University of Toronto
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APS112 & APS113
Final Design Specification (FDS)

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Project Title	Mass Staple Remover
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√ FDS (In one Google Docs file with "Final" in the title; keep identifying parts of the title)

- √ Cover Page with
- √ Disclaimer
- √ Executive Summary
- √ Project Requirements
- √ Detailed Design
- √ Updated Project Plan
- √ Conclusion
- √ Reference List
- √ Appendices

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Executive Summary
Professor Bazylak is in search of a design which can efficiently remove the industrial staples and use minimal resources. The design needs to meet ranges of requirements as well as consider the parties which are involved. Based on the five diverse designs, the best one is selected by the team due to its achievement in several conditions.

The Final Design gives pirority to efficiency and inexpensiveness that are regarded to be the preferences but also do well in durability. The use of lever in final design provides conveniently operation for the user as well as the magnet inside aims to collect the removed staples. Besides achieving the client's need, the final design also succeeds in other conditions including constraints. During design process, environmental impact, human factor and social facter have all been concerned to ensure design's satisfication. The team is prepared to supply a more oral description to the client for the coming final presentation.

1.0 Project Requirements

Teaching Stream Professor Bazylak is associated with University of Toronto[1]. The professor is currently seeking a solution to public bulletin boards made unusable by accumulated staples. As most current staple removers are ineffective when facing industrial staples[1], a new solution is required. In addition, the client requires a low-cost solution.The following sections list the relevant requirements,limits and factors that should be taken account into consideration.

1.1. Problem Statement

Public bulletin boards, as a popularly useful tool to display and spread information through the community, frequently become unusable when filled with staples[1][19]. In current market there is no specific product designed to remove staples from these boards, particularly for industrial staples[2][Appendix H**]**.The only existing products with similar function are those designed for normal staples on paper[3]. Though such staple removers may work, it is inefficient at removing larger industrial grade staples[1][4]. Another drawback of current products is that the material used for most existing staple remover material is difficult to recycle leading to increasing burden for environment[5].Thus, the current situation relects a deficiency in loosening industrial staple.

The client, Professor Bazylak,needs a new mass staple remover which can efficiently remove staples from public bulletin boards while retaining integrity of functions, collection of staples and optimal use of resources[1]. The requirement of this mass staple remover includes small impact on environment and reasonable economic budget[19].

1.2 Identification of Stakeholders

Stakeholders can have a direct impact on the design of the project . Table identifies different stakeholders, their social, environmental or economic interests, and how they influence the design process:

Table 01:Stakeholders

Stakeholders	Interests	Influence
Recycling Council of Ontario	Environmental-reduce and recycle the material [5]	-avoid materials wastes and use recyclable resources[OB]
Users' family	Social-offer safe operating for users[6]	-ensure no hazards for users[CON]
Phillip Capital Corporate Investment Company	Economic-value of the design product[7]	-minimize the material cost but maximize the value[OB] -maintain durability [OB]
Municipal Licensing and Standards of Toronto	Social-maintain substance of public message broads[8]	-prevent damage to bulletin broads[CON]

Note:[OB]=Objective [CON]=Constrains

1.3.0 Functions

Function outlines the technical requirements of the client about the product.

1.3.1 Functional Basis

-separate mass

1.3.2 Primary Functions

The design will

- remove staples

1.3.3 Secondary Functions

The design will

-collect removed staples

1.3.4 Unintended Functions

The design may

- remove posters or other paper sheets from the board

1.4 Objectives

Objectives measures the effectiveness of the product to satisfy the client's requirements.

Table 02: objectives and corresponding metrics

Objectives(The design should be)	Metric(s)
Efficient	a. possible to remove more than one staple each time[1] b. save time for collecting wastes[19]
Inexpensive	a. cost $5-25 [10] if for private use b. cost $30-40[11] if for public use
Durable	a. corrosion rate with 35 μm/y or less[12] b. tensile strength and yield strenth not less than standard values for corresponding material[13][14]
Portable	a. weigh less than current types(500 grams[16]) b. size not exceeding prototypes(dimension not larger than 10*5*10 inches[16])
Ergonomic	a. minimize frequency of bending necks,wrists or shoulders[17] b. minimize repetitive motions[18] c. automation[19]

1.5 Constraints

The following list outlines the absolute limits that the design must adhere to.

The design shall:
-cost less than $50 individually[10][11]
-impose no threat of injury[19]
-minimize environmental damage from waste[20]
-have a size not more than10*5*10 inches[16]
-not destroy surface of boards[19]

1.6.0 Service Environment

The mass staple remover is directly impacted by physical environment and living things as it operates indoor and outdoor. Toronto is chosen to be the first market for the design because it

has high amount of snowfall for almost half a year[22] and large rainfall in summer[21] which results in reaching summit of humidity that likely gets product or staples rusty. If the design withstands corrosion in Toronto, it can also be munufactured and successfully work in most of the other areas.

