
*"This person whom you see here, with an oval visage, chestnut hair, smooth open forehead, lively eyes, a hooked but well-proportioned nose, & silvery beard that twenty years ago was golden, large moustaches, a small mouth, teeth not much to speak of, for he has but six, in bad condition and worse placed…a vivid complexion, rather fair than dark, somewhat stooped in the shoulders ... this, I say, is the author of 'Galatea,' 'Don Quixote de la Mancha,' … He is commonly called MIGUEL DE CERVANTES SAAVEDRA. He was for many years a soldier, and for five years and a half in captivity …  He lost his left hand by a musket-shot in the battle of Lepanto (…)."*

Novelas Ejemplares, Author's Preface

In reality, there is no actual print or painting of Miguel de Cervantes. The portrait seen above was painted by Juan de Jáurigui and has been preserved by la Real Academia de la Lengua.  Just like other representations of Cervantes, this painting seems to be based on the description he gives of himself in his novel, las Novelas Ejemplares.


# Cervantes, Dealing with the Whole Universe

*"(...) and as he confines and restricts himself to the narrow limits of the narrative, though he has ability; capacity, and brains enough to deal with the whole universe, he requests that his labours may not be despised, and that credit be given him, not alone for what he writes, but for what he has refrained from writing".*

Quijote, II, XLIV

On numerous occasions, Cervantes toys with his readers by insinuating that he is not the true author of Don Quijote.

Accordingly, in the introduction in chapter XLIV of the second book, he claims that the actual author is an Arabic writer, Cide Hamete. This supposed author complains that readers are distracted by Don Quijote's adventures, and don't recognize the cultural and scientific references woven into the text.

The sections that you are going to work with are based on some of the adventures in Don Quijote. Prepare to get to know the technology and solve some of the same problems that they were faced with in Cervantes' time:

The advancements in our understanding of the Earth and its relationship with the universe led to the discovery of new routes of exploration and exchanges throughout the whole world. Think about the difficulties in orienting oneself and finding a specific route in an open space, like the ocean or a huge plateau, without having clear points of reference.

Get to know the measurements and their equivalences as well as the errors derived from their variations according to different cultures, geographic areas and traditions. This problem was not resolved until the introduction of the Metric system in the XIX century, 200 years later!

Experiment with the mechanisms used in Manchego windmills and see how each of them transfers energy.  All of this common knowledge and technology is condensed into one great simple machine.

# La Ciencia de las Estrellas

*"[...] Haz, Sancho, la averiguación que te he dicho, y no te cures de otra; que tú no sabes qué cosa sean coluros, líneas, paralelos, zodíacos, clíticas, polos, solsticios, equinoccios, planetas, signos, puntos, medidas, de que se compone la esfera celeste y terrestre; que si todas estas cosas supieras, o parte dellas, vieras claramente qué de paralelos hemos cortado, qué de signos visto y qué de imágenes hemos dejado atrás, y vamos dejando ahora."*

Quijote, II, XXIX

Cervantes vive en plena época de las exploraciones de los nuevos territorios en América y Asia. Es también una época de grandes conflictos entre la Europa cristiana y el avance de los turcos musulmanes.

Los viajes forman parte importante de su experiencia y participa activamente en las batallas en el Mediterráneo, por lo que conoce los términos marineros y los instrumentos y técnicas de navegación.

Estos conocimientos aparecen con frecuencia en las páginas del Quijote.

# Science in the Stars

*"Try the test I told thee of, Sancho," said Don Quixote, "and don't mind any other, for thou knowest nothing about colours, lines, parallels, zodiacs, ecliptics, poles, solstices, equinoxes, planets, signs, bearings, the measures of which the celestial and terrestrial spheres are composed; if thou wert acquainted with all these things, or any portion of them, thou wouldst see clearly how many parallels we have cut, what signs we have seen, and what constellations we have left behind and are now leaving behind."*

Quijote, II, XXIX

Cervantes lived during exciting times of exploration, when new territories in America and Asia were being discovered.  Notably, this era was also marked by great conflict, including European Christians defending themselves from advances by the Turkish Muslims.

His travels and his participation in several battles along the Mediterranean sea played an important role in shaping his identity. You can see the influence of these experiences reflected in his knowledge of navigational techniques along with nautical terms and instruments.

This knowledge he possessed is a recurring theme throughout Don Quijote.


# Scientists from Cervantes' Era (1547-1616):

The XVII century was a pivotal time in history in which there were many developments in the fundamental concepts that people held about the world and the universe.

New techniques were developed and applied as a result of the exploration of new routes across the ocean. In addition to this, many great debates were held about whether the sun or the earth was the center of the universe. This made Astronomy one of the fields of science with the most advances during this period.

It also initiated an unstoppable breakaway from Astrology, which was starting to be pushed to the side and considered superstition and divination.

Cervantes had access to all these new discoveries, not only through his firsthand experiences sailing, but also as a regular attendee at the Mathematics Academy. He listened to many debates and had the opportunity to read new scientific texts and interact with those involved.

**Pedro de Medina** (1493-1567): Mathematician, Geographer, Cartographer, Astronomist. He was the author of the famous "Arte de Navegar" which illustrated how to navigate the seas during his time period. There is a mountain named after him in Antarctica to honor him.

**Francisco Hernandez de Toledo** (ca. 1514-1587): Doctor, Ornithologist, Botanist. He specialized in the study of the birds in New Spain (currently Mexico) and created descriptions for each specimen using native Náhuatl words.

**Gerogius Agricola** (1495-1555): He is considered the founder of modern mineralogy and developed principles for metallurgy and mining.

**Johannes Kep**ler (1571-1630): Astronomer and Mathematician. He wrote laws that described the movement of the planets.

**Andre de Urdaneta** (ca. 1508-1568): Cosmographer, Mariner, Friar and he served in the military. He is most famous for discovering a route in the Pacific ocean leads from the Philippines to Mexico. It is still one of the most important navigational routes today.

**José de Acosta** (1540-1600): Anthropologist and Naturalist who believed that the Peruvian natives had their origins in Siberia. He was also one of the pioneers in discovering the effects of altitude sickness.

