a graphical environment. Practiced commands to navigate the file system for manipulating files, etc..</td>
<td></td>
</tr>
<tr>
<td>Specific objectives:</td>
<td>1, 2, 3, 12, 13</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>C Programming and development</th>
<th>Hours: 12h</th>
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</thead>
<tbody>
<tr>
<td>Description:</td>
<td></td>
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<tr>
<td>During this activity we will work on C programming and give some basic guidelines for developing small projects that will make students in the lab sessions so they have a similar structure in terms of tools, organizing files and so on.</td>
<td></td>
</tr>
<tr>
<td>Specific objectives:</td>
<td>1, 2, 3, 12, 13</td>
</tr>
</tbody>
</table>
### Development of concepts associated to process management

**Hours:** 14h  
Theory classes: 8h  
Practical classes: 0h  
Laboratory classes: 0h  
Guided activities: 0h  
Self study: 6h

**Description:**  
During these hours we will practice the concepts and basic services related to processes and threads. We will explain the concepts related to the internal organization and management that makes the OS to provide these services and features. We also discussed issues related to systems efficiency, reliability, security, etc..

**Specific objectives:**  
4, 5, 6, 7, 8, 9, 10, 11

### Basic services-related processes

**Hours:** 4h  
Theory classes: 0h  
Practical classes: 0h  
Laboratory classes: 2h  
Guided activities: 0h  
Self study: 2h

**Description:**  
During this activity we will practice basic system calls that we can find in a Linux system to create a process, change the executable and wait for the process exit. We will also practice from an administrative point of view related to the monitoring processes.

**Specific objectives:**  
6, 7, 10, 11, 12, 13

### Using advanced process and threads services

**Hours:** 4h  
Theory classes: 0h  
Practical classes: 0h  
Laboratory classes: 2h  
Guided activities: 0h  
Self study: 2h

**Description:**  
During this session we will work with threads (POSIX). We also introduce the management of events between processes (signals) both as a means of communication and as advanced service process management. We will also work aspects related to concurrency processes.

**Specific objectives:**  
4, 5, 6, 7, 10, 11, 12, 13
### Process management: problems solving session

**Description:**
During that session we will solve some process management exercises

**Specific objectives:**
4, 5, 6, 7, 8, 9, 10, 11

<table>
<thead>
<tr>
<th>Hours</th>
<th>Theory classes</th>
<th>Practical classes</th>
<th>Laboratory classes</th>
<th>Guided activities</th>
<th>Self study</th>
</tr>
</thead>
<tbody>
<tr>
<td>4h</td>
<td>2h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>2h</td>
</tr>
</tbody>
</table>

### Development of concepts associated with memory management

**Description:**
During these hours you will practice the basic concepts related to memory management, services and functionalities offered by the system users (including optimizations that are typically at the level of library) and describe the mechanisms and algorithms internal management of the kernel to manage virtual memory.

**Specific objectives:**
4, 5, 6, 7, 8, 9, 10, 11

<table>
<thead>
<tr>
<th>Hours</th>
<th>Theory classes</th>
<th>Practical classes</th>
<th>Laboratory classes</th>
<th>Guided activities</th>
<th>Self study</th>
</tr>
</thead>
<tbody>
<tr>
<td>8h</td>
<td>4h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>4h</td>
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</table>

### Basic services for memory management

**Description:**
During this session we will practice with basic services for managing the memory processes and some commands to monitor the status of processes

**Specific objectives:**
5, 6, 12, 13

<table>
<thead>
<tr>
<th>Hours</th>
<th>Theory classes</th>
<th>Practical classes</th>
<th>Laboratory classes</th>
<th>Guided activities</th>
<th>Self study</th>
</tr>
</thead>
<tbody>
<tr>
<td>4h</td>
<td>0h</td>
<td>0h</td>
<td>2h</td>
<td>0h</td>
<td>2h</td>
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</table>

**Description:**
We will evaluate different programs with different configurations in terms of processes and system load analytically. The goal is to understand how system status and application itself influences in the application performance.

**Specific objectives:**
4, 5, 6, 7, 8, 9, 11, 12, 13

<table>
<thead>
<tr>
<th>Hours</th>
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<tbody>
<tr>
<td>Theory classes: 0h</td>
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<tr>
<td>Practical classes: 0h</td>
</tr>
<tr>
<td>Laboratory classes: 2h</td>
</tr>
<tr>
<td>Guided activities: 0h</td>
</tr>
<tr>
<td>Self study: 4h</td>
</tr>
</tbody>
</table>

### Validation Exercise processors and memory management

**Description:**
After the subjects of processors and memory management, it will be an exercise laboratory scoring mark (continuous assessment).

