INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

FIMI – *SCAN section*

TRANSVERSAL PROJECTS 2023 – 2024
SCAN *first*

General presentation

&

Description of the projects

General presentation:

From January 22nd to February 1st, you will be given the opportunity to undertake a transversal team project in groups of 5. The proposed subjects cover a wide range of applications and they are rather different both from a formal and scientific point of view. A description of the projects for this year is enclosed to this document.

The projects will start on **Monday 22nd at 2p.m**. Please note that teams can be composed of students from any SCAN 1st groups. A brief presentation of the organisation of the SCAN projects will be given on **January 16th at 10AM (Amphi Coriolis.)**

In order to anticipate the beginning of the projects, you are invited to **build-up your own groups** and **rank the different project** by order of preference by filling up the following online form:

Register on project's groups and rank the project (before January 18th 2PM):

Based on this survey, each group will be assigned a project by **January 19th**.

One of the key objectives is to confront you with a problem scenario requiring more than simply a direct application of academic knowledge. Concretely, some theoretical notions needed to accomplish these tasks have not yet been studied in class. Therefore, you may have to look for relevant information in an autonomous way. The role of your tutors is to help you complete your project by offering guidance. This means that they will not resolve the scientific difficulties for you! Tutor presence time will be approximately 6 hours per tutor and per project excluding the oral presentation. You are therefore encouraged to make appointments with your tutor(s) depending on your needs and their availability.

These transversal projects are aimed at producing tangible results to be given in the form of:

a) a 20 minutes **oral presentation** followed by 10 minutes of questions on **Friday February 1st PM (1:30-5 pm)** in front others student project groups and a jury composed of tutors and other teachers who have contributed to the project.

b) a **written report** detailing your methodology and outlining your findings to be received by your tutor by **Friday 23rd February**.

Assessment: the overall mark will be broken down as follows:

a) 1/3 to be given by the tutor on an individual basis for commitment and team work**. Please note that only English must be spoken and that presence is compulsory,**

b) 1/3 to be given by the jury for the oral presentation, this will be assessed based on presentation techniques, scientific/technical production and linguistic fluency,

c) 1/3 to be awarded for the written report; linguistic accuracy, bibliographical research and scientific clarity will form the basis for this group evaluation.

Throughout the course of the projects, emphasis will be placed on team work and communication in English. We hope you will find these activities not only challenging and demanding but also fun.

Summary of key dates

Tuesday January 16th at 10 AM	**Presentation of SCAN projects (Amphi Coriolis)**
before January 18th 2PM	**Group constitution and project ranking: see online form**
January 19th	**Project Assignment to each group**
From January 22nd PM to February 1st AM	**SCAN projects**
February 1st 1:30-5PM	**Project presentations (details will be provided during the 2nd week of the projects)**

List of the projects:

Project 1: Mechanics ‘Al Dente’

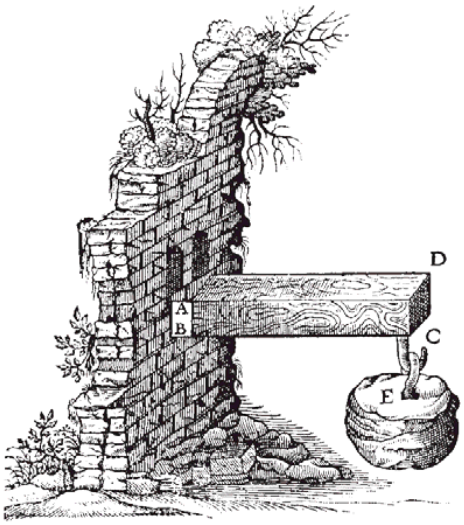


Figure 1 From: Discourses and Mathematical Demonstrations Relating to Two New Sciences (1638) - last work of Galileo

It is year 1638. Earlier, **Galileo Galilei** had been sentenced to house arrest in Arcetri near Florence and is forbidden to publish any new scientific books.

Luckily, you had a chance to sneak into his villa without being noticed. Hopefully, you can stay a while before being discovered by the guards. However isolated, the old man has not resigned to discover new secrets of nature. Maybe you can help him with his new pastime: mechanics in the kitchen.

Galileo used to be intrigued with the strength of structures in the past. The city of Venice commissioned him to investigate on the topic of breaking of ship masts. Nobody really knew at the time how to dimension a beam so that it does not break.

Now in his lonely old days, Galileo thinks back about the topic of his youth. He understands that the scale of the object has some non-trivial influence upon the strength of the object. It seems, that small objects are relatively more resistant than the big ones.

He is doing experiments with all he has left: a spaghetti and a dynamometer. He would like to find a mechanical law describing the strength of the beam supported at different lengths. Will you help him in this task?

Your project, should you accept it, is as follows:

- Set-up a ‘kitchen experiment’ by measuring the strength of a spaghetti supported at one end (cantilever) and on two ends.
- Try to guess an empirical law based on experiment describing the strength as a function of the length of a spaghetti.
- Can this law be explained theoretically and how?

Project 2: Understanding the principals of GPS (Global Positioning System)

Description :

From keeping global supply chains moving to allowing us to find our way to the nearest café, the GPS system has become an essential part of modern life. Many people take the system for granted and don't realise why it was created, how it functions, or how easily it could be withdrawn from commercial use. In this project, you will discover the answer to these questions and write a simple algorithm to calculate the position of a user on Earth based on the raw data provided by the GPS satellites.

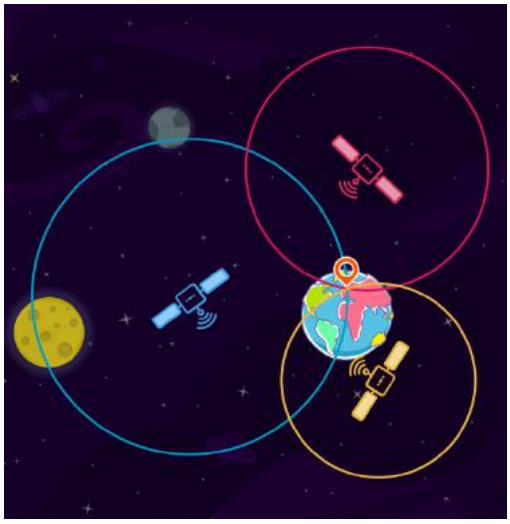


Image : www.reseau-teria.com

Objectives :

1. Understand the working principal of the GPS system (satellite constellation and orbits, communications from satellites to user's receiver device, calculation of user position).
2. Solve numerically (in Matlab) a simplified version of the geometrical problem addressed in real-time by a GPS receiver device, linking the raw data from GPS satellites to the position of the user on Earth.
3. Understand the limitations of the simplified model, and be able to comment on how real-world conditions are accounted for (eg. atmospheric interference...).
4. Discover how the GPS system was conceived, and explore new developments or competing systems to increase accuracy / ensure availability.