1.6.1 Physical Environment

Table 03: Toronto Environment - intersection of College St and McCaul St(Outdoor)

Amount of rainfall (in mm)	Ultimate high (in June):160mm Ultimate Low (in Feb):0mm[21][Appendix A] Total precipitation: 792.7mm[22]
Amount of snowfall	Greatest amount (in Feb): 38cm Lowest amount (May to Oct): 0cm Snow is persistent from December to March.[21][Appendix B] Annual range: 115.4mm[22]
Humidity	High:97% Low:14% [21][Appdendix C]
Wet days	145.5 numbers in annual avergae[22]

Table 04: Robarts Library of Univeristy of Toronto (Indoor)

Humidity	The humidity control system in Robarts Library is 50% or less [23].

1.6.2 Living Things

Table 05: Living Things in Toronto

Living Things	**Example**
Human	There are all range of people living here, including children, youths and elders [24][25]. The desgn should not cause any danger to the user or nearby people.
Pets	There are 80,000 licensed dogs and cats in Toronto [26]. There probably be pets walking in the area with the boards, such as schools or streets.

1.7 Client Ethics and Values

Jason Bazylak is a mechanical engineering professor who instrcuts programs related to engineering design and strategies at the University of Toronto. He has interest in assessment of educational methods and effectiveness of technology. As noticing the phenomenon that

many bulletin boards became unusable while filled with wasted staples,he expected to find a mass staple remover able to remove these staples more efficienctly than existing types.

2.0 Detailed Design

The proposed design is a staple remover & collecter. Staple remover & Collecter is a tool that is capable of loosening industrial graded staples on the boards as well as collect the removed staples in an efficient way[1]. This section will include:

- What the proposed design looks like and how it will work
- How Staple remover & Collector will meet the requirements of the client and Function, Objective and Constraint
- Objective Specifications of Staple remover & Collecter
- Detailed dimension of Staple remover & Collecter
- Model report

2.0.1 Final design - Staple remover & Collector.

The overview is shown in Appendix D. The final design is chosen because it is the optimal solution by comparison with others as it makes the combination of efficiency and durability. The design has less negative impact on the environment as it allows for reuse, recycle of materials use such as plastic and stainless steel[27][28]. This design uses the combination of lever's and magnetic materials' function. The form of the front part, the lever, allows removal of stables with less force[29]. Due to the lever, staples will be easily removed by hands.

The free staples slide into the groove because of the angled part of the lever and within a certain distance they will be attracted by a magnet. All the removed staples will be ultimately collected into the box. Inside the box body, there is a long box which is formed by two part, magnet box and collect box. The long box can be pulled out from the back for refreshing. Both of the magnet and staples in the collect box can be taken out from the long box as well.

2.0.2 Meeting Functions, Objectives, and Client Needs

The Mass Staple Remover & Collector achieves the primary function of removing staples. It meets the objectives through its effectiveness, durability, portability, etc. Finally, it not only meets the needs of the client by offering a way to effeciently remove and collect staples from bulletin boards, but also a solution to similar problems in other contexts, such as indoor message boards. Ultimately, the design offers an effective solution to Toronto outdoor bulletin boards currently made unusable by masses of accumulated staples. Table 06 describes in detail how the design meets these requirements.

Table 06: Meeting Objectives

Objective	Description
Efficient	This design is able to remove three staples pre operation and meanwhile collect removed staples. One unit can hold 429 collected staples. [Appendix D]
Durable	This design is made up in stainless steel and plastic. Stainless steel is for those parts that frequently be used. Its tensile strength of is 95 ksi and yield strength of stainless steel is 30 ksi.[30] And it is corrosion resistant. The magnet will remain magnetic indefinitely[31]
Ergonomic	The design applies lever principle to reduce the input force required to remove staples. [29] And there is a supporting point on the paw in order to help the operator to apply force. The drawer can be pulled out while it is filled with removed staples so time is saved.
Portable	The design has a total mass of 236.20g, which is less than current types [Appendix D][16]. The handle on the box is convenient and makes the design easy to be carried[Appendix D]
Inexpensive	The total material cost for one unit is 16.755$[Appendix D], which is much less than the expected value, which is 40$.

Removal of the staples will not pose a problem to Staple remover & Collecter because the lever part can save force and be more convenient. The magnet inside is able to attract the staples to be collect as soon as it is removed.

As Staple remover & Collecter is an easy-used product and it is designed not to be sharp, the user will not be hurt by the design.

Staple remover & Collecter is environmentally sensitive due to the use of recyclable materials. Though it still has negative effect on environment, the extent of the influence approaches to a lower point.

2.0.3 Detailed Dimension of Staple remover & Collecter

Lever to remove the staples:

- The lever, which is made of non-magnetic stainless steel, has length of 52mm. It can remove approximately three staples per operation.
- There is a fulcrum under the lever, located 29mm from the end, in order to increase the froce on staples.
- The lever is slant with an angle of 9 degree. to make the staples to be better collected.
- The lever will not deform until 500N is exerted and will not break until 1000N is exerted at one time[Appendix E]

Box to collect removed staples:

- The staple box has a dimension of 136mm*50mm*36mm and is made of plastic. It can contain approximately 429 removed staples[Appendix D].
- There is a plastic drawer inside the staple box in order to simply take out the removed staples.
- The magnet's dimensions are 36mm*46mm*17mm, and is located inside the staple box and next to the drawer[Appendix D]. However, it is separated from the drawer by a layer of plastic, so that the removed staples would not stick on the magnet.

See the overview of the design and detailed dimension(Figure 1&2).

