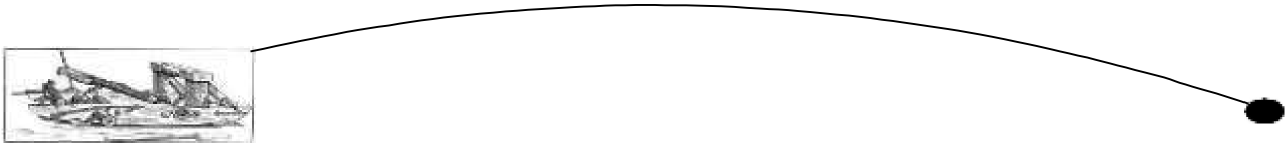
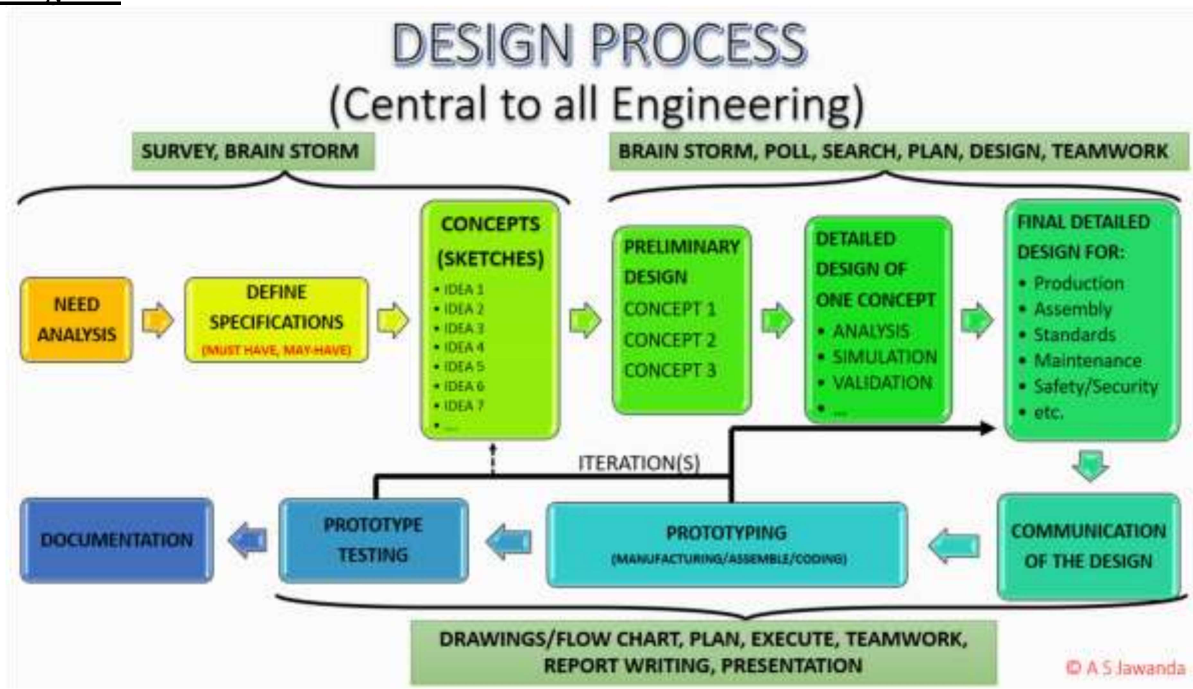


Mangonel



Aim: The objective of this course in this project is to bring together the various components of this course with a view to help you learn the **engineering design process** shown above to design, simulate and fabricate any engineered product. The design of a Precision Mangonel is used as an example to illustrate the steps involved and the implementation by a team of engineers. A 'Precision Mangonel' is designed and instrumented with the aim of firing a missile (ball) at a target which is detected by an electronic measuring circuit. The angle of launch of the missile is changed using a calibrated electro-mechanical targeting system. The velocity of launch of the missile is calibrated in the launching electro-mechanical system.

Theory: Related to the design of a Precision Mangonel, in the Electronics Laboratories you have successfully implemented, simulated and operated a micro-electronic system to allow you to measure as well as display the angular velocity of the arm. In the Mechanical Laboratories you have developed a discretized analytical model of trajectory dynamics and used this to generate a simulation tool to allow you study the influence of launch velocity, launch angle and drag on the flight path of the missile. In the Dynamics Laboratories, you have developed analytical skills in order to calculate the static and dynamic stresses in the Mangonel material so that the design remains safe when operated repeatedly. In addition, you have seen the assembly of a full Mangonel and videos of it from the point of view of performance.

