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Faculty Of Sciences And Technologies
Departement Of Electromecanics

Ref: ....

Discuss the graduation thesis in order to obtain the degree of:

MASTER

Field: Automatic Control
Option: Automatic Control and Industrial Engineering

Subject:

Dimensioning and Design of a Digital Radiography Table (DRT)

Presented by: **Ben Fredj Ismail** & **Chenouf Khalil**

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2020/2021

Dedication

Every challenging work

Needs self- efforts

As well as

Guidance of other people

Especially those who are close to our heart

With special feelings of gratitude, we dedicate our humble work to:

In memory of my beloved father **Mohamed** ``Allah yarhmo`` and my lovely mother

Our brothers and sisters, we could never succeed without their support and pieces of advice.

All our family members, whose words encouraged and motivated us. Our teachers, for

teaching us to believe in hard work and that so much could be done with little by having self-confidence.

BEN FREDJ ISMAIL

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With special feelings of gratitude, we dedicate our humble work to:

For my lovely father **Abd al Aziz** and my lovely mother

Our brothers and sisters, we could never succeed without their support and pieces of advice.

All our family members, whose words encouraged and motivated us. Our teachers, for

teaching us to believe in hard work and that so much could be done with little by having self-confidence.

CHENOUF KHALIL

Acknowledge

In the name of ALLAH, the most Gracious, the most Merciful

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Abstract

The goal of this work concerns the design of a Digital Radiography Table (DRT). The design of the DRT is realized by using software of design Solidworks. In addition, the relationship between the intelligent equipment's (sensors and actuators) and the programmable logic controller is considered in this work.

Key words: Digital Radiography x-ray system, automation, Human Machine interface,

simulation, designing software and realization.

ملخص

الهدف من هذا العمل هو تصميم طاولة التصوير الشعاعي الرقمي، يتم تحقيق هذا التصميم باستعمال برامج المختصة في التصميم (صوليد ووركس) بالإضافة الى ذلك، تم النظر في العلاقة بين المعدات الذكية (اجهزة الاستشعار والمشغلات)ووحدة التحكم المنطقية القابلة للبرمجة في هذا العمل.

الكلمات المفتاحية :

نظام التصوير الشعاعي الرقمي، تشغيل آلي، واجهة آلة-الإنسان، محاكاة، برنامج التصميم والانجاز.

Résumé

Le but de ce travail concerne la conception d'une Table de Radiographie Numérique (DRN). La conception de DRN est réalisée à l'aide de logiciels de conception SolidWorks. En plus, la relation entre les équipements intelligents (capteurs et actionneurs) et l'automate programmable est considérée dans ce travail.

Mots clés:

Système de radiographie numérique à rayons-X , Automatisation , Interface Homme-machine Simulation , Logiciel de conception et réalisation.

Table of contents

Table of contents

Acronyms

MRI: **M**agnetic **R**esonance **I**maging

MRA: Magnetic **R**esonance **A**ngiography

CT: Computed **T**omography

CAT: Computed **A**xial **T**omography

EBT: **E**lectron **B**eam **T**omography

WHIS-RAD: World **H**ealth **I**maging **S**ystem – **R**adiography

CAD: **C**omputer-**A**ided **D**esign

CAE: Computer-**A**ided **E**ngineering

AERB: **A**tomic **E**nergy **R**egulatory **B**oard

AEC: Automatic **E**xposure **C**ontrol

SID: **S**ource to **I**mage **D**istance

CE: European certificate of **C**onformity.

List of figures

List of tables

General introduction

General introduction

Radiation is emitted from unstable atoms. Unstable atoms are said to be “radioactive” because they release energy (radiation). The radiation emitted may be electromagnetic energy (X-rays and gamma rays) or particles such as alpha or beta particles. Radiation can also be produced by high-voltage devices such as X-ray machines. X-rays are a form of electromagnetic energy with a wavelength that places it into an ionizing radiation category. In a diagnostic exam, these photons can penetrate the body and are recorded on digital or film medium to produce an image of various densities that show details inside the body.

Light, radio, and microwaves are nonionizing types of electromagnetic radiation. Radio waves are used to generate MRI images. X-rays and gamma rays are ionizing forms of electromagnetic radiation and can produce charged particles (ions) in matter. When ionizations occur in tissue they can lead to cellular damage. Most damage is repaired by natural processes. In some cases, the damage cannot be repaired or is not repaired correctly which can lead to biological effects.

X-rays are a form of electromagnetic radiation, similar to visible light. Unlike light, however, x-rays have higher energy and can pass through most objects, including the body. Medical x-rays are used to generate images of tissues and structures inside the body. If x-rays travelling through the body also pass through an x-ray detector on the other side of the patient, an image will be formed that represents the “shadows” formed by the objects inside the body.

One type of x-ray detector is photographic film, but there are many other types of detectors that are used to produce digital images. The x-ray images that result from this process are called radiographs. To create a radiograph, a patient is positioned so that the part of the body being imaged is located between an x-ray source and an x-ray detector. When the machine is turned on, x-rays travel through the body and are absorbed in different amounts by different tissues, depending on the radiological density of the tissues they pass through. Radiological density is determined by both the density and the atomic number (the number of protons in an atom’s nucleus) of the materials being imaged. For example, structures such as bone contain calcium, which has a higher atomic number than most tissues. Because of this property, bones readily absorb x-rays and, thus, produce high contrast on the x-ray detector. As a result, bony structures appear whiter than other tissues against the black background of a radiograph,conversely.

Chapiter I :

Generality about X-ray radiography

1. Introduction:

In this chapter, we give generalities about radiology and the history of its development. Then, we indicate the factors that must be taken into consideration. As we know that the basis of any radiology is considered X-ray, so we set out by explaining its sources in the medical field and the method of it generate, leading to a full explanation of the characteristics of X-ray. To conclude this chapter by talking about radiology in the field of its use, its risks and benefits.

2. History

x-rays were discovered in **1895** by Wilhelm Conrad Roentgen **(1845-1923)** who was a Professor at Wurzburg University in Germany. Working with a cathode-ray tube in his laboratory **Fig. 1-1**. Roentgen observed a fluorescent glow of crystals on a table near his tube. The tube that Roentgen was working with consisted of a glass envelope (bulb) with positive and negative electrodes, encapsulated in it. The air in the tube was evacuated, and when a high voltage was applied, the tube produced a fluorescent glow. Roentgen shielded the tube with heavy black paper, and discovered a green colored fluorescent light generated by a material located a few feet away from the tube.

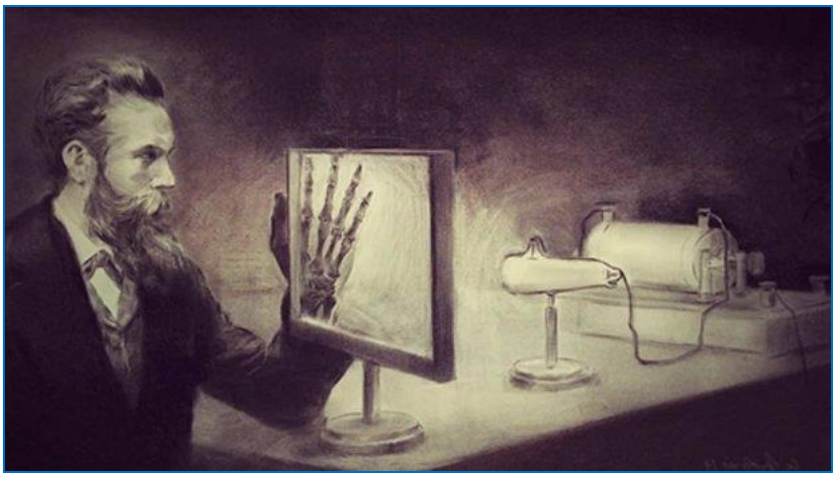

Fig. 1-1Cathode-Ray tube of Wilhem Conrad Roentgen (1845-1923).

He concluded that a new type of ray was being emitted from the tube. This ray was capable of passing through the heavy paper covering and exciting the phosphorescent materials in the room. He found that the new ray could pass through most substances casting shadows of solid objects. Roentgen also discovered that the ray could pass through the tissue of humans, but not bones and metal objects. One of Roentgen's first experiments late in **1895** was a film of the hand of his wife, Bertha. It is interesting that the first use of X-rays was for an industrial (not medical) application, as Roentgen produced a radiograph of a set of weights in a box to show his colleagues.

The x-ray image of a hand wearing a ring revealed a ring on a skeleton. Roentgen's discovery was a scientific bombshell, and was received with extraordinary interest by both scientist and laymen. Scientists everywhere could duplicate his experiment because the cathode tube was very well known during this period. Many scientists dropped other lines of research to pursue the mysterious rays. Newspapers and magazines of the day provided the public with numerous stories, some true, others fanciful, about the properties of the newly discovered rays.

Public fancy was caught by this invisible ray with the ability to pass through solid matter, and, in conjunction with a photographic plate, provide a picture of bones and interior body parts. Scientific fancy was captured by the demonstration of a wavelength shorter than light. This generated new possibilities in physics, and for investigating the structure of matter. Much enthusiasm was generated about potential applications of rays as an aid in medicine and surgery. Within a month after the announcement of the discovery, several medical radiographs had been made in Europe and the United States, which were used by surgeons to guide them in their work. In June **1896**, only 6 months after Roentgen announced his discovery, X-rays were being used by battlefield physicians to locate bullets in wounded soldiers.

An old lab for x-ray experimentation. Prior to **1912**, X-rays were used little outside the realms of medicine and dentistry, though some X-ray pictures of metals were produced. The reason that X-rays were not used in industrial application before this date was because the X-ray tubes (the source of the X-rays) broke down under the voltages required to produce rays of satisfactory penetrating power for industrial purposes. However, that changed in **1913** when the high vacuum X-ray tubes designed by Coolidge became available. The high vacuum tubes were an intense and reliable X-ray source, operating at energies up to **100,000** volts.

In **1922**, industrial radiography took another step forward with the advent of the **200,000**-volt X-ray tube that allowed radiographs of thick steel parts to be produced in a reasonable amount of time. In **1931**, General Electric Company developed **1,000,000**-volt X-ray generators, providing an effective tool for industrial radiography. That same year, the

American Society of Mechanical Engineers **(ASME)** permitted X-ray approval of fusion welded pressure vessels that further opened the door to industrial acceptance and use.

A Second Source of Radiation Shortly after the discovery of X-rays, another form of penetrating rays was discovered. In **1896**, French scientist Henri Becquerel discovered natural radioactivity. Many scientists of the period were working with cathode rays, and other scientists were gathering evidence on the theory that the atom could be subdivided. Some of the new research showed that certain types of atoms disintegrate by themselves. It was Henri Becquerel who discovered this phenomenon while investigating the properties of fluorescent minerals. Becquerel was researching the principles of fluorescence, wherein certain minerals glow (fluoresce) when exposed to sunlight. He utilized photographic plates to record this fluorescence.

One of the minerals Becquerel worked with was a uranium compound. On a day when it was too cloudy to expose his samples to direct sunlight, Becquerel stored some of the compound in a drawer with his photographic plates. Later when he developed these plates, he discovered that they were fogged (exhibited)[1].

3. classification of matter and its importance to radiology

The classification of the types of matter that make up human beings is important because everything is made of atoms and molecules and depending on the type of matter, the radiation tends to react differently with bones versus soft tissue, etc.

For example, for solid matter such as bone, muscle, and soft tissue, while all of these tissues in the human body are solid, they do vary in their atomic density. This is to say that bone is the hardest to penetrate with the radiation and then muscle, and soft tissue also have variable absorption rates. When radiation is absorbed by matter, this is referred to as attenuation. In general, as the radiation goes through the body, you will find that bone tends to absorb more radiation than does muscle and soft tissue. It can be said that bone, because of its increased atomic density, attenuates the radiation more readily. Because bone is more solid and dense, the number of electrons that make up its atomic structure is denser than it is for softer tissues therefore the radiation tends to collide with substances with a greater number of electrons.

Fluid tends to vary in viscosity and therefore there is a slight difference in attenuation when you compare the attenuation rate of blood versus clear fluids such as urine. However, it should be noted that if there is a significant amount of fluid present as sometimes happens with certain diseases, this results in more difficulty in obtaining diagnostic quality images with x-rays. This is because fluid in great quantities is hard to penetrate. Gas on the other hand is very similar in its atomic structure to the simple model we say on slide.

4. the source of medical x-rays

As you can see radiation can come from a variety of sources. These are: X-rays from extraterrestrial origins, natural background radiation, and radiation from x-ray equipment. Radiation from x-ray equipment started not long after Roentgen's discovery however, it took many years before the equipment achieved the level of reliability, safety, and dependability that we know today. So far, we have seen how x rays can interact with matter after they leave the x-ray tube, but we have not yet seen how they are actually produced in the x-ray tube. In this photograph, you can see the technologist adjusting the x-ray tube. She has her hands on part of the system that actually "shapes" the beam of radiation to the size that is needed. The device that limits the beam to a specific size is called the collimator. The collimator has a series of metal leaves that overlap to different sizes. The technologist can adjust the field of radiation to whatever size image receptor (film) is being used. Collimators can also function automatically in that when the film is positioned in the table film tray, the collimator can sense the dimensions of the image receptor and limit the beam to that size, this is known as PBL or positive beam limitation. In this figure (**Fig. 1-2**), the x-ray tube is housed in the rectangular shaped box at the top of the image.

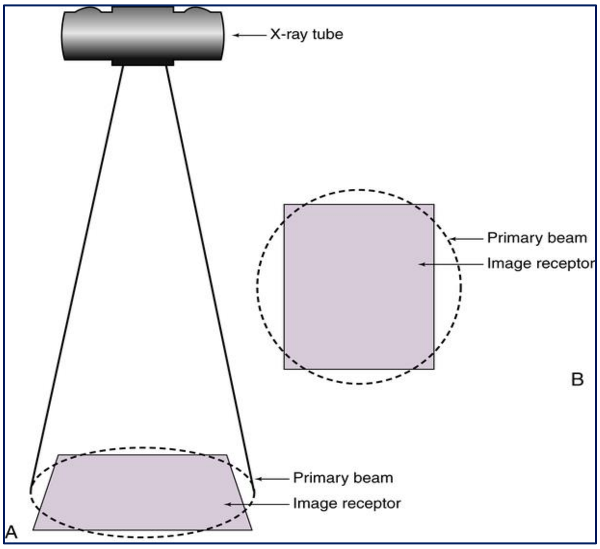

Fig.1-2 Positive Beam Limitation PBL (Afran ,2020).

5. The proprieties and characteristics of X-rays

X-rays have some physical characteristics that are important for the technologist to understand. This will help to ensure that x-rays are used safely and efficiently by the technologist in order to achieve the objectives of the examination and protect themselves as well as the patient. The physical characteristics that are essential to understand are as follows:

5.1.X-ray photons are penetrating

Depending on the type of tissue or matter x-rayed, the technologist will adjust the penetrating ability of the x-rays by adjusting the kVp of the machine. It should be noted that different parts of the body will have different thicknesses and attenuation properties therefore requiring different technical settings. We will perform some simple lab activities to demonstrate how this characteristic works.

5.2.X-rays are a form of Electromagnetic Radiation

An x-ray is like a bundle of energy moving through the air. It has wavelength which is measured in angstroms, it has frequency, and it is penetrating. X-rays are electrically neutral so they are not attracted by positive or negative polarities and cannot be focused.

5.3.X-rays are Polyene Getic

This is to say that the x-rays that are emitted by an x-ray tube are poly energetic or of many different energies. We know that with the characteristic interaction, we can predict what the energy of the photon will be **(57.5 Kev),** however with the Brems interaction, it really depends on how close to the nucleus the projectile electron passes by. Remember, the closer the electron passes to the nucleus, the higher the resulting energy of the emitted x-ray. When you consider the millions of interactions that are occurring during an exposure like this, it is easy to imagine that there are relatively few photons with exactly the same energy. If the technologist sets **100 kVp** on the control console, the reality is that the average energy of the beam is probably less than what was set. This is also dependent on the type of X-ray Equipment you are using. There are numerous varieties of machine and in general, state of the art machines are the most powerful units

5.4.X-rays may be attenuated

This is to say that x-rays can be attenuated or absorbed by matter, Depending on what the x-rays strike, if it is metal, chances are that the x-rays will be absorbed. An example of this is lead. Because lead is very dense atomically, when an x-ray strikes it, the lead will absorb or attenuate the radiation. In the human body, bone tends to absorb a significant amount of the radiation because it is relatively hard compared to other tissues. Soft tissue and air-filled organs have the least attenuation because soft tissue has a low atomic density any gas filled structure tends to facilitate the passage or transmission of x-rays.

5.5.The angle of trajectory

This refers to the how x-rays emerge from the tube. If you recall that the anode is angled slightly such that when the projectile electrons strike the surface of the target, x-rays that are produced tend to move downward. For example, if the electrons were hard particles and they simply struck the angled target, they would bounce in a downward trajectory because of the angle. However, the reality is that the electrons penetrate the surface of the target and undergo the berms and characteristic interactions just below the surface, usually around **0.5 mm** under the surface. X-rays are produced “isotopically” or when they are emitted, they go in all directions. An example of “isotropic” emission is like having a light bulb suspended in a square room. If the bulb is in the middle of the room, when the light is turned on, you would have light in all the surfaces of the room. Basically, isotropic means that x-rays are going in all directions, but only the ones that are moving downward will come out of the tube. The rest, are absorbed by the housing.

5.6.The velocity of x-rays is the speed of light

I regardless of the **kVp** that is set, please remember that the projectile electrons do achieve different velocities when they go from filament to the anode, however when the electrons are converted to x-ray energy, the speed of those x-rays is the speed of light.

5.7.X-rays cannot be focused

X-rays are not like light that a glass lens can focus. When x-rays pass through matter, they tend to go in a straight line, however if they do strike something such as an atom of bone or some other tissue, the x-ray photon will either be absorbed or it can be deflected and it will go in a different direction. This is very much like a high velocity projectile such as a bullet that strikes something. It can be deflected or it can be stopped. When it is deflected, we refer to it as a “scattered x-ray”.

5.8.When x-rays interact with film

it will cause electro-chemical changes in the structure of the film so that when the film is developed in chemicals, the film will show “blackness” or “radiographic density”. It is this density that the radiographer must learn to control to ensure that the image is not too dark or too light.

6. Uses of Radiography

Radiography is used in many types of examinations and procedures where a record of a static image **(Fig. 1-3)** is desired. Some examples include

- Dental examination.
- Verification of correct placement of surgical markers prior to invasive procedures.
- Mammography.
- Orthopedic evaluations.
- Spot film or static recording during fluoroscopy.
- Chiropractie examinations.

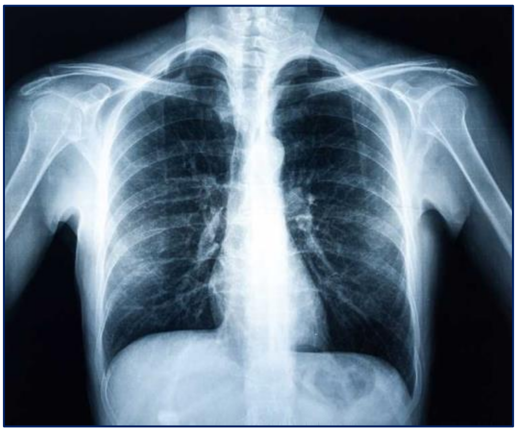

Fig. 1-3Radiography.

7. Risks/Benefits of radiography

Radiography is a type of x-ray procedure, and it carries the same types of risks as other x-ray procedures. The radiation dose the patient receives varies depending on the individual procedure, but is generally less than that received during fluoroscopy and computed tomography procedures.

The major risks associated with radiography are the small possibilities of:

- developing a radiation-induced cancer or cataracts sometime later in life, and

- causing a disturbance in the growth or development of an embryo or fetus (teratogenic defect) when performed on a pregnant patient or one of childbearing age.

When an individual has a medical need, the benefit of radiography far exceeds the small cancer risk **(Tab. 1-1)**

associated with the procedure. Even when radiography is medically necessary, it should use the lowest possible exposure and the minimum number of images. In most cases many of the possible risks can be reduced or eliminated with proper shielding[2].

Occurrence	***Risk***	***Chances***
Dying from appendicitis in a modern hospital	0.0038	1 in 263
Lifetime risk of lung cancer in a *nonsmoker*	0.0014	1 in 714
Lifetime risk of death in fire or from smoke inhalation	0.0009	1 in 1116
Lifetime risk of fatal cancer after a typical CT scan	0.0005	1 in 2000
Dying in a motor vehicle accident after driving 40,000 miles in a car	0.0005	1 in 2000

Tab.1-1Risks of radiography.

Conclusion

This chapter explains important ideas about X-ray and radiology. In addition, the history of X-ray and radiology is given.

Chapter II:
Radiography

Introduction

In this chapter, we have devoted the talk about radiology in order to clarify the most important differences between all its types by mentioning and explaining in detail each type. Then, the advantages and disadvantages of each of them will be presented. After that, we will talk about the most important factors and conditions that must be met in Radiology field to ensure its good functioning.

1. Different types of radiography

Radiology is divided into two different areas, **diagnostic radiology**and**interventional radiology**

1.1.Diagnostic radiology:

Diagnostic radiology **(Fig. 2-1)** helps health care providers see structures inside your body. Doctors that specialize in the interpretation of these images are called diagnostic radiologists. Using the diagnostic images, the radiologist or other physicians can often:

- Diagnose the cause of your symptoms.
- Monitor how well your body is responding to a treatment you are receiving for your disease or condition.
- Screen for different illnesses, such as breast cancer, colon cancer, or heart disease [3].

