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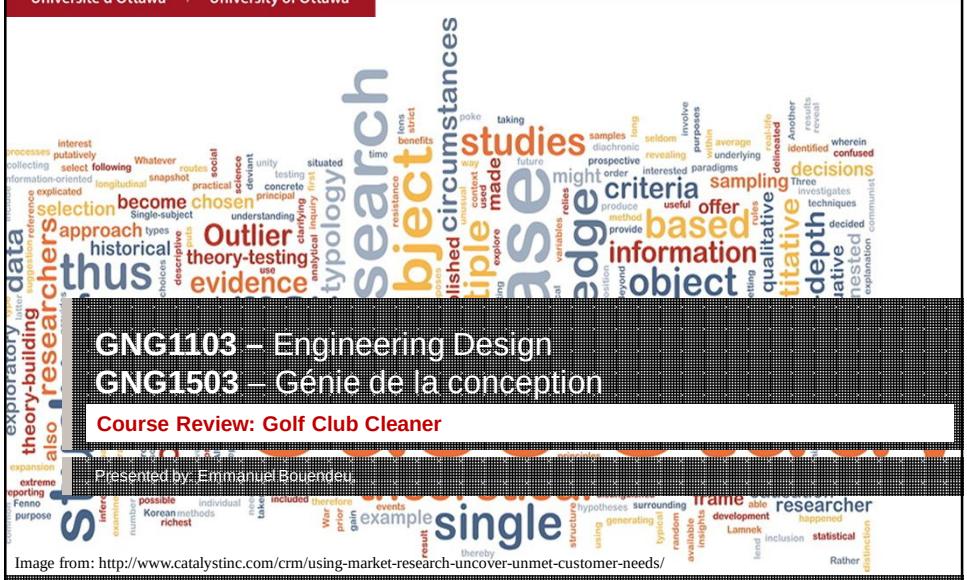

GNG1103 – Engineering Design
GNG1503 – Génie de la conception

Course Review: Golf Club Cleaner

Presented by: Emmanuel Bouendeu

Image from: http://www.catalystinc.com/crm/using-market-research-uncover-unmet-customer-needs/

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Agenda

- Quiz 4
- Reminders
- **Course Review:** Golf Club Cleaner
  - Activity 1: Needs Interpretation
  - Activity 2: Translating Interpreted Needs to Design Criteria
  - Activity 3: Benchmarking
  - Activity 4: Conceptualization
  - Activity 5: Design Analysis
  - Activity 6: Test Plan & FMEA
- Course Evaluation

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Reminders

- **Lab 10** (Project work): This week
- **Project Plan** (Week 4,6,8,**10**): Weekly revue
- **Deliverable H** (Prototype 3 + Feedback): 29 March
- **Course Evaluation**: March 23
- **Deliverable I** (Design Day materials + 3-minute video pitch.): Canceled
- **Deliverable J** (Submission of final presentation): 29 March
- Final Peer Feedback & Team Dynamics: 05 April
- **Deliverable K** (User Manual): 05 April
- **Final Exam**: 21 April, 9:30 a.m. to 12:30 p.m. (Online)

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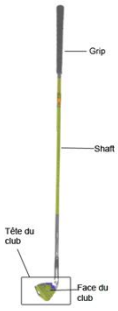
Golf Club Cleaner: Introduction

- With a durty club:
  - The golf ball will be oriented differently because of a slight accumulation of dirt on the club.
  - You want to spin and stop the golf ball on the grass but you have grooves filled with dirt on your woods, putters or wedges.
    - ➢ The ball will not spin because there are no clean grooves to grab and spin the ball.




Fers


Fers droits (Putters)


Bois


Wedges/*coins*


Groove/Rainures

https://youtu.be/jWcK15edOks

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Who are the Users and Customers?

- End user
  - Golfer
  - Golf Pro
  - Groundskeeper (Maintenance)
    - Refresh solvent
    - Repair mechanism/brushes
    - End of season
- Client
  - Golf club owner
  - Groundskeeper (Purchaser)

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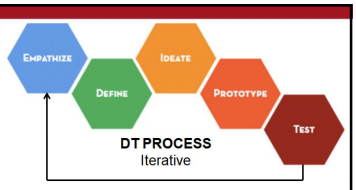
Design Thinking



- **Empathize**
  - "Beginners mindset", "Digging deeper"
- **Define**
  - Problem statement: short, specific and sexy
- **Ideate**
  - Lots of ideas, sketch, iterate based on user feedback
- **Prototype**
  - Different kinds of prototypes used at different stages in the design process and for different purposes
- **Test**
  - Iterate quickly and effectively

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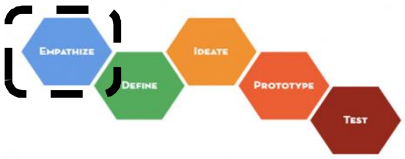
What is Empathize?



