

## Mechanical Engineering in Ancient Egypt, Part 62: Papyrus Industry

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### ABSTRACT

*This is the 62 paper in a series of research papers investigating the evolution of mechanical engineering in ancient Egypt. It investigates the papyrus industry as a mean for book production and publication during the Dynastic Periods of ancient Egypt. It presents the features of papyri produced covering topics such as: mathematics, medicine, funerary, administration, economic, business, hymns, festival and erotic. The study focused on papyrus script, dimensions, writing direction and ink color used.*

**Keywords:** *Ancient Egypt, Mechanical Engineering History, Papyrus industry*

### INTRODUCTION

This is the 62 research paper in a series of papers aiming at exploring the development of mechanical engineering in ancient Egypt. This paper handles one of the documentation means used by ancient Egyptians to authorize their great civilization. That is writing text and illustrations using papyri.

Kitchen (1976) announced that from the Old Kingdom came the earliest original papyrus found in the pyramid-temple of Nefererkare at Abusir. He added that from early 12<sup>th</sup> Dynasty of the Middle Kingdom, a series of account-papyri found in Upper Egypt (Tanis and Abydos). He also stated that under the Ramesside Kings the Anastasi papyri from Memphis preserved some references to brick making [1]. Wiedeman and Bayer (1983) announced that in the beginning of the 20<sup>th</sup> century, rich cache of papyri writings were uncovered in Middle and Upper Egypt and located in European Museums. They examined some of those papyri using analytical techniques [2].

Onstine (2001) outlined that 44 papyri in the British Museum mentioned the title 'sm yt' (chantress) where the majority owned by women. The 21<sup>st</sup> Dynasty papyri were good source of information for determining that the title 'sm yt' was popular during the Third Intermediate Period [3]. Lucarelli (2004) outlined in his Ph.D. Thesis about the book of the dead of Gatseshen that the book of the dead

papyri were in use from the beginning of the New Kingdom until the Roman Period. He compared the papyrus of Gatseshen with other funerary manuscripts produced in Thebes in the same period [4]. Van Blerk (2006) in his Master of Art Thesis about law and justice in ancient Egypt outlined that the book of the dead was in use among the Egyptians from 4000 BC to the early centuries of the Christian era. He presented some colored scenes from the papyrus of Hunefer from the 19<sup>th</sup> Dynasty located in the British Museum [5].

Pehal (2008) studied fragments of a papyrus from the New Kingdom of 4.87 m length and 11 lines / page known as 'Astarte Papyrus' [6]. Jacobsen (2011) investigated the writing materials in the ancient world and presented a tabulated analysis showing that 65 % of documentations were through using papyri [7]. Kubaski (2012) outlined the fact that Egyptian mathematics came from the Rhind and Moscow papyri. He presented the Rhind or Ahmes Papyrus as the oldest mathematical document located in the British Museum [8]. Colten (2013) stated that the oldest treatise on trauma was the Edwin Smith Papyrus presenting (possibly) the work of Imhotep [9].

Bestetti, Restini and Couto (2014) outlined that it was noted in the Edwin Smith Papyrus (1700 BC) that the peripheral pulse originated from the heart beat. They also stated that in the Ebers papyrus (1500 BC), the central relationship between the heart and the channels system had been emphasized [10]. Colledge (2015) in her

Ph. D. Thesis about the process of cursing in ancient Egypt presented a number of pages from the papyrus from Deir-el-Medina and papyrus of Bremner Rhind [11]. Mark (2016) wrote an article about the Egyptian papyrus and said that the English word 'paper' came from the word 'papyrus'. He presented two pages from the Edwin Smith papyrus [12].

Wikipedia (2016) wrote an article about the papyrus of Bakay written during the 18th Dynasty and having a 9.67 m length and 0.355 m width in display in the National Museum in Warsaw at Poland [13]. Wikipedia (2017) wrote an article about papyrus and outlined that papyrus was first used by the ancient Egyptians as early as the 1st Dynasty. They mentioned some of the documentation in papyri of: Harris, Ebers, Edwin Smith, Rhind and Westcar papyri [14]. Dunn (2017) stated that the earliest documented papyrus came from the Egyptian 1st Dynasty. He stated that the standard page size was 470 mm length and 220 mm width where they were joined to form a roll of about 20 sheets [15].