Fig. 2-1. DIAGNOSTIC RADIOLOGY

The most common types of diagnostic radiology exams include:

1.1.1. X-Rays (conventional radiology)

X rays are produced when electrons move at high speed across a vacuum and hit a target. The metal case of a diagnostic X-ray tube contains an inner glass vacuum tube (the 'Insert'). The electrons produced by the X-ray generator go across the vacuum from the cathode to the anode, and the anode becomes very hot. To obtain a good radiograph, a narrow beam of X-rays is needed so that the electrons are focused on to the focal spot; a small area of the anode. The higher the kilovoltage and the longer the exposure time, the hotter the anode becomes. To absorb so much energy, the anode is made as a rotating disc so that only a small rapidly changing segment of the periphery is the focal spot. This rotating anode can absorb a lot of heat and allows a short but very high-power exposure.

When the exposure switch is pressed to make an exposure, the anode starts to rotate but the electronic circuits prevent any exposure from being made until the anode has reached the correct operating speed. Then the exposure will occur. In some controls, there is a two-stage exposure switch. Depressing the switch half-way starts the anode rotating and then further pressure allows the exposure to be made; this is useful when a patient, especially a child, is restless, because there is no delay when the second stage is depressed; the exposure is immediate.

The technique involves penetrating the body but a portion of the rays are absorbed by the tissue encountered. The unabsorbed rays are collected on film (analog image) or on digital media to produce radiological images. This is the most applied technique in most of the radiological examinations performed, particularly for studying the skeletal frame and the lungs.

1.1.2. Ultrasound

This can be defined as a technique which is used to obtain images of the human body with the use of high-frequency sound waves. Here, the high-frequency sound waves are the key which plays a vital role in obtaining real-time images. **(Fig. 2-2)**

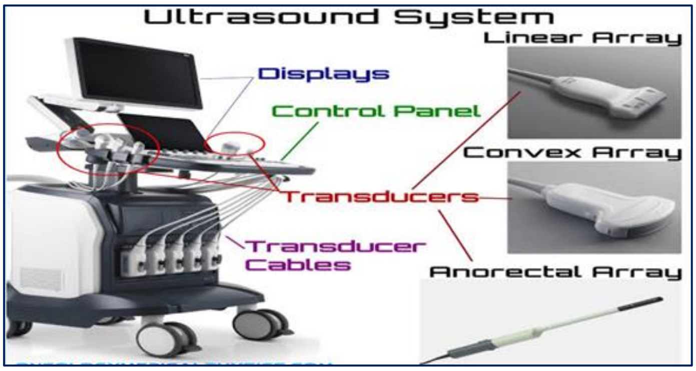

Fig. 2-2 Ultrasound System.

This does not involve the use of radiation and is completely painless. The techniques are that minute that as can detect the blow flow from Doppler ultrasound. It majorly involves the examinations of different organs and areas of the body including like:

- The arteries and veins.
- Subcutaneous tissue and muscles.
- The liver, bile ducts, spleen, pancreas and kidneys.
- The genital organs (prostate, testicles, uterus, ovaries).[4].

a. Medical ultrasound

also known as diagnostic sonography or ultrasonography is a diagnostic imaging technique, or therapeutic application of ultrasound. It is used to create an image of internal body structures such as tendons, muscles, joints, blood vessels, and internal organs. Its aim is often to find a source of a disease or to exclude pathology. The practice of examining pregnant women using ultrasound is called obstetric ultrasound, and was an early development and application of clinical ultrasonography.

Ultrasound are sound waves with frequencies which are higher than those audible to humans (**>20,000 Hz**). Ultrasonic images, also known as sonograms, are made by sending pulses of ultrasound into tissue using a probe. The ultrasound pulses echo off tissues with different reflection properties and are recorded and displayed as an image.

Many different types of images can be formed, the most common is a B-mode image (Brightness), which displays the acoustic impedance of a two-dimensional cross-section of tissue. Other types can display blood flow, motion of tissue over time, the location of blood, the presence of specific molecules, the stiffness of tissue, or the anatomy of a three-dimensional region, compared to other dominant methods of medical imaging, ultrasound has several advantages. It provides images in real-time and is portable and can be brought to the bedside. It is substantially lower in cost than other imaging modalities and does not use harmful ionizing radiation. Drawbacks include various limits on its field of view, such as the need for patient cooperation, dependence on physique, difficulty imaging structures behind bone and air or gases, and the necessity of a skilled operator, usually trained professional.

b. Advantages of ultrasounds

1. ultrasound uses non-ionizing sound waves and has not been associated with carcinogenesis. This is particularly important for the evaluation of fetal and gonadal tissue.
2. in most centers, ultrasound is more readily available than more advanced cross-sectional modalities such as CT or MRI.
3. ultrasound examination is less expensive to conduct than CT or MRI.
4. there are few (if any) contraindications to the use of ultrasound, compared with MRI or contrast-enhanced CT.
5. the real-time nature of ultrasound imaging is useful for the evaluation of physiology as well as anatomy (e.g. fetal heart rate).
6. Doppler evaluation of organs and vessels adds a dimension of physiologic data, not available on other modalities (with the exception of some MRI sequences).
7. ultrasound images may not be as adversely affected by metallic objects, as opposed to CT or MRI.
8. an ultrasound exam can easily be extended to cover another organ system or evaluate the contralateral extremity.

c. disadvantages of ultrasounds

1. training is required to accurately and efficiently conduct an ultrasound exam and there is non-uniformity in the quality of examinations ("operator dependence").
2. ultrasound is not capable of evaluating the internal structure of tissue types with high acoustical impedance (e.g. bone, air). It is also limited in evaluating structures encased in bone (e.g. cerebral parenchyma inside the calvaria).

3. the high frequencies of ultrasound result in a potential risk of thermal heating or mechanical injury to tissue at a microscopic level. This Is of Most concernin fetal Imaging.

4. ultrasound has its own set of unique artifacts (US artifacts), which can potentially degrade image quality or lead to misinterpretation.

5. some ultrasound exams may be limited by abnormally large body habitus.[5].

1.1.3. Magnetic resonance imaging (MRI)

is a medical imaging technique used in radiology to form pictures of the anatomy and the physiological processes of the body. MRI scanners use strong magnetic fields, magnetic field gradients, and radio waves to generate images of the organs in the body. MRI does not involve X-rays or the use of ionizing radiation, which distinguishes it from CT and PET scans. MRI is a medical application of nuclear magnetic resonance (NMR) **(Fig. 2-3)**

which can also be used for imaging in other NMR applications, such as NMR spectroscopy. While the hazards of ionizing radiation are now well controlled in most medical contexts, an MRI may still be seen as a better choice than a CT scan. MRI is widely used in hospitals and clinics for medical diagnosis and staging and follow-up of disease without exposing the body to radiation. An MRI may yield different information compared with CT. Risks and discomfort may be associated with MRI scans. Compared with CT scans, MRI scans typically take longer and are louder, and they usually need the subject to enter a narrow, confining tube. In addition, people with some medical implants or other non-removable metal inside the body may be unable to undergo an MRI examination safely.

Fig. .2-3. Magnetic resonance imaging

MRI was originally called NMRI (nuclear magnetic resonance imaging), but "nuclear" was dropped to avoid negative associations. Certain atomic nuclei are able to absorb radio frequency energy when placed in an external magnetic field; the resultant evolving spin polarization can induce a RF signal in a radio frequency coil and thereby be detected. In clinical and research MRI, hydrogen atoms are most often used to generate a macroscopic polarization that is detected by antennae close to the subject being examined. Hydrogen atoms are naturally abundant in humans and other biological organisms, particularly in water and fat**(Fig. 2-4)**. For this reason, most MRI scans essentially map the location of water and fat in the body. Pulses of radio waves excite the nuclear spin energy transition, and magnetic field gradients localize the polarization in space. By varying the parameters of the pulse sequence, different contrasts may be generated between tissues based on the relaxation properties of the hydrogen atoms therein.

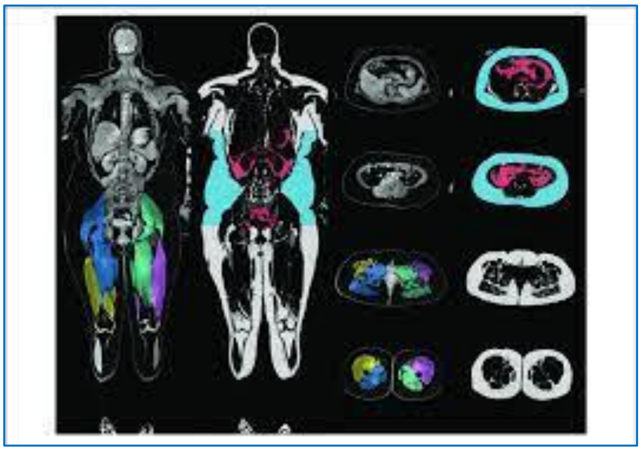

Fig. 2-4 water and fat by MRI

MRI stands for Magnetic Resonance Imaging which is a method that does not involve the use of x-rays but the electromagnetic properties of the human body when it is subjected to an intense magnetic field. The machine used to perform the examination is a very powerful magnet through which radiofrequency waves pass. The machine delivering the combined energy is used to detect the hydrogen atoms (protons) in your organs followed by the computer reconstructing images from the hydrogen distributed around your body.

a. Medical Use

The development of the MRI scan represents a huge milestone for the medical world.

Doctors, scientists, and researchers are now able to examine the inside of the human body in high detail using a non-invasive tool.

The following are examples in which an MRI scanner would be used:

1. anomalies of the brain and spinal cord.
2. tumors, cysts, and other anomalies in various parts of the body.

3. breast cancer screening for women who face a high risk of breast cancer.
4. injuries or abnormalities of the joints, such as the back and knee.
5. certains types of heart problems.
6. diseases of the liver and other abdominal organs.
7. suspected uterine anomalies in women undergoing evaluation for infertility.

This list is by no means exhaustive. The use of MRI technology is always expanding in scope and use.[6].

1.1.4. Mammography

Mammography **(Fig. 2-5)** is a specific type of breast imaging that uses low-dose x-rays to detect cancer early before women experience symptoms when it is most treatable. Mammography plays a central part in the early detection of breast cancers because it can show changes in the breast up to two years before you or your physician can feel them, particularly done for tumor screening. The additional test is then performed depending on the result.[7].

Fig. 2-5 breast imaging (mammography)

In general terms, there are two types of mammography: screening and diagnostic.

Mammography differs significantly in many respects from the rest of diagnostic imaging.

women getting a mammogram and a technician standing next to her Source: Getty Images

During a mammogram, a patient's breast is placed on a flat support plate and compressed with a parallel plate called a paddle. An x-ray machine produces a small burst of x-rays that pass through the breast to a detector located on the opposite side. The detector can be either a photographic film plate, which captures the x-ray**(Fig. 2-6)** image on film, or a solid-state detector, which transmits electronic signals to a computer to form a digital image. The images produced are called mammograms.

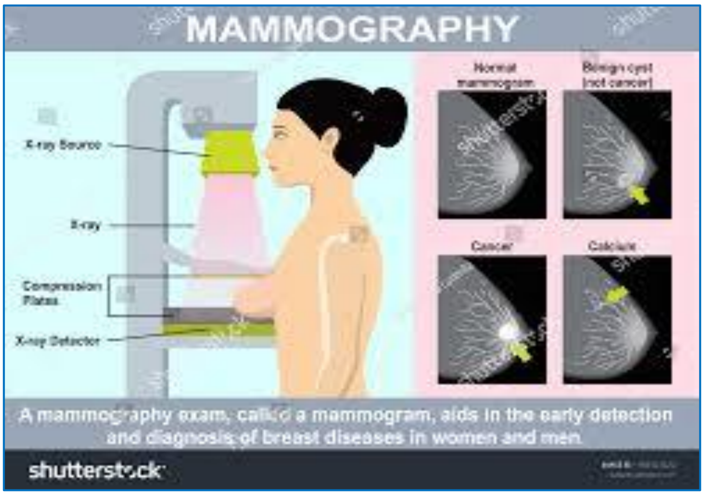

Fig. 2-6mammograms etaps

On a film mammogram, low density tissues, such as fat, appear translucent (i.e. darker shades of gray approaching the black background)., whereas areas of dense tissue, such as connective and glandular tissue or tumors, appear whiter on a gray background. In a standard mammogram, both a top and a side view are taken of each breast, although extra views may be taken if the physician is concerned about a suspicious area of the breast.[8].

1.1.5. CT scan

A CT scan or computed tomography scan (formerly known as computed axial tomography or CT scan) is a medical imaging technique used in radiology to get detailed images of the body noninvasively for diagnostic purposes. The personnel that perform CT scans are called radiographers or radiology technologists.

The device involves the use of a table for the patient to lie on and a special radiological device with an opening (gantry) into which the table will be inserted during the examination. CT scanning is especially useful for showing the various types of tissue, such as lungs, bone and joints, abdominal viscera and blood vessels. It is especially useful for showing the various types of tissue, such as lungs, bone and joints, abdominal viscera and blood vessels.

CT scanners use**(Fig. 2-7)** a rotating x-ray tube and a row of detectors placed in the gantry to measure X-ray attenuations by different tissues inside the body. The multiple X-ray measurements taken from different angles are then processed on a computer using reconstruction algorithms to produce tomographic (cross-sectional) images (virtual "slices") of a body. The use of ionizing radiations sometimes restricts its use owing to its adverse effects. However, CT can be used in patients with metallic implants or pacemakers where MRI is a contraindication.

Fig. 2-7 .CT scan or computed tomography

Since its development in the **1970s,** CT has proven to be a versatile imaging technique. While CT is most prominently used in diagnostic medicine, it also may be used to form images of non-living objects. The **1979** Nobel Prize in Physiology or Medicine was awarded jointly to South African American physicist Allan M. Cormack and British electrical engineer Godfrey N. Hounsfield "for the development of computer-assisted tomography".[9].

a. Types of CT

a.1. Spiral CT

Spinning tube, commonly called spiral CT, or helical CT**(Fig. 2-8)**, is an imaging technique in which an entire X-ray tube is spun around the central axis of the area being scanned. These are the

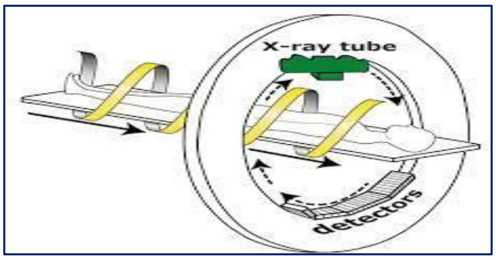

Fig. 2-8function of spiral CT scan

dominant type of scanners on the market because they have been manufactured longer and offer a lower cost of production and purchase. The main limitation of this type of CT is the bulk and inertia of the equipment (X-ray tube assembly and detector array on the opposite side of the circle) which limits the speed at which the equipment can spin. Some designs use two X-ray sources and detector arrays offset by an angle, as a technique to improve temporal resolution.[10].

a.2. Electron beam tomography

Electron beam tomography **(EBT)**(**Fig. 2-9)**is a specific form of CT in which a large enough X-ray tube is constructed so that only the path of the electrons, travelling between the cathode and anode of the X-ray tube, are spun using deflection coils. This type had a major advantage since sweep speeds can be much faster, allowing for less blurry imaging of moving structures, such as the heart and arteries. Fewer scanners of this design have been produced when compared with spinning tube types, mainly due to the higher cost associated with building a much larger X-ray tube and detector array and limited anatomical coverage. [11].

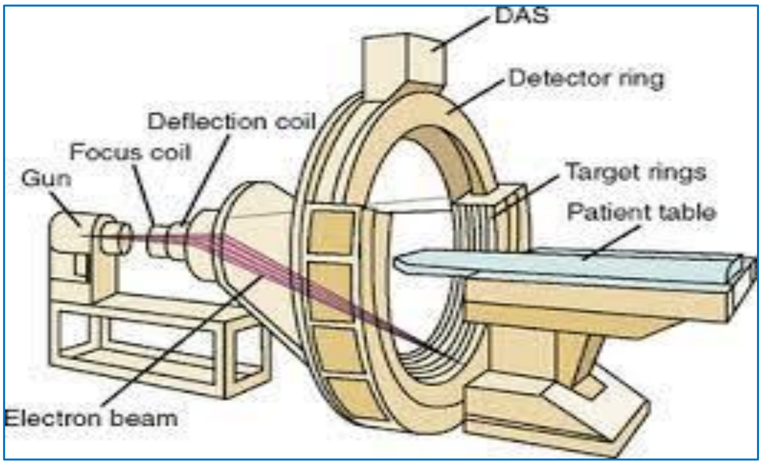

Fig.2-9 Electron beam tomography

a.3. CT perfusion imaging

CT perfusion imaging is a specific form of CT to assess flow through blood vessels whilst injecting a contrast agent Blood flow, blood transit time, and organ blood volume, can all be calculated with reasonable sensitivity and specificity. This type of CT may be used on the heart, although sensitivity and specificity for detecting abnormalities are still lower than for other forms of CT. This may also be used on the brain(**Fig. 2-10)**, where CT perfusion imaging can often detect poor brain perfusion well

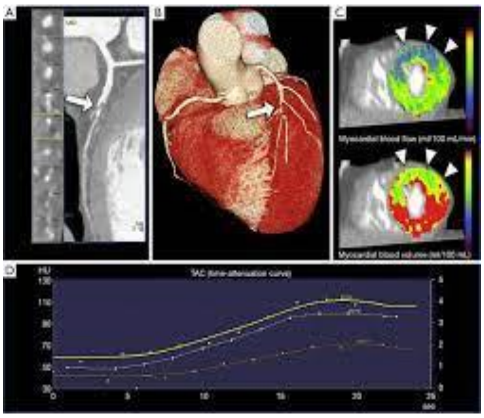

Fig.2-10 . CT perfusion imaging

before it is detected using a conventional spiral CT scan This is better for stroke diagnosis than other CT types.[12].

b. Medical uses

Since its introduction in the **1970s**, CT has become an important tool in medical imaging to supplement X-rays and medical ultrasonography. It has more recently been used for preventive medicine or screening for disease, for example, CT colonography for people with a high risk of colon cancer, or full-motion heart scans for people with a high risk of heart disease. Several institutions offer full-body scans for the general population although this practice goes against the advice and official position of many professional organizations in the field primarily due to the radiation dose applied.

The use of CT scans has increased dramatically over the last two decades in many countries. An estimated **72 million** scans were performed in the United States in 2007 and more than 80 million in **2015**.[13].

1.1.6. Magnetic resonance angiography (MRA)

The technique can be used for examining the blood vessels in order to investigate arterial thrombosis **(Fig. 2-11)**, blood vessel malformations, detecting bleeding or vascularization of a tumor etc. This procedure is generally executed under anesthesia.

Fig. 2-11Magnetic resonance angiography (MRA)

Knowing about the importance of radiology in almost every sector of the medical profession is popularity and use especially in diagnosing the diseases and further treatment is increasing day by day. The techniques usually involve utmost accuracy which is possible only in the best radiology hospital in Mumbai as the city involves some good options.

a. Medical Use

Doctors use MRA to:

1. identify abnormalities, such as aneurysms, in the aorta, both in the chest and abdomen, or in other arteries.
2. detect atherosclerotic (plaque) disease in the carotid artery of the neck, which may limit blood flow to the brain and cause a stroke.
3. identify a small aneurysm or arteriovenous malformation **(AVM),**an abnormal connection between blood vesselsinside the brain or elsewhere.
4. detect plaque disease that has narrowed the arteries to the legs and help prepare for endovascular intervention or surgery.
5. detect disease in the arteries to the kidneys or visualize blood flow to help prepare for a kidney transplant or stent placement.
6. guide interventional radiologists and surgeons making repairs to diseased blood vessels, such as implanting stents or evaluating a stent after implantation.
7. detect injury to one or more arteries in the neck, chest, abdomen, pelvis or limbs after trauma.[14].

1.2.INTERVENTIONAL RADIOLOGY:

Interventional radiologists are doctors that use imaging such as CT, ultrasound, MRI, and fluoroscopy to help guide procedures. The imaging is helpful to the doctor when inserting catheters, wires, and other small instruments and tools into your body. This typically allows for smaller incisions (cuts).

Doctors can use this technology to detect or treat conditions in almost any part of the body instead of directly looking inside of your body through a scope (camera) or with open surgery.

Interventional radiologists often are involved in treating cancers or tumors, blockages in the arteries and veins, fibroids in the uterus, back pain, liver problems, and kidney problems.

The doctor will make no incision or only a very small one. You rarely need to stay in the hospital after the procedure. Most people need only moderate sedation (medicines to help you relax).

Examples of interventional radiology procedures include:

- Angiography or angioplasty and stent placement
- Embolization to control bleeding
- Tumor ablation with radiofrequency ablation, cryoablation, or microwave ablation

  Vertebroplasty and kyphoplasty
- Needle biopsies of different organs, such as the lungs and thyroid gland
- Breast biopsy, guided either by stereotactic or ultrasound techniques
- Uterine artery embolization
- Feeding tube placement
- Venous access catheter placement, such as ports and PICCs [3].

2. Department of x-ray Radiography

2.1.Location department of x-ray Radiography (in the clinic)

The X-ray room (and ultrasound room, if different) should be where it is most easily reached by all patients: it should always be on the ground floor unless a reliable lift (elevator) can be provided and there is always electrical power for the lift. Radiation protection is not a major factor in making the choice of location, convenient access is more important. Patients will come for imaging from every part of the hospital and from all emergency and out-patient clinics. In the average small rural hospital (20-200 beds) the majority of patients for imaging can walk: some will be in wheel-chairs and a few will come on a trolley / gurney or in a bed. The X-ray room must be accessible both from the hospital and the outpatient clinic. The route to the X-ray room should preferably be protected from both the sun and the rain, even when it is windy. There must be no steps or other obstacles that would impede trolleys or wheelchairs. Easy access from the operating suite is an added advantage.

2.2.Necessary condition for imaging department

It is important that all the rooms for the imaging department are close together. Electricity must be available **(Tab. 2-1)**, a cold-water supply is desirable and, if possible, hot water also. The rooms must have windows or good ventilation.

Three rooms are preferred:

1. the X-ray / imaging room,
2. the darkroom (unnecessary if there is only a digital system),
3. the office / storeroom.