Customer empathy *or more classically called* ***customer need identification*** *is the process of determining* ***what and how*** *a user interacts with a product.*

User needs are ***non-technical****, and they reflect the users' perception of the product,* ***NOT*** *the actual design specifications.*

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Group Activity 1: Needs (6 min)

- Divide yourselves into groups of 3-5 people
- From the video and reading of the case study, interpret the customer and user needs
- Organize and prioritize

How Do We Identify Customer Needs?

1. Gather raw data from customers
2. Interpret the data in terms of customer needs
3. Organize the needs
4. Establish relative importance of needs
5. Reflect on the results

Customer need identification

Customer Statement	Interpreted Need
Dirt gets into grooves of golf club	Golf cleaner can clean the golf club including the grooves
Simple current solution takes time	Golf cleaner can clean grooves fast
$500-$1000 each, up to 10 per course	Golf cleaner is low in cost (both initial and maintenance)
Existing solutions act and look like garbage can	Golf cleaner is easy to use and looks good
Majority of courses do not have golf club cleaners	Golf cleaner can be manufactured in volume
Cleaners useful for par-3 holes	Golf cleaner is reliable and easy to maintain

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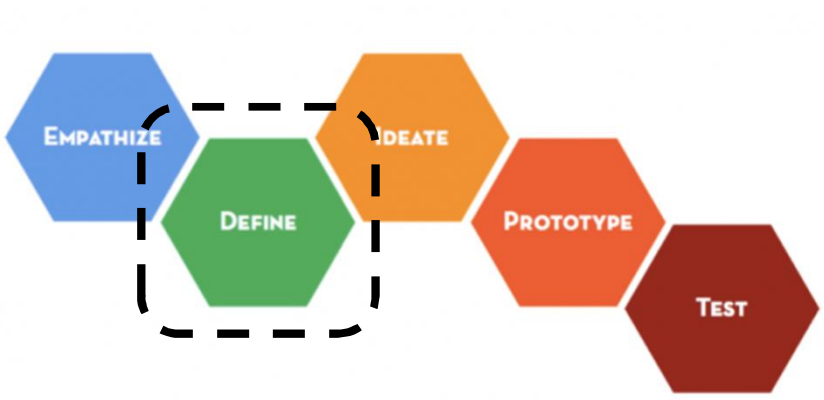
What are we Defining?



Based on the customer needs, we need a problem definition
AND we also need to define the design specifications

Image from: http://dschool.stanford.edu

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What is a Problem Definition?

*A **problem definition** is a claim of one or two sentences in length that outlines the problem that will be addressed by the design process based on the customer needs. It must be precise, concise and attractive*

It answers the question: What? Who? Scope of the final solution

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Problem Definition

"Clean club face, including grooves, easily by the golfer using water and at minimum cost and effort to the owner/groundskeeper"

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What are Design Criteria?

- A precise description of what the product has to be based on interpreted needs, also called:
  - "Requirements"
  - "Characteristics"
- Functional Requirements**:** Are design criteria that affect the solutions "function" (if measurable, then also a metric)
- Non-Functional Requirements**:** Are design criteria that do not affect the "function" of the solution
- Constraints: Set of important considerations that must be taken into account in your design

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Design Constraints

- **Water:** The device needs to use water in the cleaning processes
  - **Rationale:** Cleaning the club face with a dry brush will not remove grass stains from the face and dirt from the grooves. The water loosens the bond between the dirt particles and the club face.
- **Time:** The cleaning process needs to take a maximum time of 5 seconds
  - **Rationale:** This time was chosen based on the length of time it takes to clean a golf ball using the cleaners that exist. Golf is a sport that puts a lot of emphasis on 'pace of play' and so it is essential that the golf club cleaner doesn't hinder the golfing groups ability to keep up with the group in front of them.