**Galileo Galilei** (1564-1642): Mathematician, Philosopher, Engineer, Physicist and Astronomer. A key figure deciphering principles of the movement of the planets in respect to the Sun.

**Gerardus Mercator** (1512-1594): He created a map of the world using a new projection. This map, with his name on it, was meant for navigation and was used for the first time in 1564.

**Nostradamus** (1503-1566): Jean Michel de Notre-Dame. Astrologist and Doctor from France. He is known for the prophecies that he made predicting several catastrophes that would lead up to the end of the world. His work shows the importance of Astrology in modern day.


# Balestilha

In 1494 the Monarchs from Portugal and Spain distributed new territories in America and Africa using an imaginary line that was situated 370 leagues west of Cabo Verde Island. This created a new challenge for mariners and navigation because now, there was no way to locate a ship that was positioned in the middle of the ocean.

The instrument most used to solve this difficult task was the **balestilha**, also known as a ***ballastella, Jacob's staff, Santiago's staff***, etc…

The **Museum of Science and technology** has an excellent example of a balestilha that was made by **Gaualterius Arsenius** in 1563.

This instrument is used to measure the distance between the stars and the sun or moon. This information is sufficient for finding the location in respect to this object. Having this data, along with the latitude (thanks to the compass), one can find an approximate position on land or on a ship in the middle of the immense ocean.

This instrument was often times used together with a ***quadrant*** and an ***astrolabe***.

A **balestilha** is also a very useful for calculating height. For example, if you know the distance from a building, the height can be determined using this instrument.

## Calculate how high the roof is.

Locate the yellow point on the floor and measure the distance from it in steps.

Calculate its equivalent in meters.

Calculate the angle of "A" using the balestilha.

Calculate the height up to the roof using the table of tangents provided.


# Maps: A Flat Representation of the Earth

**Is it possible to draw a round object on a flat surface?**

If we take the surface of the Earth and cut it as if it were the peel of an orange, we will end up with something similar to the illustration above.

After placing these segments on a flat surface, we notice right away that there are open spaces.

If we want to represent the continents on a flat surface we have no other option but to extend the image and therefore the representations that we make must be distorted.

**Observe what happens when we put the map of the world on a table.**

**Do you understand why maps are implicitly incorrect?**


El problema de la Longitud

Para determinar la posición de un objeto en la superficie de la Tierra se necesitan, al menos, dos datos esenciales:

La **latitud**, distancia desde el ecuador, medida en grados, que se hacía tomando como referencia la altura sobre el horizonte de estrellas conocidas, o del Sol o la Luna, empleando un **cuadrante**, un **astrolabio** o una **ballestilla**.

La **longitud**, distancia desde un lugar concreto de la Tierra a una población conocida, se hacía calculando la diferencia entre la hora en el pueblo de referencia y la hora en el lugar deseado. Evidentemente para hacer esto es necesario tener un reloj fiable. Algo que no fue posible hasta el siglo XVIII con el **cronómetro marino** de **John Harrison**. Durante algún tiempo en el siglo XVII se empleó como referencia para calcular la hora los eclipses de las lunas de Júpiter, esto funcionaba bien en tierra, pero en un barco en movimiento esto era casi imposible de ver.

En la época de **Cervantes** el único método viable era la navegación por estima: calculando la latitud y la velocidad del barco podía determinarse aproximadamente la posición. Este método era, sin embargo, extremadamente impreciso y con frecuencia daba lugar a desastres con pérdida de vidas y mercancías.

Juega a ***Hundir la Flota***, e intenta localizar los barcos de tu enemigo conociendo solo su latitud.

# The Challenges Faced with Longitud

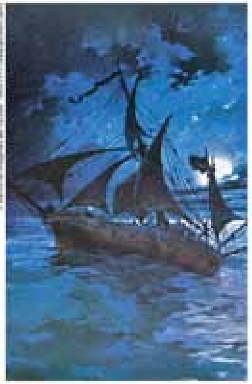
To determine the position of an object on the surface of the Earth, you must have at least two essential pieces of information.

**Latitude** is the distance from the equator measured in degrees. It can be determined by finding the height of specific stars, the sun or the moon on the horizon and then using a ***quadrant***, an ***astrolabe*** or ***balestilha***.

**Longitude**, the distance from one specific location on Earth to another location, is determined by calculating the difference between the time in one position of reference and the time in the desired position. Obviously, in this case it is very important to have a reliable clock. This was not made possible until the XVIII century when **John Harrison** invented the marine chronometer. Previously, in the XVII century, they used Jupiter's lunar eclipses as a reference to calculate time. This worked on land, but with the movement of a ship, it was almost impossible to use this method.

In Cervantes' era, the only way to do this was to make an estimation: calculating the latitude and the velocity of the ship could help determine its approximate position. This method was extremely imprecise and often caused disasters in which goods and lives were lost.

Play ***Battle Ship*** and try to to locate your opponent's ship only using latitude.

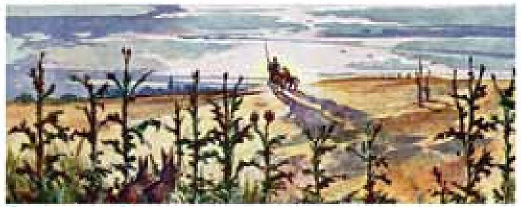


# Brújula

La **brújula** era y sigue siendo completamente decisiva para poder orientarse en mitad de la nada. Aunque su funcionamiento sea simple: conocer dónde está el norte, esto asegura determinar la dirección hacia la que nos dirigimos en relación al norte.

Los orígenes de la brújula son inciertos: en China conocían las propiedades del hierro imantado desde la Antigüedad y como instrumento se utiliza en Europa desde el siglo XII.

Conseguir que la aguja no se viera afectada por los movimientos del barco era un problema que se solucionó con mecanismos como el que puedes ver aquí.



Localiza en el mapa dónde está *El Toboso*. Se supone que tú te encuentras en ***Alcalá de Henares*** (donde está la brújula).