The X-ray room can be used for ultrasonography if there are not too many patients, but cannot be used for anything unrelated to imaging. The darkroom cannot be shared or used for any other purpose(**Fig. 2-12**). With a digital system, a dark room will only be necessary when there is back-up film processing. If there is not enough space for three rooms, the combined office and storeroom is the least essential of the three rooms. However, unless there is a digital system, storage for both used and unused X-ray films, chemicals, etc., will have to be provided somewhere in the hospital complex, and should be close to the X-ray room and darkroom.

Tab. 2-1 Best sizes for the rooms in an X-ray department

	Minimum	Preferred
Total space	**29 m^2 (312 sq ft)**	**50 m^2 (540 sq ft)**
X-ray room	16 m^2 (172 sq ft)	24 m^2 (258 sq ft)
Darkroom	5 m^2 (54 sq ft)	10 m^2 (108 sq ft)
Office/store/film file	8 m^2 (86 sq ft)	16 m^2 (172 sq ft)

2.3.Alternative room layouts for a radiographic suite

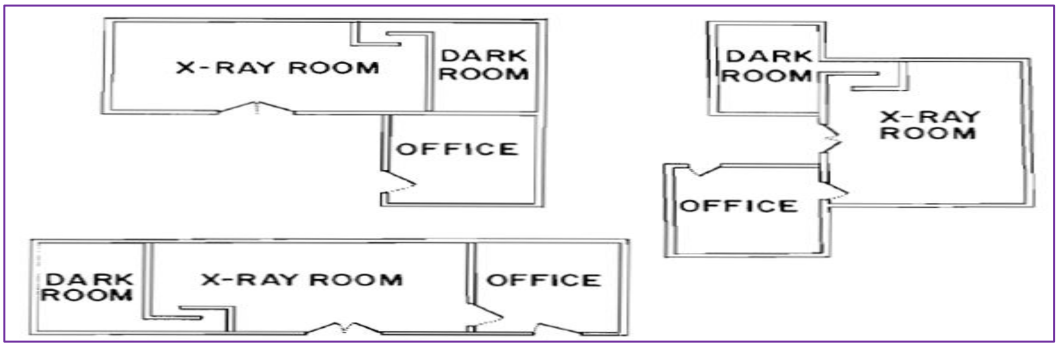

Fig. 2-12 radiographic suite

2.4.Building materials of X-rays rooms

Almost any local material is suitable, provided it is;

- Waterproof and dust-proof,
- Strong, especially the floor,
- Durable, lasting 20 years or longer
- Useable in thicknesses appropriate for radiation protection where necessary.

Thickness will be dictated by the type of X-ray equipment and the number of patients examined each day. Materials differ in their capacity to protect against radiation: wood is the least satisfactory, wood that is covered with plaster, preferably two or more layers thick, can be used but is much less satisfactory than brick or concrete.[15].

Conclusion

In this chapter, the reader can learn about the different types of radiology. information given in the chapter are sufficient to distinguish between them.

Chapter III:

Design of a Digital Radiography Table using SolidWorks Software

Introduction

In this chapter, we explain the constitution ofan x-ray digital radiography system (**X-ray** imaging system) by giving its important equipment's.

Then we mentioned all the graphic radio equipment's that we want to create with all the basic information from the measurements to the most accurate details of those equipment's, then we went to talk and explain a computer program specialized in construction and drawing by mentioning its history, field of use and to draw all the parts that make up a radiography, so we gave an example of how to create a part of this radio to clarify and show the method of construction in it.

1. Equipment of a radio X-ray system

There is a wide variety of equipment's, but all installations have components which produce the image and ancillary equipment which record it. The components which produce the X-rays and align the tube with the patient are the same for both film and digital imaging systems.

1. The **X-ray** generator and its control.
2. The **X-ray** tube and connecting cables.
3. The **X-ray** stand (tube-support) and table (the patient support).
4. For non-**WHIS-RAD** units, a chest-cassette stand.

The ancillary components which record the images are quite different for film and digital systems:

Film systems require:

1. Cassettes with screens.
2. Processing equipment with chemicals (e.g., Manual processing tanks or an automatic processor).
3. Patient identification / film marker. (Fig. 3.1)
4. Film dryer if there is not an automatic processor.

Fig. 3.1 *X-RAY film*

Digital recording systems require:

1. Digital image receptor.

2. A digital plate reader.

3. A computer workstation to process the digital image and record patient data.

4. A monitor / screen to view the image.

5. A computer archive to store images and patient records.

1.1.X-ray generator

Apart from the mains supply for the generator, it is wise to provide at least two additional and independent wall outlets (10A-220V or 15A-110V), independent wall outlets in the office. The darkroom also needs a good independent electrical supply. preferably on each of the two long walls of the **X-ray** room. There should be at least two more strictly means the high-tension generator and any rectification circuits. Any type of power storage (a large capacitor or a battery pack) is also included in the general term "**X-ray generator".**

1.2.X-ray unit

The X-ray unit includes the generator, the controls and at least one **X-ray** tube and the connecting high-tension cables. Because the high-tension cables can affect the balance of the circuit, they must be ordered together from the same manufacturer. Trying to save money by ordering cables and tubes separately is likely to be an expensive error. Usually, the X-ray generator and its controls are supplied either as a single piece of equipment or as two separate units which can be installed in different parts of the room.

1.3. The tube

is usually but not always separate from the generator. It is possible to connect several **X-ray** tubes to one **X-ray** generator, but this is not necessary in a small department and will add to the expense. Only the manufacturers or their agents should do this if an extra tube is deemed essential.

1.3.1.X-ray tubes

There are seven basic designs (Fig. 3.2**)**for tube supports used in general radiography (specialized stands excluded):

1. A movable column mounted on double floor rails, with a movable horizontal crossarm for the **X-ray** tube. This is a floor B.

2. A movable column mounted on a single floor rail having a stabilizing ceiling rail and a movable horizontal cross-arm for the **X-ray** tube. This is a tube stand. floor-to-ceiling

3. A ceiling-suspended telescopic tube support moving on ceiling rails. This is a tube stand. Ceiling tube stand.

4. A column integrated with a complete **X-ray** generator, mobile on wheels as a unit (designed for use with patients who cannot be moved to the **X-ray** department). This is a mobile.

5. A column fixed on the side of an X-ray table (either the column or the table top or both can be moved). This is X-**ray** unit. an integrated tube

6. A fixed column with a straight, balanced swiveling arm, movable up and down the column, carrying the **X-ray** tube and a cassette holder at opposite ends: or- column.

7. As above but with the swiveling arm shaped like an S or like a "prone question mark". DIAGRAM

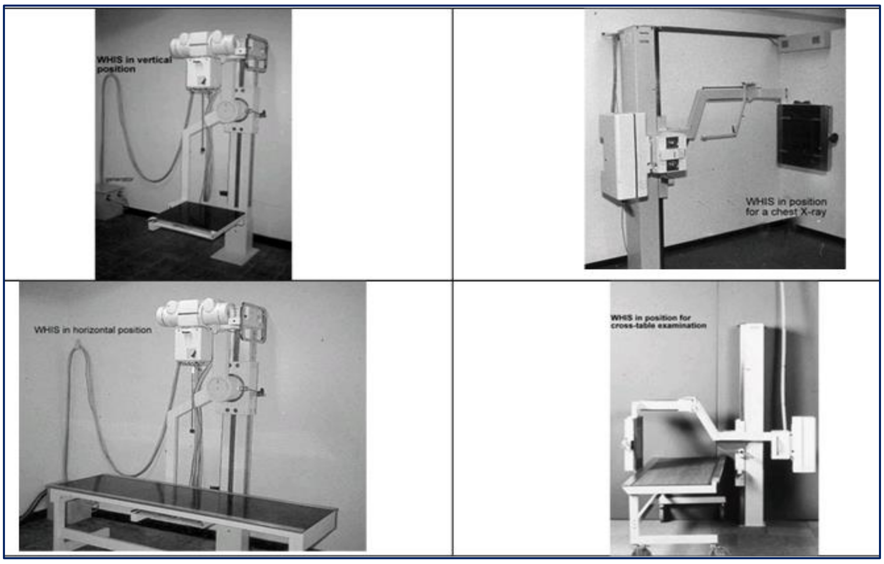

Fig.3-2. *some examples of tubes*

1.3.2. movement a heavy X-ray tube

The tube must move easily up and down if patients are going to be successfully radiographed. Because tubes and cables are very heavy, a counterbalance is required. There are three basic balance mechanisms:

a. Counter weights

Supported by wires or chains that run over a pulley at the top of the column. Simple counterweights are the most reliable. The balance can be easily adjusted if a different (replacement) X-ray tube must be used later.

b. Springs

Can be of variable or fixed tension. They are usually combined with a cable running over a pulley with variable ratio. This combination functions very well, but may eventually become fatigued and adjustment is less simple. Direct support by a spring via a variable-ratio pulley is not acceptable. An automatic safety brake must be included in any of the designs using cables in order to provide protection if a cable should break.

c. Electrically

Powered movements in both vertical directions require a constant steady electrical supply and regular maintenance. The manufacturers use the same counterbalancing alternatives. Simple weights on a cable are preferred. It is better if there are two supporting counterweight cables because, as well as the X-ray tube, (Fig. 3.3**)** they must also hold the weight of the rotating arm, cables and the cassette holder. In any of the designs the cables can be satisfactorily replaced by chains running over a toothed pulley (a cog), but these will need more maintenance than a simple pulley. Electric motors can work very well but are not recommended because they require electric power, more maintenance and are more expensive. If they fail, the whole unit will become unusable because the tube-arm falls and cannot be moved. When the electrical supply to the X-ray department is poor (or intermittent), a battery-powered generator can continue to radiograph many patients but the batteries cannot be relied upon to supply sufficient electricity to the servo-motors which make the brakes work.

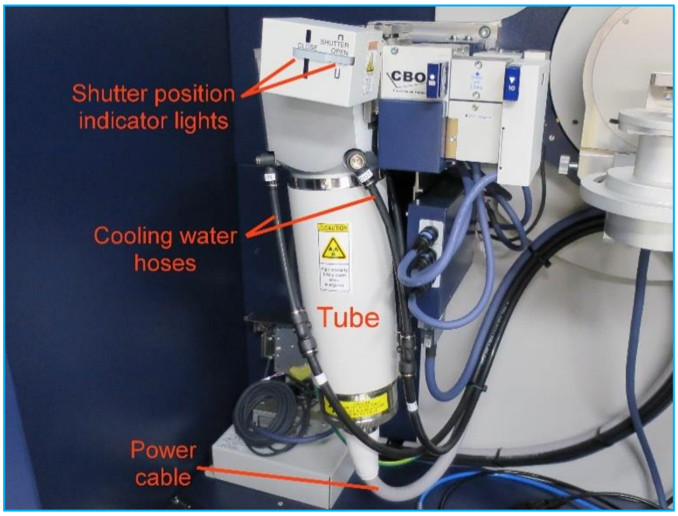

Fig. 3-3*X-Ray tube*

1.3.3.Control movements of the X-ray tube

a. Friction brakes

Locked either by a simple lever or large knobs, or activated by an electronic (electro-magnetic)(Fig. 3-4**)** mechanism which applies the brakes when the power is off. Friction brakes are best. They should be operated by a simple hand-operated screw mechanism which will bring together large contact surfaces, Locks with predetermined positions. These are not acceptable, Powered brakes add complexity and will require additional maintenance and repair. The brakes must be working all the time and cannot be used without an electrical supply. Electric brakes will require an electrical supply to their auxiliary circuit. If there is no electricity the whole X-ray unit will be inoperable. If electromagnetic brakes are chosen, the switches should be positioned where they are convenient to use. These brakes are often less efficient, collect dirt and fluff and become unreliable. They have few advantages over hand operated brakes and, because of their complexity, are not suitable for small departments. They are almost always more expensive to purchase and maintain.

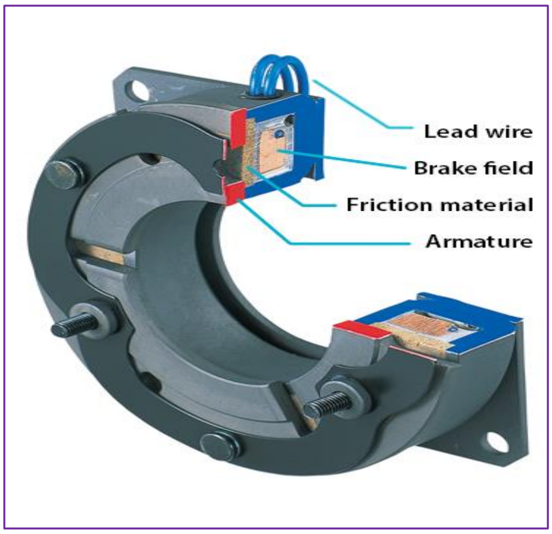

Fig. 1-4Electro-magnetic brakes

1.4. X-ray table

Many patients will have to lie or sit on an X-ray table to be examined. An X-ray table has a flat X-ray-translucent top, usually 2m (7ft) long and about 70cm (28ins) wide. This must be able to support at least a 120 kg (260 lb) patient without appreciable distortion. There are three varieties:

1.4.1. Fixed

This table is fixed to the floor(Fig. 3-5**)**, should be very rigid, and is usually mounted on four legs, but alternatively on a cantilever support. The cantilever design is usually not sufficiently rigid. This type of table is an old design but may be used with a floorto-ceiling tube column. It can also be used with a mobile X-ray unit.

Fig.3.5. *Fixed X-ray table*

1.4.2. Fixed, with a mobile floating top

This type of floating- or sliding table-top (Fig. 3.6**)**may be mounted on four legs or on a cantilever support. The table top moves on ball bearings and can easily be pushed lengthways and transversally. The movements are usually controlled by electromagnetic brakes using hand or foot-operated switches, but mechanical brakes are available. This table may be used with any **X-ray** tube support except those with the tube and the cassette holder in a fixed combination (e.g, the **WHIS-RAD**). Moving top tables are very useful in a busy X-ray department but they add expense and complexity and require qualified maintenance. The electromagnetic brakes need a special power supply and should not be connected to an X-ray generator's battery-pack; they are only suitable where there is a reliable and continuous power supply. They are not really worth the extra cost in a small hospital or clinic.

Fig .3.6. floating top X-ray table

1.4.3. Mobile

A mobile X-ray table is a trolley with an X-ray-translucent top supported on four legs with wheels, which should be on the corners of the table to make it more stable and less likely to distort. There must be brakes on at least two wheels, one at each end of the trolley. The brakes should be mechanically simple and reliable friction brakes, which can easily be operated by a foot or by hand from a lever on the side of the table. The wheels must be at least 12cm (5ins) in diameter, with rubber treads/tires. Double wheels are an advantage. A mobile table must be without cross-bars which would prevent free access below the table, but must be able to support at least a 120kg (260lbs) patient without distortion.

Fig.3.7Mobile X-ray table

1.5. film-cassettes

Most stationary X-ray tables have a cassette holder (Fig. 3-8**)** which is always beneath the table top and is used in combination with a ceiling tube stand or an integrated tube column. It must be movable along the length of the table. Most of these cassette holders incorporate an anti-scatter grid, either stationary or in a Bucky mechanism. The WHIS-RAD design includes a mobile X-ray table which does not have a cassette /receptor holder. The cassette/receptor and grid holder of a WHIS-RAD is an integral part of the tube support and can be used with or without the mobile patient trolley.

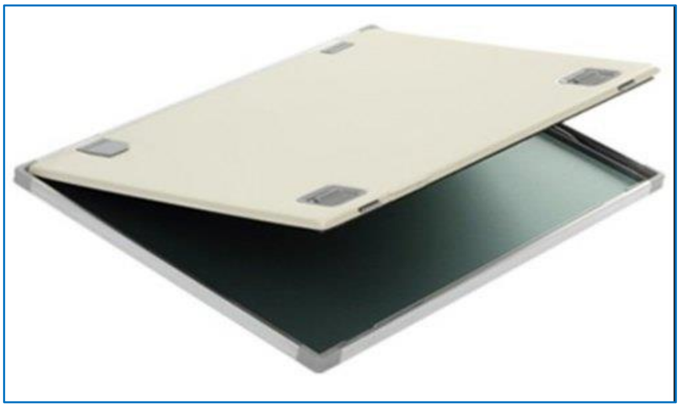

Fig. 3.8film-Cassette

1.6. collimators and diaphragms

Scattered (secondary) radiation that has been reflected off or deviated from within the patient is a major source of hazard to staff and to others. It also reduces the quality of the radiograph. To limit this scattering, X-ray beam should be well defined and confined to the exact area to be radiographed. This may be done either by beam limiting devices such as circular or rectangular "cones" or by collimators. (Fig. 3-9**)** both are fastened to X-ray tubes, or in some models are interchangeable.

Fig.3-9 collimators

Square or circular cones are not common on modern equipment for general radiography. They are open ended metal cones, designed so that the beam of radiation is limited to a standard size, usually the size which exactly covers or is slightly smaller than the chosen film when the X-ray tube is at the correct distance from the patient. Unfortunately, because they can be detached, they are not always put back in place, exposures may be made without any beam limitation. [16].

2. Description of function

Digital Radiography (Fig. 3.10**)** system with single flat panel detector, capable to take digital images in horizontal, vertical and oblique positions of all skeletal body including spine and chest. The developed radiography table is given in *Fig. 3.10.*

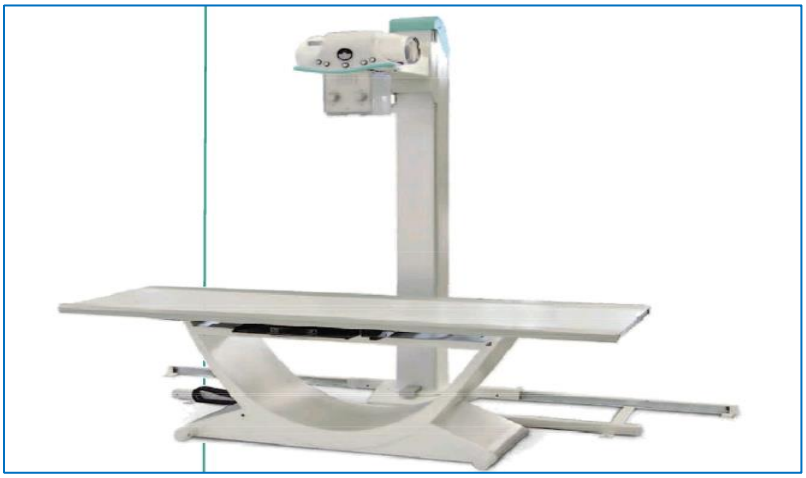

Fig. 3.10 designed system

2.1.Technical specifications

Tab.3-1 Technical data of our design

	TECHNICAL DATA	
HORIZONTAL TABLE	• Tabletop dimensions	2250 x 800 mm
	• Longitudinal travel	900 mm (± 450 mm)
	• Transversal travel	250 mm (± 125 mm)
	• Tabletop - floor distance	718 mm
	• Max patient's weight	200 Kg
	• Electromagnetic brakes on all movements, controlled by a photo-cell device at the table base	
	• Power supply	single phase, 230 V, 50/60 Hz
	• Weight	160 Kg
PLOTTER BUCKY	• For all standard radiographic cassettes	size from 13x18 to 35x43 cm
	• Longitudinal travel	560 mm, controlled by electromagnetic brakes
	• Vibrating grid	R = 10:1, 103 lines/", F = 120 cm
	• Preset to receive a detection chamber for automatic exposure control	
COLUMN STAND	• Column height	2275 mm
	• Floor rails length	2800 mm
	• Longitudinal travel	1900 mm (± 950 mm)
	• Vertical travel	1620 mm
	• Focus-floor distance	variable from 365 to 1985 mm
	• Telescopic travel tube supporting arm	200 mm (± 100 mm) with mechanical detent of the central position
	• Column stand rotation	±180° with mechanical detents every 90° and locks released by foot pedal
	• X-ray tube rotation	± 180° with mechanical detents ± 90° and angle indication by a goniometer
	• Electromagnetic brakes for the longitudinal and vertical movements of the column stand, the X-ray tube rotation and the telescopic movement of the tube supporting arm	
	• Multi-leaves light beam collimator with retractable meter for FFD indication	
	• Weight	220 Kg (column stand, rails, X-ray tube and collimator)

2.1.1. X-RAY TABLE / HORIZONTAL BUCKY

- Table top should be a **carbon fiber** top at least **220 cm** (length) and **77 cm** (width)
- Table top height (from ground) to be at least **55cms.**(Fig. 3.11**)**
- Table top material to have low radiation absorption.
- The unit should be coupled to a horizontal table having floating table top with both longitudinal (at least **+/- 43cm**) and transverse (at least **+/-11cm**) movements.
- It should have front pedals with electromagnetic locks for locking and releasing the table movements. (Fig. 3.12**)**
- The table should have a mobile bucky with a grid ratio of 12:1 (or better) at a focal distance of **115 cm.** The bucky should be compatible with standard size cassette **35*43cm** (14"x17").
- Auto-centering of X-Ray tube over the bucky (in the transverse direction) after every exposure.
- Two AEC chambers, one Ion chamber.
- It should have a weight bearing capacity of **200kg** or more.
- Power input to be **220-240VAC, 50HZ**.
- Patient hand grips.