### OLD KINGDOM PAPYRI

The oldest known papyrus is one in display in the Egyptian Museum at Cairo and dated to the 4th Dynasty (2500 BC) detailing the daily life of the pyramid builders among the King Khufu papyri discovered at Wadi El-Jarf port. A piece of this papyrus is shown in Figure 1 [16]. It was written using vertical columns and text written using one black color and the hieroglyphic script. The scribe marked the borders of the typing columns using thin lines.

### MIDDLE KINGDOM PAPYRI

The Middle Kingdom comprises the 11th and 12th Dynasty where we have a number of examples of papyrus production and use for writing purposes presented and investigated as follows:

- The first example is a mathematical papyrus from Lahun (of Fayum) written during the 12<sup>th</sup> Dynasty near the pyramid of Senusret II (1887-1878 BC) presenting problems on 'arithmetical progression' and known as 'Kahun IV papyrus'. It is in display in the Petrie Museum and shown in Figure 2 [17]. This text was written using the hieratic script and presented an application on the arithmetical progression.



Figure1. Papyrus piece from the 4<sup>th</sup> Dynasty [16]



Figure2. Papyrus piece from the 12<sup>th</sup> Dynasty [17]

- The second example is Berlin mathematical papyrus number 6619 which was written during the 12th-13th Dynasties (1991-1725 BC) in display in the Egyptian Museum at Berlin and a page of which is shown in Figure 3 [18]. This papyrus presented the solution of a mathematical problem representing two simultaneous equations in two unknowns, one of them was a second order equation and the second was a first order one. This papyrus proves that the ancient Egyptians could solve simply second-order algebraic equations. It was written using the hieratic script.

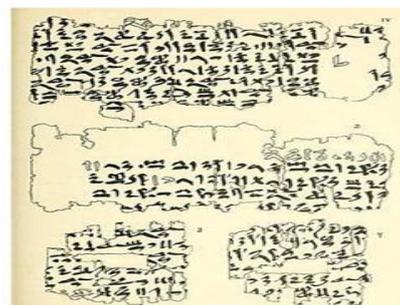


Figure3. Berlin Papyrus page from the 12<sup>th</sup>-13<sup>th</sup> Dynasties [18]

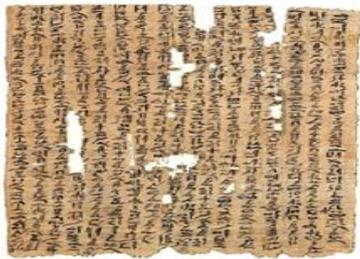
- The third example is the Kahun (Lahun) medical papyrus from the end of the 12th Dynasty (1800 BC) in display in the Petrie Museum at London and shown in Figure 4 [19]. It is the oldest medical papyrus dealing with women health, gynaecological diseases, fertility, pregnancy, contraception, etc. The papyrus text was divided into 34 sections, each section studied one women medical

problem including diagnosis and treatment [19]. It was written using the hieratic script.



**Figure4.** *Kahun Papyrus page from the 12<sup>th</sup> Dynasty [19]*

- The fourth example is a Heqanakht letter from the 12th Dynasty, reign of King Senusret I (1961-1917 BC) in display in the Metropolitan Museum of Art and shown in Figure 5 [20]. The papyrus length is 0.284 and its width is 0.271 m. The papyrus deals with rent and taxes paid during the 12th Dynasty to the King in grain [21]. It was written in vertical parallel columns using the hieratic script with one black ink.



**Figure5.** *Heqanakht Papyrus page from the 12<sup>th</sup> Dynasty [20]*

- The fifth example is a papyrus with non-standard hieroglyphs (the first example on cryptography) from the 12th Dynasty (1900 BC) shown in Figure 6 [22]. I could not trace the location of this wonderful papyrus. From the neat writing and design of the papyrus page, one can say that the writing scribe was a highly professional one. He wrote inside vertical parallel bands bounded by thin vertical lines using a black ink for his graphical font (hieroglyphic script).