Deliverables :

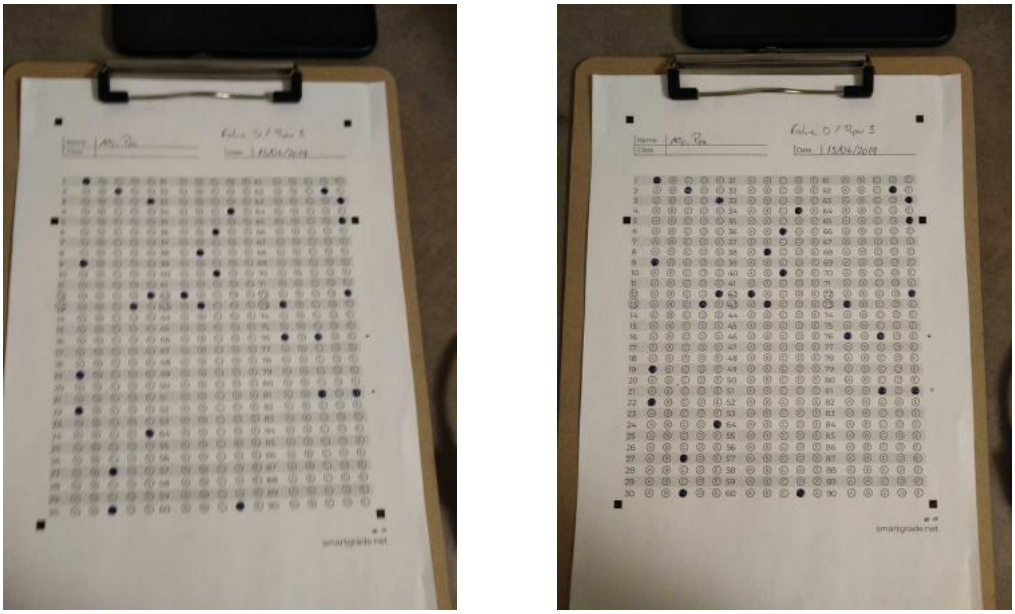
- The presentation to be given at the end of the project should enable the audience to understand the operating principle of GPS, and give an animated example showing how a user's position can be determined.

- The written report should give details on points 1, 3 and 4 above, and be a stand-alone didactic document allowing a student in ‘Terminale S’ (lycée) to understand the operation of the GPS system.

Key concepts : coordinate system transformations, numerical modelling, real-world perturbations to ideal systems.

Project 3: Quantifying (and correcting) the blur in pictures

Description :
Communication in Today's society is largely based on images and movies. An image is indeed said to be worth a thousand words (proverb popularly attributed to Confucius). From a scientific point of view, psychologist Albert Mehrabian demonstrated in the 1960s that 93% of communication is non-verbal.
Visual communication is "non-verbal" communication that is transmitted through a visual medium, and is described as the transmission of ideas and information in forms that can be perceived in whole or in part by sight. It is often presented or expressed in two-dimensional images, and includes: signs, typography, drawings, graphics, illustrations, industrial design, advertising, animation, color and electronic resources. The roots of visual communication extend to the earliest expressions of humanity with the prehistoric cave drawings. Nowadays, it includes images and videos on social media (Tiktok, Pinterest, …).
Having the perfect image is difficult! One of the most common defects is blur. There are 2 types of blur: motion blur (for objects in motion) and defocus blur (when the image is out of focus). In this project, you will investigate how to quantify defocus blur in greyscale images.



Blurry and sharp images
From https://rbaron.net/blog/2020/02/16/How-to-identify-blurry-images.html

Objectives :

- Take pictures with different conditions of defocus blur.
- Understand the role of Fast Fourier Transform (FFT) in ImageJ.

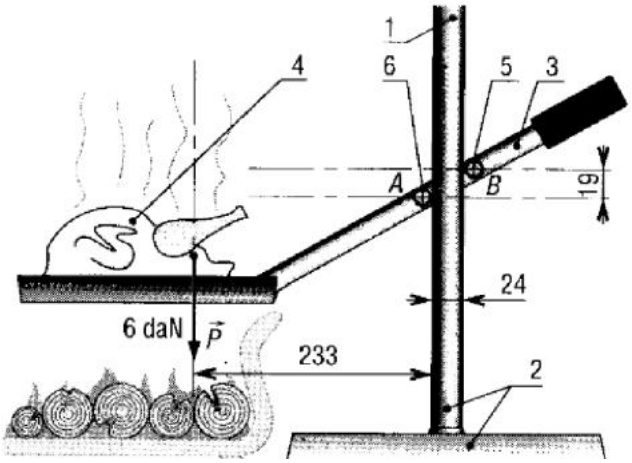
- Propose a script (in Python) to quantify the level of blur in the images, based on FFTs.
- Test your script on images acquired with an Environmental Scanning Electron Microscope (images already available)

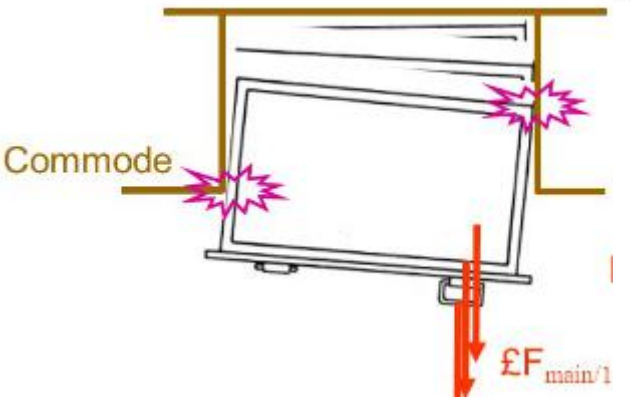
A tour of the microscopy lab will be organized and if possible, you will be allowed to take part to an experiment!