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Design Constraints

- **Club Damage:** No damage can be made to the club while in the device
  - **Rationale:** Golf clubs can be very expensive. Damage to the shaft or face could cause a decrease in the clubs performance level. No golf course wants to take the risk of being liable for such damage.
- **Left-handed Clubs:** The device needs to work for both right and left handed clubs
  - **Rationale:** In order to take full advantage of the available market the device needs to work for all irons regardless of whether the golfer is right handed or left handed.

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Group activity 2: Translate Needs into Design Criteria (10 min)

- Divide yourselves into groups of 3-5 people
- Determine design criteria based on the interpreted needs and develop target specifications
- Think of your design constraints!

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Translating Needs into Design Criteria

#	Need	Design Criteria and target specifications
1	Golf cleaner can clean the golf club including the grooves	
2	Golf cleaner can clean grooves fast	
3	Golf cleaner is low in cost	
4	Golf cleaner looks good	
5	Ease of use	
6	Golf cleaner is reliable and easy to maintain	

Translating Needs into Design Criteria

#	Need	Design Criteria
1	Golf cleaner can clean the golf club including the grooves	Effective at removing dirt (%)
2	Golf cleaner can clean grooves fast	Efficiency (s)
3	Golf cleaner is low in cost	Total Cost is low ($)
4	Golf cleaner looks good	Aesthetically pleasing
5	Ease of use	Effort to activate (N)
6	Golf cleaner is reliable and easy to maintain	In operation (%)

Translating Design Criteria Into Target Specs

#	Need	Design Criteria and target specifications
1	Golf cleaner can clean the golf club including the grooves	Effective (min. residual dirt < 5% of the initial dirt)
2	Golf cleaner can clean grooves fast	Efficiency (the club face should be cleaned < 5s)
3	Golf cleaner is low in cost	Total Cost is low < $1000
4	Golf cleaner looks good	Aesthetically pleasing
5	Ease of use	Effort to activate < 100N
6	Golf cleaner is reliable and easy to maintain	In operation > 99% of time

Design Criteria (Case Study)

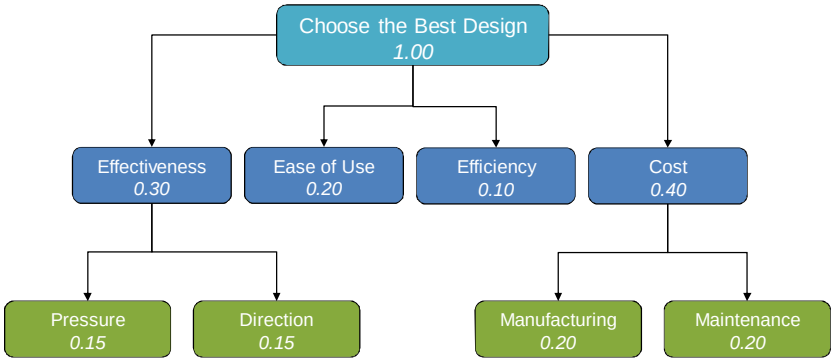

Figure 1: Criteria tree showing the percentage weighting and sub-criteria breakdown

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Benchmarking

- Two kinds of benchmarking data:
  - Benchmarking competitive products in terms of customers' perceptions
  - Benchmarking competitive products in terms of technical performance
- To create a competitively superior product, the team must know what the competition can do
- There are opportunities to learn specific design approaches by observing competitors' products

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Group Activity 3: Benchmarking Exercise (6 min)

In your same groups, go through one of these products and do some benchmarking

- Brush:
  http://www.brookstone.com/pd/groove-doctor-retractable-golf-club-groove-cleaner/876327p.html
- Club clean:
- http://www.mygolfproshop.com/golf-accessories_club_clean.htm
- Club Washer:
  http://www.kirbybuilt.com/golf-15-round-club-washer
- Ultrasonic Golf Club cleaner:
  http://www.sharpertek.com/ulgoclcl1.html

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Comparing Different Concepts

	Brush	Club clean	Club washer	Ultrasonic
Pressure	High	Push between two brushes	Push between two brushes but with a spring	N/A
Manufacturing cost	Excellent	Medium	Medium	Unacceptable
Ease of use	Excellent	Excellent	Excellent	Excellent
Efficiency	Unacceptable	Two linear brushes	Two linear brushes	Excellent

