



Historical Wheels and Its Applications

Alena Šolcová, 2019

CTU in Prague



What is a wheel?

A **wheel** is a device that allows heavy objects to be moved easily through rotating on an axle through its center, facilitating movement or transportation while supporting a load, or performing labor in machines.

- **Common examples found in transport applications.**
- A wheel, together with **an axle**, overcomes **friction** by facilitating motion by **rolling**.
- In order for wheels to rotate, a **moment** needs to be applied to the wheel about its axis, either by way of gravity, or by application of another external force.
- More generally the term is also used for other circular objects that rotate or turn, such as a **ship's wheel**, **steering wheel** and **flywheel**.

The Oldest Evidence of wheels

- Evidence of wheeled vehicles appears from **the mid 4th millennium BCE**, near-simultaneously in Mesopotamia, the Northern Caucasus (**Maykop culture**) and **Central Europe**
- so that the question of which culture originally invented the wheeled vehicle remains unresolved and under debate.



Southern Poland

- The earliest well-dated depiction of a wheeled vehicle (here a wagon—four wheels, two axles), is on the **Bronocice pot**, a ca. 3500–3350 BCE clay pot excavated **in a Funnelbeaker culture settlement in southern Poland.**

3rd and 2nd Millenium BCE

- The wheeled vehicle spread from the area of its first occurrence (Mesopotamia, Caucasus, Balkans, Central Europe) across Eurasia, reaching the **Indus Valley by the 3rd millennium BCE.**
- During the 2nd millennium BCE, the **spoke-wheeled chariot** spread at an increased pace, reaching both **China and Scandinavia by 1200 BCE.**
- In China, the wheel was certainly present with the adoption of the chariot in ca. 1200 BCE, although Barbieri-Low argues for earlier Chinese wheeled vehicles, circa 2000 BCE.

Iran - 1000 BC



Olmecs

- Although they did not develop the wheel proper, the Olmec and certain other western hemisphere cultures seem to have approached it, as **wheel-like worked stones** have been found on objects identified as children's toys dating to about 1500 BCE. It is thought that the primary obstacle to large-scale development of the wheel in the Western hemisphere was **the absence of domesticated large animals** which could be used to pull wheeled carriages.
(The closest relative of cattle present in Americas in pre-Columbian times, **the American Bison**, is difficult to domesticate and was never domesticated by Native Americans;
several horse species existed until about 12,000 years ago, but ultimately went extinct,
likely due to overhunting by newly-arrived humans.
The only large animal that was domesticated in the Western hemisphere, **the llama**, did not spread far beyond the Andes by the time of the arrival of Columbus.)

Toy from New World



Nubie and Egypt

- Early antiquity **Nubians** used wheels **for spinning pottery and as waterwheels.**
- It is thought that Nubian **waterwheels** **may have been ox-driven.**
- It is also known that Nubians used horse-driven chariots **imported from Egypt.**

Bronze Age

- The invention of the wheel thus falls in the late Neolithic, and may be seen in conjunction with other technological advances that gave rise to the early Bronze Age. Note that this implies the passage of several wheel-less millennia even **after the invention of agriculture and of pottery**:
- 9500–6500 BCE: Aceramic Neolithic
- 6500–4500 BCE: Ceramic Neolithic (Halafian)
- ca. 4500 BCE: **invention of the potter's wheel**, beginning of the Chalcolithic (Ubaid period)
- 4500–3300 BCE: Chalcolithic, earliest wheeled vehicles, **domestication of the horse**
- 3300–2200 BCE: Early Bronze Age
- 2200–1550 BCE: Middle Bronze Age, **invention of the spoked wheel and the chariot.**

Bronze Age



Ur , 2500 BC



Etruscan Wheel

Problem of Roads

- Wide usage of the wheel was probably delayed because **smooth roads** were needed for wheels to be effective. Carrying goods on the back would have been the preferred method of transportation over surfaces that contained many obstacles.
- The lack of developed roads prevented wide adoption of the wheel for transportation until well into the 20th century in less developed areas.

Wooden Wheel

- Early wheels were simple wooden disks with a hole for the axle.