Project 4: Buttress locking mechanism

Emily : “This chicken just does not slide into the fire… how is it possible? Apparently, nothing prevents it from doing so…”
Sandro: “This drawer blocks all the time, it is brand new, though, why cannot I open it?”

By the end of this project, you will be able to explain in detail the problems mentioned by Emily and Sandro. What do they have in common? Are there other similar situations where this phenomenon arises? How is it possible to increase /reduce its existence?
You should work on a small experimental device and try to “happy-guess” the mathematical model and the underlying principle of buttressing.
A **heuristic approach** is proposed, you are free to explore!





Project 5 : Artificial Neural Networks

The continuous increase in computing performances over the last 50 years has been one of the driving force of the development of artificial intelligence (AI). Although the concept of Artificial intelligence was coined as early as 1950 with the seminal works from Alan Turing, its large-scale deployment in consumer electronics was only made possible with the performance level reached by modern computers.

AI is today supported by many electronic-driven systems in order to interact with their environment; autonomous car, face-recognition or vocal assistant in smartphones or even spam filters are functionalities currently supported by AI algorithm. Among AI, Machine Learning (ML) is a technique allowing machines to extract the necessary knowledge from given data automatically using classifier or Artificial Neural Networks.

In this project we will focus on Artificial Neural Networks (ANN) which is consist in mimicking the human brain functionality by replicating artificial neurons by means of a computing algorithm. More specifically we will try to set up an ANN able to recognize handwritten characters such as depicted in Figure 1.

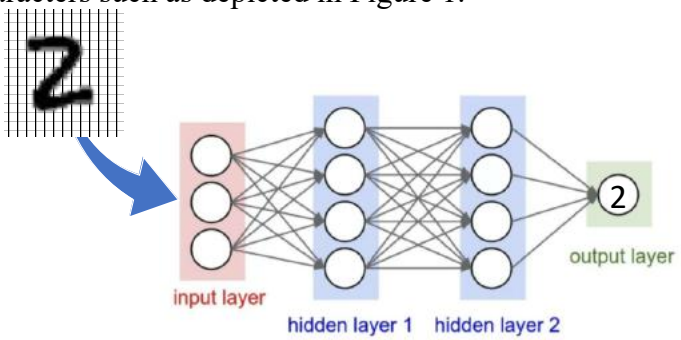


Figure 1. Scheme of an Artificial Neural Network for handwritten character recognition

The main tasks of the project are as follows:

- Literature survey in order to:
  - clarify the definition of Artificial Intelligence, Machine Learning, and Artificial Neural Networks
  - Understand how neurons can be modeled
  - Understand classification procedure based on classifiers and ANN
- The next building step will consist in buildinbg a basic ANN using python:
  - setting-up a single artificial neuron model
  - arrange artificial neurons into a network
  - enable training capabilities of the artificial neural network
- Finally, a validation step will conclude the project:
  - Train the ANN on a dataframe (eg: handwritten character database https://fr.wikipedia.org/wiki/Base_de_données_MNIST)
  - Validate the functionality of the network and evaluate its recognition rate

Project 6: Measuring the Internet

1 Introduction

The Internet is part of our daily lives. We use it to access websites, call relatives on the other side of the planet or to stream movies on our TV. Behind those services lies a huge communication network composed of millions of elements communicating with each other. The goal of this project is to explore this complex structure, study the propagation time of information on the network, and to "measure" this worldwide network.

2 Preliminaries

Search the definition (in the context of computer networks) of the following terms:

- host
- packet
- hop

3 Network measurement tools

3.1 Ping

Ping is a tool used to measure the time taken by a network packet to perform a round trip to a given host on the Internet. This tool is installed by default on most operating system and must be called from the command line, ie a terminal. For instance, to "ping" the host google.com we use the command *ping google.com* and get the following result:

```
$ ping google.com
PING google.com (216.58.211.78) 56(84) bytes of data.
64 bytes from par03s14-in-f14.1e100.net (216.58.211.78): icmp_seq=1
ttl=54 time=1859 ms
64 bytes from par03s14-in-f14.1e100.net (216.58.211.78): icmp_seq=2
ttl=54 time=1208 ms
--- google.com ping statistics ---
3 packets transmitted, 2 received, 33% packet loss, time 2005ms
rtt min/avg/max/mdev = 1208.805/1534.291/1859.778/325.488 ms, pipe 2
```

Explain the information **icmp_seq** and **time** displayed for each ping:

```
64 bytes from par03s14-in-f14.1e100.net (216.58.211.78): icmp_seq=1
ttl=54 time=464 ms
```

Explain the meaning of the **min/avg/max/mdev** values in the statistics section:

```
--- google.com ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4000ms
rtt min/avg/max/mdev = 264.162/554.923/905.220/251.696 ms
```

Which of this value represents the best estimation of the packet travel time ?

3.2 Traceroute

Traceroute is a tool used to identify the hosts through which network packets are going to reach their destination. As *ping*, it is used through the command line. In order to identify the hosts between us and google.com, we use the command *traceroute google.com.*

```
$ traceroute google.com
traceroute to google.com (64.15.116.23), 30 hops max, 60 byte packets
 1  192.168.0.254 (192.168.0.254)  1.290 ms  2.096 ms  2.580 ms
 2  88.174.96.254 (88.174.96.254)  45.584 ms  55.760 ms  55.854 ms
 3  78.254.9.254 (78.254.9.254)  66.968 ms  67.112 ms  67.433 ms
 4  sto93-1-v902.intf.nra.proxad.net (78.254.255.89)  55.937 ms
56.036 ms  56.131 ms
 5  cbv-6k-2-po11.intf.nra.proxad.net (78.254.255.85)  57.146 ms
57.143 ms  57.141 ms
 6  bzn-crs16-2-be1009.intf.routers.proxad.net (194.149.161.9)
58.640 ms  48.501 ms  48.612 ms
 7  g-pni-1.routers.proxad.net (212.27.40.6)  45.827 ms  47.541 ms
49.955 ms
…
```

Using the traceroute command, observe the path between your computer and some the hosts listed in Annex A.