A ¿Qué dirección debes tomar para ir hacia *El Toboso*?

B ¿Y hacia *Barcelona*?

Localiza el **Norte** en el mapa y mueve el anillo exterior para saber la ruta que deberías seguir.

La enorme ventaja de la **brújula** en la exploración de territorios desconocidos y sobre todo en la navegación en mitad de un mar, sin referencias de montañas, árboles o edificios, es que puedes fijar un lugar al que dirigirte aunque nunca hayas estado allí y gracias a que la aguja siempre indica el Norte puedes mantener el rumbo hacia el lugar elegido.

# The Compass

The compass was, and still is, a crucial tool used to orient oneself in the middle of nowhere. Even though it is a very simple device: if we can figure out which direction North is, we can then correctly determine the direction which we are moving towards in relation to the North.

The origins of the compass are still unknown: Long ago, in China, they were able to recognize the properties of magnetized iron and in Europe this knowledge had been used as a tool since the XII century.

Keeping the needle from being affected by the ship's movements was a problem that was later solved by using the mechanisms seen here.

Locate **El Toboso** on the map. Imagine that you find yourself in **Alcalá de Henares**, where the compass is located.

A: What direction would you have to go towards to get to **El Toboso**?

B: And to get to **Barcelona**?

Locate North on the map and rotate the outer dial to figure out which route you should take.

The compass' great advantage for exploring uncharted territories, especially for navigating ships in the middle of the ocean (where mountains, trees or buildings can't be used as points of reference), is that you can center on a specific spot and direct yourself towards there, despite it being an unknown location. Due to the fact that the needle always points north, you can maintain the course in the correct direction, towards your chosen location.

# Reloj Nocturno

En tiempos de Cervantes, para orientarse, los marinos se valían de la posición del Sol durante el día y de la posición de la estrellas por la noche.

Claro que las nubes podían impedir la visión de las estrellas y esto conllevaba no saber la ubicación en mitad de un mar inmenso y desconocido. Cervantes recuerda esta situación en un soneto comparando la falta de estrellas con la ausencia de la amada:

*Yo sé que muero; y si no soy creído,*
*es más cierto el morir, como es más cierto*
*verme a tus pies, ¡oh bella ingrata!, muerto,*
*antes que de adorarte arrepentido.*

*Podré yo verme en la región de olvido,*
*de vida y gloria y de favor desierto,*
*y allí verse podrá en mi pecho abierto,*
*cómo tu hermoso rostro está esculpido.*

*Que esta reliquia guardo para el duro*
*trance que me amenaza mi porfía,*
*que en tu mismo rigor se fortalece.*

*¡Ay de aquel que navega, el cielo oscuro,*
*por mar no usado y peligrosa vía,*
*adonde norte o puerto no se ofrece!*

Quijote, I, XXXIV

# The Nocturnal

In Cervantes' time, in order to determine their direction, sailors used the position of the sun during the day and the stars at night.

Of course the clouds could obstruct the view of the stars, which would mean that sailors did not know their location in the middle of immense, uncharted waters. Cervantes remembers a situation like this in a sonnet, comparing the absence of stars in the night sky to a missing loved one:

*I know that I am doomed; death is to me*
*As certain as that thou, ungrateful fair,*
*Dead at thy feet shouldst see me lying, ere*
*My heart repented of its love for thee.*
*If buried in oblivion I should be,*
*Bereft of life, fame, favour, even there*
*It would be found that I thy image bear*
*Deep graven in my breast for all to see.*
*This like some holy relic do I prize*
*To save me from the fate my truth entails,*
*Truth that to thy hard heart its vigour owes.*
*Alas for him that under lowering skies,*
*In peril o'er a trackless ocean sails,*
*Where neither friendly port nor pole-star shows."*

Quijote I, XXXIV

Hasta la invención de los meridianos, en el siglo XIX, la orientación en mitad del océano solo podía hacerse determinando el paralelo y sabiendo la hora.

La posición respecto a los paralelos se hacía con la ayuda de la brújula y por la posición del Sol o alguna estrella conocida, pero saber la hora con exactitud era muy complicado hasta la invención de los relojes de cuerda por el movimiento de los barcos, por lo que su precisión era muy escasa. Imagina el comportamiento de un reloj de péndulo en un barco en alta mar.

Para calcular la hora, los marinos se valían de la posición del Sol durante el día y de la posición de las estrellas por la noche. En el hemisferio norte generalmente se tomaban como referencia **la estrella Polar** y las estrellas ***Dubhe* y *Merack* de la Osa Mayor**.

- Gira el cielo hasta la posición de la fecha de hoy.
- Busca la estrella Polar a través del orificio del reloj nocturno.
- Orienta la flecha hacia las estrellas Dubhe y Merack.
- Gira el limbo para que coincida la fecha de hoy con la indicación del mango.
- Podrás leer la hora en el limbo.

Until the invention of meridians in the XIX century, you could only determine a ship's direction, in the middle of the ocean, by using parallels and knowing the time.

Location with respect to parallels was determined by using a compass and the position of the sun or a known star. Up until the invention of the pocket watch, figuring out the exact time was very complicated and imprecise due to the movement of the ship. Imagine the movement of a pendulum clock on the high seas.

To calculate the time, sailors used the position of the sun during the day and the position of stars at night. In the northern hemisphere, they generally used Polaris (the North Star) and the stars Merak and Dubhe, found in the constellation Ursa Major (the Big Dipper).

Turn the sky and position it to today's date.

Look through circular opening in the nocturnal and locate Polaris.

Direct the arrow towards Dubhe and Merak.

Turn the dial to figure out today's date, indicated by the handle.

You will be able to tell the time by looking at the dial.