Mangonel

The engineering challenge is to design electro-mechanical systems which will convert the existing structure of the Mangonel under constraints of not changing the design of the basic structure or its materials (to preserve the design connect to history) to make it perform as a Precision Mangonel. Specifically, you are also required to custom design the throwing arm and missile (ball) holder's shape and material so that the range at which a target can be hit is maximised. The torque provided by the skein can be maximised by modifying the number of loops, and without changing it's material. In conjunction with the accompanying lecture series, you should be in a position to instrument and calibrate the Mangonel with a view to make it into a Precision Mangonel.

UTA016: Final Group Project

The physical Model of the Mangonel at the campus is accessible to you. Morover, the videos shared with you during the course will help you in understanding the structure of the Mangonel and its working. At present, we should be able to demonstrate our understanding using redesign Mangonel components and simulations.

For this particular activity students in each subsection are required to form **groups of 6-7 students**.

Mechanical Competition: 10 marks

Your design team is required to demonstrate using any materials available to you easily available from nearby market or at home, for the fabrication of a 'Mangonel arm' which meets the requirements as follows. As our Mangonel is a scaled down model of a weapon (20 times smaller than the original weapon used by the romans), SAFETY is an important criterion which must be demonstrated for every step in real life described below.

1. Make/take an arm of any appropriate material and dimension with a receptor at one end to hold a ball (any soft material) steady before launch and launch it at an angle which is predictable for every launch. The design of the ball holder is also unrestricted but it must operate and connect securely with the arm.
2. Demonstrate the working of a torsion spring, like a skein is used on the actual Mangonel to store energy when in loaded position for launching the ball from the arm taken in the first step. Specifically, arm must receive its power from the Skein and be triggered.
3. Make a video to demonstrate the launch of the ball to hit a target repeatedly with precision which is engineered by controlling the velocity and angle of launch of the ball through the

calibration of the tightening of the skein and the design of the ball launching at a desired angle.

4. Show how your team tried different ideas for the above measurement and prediction of velocity and angle of launch. Show how the failures help in learning from the iterations to make the design better.
5. Your project team has to calculate physically the FOS (Factor of Safety) of the throwing arm materal you have used. Show an experimental determination of the strength of the material of the arm.

Rubrics and guidelines

- Attach the throwing arm with a receptor at one end to hold a ball (e.g. spoon, slingshot) steady before launch and launch it at an angle which is predictable for every launch. The design of the ball holder is also unrestricted, but it must operate and connect securely with the arm
- During the competition lab instructor will give 3 different ranges to each group. The first value will be from 5 meters to 20 meters in steps of 5 i.e. 5, 10, 15 and 20 meters. The remaining two values will be random between ranges 5 – 20 meters.
- Projectile will be a squash ball with 2 yellow dots. Same has been given in the workshop for yourpractice during the lab session.
- Each group must come prepared i.e. to achieve the above ranges what calibration they have to do in their Mangonel in terms of changing the launch angle and angular velocity of the throwing arm.
- An example for the marking scheme.

  Suppose a group is asked to through

  1m

  ✓ If projectile falls within 15 ± 0.5 m, group will be awarded 10 marks

  ✓ 14 to 14.5, 15.5 to 16 group will be awarded 8 marks

  ✓ 13.5 to 14, 16 to 16.5 group will be awarded 6 marks

Mechanical Viva & Poster (It can be from course or the design of Mangonel): 10 marks

Each group need to prepare an A3 poster (Hard copy need to be submitted during competition). This Poster will contain only mechanical part Following are some of the desirables that are needed in the mechanical component of the poster. However, this is not the limit one can find more suitable ideas/things to present on their poster according to their understandings and learning's during the course and design of the precision Mangonel.

Mangonel

- Show how your team tried different ideas for achieving precisely the above mentioned series of ranges. Show how the failures help in learning from the iterations to make the design better in terms of precision. Ideas can be in term of changing the receptor/ ball holder.
- What is the angle of launch and angular velocity required to achieve the above mentioned series of ranges.
- Develop/simulate any theoretical/simulation model to predict the angular velocity and angle of launch. Compare with the angular velocity and angle of launch shown by the electronic sensors placed on your Mangonel. If there is any error give suitable explanation.
- Prepare a model to show the nature of forces generated in various parts of the Mangonel during its working.