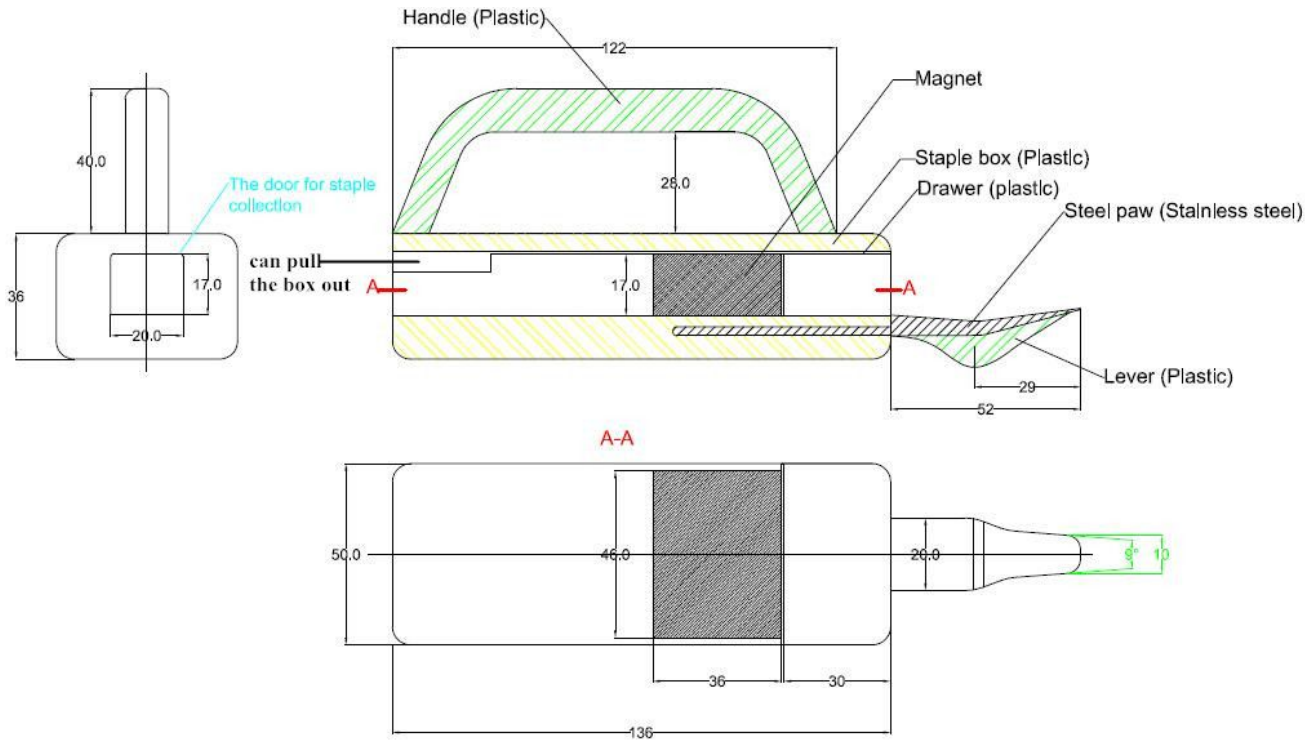

Figure 1: Staple Remover & Collecter. Overview of the picture from front, top and side.