What is the meaning of * (stars) in the output of traceroute ?

4 Propagation time on the Internet

Select a list of host on the Internet

At what speed does the information propagate on an Internet link (copper cable, fiber-optic cable, satellite link) ?

The round trip time is not time is composed of the propagation time over the link. What are the other elements composing this round trip time ?

Measure the propagation time to an host in the USA (see annex A). From the measured round trip time, determine if the packet have traveled through a satellite or another path.

5 Routing

Information on the Internet is transmitted over links between hosts. Connexion between hosts often follow other major communication axis. In addition, the path taken by a packet to reach its destination can be influenced by many factors (e.g. peering contracts between network operators). As a consequence the path is rarely direct and straightforward.

Draw a map of the routing between your computer and some remote hosts (e.g. from Annex A). You can use tools such as Visual traceroute (http://www.yougetsignal.com/tools/visual-tracert/) or you can manually get the coordinates of each host from its IP using IP geolocation tools (https://www.iplocation.net/).

What can you observe ? Can you identity the highways of the Internet ?

6 Applications

6.1 Host geolocalisation

Measure the round trip time to the hosts of annex A. For each host, retrieve the GPS coordinates. Using the previous measurements, compute the barycenter of the hosts. Compute this barycenter with all the host located in 1) France 2) Europe 3) World.

What can you observe ?

Is this method reliable ?

Some web sites are providing Internet host geolocation (http://whatismyipaddress.com/ip/). Try this service to get the geolocation of some hosts. What can you say about those results ? What method is employed by those services to get the geolocation ?

6.2 Physical distance, round trip time and number of hop.

Given a host on the Internet, you have all the tools to measure the physical distance from your host, the round trip time over the Internet as well as the number of hops between your computer and the remote host.

Plot on a graph, the round trip time (resp. the number of hop) as a function of the physical distance.

What can you say of the relation between the physical distance and the the round trip time (resp. the number of hop) ?

According to those results, what do you think is the best way to “measure” the Internet ?

References

[1] Understanding Computers and the Internet (Lectures 3 & 4)
http://computerscience1.tv/2011/spring/

http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-033-computer-system-engineering-spring-2009/video-lectures/lecture-9/

[2] TeleGeography, Global Internet Map

https://www.telegeography.com/telecom-maps/global-internet-map.html

[3] How-to Geek 8 Common Network Utilities Explained
http://www.howtogeek.com/190148/8-common-network-utilities-explained/

[4] The 2015 Internet Measurement Conference (IMC)
http://conferences2.sigcomm.org/imc/2015/program.html

Annex A

Country	**Entity**	**Host name**
France	University of Strasbourg	*unistra.fr*
France	University Pierre et Marie Curie	*upmc.fr*
Germany	Technische Universität Berlin	tu-berlin.de
Spain	University of Barcelona	*ub.edu*
Italy	University of Turin	*unito.it*
England	University College London	*ucl.ac.uk*
Ireland	Trinity College Dublin	*tcd.ie*
Scotland	University of St Andrews	*st-andrews.ac.uk*
Egypt	Cairo University	*cu.edu.eg*
Turkey	Istanbul Technical University	*itu.edu.tr*
India	Indian Institute of Technology Delhi	*iitd.ac.in*
Japan	*Keio University*	*keio.ac.jp*
Brazil	University of São Paulo	usp.br
Australia	University of New South Wales	unsw.com
U.S.A	University of California: Berkeley	*berkeley.edu*
U.S.A	MIT - Massachusetts Institute of Technology	*mit.edu*
China	Shanghai Jiao Tong University	*en.sjtu.edu.cn*
South Africa	University of Pretoria	*up.ac.za*

Project 7: Using Photovoltaic panels to power a system

Project description:

In recent years, there has been a remarkable surge in the adoption of photovoltaic (PV) panels, marking a significant shift towards sustainable energy solutions. As global awareness of environmental issues intensifies, individuals and businesses alike are increasingly turning to PV panels to harness clean and renewable solar energy. The declining costs of PV technology, coupled with government incentives and a growing emphasis on carbon footprint reduction, have fueled this upward trend. n this project, you are proposed to dimension a PV installation to sustain a given system with its energy needs. You will be presented with different target applications (e.g., an isolated cottage in the French Alps, energy sustainment of a camping car, meeting the water energy needs of INSA residences…) but the project will also be open to any suggestions from you.

Useful link:

- PV energy calculation tool : http://re.jrc.ec.europa.eu/pvgis/apps4/pvest.php

Project 8: Prime Numbers and Cryptography

a. Project objectives

The goal of this project is to implement and study methods used to find prime numbers, which are required in several modern cryptographic systems used on our everyday life (Internet, smartcards, phones, etc.).

1 Introduction

A prime number is a natural number that can only be divided by itself and one. Prime numbers have been studied since the antiquity when Euclid showed around 300 BC that there exist an infinite number of prime numbers. Prime numbers are associated with a number of interesting mathematical problems. In the 1970's one of these problem have been used to create a revolutionary cryptographic system called RSA.

2 Finding prime numbers

Finding a prime number is not a straightforward task. Prime numbers can be obtained using two types of methods :

- Trial division and Sieves
- Primality testing

2.1 Trial division and Sieves

The trial division consist in testing if a number n is prime by checking if any of the integers $i \in [2..\lceil \sqrt{,()n} \rceil]$ is a divisor of n. If no number in $[2..\lceil \sqrt{,()n} \rceil]$ is a divisor of n, then it is prime. A variant of this method is to use sieves to perform an exhaustive search of the prime numbers in a given interval $[2..M]$. This method uses a table containing all the number of the considered interval. The method works as follow: starting from one and for each number i in the interval, mark all the multiple of i in the table as non-prime. At the end of this process only the prime numbers will be left unmarked in the table.

2.1.1 Program implementation

The previously presented can be automatized and left to a computer.

- Implement a program testing if a number n is prime.
- Implement the Sieve method: given an integer M compute all the prime numbers in $[2..M]$
- Try these algorithms by progressively increasing the input (n or M). What can you observe?