**Specific objectives:**
6, 8, 10, 11

<table>
<thead>
<tr>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>Guided activities: 2h</td>
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<tr>
<td>Self study: 2h</td>
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</table>

### First continuous assessment control

**Description:**
This control will include the topics Introduction, Processes and memory. This exam may include both theoretical questions such problems.

**Specific objectives:**
1, 2, 3, 4, 5, 6, 7, 8, 9

<table>
<thead>
<tr>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>Guided activities: 2h</td>
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<tr>
<td>Self study: 6h</td>
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</table>

### Development of concepts associated with the input / output data

**Description:**
During these hours, we explain the concepts related to managing the input / output data: devices, services and functions related to input / output management system and device independence.

<table>
<thead>
<tr>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>Theory classes: 10h</td>
</tr>
<tr>
<td>Practical classes: 0h</td>
</tr>
<tr>
<td>Laboratory classes: 0h</td>
</tr>
<tr>
<td>Guided activities: 0h</td>
</tr>
<tr>
<td>Self study: 8h</td>
</tr>
</tbody>
</table>
## Basic services for I/O Management

<table>
<thead>
<tr>
<th>Specific objectives:</th>
<th>4, 5, 6, 7, 8, 9, 10, 11</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hours:</strong></td>
<td>4h</td>
</tr>
<tr>
<td>Theory classes:</td>
<td>0h</td>
</tr>
<tr>
<td>Practical classes:</td>
<td>0h</td>
</tr>
<tr>
<td>Laboratory classes:</td>
<td>2h</td>
</tr>
<tr>
<td>Guided activities:</td>
<td>0h</td>
</tr>
<tr>
<td>Self study:</td>
<td>2h</td>
</tr>
</tbody>
</table>

### Description:
In this session we will practice with basic services to manage the input / output of data from/to processes. There will be exercises to consolidate the concepts related to the independence of devices.

### Specific objectives:
5, 6, 12, 13

## Advanced services to manage the input / output of data from/to processes

<table>
<thead>
<tr>
<th>Specific objectives:</th>
<th>4, 5, 6, 7, 11, 12, 13</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hours:</strong></td>
<td>4h</td>
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<tr>
<td>Theory classes:</td>
<td>0h</td>
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<tr>
<td>Practical classes:</td>
<td>0h</td>
</tr>
<tr>
<td>Laboratory classes:</td>
<td>2h</td>
</tr>
<tr>
<td>Guided activities:</td>
<td>0h</td>
</tr>
<tr>
<td>Self study:</td>
<td>2h</td>
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</table>

### Description:
During this session we will practice into more complex services and commands for managing input / output of data from/to processes and relationships with other system services such as management of events (signals).

### Specific objectives:
4, 5, 6, 7, 11, 12, 13

## Management of input / output devices

<table>
<thead>
<tr>
<th>Specific objectives:</th>
<th>6, 10, 12, 13</th>
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</thead>
<tbody>
<tr>
<td><strong>Hours:</strong></td>
<td>6h</td>
</tr>
<tr>
<td>Theory classes:</td>
<td>0h</td>
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<tr>
<td>Practical classes:</td>
<td>0h</td>
</tr>
<tr>
<td>Laboratory classes:</td>
<td>2h</td>
</tr>
<tr>
<td>Guided activities:</td>
<td>0h</td>
</tr>
<tr>
<td>Self study:</td>
<td>4h</td>
</tr>
</tbody>
</table>
### Systems Files and data Files

**Description:**
During that session we will use specific commands for system file management and specific system calls for data file management.

**Specific objectives:**
5, 6, 7, 8, 9, 12, 13

<table>
<thead>
<tr>
<th>Hours</th>
<th>Theory classes: 0h</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Practical classes: 0h</td>
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<tr>
<td></td>
<td>Laboratory classes: 2h</td>
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<tr>
<td></td>
<td>Guided activities: 0h</td>
</tr>
<tr>
<td></td>
<td>Self study: 2h</td>
</tr>
</tbody>
</table>

### Input/ Output management: Problem solving session

**Description:**
During that sessions, we will solve some exercises related with input/output data management and process communication

**Specific objectives:**
4, 5, 6, 7, 8, 9, 10, 11

<table>
<thead>
<tr>
<th>Hours</th>
<th>Theory classes: 2h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Practical classes: 0h</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 0h</td>
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<td></td>
<td>Guided activities: 0h</td>
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<tr>
<td></td>
<td>Self study: 2h</td>
</tr>
</tbody>
</table>