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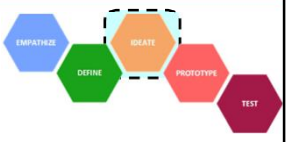
Conceptual Design and Ideation



- Ideation is a ***divergent*** process
  - Creative one too!
  - Sketching and different types of sketches
  - Block diagrams (Basic "control loop" block diagram example)
- Brainstorming
  - Individual process ("crazy" ideas OK; suspend own self-judgement)
  - cross-stimulation to 'amplify' ideas and make more divergent,
  - suspend judgement, as a team
  - formal setting and organization important (e.g. chairman role)

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Group Activity 4: Developing Conceptual Design (10min)

- In your groups develop a conceptual design for the cleaning brush assuming top loading

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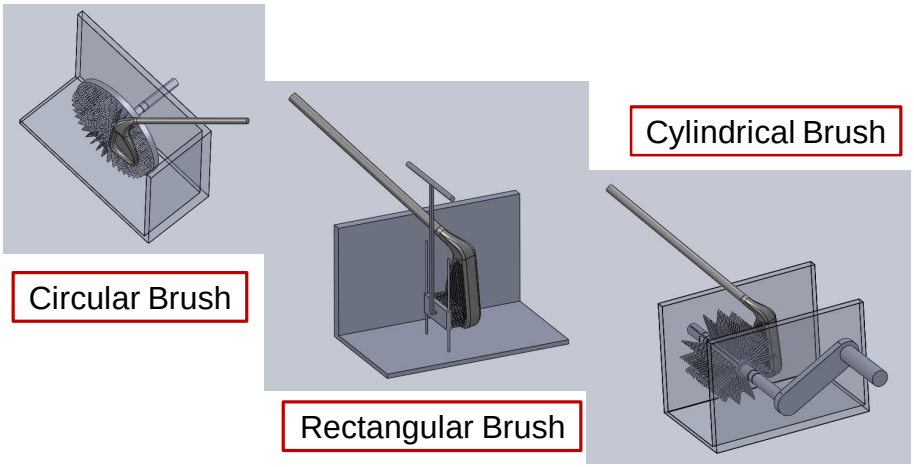
Conceptual Design



Circular Brush

Rectangular Brush

Cylindrical Brush

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Engineering Design Analysis

- Scientific principles and analysis techniques
  - ⇨ Predict and prevent failures
- General Process:
  1. Determine list of components/materials to meet target specifications (use available or commonly-used components to save cost or use new material for strategic reasons)
  2. Use values of properties (metrics) to calculate specific values
  3. Compare with target specifications… and repeat steps 1-3
- Use prototypes (different *types* of these!)
- Use *existing knowledge*, but identify and fill "gaps"

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Group Activity 5 : Engineering Analysis (10 min)

- In your groups, find the most efficient brush shape and size. Assume the maximum club face size to be 80 mm (width) X 60 mm (Height) and the number of strokes for the club to be clean is 30 strokes (based on testing)

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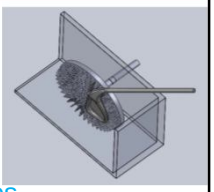
Engineering Analysis

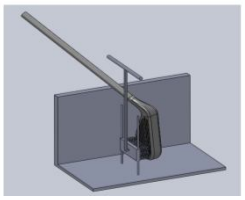


- Maximum club size: 80 mm X 60 mm
- Number of strokes till it gets clean = 30 (15X2) strokes
- Total Cleaning Distance (TCD)= 30 strokes X 80 mm = 2400 mm
- **Circular brush ($60)**:
  - Radius = 90 mm (> 80 mm which is the biggest club dimension
  - Brush circumference (C) = 90 mm X 2 π
  - Since brushes don't rotate parallel to the grooves, dirt removal is impaired (assume a correction factor of 1.5 to account for this)

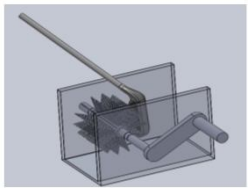
$$No.\,of\ Rotations = \frac{1.5 * TDC}{C} = \frac{1.5 * 2400\ mm}{565.5\ mm} = 6.4\ rotations$$

Engineering Analysis (cont.)