***numbers in green color is 9° and 10mm. All other numbers are in mm.**

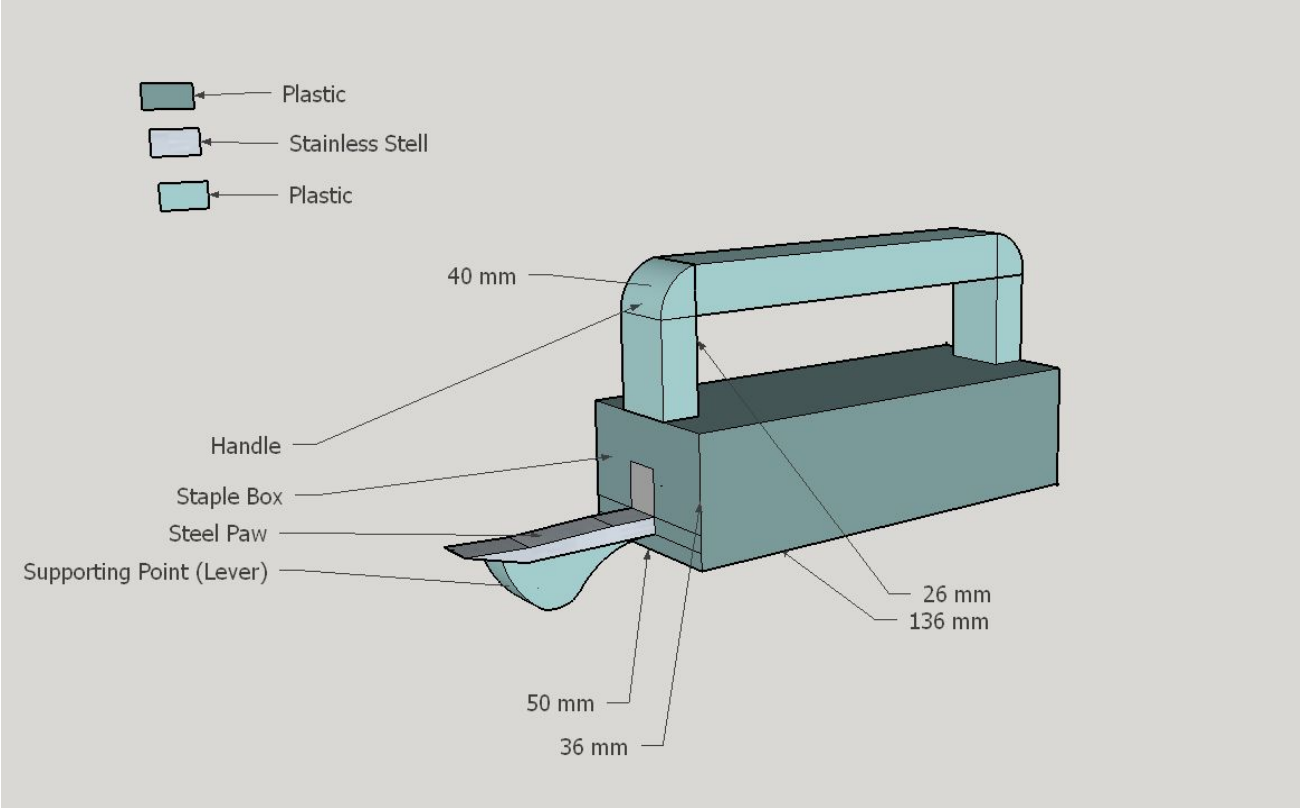

Figure 2: Staple Remover & Collecter. 3D overview of the design.

2.0.4 Final Deliverable

We will deliver detailed documentation to the client, including:

- accurate dimension and bending angles of the components
- brief description of the design
- tables describing how the design may satisfy client's requirements
- diagrams from various views
- calculation of cost, strength,weight and estimation of efficiency

2.1. Regulations, Standards, and Intellectual Property

The following table demonstrates the regulation and standards concerned with Staple remover.

Table 07: Standards or Regulations

Standards or Regulations	Description	Effect on design
Canada's Occupational Health and Safety[32] ● Reg: sec 12.1-12.6	Details standards for inspection and use barrier guards	Saftey laws must be enforced while using design

Canada's Occupational Health and Safety[32][33] ● Reg: Part 16, Mobile Equipment	Details standards for load limits that worker can hold	The staple remover must meet the mass and dimension requirements
OSHA Noise Standards ● Occupational Noise Exposure: 29 CFR 1910.95[34]	Details standards for generated sound by industial machines	The design must meet the sound range that is acceptable for both long term and short term use
Environmental management ● ISO 4001[35]	Details standards for enviromental and sustainability performance of devices	The design must meet all requirment while using it

2.2 Testing

The following table shows a plan to test the most critical objectives for the conceptual design.

Table 08: Tests and Results

Objectives	Tests	(Expected)Result
Efficient	ISO 18431-3:2014 Mechanical vibration and shock[36]	-take less time than manual removal [Appendix D]
Durable	ISO 10275:2007 Determination of tensile strain hardening exponent[37] ASTM D638 - 14 Standard Test Method for Tensile Properties of Plastics[38] ASTM E8 / E8M - Standard Test Methods for Tension Testing of Metallic Materials[39]	-yield strength of stainless steel is not less than 240 MPa, tensile strength not less than 400 Mpa [41][42] -tensile strength of HDPE is not less than 28 Mpa[43]

Ergonomic	ISO 11228-3:2007,Ergonomics -- Manual handling [40]	-risk factor is less than 50[44]

2.3. Implementation Requirements

The client :

-needs to order proper factory to manufacture this design

-needs to determine packaging requirements -

- the sharp metal paw requires more packaging
- should include an instruction paper inside

-should consider choices of stainless steel since it is iron-based alloy because austenitic stainless steels are not magnetic but ferritic ones are generally attracted by the magnet[45].

-may require extra bin or other containers

- the container can hold more staples than drawer of the staple remover so it saves time of disposing the removed staples
- may avoid cases that there is no rubbish bin nearby

2.4 Life Cycle and Environmental impact

2.4.1 LCA

The LCA contains major inputs and outputs in each stage of manufacturing, transportation and operation. Our proposed design is made from heavy duty plastic, HDPE, stainless steel and magnet. A combination of these materials is expected to cost mechanical and heat energy while producing residuals. However all these materials require production from further corresponding raw materials which produces more wastes than simple evaluation of staple remover. In addition, transportation is another cause of pollution by exhausts from veichles. Luckily, at the end of use, both the staple remover and removed staples can be recycled to save cost and energy[Appendix I].