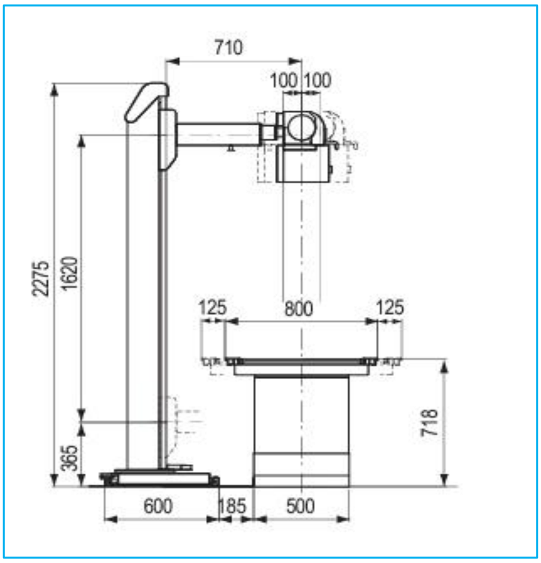

Fig. 2-12 side 1 of our design

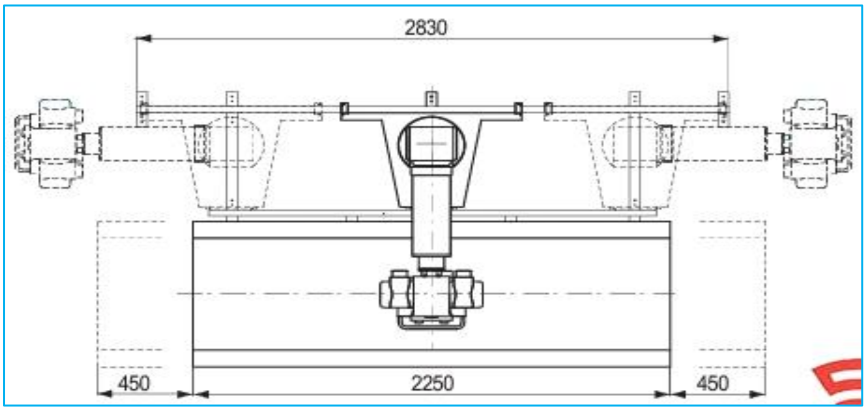

Fig.2-12 side 2 of our design

2.1.2. VERTICAL TUBE STAND

- Tube stands to be integrated with table, requires no wall/ceiling support.
- It should have manual locking for various movements.
- It should have movements in all directions i.e. 3D transverse **140 cm** or more, longitudinal **290 cm** or more and vertical **125 cm** or more. (Fig. 3.13**)**
- All movements should have electromagnetic brakes with fully counter balanced mechanism.
- It should have facility to display FFD/SID (Source to Image Distance) in vertical positions **150 cm** or more, in horizontal position **180 cm** or more.
- It should have provision of auto centering with the detector.
- Tube rotation at vertical axis and horizontal axis **+/ - 180**degree. (Fig. 3.14**)**
- Cranio-caudal tube tilt (tilt along long axis of the table) to be **-200 to +200** or better.

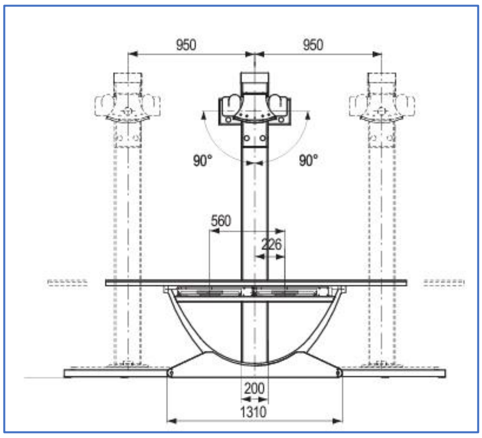

Fig. 2-13Vertical tube stand 1

Fig.3-14*Vertical tube stand 2*

2.1.3. VERTICAL DETECTOR STAND

A vertical detector stand should have:

- An in-built detector capable to take digital images in horizontal, vertical and oblique positions with suitable movements allows for a complete range of exams from skull, skeletal body including spine, chest, bearing knee and ankle exams.
- A vertical bucky with oscillating/moving grid for chest radiography (grid ratio - 10:1 or better).
- A provision to do chest radiography without grid. (Fig. 3.15**)**
- A automatic exposure control with at least 3 fields.
- The detector should be capable of rotating on its axis across **+90 to -15** degrees.
- The vertical movement range should be **125cm** or more with the lowest point (from cassette center to ground) being not more than **55cm** and the highest point being not less than **175 cm.** The bucky should have electromagnetic lock that allow for easy positioning.

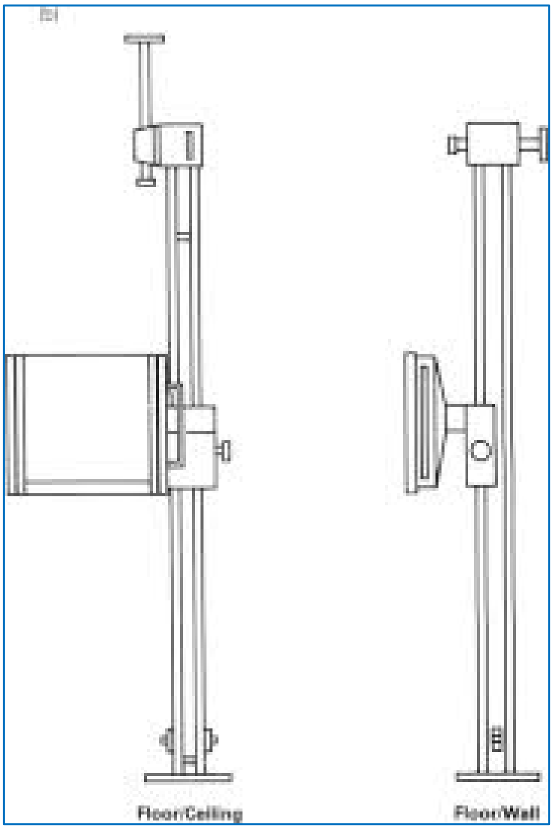

Fig.3-15VERTICAL DETECTOR STAND

2.2.X-RAY COLLIMATOR

- Should be a high-speed rotating anode dual focus tube of **2600 rpm** or more compatible with the generator. (Fig. 3.16**)**
- Should have dual focal spots with the following focal spot size range: small focal spot size: **0.6** or better, large focal spot size: **1.2mm** or better. Smaller focal size would be preferred.
- mA range: **10-600** milliampere or more.
- mA range: **0.5-600** (or more)
- Tube anode heating capacity: at least **300KHU** or more.
- Tube anode heat dissipation capacity: at least **40 kilo Heat** units per minute
- Should have a collimator with auto-off function
- Incoming voltage indicator should be present.

- Automatic exposure control (AEC) should be available
- Manual shutter control collimator
- Should have a multi leaf collimator having halogen/bright light source with auto shut provision for the light.
- Should have over load protection

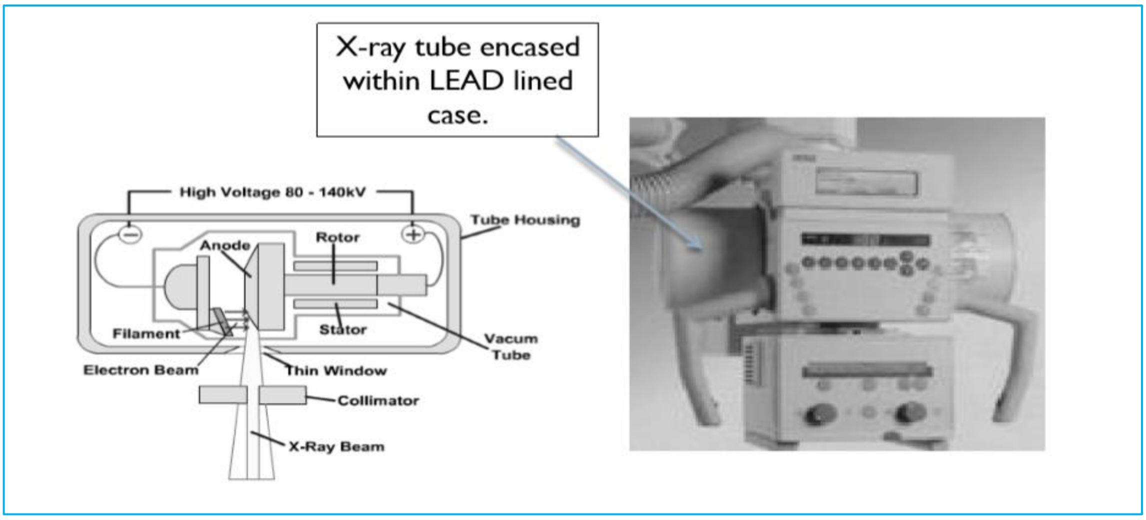

Fig.3-16X-ray collimator

2.3.DIGITAL DETECTOR

- Two detectors located one in the radiological table and one in the vertical/chest bucky.
- The size of the detector should be **35 cm x 43 cm** or more.
- The active-matrix size should be **2800 X 2400** pixels or more at **140µm** pitch.
- Should have a minimum image depth of **16 bit**.
- Housing material: built in material resistant to blows and falls
- Interface: Ethernet (**1000 Base-T**). Cables and necessary input and output devices (USB) to connect it to the computer.

3. DR WORKSTATION (IMAGE ACQUISITION, IMAGE PROCESSING)

- The digital workstation should be based on the latest high-speed processors of at least **32 bits.**
- It should have the capability of acquiring the image from the detector system.

- Should have preview time **5 seconds** or better.
- The system should be ready DICOM interface and networking capability with RIS/HIS/PACS.
- Should provide for HL-7 compatible interface.
- Advance Post Processing Software with function: for sorting of patient image based on name, date, exam etc. using predefined parameters or user defined and stored image parameters;
- Correcting typographical in-patient demographic module, in case RIS connection was down and manual data entry was done;
- Capability of changing R/L, Flipping, Rotating, Zooming, Collimating, annotating the incoming image.
- Workstation: one (1) latest Pentium system, Processor (**Intel Core i5 or better**): **2.4 GHz** or better, with **Windows 8.1** (OS) or higher, minimum **8 GB RAM**, minimum **1.0 Tera-Byte** Hard disk, medical grade 19’’ monitor supported by all necessary software for all the various DR functions. All the accessories like mouse, keyboard, power cable etc.

4. STANDARDS AND SAFETY

The X-ray unit should be type approved by AERB (Atomic Energy Regulatory Board).

Should be also FDA or CE approved product Electrical safety conforms to standards for electrical safety **IEC-60601 / IS-13450.** All products shall have the CE Mark and a supplier should provide US FDA or European CE certificate of conformity. Comprehensive guarantee for 5 years of complete system.[17].

5. SolidWorks

Is a solid modeling computer-aided design (CAD) and computer-aided engineering (CAE) computer program published by Dassault Systems that runs primarily on Microsoft Windows. While it is possible to run SolidWorks on an Intel-based Mac with Windows installed, the application's developer recommends against this. SolidWorks does not support **MACOS**. According to the publisher, over two million engineers and, designers at more than **165,000** companies were using SolidWorks as of **2013**. Also, according to the company, fiscal year **2011–12** revenue for SolidWorks totaled **$483 million.**

Fig3-17 SolidWorks

5.1.Use SolidWorks

Solidworks(Fig. 3.17) is used to develop mechatronics systems from beginning to end. At the initial stage, the software is used for planning, visual ideation, modeling, feasibility assessment, prototyping, and project management. The software is then used for design and building of mechanical, electrical, and software elements. Finally, the software can be used for management, including device management, analytics, data automation, and cloud services.

The Solidworks software solutions are used by mechanical, electrical, and electronics engineers to form a connected design. The suite of programs is aimed at keeping all engineers in communication and able to respond to design needs or changes.

A sample of the products that are a part of Solidworks, as described on their website, include:

- Circuit Works: an electronic CAD/ECAD translator that enables engineers to create accurate 3D models of circuit boards.
- CAM: an add-on to all versions of Solidworks CAD that lets you prepare your designs for manufacturability earlier in the development cycle.
- Electrical 3D: enables you to place electrical components and use Solidworks routing technology to automatically interconnect electrical design elements within a 3D

model. 2D schematics and 3D models are synchronized bi-directionally in real time so any changes are automatically updated.

- Simulation: uses Finite Element Analysis (FEA) to predict a product's real-world physical behavior by virtually testing CAD models.
- Visualize: leverage your 3D CAD data to create photo-quality content in the fastest and easiest way you can–from images to animations, interactive web content, and immersive Virtual Reality.

Solidworks continues to adapt their solutions to include new capabilities based on the feedback of users. SOLIDWORKS **2020** features a number of enhancements, such as improved performance, streamlined workflows, and 3DExperience, a cloud-based platform.

Programs such as SOLIDWORKS are vital to the work of everyone in the field of Mechatronics. Students studying Mechatronics at Capitol will take courses in CAD, automated systems design, and mechatronic systems design.

5.2.Advantages

The best thing about Solidworks is that it is easy to use and designers can make modifications to the design at any given phase of the design process. BluEntCAD experts have highlighted the significance of Real View graphics and Photo View **360**. While the former assists in visualizing designs in real time frames, the latter aids in developing brilliant photorealistic 3d renderings and animations.

Solidworks *3D models* is a a powerful dynamic that enables designers to showcase the designs become it actually comes to life. Not only this but it even displays the most excruciating details.

- Show immaculate details of every single part of the design.
- Give accurate mass properties.
- Crosscheck every error and interference.

Every minute error is extracted from the above process automatically way before a countless number of prototypes are built, This in turn ensures the entire design process saves both time and money.

Once the errors are detected it gives designers ample time to quickly make the necessary changes and solve the challenges more effectively and efficiently. The estate agents are able to use this to their advantage by communicating the 'perfect' designs to their potential clients.

5.3.high on flexibility and accessibility

BluEntCAD puts immense weightage on Solidworks. This amazing software enables the team to create the most quality defined designs in the shortest of duration. The designs are tested in real time and in various scenarios and environments making the whole process a lot more productive and brilliant. The modifications required is applied to the 3D models way before the completion process and at every stage of the operations. It makes the entire design development process more flexible and economical.[18].

6. Steps in our project using Solidworks

elementary modules: Part, Assembly, Drawing.

Step1:

To create a new part, we must click double click in the box part

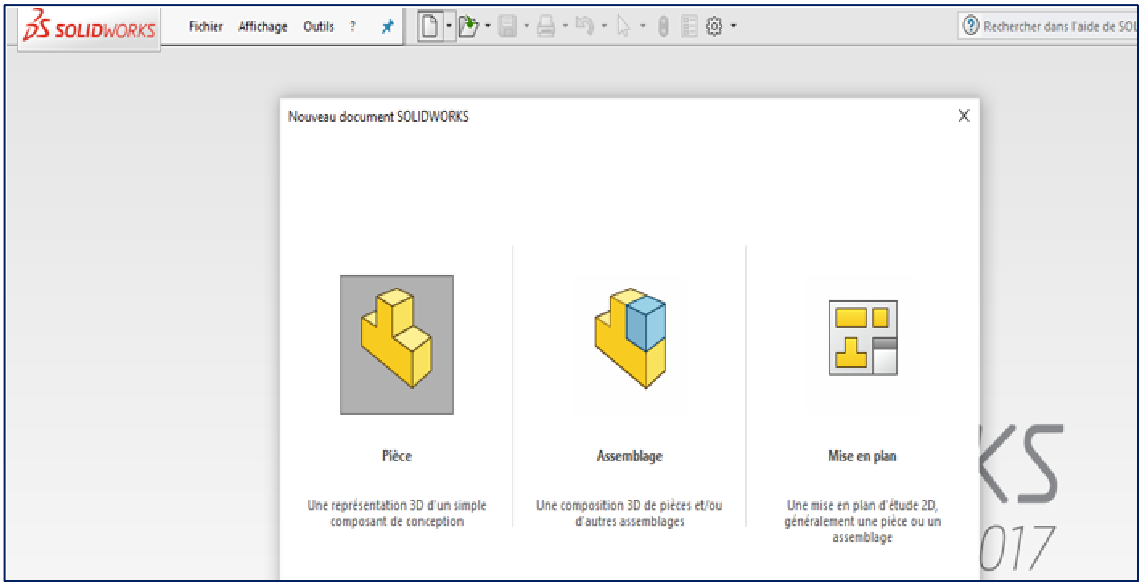

Fig. 3-18 create file using Solidworks

Step 2:

After we click in the box part this page appears:

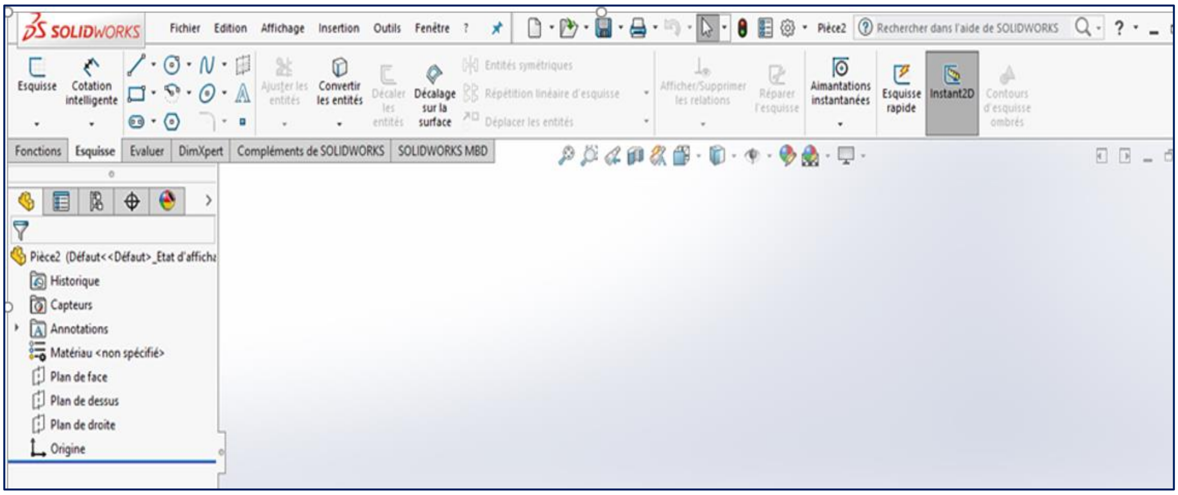

Fig3-19 work surface interface of Solidworks

Step 3:

When this page appears, to reach the shape of the part to be created, you must go through several steps necessary to make any part:

Firstly, we must select the plain that which fits the part that we will create, because there are three types of plains (plan de face –plan de dessus- plan droite) so that each plain is in a different way of drawing from the rest of the plains, in order to define a plain, it is necessary to specify and fully understand the part to be created.

In our case to create the based table X- ray: According to the study of the shape of this part, it is preferable and better to choose Face Plain (plan de face)

As shown in the following figure:

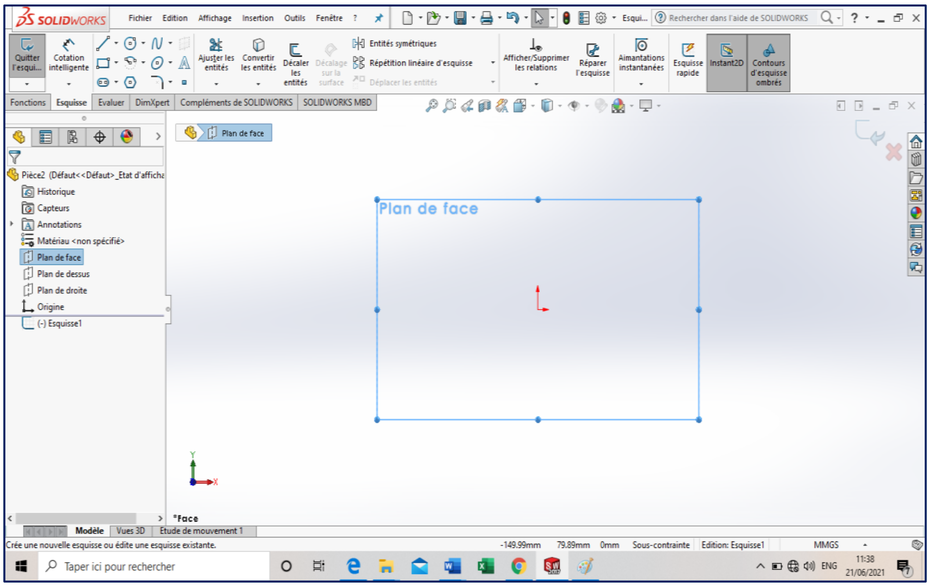

Fig.3-20 face plane

Step4:

When we finished from choose the plain, we proceed to the beginning of drawing the shape that we want to realize , through a large and different set of tools that facilitate the user of Solid Works to achieve any shape he wants, these tools are at the top of Solid-works page.

In our X-ray base to draw its initial shape, we need some of the tools that we talked about them (sketch: line, circle, mirror entity) those tools allow for us to realis our shape that shown in the following figure:

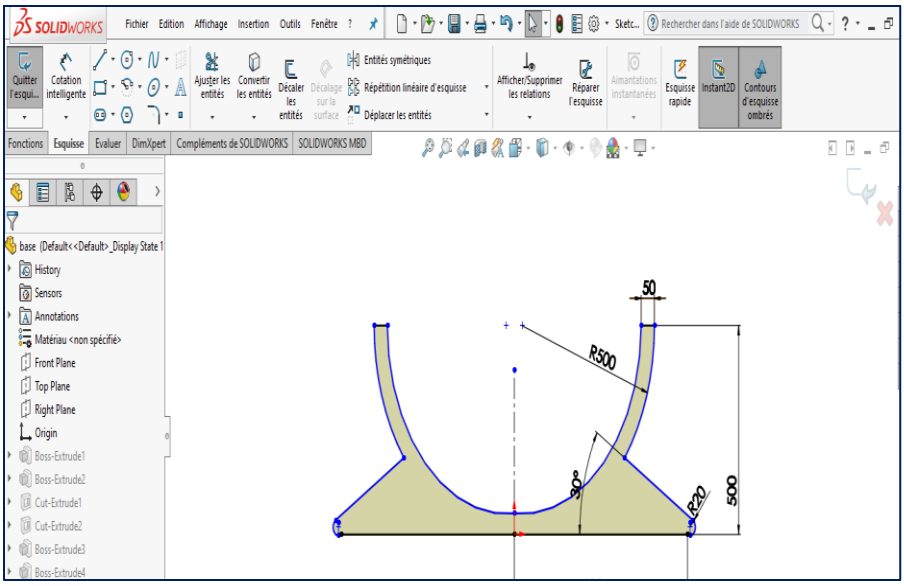

Fig. 3-21 base design using Solidworks

By Following this figure, it appears to us that it is from the form 1 d, so to make it 3 D form it is necessary to resort to one of the tools at the top of SolidWorks page that called **Extruded Boss/Bas (base/ bossage extrude)** we fined it in **Features** that extrudes a sketch or selected a sketch contours in one or two directions two create a Solidworks feature.