- **Rectangular brush ($10):** width needs to be wider than the height of the club face and minimum height of approximately ¼ of the club face width. So dimension is 70 mm X 20 mm,
  - Hand slider=30/2=15 pumps



- **Cylindrical brush ($300):**
  - Dimensions (LXD): 70 mm X 90 mm



$$\text{Cleaning Distance} = \pi * D = 282.7 \text{ mm}$$

Therefore,

$$\text{No. of Rotations} = \frac{2400 \text{ mm}}{282.7 \text{ mm}} = 8.5 \text{ rotations}$$

Comparing Different Concepts

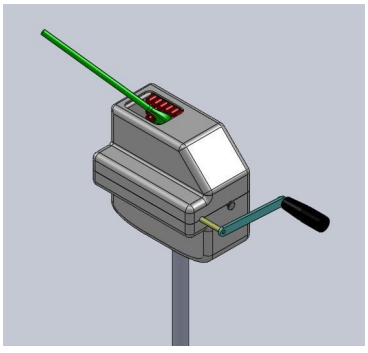
	Circular	Rectangular	Cylindrical	Comments
Pressure	Excellent	Excellent	Good	Circular and rectangular brushes allow the club face to be flat against the brush bristles during cleaning. This provides uniform pressure in the centre of club face
Direction	Very good	Excellent	Excellent	Rectangular and cylindrical brushes clean by aligning bristles with groves of club
Manufacturing cost	Very good	Excellent	Unsatisfactory	Cylindrical is very expensive while rectangular is cheapest
Maintenance cost	Excellent	Good	Good	All designs have same moving part but the brush on the rectangular will be replaced the most
Ease of use	Excellent	Good	Excellent	Based on ergonomics, cylindrical and circular are easier to use
Efficiency	Excellent	Satisfactory	Very good	The circular brush will get cleaned the fasted and rectangular will take longest

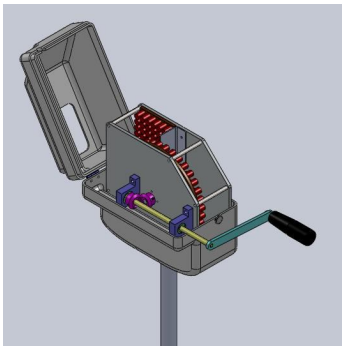
Decision Matrix

Table 3: Decision Making Matrix for Final Design

		Circular		Rectangular		Cylindrical	
Criteria	Criteria Weighting	Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
Pressure	0.15	5	0.75	5	0.75	3	0.45
Direction	0.15	4	0.6	5	0.75	5	0.75
Manufacturing cost	0.2	4	0.8	5	1	1	0.2
Maintenance cost	0.2	3	0.6	3	0.6	3	0.6
Ease of use	0.2	5	1	3	0.6	5	1
Efficiency	0.1	5	0.5	2	0.2	4	0.4
Totals			4.25		3.9		3.4

Final Design





Final Design
Estimated Manufacturing Cost: $520

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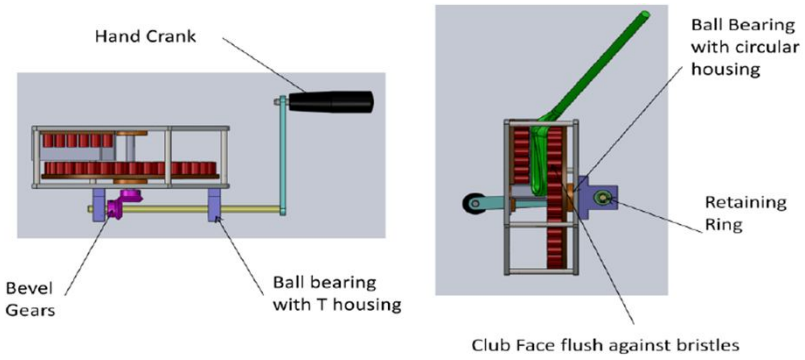
Final Design



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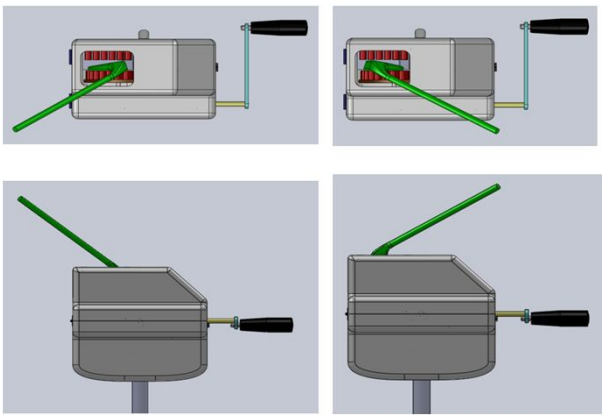
Final Design