2.4.2 Positive environmental impact

Table 09: Positive environmental impact

Process	Description	How design increases impact
Recycle staple remover	Recycling saves resources and reduce accumulation of residuals[46]	-raw materials involved are recyclable

Collect removed staples	Steel has high sustainability[47]	-magnet avoids scattering of staples

2.4.3 Negative environmental impact

Table 10: Negative environmental impact

Process	Description	How design decreases impact
Manufacture plastic	Plastic decompose poisonous substance to induce pollution to soil and water[48]	-both plastic are recyclable
Manufacture stainless steel	Combustion of fossil fuel for 1 ton of steel produces 2 tons of carbon dioxide[49] -raw material metals come from mining	-steel is recyclable
Manufacture staple remover	Industrial residuals and polluted water	-durability reduces mass-manufacture
Transport staple remover	Emission of nitrogen oxides from exhaust is cause of acid rain[50]	-small size reduces number of transports

2.5 Human Factors

Interaction of design with people

- Design is easy for people to operate
  --Design uses lever and fulcrum to reduce required force from users[29]
  --Design uses magnet to collect free staples for users
  --Design contains drawers for magnet and collected staples, which can be easily taken out
- Design is portable for people
  --Weight of design is easy for users to carry, according to anthropometric data.[51][Appendix D]
  --Dimension of design is not large[Appendix D][16]
  --Design contains a handle for users to carry

User experience and how design interact with people is considered by using a user story and a snapshot.

User Story:

As a user, I do not want to use so much force just for removing staples and I do not want many repeat actions during that process. It is better if I do not have to collect staples by myself. I want the device to be easily carried, have a simple way to use it.

Snapshot：

Table 11: Snapshot

Snapshot	Actor	Technology Being Designed
User uses staple remover to remove staples from bulletin boards	User	Staple remover
Staple collector collects removed staples	Removed staples	Staple collector
Staple taken out removes collected staples from Staple collector	Collected staples	Staple taken out

This is a universal design. Strong people can use this design as well as weak people because it does not require much force to use[29] and carry[Appendix D]. High-educated people know how to use it as well as poor-educated people because it has a simple way to use and some obvious intuitive. In addition, it fits both indoor and outdoor.

2.6. Social Impact

Social impacts of our proposed design include businesses and psychological aspects in terms of stakeholders (see Table 12). Additionally, priority of balancing stakeholders is determined according to constraints and objectives.

Table 12 : Social Impact

Affected Stakeholders	Social Impact	Balancing Stakeholders
Recycling Council of Ontario	More recyclable project --Design uses recyclable material thus can be recycled[27][28] --Collected staples can be recycled[52]	Design meets requirement from Recycling Council of Ontario to be recyclable but results in higher price.[Appendix D]
Users' family	No safe concerns for users	Design satisfies safe issues

	--Design uses magnet to collect free staples preventing from hurting users No health problems caused by design --Design uses lever to lessen force required from users[29]	but results higher price.[Appendix D]
Phillip Capital Corporate Investment Company	Minimize cost --Design uses the cheapest material which meet all other requirement[Appendix D][16][30]	Based on fulfilling other concerns, design meets economic goal from Phillip Capital Corporate Investment Company's concern.[10][11]
Municipal Licensing and Standards of Toronto	No social impact	Design meets requirement of Municipal Licensing and Standards of Toronto (causes no harm on bulletin boards) without much effect on other concerns.

2.7. Economics

The following table shows various types of cost, captital costs, fixed operating costs and variable operating costs during three processes of the design. (All costs are in Canadian Dollars.)

Table 13: Economics during design process

Capital Cost	
Material	**Dollar (per design)**
Stainless steel for lever	$0.00498[Appendix D]
Magnet for collecting part	$12.75[53][Appendix D]
Plastic use	$4[54][Appendix D]

Fixed Operating Cost	
Labour	**Dollar**
Manufacturing	$32.63/hour [55]
Driver for transporting the design from the factory to the user	$4.10[56]
Variable Operating Cost	
External	**Dollar**
Noise pollution when manufacturing	**N/A**
Exist possibility for hurting worker	**N/A**

Table14: Economics for use process

Capital Cost	
Material	**Dollar**
NONE	**N/A**
Fixed Operating Cost	
Labour	**Dollar**
NONE ***unless the client employ someone to clean the board for him**	***$11.25/hour[57]
Variable Operating Cost	
External	**Dollar**
The board maintenance if the user causes damage to the board	$17.00/hour[58]

Table 15:Economics for disposal process

Capital Cost	
Materials	**Dollar**
Recycle of plastic box	$1.5 billion annual[59]
Fixed Operating Cost	
Labour	**Dollar**
Employee who collect the used material	$15.00/hour[60]

Employee who remelts plastic[27] or stainless steel[28] for reuse	$34.97/hour for average[61]
Variable Operating Cost	
External	**Dollar**
Environment maintenance when pollution is caused during remanufacturing	$17.00/hour[58]

2.7.1. Market Issues

As this is a universal design, it has a broad boundary of market. The consumer group of this design includes normal families, schools and companies. Besides, government is also a intended consumer of this design. For example, outdoor public bulletin boards, that supervised by the City of Toronto, are filled with useless staples. Therefore, this design, as a useful tool in dealing with staple problems, could become a object of investment of City of Toronto public servise system.

The main competitor of our design are those current-existing common staple removers produced by all kinds of different companies. Those prototypes are faimilar to customers and they are very similar to each other. For example, most of the existing staple removers can only remove one staple once and mainly focus on staples on paper. However, what makes our design different from thoes existing staple removers is that our design can praise better efficiency and ergonomics in both removing and collecting staples.

The retail price of Staple remover & Collect is expected to be $25 with the considerations material cost and manufacture cost. The design is able to be marketed during any season of one year because it does not have any limit time of using.