**Figure6.** *Cryptographic script Papyrus from the 12<sup>th</sup> Dynasty [22]*

- The sixth example is a Meketre papyrus from the reign of King Senusret I (1981-1975 BC)

from the Tomb of Meketre TT 280 in display in the Metropolitan Museum and shown in Figure 7 [23]. The papyrus is a single page having an 0.26 m height and an 0.16 m width. I could not trace the subjects handled in Meketre papyrus. Metropolitan Museum of Art didn't refer to its contents nor the Egyptian archaeologists !!.



**Figure7.** *Meketre Papyrus from the 12<sup>th</sup> Dynasty [23]*

- The seventh example is a Lahun Papyrus from the reign of King Amenhotep III (1860-1814 BC) in display in the Petrie Museum at London and shown in Figure 8 [24]. It dealt with subjects including business, hymns, medicine, mathematics and festival listing [24].



**Figure8.** *Lahun Papyrus from the 12<sup>th</sup> Dynasty [24]*

## SECOND INTERMEDIATE PERIOD PAPYRI

The Second Intermediate Period of ancient Egypt comprised the 13<sup>th</sup> to 17<sup>th</sup> Dynasties. We have a number of example about the development of the writing-papyrus industry during this period presented as follows:

- The first example is the Moscow mathematical papyrus written during the 13th Dynasty (1803-1725 BC) in display in the Pushkin State Museum of Arts at Moscow and shown in Fig.9 [25]. The papyrus has a 5.5 m length and 76 mm width and presenting 25 mathematical problem with solutions. Figure 9 depicts a part of the papyrus for problem number 14. The problem dealt with the volume of a truncated pyramid with square base [26]. This papyrus was written using the hieroglyphic script with horizontal parallel text.



**Figure9.** *Moscow mathematical Papyrus from the 13<sup>th</sup> Dynasty [25]*

- The second example is Edwin Smith papyrus from the 16th Dynasty (1600 BC) in display in the New York Academy of Medicine and shown in Figure 10 [27]. This papyrus was considered as the oldest survival surgical text presenting 48 cases of wounds and trauma and it is a scroll of 4.68 m length. It was written using the hieratic script with text written in horizontal parallel lines using both black and red ink.



**Figure10.** *Edwin Smith medical Papyrus from the 16<sup>th</sup> Dynasty [27]*

- The third example is an Ahmes or Rhind mathematical papyrus from the 15th Dynasty (1550 BC) in display in the British Museum at London and shown in Figure 11 [28]. It was written using the hieratic script and included exercises on: fractions, notations, arithmetic, algebra, geometry and mensuration [29]. It was written using the hieratic script with text written in horizontal parallel lines using only black ink.



**Figure11.** *Rhind mathematical Papyrus from the 15<sup>th</sup> Dynasty [28]*

- The fourth example is a papyrus scroll fragment from the 17th Dynasty (1500 BC)

in display in the Rochester Institute of Technology at NY and shown in Figure 12 [30]. It was written using the hieroglyphic script in vertical parallel columns separated by a thin line. It was written using black and red ink.



**Figure12.** *Papyrus fragment from the 17<sup>th</sup> Dynasty [30]*

### NEW KINGDOM PAPYRI

The New Kingdom represented the strongest and richest ancient Egyptian historical era and comprising the 18<sup>th</sup>, 19<sup>th</sup> and 20<sup>th</sup> Dynasties. This strength definitely will be reflected to their use of papyri for documentation to authorize their great civilization. Let us see what we have from the New Kingdom:

- The first example is a page from the papyrus of Bakay from the 18th Dynasty (second half of the 15th century BC) in display in the National Museum of Warsaw, Poland and shown in Figure 13 [31]. The papyrus was from the class of the 'Book of Dead' having 9.67 m length and 0.355 m width written using the hieroglyphic script with black and red fonts. It was written in vertical lines without any marked borders between them and including shapes in the top of the pages.