2.1.2 Complexity evaluation

The complexity of an algorithm is the number of basic operations that are performed by it. This complexity is tightly linked to the execution time and some algorithm are so complex that for some inputs, they cannot be finished in a reasonable time (less than a year for instance). As previously said, the number of operations performed by an algorithm often depends on the input. This is the case with the two previously implemented algorithms.

- Count the number of basic operation performed during the execution of each algorithm (1 basic operation = 1 test division / 1 multiplication)
- Plot the number of operation as a function of the input (n or M)

2.2 Primality testing

With the previously presented methods, one can say with 100% certainty if a number is prime or not. However, their complexity can become a problem. Indeed the number of operation required to finish the algorithm may be so large that the program may take hours, day, years or even centuries to complete. This is why a second class of method, called probabilistic primality tests, have been invented. They return an answer that is true with a certain probability (often close to 1 - e.g. 99.999%), but have a much lower complexity.

The Miller-Rabin primality test is a probabilistic algorithm commonly used to test numbers in real world application. The Miller-Rabin test if a number is prime by testing a set of properties.

Let s and d, two positive integers such that $n-1=2^s.d$ and given an integer $a \in [1..n-1]$ if

$$a^d \neq 1 (mod n)$$

AND

$$a^{2^r d} \neq -1 (mod n) \text{ for all } 0 \leq r \leq s-1$$

then a is called Strong Witness for the primality of n. Each Strong Witness is an additional evidence that the number is prime. However, if for some a the previous relations do not hold, then n is not prime.

The accuracy of the test is the probability of n being prime knowing that k Strong Witness have been found.

$$P(n \text{is Prime} | k) < 4^{-k}$$

- Implement the Miller-Rabin test
- Plot the complexity of the algorithm along with the accuracy as a function of the number of Strong Witness

3 Application to RSA

RSA is a cryptosystem invented by Rivest, Shamir and Adleman, which is based on prime numbers. Cryptography relates to the art of concealing information. RSA cryptosystem employs two keys: private key (K_{priv}) and public key (K_{pub}). A message m is encrypted into a ciphertext m as follows:

$$E_{K_{pub}}(m)=c$$

where $E_{K_{pub}}(.)$ is the encryption function.

Then the ciphertext c can be deciphered into m using the associated private key as follows:

$$D_{K_{priv}}(c)=m$$

. where $D_{K_{priv}}(.)$ is the decryption function.

The internals of the RSA cryptosystem are presented on the following page: `http://en.wikipedia.org/wiki/RSA`

Using this information:

- Implement the method generating the public and private key pair;
- Implement the Encryption and Decryption functions.

RSA in our everyday life

RSA and other public key cryptosystems are found in many objects and application. Explain where and how they are used.

Resources

- `http://en.wikipedia.org/wiki/Primality_test`
- `http://en.wikipedia.org/wiki/Miller%E2%80%93Rabin_primality_test`

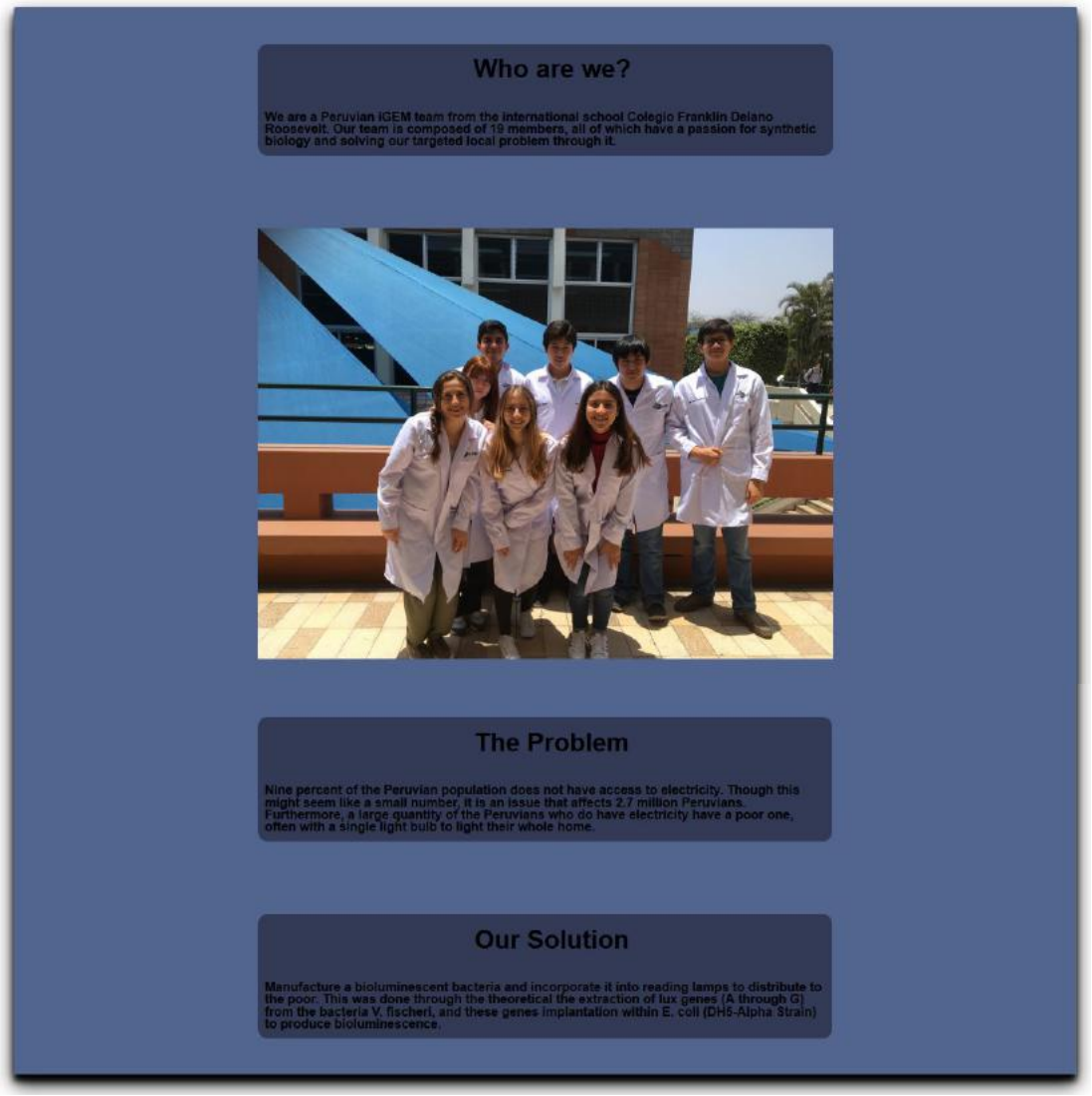
Project 9: Reading Light using bioluminescence

TProblematic :

For families without access to electricity, the bioluminescence principle can be a solution to light up, especially to allow children to study. This project consists in designing a reading light using bioluminescence.