Electronics Evaluation: 20 Marks

(10 marks for Viva and 10 marks for project and poster presentation)

Each group is required to design and simulate a ***micro-electronic project for Precision Mangonel***, capable of

1. Evaluating angle of launch of ball by the Mangonel.
2. Initial Velocity of Launch of the ball, Calibration of the circuit already done in labs to measure the angular velocity of the throwing arm with the actual velocity of launch of the ball is expected now. Use the Mechanical rig made by your group above,
3. Measure the distance of the target to be hit by the ball (missile).
4. The distance from step 3 can be used to drive a motor which will position the Mangonel structure (given in PDF files) at an inclination to repeatedly launch the ball at the target at the angle evaluated in step 1. **Think** how to use the weight and location of CG of the Mangonel in triggered position given at the end of this document.

Mangonel

Poster Presentation: 5 marks

Each group is required to make a A3 size poster (hard copy to be submitted at the time of evaluation), for demonstrating the use of the engineering design process for the **implementation of precision-based data acquisition and automation** of the desired design of the Precision-Mangonel. ***The poster will only contain electronic part of the project.***

The following specific design aspects should be explored and demonstrated in the poster:

The processes of design, alternative selection, analytical and experimental testing is to be presented using text, pictures, graphs, diagrams etc. as you like. For example, while simulating the precision Mangonel, taking pictures of the working sketch of the micro-electronic project as well as of the coding section is required.

Viva-Voce: 10 marks

Your team should explore and be able to answer the following for the final design and viva-voce.

i. What factors will affect the precision of the Mangonel and how can you attain a greater **precision?**

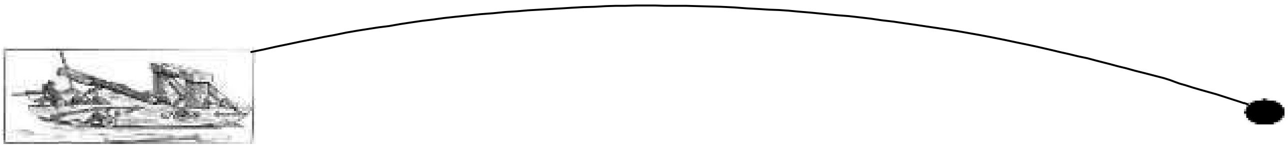
ii. Methods to obtain max. **precision** for given distance of throwing the ball (i.e., selection of suitable electronic components to design a Precision Mangonel)

iii. We have learnt that the velocity and launch angle are critical for precision in hitting a target. Hence, your redesign of the Mangonel as well as the design of micro-electronic project should seek to optimize these for precision. Accordingly, consideration should be given to methods to vary these parameters.

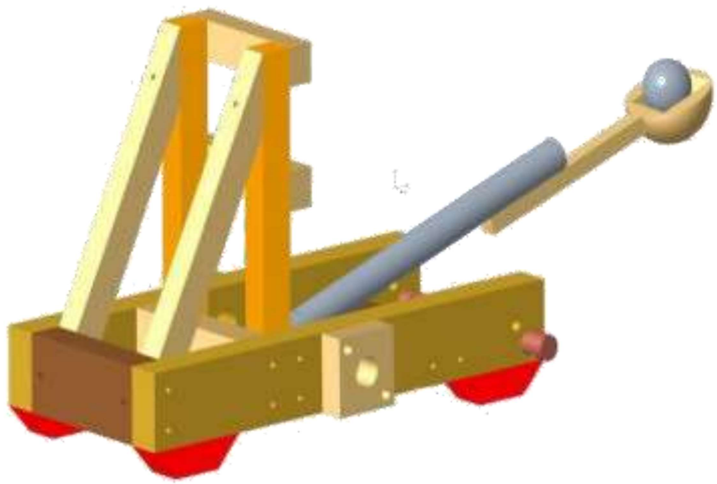
iv. Refer to the design given below. The detailed drawings of the parts are given in the file 'TheMightyRomanMangonel.pdf' the 3D PDF of the assembly is given in the file 'Mangonel_3D_Creo.pdf'.