**Figure13.** *Bakay Papyrus page from the 18<sup>th</sup> Dynasty [31]*

- The second example is the Book of Dead of Sebekmose, the goldworker of Amun from the 18th Dynasty (1430-1400 BC) in display in te Brooklyn Museum at NY and shown in Figure 14 [32]. The length of the papyrus is 7.3 m and its width is 0.355 m and it was written using the hieroglyphic script on both sides of the papyrus from right to left [32]. 0020



**Figure14.** *Sebekmose Papyrus from the 18<sup>th</sup> Dynasty [32]*

- The third example is the book of dead of Maherperi from the reign of Pharaoh Thutmose III (1398-1388 BC) of the 18th Dynasty in display in the Egyptian Museum at Cairo and shown in Figure 15 [33]. This papyrus was neatly written in vertical columns bounded by vertical lines using the hieroglyphic script in one black font.
- The fourth example is a page from Scribe Nebqed papyrus of the Book of Dead from the 18th Dynasty, reign of Pharaoh Amenhotep III (1388-1350 BC) in display in the Louver Museum at Paris and shown in Figure 16 [34]. The page shows the deace before Osiris in the hereafter. It was written using the hieroglyphic script in vertical columns with a lot of funerary scenes.



**Figure15.** *Maherperi Papyrus from the 18<sup>th</sup> Dynasty [33]*



**Figure16.** *Nebqet Papyrus from the 18<sup>th</sup> Dynasty [34]*

- The fifth example is the book of dead papyrus of Royal Scribe Nakht from Late 18th Dynasty (1350-1300 BC) in display in the British Museum and shown in Figure 17 [35]. The papyrus was written using the hieroglyphic script in vertical columns using two colors fonts with plenty of colored scenes. Figure 17 shows the Scribe Nakht

setting in a River-boat with sail and looking to the future waiting him.



**Figure17.** *Nakht Papyrus from Late 18<sup>th</sup> Dynasty [35]*

- The sixth example is Anastasi 5 papyrus from the 19th Dynasty (1292-1187 BC) in display in the British Museum at London and shown in Figure 18 [36]. The papyrus sheet 7 shown was written in horizontal lines using the hieratic script without any borders while justified exactly from both sides in two columns per page. The sheet has an 0.648 m length and an 0.275 m width and text written in two columns (the second column is not shown in the figure here to zoom the text).



**Figure18.** *Anastasi 5 Papyrus from 19<sup>th</sup> Dynasty [36]*

- The seventh example is the book of dead of Scribe Ani (papyrus of Ani) from the 19th Dynasty (1250 BC) in display in the British Museum at London where one page of it is shown in Figure 19 [37]. The papyrus was written using the hieroglyphic script in vertical bounded columns with extensive use of colored scenes for the activities of the afterlife as believed by the ancient Egyptians. The length of Ani papyrus was 23.77 m when unearthed. It was stolen from an Egyptian Government Storeroom in 1888 by the British Sir E. Budge where he cut it into 37 pieces and shipped them to the United Kingdom !!!!! [37].



**Figure19.** *Ani Papyrus from 19<sup>th</sup> Dynasty [37]*

- The eighth example is a page from the book of dead of Anhay, Chantress of Amun and Leader of the Musicians of Osiris from the 20th Dynasty (1187-1069 BC) in display in the British Museum at London and shown in Figure 20 [38]. The length of the manuscript is 0.786 m and its width is 0.455 m written using the hieroglyphic script.

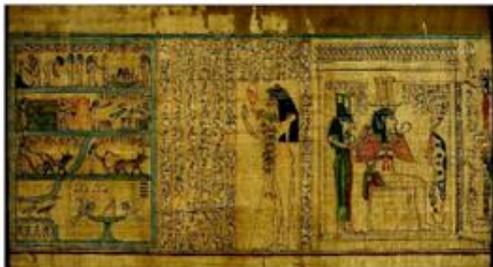


Figure 20. Anhay Papyrus from 20<sup>th</sup> Dynasty [38]

- The ninth example is the Great Harris Papyrus from the reign of Pharaoh Ramses III of the 20th Dynasty (1186-1155 BC) in display in the British Museum and shown in Figure 21 [39]. The papyrus length is 41 m and includes 1500 line of the hieratic script text.
- The tenth example is a Turin erotic papyrus from the 20th Dynasty (1150 BC) of 2.6 m length and 250 mm width in display in the Egyptian Museum at Turin, Italy and a page of which is shown in Figure 22 [40]. The papyrus was written using the hieratic script and included too many graphical illustrations.
- The eleventh example is Wilbour papyrus from the 20th Dynasty having a total length of 10.33 m in display in the Brooklyn Museum at NY and a page of which is shown in Figure 23 [41]. It was written during the reign of Pharaoh Ramses V (1151-1145 BC) [42] and it was considered the longest non-funerary papyrus from ancient Egypt. It handles taxation, Late Ramesside administration practices, temple economy, population and land donated to deities [41]. It was written using the hieratic script and horizontal text as clear from Figure 23.