### File systems: problems

**Specific objectives:**
1, 2, 4, 5, 6

<table>
<thead>
<tr>
<th>Hours</th>
<th>Theory classes: 2h</th>
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<tbody>
<tr>
<td></td>
<td>Practical classes: 0h</td>
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<td></td>
<td>Laboratory classes: 0h</td>
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<td></td>
<td>Guided activities: 0h</td>
</tr>
<tr>
<td></td>
<td>Self study: 2h</td>
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</tbody>
</table>

### Validation Exercise: input/ output management and filesystems

**Description:**
After the lab sessions dedicated to processes input/output management and file systems, it will be an exercise laboratory scoring mark. (Continuous assessment)

**Specific objectives:**
6, 8, 10, 11

<table>
<thead>
<tr>
<th>Hours</th>
<th>Guided activities: 2h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Self study: 2h</td>
</tr>
</tbody>
</table>
### Second control continuous assessment

**Hours:** 8h  
Guided activities: 2h  
Self study: 6h  

**Description:**  
This second control may include questions regarding all topics presented during the year but will focus on recent issues not evaluated in the first part. This examination may include questions both theoretical and problems.  

**Specific objectives:**  
1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

### Final exam lab

**Hours:** 3h  
Guided activities: 0h  
Self study: 3h  

**Description:**  
Final exam will include any laboratory system calls, tools, concepts, etc. practiced in the laboratory.  

**Specific objectives:**  
6, 10, 11

### Final Exam

**Hours:** 5h  
Guided activities: 2h  
Self study: 3h  

**Description:**  
Written exam will include all course content. This examination may include questions both theoretical and problems.  

**Specific objectives:**  
1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

### Inter-process communication

**Hours:** 7h  
Theory classes: 0h  
Practical classes: 0h  
Laboratory classes: 4h  
Guided activities: 0h  
Self study: 3h
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**Qualification system**

Note = \text{max (Continuous evaluation , Not continuous evaluation)}

Continuous evaluation = Theory \ 50\% + 50\% \ Lab

**THEORY:** Result of 2 controls. The first exam (40\%) will be at the end of the chapter of memory and the second (60\%) at the end that includes everything.

**LAB:** Resulting from 2 laboratory exercises at the end of the scoring issues of (processes + memory) and (I/O + file systems). These exercises are taken outside of time class and weight 45\% each of them. The remaining 10\% will correspond to the marks obtained with the Atenea tests.

For those students that have not passed the continuous evaluation, it will be able to re-evaluate it with the non continuous evaluation.

To be able to apply to the continuous evaluation, the student must assist to a minimum of the 80\% of the lab sessions (the whole session, that means 2 hours). Otherwise, it will be evaluated through the not continuous evaluation method.

Not continuous evaluation = Theory \ 50\% + 50\% \ Lab
- 50\% final exam theory.
- 50\% final exam lab.

**Evaluation of Generic Competition**

In this case, be considered the following points:
- At the beginning of the laboratory sessions, students will do one Atenea test to validate the work of the previous week. From these tests, we will get information about the punctuality, the attendance and the their attitude in front of the course.
- 1) **proactive (accuracy) in professional development.**
  - Attendance. Students must attend 80\% of the lab sessions. They must make deliveries to all lab sessions but only explicitly marks 2.
  - Punctuality. Students must get off to class with a margin of 10 minutes. Be penalized for students who repeatedly arrive late.

- This information will be obtained from the Atenea tests.

- 2) **proactive attitude (motivation) for quality and continuous improvement.**
  - Motivation. Students have to submit additional papers to assess both the attitude and quality of work established in the course.

- Quality. We assessed the quality of code delivered taking into account mainly: the fulfillment of the requirements of the statements, the clarity of the code and the organization of the document.
  - The previous work related questions that will help identify and penalize students who do not perform these tasks properly. But be evaluated very positively about those students who perform outstanding work slices.

**NOTE Competition:**
The notice of competition obtained from the values of the information obtained by: Attendance, Punctuality, Respect, Motivation, Quality and Responsibility.

**Special cases:**
- If one student doesn't attend the minimum number of sessions in the lab, will receive automatically a D in the evaluation.
- If one students shows a clear unmotivation for the course, for instance, passing the deadline for the notification to the qualification system.
final exam, will be automatically evaluated with a D

Bibliography

Basic:


Complementary:


Others resources:

Hyperlink


http://www.gnu.org/prep/standards/standards.html

http://www.unixtutorial.org/commands/

http://docencia.ac.upc.edu/F Ib/grau/ASO/files/lab10-2q/as o-lab-bash-guide.pdf

Resource