Course code and name: OENG1205 Creative Engineering CAD

Assessment name: Group Project – Design a Counterweight Trebuchet.

Weighting: 20%

Length: Design Report 10 pages maximum (not counting title page, table of content, and appendix), Presentation Slides 12 slides maximum (not counting title slide, table of content, reference, and Q&A slide).

Due date: Design Report Saturday December 19th 2020 by 23:59. Presentation slide is due prior to the Presentation date.

Type: Group submission (one submission per group). Project Report + Presentation

Feedback mode: Directly to the student after the presentation + Written, on Canvas

Late work:

- Between one to three days late: a penalty of 10% (of total available marks) per working day.
- More than three days: a penalty of 100% will be applied.

Learning Objectives Assessed

The following objectives can be achieved upon successful completion of this assessment:

1. Integrate the role of graphic communication in the engineering design process;
2. Generate and interpret engineering technical drawings of parts and assemblies according to engineering design standards; and
3. Use CAD software to generate a computer model and technical drawing for a simple, well-defined part or assembly.

Ready for Life and Work

This assessment contributes to the following program learning outcomes:

1.6. Understanding of the scope, principles, norms, accountabilities, and bounds of contemporary engineering practice in the specific discipline.

2.2. Fluent application of engineering techniques, tools, and resources.

3.2. Effective oral and written communication in professional and lay domains.

Assessment Details

You are required to examine the design requirements for a simple mechanism and produce a set of designs to ensure the mechanisms will satisfy those design requirements.

Since ancient times from the moment a first walled settlement was built, a new kind of warfare was invented called siege warfare. Siege warfare is prevalent throughout antiquity and the Middle Ages and is characterized by its prevalent use of different Siege Engines. The most famous siege engine is the Catapult which is a device capable of throwing large rocks (or similar projectile) over long distances with the intention of knocking down structures and fortifications.

Among the different types of Catapults, the most famous one is the Trebuchet which has longer throwing arms, and thus capable of throwing object further. There are 2 main types of Trebuchet: the ancient Traction Trebuchet and the more advance Counterweight Trebuchet. Traction Trebuchets rely on manpower to generate the torque necessary to throw the projectile whereas Counterweight Trebuchets take advantage of gravity and a counterweight to generate the throwing energy. Illustrations of both types of Trebuchet is given below:

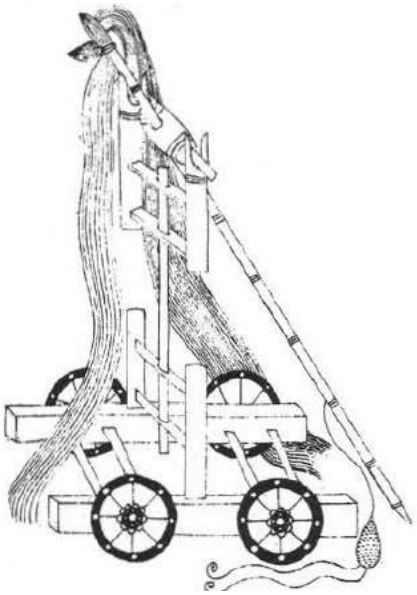


Figure 1: Chinese Traction Trebuchet (Wujing Zongyao)

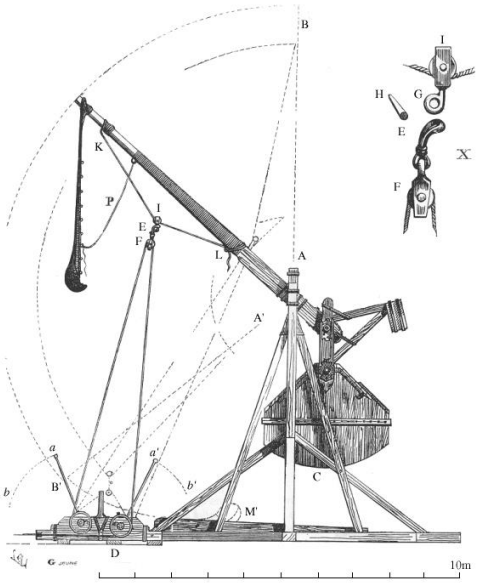
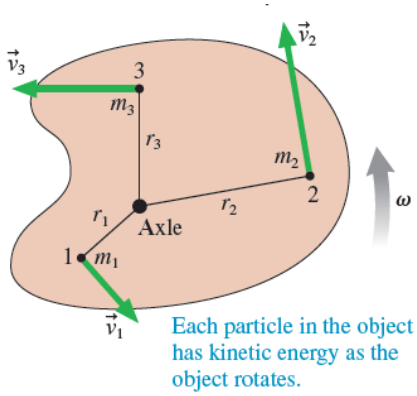


Figure 2: European Counterweight Trebuchet

When the object is in rotational motion, it carries a certain amount of Kinetic Energy called Rotational kinetic energy, which is given by the formula:

$$K_r = \frac{1}{2} I \omega^2$$



Each particle in the object has kinetic energy as the object rotates.