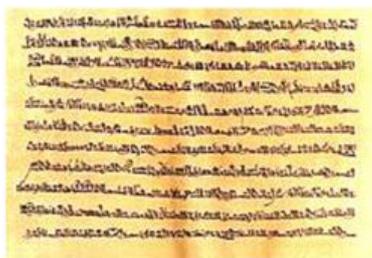


Figure 21. Page from Great Harris Papyrus from 20<sup>th</sup> Dynasty [39]

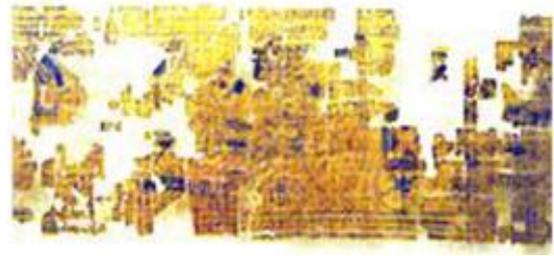


Figure 22. Page from Turin erotic Papyrus from 20<sup>th</sup> Dynasty [40]



Figure 23. Pieces from Welbour Papyrus from 20<sup>th</sup> Dynasty [41]

- The twelfth example is the book of dead of Nedjmet, daughter of Ramses XI, last Pharaoh of the 20th Dynasty (1107-1077 BC) in display in the British Museum and a page of the book is shown in Figure 24 [43]. The papyrus page shows Nedjmet adoring Osiris indicating the hieroglyphic script of the papyrus. Lenzo stated that this papyrus was written by Queen Nedjmet and its original length was over 14 m where it was cut into three pieces: a 4.19 m piece in the British Museum, an 8.92 m piece in the Louvre Museum and about 1.5 m in Munich (which was lost or damaged) [44].

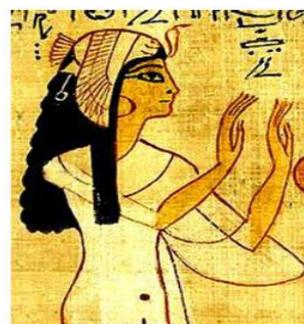
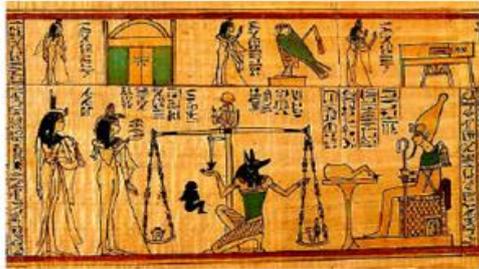


Figure 24. Page from Nedjmet Papyrus from 20<sup>th</sup> Dynasty [43]

### THIRD INTERMEDIATE PERIOD PAPYRI

The Third Intermediate Period of ancient Egypt covers the 21<sup>st</sup> through the 25<sup>th</sup> Dynasties covering a time span from 1070 to 656 BC. We have a number of example about papyrus production during this period covering a time span from 1050 BC to 975 BC presented as follows:

- The first example is the book of dead of Nany, the Singer of Amun during the 21st Dynasty (1050 BC) written during the reign of Pharaohs Psusennes I and Psusennes II in display in the Metropolitan Museum of Art at NY and one of its pages is shown in Figure 25 [45]. The Nany papyrus has a length of 5.215 m and a width of 0.35 m. It was written using the hieroglyphic script written in vertical columns in black colors and bounded by thin red lines. All the graphic scenes were nicely colored as depicted from Figure 25.