Gigantes de Brazos Largos

*—¿Qué gigantes? dijo Sancho Panza.*
*—Aquellos que allí ves, respondió su amo, de los brazos largos, que los suelen tener algunos de casi dos leguas.*
*—Mire vuestra merced, respondió Sancho, que aquellos que allí se parecen no son gigantes, sino molinos de viento, y lo que en ellos parecen brazos son las aspas, que volteadas del viento hacen andar la piedra del molino.*

Quijote, I, VIII

Se ha considerado con frecuencia que las alucinaciones de don Quijote confundiendo a los molinos con gigantes, eran debido a lo novedoso de estas máquinas en la época de Cervantes, pero hay constancia de la presencia de molinos de viento ya hacia el siglo XI. Del texto de Cervantes es fácil deducir que estas máquinas eran muy populares y bien conocidas, como demuestra Sancho.

Durante muchos siglos la principal industria agraria de transformación, en el centro de la Península, fue la producción de harina, como corresponde a la importancia alimenticia del pan. La cantidad de tierras dedicadas al cultivo de los cereales era abrumadoramente mayor que la dedicada a otros cultivos y, en sintonía con esta importancia, los molinos estaban presentes en casi todos los rincones de la Península. Su número era tan elevado que en lugares como, por ejemplo, Campo de Criptana llegó a haber hasta 34 molinos (cifra superior a la de muchos parques eólicos actuales).

# Long Armed Giants

*"What giants?" said Sancho Panza.*
*"Those thou seest there," answered his master, "with the long arms, and some have them nearly two leagues long."*
*"Look, your worship," said Sancho; "what we see there are not giants but windmills, and what seem to be their arms are the sails that turned by the wind make the millstone go."*

Quijote, I, VIII

Don Quijote's hallucination, when he confused windmills for giants, is often explained by the recency of these new machines during Cervantes' lifetime.  Contrary to this theory, there is evidence of the presence of windmills that dates back roughly to the XI century.  From the writer's texts it's easy to see that these machines were popular and well known, as Sancho shows us.

Throughout many centuries the agricultural industry on the Iberian Peninsula was centered around the production of flour because it was the fundamental for making a staple in their diet: bread.  The quantity of land dedicated to the cultivation of cereales was abundantly greater than that dedicated to other crops. In harmony with this land/crop distribution, windmills were constructed in almost all corners of the peninsula. Many were constructed and some areas had a very high concentration of them like ***Campo de Criptana***, where there were at least 34 windmills (a statistic higher than many windparks that exist today).

La industria harinera ocupaba un lugar muy importante en la generación de riqueza en muchísimos lugares. Los molineros, sin embargo, con frecuencia eran considerados personas poco fiables, con cierta tendencia a engañar en las cantidades molidas. El molinero hacía su ganancia con un porcentaje de la molienda acordado previamente.

Eran además objeto de cierta envidia porque el nivel de automatismo del molino les permitía dejarlo funcionando, una vez terminadas todas las tareas para ponerlo en marcha, y dedicarse a otras actividades como atender las tierras o los animales. Esto suponía que el molino, si era necesario, podía funcionar de día y de noche, siempre que hiciera el viento adecuado.

A pesar de todo la mayoría de los molinos eran movidos por la fuerza del agua (**hidráulicos**). Este tipo de molinos estaban generalmente dedicados a las tareas de compactar la lana (**batanes**) para hacer paños más gruesos e impermeables.

En otro pasaje Cervantes hace estremecer de miedo a los protagonistas al pasar la noche escuchando un tremendo y continuo estruendo.

Quijote, I, XX

Aún así las aventuras de don Quijote inmortalizaron la imagen de los molinos de viento (eólicos) manchegos.

The flour industry had a sizable amount of importance and gave way to a wealthy generation in many regions. The mill owners however, were usually considered untrustworthy. They made their profit from a percentage of the mills product, agreed upon beforehand and they had the tendency to lie about the amounts of flour that were ground.

Additionally, the mill owners were the object of envy because of the level of automatism that windmills provided. After finishing all the tasks needed to start the process, they could leave the windmill working, and then dedicate their time to other activities such as taking care of animals or cultivating their land. One must also keep in mind that, if necessary and assuming there was enough wind power, mills could function day and night.

Despite everything, the majority of mills were powered by water (hydraulic). This type of mill was generally dedicated to tasks like compacting wool (water or fulling mills) to make clothes that were thicker and more waterproof.

In another passage Cervantes makes his protagonists shiver with fright as they spend the night listening to a continuous, terrible banging.

*"At the foot of the rocks were some rudely constructed houses looking more like ruins than houses, from among which came, they perceived, the din and clatter of blows, which still continued without intermission. Rocinante took fright at the noise of the water and of the blows, but quieting him Don Quixote advanced step by step towards the houses, commending himself with all his heart to his lady, imploring her support in that dread pass and enterprise, and on the way commending himself to God, too, not to forget him. Sancho who never quitted his side, stretched his neck as far as he could and peered between the legs of Rocinante to see if he could now discover what it was that caused him such fear and apprehension. They went it might be a hundred paces farther, when on turning a corner the true cause, beyond the possibility of any mistake, of that dread-sounding and to them awe-inspiring noise that had kept them all the night in such fear and perplexity, appeared plain and obvious; and it was (if, reader, thou art not disgusted and disappointed) six fulling hammers which by their alternate strokes made all the din."*

Quijote, I, XX

Even so, this is the way that Don Quijote has immortalized the image of Manchego windmills and wind parks.


# Manchego Mills

The transformation of energy for the purpose of powering machines was one of the key technological developments for humanity. Wind (or water) is an excellent source of energy, but the greatest challenge is harnessing their power.

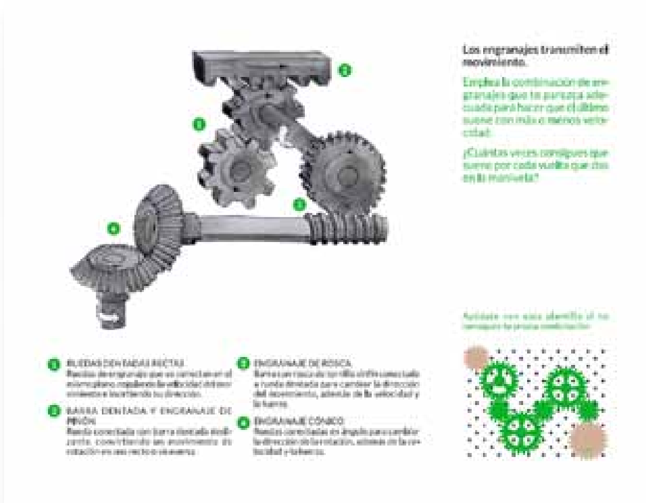
Gears are the most precise and efficient tool used to transmit the movement from a source of energy (air, water…) to where needs to be transferred.