Because of **the structure of wood**, a horizontal slice of a tree trunk is not suitable, as it does not have the structural strength to support weight without collapsing; rounded pieces of longitudinal boards are required.

The oldest known example of a wooden wheel and its axle were found in 2003 at the Ljubljana Marshes some **20 km south of Ljubljana, the capital of Slovenia.**

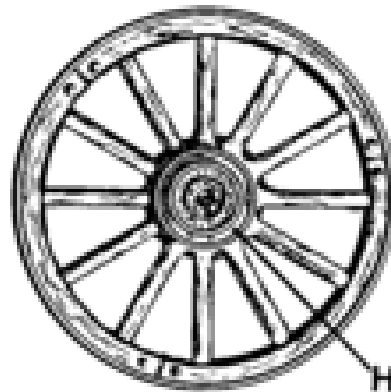
According to the **radiocarbon dating**, it is between 5,100 and 5,350 years old.

The spoked wheel

- The **spoked wheel** was invented more recently, and allowed the construction of lighter and swifter vehicles.
- In the **Harappan civilization** of the Indus Valley and Northwestern India, we find toy-cart wheels made of clay with spokes painted or in relief, and the symbol of the spoked wheel in the script of the seals, already **in the second half of the 3rd millennium BCE**.
- The earliest known examples of wooden spoked wheels are in the context of the **Andronovo culture**, dating to ca 2000 BCE.
- Soon after this, **horse cultures of the Caucasus region** used horse-drawn spoked-wheel war **chariots** for the greater part of three centuries. They moved deep into the Greek peninsula where they joined with the existing Mediterranean peoples to give rise, eventually, to classical Greece after the breaking **of Minoan dominance** and consolidations led by pre-classical **Sparta** and **Athens**.

Celtic Chariots

- Celtic chariots introduced an **iron rim** around the wheel in the 1st millennium BCE.
- The spoked wheel was in continued use without major modification until the 1870s, when wire wheels and pneumatic **tires** were invented.



General Technology and Wheel

- The invention of the wheel has also been important for technology in general, important applications including the **water wheel**, the **cogwheel** (also antikythera mechanism), the **spinning wheel**, and the **astrolabe** or **torquetum**.
- More modern descendants of the wheel include the **propeller**, the **jet engine**, the **flywheel** (**gyroscope**) and the **turbine**.

Wheels -20th century



Michelin

Modern disc brake



Automobil wheel

Mechanics and Function

- The wheel is a device that enables efficient movement of an object across a surface where there is a force pressing the object to the surface. Common examples are a cart pulled by a horse, and the rollers on an aircraft flap mechanism.
- Wheels are used in conjunction **with axles**, either the wheel turns on the axle, or the axle turns in the object body. The mechanics are the same in either case.
- The low resistance to motion (compared to dragging) is explained as follows (refer to **friction**):
 - the normal force at the sliding interface is the same.
 - the sliding distance is reduced for a given distance of travel.
 - the coefficient of friction at the interface is usually lower.

Wheel Is Not a Machine

- The wheel alone is not a machine, but when attached to **an axle** in conjunction with bearing, it forms **the wheel and axle, one of the simple machines.**

A driven wheel is an example of a wheel and axle. Note that wheels pre-date driven wheels by **about 6000 years.**