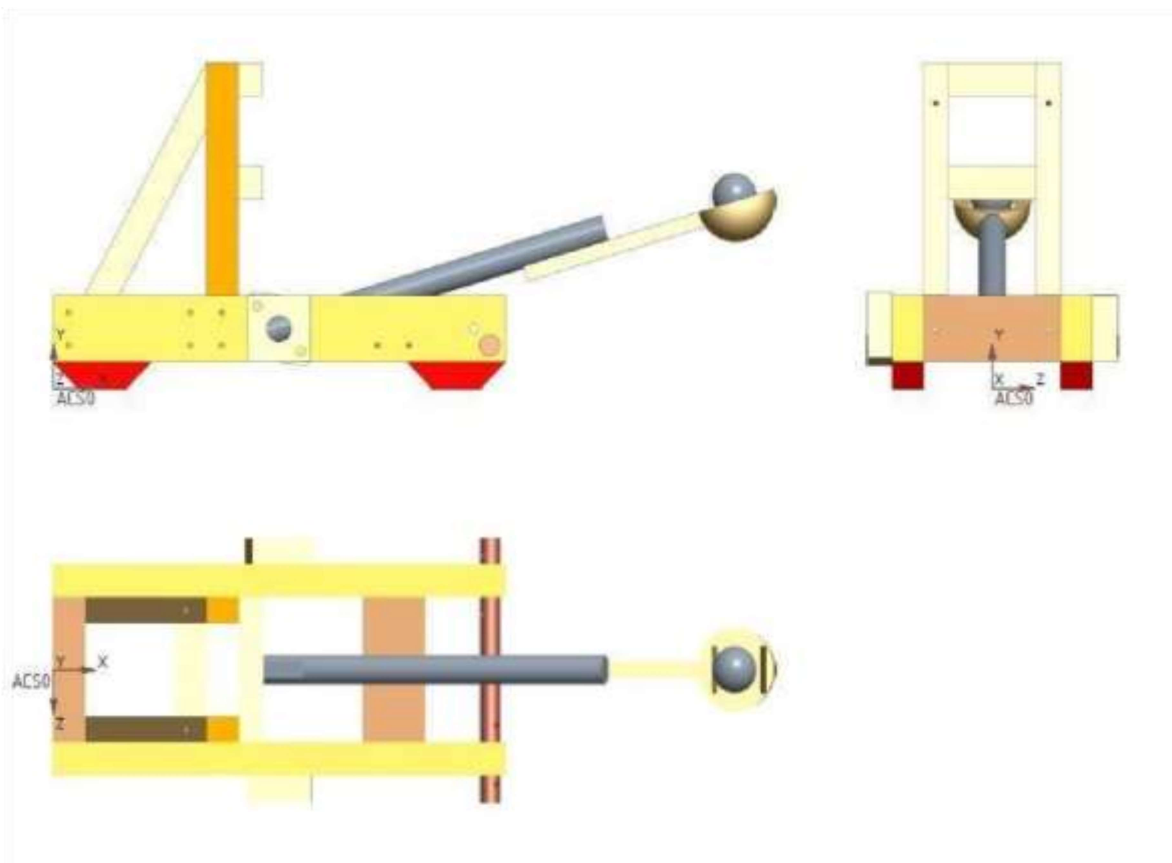
   a. If you need to automate the working of this Mangonel (automatic operation with control over the launch angle and velocity as per the requirement). Please suggest how you can do that.

   b. What kind of **sensors** are you going to use and **where you are going to place the same?**



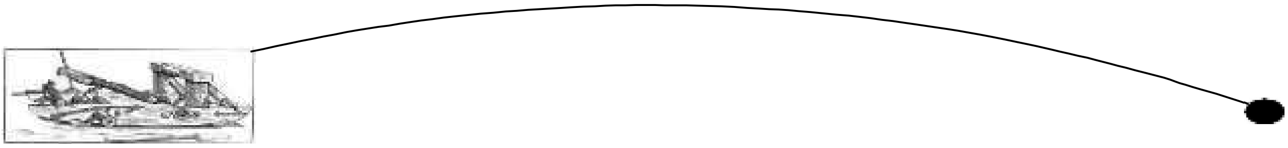
Mangonel





Location of CG from shown Coordinate system ACS0 is

X, Y, Z = 6.6594880e+02, 1.6273166e+02, 0.0000000e+00 in MM



Mangonel

Weight of the full assembly = 2.5 Kg.