Gears have always been fundamental in the operation of windmills as much as in water powered mills.

In the case of Manchego mills, the great spur wheel sends the movement from the sails to the grinding wheel by rotating the central axis. As the wheel spins, the big teeth on the gear connect with slots on the axis making it move and as a result, the sails' energy is transmitted to the rotating grinding wheel.

Look at the diagram of the windmill. What are the names of each part and what is their function?

1. Sails - Covered in cloth, their job is to catch the wind's energy. They are slightly angled to take full advantage of the windpower. The are approximately 7.90 meters long.
2. Windshaft - A wooden bar that is used to transmit the sails' movements to the mechanism inside the mill.
3. Cap - Where the rotary is located.
4. Rotating grinding stone - stone that spins.
5. Fixed stone - stone does not move.
6. Steering Pole - A long wooden pole that rotates the cap and positions the sails towards the direction that the wind is blowing. It is 16 meters long.
7. Great Spur Wheel - It interlocks with wooden teeth on the central axis causing it to rotate.
8. Brake handle - It stop the great spur's movement.
9. Upright Shaft - Transmits power to from the great spur to the stone nut.
10. Wooden supports- 4 beams, 8 rollers, and 8 semi-curved pieces on top of 4 beams. Together, they form the base of the cap.
11. Windows - There are 12 small windows that function with the wind. When open, the miller knows which direction the wind is blowing and can then decide which way to turn the cap and sails.
12. Machine base - supports the millstones (grinding stones) and the hopper
13. Vertical joints - 2 beams that support the weight of the millstones
14. Mill spout - Flour is sent down this chute to the meal floor where it is bagged.

## Gears

What is a Gear? It's a wheel with teeth (or cogs).

In general, the larger gear is called the **wheel** and the smaller gear is the **pinion**.

The relationship between the diameter and number of teeth on each gear is key for creating the correct type of motion when they are working together. These two factors affect the amount of energy needed and the velocity that is produced.

There is evidence that the gears were used in Greece and China in the II century B.C.

1. Wheels with straight teeth: gears that connect on the same plane and regulate movement. They invert the other gears direction.

2. Toothed Bar with Pinion Gear: Wheel connected to a sliding toothed bar. This converts a rotating motion into a straight one, or vice versa

3. Threaded Gear: A bar with an endless screw thread connected to a toothed wheel. This changes the direction of motion and effects the velocity and power needed as well.

4. Conical gear: Wheels connected at an angle in order to change the direction of rotation as well as the velocity and power.

**Gears transfer motion**

Use the number of gears that you see fit to make the last gear spin faster or slower.

How many times did the gear to spin each time you turned of the handle?


# The relative size of things

*"Like red wine, your worship had better say," replied Sancho; "for I would have you know, if you don't know it, that the dead giant is a hacked wine-skin, and the blood four-and-twenty gallons of red wine that it had in its belly, and the cut-off head..."*

Quijote, I XXXVII

On the Iberian Peninsula during the XVI and XVII centuries, two hundred years before the ***metric system*** was invented, they used a multitude of diverse coins, units of weight and volume and measurements of length and area. All of these units varied from one kingdom to the next, even one province to another. Imagine traveling from Madrid to A Coruña and having to exchange currency in each community you passed through, or in order to buy fruit, having to know the different measurements that they used in each place.

To measure distance between towns they used ***leagues***: the distance a person can walk in an hour. But of course, one needs to consider that if you go by horse you cover more distance...

To measure the amount of wine that could fill a container, they used ***arrobas***, which were equivalent to 16 liters more or less. They also used ***arrobas*** to measure a person's weight, but in this case, one unit was equivalent to about 11 kilos and again, there was variation in these measurements depending on the province you were in. As you can see, this system was very convenient, especially if you worked in sales.

Imagine a traveler like Sancho. Try to precisely measure some things the way he would.

Esta es una selección de las medidas más comunes usadas en la época de Cervantes. Las medidas tenían variaciones notables entre las regiones de España y aun entre pueblos relativamente próximos.

Pese a los ensayos unificadores que se remontan a Alfonso X el Sabio, que adoptó los patrones de Toledo, Valladolid o Burgos, solo con los Reyes Católicos se pudieron aplicar con rigor disposiciones tendentes a homogeneizar pesos y medidas, aunque su efectividad fue mínima. Este desorden se mantuvo hasta bien entrado el siglo XIX.

Capacidad de Granos

| | | |
|---|---|---|
| Cahíz | 666 litros | 12 fanegas |
| Fanega | 55,5 L aprox. | 12 celemines |
| Celemín | 4,6 L aprox. | 4 cuartillos |
| Un Medio (1/2 celemín) | 2,3 L aprox. | 2 cuartillos |
| Cuartillo | 1,15 L aprox. | |

Capacidad para Vinos

| | | |
|---|---|---|
| Cántara o Arroba | 16 L aprox. | 8 azumbres |
| Azumbre Fanega | 2 L aprox. | 4 cuartillos |
| Botella | 0,75 L aprox. | 1 ½ cuartillos |
| Cuartillo | 0,50 L aprox. | 4 copas |
| Copa | 0,12 L aprox. | |

Longitud

| | | |
|---|---|---|
| Legua | 5,5 km aprox. | 20.000 pies |
| Paso | 1,3 m aprox. | 5 pies aprox. |
| Vara (castellana) | 84 cm aprox. | 3 pies |
| Pie | 28 cm aprox. | |
| Palmo | 20 cm aprox. | |

Peso

| | | |
|---|---|---|
| Arroba | 11,5 kg | 25 libras |
| Libra | 460 g | 16 onzas |
| Cuarterón | 120 g | ¼ de libra |
| Onza | 28 g aprox. | |

Superficie

| | | |
|---|---|---|
| Fanega | 6.400 m² aprox. | 12 celemines |
| Celemín | 533 m² aprox. | 4 cuartillos |
| Cuartillo | 133 m² aprox. | 12 estadales |
| Estadal | 11 m² aprox. | 16 varas |
| Vara | 0,7 m² aprox. | 9 pies |

Captura estas medidas con tu móvil. Las necesitarás más adelante.