3.0 Updated Project management plan

- The Final Design Specification (FDS) is planned to be delivered to the client in the week of 4th, Apr, 2016.
- The fourth client meeting is planed to occur in the week of 4th, Apr, 2016.
- The whole project will last four months and end in the week of 10th, Apr, 2016.

4.0 Conclusion/Recommendation

Staple remover & Collecter most adequately reflects the client's need and FOCs. The design is conveniently operated product to loosen staples as it can collect them by the use of magnet. Involving in the design process, environmental, economical and social impact are concerned. As the product should be a marketable design, Staple remover & Collcter is conscious of

market issues. There still exist requirments which should be taken into account when operating it by the user.

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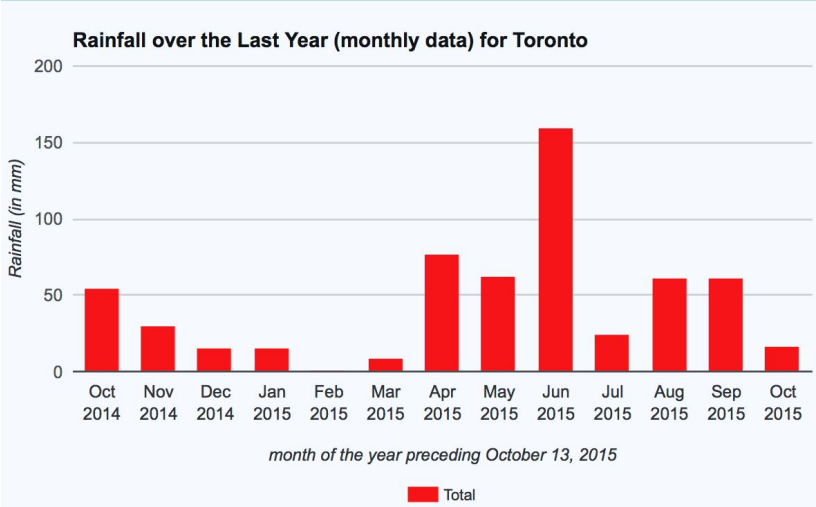
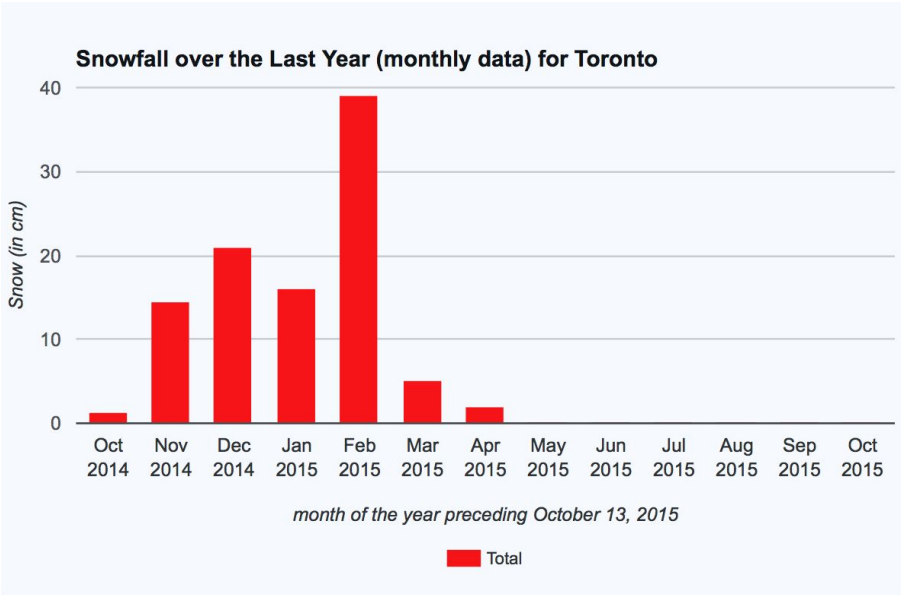
Appendix:

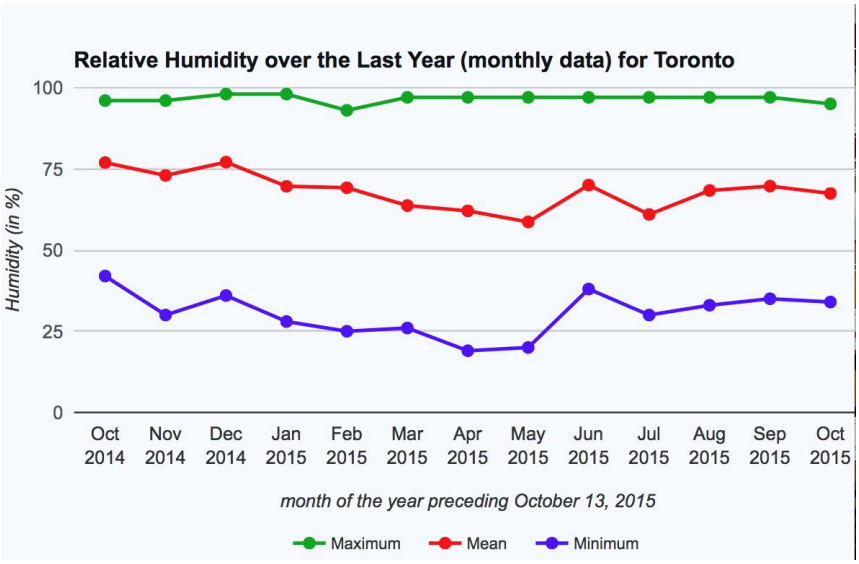
Appendix **A**: Rainfall over the Last Year (monthly data) for Toronto