Where:

$I =$ the Moments of Inertia of the Object (kg.m^2)

$\omega =$ the angular speed of the object (rad/s)

The Moment of Inertia I of an object is defined to be:

$$I = \sum_i m_i r_i^2 = m_1 r_1^2 + m_2 r_2^2 + m_3 r_3^2 + \cdots$$

Where:

$m_i =$ the mass of the particle located at distance r_i away from the center of rotation (kg)

$r_i =$ the distance from the particle to the center of rotation (meter)

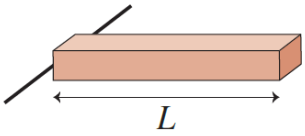
Normally, the value of I is determined experimentally or using a simulating software like Solidworks. For the special cases of a long thin rod, rotated about one of its ends, the value of I is given by the formula:

$$I = \frac{1}{3} m L^2$$

Where:

$m =$ the mass of the rod.

$L =$ the length of the rod.



Your team had been transported to Xiangyang, modern day Hubei province in China, and the year is 1267. The historic battle of Xiangyang has just begun and your team had ended up in the camps of the Mongol Empire. Historical records indicate that the Mongol army utilized a large number of counterweight trebuchets in this battle which were vital for their capture of Xiangyang in March 14th 1273. This eventually led to the collapse of the Song Empire and the rise of the Yuan dynasty in China. History says that the Mongol army used the trebuchet design brought from the Middle East by siege engineers from Persia. However, in our (fictional) version, these

engineers sought help from a group of time travelers who had accessed to modern day Internet and RMIT Advanced Manufacturing Workshop. Your team has an appointment with Kublai Khan in about 4-weeks time. Let's assume he has a European translator who understands modern day English. Kublai Khan expects a design for a model counterweight trebuchet with the following specifications:

1. The Trebuchet should be able to loft a spherical projectile with diameter up to 45 mm and weight 2.7 grams (e.g. a ping pong ball) over a distance of at least 5 meters.
2. The Trebuchet shall be able to utilize at least 2 PASCO hooked mass, each weight up to 500 grams, as counterweight.
3. The Trebuchet shall permit aiming, which means it should be able to be adjusted for firing at different ranges and angles.
4. The Trebuchet should not have more than 12 parts.
5. Each part should be able to fit into a 15 x 15 x 15 cm box.
6. Each part should bear the name of your group and a designation particular to the design assembly.
7. Four parts at most will be 3D printed using RMIT 3D printer with Tough Material.
8. The remaining parts should be fabricated using the Laser Cutter in RMIT SGS Advanced Manufacturing Workshop. This means the parts should have constant thicknesses of either 3 mm, 5 mm, or 10 mm and be made from Acrylic materials.
9. The parts of the Trebuchet can be assembled with threaded fasteners, glues, or other means. The fasteners shall not be counted toward the part number limit.
10. The Trebuchet will be stationary.
11. The Trebuchet firing mechanism should be safe to the user, which means the user should be able to fire it without getting in the way of moving parts to avoid the risk of injury.

References

The following websites may prove useful to help you get started on the design process:

1. Virtual Trebuchet Simulator: The website allows you to test the theoretical range of your trebuchet as a function of different parameter such as the length of the trebuchet's throwing arm, the sling, the height of pivot point, etc.
2. Ingenious Machines: the website has a basic model with illustrations for a simple trebuchet. It also explains the physics behind the trebuchet for your understanding.
3. Real World Physics Problems: the website is an alternative to No. 2 above. This one discusses the physics theory behind trebuchets in greater details.

Requirements

1. From the details provided in "Assessment Details", perform the calculations and sizing necessary to produce a set of drawings for the Trebuchet and its key components. The drawings, calculations, and descriptions shall be captured using the Design Report Template (download link). Submission Deadline for the Design Report is Saturday, December 19th by 23:59 Pm.
2. Prepare a PowerPoint Presentation to present your design to the class. The PowerPoint Presentation should be no more than 12 slides in length (not including the title slide, reference slide, and Q&A slide).
3. Deliver a Presentation on your design in the Tutorial Session of Week 8. All presentations will be done in groups and everyone need to present a component of the design.
4. The Design Report should have high level of details with SMART (Specific, Measurable, Achievable, Relevant, Time-based) descriptions.
5. All sections within the report must be fulfilled. In case it cannot be filled, note the reason why. Make sure you discuss the reason with the Lecturer beforehand, otherwise you may lose point to that portion.
6. Your final design part files (.stl for 3D printing and .dxf for laser cutting) will be submitted for fabrication immediately after the presentation, if the design is deemed adequate. If there is any problem with the design, you will need to modify your design and resubmit within 1 week. Fabrication is carried out on a first-come-first-serve basic so you may need to wait a long time to receive your model if you submit your design late. This may negatively impact your schedule for the 2nd half of the project.
7. All submitted designs and works must be original. If plagiarism is detected, penalties and disciplinary actions will apply per RMIT Code of Conduct.

Submission instructions

Export your Design Report and Presentation Slides as pdf files and submit on the Assignment Canvas page. You may re-submit your files as many times as you want but only the final submission will be evaluated.

Your 3D printing files should be in .stl format and your Laser Cutting files should be in .dxf format, ready for transfer to the Lecturer's USB on Presentation day.