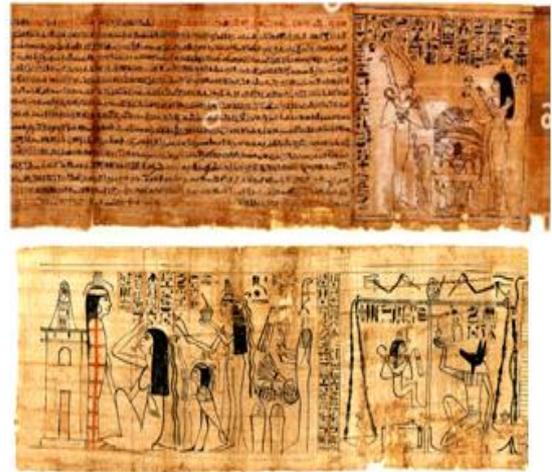
**Figure 25.** Page from Nany Papyrus from 21<sup>st</sup> Dynasty [45]

- The second example is the funerary papyrus of Djedkhonsuiefankh, the High Priest of Amun in Thebes during the 21st Dynasty (1046-1045 BC) in display in the Egyptian Museum at Cairo and shown in Figure 26 [46]. I couldn't trace the dimensions of the papyrus. It was written using the hieroglyphic script in vertical and horizontal lines using black ink. The scene shown in the figure depicts some of the ancient Egyptian symbols such as: Sphinx, Hedjet and Seba (star). The object on the back of the Sphinx represented the ship of Ra landing from the sky and radiating bright light [46].



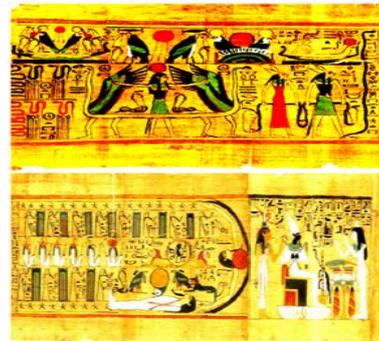
**Figure 26.** Page from Djedkhonsuiefankh Papyrus from 21<sup>st</sup> Dynasty [46]

- The third example is the papyrus of Henettawy, daughter of Isetemkheb from the 21st Dynasty (990-970 BC) in display in the Metropolitan Museum of Art and shown in Figure 27 [47,48]. It has a 1.39 m length and 235 mm width and written using the hieratic script in horizontal lines using black ink for the main text and red ink for the first line in the top.



**Figure 27.** Page from Henettawy Papyrus from 21<sup>st</sup> Dynasty [48]

- The fourth example is the book of dead of Gautsoshen from the 21st Dynasty (1000-945 BC) in display in the Metropolitan Museum of Art at NY and shown in Figure 28 [49]. He papyrus presents colored scenes and symbols from ancient Egypt and the script type is not clear in the papyrus part shown in Figure 28.



**Figure 28.** Gautsoshen Papyrus from 21<sup>st</sup> Dynasty [49]

- The fifth example is the funerary papyrus of Singer Tiye from Late 21st Dynasty (975-945 BC) in display in the Metropolitan Museum of Art at NY and shown in Figure 29 [50]. The papyrus has a 1.225 m length and was written using the hieroglyphic script in vertical columns bounded by thin red lines in some parts of the papyrus. It presented colored scenes for the deceased during weighing her heart in the hereafter as the ancient Egyptians believed.



**Figure 29.** Singer tiye Papyrus from 21<sup>st</sup> Dynasty [50]

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- The sixth and last example is a funerary papyrus of Amduat from Early 22nd Dynasty (945-715 BC) in display in the Cleveland Museum of Art at Ohio, USA and shown in Figure 30 [51]. It is a single page papyrus of dimensions: 0.48 m length and 0.245 m width written using the hieroglyphic script in vertical columns. The page is full of funerary scenes drawn using the black ink.



**Figure30.** Amduat Papyrus from 22<sup>nd</sup> Dynasty [51]

### LATE PERIOD PAPYRI

The Late Period of the ancient Egyptian History comprised the 26<sup>th</sup> Dynasty down to the 30<sup>th</sup> Dynasty over a time span from 664 BC to 343 BC. We have papyri examples covering the time span from 700 BC to 450 BC presented as follows:

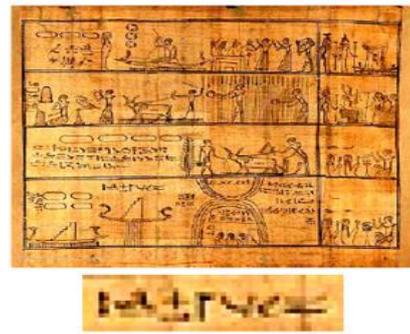
- The first example is the book of dead of Khamhor from the 26th Dynasty (664-525 BC) in display in the Metropolitan Museum of Art at NY and shown in Figure 31 [52]. The papyrus length is 2.95 m and its width is 0.37 m and was written in horizontal lines using either the hieratic or demotic scrips with black and red ink. There was no borders between the lines but they were perfectly parallel without any guide.