Context of the study :

The origin of this study comes from a project led by Peruvian students in 2016 for the IGEM competition, an international competition for students interested in the field of synthetic biology :



Project objectives :

- Understand and explain the principle of bioluminescence
- Design the mechanical support of the reading light with CAD software
- Make 2 or 3 prototypes of the reading light

Functional specifications :

- **The bulb** of the light will be made with a laboratory tube containing a bacterial solution : see appendix for the tube, you can contact the association IA2C (INSA AND Concept Club) for the bioluminescence principle.

- **The mechanical support** :
  - The support will hang on a book
  - It will be possible to adjust the orientation of the bulb
  - To build the parts with 3D printers, the dimensions of the parts will not exceed 100mmx100mmx100mm
  - The system will be designed with Solid-Edge : parts, assemblies and drawings
  - The system should be assembled easily
  - You can use reflective tape to increase the light.

Project tasks :

- Understand the principle of bioluminescence and confirm the feasibility and the viability of such a light.
- Think about the environmental impact of the use of several thousand copies of this light.

- Propose several possible designs of the reading light (with diagrams, hand sketches, …). Choose 2 or 3 systems to study in detail.
- Using Solidedge, create volumic models of the reading light.
- Using a 3D printer, create at least 1 prototype for the entire reading light.

Appendix : Technical specifications for tubes for the bulb

CULTURE CELLULAIRE FALCON®

Tubes à fond conique Falcon®

- Tubes certifiés stériles, non pyrogènes, et non-cytotoxiques
- Emballage de grade médical garantissant une stérilité parfaite
- Graduations sérigraphiées et large surface de marquage
- Excellente clarté optique
- Faible adsorption des protéines sur les parois des tubes en polypropylène clarifié

CULTURE CELLULAIRE

- Centrifugation
- 50 ml polypropylène clarifié : 16000 g
- 15 ml polypropylène clarifié : 12000 g
- 15 ml polystyrène : 1800 g
- 175 ml et 225 ml en polypropylène : 7500 g

Tubes en polypropylène clarifié à fond conique 15 ml et 50 ml

Référence	Désignation	Unités/ sachet	Unités/ carton	€ HT/ carton
352070	Tube 50 ml 30 x 115 mm (vrac)	25	500	NC -
352098	Tube 50 ml 30 x 115 mm (sur socle)	25	500	NC -
352097	Tube 15 ml 17 x 120 mm (sur socle)	50	500	NC -
352096	Tube 15 ml 17 x 120 mm (vrac)	50	500	NC -

Tubes en polystyrène à fond conique 15 ml et 50 ml

Référence	Désignation	Unités/ sachet	Unités/ carton	€ HT/ carton
352095	Tube 15 ml 17 x 120 mm (vrac)	50	500	NC -
352099	Tube 15 ml 17 x 120 mm (sur socle)	50	500	NC -

Tubes en polypropylène à fond conique 175 ml et 225 ml

Référence	Désignation	Unités/ sachet	Unités/ carton	€ HT/ carton
352075*	Tube 225 ml ø 61 x 137 mm	8	48	NC -
352076*	Tube 175 ml ø 61 x 118 mm	8	48	NC -
352090	Coussin de centrifugation pour tubes 175 ml et 225 ml	8	8	NC -

* tubes stériles non certifiés non pyrogènes et non cytotoxiques.

CORNING **Life Sciences** | Document Number: **LSR00042** | Rev.: **7**

Description (Class): **Reference, Customer Technical Data Sheet – Conical Centrifuge Tubes, 50 mL PP w/cap** | Page: **2 of 2**

Material: Clarified Polypropylene

Related Catalog Numbers:

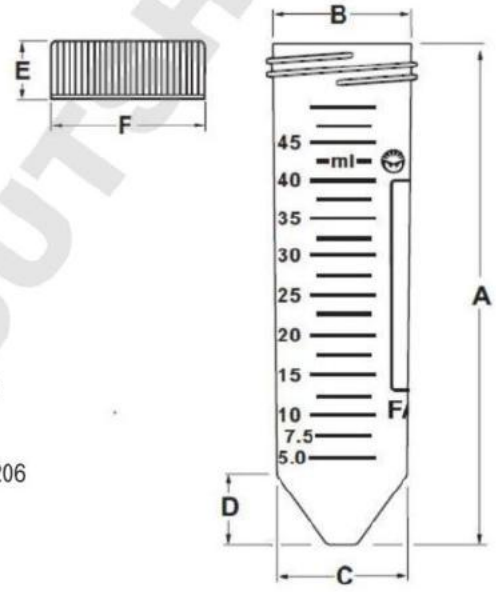
Cat. No.	Packout Description	Cap	Sterile	Graduations	Wr. Patch	Rack
352070	25/Bag, 500/Case	Plug Seal	Yes	Printed	Yes	No
352098	25/Rack, 500/Case	Plug Seal	Yes	Printed	Yes	Yes

Dimensions = mm (inches)

TUBE
A = 114.55 (4.510)
B = O.D. 29.72 (1.170)
C = O.D. 27.94 (.1.100)
D = 16.00 (.630)

Tube height w/cap	= 115.80 (4.56)
Top I.D. at rim	= 27.81 (.1.095)
O.D. at thread	= 6.15 (.242)
Bottom I.D	= 31.50 (.1.240)
Bottom angle	= 70 degrees
Min. wall thickness	= .97 (.038)
Nominal volume	= 50 mL
RCF ratings	= 16,000xg

- Chem. Compatibility: See Chemical Resistance Chart
- Threads to fit special cap design



CAP 33 mm Polyethylene Threaded. Cat. No. 358206
Material: Blue HDPE
E = 13.21 (.520)
F = O.D. 34.75 (.1.358)
I.D. (bottom) = 31.65 (.1.368)

Threads are designed to fit Falcon® Tubes only.