Appendix **B**: Snowfall over the Last Year (monthly data) for Toronto



Appendix **C**: Relative Humidity over the Last Year (monthly data) for Toronto



Appendix **D** (Proposed design)

1.Mass of the design

dimension for the box=136mm*36mm*2*0.5mm+136mm*50*2*0.5+36*50mm*0.5*2mm=13496mm3

dimension for drawer=17mm*30mm*2*0.5mm+30mm*50mm*2*0.5mm+17mm*50mm*2*0.5mm=2605mm3

dimension for handle=(122mm+9mm0)*40mm/2-(100mm+90mm)*28mm/2=1580mm3

dimension for support=52mm*10mm*20mm-(52mm-29mm)*10mm*20mm/2-29mm*10mm*20mm/2=5200mm3

dimension for lever=52mm*0.4mm*20mm=416mm3

dimension for magnet=36mm*46mm*17mm=28152mm3

density for plastic=0.95g/cm3[56]

density for stainless steel=8000 kg/m^3 [57]

density for magnet=7.5g/cm3

mass of magnet=416mm3/1000*8g/cm3=3.328g

mass of the box in total=(13496m3+2605mm3+1580mm3+5200mm3)/1000*0.95g/cm3+28152mm3/1000*7.5g/cm3+416mm3/1000*8g/cm3=236.20g

2.Design Cost

-average cost for stainless steel is 1.5$/kg [44]

-price for Neodymium Block Magnet is 12.75$/unit [45]

-price for plastic is 8$/0.375inches by 12 inches by 24 inches unit

Total price = 12.75$+1.5$/kg*3.328g/1000+8$/2=16.755$

3.Efficience
volumn of drawer=30mm*50mm*17mm(2605mm3)
5000 staples in 10cm*3.3cm*4.5cm(148.5cm3) size box [58]
box collection=2605mm3/(148.5cm3*1000)*5000=858 units
However, staples may not be in ordered, so the worst situation is considered to be half of the units will be collected.
Actual box collection is approximately 429 units.

Length of the paw: 29mm
Averagely can remove staples per operation.

Appendix **E**: testing force required to remove a single staple
We borrowed an electronic testing tool from our client on Mar 28th and used it to measure the approximate force required to remove a staple from the board.

force required (N)	7.9	13.2	13.5	8.5	17.0	11.2

Based on experiment data, the required force may vary according to the position and type of the staples.However considering some of the staples had corroded which made it harder to remove,our team decided to take the maximum value among these testing results as the data used to calculate the failure force and force required to remove each staple.

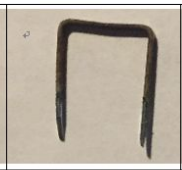
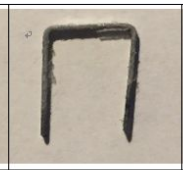
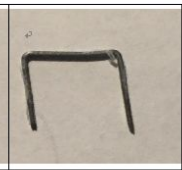
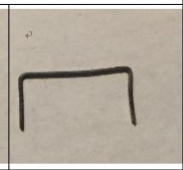
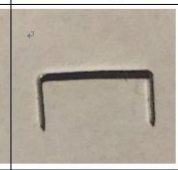
Appendix **F**:force for removing and failure force
force taken to remove each staple:
distance between pivot and midpoint of handle:122/2+(52-29)/2=72.5mm
resistant force of the staple: 17N
angle of bending of paw:9 degrees
force required for removing:(17sin9 *14.5*tan9 +17cos9 *(14.5+11.5))/72.5=6N

failure force of the paw:
tensile strength:400Mpa
b=20mm
d=5mm
L=52-29+60=83mm
F=(2*0.02*0.004^2*400*10^6)/(3*0.083)=1000N
This indicates that the paw will not break unless it takes a burden of 1000N at a time,However the resistant force of each single staple is only 17N which has negligible

impact on deformation of stainless steel even if it removes 3 staples(51N) each time.So this design is strong enough for the client's requirement.