This operation it shown in this following figure:

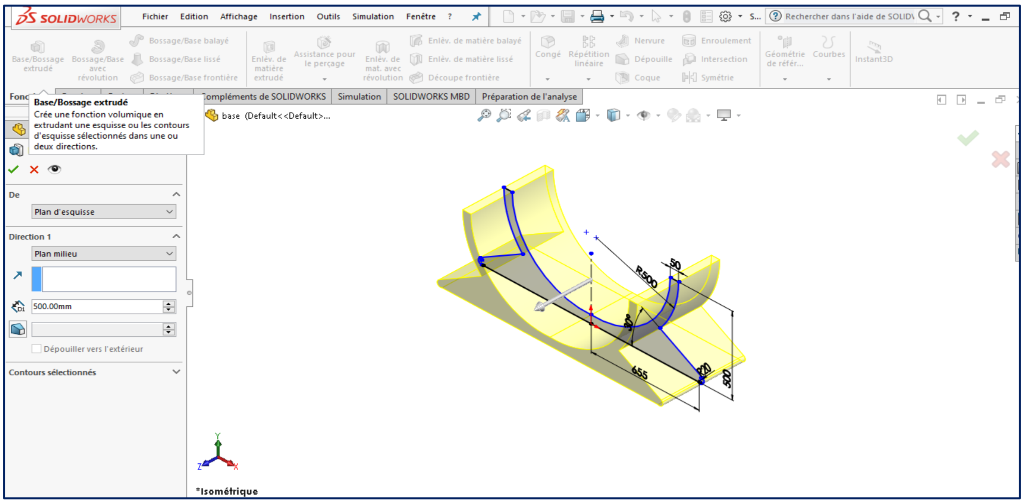

Fig. 6-22 3D Vue of base

Step5:

After that we need to sketch another important part in this table X-ray that support mechanism of radiographic cassette, so we click in sketch (esquisse) and choose the tools that needs in our shape (line, rectangle) to draw surface:

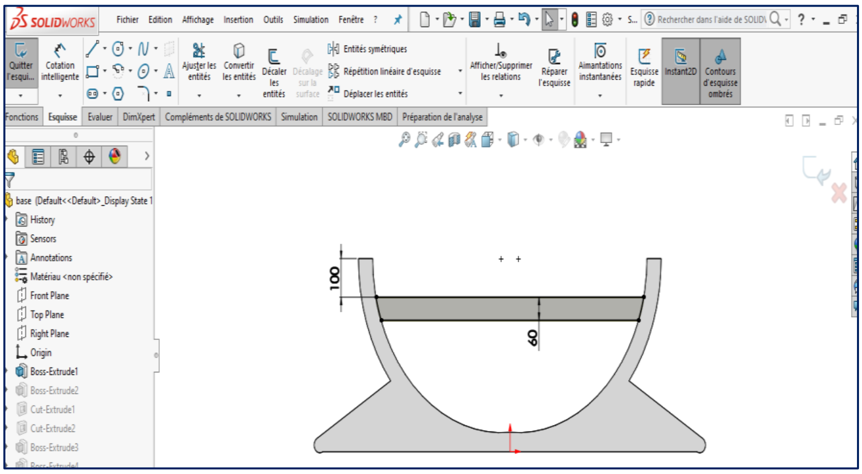

Fig. 6-26 front vu

Step6:

To complete this part we must also click in**Features (Function)** and choose **Extruded Boss/Bas (base/ bossage extrudé)** to have the necessary height the shape become like this :

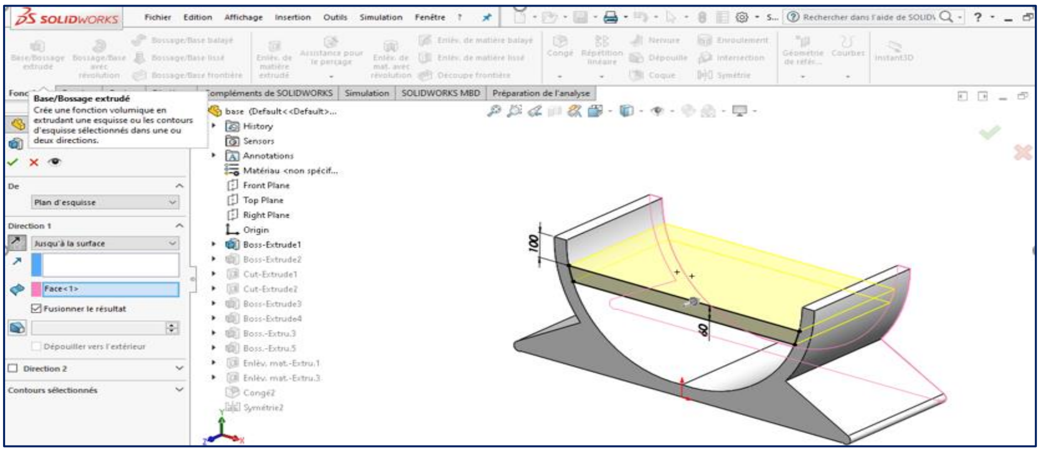

Fig3-24 3D Vue from the side

Step7:

To get the final shape of the based table X-ray to be created, we need to draw another rectangle above the part we completed before and to draw this rectangle, we need the tools at the top of trestlework page, and exactly in **sketch** (line or rectangle), the shape will be like the following figure:

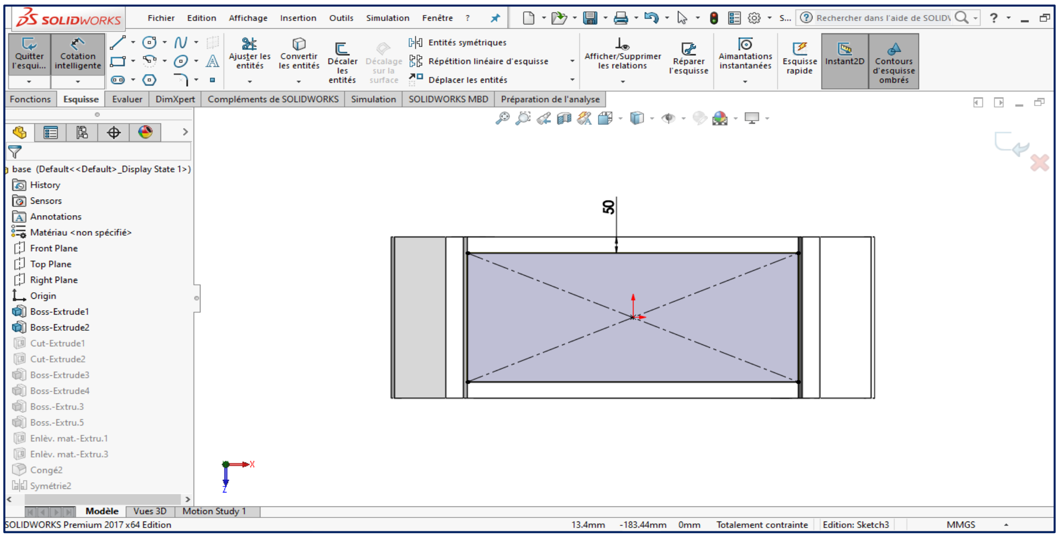

Fig.6-25 top Vue

Step8:

After that we need to remove the material of the rectangle which we paint up to the surface of the part so we use a function which is in the top of the page Solidworks exactly in **Features (Function),** and we click in **Extruded out** to have the final model that we want it . The based table X-ray will be like the following figure :

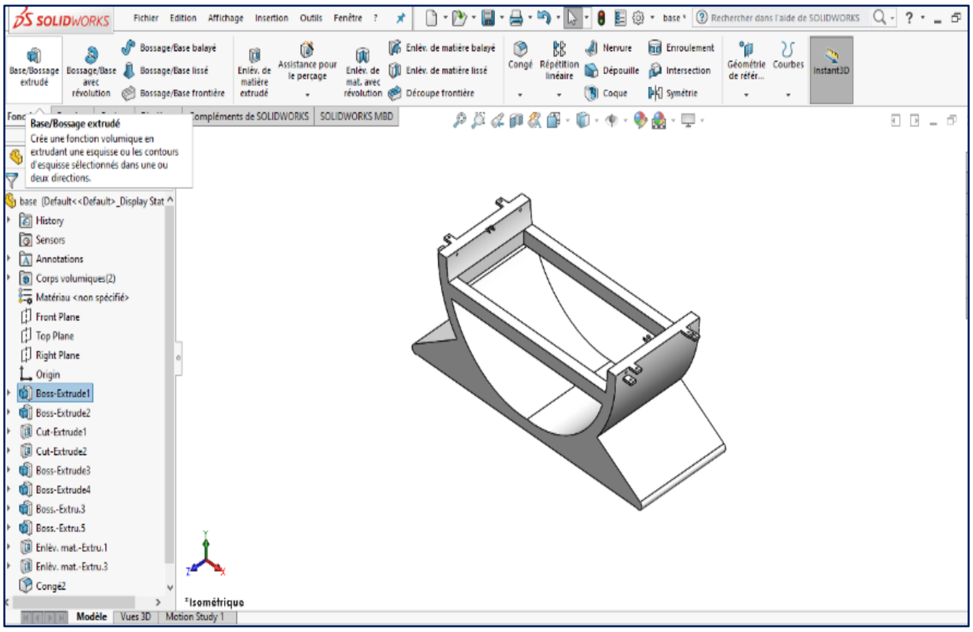

Fig.3-26 extruded out

Conclusion

This chapter, allows to present a clear picture and a lot of information about the radio to be created through the explanation and a detailed mention of all its equipment's. The creation of all equipment's of the system is based on the main steps given before.

General conclusion

The project developed in this work, allows us to use our theorical knowledge in the medical field. In this study we learn about the different parts of radiography especially the table of X-ray radiography.

To develop this work, Solidworks have been used as a principal software to design a x-ray table. So many models of tables are studied and the important components of an x-ray radio are discussed. However, in this work only one table model has been considered for the design. The design of the desired table is based on the separation of the table to several parts. Each table's part is designed and dimension separately in the the Solidworks software.

Finally, the design software allows to the evaluate the table performances in terms of quality and cost. As a perspective for the future work, it is recommended to realize this table using the design results obtained in this study.

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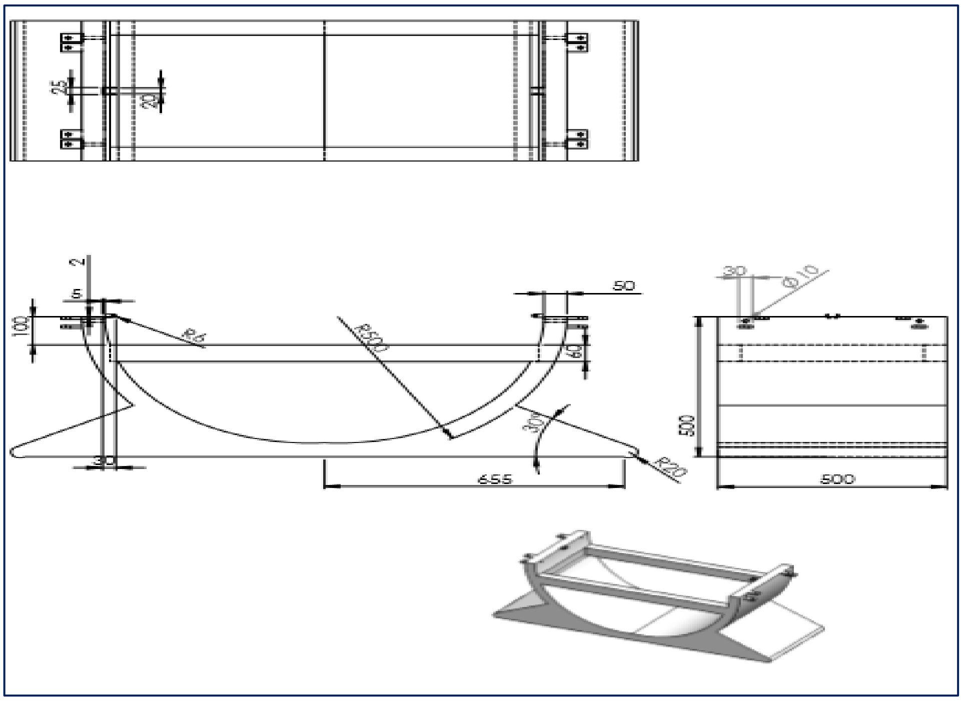
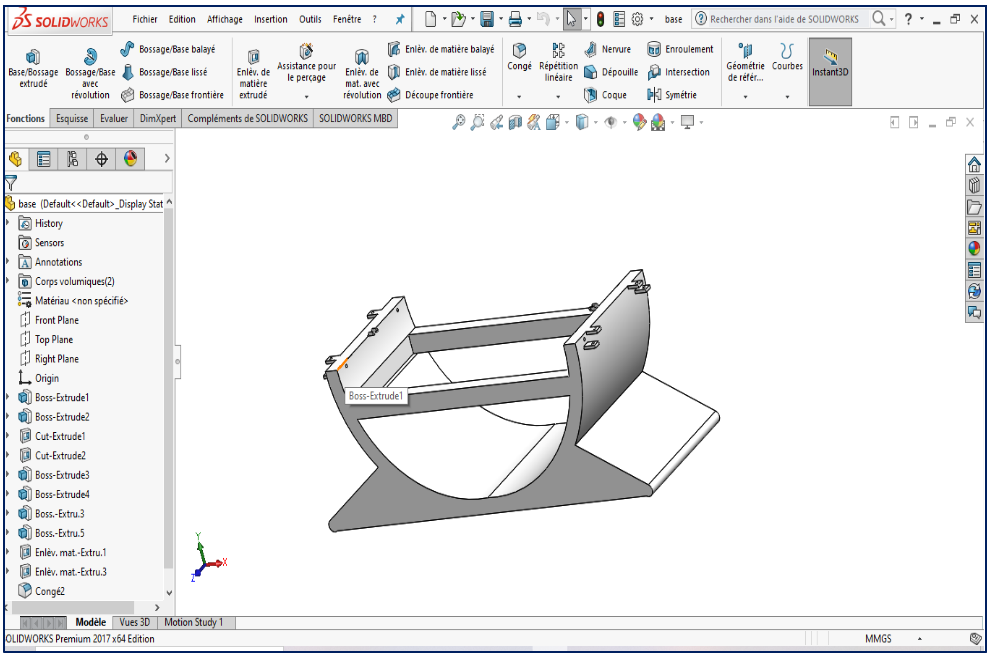
Annex