Project 10: Shuttlecock dynamics

When playing badminton, the shuttlecock (also referred to as *shuttle* or *birdie*) plays a central role, and its quality may impact significantly your play. Many types and materials exist, for different performances (speed, control, for instance). Among the different technologies, a sports gear store proposes three shuttles, adapted to slow, moderate and high wind (see Figure). What can make this difference?

This project aims at understanding and explaining this property, by studying the three shuttlecocks presented in the picture. What are their differences, and how do these differences play on their response to wind? Several features can be considered, such as mass, shape, fall velocity, color (…!) and so on.

To that end, you will have to

- measure the different shuttlecock properties
- design and conduct different experiments (fall, throw…)
- use computer image analysis to track trajectories and velocities (Python, ImageJ for instance), in order to extract key features of the shuttlecock's flight.

Trajectory modelling using Python will also be possible, as well as a comparison with other types of shuttlecocks.

Project 11: Polar Pod expedition

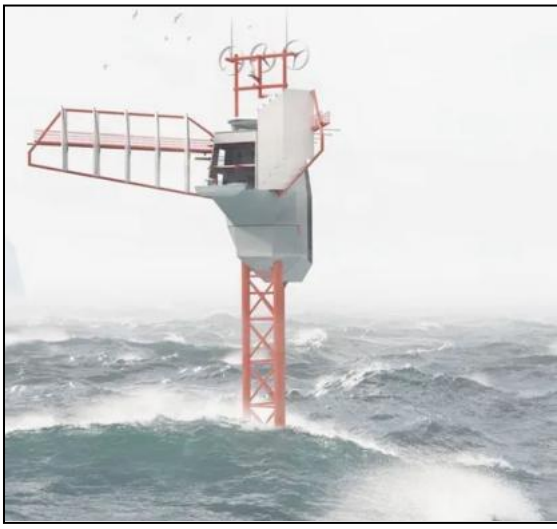
Problematic :

In the Southern Hemisphere, the Southern Ocean is not partitioned by continents; it's an open ocean that circulates around Antarctica. Driven by the westerlies, the Antarctic Circumpolar Current (CCA) brings together the three oceans, the Indian, the Pacific and the Atlantic.

At the other end of the world, this huge ocean is still unknown, oceanographic campaigns are rare. A major player in the climate and marine biodiversity reserve, the international scientific community is unanimous: we need in situ measurements.

Context of the study :

To explore this ocean of storm, which sailors call the « furious fifties », the naval engineering office SHIP ST of Lorient designed the POLAR POD.



Driven by the circumpolar current, like a satellite around Antarctica, POLAR POD will allow the acquisition of data and long-term observations that will be transmitted to researchers, oceanographers, climatologists, biologists; 43 scientific institutions from 12 countries are involved in the project.

This expedition worthy of Jules Verne, will animate in real time a large international educational project on the Life Sciences of the Earth and the Environment in collaboration with the International Union for the Conservation of Nature (UICN).

Project objectives :

- Study the technical platform designed for the expedition (from a mechanical point of view)
- Make a simplified prototype of this platform (scale and details to be defined)
- Explain all the reasons why this platform is considered an "ecological vessel"
- Detail the scientific program and the associated material of the expedition

Project tasks :

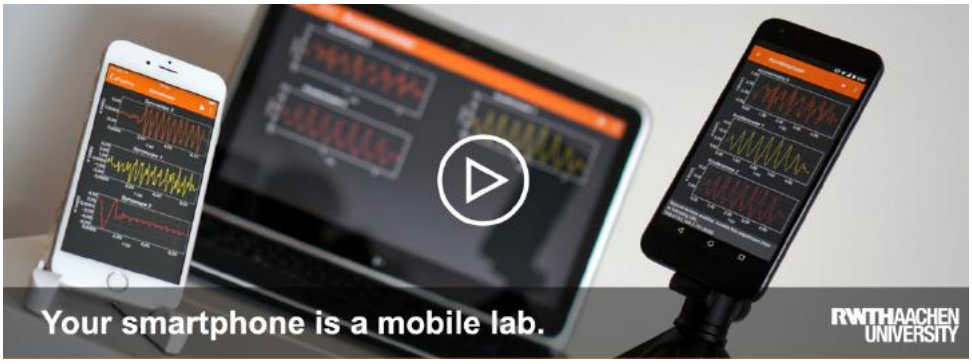
- *Study the technical platform designed for the expedition :*
  => Explain how the platform will be towed and then installed in the study area
  => Explain how and why other parts move on this platform
- *Using SolidEdge, create volumic simplified model of the platform.*
- *Using 3D printers and standard elements, create at least 1 prototype of the platform :*
  => Try to use this prototype to illustrate different technical functions of the platform.
- *Describe why the platform is called an "ecological wessel"*
- *Describe the scientific program and the associated material (especially sensors used for measurements)*

Functional specifications to build the simplified prototype :

- *The system will be designed with SolidEdge : parts, assemblies and drawings*
- *To buid the parts with 3D printers, the dimensions of the parts will not exceed 150mmx100mmx100mm*
- *The system should be assembled easily*
- *You can use standard elements (screws, nuts, pins, …)*

Project 12: “Smartphone Physics”

We use the sensors embedded in our smartphones every day, often without even realizing it. The screen flips as you hold your phone in a landscape position because an accelerometer has detected the change. The ambient light sensor tells your screen to brighten when you go outside, and the proximity sensor tells your device to deactivate the touch screen when you hold the phone to your ear.
These accurate sensors (accelerometer, gyroscope, barometer, magnetometer, thermometer…) make your phone aware of its environment and actively interface with it.



The objective of this project is to do experimental physics with your smartphone. For instance, can you design and realize different experiments to measure the gravitational constant “g”?