Below you have a selection of the most used units of measurement during Cervantes' time. There was a notable difference in the measurements in each region, even between relatively close towns and villages in Spain.

Texts that outlined standardized measurements date back to **Alfonso X *el Sabio***. These measurements were adopted by masters in places like Toledo, Valladolid and Burgos, but they weren't able to strictly apply these regulations that moved towards homogenizing weight and measurements until the **Catholic Monarchs** era and even still, its effect was minimal. This chaos continued on well into the XIX century.

### Measurements for Grains

| | | |
|---|---|---|
| Cahíz | 666 liters | 12 fanegas |
| Fanega | 55.5 L approx. | 12 celemines |
| Celemín | 4.6 L approx. | 2 cuartillos |
| Un medio | 2.3 L approx. | 2 cuartillos |
| Cuartillo | 1.15 L approx. | |

### Measurements for Wine

| | | |
|---|---|---|
| Cántara or Arobba | 16 L approx. | 8 azumbres |
| Azumbre Fanega | 2 L approx. | 4 cuartillos |
| Botella | 0.75 L approx. | 1 ½ cuartillos |
| Cuartillo | 0.50 L approx. | 4 copas |
| Copa | 0.12 L approx. | |

### Length

| | | |
|---|---|---|
| League | 5.5 km approx. | 20,000 feet |
| Paso | 1.3 m approx. | 5 feet |
| Vara (spanish) | 84 cm | 3 feet |
| Foot | 28 cm approx. | |
| Palm | 20 cm | |

### Weight

| | | |
|---|---|---|
| Arroba | 11.5 kg | 25 pounds |
| Pound | 460 g | 16 ounces |
| Cuarentón | 120 g | ¼ pound |
| Ounce | 28 g approx. | |

### Area

| | | |
|---|---|---|
| Fanega | 6,400 m2 approx. | 12 celemines |
| Celemín | 533 m2 approx. | 4 cuartillos |
| Cuartillo | 133 m2 approx. | 12 estadales |
| Estadal | 11 m2 approx. | 16 varas |
| Vara | 0.7 m2 approx | 9 feet |

Take a picture of these measurements with your mobile phone. You will need them later.


# Measuring Length

*"There was besides in the inn, as servant, an Asturian lass with a broad face, flat poll, and snub nose, blind of one eye and not very sound in the other. The elegance of her shape, to be sure, made up for all her defects; she did not measure seven palms from head to foot, and her shoulders, which overweighted her somewhat, made her contemplate the ground more than she liked."*

Quijote, I XVI

Just like the units used for volume and weight, measurements for length and distance were extremely imprecise.

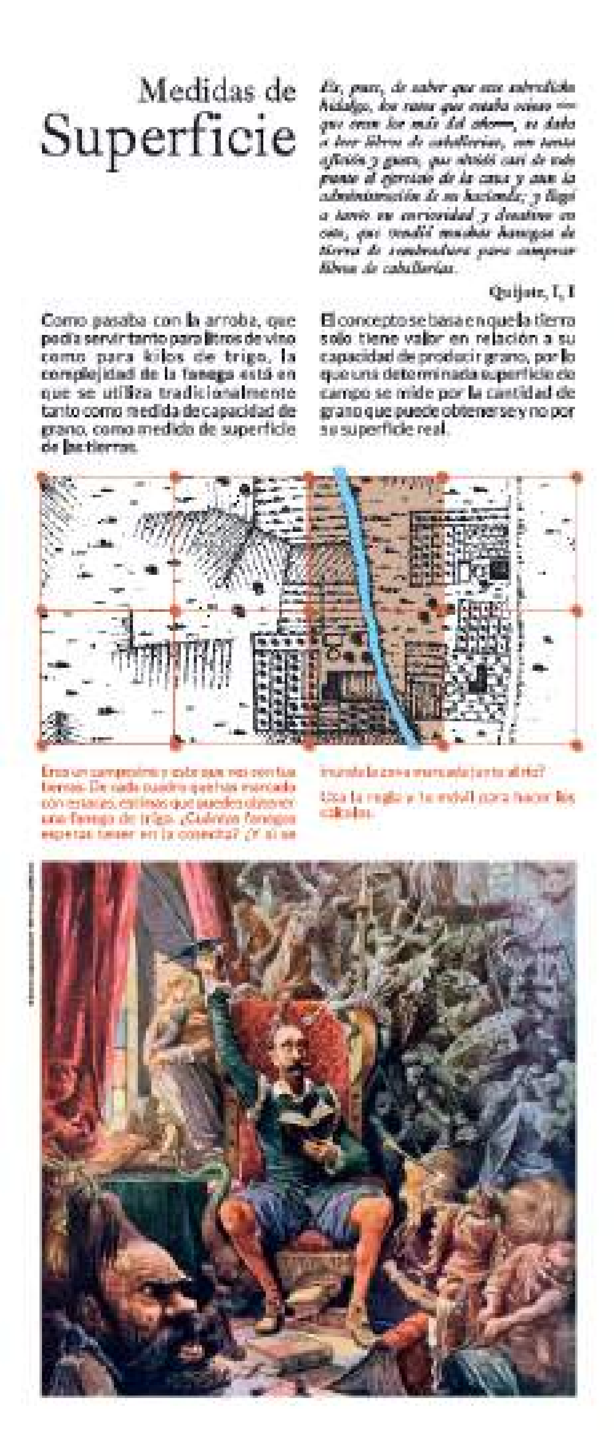
Almost all of these units were based on anthropometrics, which is to say that they made reference to parts of the human body: ***finger, thumb, coto, palm, foot, elbow, vara, braza***. Keep in mind, not all bodies are the same size. A ***palm*** is the measured distance from the tip of the thumb to the tip of the pinky finger with all fingers splayed. A ***foot*** is the distance from the heel to the tip of the big toe. A ***vara*** is the measurement of an extended arm from the center of the body to the end of the hand.