Right-handed Left-handed



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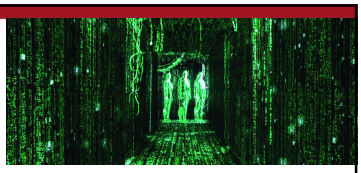
Modeling



- Modeling refers to using physical or mathematical prototypes to simulate and analyse systems, entities, phenomenon or processes
- Modeling can help:
  - Reduce costs
  - Increase the quality of products and systems
  - Document and archive lessons learned
- When modeling, it is important to understand:
  - Assumptions
  - Concepts
  - Constraints

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Group activity 6: Creating a Test Plan (10 min)

- Determine a risky or critical aspect of the **golf- club cleaner** that you think you need to model in order to gain a better understanding
- In the section "**What** is going on and **how** is it being done?", make sure you describe what kind of model you should use, how you will use it and why its the best choice!

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Testing: Pressure Required for Effective Cleaning

- Commercial club cleaning tool with a small rectangular brush was used for testing
- Brush was loaded with different weights.
- Mass needed was 800 g
- The design consists of carbon steel shaft of 8 mm in diameter
- The yield strength is 530 MPa

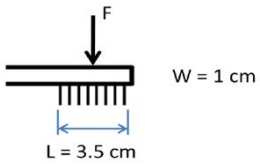

Figure 6: Pressure Test Apparatus

$$Applied\ Pressure\ (P) = \frac{F}{A_{TB}} = \frac{9.81 * 0.8}{3.5 * 10^{-4}} = 22422\ Pa = 22.4\ kPa$$

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Testing: Pressure Required for Effective Cleaning

$$N = PA_{FB} = 107.63N$$
$$F_f = \mu N = 0.7 \times 107.63N$$
$$T = F_f \times 0.09 = 6.78Nm$$
$$\sigma = \frac{Tc}{J} = 67.4\ MPa$$

$where\ J = \frac{\pi r^4}{2}\ and\ c = r = 0.004$

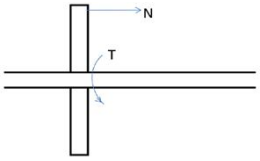

Figure 7: Shaft and brush with associated torque

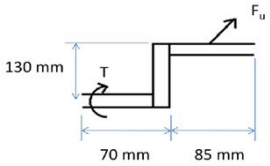

Figure 8: Shaft and crank connection

$$F_u = \frac{T}{0.13m} = 52.15\ N$$
$$\sigma = \frac{My}{I} = 52.15 \times \left(0.07 + \frac{0.085}{2}\right) \times \frac{1}{I} = 116.8\ MPa$$

$where\ I = \frac{\pi r^4}{4}$

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FMEA Analysis

- For each design component:
  1. Identify failure modes
  2. Determine the possible effects or consequences of the failure
  3. Assess potential severity of the effect
  4. Identify failure causes (and take action!)
  5. Estimate probability of occurrence
  6. Assess likelihood of failure detection

Image: https://sciencenotes.files.wordpress.com/2008/06/car-bike-crash-mexico-crop.jpg

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Course Evaluation

- Take **10 minutes** for the course evaluation on March 23
- Use your Laptop, Tablet or Smartphone
- Use this link: https://uottawa.ca/tces

Évaluez vos cours!

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1. Rendez vous sur https://uottawa.ca/tces.
2. Entrez votre nom d'usager et votre mot de passe uoZone, puis cliquez sur **Connexion**.
3. Choisissez le cours à évaluer.
4. Répondez aux questions et à la section « Commentaires »*, puis cliquez sur **Soumettre**.

* La section « Commentaires » a pour but de fournir au professeur des critiques constructives. Vos commentaires sont anonymes, le professeur ne les reçoit qu'après avoir remis les notes finales.

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2. Enter your uoZone username and password and click **Login**.
3. Select the course to be evaluated.
4. Answer the questions and complete the "Comments" section* and click **Submit**.

* In the "Comments" section, you can give constructive feedback. Your comments are anonymous, the professor receives these comments only after the final marks have been handed in.