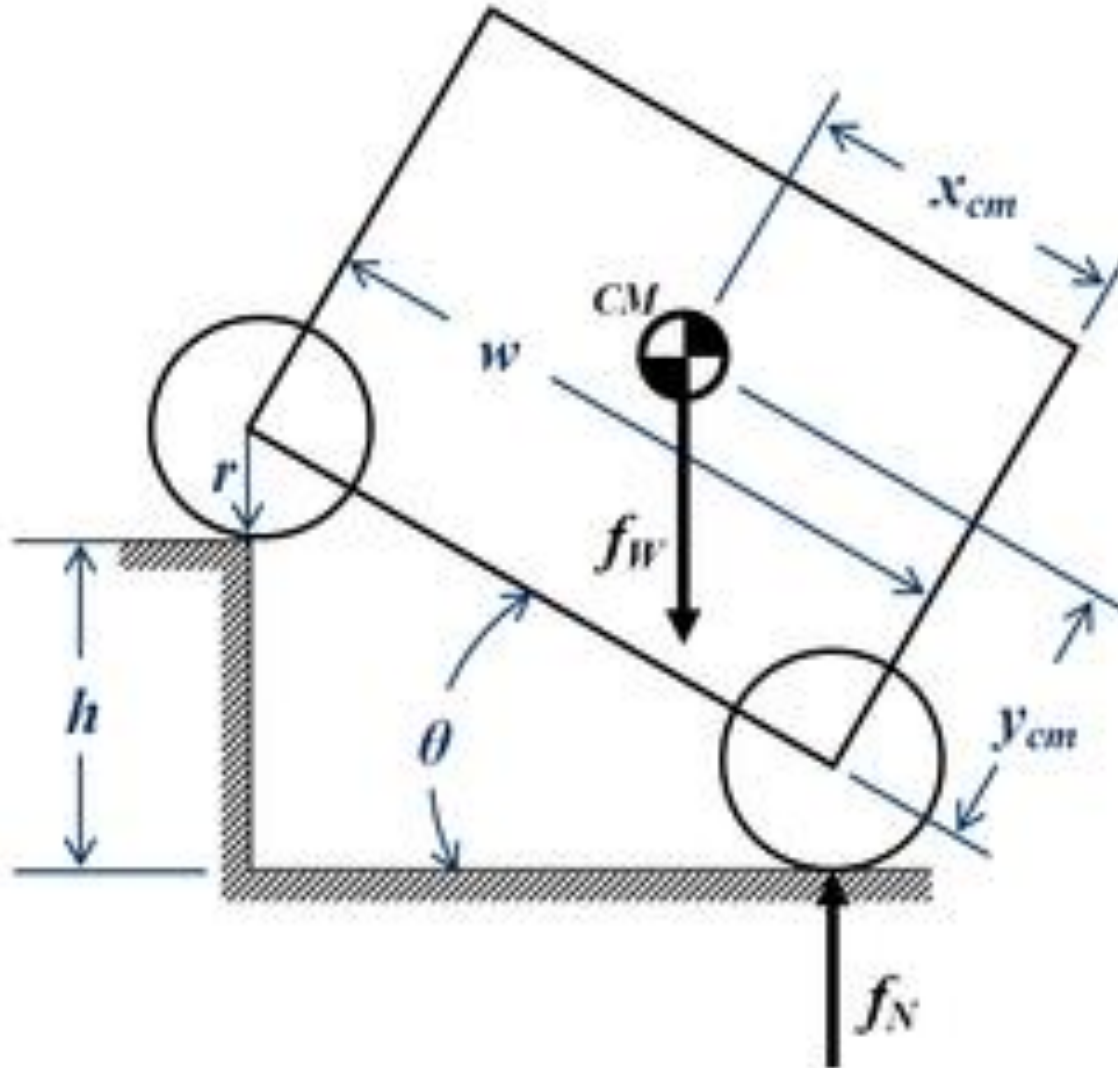
Bicycles



Stability

- For unarticulated wheels, climbing obstacles will cause the body of the vehicle to rotate.
- If the rotation angle is too high, the vehicle will become statically unstable and tip over.
- At high speeds, a vehicle can become dynamically unstable, able to be tipped over by an obstacle smaller than its static stability limit.
- Without articulation, this can be an impossible position from which to recover.

Stability in Pictures



Alternatives

While wheels are very widely used for ground transport, there are alternatives, some of which are suitable for terrain where wheels are ineffective.

Alternative methods for ground transport without wheels (wheel-less transport) include:

- Being raised by **electromagnetic** energy
- Dragging with runners or without travois
- Being raised by air pressure (hovercraft)
- **Riding an animal such as a horse**
- Human powered:
 - **Walking on one's own legs**
 - Being carried (litter/sedan chair or stretcher)
- **A walking machine**
- **Caterpillar tracks** (although it is still operated by wheels)
- **Pedrail** wheels, using aspects of both wheel and caterpillar track
- **Spheres** , as used by Dyson vacuum cleaners and hamster balls.