One vara equals 3 feet or 4 palms.

Use your hand to measure the height of your partner in palms. In many cases it will not be exact, that is to say, he or she will be 5, 6 or 7 palms and a little more. How much is a little more? What is the measurement for half a palm? It's impossible to know!
Use a ruler to check the accuracy of your measurement.

Compare your foot with the measurement used in Cervantes' era. Does it seem like measuring distances in feet is accurate?
Walk five steps (feet), putting one foot directly in from of the other. Does your measurement match with ruler's measurement? Check the accuracy of the measurement. Can you imagine the errors that would occur if you are measuring further distances?

Measure the height of this space in feet, varas and palms.
Measure the distance between this space and the door, then measure your partner's height.




# Measuring Area

*"You must know, then, that the above-named gentleman whenever he was at leisure (which was mostly all the year round) gave himself up to reading books of chivalry with such ardour and avidity that he almost entirely neglected the pursuit of his field-sports, and even the management of his property; and to such a pitch did his eagerness and infatuation go that he sold many an acre of tillageland to buy books of chivalry to read."*

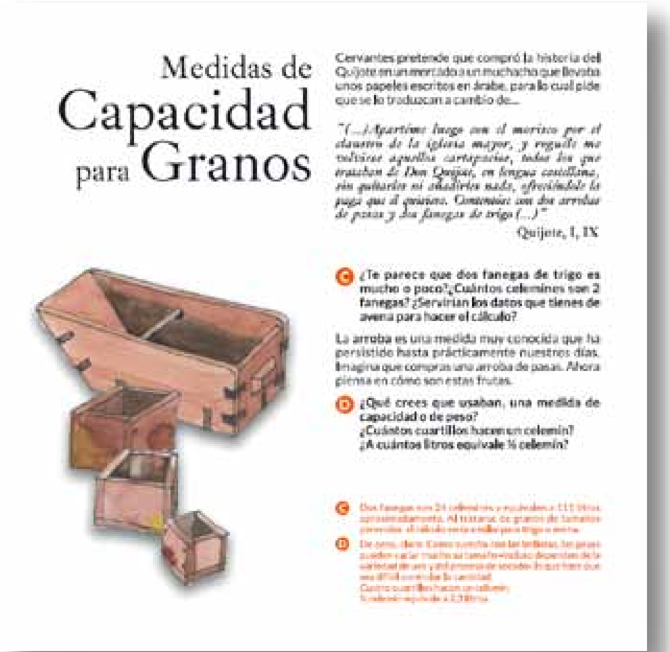
Quijote, I, I

Just like the ***arroba***, that could serve for liters of wine as well as kilos of grain, the difficulty with the ***fanega*** (a peck or a bushel) is that they were traditionally used for measurements of grain as well as the surface area of land.

The concept is based on the idea that land's value is related to the amount of grain that can be grown there. Due to this fact, the surface area of land is measured by the quantity of grain that can be produced and not by its actual surface area.

You are a farmer and what you see here is your land. Estimate how many ***fanegas*** of grain you can grow in each squared off area. How many ***fanegas*** of wheat do you expect for this harvest? And what if the area around the river floods?

Use a ruler and your mobile phone to do the calculations.


# Measuring the volume of grains

Now that **Sancho** is the mayor of ***Barateria Island***, the duchess of the island sends his wife a card to congratulate them on the good work he is doing. Additionally, she asks that they send her two dozen acorns (that are known for being big and delicious) and Sancho's wife responds:

*"And as for the acorns, senor, I'll send her ladyship a peck and such big ones that one might come to see them as a show and a wonder."*

Quijote, II, L

Craftsmen made wooden boxes for measuring. Each box corresponded to the specific quantity that needed to be measured. Look at the ***celemín***. Now imagine it's full of acorns.

**A.** Do you think each ***celemín*** will have the same number of acorns? Do you think a celemin would be more useful to measure acorns or oats?

In those times, some people made their own **celemín** to try try and trick their customers. They made them smaller so that they could fill it with less than what was paid for. Fill two ***celemines*** with grain.

**B.** Would you know how to tell which of the ***celemines*** is the fake? Check it out!

A: No, due to their shape and size it is almost impossible to fill it with the same number of acorns each time. It's easier to measure oats because they are small and their shape and size are more or less uniform (which is the same for wheat, rye, etc.).

**Cervantes** pretends that he bought the story of Don Quijote in the market, from a man that was carrying the manuscript written in Arabic. He asks for the story to be translated in return for...

*"I withdrew at once with the Morisco into the cloister of the cathedral, and begged him to turn all these pamphlets that related to Don Quixote into the Castilian tongue, without omitting or adding anything to them, offering him whatever payment he pleased. He was satisfied with two arrobas of raisins and two bushels of wheat"*

Quijote, I, IX

**C.** Do 2 ***fanegas*** seem like a large or small quantity to you? How many ***celemines*** are in 2 ***fanegas***? Would the information you have about the oats help in doing the calculations?

The arroba is a well-known measurement that has maintained its presence almost up until the present. Imagine that you buy an arroba of raisins. Now think about what these dried fruits look like.

**D.** Do you think they are measured by their weight or volume? How many ***cuartillos*** are in a ***celemin***? How many liters are equal to a ***celemin***?

C: 2 fanegas are 24 celemines and equivalent to 111 liters approx. This is the case of grains that are a similar size. The calculation would be the same for wheat or oatmeal.

D: Weight. Just like with acorns, raisins' sizes vary, plus it depends on the type of grape that they come from and how they were dried. All these factors make it hard to control the amount. There are cuartillos in a celemin. ½ celmin is equal to 2.3 liters.