Appendix **G**:Common staples on Toronto outdoor bulletin board and home/office

Table 13: Common staples on Toronto outdoor bulletin board and home/office

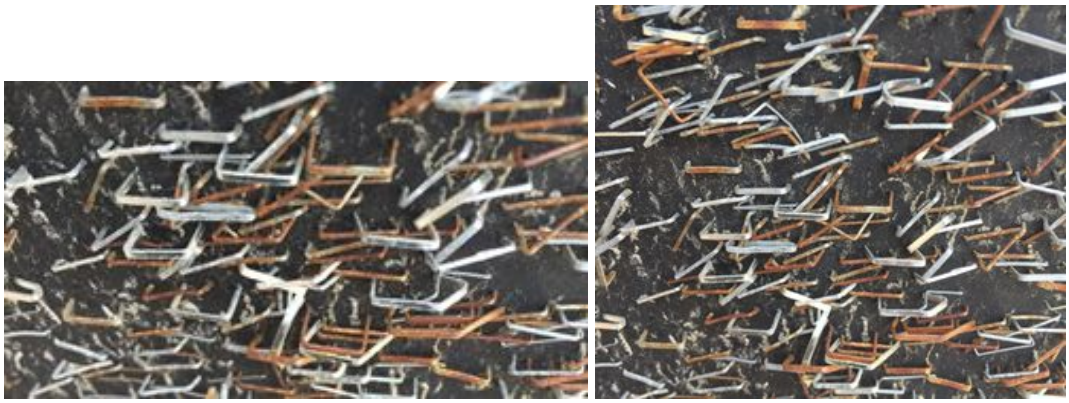
	Common bulletin board staples					Common home/office use staple
Staple						
Total length	12 mm	13 mm	12 mm	8 mm	6 mm	5 mm
Width	11 mm	10 mm	10 mm	11 mm	13 mm	13 mm
Length out of the bulletin board	8 mm	8 mm	7 mm	5 mm	4 mm	

time taken of manual removal	3s	2s	3s	4s	can not be removed	3s

- The results above are calculated by the avarage of 10 same kind of staples.
- The "Common bulletin board staples" focus on staples on Toronto bulletin boards.
- The "Length out of the bulletin board" refers to the part of staple on the surface of board [Appendix D], calculated by the avarege length of rusty part on staples.
- Average time taken to remove each staple by hand is approximately 3 seconds
- Smaller staples are more difficult to be removed than larger grades

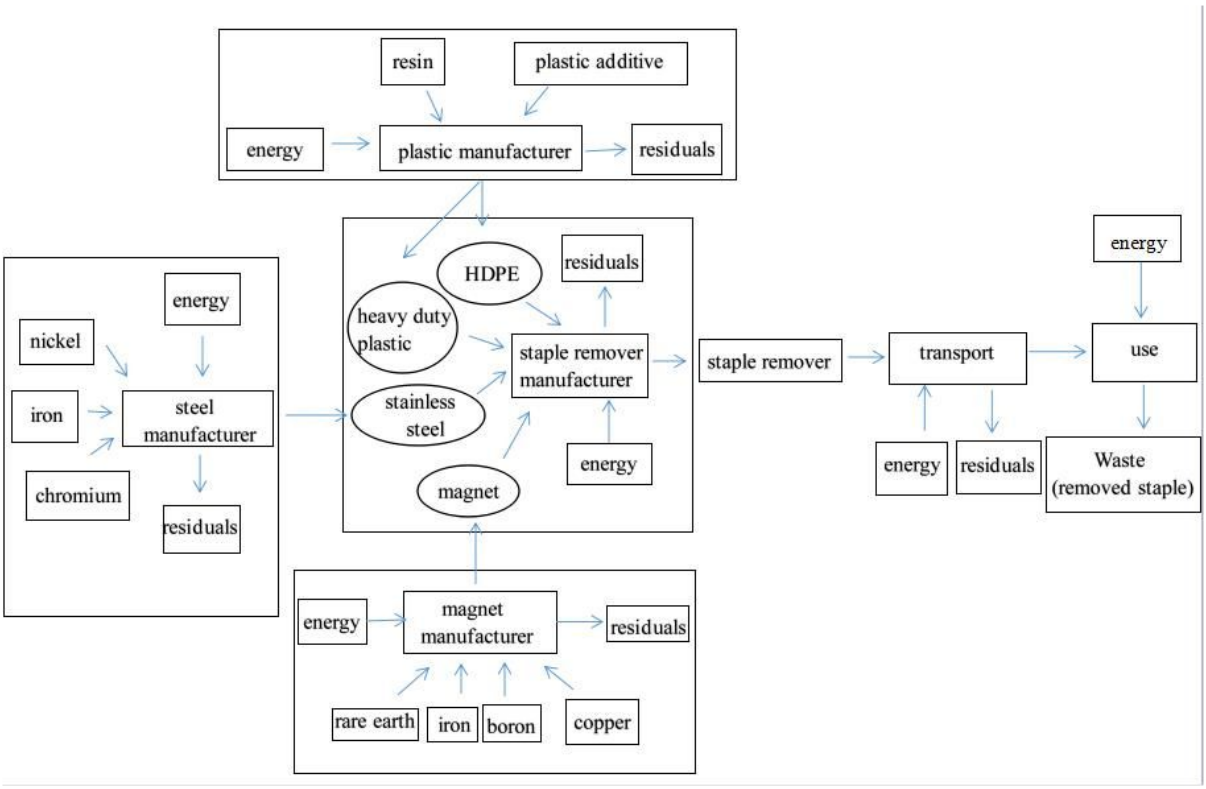
Appendix **H**: Photos of staples on Toronto ourdoor bulletin board and staples on it

Location: College St and McCaul St, Toronto.



Based on observation, staples on the bulletin boards in Toronto are isolate from the boards, rather than closely attach to the boards.

Appendix **I**:


resin
plastic additive
energy
plastic manufacturer
residuals
energy
nickel
iron
steel manufacturer
chromium
residuals
HDPE
residuals
heavy duty plastic
staple remover manufacturer
stainless steel
energy
magnet
staple remover
transport
energy
use
energy
residuals
Waste (removed staple)
energy
magnet manufacturer
residuals
rare earth
iron
boron
copper