**Figure31.** Fragment of Khamhor Papyrus from 26<sup>th</sup> Dynasty [52]

- The second example is a fragment of a book of dead from the Late Period (664-332 BC) in display in the Louvre Museum and shown in Figure 32 [53]. The scene show somebody called 'Djedhor' working in a field and the text was written using the hieratic script in

horizontal lines as depicted in the zoomed text in Figure 32.



**Figure32.** Funerary Papyrus from Late Period [53]

- The third example is a set of fragments of an astronomical papyrus from the 25th-26th Dynasties (700-525 BC) in display in the Metropolitan Museum of Art at NY and shown in Figure 33 [54]. The papyrus was written using the hieroglyphic script in horizontal unbounded text and vertical bounded text using only black ink.



**Figure33.** Astronomical Papyrus from 25<sup>th</sup>-26<sup>th</sup> Dynasties [54]

- The fourth example is a medical papyrus from the 27th Dynasty (450 BC) in display in the Brooklyn Museum at NY and shown in Figure 34 [55]. The papyrus length is 1.75 m and its width is 0.27 m written using the hieratic or demotic script in horizontal lines equally spaced with black and red ink. It handles the snakes types in ancient Egypt and the snakes and scorpions bites and their treatment.



**Figure34.** Medical Papyrus from 27<sup>th</sup> Dynasty [55]

### CONCLUSION

- The evolution of mechanical engineering in ancient Egypt was investigated through the study of the papyrus industry in ancient Egypt.
- The oldest available papyrus written by the ancient Egyptians returned back to the time of the 4th Dynasty (4500 years ago) registering the daily life of the pyramid builders using a hieroglyphic script.
- A mathematical papyrus was written in Lahun of Fayum during the 12th Dynasty presenting problems arithmetical progression written using the hieratic script.
- The ancient Egyptians presented the solution of two simultaneous equations one of them second-order in a papyrus written during the 12th Dynasty using the hieratic script
- They wrote the oldest medical papyrus about women health during Late 12th Dynasty. It presented 14 women medical problems and written using the hieratic script.
- They wrote economical papyri during the 12th Dynasty handling rent and taxes paid to the King as grain using the hieratic script.
- They wrote multi-disciplinary papyri during the 12th Dynasty handling subjects such as: business, hymns, medical, mathematics and festival.
- They wrote a mathematical papyrus during the 13th Dynasty including up to 25 problems with solutions. They could evaluate the volume of a truncated pyramid with square base. They used the hieroglyphic script in writing the text in parallel horizontal lines.
- They wrote a mathematical papyrus during the 15th Dynasty using the hieratic script including: fractions, notations, arithmetic, algebra, geometry and mensuration.
- They wrote surgical papyrus during the 16th Dynasty including 48 cases of wounds and trauma written using the hieratic script with text in parallel horizontal lines and adjacent pages.
- They wrote the 'book of dead' as a funerary text during the 18th, 19th, 20th, 21st, 22nd and 26th Dynasties.

- They wrote an erotic papyrus during the 20th Dynasties written using hieratic script with many graphical illustrations.
- They wrote an administration papyrus during the 20th Dynasty including taxation, administration practices, temple economy, population and land survey written using a hieratic script.
- They wrote an astronomical papyrus during the 25th Dynasty using the hieroglyphic script in horizontal and vertical text using black ink.
- They wrote a medical papyrus during the 27th Dynasty using the hieratic (or demotic) script in horizontal lines. The text handled snake bites in Egypt and the snakes and scorpion bites and their treatment.
- They wrote papyrus letters and books with length ranging from 0.26 m to 41 m and width ranging from 0.076 m to 0.455 m.

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