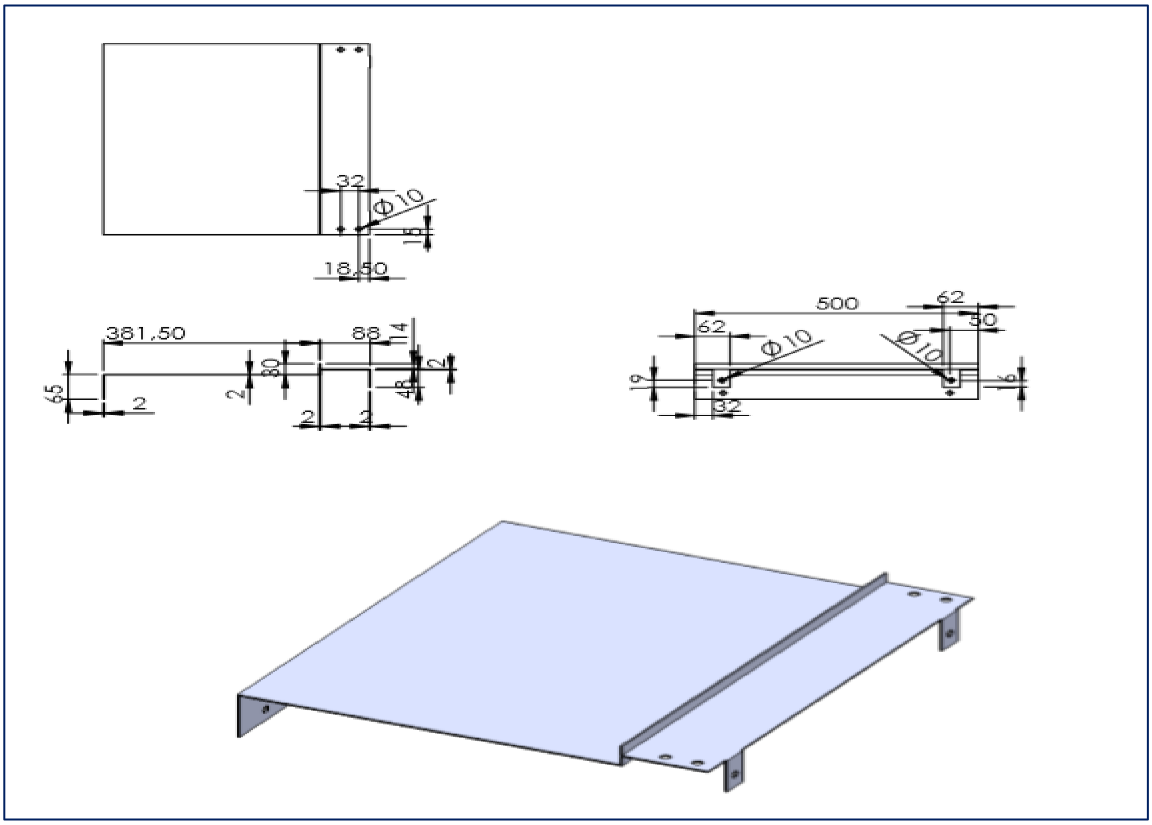
Solidworks

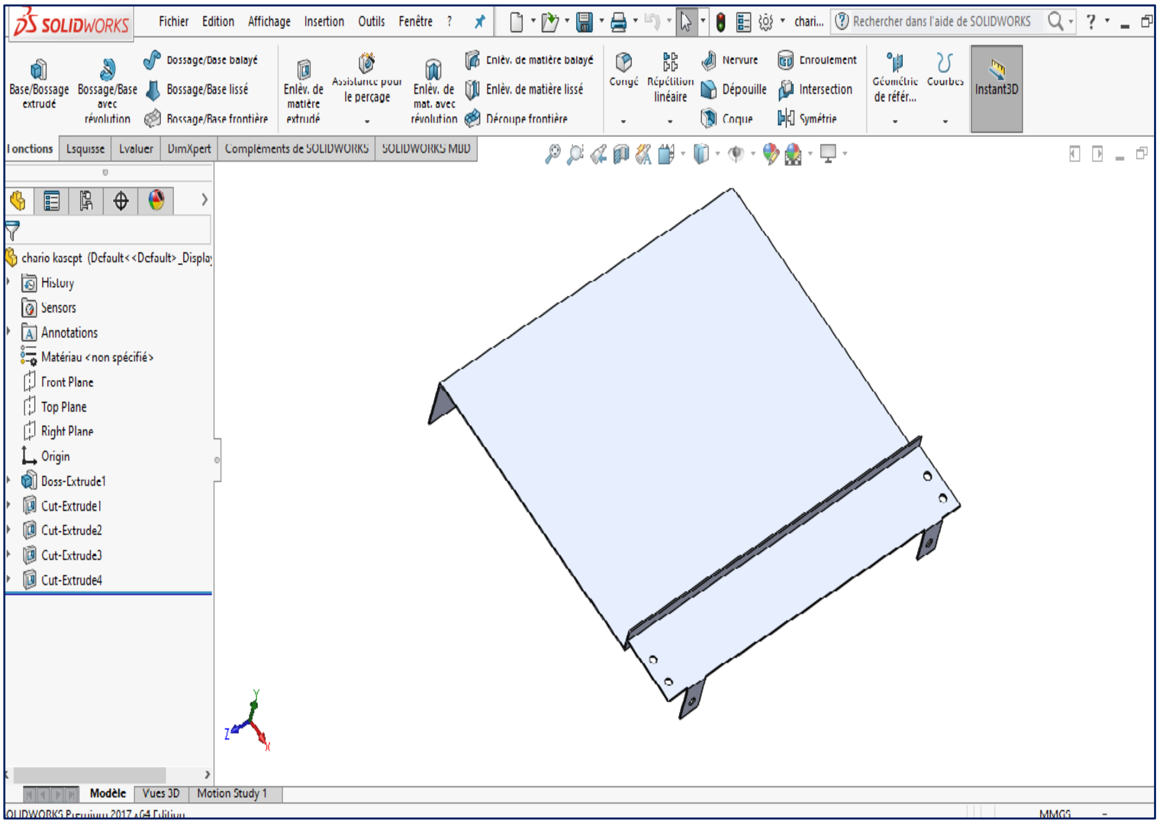
Table

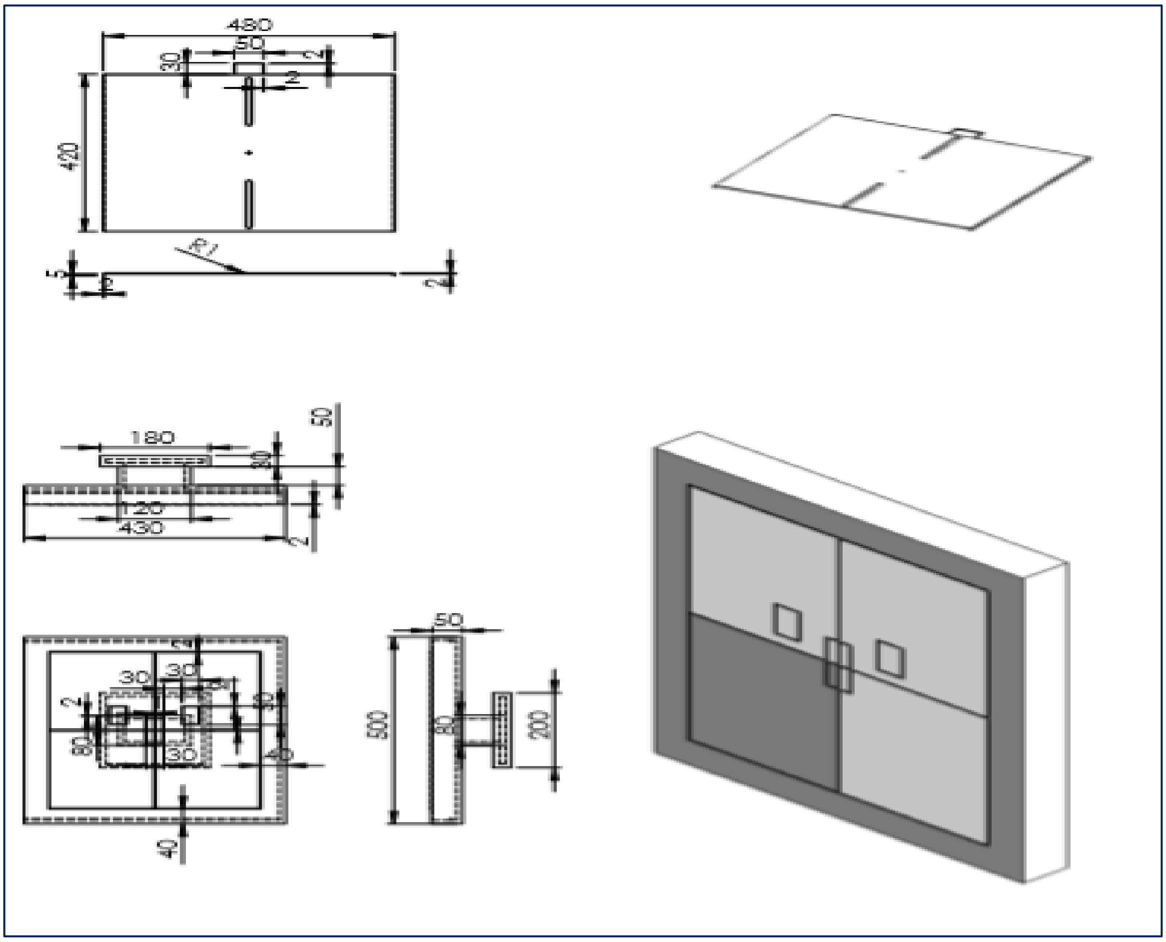




x ray film cassette holder



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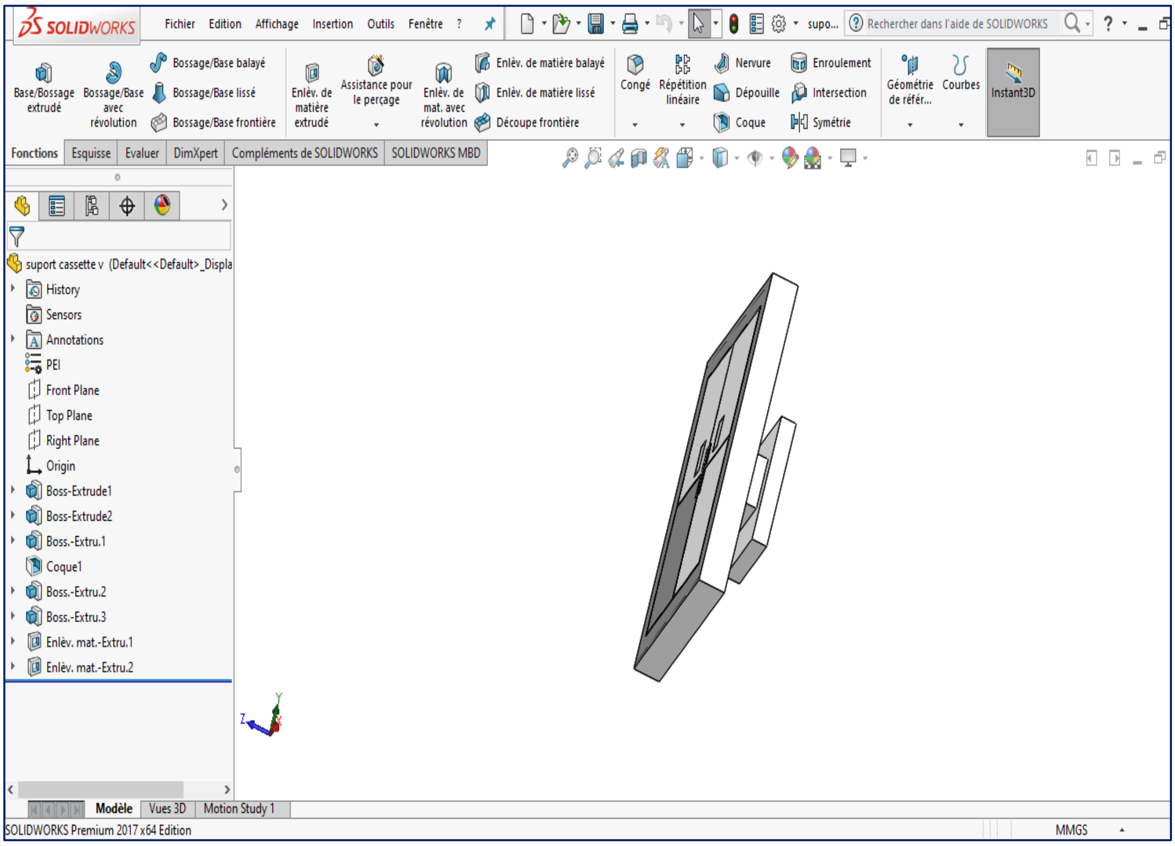
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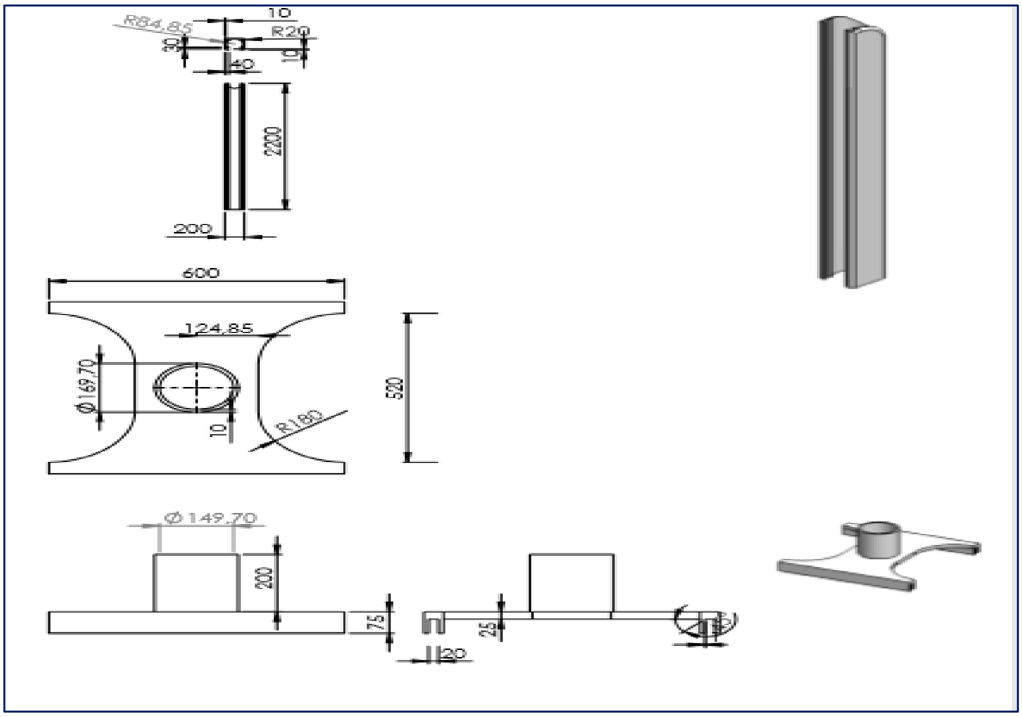
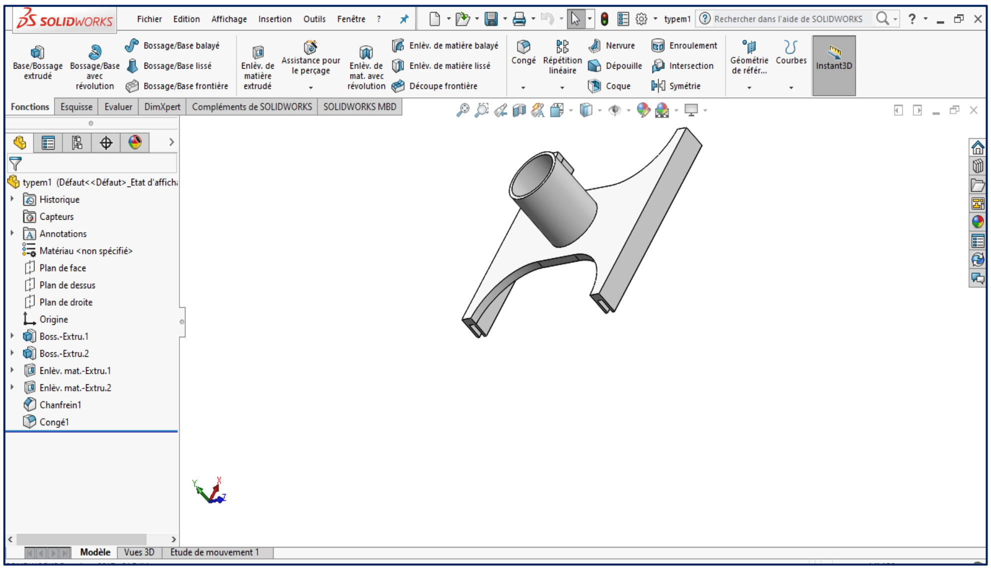
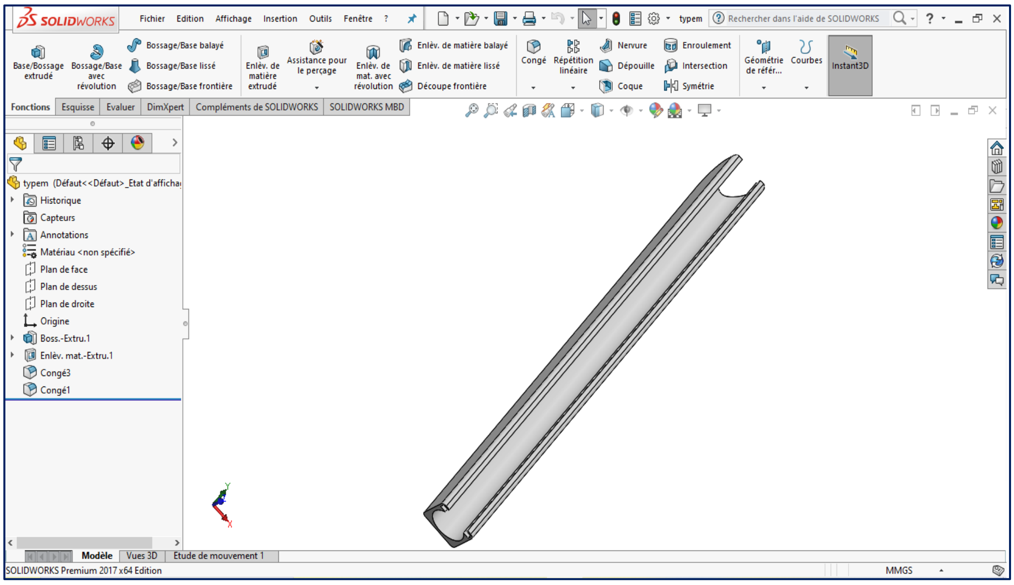
horizontal and vertical tube







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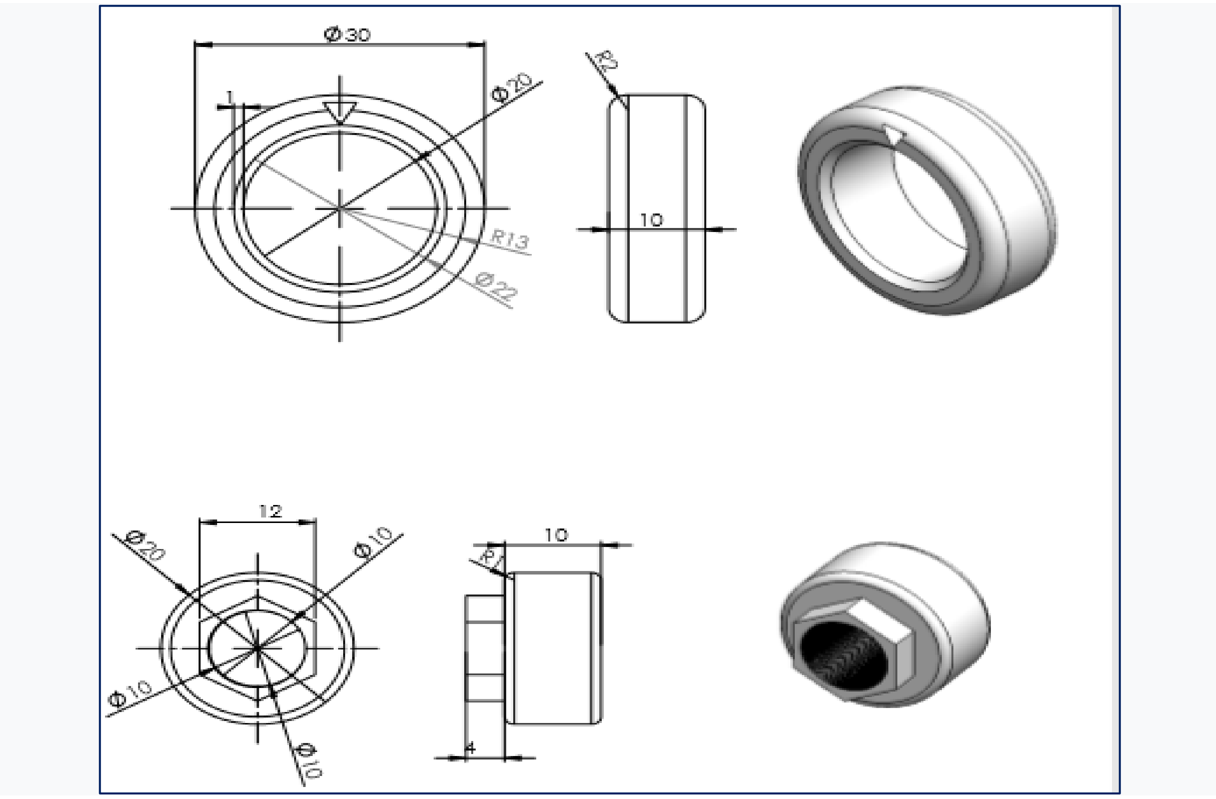