To turn your mobile phone into a pocket measurements lab, you will use the free application Phybox (https://phyphox.org) available for Android and IoS systems. This application will allow you to visualize, record and export data from your smartphone’s sensors.

Tasks

- Design different experiments with objects of everyday life to measure any physical constant or quantity.
- For each experiment, determine the protocol, get measures, and analyze them with simple physical models.
- Make small videos of your experiments
- Rank them in order of increasing precision.

Project 13: Microscopic image analysis with Python

Microscopic images are used in a variety of domains to analyze, for examples, the structure of metal grain, the deposit of silicon nanocrystals or biological organisms. In order to efficiently extract information from these images, one need images analysis tools that can extract and count structures in such images. In this project, we will focus on microscopic images showing the structure of materials (such as metals or crystals), in which we will be interested in separating the different grains or micro-structures.

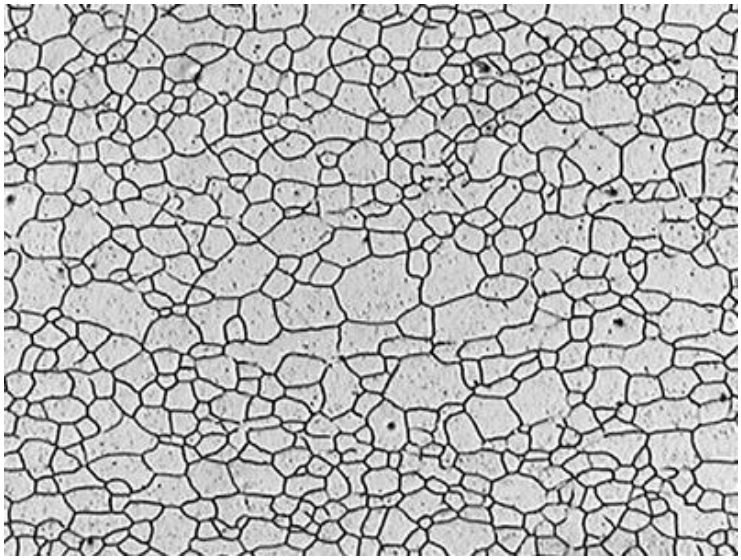


Figure 2 Microscopic structure of metal, showing grains that can be counted and measured. The size or density of the grains is crucial to verify the compliance with industrial norms.

In order to extract such information, the image will undergo a variety of mathematical operations to transform it and make it usable for computation. Typical image analysis operations include: convolution filtering, morphological operators, thresholding, flood filling algorithms and more. A popular tool to perform such operations is ImageJ, a scientific software for microscopic images. The goal of this project is to implement your own library for image analysis in Python, and use it to analyze microscopic images. The project will be done in collaboration with the MATEIS research lab that will provide microscopic images to be analyzed.

You will be allowed to use existing python libraries to load and visualize images, but not to perform any operations on them.

Objectives:

- Find and understand the main image filtering algorithms that are typically used to analyze microscopic images
    - list the main algorithms
    - identify the ones you will need to perform the given task
    - understand how they work and test them using existing libraries
- Implement a python library that allows to implement these operations without relying on existing libraries
- Use your library to analyze microscopic images
    - identify the different steps
    - explore the parameters that will allow to perform the task the best
    - analyze the resulting data

Deliverables:

- Your presentation should explain the different image filtering algorithms you used to extract the information from a microscopic image, and the important parameters that you had to chose
- The report should detail the different image algorithms that are included in your library with a basic explanation on them as well as the different steps you used to analyze the microscopic image and what information about the material it
- The python library and the code to analyze the image

Project 14: Tensegrity

Tensegrity, a portmanteau of "tensional integrity," represents a unique structural concept where elements are arranged in a state of continuous tension and compression. This innovative design principle has applications ranging from architecture (Fig1) to biomechanics. This student project aims to delve into the fascinating world of tensegrity structures by constructing a demonstrator using a 3D printer. Through this hands-on experience, participants will gain a deeper understanding of tensegrity's principles and its real-world applications.

Fig. 1: Kurilpa Bridge, Brisbane (Australia), is the world largest tensegrity bridge

Tasks and Objectives:

The primary objective of this project is to introduce and understand the underlying principles of tensegrity (i.e. intricate balance between tension and compression in structural design).
By utilizing 3D printing technology and any other technique you would judge relevant, you will be invited to build and study a demonstrator consisting in a mechanical structure whose mechanical equilibrium rely on tensegrity principles.

Project 15: Felix Baumgarten's free fall

The aim of this project is to simulate the free fall of Felix Baumgarten an Austrian skydiver and former professional BASE jumper. On 14th October 2012, Baumgartner flew at a height of 39.045 kilometers into the stratosphere over New Mexico, United States, in a helium balloon before free falling in a pressure suit and then parachuting to Earth. The total jump, from leaving the capsule to landing on the ground, lasted approximately ten minutes. Baumgartner deployed his parachute after 4 minutes and 19 seconds, completing a total free fall distance of 36,529 meters.
At approximately 30,000 meters (98,000 ft), Baumgartner reached the speed of sound after approximately 40 seconds of free-fall, thus becoming the first human to brake the sound barrier without any form of engine power. The maximum speed achieved was measured 1,342.8 km/h (Mach 1.24).
From http://en.wikipedia.org/wiki/Red_Bull_Stratos

The idea of the project is to compare the numerical values from this "experiment" with the outputs from models of increasing complexity: you will first start with a very simple model that you'll solve analytically. You will then look into more details into some of the simplifying assumptions you made, for example:

- dependence of the gravitation with altitude?
- drag, air friction (how does it depend on Felix position, on the air pressure? How does the air pressure vary with altitude?)
- dependence of the speed of sound with altitude?

You will then have to solve the new movement equation numerically, and apply to different situations (balloon ascent, free fall and parachute landing)
You will discuss how well you can reproduce the values from the experiment and summarize clearly the impact of each model improvement and each parameter change you made You could also compare Felix's fall to the one from Alan Eustace on 24th October 2014.

Curriculum put into practice:
Numerical integration of ODEs using python. Mechanics: trajectory equations, drag force, fluids statics (equilibrium of the atmosphere) .