Medidas de Capacidad para Vinos

Una de las grandes complicaciones de la variedad de unidades de medida que existían en la época de Cervantes es que había medidas de capacidad diferentes para vino, aceite, agua y sólidos.

No solo era complicado por la variedad de unidades que había. Además, en algunos lugares se utilizaba el mismo nombre , como por ejemplo **arroba**, tanto para una cantidad de vino como una de... ¡grano!

En el episodio de las bodas de Camacho, Sancho descubre, según van entrando, la cantidad de manjares preparados para la fiesta:

*"(...) Contó Sancho más de sesenta zaques de más de a dos arrobas cada uno, y todos llenos, según después pareció, de generosos vinos..."*

Quijote, II, XX

En el episodio de la defensa de la hija de la dueña doña Rodriguez, el Quijote se enfrenta con Tosillos para forzar la boda de este. Cervantes describe el caballo del oponente del Quijote:

*"El caballo mostraba ser frisón, ancho y de color tordillo; de cada mano y pie le pendía una arroba de lana..."*

Quijote, II, LVI

Medidas de Capacidad para Vinos

No solo era complicado por la variedad de unidades que había. Además, en algunos lugares se utilizaba el mismo nombre , como por ejemplo *arroba* tanto para una cantidad de vino como una de... ¡grano!

En la época de Cervantes, la medida de capacidad del vino era la *arroba* o *cántara*, que se dividía en **azumbres, cuartillos**, o **copas**.

**A** Como has leído en el panel de introducción, Don Quijote arremete contra unos odres de vino, al confundirlos con gigantes. Si en la posada había cuatro odres llenas de vino, con la siguiente capacidad:

Odre 1 : 2 arrobas
Odre 2 : 25 cántaras
Odre 3: 45 cuartillos
Odre 4: 12 azumbres

¿Cuántos litros de vino contenían los odres que confunden a don Quijote?

Usa el rompecabezas, para averiguar cuántos **azumbres**, **cuartillos** o **copas** caben en una arroba y a cuántos litros equivalen.

# Measuring amounts of Wine

Some of the most complicated units of measurement during Cervantes lifetime were those used for liquids. This is because different measurements were used for wine, olive oil, water and solids.

It wasn't only difficult because the measurements varied, also, in some places they used the same name, like ***arroba***, for wine and grains!

In this chapter as they are entering the wedding of Camacho, Sancho lays eyes on the quantity of delicious delicacies that have been prepared for the party.

*"Sancho counted more than sixty wine-skins of over six gallons each, and all filled, as it proved afterwards, with generous wines."*

Quijote, II, XX

In this chapter, the defense of the the daughter Doña Rodríguez, Don Quijote is faced with an enemy, Tosillos. Cervantes describes his opponents horse:

*"The horse was a manifest Frieslander, broad-backed and flea-bitten, and with half a hundred of wool hanging to each of his fetlocks."*

Quijote, II, LVI

It wasn't only difficult because measurements varied, also, in some places they used the same name, like arroba, for wine and grains!

In Cervantes' era the measurements for volume were the ***arroba*** or the ***cántara***, and they could be divided into ***azumbares***, ***cuartillos*** or ***copas***.

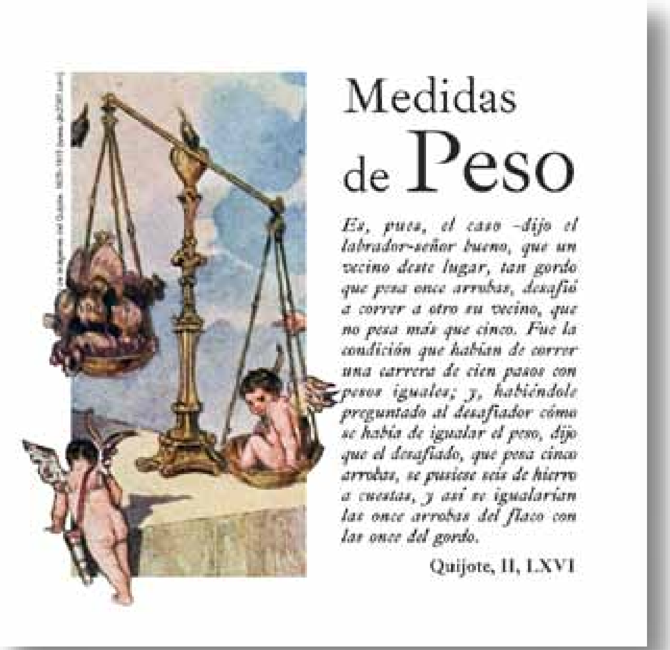
**A:** As you read in the introduction, Don Quijote thought he was being attacked by some wine-skins (large containers used for wine) that he confused for giants. Imagine that in the inn there were four wine-skins, full of wine, with the following volume:

wine-skin 1: 2 arrobas
wine-skin 2: 25 cántaras
wine-skin 3: 45 cuartillos
wine-skin 4 12 azumbres

How many liters of wine are in the containers that confused Don Quijote?

Use the puzzle to figure out how many azumbres, cuartillos or copas fit into an arroba. Now find the equivalent in liters.

A: Wine-skin 1: 32 liters, Wine-skin 2: 2.80 liters, Wine-skin 3: 3.90 liters, Wine-skin 4: 4.24 liters




# Measuring weight

*"Well, here it is, worthy sir," said the peasant; "a man of this village who is so fat that he weighs twenty stone challenged another, a neighbour of his, who does not weigh more than nine, to run a race. The agreement was that they were to run a distance of a hundred paces with equal weights; and when the challenger was asked how the weights were to be equalised he said that the other, as he weighed nine stone, should put eleven in iron on his back, and that in this way the twenty stone of the thin man would equal the twenty stone of the fat one."*

Quijote, II, LXVI


**A:** How much did each runner weigh?

**B:** What is the approximate distance of a 100 pace race?

**C:** How many kilos are there in 6 pounds? How much do you weigh in pounds?

A: 126.5 and 57.5 kilos B: 130 meters C: 2.7 kilos