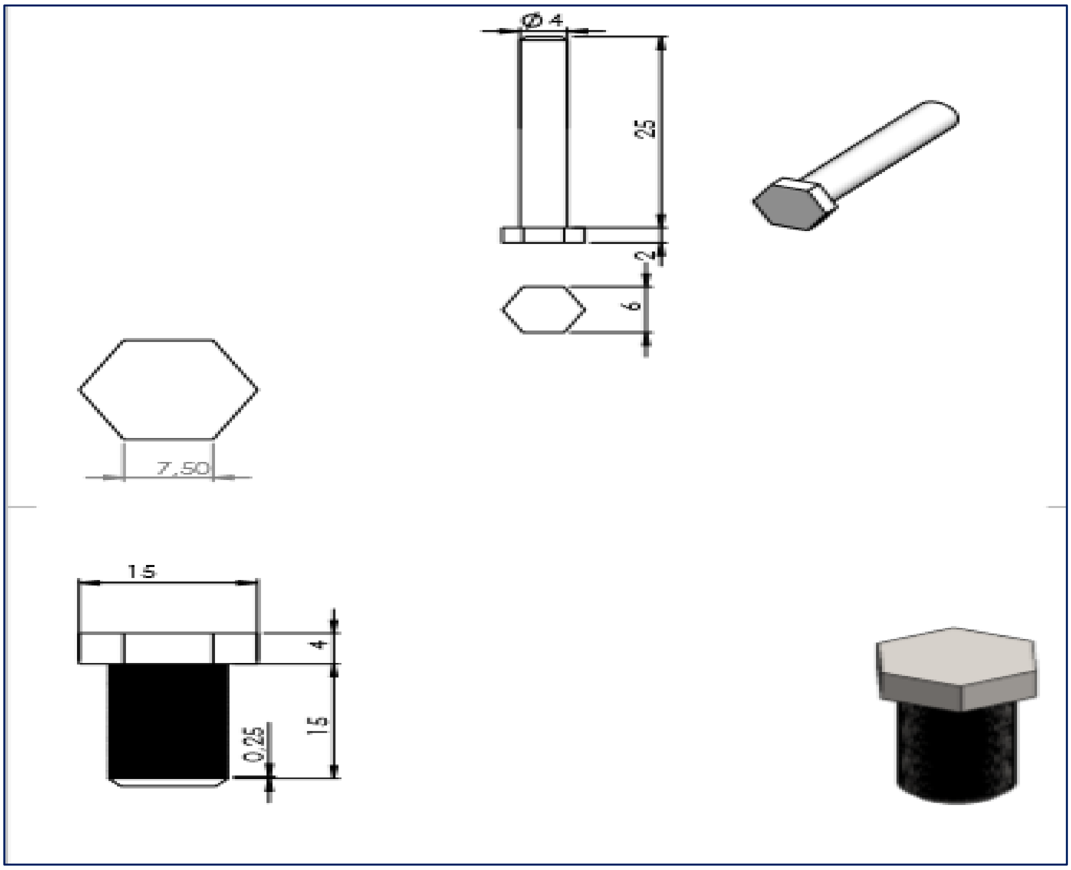
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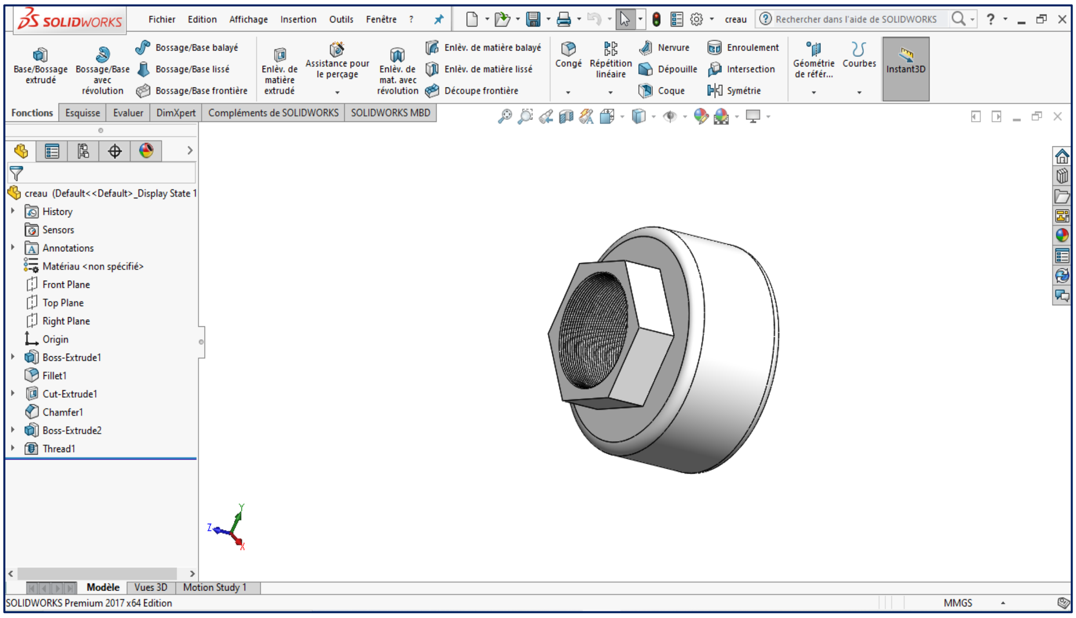
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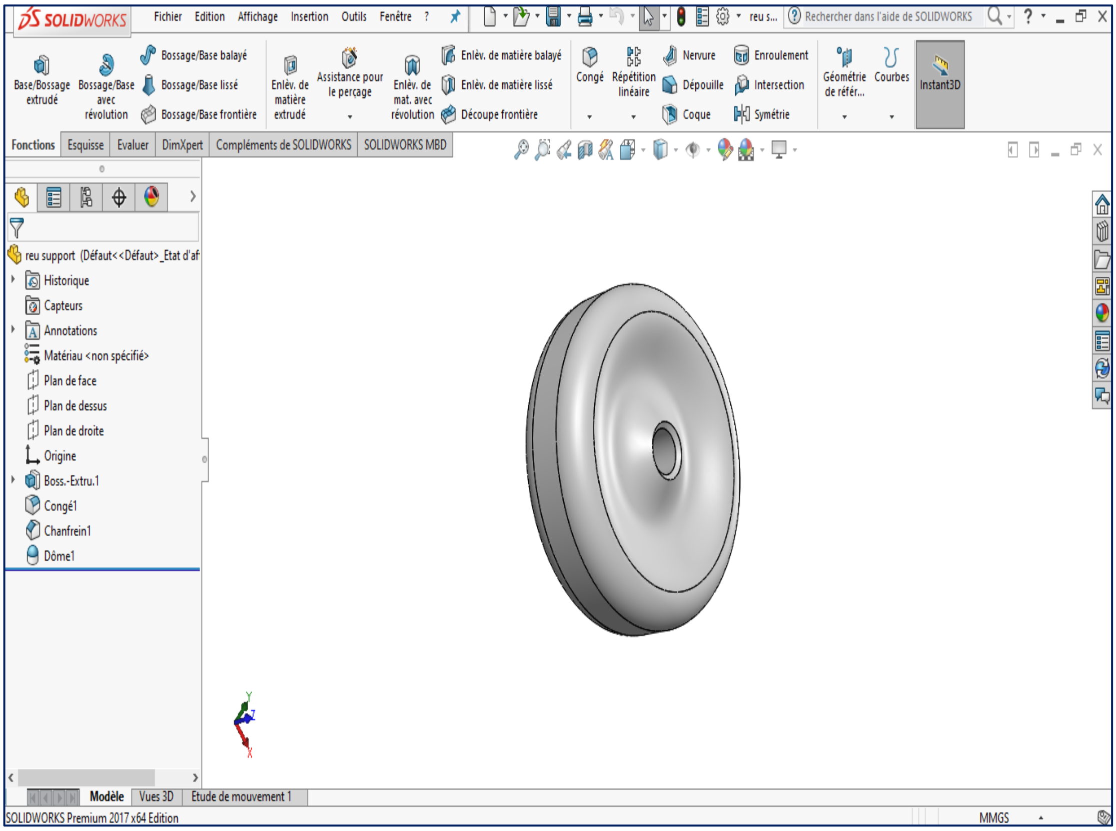
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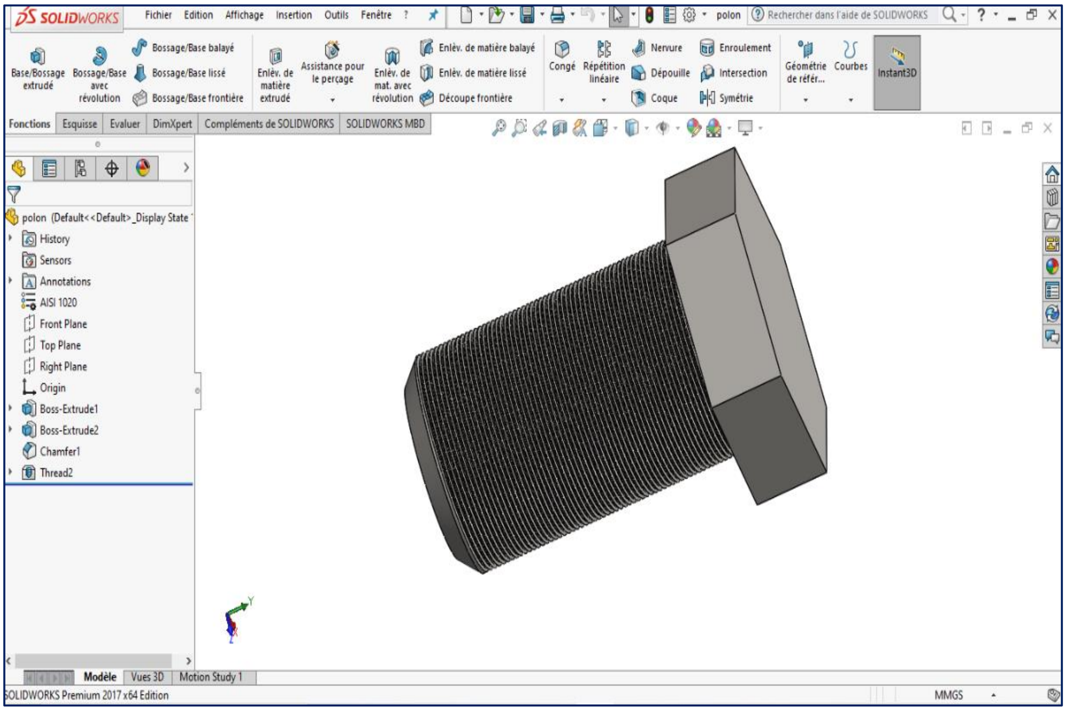
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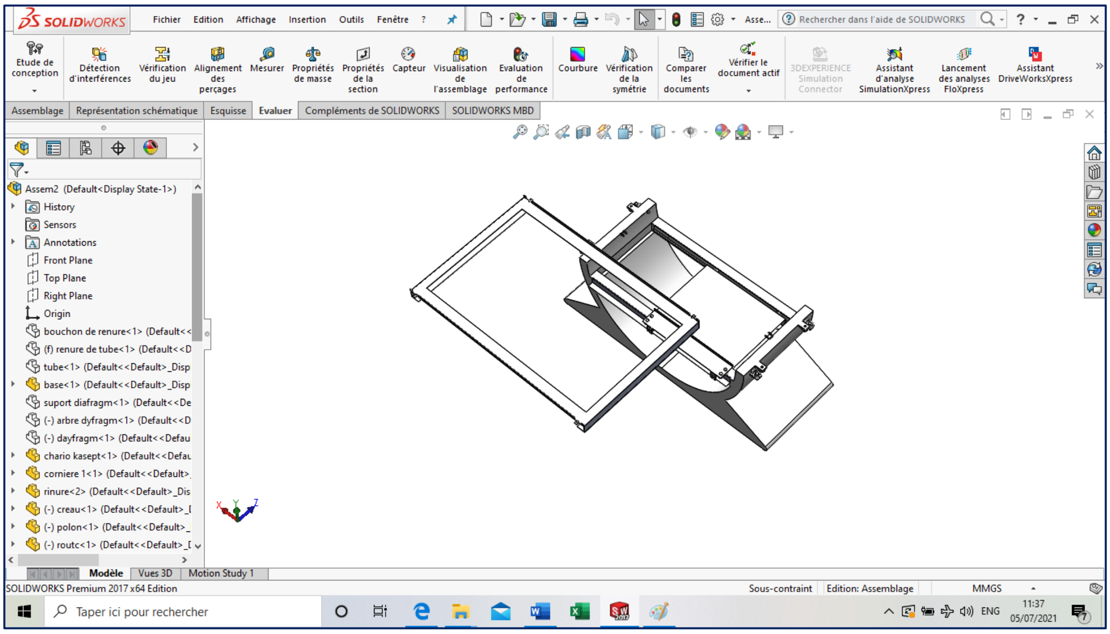
Assembling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Etude de conception
Détection d'interférences
Vérification du jeu
Alignement des perçages
Mesurer
Propriétés de masse
Propriétés de la section
Capteur
Visualisation de l'assemblage
Evaluation de performance
Courbure
Vérification de la symétrie
Comparer les documents
Vérifier le document actif
3DEXPERIENCE Simulation Connector
Assistant d'analyse SimulationXpress
Lancement des analyses FloXpress
Assistant DriveWorksXpress
Assemblage
Représentation schématique
Esquisse
Evaluer
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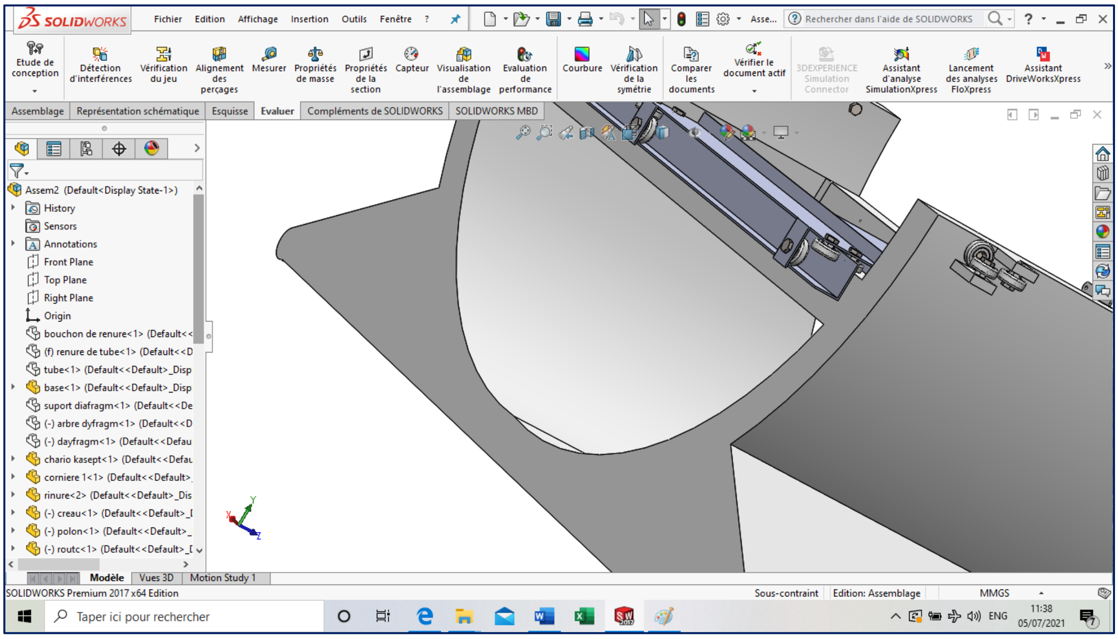
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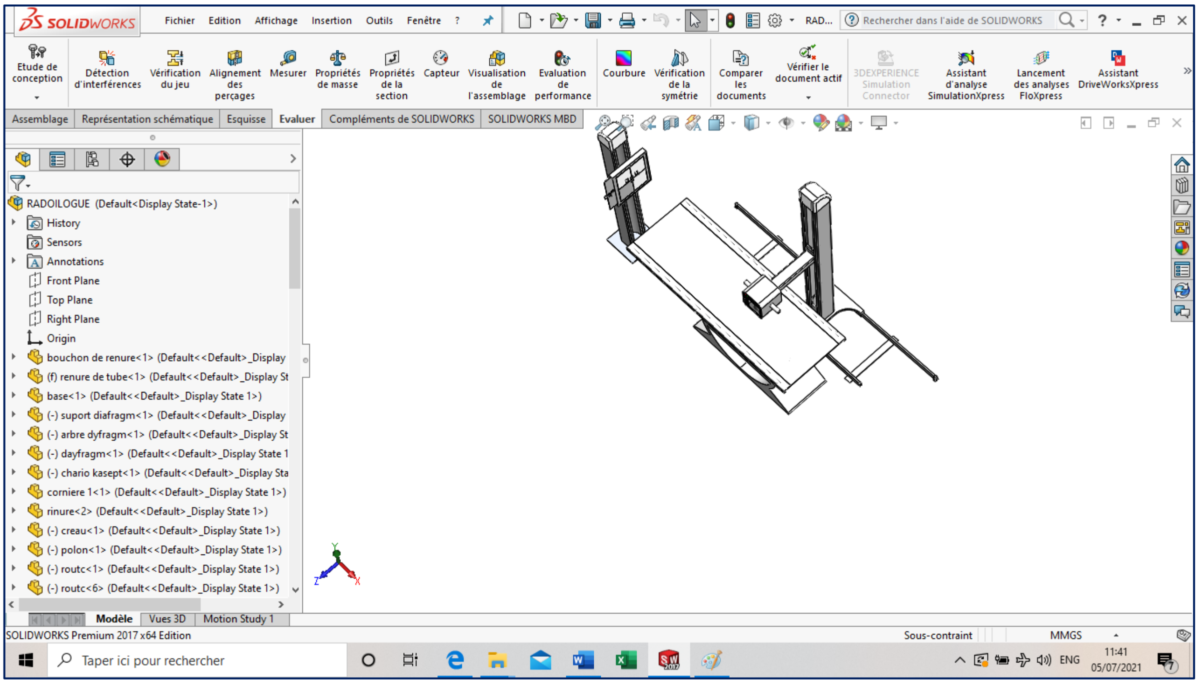
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Vérification du jeu
Alignement des perçages
Mesurer
Propriétés de masse
Propriétés de la section
Capteur
Visualisation de l'assemblage
Evaluation de performance
Courbure
Vérification de la symétrie
Comparer les documents
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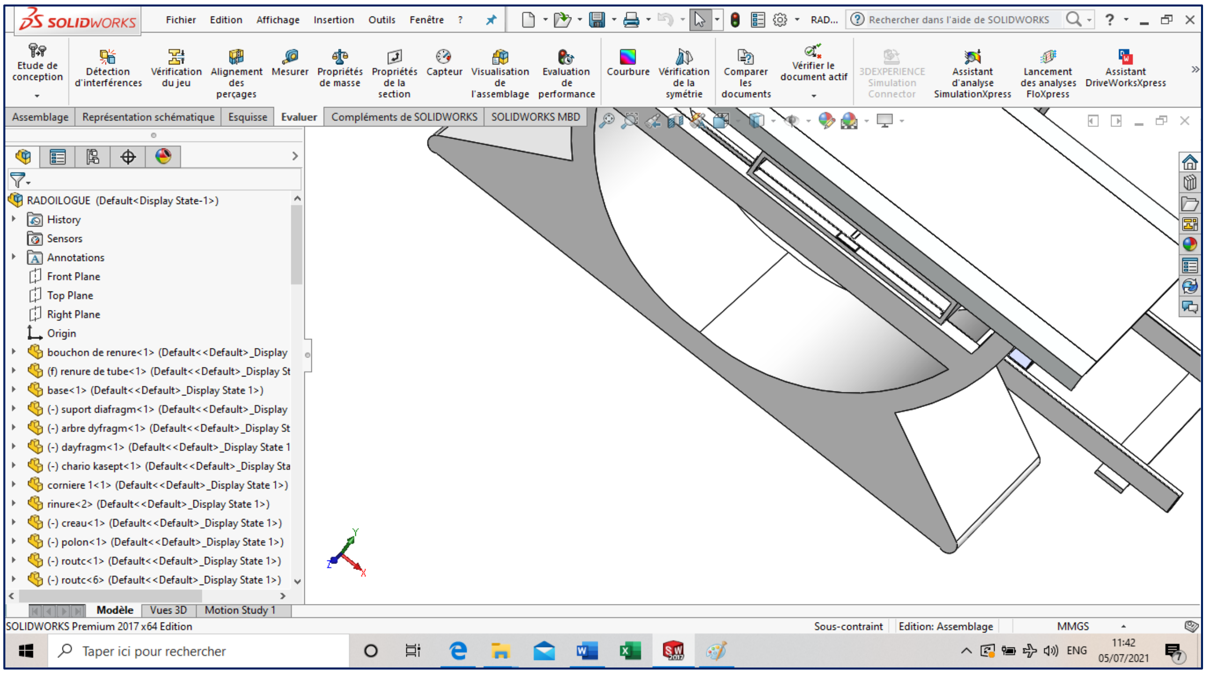
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Visualisation de l'assemblage
Evaluation de performance
Courbure
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Comparer les documents
Vérifier le document actif
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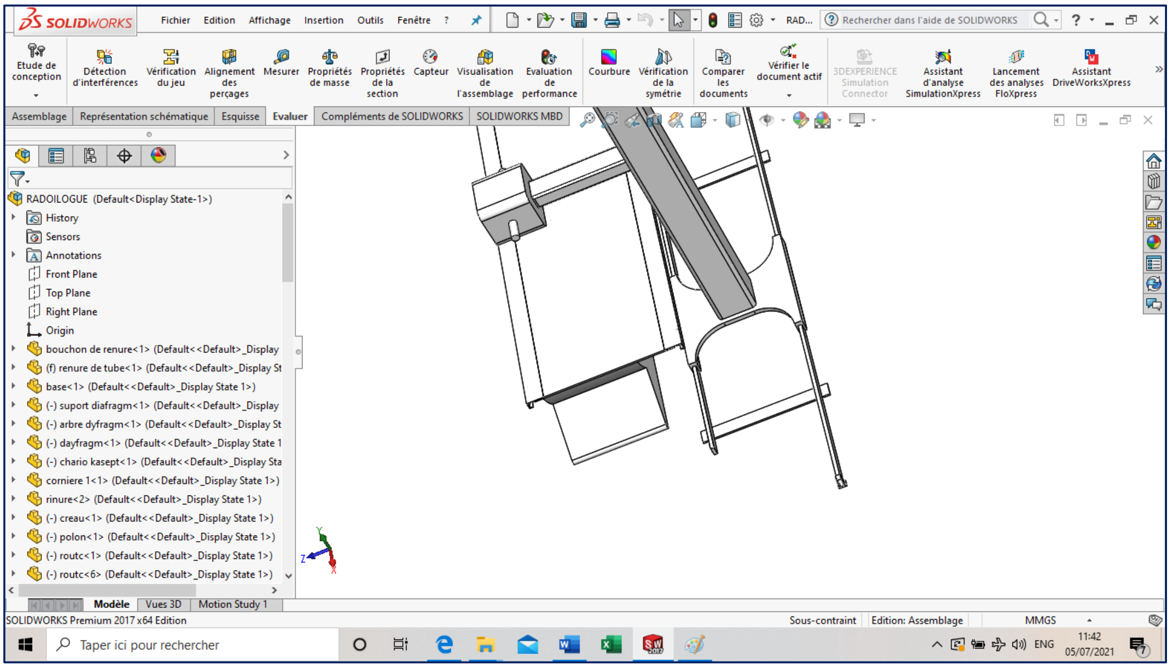
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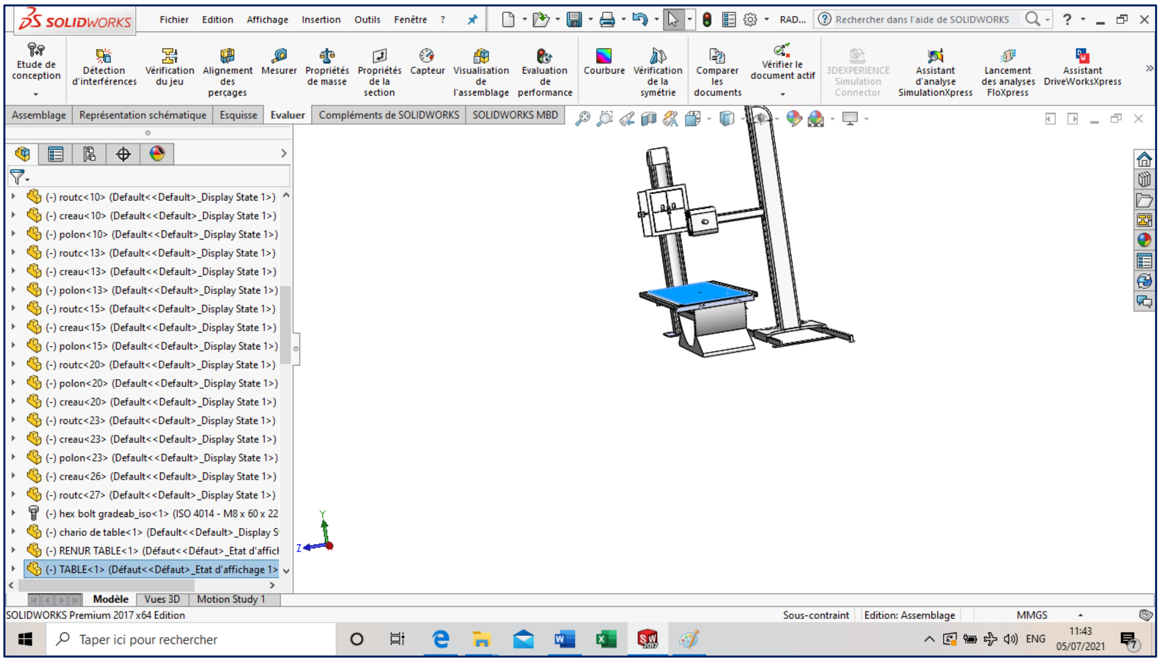
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Alignement des perçages
Mesurer
Propriétés de masse
Propriétés de la section
Capteur
Visualisation de l'assemblage
Evaluation de performance
Courbure
Vérification de la symétrie
Comparer les documents
Vérifier le document actif
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Assistant d'analyse SimulationXpress
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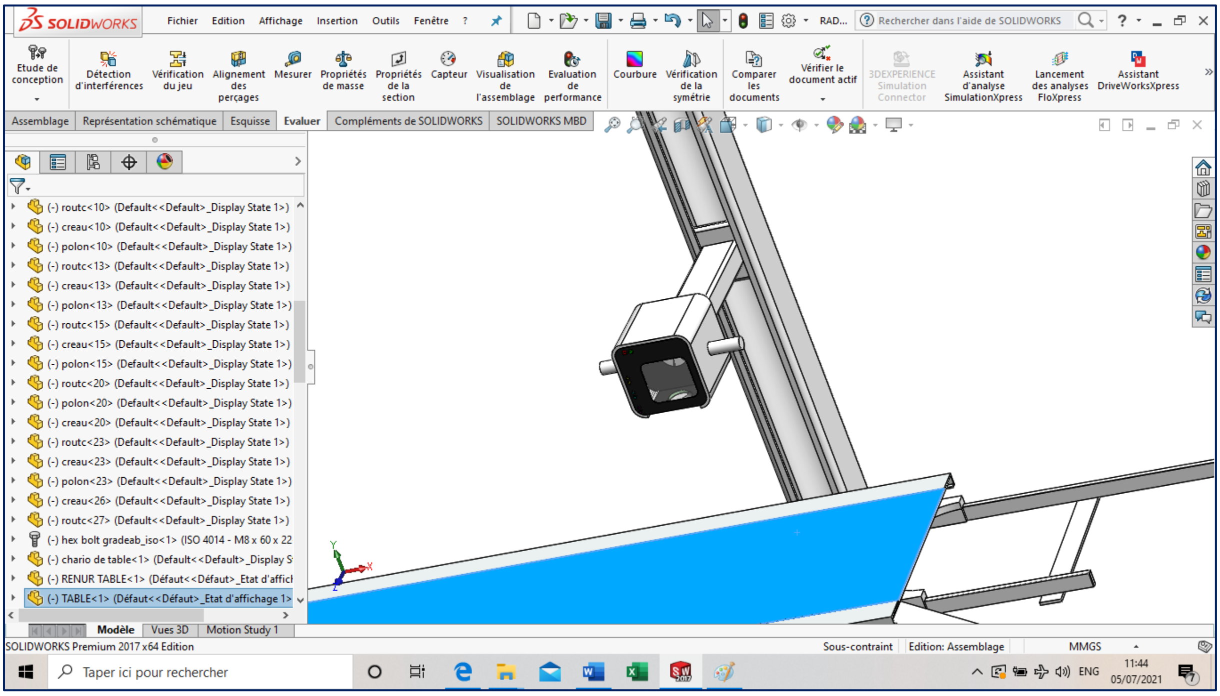
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Etude de conception
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Vérification du jeu
Alignement des perçages
Mesurer
Propriétés de masse
Propriétés de la section
Capteur
Visualisation de l'assemblage
Evaluation de performance
Courbure
Vérification de la symétrie
Comparer les documents
Vérifier le document actif
3DEXPERIENCE Simulation Connector
Assistant d'analyse SimulationXpress
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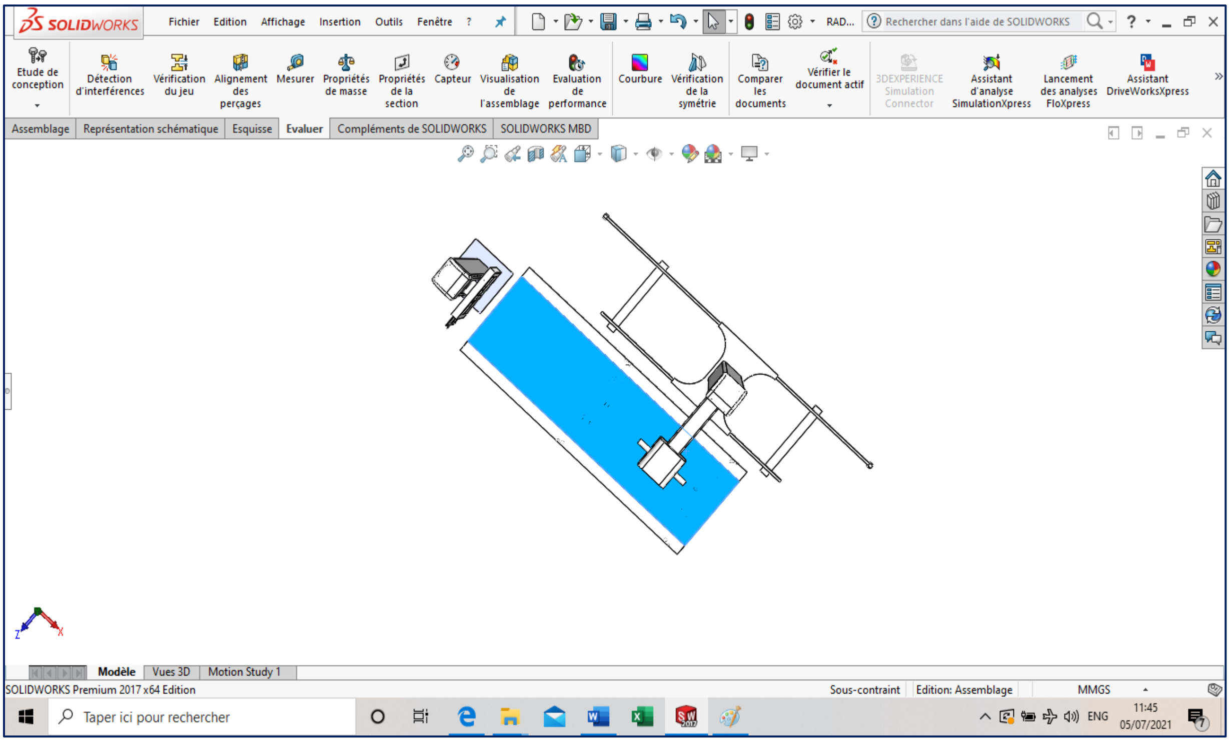
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Mesurer
Propriétés de masse
Propriétés de la section
Capteur
Visualisation de l'assemblage
Evaluation de performance
Courbure
Vérification de la symétrie
Comparer les documents
Vérifier le document actif
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Assistant d'analyse SimulationXpress
Lancement des analyses FloXpress
Assistant DriveWorksXpress
Assemblage
Représentation schématique
Esquisse
Evaluer
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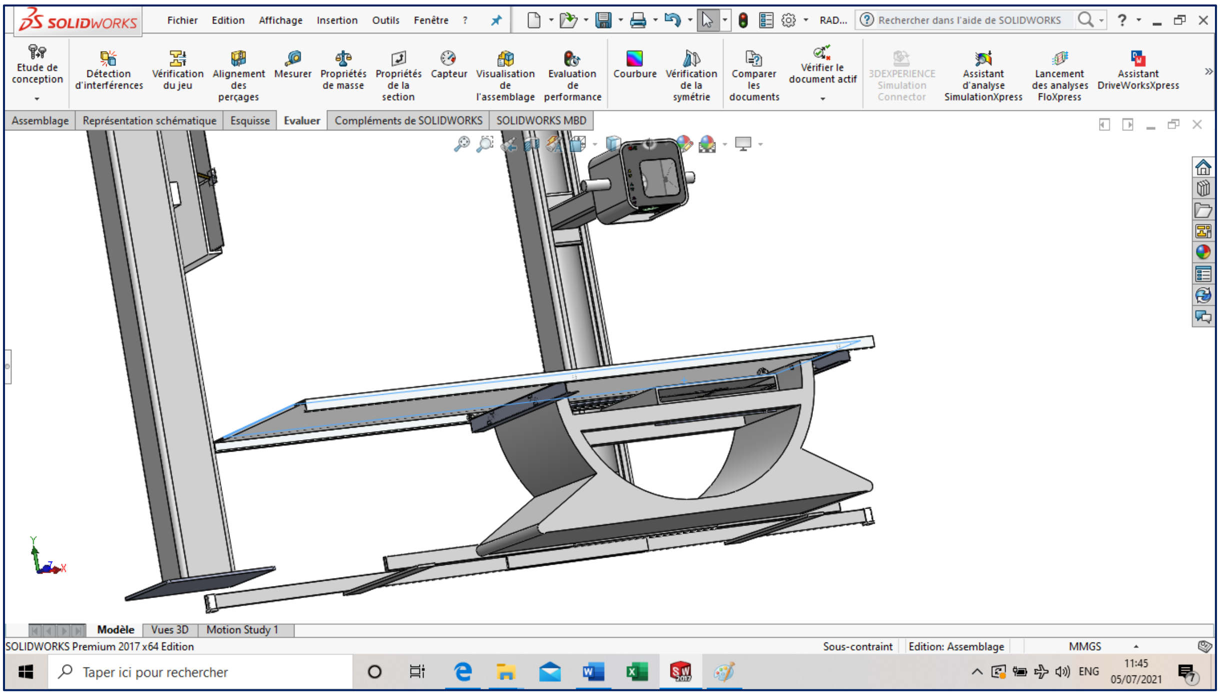
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Capteur
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Evaluation de performance
Courbure
Vérification de la symétrie
Comparer les documents
Vérifier le document actif
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Lancement des analyses FloXpress
Assistant DriveWorksXpress
Assemblage
Représentation schématique
Esquisse
Evaluer
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SOLIDWORKS MBD
Modèle
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Motion Study 1
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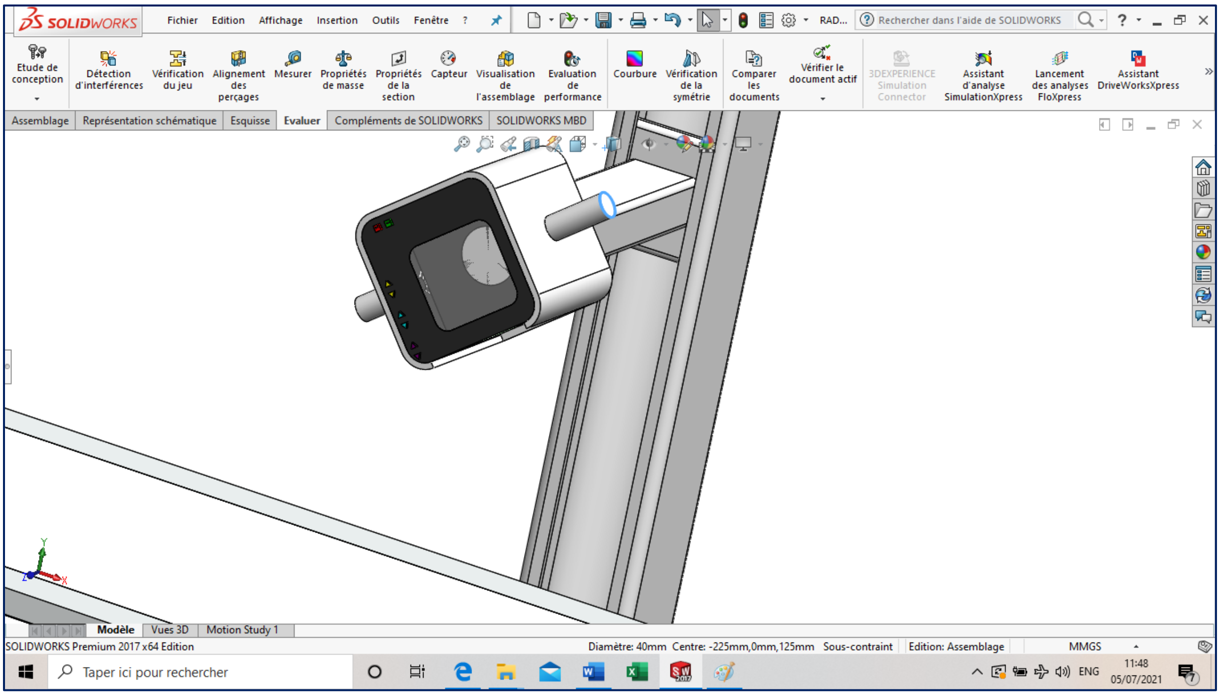
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Vérification du jeu
Alignement des perçages
Mesurer
Propriétés de masse
Propriétés de la section
Capteur
Visualisation de l'assemblage
Evaluation de performance
Courbure
Vérification de la symétrie
Comparer les documents
Vérifier le document actif
3DEXPERIENCE Simulation Connector
Assistant d'analyse SimulationXpress
Lancement des analyses FloXpress
Assistant DriveWorksXpress
Assemblage
Représentation schématique
Esquisse
Evaluer
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Modèle
Vues 3D
Motion Study 1
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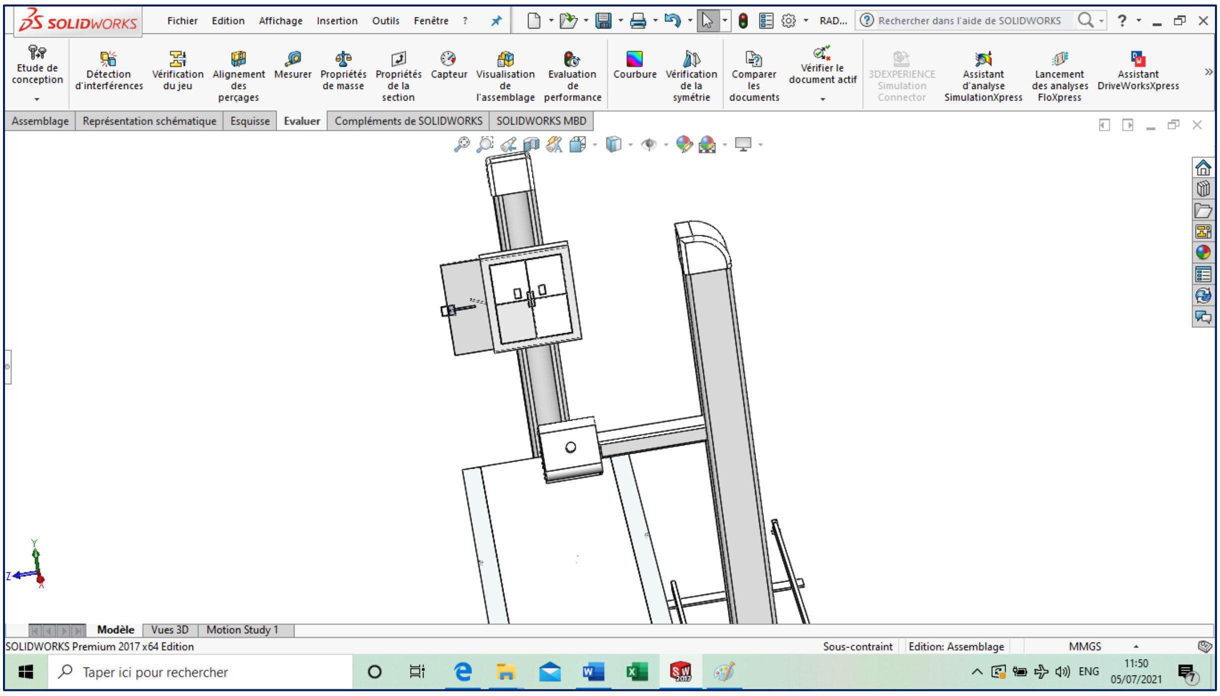
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Etude de conception
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Vérification du jeu
Alignement des perçages
Mesurer
Propriétés de masse
Propriétés de la section
Capteur
Visualisation de l'assemblage
Evaluation de performance
Courbure
Vérification de la symétrie
Comparer les documents
Vérifier le document actif
3DEXPERIENCE Simulation Connector
Assistant d'analyse SimulationXpress
Lancement des analyses FloXpress
Assistant DriveWorksXpress
Assemblage
Représentation schématique
Esquisse
Evaluer
Compléments de SOLIDWORKS
SOLIDWORKS MBD
Modèle
Vues 3D
Motion Study 1
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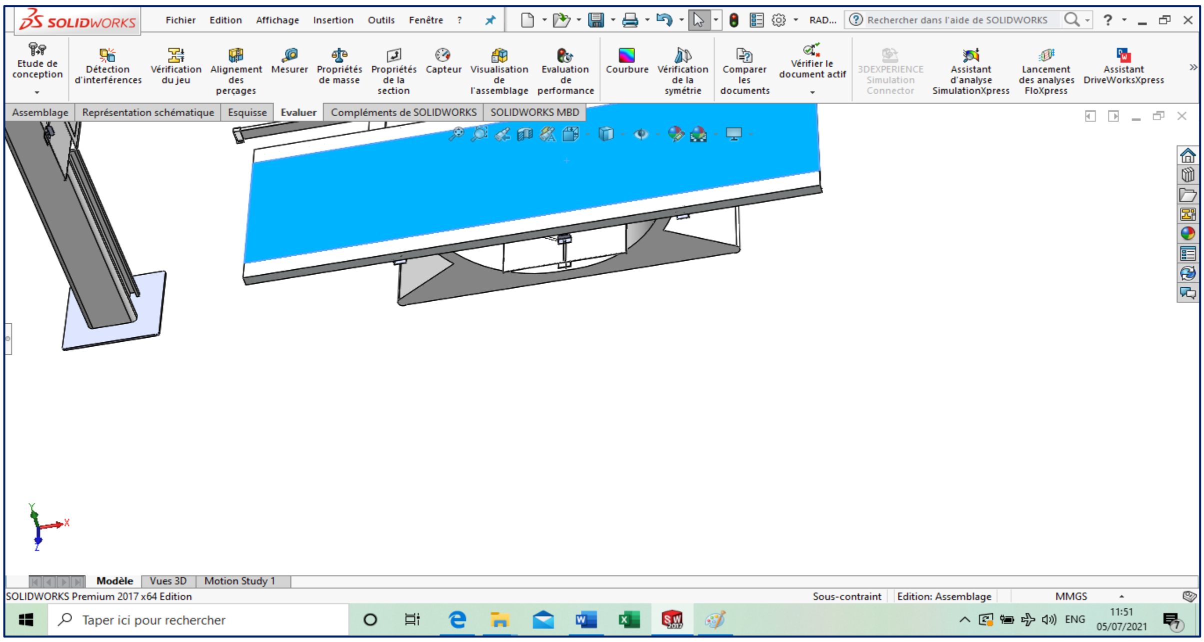
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Etude de conception
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Vérification du jeu
Alignement des perçages
Mesurer
Propriétés de masse
Propriétés de la section
Capteur
Visualisation de l'assemblage
Evaluation de performance
Courbure
Vérification de la symétrie
Comparer les documents
Vérifier le document actif
3DEXPERIENCE Simulation Connector
Assistant d'analyse SimulationXpress
Lancement des analyses FloXpress
Assistant DriveWorksXpress
Assemblage
Représentation schématique
Esquisse
Evaluer
Compléments de SOLIDWORKS
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Modèle
Vues 3D
Motion Study 1
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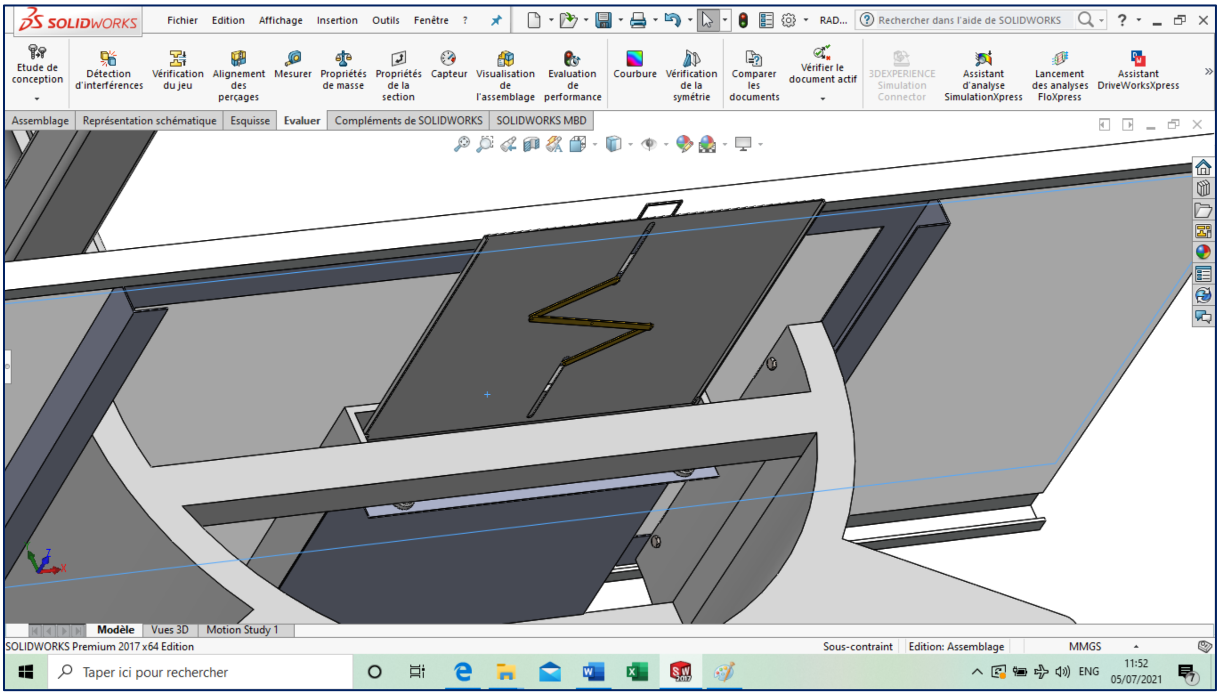
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Représentation schématique
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Evaluer
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Modèle
Vues 3D
Motion Study 1
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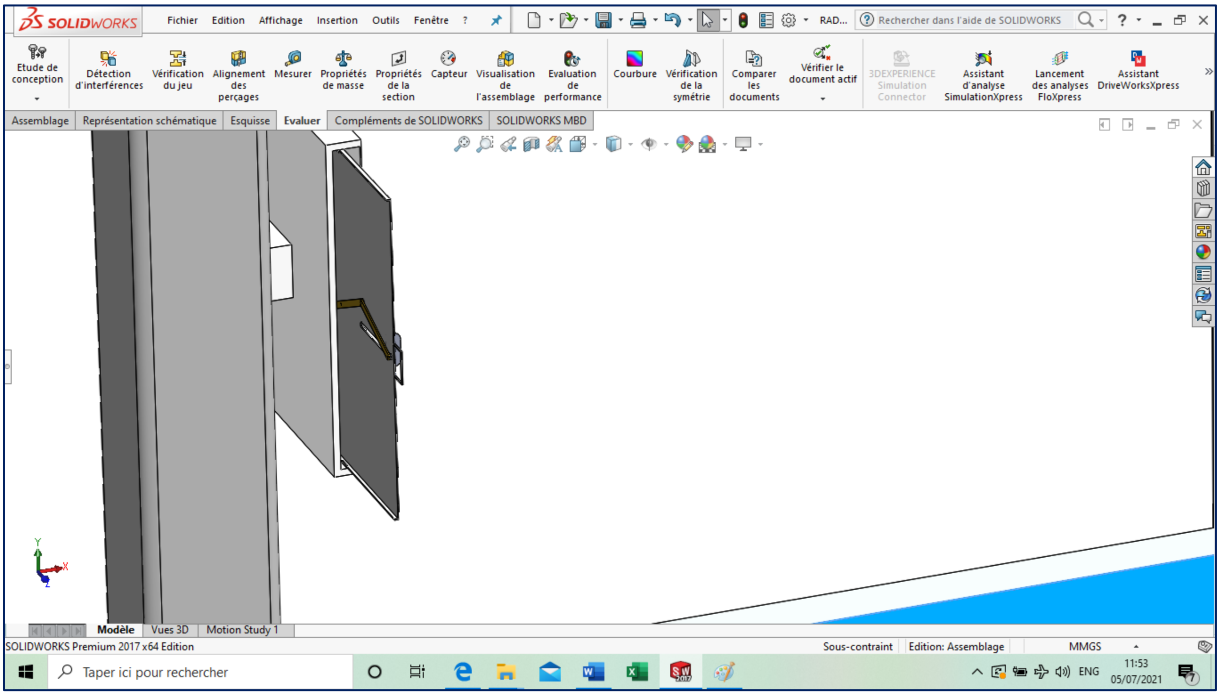
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Assistant DriveWorksXpress
Assemblage
Représentation schématique
Esquisse
Evaluer
Compléments de SOLIDWORKS
SOLIDWORKS MBD
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Motion Study 1
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MMGS
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